A DYNAMIC PARTICIPATION DECISION MODEL APPLIED TO THE CONSERVATION SECURITY PROGRAM FOR NORTHEASTERN UNITED STATES DAIRY FARMS

A Thesis

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ABSTRACT

The Conservation Security Program was authorized in the 2002 Farm Bill and is hailed by many observers as the first true “green payments” program for working lands in the United States. Previous analysis and anecdotal evidence for similar conservation programs show that premature termination of contracts is a persistent issue. This type of producer behavior is not easily explained using the standard assumptions of profit-maximization under perfect information and perfect rationality. Rather, this unexpected termination behavior demonstrates the need for analyses that take into account biophysical complexities and alternative decision-making assumptions. An alternative set of behavioral assumptions is explored in this research that employ descriptive rather than normative participation decision rules.

The objective of this research is to explore the impact of alternative behavioral assumptions and dynamic biophysical effects of conservation practices on the participation and termination decisions of New York dairy producers. A simulation model is constructed to represent the effects of selected biophysical processes on farm profitability, producers’ ability to gather and utilize this information, and finally their decisions to participate in the program. The results of this simulation model provide insights concerning observed termination behavior and suggestions for policy design and implementation.

The results of the dynamic participation decision model indicate that premature termination of CSP contracts is possible and even probable under certain conditions. These conditions include the complex biophysical effects of conservation practices, behavioral characteristics of decision makers, and payment schedules of the Conservation Security Program. These are all significant factors affecting if and when producers decide to termination CSP contracts. Termination decisions, in this model, are a result of learning processes, that is, the producer’s realization of new information

concerning the profitability, or net revenue from participating in the Conservation Security Program.

Behavioral characteristics play a significant role in shaping producers' learning processes and the formation of expectations of net revenue from the CSP contract. Most important for determining participation is the magnitude of the producer's initial estimation error as well as delays in updating their perceptions and expectations of net revenue. These delays determine a producer's adjustment times for perceiving new information and the incorporation of that learning into new expectations about net revenue. This expectation formation process can further encourage farmers to terminate their CSP contracts by creating greater amounts of volatility in expectations. The type of decision rule used by the farmer is also of significance when determining if or when a farmer might terminate participation in CSP. This analysis examines ten alternative decision rules.

This analysis presents several implications for pragmatic policy solutions to the problem of premature termination of CSP contracts. Foremost, policy makers should look beyond typical cost/benefit models of decision-making when designing inventive structures for conservation programs. Taking into account alternative decision-making behavior, this research recommends an alternative payment schedule to what was implemented in the 2005 CSP sign-up. A more robust policy would be to vary the payment rates to compensate for the expected downturn in farmer perceptions and expectations. Evaluation of several dynamic payment schedules indicated that there are a variety of possible schedules that can increase initial sign-up rates, decrease termination rates, and decrease government expenditures simultaneously. The policy "fix," suggested by this analysis, is robust over variations in behavioral characteristics and for multiple decision rules. With this approach, it is possible to simultaneously decrease government expenditure and decrease cumulative termination rates.

BIOGRAPHICAL SKETCH

Joseph A. Shultz was raised on a 4th generation family farm in western Ohio. He continues to participate in the management of the farm with his parents Bill and Susan Shultz. Shultz took a two-year leave of absence from the Ohio State University to serve as the State President and National Vice-President of the FFA, known as Future Farmers of America. While attending Ohio State, Shultz was an active member of Ohio Staters, Inc. a nonprofit service organization and was appointed by Ohio Governor Taft to serve as the undergraduate member of the Ohio State University Board of Trustees. Shultz graduated from Ohio State University in 2003 with a bachelor of science in agriculture majoring in Agribusiness and Applied Economics. When not studying or working, Joe enjoys traveling, spending time outdoors, and cheering on the Ohio State Buckeyes.

To my ever-supportive parents Bill and Susan Shultz.

Thanks Mom and Dad.

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CHAPTER ONE

INTRODUCTION

General Problem

There are numerous interactions between agricultural production and the environment, many of which are negative. One of the most pressing issues in the United States surrounds water quality. National water quality assessments strongly suggest that agriculture is the largest single contributor to the remaining water quality problems in the United States (Claassen, et al. 2001). Soil erosion, although decreasing from 3.1 billion tons per year in 1982 to 1.9 billion tons per year in 1997, continues to be a major problem (Claassen, et al. 2001). The Environmental Protection Agency (1996) identifies sediment as the leading pollution problem in rivers and streams across the country. In addition, nitrogen used as fertilizer on U.S. farms is the leading cause of eutrophication in coastal areas including a large hypoxic zone in the Gulf of Mexico (Claassen, et al. 2001).

Production agriculture creates positive externalities as well, albeit somewhat less quantifiable. Many commonly-mentioned positive externalities include: assurance of available food, sustaining rural landscapes, supporting agrarian heritage, and creation of open space (Abler, 2003). Several environmental externalities can be positive or negative, depending on the specific management practices of a given agricultural operation. Properly managed agricultural systems can provide flood control, wildlife habitat, groundwater recharge, and increased biodiversity. However these effects can all be negated through improper management of agricultural production. Thus, agricultural operations have the potential to produce several positive and negative externalities (Abler, 2003).

This conceptual framework undergirds the notion of the multifunctionality of agriculture: an idea that the production of agricultural commodities generates multiple outputs beyond the commodity itself. Often these additional outputs do not have efficient markets and thus can be considered externalities. There continues to be a growing acceptance of the multifunctional nature of agriculture, however identifying which externalities are in legitimate need of government intervention, (e.g. rural landscapes, cultural heritage, and environmental degradation) is subject to debate. Agri-environmental policy in the United States generally addresses the multifunctionality of agriculture by encouraging farmers to adopt environmentally sound production practices (Claassen et al, 2001.)

The multifunctionality of agriculture seems to fit the classic environmental economic model of environmental externalities that need government intervention in order to provide the socially optimal incentives for agricultural production. Otherwise, agricultural producers will oversupply commodities with net negative externalities and undersupply commodities with net positive externalities relative to the social optimum (Baumol and Oates, 1988). However, simply taxing or subsidizing commodity outputs will not typically be effective due to several complex interactions between agriculture and the environment (Brendal et al, 2004). An example is the production of a negative externality of agriculture, such as nitrogen runoff. Although certain agricultural cropping practices reduce runoff, the relationship between these practices and the bushels per acre of grain produced is largely unrelated. Thus, it can be deduced that simple Pigovian taxes reducing the price of the grain per bushel would be an inefficient policy mechanism to achieve the socially optimal level of nitrogen loadings in rivers and streams. An ideal alternative would be to measure the environmental outputs of agricultural production directly and tax or subsidize their production appropriately. However, for many agri-environmental systems, actual environmental outcomes are difficult to attribute to an individual producer’s behavior because of complex spatial, temporal, and unpredictable factors such as weather (Brendal et al, 2004).

Despite these inherent difficulties, the federal government has implemented several policies designed to mitigate agriculture's impact on the environment. The inability to directly measure environmental outcomes has contributed to the development of agri-environmental policies focused on providing incentives for producers to retire environmentally sensitive land or to use environmentally friendly management practices on land remaining in production. The most notable federal agri-environmental programs include: the Conservation Reserve Program (CRP), which funds voluntary retirement of highly erodible land; the Environmental Quality Incentives Program (EQIP), which provides federal cost-sharing for several conservation management practices; and environmental cross-compliance requirements, which are mandatory for producers who want to remain eligible for traditional farm commodity payments (NRCS website, 2005—http://www.nrcs.usda.gov/programs/farmbill/2002/pdf/ProgSum.pdf). Although the majority of USDA agri-environmental programs are voluntary, some policies under the jurisdiction of the Environmental Protection Agency are mandatory—for example regulations pertaining to the Clean Water Act (Claassen, et al. 2001).

In 2002, Congress wrote legislation that created another agri-environmental program focused on providing financial incentives to individual agricultural producers for exemplary environmental stewardship. The Conservation Security Program (CSP) was legislated by the 2002 Farm Bill, rolled out in autumn of 2004, and has grown in scope in 2005. This new program can be conceptualized as "green payments" or financial incentives for agricultural producers to act as environmental stewards. CSP provides multiple layers of incentives and cost-sharing for ranchers and farmers to undertake changes in on-farm conservation structures or management practices in order to enhance the environmental impacts of their agricultural operation. In the words of the USDA, CSP is designed to “reward the best and motivate the rest.” The voluntary program uses five- or ten-year individualized contracts that focus on environmental issues such as improving water quality, reducing soil erosion, improving air quality, and addressing wildlife issues (NRCS website, 2005—http://www.nrcs.usda.gov/programs/csp/cspqa5905.pdf).

The Conservation Security Program is unique among the USDA’s cadre of agri-environmental policies for several reasons. First and foremost, CSP follows the trend of the Environmental Quality Incentives Program (EQIP) in departing from the USDA’s attempts environmental improvement through large-scale land retirement such as Conservation Reserve Program and Wetland Reserve Program. CSP, like EQIP, focuses on changing management practices on lands that continue to be used in production, termed “working lands” by USDA. Secondly, CSP, unlike EQIP, requires participants to take a whole-farm approach to conservation and environmental management and provides contracts only to producers willing to address several, if not all of the environmental concerns on their operations. CSP contracts are customized to each agricultural operation allowing for flexibility in identifying and addressing the unique environmental challenges faced by each participant. Given the heterogeneous characteristics of individual agri-environmental systems, this flexibility is crucial for providing public environmental benefits in an efficient manner. Thirdly, CSP contracts have multiple layers of payments, including an annual payment based upon the past environmental performance of an operation—for example the historical change in cropland soil organic matter. Addressing past performance is essential for rewarding “good actors” who have demonstrated good stewardship practices prior to enrollment. CSP also goes beyond the EQIP partial cost-sharing model by providing 100% cost-sharing for designated conservation practices that enhance the environmental impact of the operation.

The CSP incentive structure, which attempts to merge both targeted and holistic environmental outcomes, presents challenges as CSP contracts are lengthy, complex, and require a much greater level of planning, management, and commitment from agricultural producers than previous agri-environmental programs. The additional effort required might be offset by larger potential financial benefits for participating producers, which can also exceed previous levels. However, with little empirical data on the participation rates, the program's complex incentives provide a basis for many research questions. The effectiveness of CSP has not yet been analyzed, but its unique place in federal agri-environmental policy makes it deserving of additional analysis.

Designing effective federal conservation programs, such as CSP, is challenging due to the diversity of farm types, crops, farming practices, and environmental concerns. Environmental effectiveness and implementation costs can vary significantly from farm to farm and implementation is difficult to monitor. In general, it is difficult to accurately predict which producers will participate and what land and practices they will offer in response to a given set of participation incentives. A USDA review of conservation program design on working lands stated: "because of the complexity of farm household decision-making and the non-point source and site specific nature of agri-environmental problems, forecasting the benefits of agri-environmental conservation programs is data-demanding and technically challenging (Cattaneo et al., 2005)."

Effective program design is additionally hindered due to the lack of models that can accurately predict participation behavior. This difficulty is most clearly seen in the NRCS CSP Benefit-Cost Assessment (BCA). The CSP BCA utilizes a simulation model to predict aggregation participation rates based on profitability, demographic characteristics, and historical participation in conservation programs (USDA, CSP Benefit-Cost Assessment, 2005). However, this model is poorly suited for predicting the participation of an individual agricultural producer because it does not address the complex processes of farmer decision-making or the dynamic biophysical effects of individual conservation practices over heterogeneous farm types.

It is not to say, however, that the lack of an effective predictive model represents a deficiency of research on understanding the participation decision, or the closely related decision to adopt new technologies such as conservation practices. To the contrary, there is a sizable literature of *ex post* empirical studies, which analyze the decisions of farmers either to adopt conservation practices or to participate in conservation programs. These studies commonly frame the decision as a dichotomous choice problem and examine the demographic or physical factors that influence the decision to adopt conservation practices or equivalently to participate in conservation programs. Most studies include factors such as farmer characteristics, natural features of the farm, or the financial attributes of the agricultural operation. However, many studies lack cost data for conservation practices, which makes them relatively unsuitable for setting practice payment rates. In general, the existing literature provides little guidance to policy-makers on how to design programs and incentive structures to in order to achieve the desired level of participation.

Participation in government programs has often been included in simulation models examining optimal behavior of decision-makers. For example, Perry et al. (1989) uses a linear programming model to analysis the whole-farm planning decisions associated with crop mix decisions and participation in government programs such as commodity deficiency payments and CRP. Due to the heterogeneous characteristics of farms implementing conservation practices, simulating the biophysical effects simultaneously with the economic effects is helpful for greater understanding of the conservation program performance. Integrated biophysical and economic models can shed light upon both the environmental impact of conservation programs and the on-site biophysical effects (Tanaka and Wu, 2004; Westra et al, 2002; Dobbs and Streff, 2005).

Although there are significant research efforts focused on integrated biophysical and economic simulation modeling, there is far less focus on the complex processes of participation decisions in conservation programs. Little is known about these processes as pointed out in Cattaneo (2005). However, neoclassical economic theory presents normative theories as to how a farmer should make a participation decision. These normative theories, which are the base for most *ex ante* research, are often based on a dichotomous choice model, focusing on the "event" of the decision-making rather than the "process." Johnson (1987) argues that the concept of expected utility has been emphasized to the neglect of other aspects of decision-making such as problem definition, learning, analysis, and other decision-making rules. These alternative behavioral assumptions have not played a significant role in participation or technology adoption literature. Nowak (1992) points out: "Unless we begin to spend more time and effort trying to understand all of the complex reasons why farmers are unable or unwilling to adopt new production techniques, out aspirations for wide scale adoption of residue management are destined to fail."

Specific Problem

In the absence of significant empirical evidence concerning participation in the Conservation Security Program, it is appropriate for an *ex ante* analysis of program effectiveness. Of particular interest is the complexity of the participation decision-making process due to the biophysical effects of conservation practices, unique incentives, and dynamic information gathering processes of agricultural producers. The relevance of this type of evaluation is demonstrated by the unexpectedly high percentage of contract cancellations made by agricultural producers in the EQIP program during the late 1990's (Cattaneo, 2003). Contract termination rates were higher than 20% for certain high-cost management practices. Contract cancellations occurred more frequently in the first few years of the contract period, perhaps indicating "learning" by the producer. This type of producer behavior is not easily explained using the assumptions of neoclassical economic theory of profit-maximization under perfect information and perfect rationality. In addition, due to a lack of appropriate data, approaching the participation question using multivariate regression analysis techniques, such as binary choice models seem inadequate for supplying a satisfactory answer.

Instead, more realistic behavioral assumptions are required to support a descriptive rather than normative model of participation decision-making. This model should explore the impact of alternative behavioral assumptions and dynamic biophysical effects of conservation practices on the participation and termination decisions of agricultural producers. Such a model is needed to understand the complexities of biophysical processes on farm profitability, producers' ability to gather and utilize this information, and finally their decisions to participate in the program. Variations from neoclassical economic assumptions such as "anchoring and adjustment" and other descriptive theories found in the behavioral economics literature provide an opportunity to explore this participation behavior (Plous, 1993). These deviations from neoclassical theory can be explicitly modeled using techniques commonly used in the field of system dynamics. The results of such models can supply answers to important questions concerning unexpected participation behavior and provide pragmatic insight into policy design and implementation for policy-makers.

Additional consideration for alternative behavioral assumptions and non-traditional modeling techniques is prompted by the unique incentive structure and biophysical effects of conservation practices embedded in a CSP contract. These distinct characteristics might have unintended effects on the initial and continuing participation decisions of individual agricultural producers. Although described in detail in a subsequent section of this thesis, specific examples of these unique characteristics of participation in CSP include a no-penalty clause for breach of contract and multiple layers of payments provided to a participant. Producers attempting to understand the structure and actual effect of the incentive payments will have no small task considering that each CSP "contract" is actually a bundle of several legal agreements covering management practices or conservation structures on individual tracts of land on the farm. In addition, a producer, even with the assistance of technical support, cannot usually predict the biophysical effects of planned changes in management practices. This difficulty in accurately analyzing the complex dynamic biophysical effects of CSP participation compounds the traditional market uncertainties faced by agricultural producers.

Considered together, these attributes of participation in CSP lead to several important questions. Most importantly, what factors will influence producers' decisions to sign-up for CSP but subsequently not fulfill the entire length and breadth of their contract? More specifically, how do the dynamic biophysical processes of the conservation practices affect profitability over the course of a ten-year contract? Furthermore, how will this change in profitability affect producers' learning and decision-making processes? To approach these questions, this analysis will start with the traditional assumptions that producers have perfect information and use the calculations of net present value as a decision rule, and then examine the effects of alternative behavioral assumptions. Doing so acknowledges the complex process by which producers gather, process, and make use of information in order to make decisions related to participation in agri-environmental programs. Therefore, it is useful to ask the little-studied question: what role does learning and expectation formation play in influencing participation decisions? Additionally, what management decision processes, beyond the assumptions of perfect information and rationality, will contribute to the participation decision making process of the producer? Answers to these questions will naturally lead to pragmatic policy questions related to the design of structure, mechanisms, and incentives of CSP to decrease the likelihood of cancellation of contracts.

Unexpected cancellation behavior in a recent federal conservation program has demonstrated the need for analyses that take into account biophysical complexities and alternative decision-making assumptions. A descriptive rather than normative model is useful for understanding the complexities of farmers' decision-making processes. Such a model can then be applied to dairy farmers in the Northeastern region of the United States, who face a unique set of challenges related to both profitability and to environmental concerns, such as nutrient management issues. A focus on this subset of agricultural producers is also motivated by a perception that previous federal agricultural programs have been less beneficial to Northeastern farmers relative to other regions of the United States. The application of these questions to a specific farm type and region will allow for much more realistic and applicable answers to important policy questions.

Objectives

The general objective of this research is to model, *ex ante*, the CSP participation and termination decisions of a representative NY dairy farmer in order to gain insight and understanding for program design and implementation. Specific objectives include:

1. Summarize the available information on the dynamic biophysical effects of four conservation practices likely to be used on NY dairy farms and their subsequent impacts on net revenue over the course of a ten-year CSP contract.
2. Describe alternatives to behavioral assumptions that assume profit-maximization under perfect information and rationality for producers. These alternatives will include assumptions regarding initial estimation error, learning processes, expectation formation, and a range of participation decision-making rules.
3. Construct a dynamic simulation model for an individual representative farmer in order to explore the impacts of the interactions between biophysical dynamics, incentive structure, and alternative behavioral assumptions on participation decisions, particularly focusing on the decision to terminate participation.
4. Analyze the impacts of specific policy alternatives, such as timing and amount of incentives, education of producers, and implementation procedures, on the decision to terminate participation in CSP.

Thesis Organization

The remainder of this thesis is organized as follows. *Chapter Two* provides a summary of the Conservation Security Program and places it in the context of recent U.S. Agri-Environmental policy. This chapter also explicitly describes the requirements, procedures, and implementation of CSP including determination of eligibility and payments. The methods for this research endeavor are discussed in *Chapter Three*, paying particular attention to the modeling paradigm of system dynamics, its notation, and how it complements traditional applied economic policy analysis. *Chapter Four* presents the formal dynamic participation model and provides justification for model structure, parameter estimates, and various simulation runs to be used for policy analysis. This model is described in three distinct sectors: conservation practices and payments, information and management processes, and participation decision rules. These sectors are derived directly from the defined problem and stated objectives. *Chapter Five* presents the results and findings of the dynamic participation decision model and provide an evaluation of the model. Finally, *Chapter Six* provides further discussion of results, limitations of the model, implications for policy design, and suggestions for future research.

CHAPTER TWO

CONSERVATION SECURITY PROGRAM

Introduction

The Conservation Security Program (CSP), legislated in 2002 and partially implemented in 2004, is the subject of this *ex ante* policy analysis. The CSP is a voluntary program which provides financial and technical assistance to agricultural producers in order to promote the conservation and improvement of soil, water, air, energy, plant and animal life on Tribal and private working lands. It is administered by the United States Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS). The CSP adds a distinctly new dimension to the United States approach to environmental concerns on farms and ranches. The CSP's unique objectives, complex incentive structure, and potential for impact can be better understood and appreciated when put into a context of all federal agri-environmental programs. The development of agri-environmental programs and the current status of these policies are summarized below. Additionally, the details of the program, including eligibility, payment structure, and participation rules, are examined in order to develop the simulation model found later in this study.

Agri-Environmental Policy Context

Existing agri-environmental policy has its origins in farm crisis of the 1930's. Soil conservation and farmer financial assistance became a justifiable public expenditure, as the devastation of the Dust Bowl was brought into the spotlight as in the novels of John Steinbeck and the music of Woody Guthrie. The 1936 farm bill, The Soil Conservation and Domestic Allotment Act, "provided for the protection of land resources against soil erosion and for other purposes." These "other purposes" included the transfer of revenue to American farmers (Cain and Lovejoy, 2004). Thus, the dual objectives of agri-environmental policy were present at conception: a dichotomy of increasing farmer income and protecting natural resources. Early efforts at conservation could accomplish the dual policy goals without conflict. The financial assistance program in the 1936 Act, called the Agricultural Conservation Program, paid farmers to replace seven soil-depleting crops with other crops thought to be soil-conserving such as grasses, legumes, or cover crops. Subsequently, Congress provided incentive payments for several more conservation practices, which reduced resource problems on farms (Helms, 2003). However, public concern began to grow in the early 1980's about the sometimes deleterious nature of intensive agricultural production. These concerns led to a policy shift that began to address environmental issues that had off-farm consequences as well as an effect on farm revenue (Zinn, 2005). The 1985 Farm Bill was the first Farm Bill to have a specific title devoted to conservation issues and included groundbreaking new conservation programs: Sodbuster, Swampbuster, conservation cross-compliance, and the Conservation Reserve Program (CRP). The 1985 farm bill ushered in a new era of agri-environmental policy initiatives from which the Conservation Security Program has evolved (Helms, 2003). From 1985 through the present, USDA administered agri-environmental programs can be divided into three distinct categories: conservation compliance mechanisms, land retirement programs, and working land payment programs. Additionally, significant expenditures have been made for producer education and technical assistance, which is, linked to the implementation of most conservation programs including conservation cross-compliance. Although the implementation details, funding levels, and relative prominence of each type of policy has waxed and waned with each successive Farm Bill, each of the three remain important to understanding the overall framework of federal agri-environmental policy. Though USDA agri-environmental policy operates in concert with the regulatory requirements and initiatives of other federal agencies, this summary will focus its attention on the voluntary and incentive-based programs administered by the USDA.

Compliance mechanisms enacted in the 1985 Farm Bill made protection of highly erodible soil and wetlands a prerequisite for receiving federal monies through other farm payment programs. These mechanisms include the Conservation Compliance, Sodbuster, and Swampbuster provisions. Under these provisions, farmers can only remain eligible for farm program payments, including CRP, disaster payments, and Federal Crop Insurance, when they comply with certain environmental practices. Conservation Compliance requires those who farm highly erodible lands to implement conservation plans to reduce soil erosion. The Sodbuster provision requires producers to apply strict conservation systems to any new highly erodible lands that they bring into production. The Swampbuster provision excludes farmers from farm program payments if they drain wetlands in order to bring land into agricultural production.

These provisions were enacted in order to remove the incentive, magnified by commodity price supports, to expand crop production onto environmentally sensitive land. However, the effectiveness of compliance mechanisms is limited to addressing the environmental concerns on farms that already receive other forms of federal farm payments. Nonetheless, between 1982 and 1987, erosion fell on highly erodible land by 331 million tons annually (Claassen et al, 2004). From a policy design perspective, conservation compliance mechanisms are a more cost efficient mechanism than incentive-based policies at achieving environmental benefits. Although compliance mechanisms do not make direct payments to farmers and ranchers, there is a significant cost to the federal government for the monitoring and enforcement activities, as well as the conservation planning and technical assistance required to implement these provisions (Claassen et al, 2004). These educational and information services, officially called Conservation Technical Assistance (CTA), amounted to $742 million in the 2004 USDA budget and have been provided to farmers and ranchers in some form since 1935 (USDA website, 2005—http://www.usda.gov/agency/obpa/Budget-Summary/2006/FY06budsum.htm).

Regulatory requirements are mostly used as agri-environmental policy tools by agencies other than the USDA. Although a comprehensive overview of federal regulations affecting agriculture and the environmental is beyond the scope of this study, a few notable policies are summarized below. The Environmental Protection Agency (EPA) carries out the most prominent regulatory action, which affects agricultural producers. The Federal Water Pollution Control Act of 1972, commonly referred to as the Clean Water Act, focuses on reducing the water quality impact of point sources of pollution such as factory discharge and municipal sewage. In recent years, the focus of the Clean Water Act has turned to non-point sources including runoff from agricultural operations (Claassen, 2001). In addition, agricultural point source pollution from confined animal feedlot operations (CAFO's) is regulated. As of 2001, over 6,000 livestock operations were large enough to be classified as CAFO's under the Clean Water Act (Claassen, 2001). This designation requires CAFO's to obtain a permit to discharge of manure and nutrients. The Coastal Zone Act Reauthorization Amendments (CZARA) of 1990 is a federally mandated program requiring specific measures to deal with agricultural non-point source pollution in order to restore and protect coastal waters. The program requires each of the twenty-nine states with approved coastal zone management plans to utilize voluntary incentives to encourage farmers to adopt measures that control non-point source pollution. If voluntary measures fail, however, then states must enforce adoption

(Claassen, 2001). The Endangered Species Act of 1973 was enacted to conserve endangered or threatened species and their ecosystems. Under this law, farmers are prohibited from “taking” a member of a species determined to be endangered or extinct. And in some cases, habitat destruction, cropping practices or the use of certain pesticides can be prohibited. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1947 regulates the use farm chemicals. Certain chemicals can be banned if they pose unacceptable risks to human health or the environment (Claassen, 2001).

Land retirement programs have long dominated federal spending on agri-environmental programs (Claassen, 2001). The current iterations of land-idling programs include the Conservation Reserve Program (CRP), the Wetland Reserve Program (WRP), and the Conservation Reserve Enhancement Program (CREP). Each program offers annual payments and cost-sharing to take environmentally sensitive land out of production and establish long-term cover (Cattaneo, 2005). The CRP, the largest of the three policies, was initiated in the 1985 Farm Bill and provides annual rental payments on land enrolled in ten to fifteen-year contracts. Between $1.5 and $2 billion has been spent annually on land retirement through CRP. More than 36 million acres, approximately 10% of U.S. cropland, is currently enrolled. (ERS website—2005, http://www.ers.usda.gov/Briefing/ConservationAndEnvironment/Questions/consenvcp3.htm) In addition to the environmental benefits stemming from reduced soil erosion and increased wildlife habitat, land retirement programs have received broad-based political support as they reduce the supply of commodities thus boosting prices, and provide reliable stream of income to farmers and ranchers who receive annual payments (Cain and Lovejoy, 2004).

Agricultural land preservation programs also address land-use issues, although designed with different objectives than land retirement programs. Such programs include the Farm and Ranchland Protection Program (FRPP) and Grassland Reserve Program (GRP). FRPP is a voluntary program that is designed to help agricultural producers keep their land in agricultural use. The FRPP provides matching funds to State and Local governments or non-governmental organizations in order to purchase conservation easements or other interests in land. The GRP preserves native-grass grazing land by restricting cropping practices through long-term contracts and easements (Cattaneo, 2005).

Although land retirement programs have been the mainstay of federal agri-environmental policy since 1985, in many instances payment programs directed to working lands can achieve environmental benefits at a lower cost per acre. This is due to the fact that when agricultural land remains in production, farmers are willing to accept a smaller payment for simply changing management practices compared to taking the land out of production entirely (Cattaneo, 2005). This approach of providing incentive payments or cost-sharing to lands remaining in production has become the focus of several conservation programs in the late 1990's. Incentive payments and cost-sharing provide direct payments to farmers and ranchers to implement environmentally beneficial practices. Cost-share policies typically pay 50 to 75 percent of the adoption costs depending on the program, although it is important to note that many of the conservation practices have positive biophysical effects for agricultural production and can thus increase net revenue to farmers. This is particularly true of soil conservation measures, which offer both on-farm revenue enhancement as well as off-farm environmental benefits. The Environmental Quality Incentives Program (EQIP) was established in the 1996 Farm Bill in order to consolidate many previous cost-share programs and to better target their benefits. The objective of EQIP, like its predecessors, is to encourage farmers to adopt practices that reduce environmental and resource problems by providing education, technical assistance, and financial incentives through the cost-sharing of implementing best management practices or installing on-farm structures (NRCS website—2005, http://www.nrcs.usda.gov/programs/eqip/). Over half of its funds are dedicated to livestock operations to specifically address manure and nutrient management systems. The EQIP budget has grown rapidly from yearly expenditures of roughly $200 million in 1996 to just over $1 billion in the FY 2005 (USDA website, 2005—http://www.usda.gov/agency/obpa/Budget-Summary/2006/FY06budsum.htm). The Wildlife Habitat Incentives Program (WHIP), created in 1996, provides cost-sharing assistance for farmers who develop wildlife habitat and protect threatened and endangered species. Participants with assistance from NRCS district offices develop plans for installing and maintaining wildlife habitat development practices. (Claassen, 2001). In general, federal agri-environmental policy funding has been shifting towards working land payment programs, which includes the Conservation Security Program. Although annual budgets will ultimately dictate expenditures, the 2002 Farm Bill projected working land payment programs to receive an $11 billion increase in funding over 10 years, compared with an increase of $3 billion for land retirement programs over the same time period (ERS website-2005, http://www.ers.usda.gov/Features/farmbill/analysis/conservationoverview.htm).

The Conservation Security Program is an extension and broadening of previous working land payment programs. However, its development was significantly nurtured by current circumstances in the arena of international agricultural trade. Global trade agreements, particularly the Uruguay Round Agreement on Agriculture (URAA) have complicated the farm policy debate and have played a key role in the development of the CSP and related agri-environmental policies (Johnson, 2004). Under the URAA, signatory countries agreed to reduce domestic commodity price support and export subsidies. All farm support was categorized into “boxes” based on the degree to which it was deemed trade distorting. The amber box contained the most production-distorting measures of support such as government support of prices. These subsidies were expressed in terms of a total Aggregate Measure of Support (AMS), and then placed on a reduction schedule. Green Box subsidies, which were termed minimally trade-distorting, were free from reduction commitments and could be increased without penalty (Ingco and Croome, 2004). The United States met its commitment to limit farm commodity support, or AMS, to no more than $23.1 billion in 1995 and 19.1 billion in 2000 (Claassen, 2001). However, many U.S. farm programs do not count against the AMS such as "decoupled" direct payments or payments off-setting the cost of environmentally beneficial management practices. For direct payments to be considered "decoupled," they must not be linked to current production and must be provided even if there is no agricultural production (Ingco and Croome, 2004). This is the conceptual underpinning of U.S. Direct Payments, which are calculated according to a base year. All federal agri-environmental payments, including CRP, EQIP, and CSP are given green box status and thus unrestricted according to the WTO. This "Green Box" status, which could have income-enhancing characteristics depending on payment levels, makes CSP attractive to legislators who want to provide farm income support while continuing to meet the amber box commitments of the URAA.

Two pending agricultural trade issues could affect the future design, funding, and implementation of CSP or related agri-environmental policies. The first concerns the current Doha Round of WTO talks, where the further reduction of agricultural subsidies has emerged as a key issue. One facet of this problem has been the use of trade-distorting measures to affect multifunctionality of agriculture. An argument has been made by several countries that some trade-distorting production subsidies, which provide multifunctional benefits, should be moved to the green box and not be subject to further restrictions. The United States opposes this viewpoint and has pointed out that many of the countries advocating this position are becoming close to hitting the ceilings of their own amber box commitments (Vanzetti and Wynen, 2004). Allowing trade-distorting payments providing multifunctional benefits could lead to the inevitable messy debate over which benefits are worthy of trade distortion.

The second important development regards the 2004 WTO ruling on the cotton case brought against the United States by Brazil. The WTO Dispute Settlement Panel ruled that the U.S. cotton Step-2 payments to exporters are prohibited export subsides and Step-2 payments to domestic users are prohibited import subsidies. Additionally, the panel found that domestic support to U.S. cotton producers did not qualify for exemption under the now expired Peace Clause due to the finding that production flexibility contracts and direct payments were not fully decoupled within the definition of the WTO. The Panel went on to find price contingent U.S. cotton measures to have an adverse effect on world prices through significant price suppression and therefore causing “serious prejudice” to Brazil (Cook, 2005). This ruling could have implications for U.S. direct payments and counter-cyclical payments for all commodities as authorized under the 2002 Farm Bill. It is possible that future WTO cases could reclassify all Direct Payments “Amber Box,” due to required planting restrictions. Regardless of the eligibility status of Direct Payments, some have suggested that the tightening of agricultural payments definitions and the possibility of reaching the AMS ceiling will give greater prominence to programs such as CSP that can provide farm income support payments within the “minimally trade distorting” rules of the green box (Claassen, 2001).

CSP Design

Since 1985, the primary target of USDA agri-environmental program dollars has been financial incentives for retiring environmentally sensitive land. Cost-sharing programs on working lands retain a significant, yet smaller share, of federal program dollars. Congress enacted the Conservation Security Program in the 2002 Farm Bill to specifically address the perceived need for more conservation incentive payments on working lands. The background issue of green box compatibility was cited by farmers' groups as a potential benefit of the program (Johnson, 2004). The Conservation Security Program is authorized under the provisions of Title II, Subtitle A, of the Farm Security and Rural Investment Act of 2002, Public Law 107-171, commonly known as the 2002 Farm Bill. As designed by Congress, CSP fits the traditional role of providing incentives for conservation practices on working lands, similar to its companion program EQIP; however it also goes beyond traditional cost-sharing in three unique ways. First, CSP provides rewards producers for prior environmental performance. Second, CSP encourages participants to address all resource concerns on their entire agricultural operation. And finally, it has the potential to provide significant incentives, through its enhancement payments, for agricultural producers to go beyond meeting the minimum standards of conservation and provide environmental benefits such as those mentioned by proponents of multifunctionality (Dobbs and Pretty, 2004).

Implementing a new nationwide conservation program, however, is easier said than done. Indeed, implementation has proven difficult as the design, funding, and rollout of the program has been convoluted and controversial. Uniquely, Congress designated CSP as an entitlement program, which gave it an unlimited spending cap and guaranteed it for all agricultural producers. This provided it a status unlike any of the other NRCS agri-environmental programs focused on working lands. After passage of the bill, the Congressional Budget Office (CBO) estimates of the cost of the program grew from 2.0 billion over ten years in 2002 to 6.8 billion in 2003, and finally 8.9 billion over ten years in 2004 (Johnson, 2004). With CBO spending projections seemingly untenable, appropriators prohibited funding in FY2003, and then budgeted only $41.4 million in FY2004 and $202 million in FY2005. The under-funding of CSP is also viewed as partially a result of the political considerations of a Republican controlled Congress and White House that wanted to stifle legislation proposed by a Democratic Senator, namely Tom Harkin of Iowa (Hoefner, 2005). These annual budget caps make CSP enrollment effectively competitive, contrary to the original designation of CSP as an entitlement program. NRCS issued a draft rule that generated more than 10,000 comments, then issued a final interim rule on June 21, 2004, and finally issued an amended final interim rule on March 18, 2005 (Johnson, 2004). NRCS states that it plans to issue a final rule after collecting data from the full-scale sign-up in 2005. In a separate action that will affect future CSP funding, Congress capped total funding for CSP over the next ten years at $6.0 billion in order to transfer $2.9 billion in funds to pay for disaster assistance during October 2004 (Johnson, 2004).

Funding limitations led the NRCS to implement CSP in only eighteen selected watersheds during the FY2004 sign-up and 202 watersheds in FY2005. These watersheds are based on 8-digit hydrological codes and average 450,000 acres in size (NRCS, CSP Amendment to Interim Final Rule, 2005). These particular watersheds were selected on a complicated, and somewhat opaque, ranking system based on environmental concerns, the NRCS capacity to implement the program in those watersheds, and regional distribution. NRCS states that all 2,119 watersheds in the United States will be eligible for CSP contracts within 8 years; however this would mean an increase to 264 watersheds a year which would require an increase in the CSP budget. Also constraining the rollout and management of the CSP is a 15% cap on technical assistance imposed by Congress. This cap assures that 85% of CSP funds are used solely for payments; however it has been cited by NRCS as a major constraint on the rollout of the program (Johnson, 2004).

Eligibility

To be eligible for CSP, an applicant must be in compliance with the highly erodible land (Sodbuster) and wetland conversion (Swampbuster) provisions of the 1985 Farm Bill. CSP contracts can be awarded to landowners, tenants, sharecroppers, or renters. CSP provides for the fair treatment for tenants, allowing a tenant to receive CSP contracts as long as the tenant provides NCRS with written evidence of control of land from the landowner. The applicant must have an active interest in the agricultural operation and share in the risk of producing a crop or livestock and be entitled to a share in the crop or livestock marketed from the operation. Therefore, landlords and owners are ineligible to submit an application for exclusively cash rented agricultural operations. Only one active CSP contract is allowed per participant. Finally, the applicant must complete a benchmark resource inventory for land being enrolled in the program (NRCS, CSP Amendment to Interim Final Rule, 2005).

To be eligible for CSP, the land in question must be privately owned land or Tribal land, the majority of which must be located within the selected watershed. Other lands designated by NRCS are eligible for CSP payments such as forested land that is an incidental part of an agricultural operation. These incidental forested lands must be less than 10-acre individual parcels and a total of less than 10% of the total acres under contract. Other incidental parcels determined by NRCS, such as small adjacent areas center pivot corners, field borders, turn rows, or riparian areas, are also eligible. Additionally, NRCS can designate areas outside of the boundary of the agricultural operation that will provide additional environmental benefits such as farmsteads, barnyards, feedlots, equipment storage areas, etc. However, any land brought into crop production after May 13, 2002 or devoted to crop production for less than four out of the six years preceding May 13, 2002, is ineligible for CSP contracts. This provision is an attempt to prevent CSP from becoming an incentive for producers to put more land in production. However, this provision will only be effective if agricultural producers have the expectation that base year of 2002 will be maintained throughout the life of the program. Land enrolled in CRP, WRP, or the Grassland Reserve Program is also ineligible for payments; however these lands can be counted in the benchmark inventory as contributing to addressing resource concerns on the entire operation. Specifically excluded from program payments are animal waste practices or other structural improvements relating to nutrient or manure management. The EQIP program has specifically addressed these environmental needs through cost-sharing programs (NRCS, CSP Amendment to Interim Final Rule, 2005).

Applications that meet the minimum requirements will be placed in enrollment categories to determine funding priority. Although no eligible producers were denied funding in the FY2004 sign-up, there exists the possibility that limited funding will create a situation in which enrollment categories will be used. These categories are based on an operation’s initial benchmark assessment of resource concerns, past conservation practices, and willingness to implement additional conservation practices. Category placement will determine funding priority if all applications within a given watershed cannot be funded. For agricultural operation composed primarily of cropland, the categories will be based on a producer’s willingness to adopt new conservation practices and the Soil Conditioning Index, a model that predicts the consequences of cropping systems and tillage practices on the status of soil organic matter in a field (NRCS website—2005, http://soils.usda.gov/sqi/assessment/sci.html).

If limited funding becomes an issue in a particular watershed, this category assignment process could create incentives for producers to sign-up for conservation practices, which have either uncertain or marginally profitable outcomes. Limited resource operations, as defined by USDA, will be given first priority in funding in each their respective funding categories (NRCS, CSP Amendment to Interim Final Rule, 2005).

Payments

Agricultural producers enrolled in the Conservation Security Program are entitled to receive payments for several aspects of their conservation efforts. The total Conservation Stewardship Contract payment is the sum of four distinct payments, each with different purposes and requirements. These components include the Stewardship payment (base payment), the Existing Practice payment, the New Practice payment, and the Enhancement payment. Each of these payments is unique to specific tracts of land where resource conditions are similar and conservation practices both past and planned are compatible. Thus, agricultural operations are divided into tracts of land each with multiple agreements. Anecdotal evidence shows that overall contracts can become quite complex with dozens of separate agreements for any single agricultural operation. The sheer volume of information contained within so many agreements makes understanding and analyzing the impact of the entire CSP contract a daunting task for a participating producer.

Delineation of the agricultural operation is a significant concept in the payment structure of CSP due to the program's focus on whole farm planning and requirement of addressing all resource concerns on an operation. The NRCS has developed a specific criteria by which an agricultural operation is delineated for the purposes of CSP: "the applicant will delineate the agricultural operation to include all agricultural lands…under the control of the participant and constituting a cohesive management unit, and is operated with equipment, labor, accounting system, and management that is substantially separate from any other land (NRCS, CSP Amendment to Interim Final Rule, 2005).” If the applicant chooses to use USDA farm boundaries, then the entire farm must be included, however, an applicant can offer one farm or aggregate farms into one agricultural operation for purposes of the program (NRCS, CSP Amendment to Interim Final Rule, 2005).

All CSP contracts will be placed into one of three tiers of participation. An applicant’s tier is determined by the benchmark inventory conducted in the sign-up period. Tier designation considers only the majority land type on the agricultural operation. For example, a 100-acre farm with 45 acres of pasture and 55 acres of cropland will placed in a tier based only on the cropland indicators. The tier of participation will have an impact on two of the four CSP payments and most of the contract limitations. The tier system is used to reward producers for their level and scope of conservation practices prior to sign-up. In addition, the tier system is designed to provide incentives producers to increase their conservation efforts in order to move up to a higher tier. Tier I participants are limited to five-year CSP contracts, whereas tier II and tier III participants can have up to ten-year CSP contracts. Specific tier requirements are summarized below.

Applicants participating in Tier I must address the soil and water quality resource concerns on part of their agricultural operation prior to sign-up. These nationally significant resource concerns are reflected in the applicant’s benchmark inventory for cropland revealing a score of 0.0 or better on the Soil Conditioning Index (SCI). The SCI provides an overall indication of the trend and quality of a soil resource. The SCI can predict the consequences of cropping systems and tillage practices on the trend of soil organic matter. Organic matter is a primary indicator of soil quality and an important factor in carbon sequestration and is also an indicator for air quality, reduction of green house gases, and soil moisture conservation (NRCS website—2005, http://soils.usda.gov/sqi/assessment/sci.html). Meeting the minimum quality criteria for water quality requires addressing the risks that nutrients, pesticides, sediment, and salinity present to water quality. If the SCI rating is positive, the system is predicted to have increasing soil organic matter (NRCS, CSP Amendment to Interim Final Rule, 2005). Rangeland and pasture have different determinants for tier participation including: a forage-animal balance, proper livestock distribution, timing of use, and managing livestock access to watercourses.

Applicants meeting the requirements for tier II participation must address the resource concerns of soil and water quality, but on their entire agricultural operation. Tier II participants must also agree to address one additional resource concern, such as soil condition, water quantity, or wildlife habitat, by the end of the contract period.

Applicants participating in tier III must address all resource concerns on their entire operation. This includes meeting the above requirements for tier I and II and adds the additional requirement of addressing all other significant applicable resource concerns such as wildlife habitat, and water quantity, and protection of riparian corridors to the minimum quality level as established by the NRCS Field Office Technical Guide (NRCS, CSP Amendment to Interim Final Rule, 2005). Tier III participants must also agree to conduct additional practices and activities. CSP participants are permitted to move to a higher tier of participation during the contract period. Upon transition to a higher tier, NRCS will recalculate all payments. Participants will not be eligible for higher payments until they have participated a period of at least twelve months in their current tier.

Also notable for the purposes of this study is the lack of disincentive for the cancellation of contracts by participants. Specifically, a "participant may voluntarily terminate a contract, without penalty or repayment, if the State Conservationist determines that the contract terms and conditions have been fully complied with before termination of the contract" (NRCS, CSP Amendment to Interim Final Rule, 2005).

An annual stewardship, or base payment, will be awarded on a per acre basis. It is calculated separately for each land use type in the agricultural operation: cropland, irrigated cropland, pastureland, irrigated pastureland, or rangeland. Incidental land, such as fence rows, grass waterways, and forest land adjacent to the above mentioned land types will be included in the overall acres receiving the stewardship payment. The annual stewardship payment will be based on stewardship payment rates (rental rates) multiplied by two tier specific reduction factors. The stewardship payment rate is the estimated 2001 land rental rates calculated as a flat rate for the entire watershed. NRCS will initially calculate the average 2001 rates using the Agriculture Foreign Investment Disclosure Act (AFIDA) Land Value Survey, the National Agriculture Statistics Service (NASS) land rental data, and Conservation Reserve Program (CRP) rental rates. Where typical rental rates for a given land use vary widely within a State or between adjacent States, NRCS will adjust the county-level rates to ensure local and regional consistency and equity (NRCS, CSP Amendment to Interim Final Rule, 2005).

This stewardship payment is multiplied by a tier factor (0.05 for tier I, 0.10 for tier II, and .15 for tier III.) and a reduction factor (0.25 for tier I, 0.50 for tier II, and .75 for tier III). Combining these reduction factors produces a rate of 1.25% for tier I, 5% for tier II, and 11.25% for tier III, to be multiplied by the stewardship rate (rental rate) of the watershed (NRCS, CSP Amendment to Interim Final Rule, 2005). These reduction factors are expected to remain constant throughout the life of the program. It can be seen that the tier of participation and the stewardship rate (rental rate) will have a significant impact on the total contract payment particularly for agricultural operations with large acreages. An annual payment called the existing practice payment will be made to subsidize the maintenance of conservation practices existing prior to sign-up. However, there is no determination of actual costs of existing conservation practices, therefore this payment will be calculated as a flat rate of 25% of the stewardship payment for all participants (NRCS, CSP Amendment to Interim Final Rule, 2005).

The third type of annual payments under CSP is designated for the implementation or installation of new conservation practices. These payments will be made based on each individual practice and will not be more than 50% of the cost-share rate and limited to a total of $10,000 over the life of the contract. These cost-sharing payments are thus very similar to the existing EQIP program and in fact CSP participants are encouraged to take advantage of such programs as opposed to getting the cost-sharing through CSP. As a result, the 2004 sign-up showed a very small percentage of the total payments being made through new practices (USDA, 2005).

The final and most significant annual payments are called enhancement payments. These are made for exceptional conservation efforts and "additional conservation practices or activities that provide increased resource benefits beyond the prescribed level" (NRCS, CSP Amendment to Interim Final Rule, 2005). The payment rates for each enhancement will be based primarily on expected environmental benefits and secondarily on the producer's cost to implement the enhancement. Each watershed will have a specific list of available enhancements with fixed payments from which participants can choose. Examples of enhancements that will receive payment in the 2005 sign-up period include: increasing the SCI of cropland, implementing energy management practices, and installing structures beneficial to wildlife. Some payment rates for enhancements will be set at the federal level, such as increasing SCI, while others will set for each watershed individually.

Newly implemented for the 2005 sign-up is a rule that requires participants to take a variable payment rate for all enhancements. This rate begins at 150% of the enhancement payment in year one, then dropping each year to 90%, 70%, 50%, 30%, 10%, and 0% respectively, for the remainder of the contract (NRCS, FY2005 CSP Sign-Up Announcement, 2005). The rationale for this variable payment rate, cited by NRCS, is to provide contract capacity to add additional enhancements in the out-years and to encourage participants to make continuous improvements to their operation by adding additional enhancements throughout the life of the contract. All additional enhancements after the initial sign-up will be paid at a flat rate of 100%. Also available is the advancing of enhancement payments into the first-year payment and deducting those payments from following years' payments (NRCS, FY2005 CSP Sign-Up Announcement, 2005). Data from the FY 2004 sign-up shows that the enhancement payments make up the largest portion of the total CSP payment for most participants (NRCS website—2005, http://www.nrcs.usda.gov/programs/csp/).

Several contract limitations have been imposed on the CSP payments. The stewardship component of a CSP contract cannot exceed $5,000 per year for tier I, $10,500 for tier II, and $13,500 for tier III. Annual enhancement payments will be capped at $13,750 for tier I, $21,875 for tier II, and $28,125 for tier III participants (NRCS, CSP Amendment to Interim Final Rule, 2005). It is difficult a priori to calculate the effect of the enhancement cap on actual participation behavior; however it is interesting to note that when assuming a $75 per acre rental rate, a tier III participant would reach the stewardship cap at 1,600 acres of cropland. This implicit acreage cap is considerably higher for tiers II and I at 2,800 and 5,333 acres respectively. Assuming a lower rental rate would increase the implicit acreage cap while a higher rental rate would decrease the cap. Total annual maximum contract payments cannot exceed $20,000 for tier I, $35,000 for tier II, and $45,000 for tier III participants. This payment cap is redundant however, because the capped stewardship payment multiplied by the automatic payment for existing practices, plus the cap for enhancements is equal to the total maximum contract payment. The CSP tier and payment structure is summarized in Table 2.1.

Although only 18 watersheds participated in the 2004 CSP sign-up, there is still information to be gleaned about participation and implementation issues. In 2004, a total of 2,188 CSP contracts were approved (all farms that applied were accepted) covering 1,885,400 acres in 18 watersheds at a cost of $35 million. Of the 27,300 farms in the 18 watersheds, only 8% of farms applied and received contracts, comprising 14% of the 14 million eligible acres (Cain and Lovejoy, 2004).

Table 2.1 Summary of Conservation Security Program Tier and Payment Structure

Tier Level	TIER ONE	TIER TWO	TIER THREE
Tier Determination	Soil Quality must have a minimum score of 0.0 on the SCI; Water Quality must meet the minimum quality criteria for nutrients, sediments, pesticides, and salinity.	Soil Quality must have a minimum score of 0.0 on the SCI; Water Quality must meet the minimum quality criteria for nutrients, sediments, pesticides, and salinity.	All applicable resource concerns must be addressed to a minimum level, as well as a soil quality minimum score of 0.0 on the SCI and meeting the minimum criteria for water quality.
Tier Requirements	None	Agree to address one additional resource concern	None
Breadth of Contract	Part of Operation	Entire Operation	Entire Operation
Length of Contract	5 years	5 to10 years	5 to10 years
Stewardship Payment	1.25% x (the watershed rental rate) x (total acres)	5% x (the watershed rental rate) x (total acres)	11.25% x (the watershed rental rate) x (total acres)
Stewardship Cap	$5,000 per year	$10,500 per year	$13,500 per year
Existing Practice Payment	25% of Stewardship Payment	25% of Stewardship Payment	25% of Stewardship Payment
New Practice Payment	Less than 50% cost-share and limited to $10,00 over the life of the contract	Less than 50% cost-share and limited to $10,00 over the life of the contract	Less than 50% cost-share and limited to $10,00 over the life of the contract
Enhancement Payment	Producer can pick from watershed specific practices*	Producer can pick from watershed specific practices*	Producer can pick from watershed specific practices*
Enhancement Cap	$13,750 per year	$21,875 per year	$28,125 per year
Total Payment Cap	$20,000 per year	$35,000 per year	$45,000 per year

CSP Summary

Designed to fulfill a specific niche in the current cadre of agri-environmental programs, CSP has been shaped by past programs, concurrent programs, and issues surrounding international trade agreements. CSP has several unique design features worthy of analysis due to their originality and their previously unobserved consequences. Participation in CSP is not limited by commodity or land type, with the exception of confined animal feeding operations. However, participation is limited to those producers who have already addressed resource concerns to a minimal extent on their agricultural operation. “Good actors” are further rewarded with higher levels of stewardship payments as they move up to the second and third tiers. Finally, prior efforts will place applicants higher on the funding priority ladder if a given watershed does not have sufficient funding. The emphasis placed on previous environmental performance is unique among the field of federal agri-environmental programs.

Furthermore, the prominence of incentives promoting whole-farm planning, with regard to the NRCS designated environmental concerns, is significant. Most notable is the requirement to address all natural resource issues in order to reach tier II or III, thereby receiving higher stewardship payments and larger payment caps. However, this bold payment design, composing multiple program objectives, has created an incentive structure, which is highly complex. It is possible that this complexity of payments, paired with the biophysical uncertainties inherent in conservation practices, might lead to difficulties for participants understanding the nuanced economic impacts of the program. This lack of perfect information and understanding could generate unintended participation behavior, such as termination of CSP contracts, which this study explores.

CHAPTER THREE

METHODS FOR EX ANTE ANALYSIS OF DYNAMIC CSP PARTICIPATION DECISIONS

This chapter provides an overview of the methods utilized to assess dynamic participation decisions related to the Conservation Security Program. It begins with a description of the unique characteristics of this research problem, which are relevant for selecting an appropriate analytical method. It then briefly describes methods that which have been used to analyze participation decisions in the past. A succinct justification is made for the application of system dynamics to this particular research question. Lastly, this chapter provides an introduction to system dynamics as a method including both the technical modeling conventions of system dynamics and its broader principles of systems thinking. There is a discussion of the use of simplifying assumptions, data and sources, and the types of results that can be expected from a research endeavor that utilizes a system dynamics as a method for examining dynamic CSP participation behavior.

Research Problem

Among the many questions regarding the design and implementation of the CSP is that some farmers have withdrawn or chosen not to implement some of the planned practices in similar agri-environmental programs in the past. From 1997-2000, farmers enrolled in the Environmental Quality Incentives Program (EQIP) withdrew almost 3,700, or five percent of their contracts in entirety. On 6,800 other contracts, or eight percent of the entirety, farmers opted not to implement one or more practices (Cattaneo, 2001). For the effective design and implementation of CSP, it is important to answer the question of why farmers are making these decisions to terminate participation, and what, if any, policy changes can be made to prevent this behavior.

An analytical method must adequately address a number of key characteristics of the research problem. First and foremost is the dynamic complexity that exists in the biophysical and decision-making processes. Delays in the updating of perceptions and expectations can lead to outcomes not predicted under the assumptions usually used to determine optimal decision-making. A model of participation decision-making must also consider the effects of imperfect information. This occurs in this particular decision-making process through the inclusion of a possible bias created by a farmer's uncertainty of the biophysical effects of conservation practices and the delays in a farmers' formation of perceptions and expectations. There also exists considerably uncertainty, in most instances, concerning the actual decision rules used by farmers to participate and subsequently withdrawal from the program. Most importantly, in order to answer these research questions to be more useful for policy-makers, the methods should employ assumptions regarding farmer decision-making in a descriptive rather than normative sense.

Alternative Methods

There are several methods by which economists have analyzed producer participation decisions in conservation programs. These methods can be placed into two general categories: empirical *ex post* studies and a broader set of *ex ante* analyses based on simulation. At base, most empirical studies utilize a dichotomous choice model of decision-making. Most program participation models are structured similarly to technology adoption models and thus the literature reveals significant overlap in techniques and approaches. According to Besley and Case (1993), who conducted a review of adoption decision-making, there are three basic empirical *ex post* approaches to understanding the adoption or participation decision.

The first empirical approach to the analysis of technology adoption or program participation involves time-series studies. Much of the current knowledge of aggregate adoption trends comes from these types of studies. In these studies, one observes only an aggregate measure of adoption at each date. The classic study of adoption of hybrid corn technology by Griliches (1957) is an early example of this work. Griliches found that the S-shaped trend of adoption could be explained by differences in availability and profitability of hybrid corn varieties. In general, these studies attempt to capture the rate of diffusion process and determine the shape of a diffusion curve. Most studies use a logistic-shaped function over time. While these studies can be disaggregated by region to investigate the effects of regional differences on adoption, the main purpose is usually to estimate the base rate of adoption. A key limitation however, is the inability of this approach to explain the underlying causal dynamic processes at work (Besley and Case, 1993). More recent work however, has attempted to use a more causal approach to adoption diffusion by applying dynamic simulation models to understanding the underlying structure of aggregate adoption rates (Fisher, et al., 2000).

A second empirical approach to studying the adoption decision is through the use of cross-sectional data. This approach constitutes the majority of studies addressing farmers' decisions concerning adoption of conservation practices and participation in conservation programs (Ervin and Ervin, 1982; Force and Bills, 1983; Gauthier et al., 2005; Konyar and Osborn, 1990; Soule et al., 2000; Zbinden, 2003; Hua et al., 2004). These econometric analyses make use of historical cross-sectional data to statistically estimate correlations between variables, which, when used in conjunction with appropriate theoretical constructs, result in causal inference. Previous econometric studies of participation decisions in conservation programs have been modeled similarly to the decision-making process of technology adoption. These analyses use a binary decision model influenced by two general types of variables, program and demographic. The model assumes that the decision maker maximizes utility or profit using each of these vectors of variables. It is then possible to use various regression techniques to show which variables were significant in making the participation decision. The vector of program variables is considered exogenous to the decision and is not usually estimated (Zbinden, 2002). However, by calculating costs and revenues from participation, some studies estimate the effect of payment levels on the participation decision.

A seminal study in the area is Ervin and Ervin (1982). This was one of the first studies to develop an integrated behavioral model that includes physical, economic, personal, and programmatic factors. They hypothesized a three-stage decision process: identifying erosion as a problem, deciding whether to adopt conservation tillage practices, and determining the level of effort when implementing the conservation practices. They used multiple regression analysis to understand the impact of each of their hypothesized factors. Among the many factors analyzed, Ervin and Ervin (1982) found that education was positively correlated with identifying erosion as a problem and the decision to adopt. In addition, they found that risk orientation, that is, the willingness to take chances, and an attitude of stewardship were positively correlated with the adoption of conservation practices.

Soule et al., (2000) explored the relationship between tenure and adoption of conservation practices. The base model included farmer attributes, attributes of the farm, variables specific to the field, regional attributes and a dummy variable for tenure. Findings of the study suggested that land tenure, timing of benefits, and land erodibility were influential factors in a farmer's decision to adopt conservation practices. Konyar and Osborn (1990) develop a linear random utility model to examine the adoption of CRP. The decision rule used for this study was “if the expected utility of participation is greater than the expected utility of not participating, then the farmer participates.” Utilizing a logit function they estimated the effects of land value, land tenure, farm size, age, and erosion characteristics of the land in question. Using regional data, they found that the probability of participation decreases with higher land value, larger farm size, and age. Hua et al. (2004) explored the relationship between farm programs, watershed groups, and conservation decisions through survey data. Their results indicated that conservation tillage decisions are mainly influenced by age, education, conservation compliance requirements and attitudes. Cooper and Keim (1996) used observations of farmer adoption of water quality protection practices. They estimated farmers’ “willingness to adopt” values, that is, the additional dollars per acre that farmers were willing to take in order to change management practices.

The intention of this method is to measure the effect of the physical and demographic characteristics on the adoption decision. However, this can be problematic, if as a time-series analysis suggests, there is some dynamic structure to the adoption or participation decision. The cross-sectional study therefore provides only a snapshot of adoption. This confounds the interpretation of the coefficients (Moser and Barrett, 2003). “The dynamics of technology diffusion confound most cross-sectional analyses of adoption patterns, at a minimum rendering coefficient estimates difficult to interpret and usually causing them to be biased and inconsistent (Moser and Barrett, 2003) Thus, cross-sectional econometric studies of this kind may be able to provide insight into the demographic or physical farm characteristics significantly associated with participation in a new government program, but the data are of limited use in understanding the adoption or participation process itself (Besley and Case, 1993). In addition, the assumptions used in these analyses are often poorly suited to directly evaluate the effects of implementation mechanisms such as incentive payments, biophysical characteristics, and information limitations on the participation decision in agri-environmental programs. This limits their applicability to questions of policy design.

Utilizing panel data, a third *ex post* empirical method, can meet some of the objections to each of the previous two methods. The dynamic component can be well represented, however specification of dynamic discrete choice can be difficult because it requires an answer to the question of how these models relate to the underlying choice problem that individual farmers face (Besley and Case, 1993). Fuglie and Kascak (2001) used panel data gathered through the use of recall, asking respondents when they had adopted a given technology. Despite potential biases in recall data, they found that adoption of natural resource conserving technologies has been slow, relative to expected adoption rates, due to differences in land quality, farm size, farmer education, and regional factors. This study suggests that factors such as these can cumulatively impart lags, as much as one or two decades, on the adoption of resource-conserving technologies.

Standard neoclassical economic theory, which buttresses these econometric models, makes the assumption that decision-makers have perfect information and are perfectly rational. Therefore, econometric methods can sometimes ignore the dynamics and delays that are present in the biophysical and expectation formation processes of the participation decision. For at least 20 years, economists within the USDA have recognized the limitations of neoclassical assumptions for modeling farmer decision-making. Baum (1983) suggests that traditional comparative statics does not address non-linear negative feedback, target planning, "satisficing" behavior, and the imperfect information available to decision makers. In addition, Baum states that the typical assumptions are of limited usefulness in explaining observed (and sometimes unexpected) participation behavior by farmers. Furthermore, an *ex post* econometric approach to understanding CSP participation behavior is severely limited by the lack of numerical data on the full "lifetime" of a CSP contract. After only the first two-years of a limited CSP sign-up, few contract terminations are likely to have been observed. In addition, the data needed to address the behavioral processes assumed important for an analysis of contract termination have not been collected, and primary data collection is beyond the scope of this study. In sum, econometric techniques seem both infeasible and inappropriate at this time for examining the processes underlying participation termination decisions in the CSP.

Ex ante simulation models are used by NRCS to understand the effects of policy design changes on participation rates. These models are often framed in terms of an aggregate benefit cost analysis, that is, a program's total expected cost in government expenditures or loss of tax revenue minus an estimate of the expected gain in monetized public benefits. Other *ex ante* simulation models have made progress in integrating economic and biophysical models to take into account the important biophysical effects of conservation practices. However, in each of these models, significant challenges remain in accurately simulating a producer's willingness to participate, that is, the amount of money required to induce participation. This is difficult due to heterogeneous farm characteristics, multiple decision variables, and little understood farm household decision-making processes (Cattaneo, et al. 2005).

The most comprehensive assessment of participation in CSP is found in the NRCS Benefit-Cost Assessment (BCA). The CSP BCA model is designed to simulate a producers' willingness to participate in CSP and predict the resulting aggregate costs and benefits. NRCS describes this model as poorly suited for predicting actual participation rates, but rather, as a useful tool for comparing changes in policy design (USDA, CSP Benefit-Cost Assessment, 2005). For example, the BCA examines the shift in payments due to the removal of the regulatory payment caps on enhancement payments. The BCA does not examine the producer decision-making process for enhancement practices on an individual practice basis. Thus, the model is best used for predicting the direction of effects resulting from changes in policy design, rather than the actual magnitude of those effects.

The BCA model uses 2002 Agricultural Resource Management Survey (ARMS) data to construct 6,105 farm types representing the 2.1 million farms in the United States (USDA, 2005). Each representative farm type is assigned potential payments, costs, on-site benefits, off-site environmental benefits, and appropriate resource concerns such as soil erosion. An expansion factor, or multiplier, is associated with each representative farm so that the model results can be expanded proportionately to accurately describe program costs and benefits in aggregate. The resource concerns of each representative farm are used as a proxy for identifying conservation practices that will be adopted. Therefore, the BCA lumps all practices relating to a single resource concern under the same decision making process. For example, the model does not distinguish between a producer's decision-making process of conservation tillage, grass waterways, and buffer strips, because all practices are designed to address sediment runoff. The model assumes that if sediment runoff is an identified resource concern, then producers will implement 1.5 practices per acre for each particular resource concern. Practice costs, on-site benefits, and off-site environmental benefits are all based on resource concern rather than individual practice and then are adjusted for the characteristics of each representative farm (USDA, 2005).

The model simulates participation through a series of database queries designed to select likely participants based on expected net return to participation, the conservation participation history for a given farm type, and demographic data believed to be relevant. The calculation of expected net return to participation does not use individual conservation practice payment rates and implementation costs, but rather average costs, based on addressing the resource concerns assigned to a particular representative farm. The average costs are estimated from EQIP contract data for 1996-2003 for each representative farm. Although there are on-site financial benefits to addressing many of the resource concerns, producers are assumed to recognize only 25% of the on-site benefits derived from the conservation practices, thus reducing expected participation rates if expected net returns are a significant factor in the decision making process. Although enhancement payment levels are designed so as to not to exceed a participants estimated cost of implementation or the expected environmental benefit value, for the purposes of the simulation model, NRCS assumes producer costs to be 25% of the payment levels for each of the enhancement conservation practices. Therefore, if a resource concern exists on a representative farm and the producer decides to participate in CSP based on total expected net return, demographic characteristics, and participation history, then the producer is assumed to maximize the number of enhancement practices until the enhancement payment cap is reached. With this construction, it can be seen that this model does not examine a producer’s decision to adopt a single conservation practice based on its particular costs and benefits (USDA, 2005).

The BCA model then varies program design parameters to assess the aggregate effect of design changes, such as increasing the contract limits for enhancements and increasing the contract length, on participation and subsequently net benefits. The results can then be disaggregated in order to better understand the distribution effects of these policy changes on farm size, region, and resource concern. The simulation model examines only the sign-up decision and tier determination and thus does not allow for reduced participation or contract cancellation.

Additional *ex ante* simulation models, developed outside of USDA, provide insights into methods for integrating biophysical and economic models, which are important for the study of adoption of conservation practices. Due to the heterogeneous characteristics of farms implementing conservation practices, simulating the biophysical effects simultaneously with the economic effects is helpful for better understanding of conservation program performance and environmental outcomes (Westra et al., 2004). Integrated biophysical and economic models can shed light upon likely environmental impacts of conservation programs such as a simulation model formulated by Tanaka and Wu (2004), who used an empirical benefit-cost model to predict farmers' crop rotations, tillage practices, and participation in CRP. Their integrated biophysical model estimated the effect of policies on social costs due to reduced nitrogen loadings in the Mississippi River and for controlling hypoxia in the Gulf of Mexico (Tanaka and Wu, 2004).

An *ex ante* simulation model of CSP in Westra et al., (2004) examined the relationship between conservation practices, fish communities, and farm income in two watersheds in Minnesota. The model used field-level biophysical information and production activities to estimate production costs and returns with CSP and CRP payments. They analyzed the potential effects of adoption of certain conservation practices intended to address resource concerns of sediment losses, such as buffer strips and resulting changes to fish populations. This analysis included cropping mix decisions and resulted in average measure of change in net farm income and a watershed level effect upon fish populations. Simulated results showed both lower costs and lower revenues with a net loss of approximately 1 percent and 3 percent in annual net farm income for the two watersheds examined. When participation in conservation programs was assumed to be profitable, all producers enrolled in CSP and CRP and received the appropriate payments. When both CSP and CRP payments—the latter for removing land from production within 100 yards of water bodies—were included, estimated net farm incomes actually increased by 7-8 percent in both watersheds. However, this analysis did not include all relevant CSP payments, therefore it is not a reliable predictor of program success. Westra et al. did, however, demonstrate a method that successfully linked an economic model based on net farm income and a biophysical model of farm-level conservation practices to watershed level environmental benefits.

Dobbs and Streff, (2005) also used an integrated biophysical and economic framework to examine the profitability of conservation crop rotation systems under CSP. This model used estimated cost and returns to various conservation crop rotations and estimated both government commodity payments and estimated CSP base payments. Significantly, however, the model did not specify actual enhancement payment rates but relied solely upon base payment rates. Without modeling enhancement payments, they were unable to include a large portion of CSP payments. Although not modeling the participation decision directly, Dobbs and Streff demonstrated a possible method for understanding the farmer decision-making process by explicitly representing the costs and benefits of participation in CSP or related conservation program.

In summary, both econometric analysis and *ex ante* simulation methods are valuable methods for understanding participation decisions. However, it is important to note that contract cancellation, termination decisions, or disadoption behavior receives limited treatment in the previous econometric and *ex ante* simulation methods used to describe adoption or participation behavior related to conservation. Unexpected participation behavior, such as contract termination, is a dynamic phenomenon, which requires modeling the changes in perceived profitability over the length of a program contract and relaxing key assumptions embedded in the neoclassical economic theory of profit-maximization under perfect information and perfect rationality. In addition, approaching the participation question using regression techniques, such as binary choice models, seem inadequate for supplying satisfactory answers to the questions regarding contract cancellation. *Ex ante* simulation models should capture the complex decision-making processes if they are to understand program performance. The unique characteristics and objectives of this research problem require an *ex ante* approach that can integrate biophysical and economic factors into a dynamic simulation model. System dynamics is a modeling method that meets these requirements.

System Dynamics Overview

System dynamics is an appropriate method for addressing *ex ante* participation behavior in the Conservation Security Program. Because system dynamics is a seldom-used tool in agricultural economics, it is beneficial to describe it at a level of detail greater than for more commonly used methods. Thus, this chapter provides an introduction to system dynamics as a method including both the technical modeling conventions of system dynamics and its broader principles of systems thinking. The objective of this research is to model the *ex ante* CSP participation decisions of a representative NY dairy farmer in order to gain insight and understanding for program design and implementation. In order to meet this objective, a modeling method must provide both the technical tools and modeling conventions, which provide pragmatic policy answers. A dynamic simulation model can explore the impacts of the interactions between biophysical dynamics, incentive structure, and alternative behavioral assumptions for participation decisions. Through parameter and structure testing, it can also analyze the impacts of specific policy alternatives, such as timing and amount of incentives, education of producers, and implementation procedures, on the decision to terminate participation in CSP.

What is system dynamics? Such a question would result in many different answers depending, of course, on who was being asked and how much time was given for a response. George Richardson, a noted expert in the field of system dynamics and a Professor in the Department of Public Administration and Policy at the University of Albany, SUNY, provides a succinct answer:

> System dynamics is the use of computer simulation for policy analysis in complex systems. Its big contribution is helping people to build progressively richer understandings of some dynamic problem, and anticipate weaknesses in policy initiatives that would develop over time… It gets a lot of its power from a 'feedback' perspective—the realization that tough dynamic problems arise in situations with lots of pressures and perceptions that interact to form loops of circular causality, rather than simple one-way causal chains. Humans are really good at thinking up all that interconnected complexity and really weak at inferring its implications without the support of simulation models (stewardshipmodeling.com, accessed June 2005).

Richardson remarks on the need for greater understanding of dynamic problems specifically with regard to weaknesses in policy initiatives. These failures, or “policy resistance,” are where well-intentioned policies designed to solve complex problems are instead delayed, diluted, or defeated by unintended consequences (Sterman, 2000). This is not usually due to unexpected external shocks to the system, but rather to unforeseen reactions to the original policy intent. Policy-makers sometimes have difficulty understanding and predicting the outcomes of complex systems due to a flawed understanding of the system. Often, policy-makers construct too narrow of a boundary around the problem at hand by failing to include the breadth of interrelationships between actors and policies and the resulting behavior of the over time (Sterman, 2000). Contract cancellation in conservation programs can be considered an example of policy-resistance. One potential reason for this unexpected behavior is the lack of dynamic participation models that consider the complexities of farmer decision-making. It is these dynamically complex problems in which a perspective grounded in system dynamics can assist policy-makers in developing robust policies. This perspective is often termed “systems thinking,” and although its meaning has been diluted by overuse, it continues to convey a holistic worldview where “everything is connected to everything else” and frequently one action leads to unintended consequences.

System dynamics provides both a paradigm and a set of methods for learning about complex systems and providing practical insight for policy-makers. More specifically, system dynamics facilitates this learning through the building of formal simulation models. System dynamics modeling conventions inform practitioners on the modeling process, how to formulate mathematical relationships, which simplifying assumptions to use, and offers suggestions for interpreting and evaluating resulting model behavior. However, before describing these modeling conventions, it is useful to highlight two “systems thinking” perspectives that are foundational for formal system dynamics modeling.

System Dynamics Paradigm

The system dynamics paradigm suggests specific ways to structure, organize, and filter information when modeling a problem behavior. Most importantly is a focus on the dynamic, rather than the detail, complexity of a problem. Detail complexity arises from systems with many variables resulting in large number of possible combinations. This combinatorial, or detail, complexity leads to a search for solutions that are “needle-in-the-haystack.” Such problems include the optimal scheduling of flights and crews for an airline company (Sterman, 2000). Dynamic complexity, however, can result from a low of number of variables that are interrelated, often nonlinearly, over time. Adding to this dynamic complexity are significant time delays inherent in many real-world systems, which are often overlooked or assumed away in traditional economic analysis.

Dynamically complex systems can produce counterintuitive behavior with ambiguous causation. In simple systems, the cause of behavior is often closely related to the observed behavior. However, in complex systems causes can be far removed, both in time and space, from the observed effects (Forrester, 1989). These types of systems require a different set of tools and methodologies for developing understanding and insight. The system dynamics method often represents the dynamic complexity of a problem rather than including large amounts of detail. This perspective leads to practical modeling conventions such as using a high level of aggregation and keeping models simple and clear so that they can be used for testing policies and asking "what-if" questions. Additionally, system dynamics models often focus on providing an understanding of the causes of general tendencies of behavior of a system over time, rather than attempting to make specific point predictions for any particular variable. Thus, system dynamics models typically emphasize careful specification of the underlying "structure" of a system, rather than including only those elements for which (formal) numerical data are available. This is a significant departure from an econometric approach, which disregards most information not in the form of numerical data. This focus on structure, even when numerical data is limited, is relevant for this study because of the largely unobserved parameters, such as time to update expectations, which affect farmer decision-making. In fact, if the underlying structure is adequate, system dynamics models can often identify priority information needs such as parameter values. Where an analysis relying solely upon numerical data fails to explain the observed participation behavior, a more structural approach can provide an alternative understanding of behavior. Thus, many system dynamics models include “soft” variables, which are harder to quantify, but are important in the causation of the behavior of interest.

A second viewpoint common to system dynamics modelers is a focus on endogenous rather than exogenous causes of behavior. Often, policy-makers and even researchers employ narrow model boundaries for their problems and assume exogenous, or external, forces are the cause of the behavior of interest. System dynamics models, on the other hand, seek explanations for phenomenon that are endogenous to the system (Sterman, 2000). Behavior is assumed to arise from a model’s internal causal structure, that is, the interconnected mathematical relationships between variables in the model, rather than external shocks. This endogenous behavior is often the result of feedback loops, stock and flow structure, and nonlinearities. A broad model boundary, which captures important feedback in the system, can often provide more insight into the causes of behavior, rather than modeling additional detail on individual components of the system (Sterman, 2000).

System Dynamics Modeling

Mathematically, system dynamics models are simply systems of ordinary differential equations that are solved using numerical integration. The origin of the field can be traced to the 1950’s when engineering concepts were applied to social systems. However, system dynamics modeling goes well beyond the computation of differential equations; indeed, system dynamics modeling conventions address the modeling process, techniques, archetypal behavior, notation, and the appropriate use of data sources. Stemming from a focus on dynamic complexity, rather than detail complexity, system dynamics models seek to explicitly represent feedback in complex systems. This focus on feedback effects is used to better understand dynamically complex behavior of systems. These feedback effects are represented by causal loop diagrams, which indicate causation over time. An arrow, or link, represents causal relationship, a (+) signifying a positive relationship, that is, an increase in one leads to an increase in the other; and a (-) for a negative relationship, that is, an increase in one causes a decrease in the other. Combinations of causal linkages create feedback loops (See Figure 3.1).

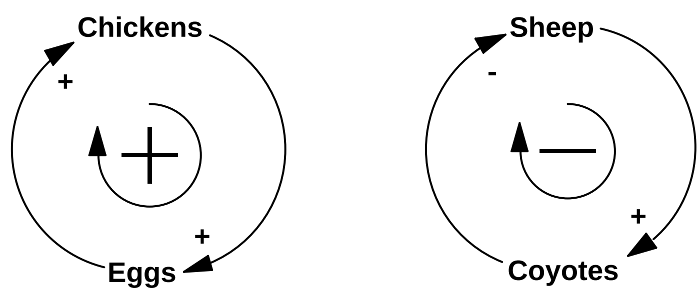

Figure 3.1 Examples of a Positive and Negative Feedback Loop

It is a fundamental premise of system dynamics that dynamic behavior is the consequence of system structure (Richardson and Pugh, 1981). In general, most of this dynamic behavior results from the interaction of two types of feedback loops: positive or (self-reinforcing) loops, and negative (self-correcting) loops. The polarity of any given loop is often designated by a (+) or (-). Positive loops tend to amplify any disturbance and produce exponential growth, whereas negative loops tend to counteract any disturbances and to move the system towards an equilibrium point or goal (Richardson and Pugh, 1981). A model containing several positive and negative feedback loops can produce a wide variety of behaviors. However, even simple structure can create common modes of behavior such as exponential growth, goal seeking, or S-shaped growth.

Often, system dynamics modelers will construct causal loop diagrams of the problem of interest to get an initial sense of the dynamics at work, understand the scope of the problem, and identify the key variables in the system. Casual loop diagrams can also be a useful communication and discussion tool for policy-makers who do not want or need to understand the underlying mathematical simulation model. However, causal loop diagrams have many limitations due to their simplicity of relationships, lack of mathematical specificity, incapability of distinguishing between stocks and flows, and ultimately, an inability to predict complex behavior.

Stock and flow diagrams are the central conceptual tools used in system dynamics simulation models. They allow for explicit representation of mathematical relationships in a graphical nature that is intuitive and easy to manipulate. A stock and flow diagram corresponds to a specific mathematical expression, that is, an integral equation. This notation conveys a sense of physical accumulations and flows, not surprising given that it was developed by an engineer. However, stock and flow diagrams are not limited to representing physical material, rather they can correspond to softer variables such as perceptions, beliefs, or attitudes. A rectangular box represents a stock or state in a system, while pipes with arrows represent inflows and outflows or rates in a system. Valves on the pipes represent the control of the flows. Finally, clouds at the beginning or ending of a pipe represent an unlimited source or sink respectively, denoting a boundary of the model (Richardson and Pugh, 1981). Figure 3.2 shows the stock and flow notation and its mathematical equivalents.

$$Stock(t) = \int_{t_0}^{t} [Inflow - Outflow]ds + Stock(t_0)$$

$$d(Stock)/dt = NetChangeInStock = Inflow(t) - Outflow(t)$$

Source: Sterman (2000)

Figure 3.2 Equivalent Stock and Flow Structure

The mathematical equivalents, as seen in Figure 3.2, demonstrate the specificity of stock and flow diagrams in representing the structure of a system. As seen in the integral equation, a stock accumulates, or integrates, its net flows from time (0) to time (t). Or correspondingly, as seen in the differential equation, a net change in the stock, that is, its derivative is equal to its inflow minus its outflow from time (0) to time (t). The concept of a stock is also important to system dynamics modeling because it denotes a delay in the system. A delay is simply a process where an output lags behind its input, and a stock represents the accumulated difference between these inputs and outputs (Sterman, 2000). Modeling information delays is important for the development of alternative behavioral assumptions, which is a common system dynamics modeling convention. For example, there is a significant delay between the actual effect of conservation practices on crop yields and a producer's perception of those changes in yields. System dynamics can explicitly model those information delays between actual changes and perceived changes. The concept of using a stock to represent the perceptions or expectations of a decision-maker is not common in traditional economic analyses. In short, system dynamics conventions suggest building descriptive rather than normative models of decision-making. In doing so, system dynamics models attempt to recreate the decision-making process as it would actually occur, with its delays, biases, shortcuts, less than perfect information, and varying degrees of rationality all explicitly modeled. Every decision rule can be thought of as an information processing procedure (Sterman, 2000). This mode of decision-making modeling follows from the work of Herbert Simon, the Nobel Prize winning economist, and his theory of "bounded rationality." Later work in the fields of behavioral economics and behavioral decision theory all focus on the notion of an individual's limitations as an "optimal" decision-maker. Often, this practical application of this research leads to another convention of system dynamics modeling which is to distinguish between actual and perceived conditions. Perceived conditions can differ from actual conditions due to delays in measurement and reporting or disturbances due to error, noise, or bias (Sterman, 2000). Many of these behavioral assumptions become key features in the perception and expectation sector of the participation decision-making model described in *Chapter Four*.

Conclusion

Pragmatic *ex ante* policy analysis should answer two questions: which policies work and why? In the absence of significant empirical evidence related to participation in the Conservation Security Program, several specific policy questions require attention and analysis. In particular, the decision to terminate participation in the program has been little studied by applied economists. This behavior can be difficult to explain due to the inherent complexities resulting from the biophysical characteristics of conservation practices, unique incentive structure of the CSP, and participation decision-making behavior of farmers. Modeling techniques typically used in applied economics research seem less suitable for constructing formal models of this behavior. The modeling approach of system dynamics can be successful employed in this case to bring insight and understanding to a complicated problem.

CHAPTER FOUR

DYNAMIC PARTICIPATION DECISION MODEL

Introduction

This chapter describes the simulation model constructed to analyze the participation behavior of a representative NY dairy farm enrolled in the Conservation Security Program. An overview of the model is presented, followed by detailed descriptions of the representative farm, and incentive, biophysical, expectation formation, and decision rule sectors of the model. Causal loop diagrams and stock and flow diagrams accompany descriptions of the model sectors where appropriate. Parameter values are listed in Appendix A.

Overview of Model

The objective of this model is to understand the participation decisions of a representative NY dairy farmer in order to gain insight for conservation program design and implementation. The complexities of producers' decision-making processes suggest that a descriptive simulation model that considers additional relevant information will be useful. This simulation model includes four distinct sectors: CSP incentive structure, biophysical effects of enhancement practices, expectation formation, and decision rules. The model links these sectors together to illustrate possible connections between the biophysical effects and CSP payments on farm revenue, and the subsequent updating of expectations. The model is constructed with the goal of understanding the general dynamic tendencies of these interactions and resulting potential policy implications, rather than predicting specific termination dates.

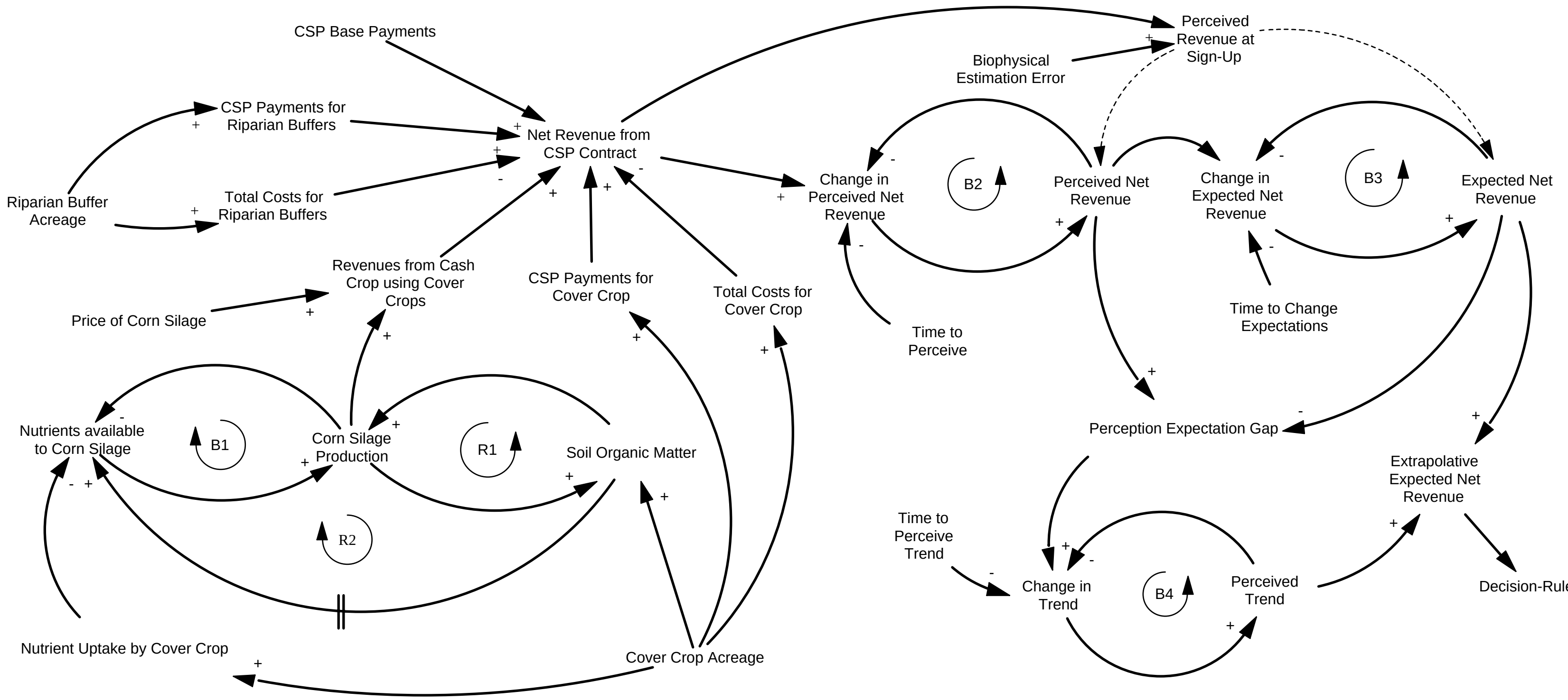

Figure 4.1 Simplified Casual Loop Diagram of Dynamic Participation Decision Model

Note: Dotted arrows indicate causal links for a stock's initial value.

Figure 4.1 provides an overview of the dynamic participation decision model in a simplified causal loop diagram. The above figure can be easily simplified by dividing it into two halves, each separated by the variable Net Revenue from CSP Contract. All elements of the diagram to the left of Net Revenue from CSP Contract are used as determinants of the actual net revenue derived from participating in the CSP. All elements to the right of Net Revenue from CSP Contract are used in the expectation formation and decision-making process. The purpose of this diagram is to provide a conceptual overview and thus does not portray the detailed structure or parameters actually used in the simulation model.

Starting at Net Revenue from CSP Contract and backtracking through the causes of net revenue is the most straightforward method for systematically understanding the diagram. The determinants of Net Revenue from CSP Contract are structured much like a dynamic partial budget over a ten-year period. The determinants of net revenue considered in this model include CSP payments, costs of implementing CSP practices, and changes in corn silage yields due to the biophysical effects of conservation practices.

Although the determination of net revenue is relatively straightforward, the biophysical effects are more complex. The biophysical effect consists of two reinforcing loops and one balancing loop. Reinforcing loop one (R1) illustrates the relationship between increased soil organic matter provided by the cover crop practice and cash crop production. A second reinforcing loop indicates a longer-term effect of increased soil organic matter on the capacity of soil to hold nutrients thus increasing cash crop production. Reinforcing loop two (R2) is thus marked with a hash mark to indicate a delay in the effect. Balancing loop number one (B1) exists between the nutrients available to cash crops and production, thus showing that more production reduces available nutrients. Several additional biophysical feedback loops, both balancing and reinforcing are present in this system (Magdoff and van Es, 2000), but are not explicitly modeled because that level of detail is not needed for the purposes of this study. However, the loops present should capture the essential effects that impact net revenue over the designated time horizon of ten years.

The expectation and decision-making half of the diagram is to the right of Net Revenue from CSP Contract. In effect, the biophysical sector of the model is developed in order to provide an abstracted but realistic input to the subsequent expectation formation sector. It is the linking of these two sectors, the biophysical and expectation formation that the simulation model begins to provide insight into the complexities of the decision-making process. In its most basic form, the expectation formation sector allows for the introduction of several modifications to the traditional assumptions of perfect information and rationality in the decision-making processes. The assumptions used in the expectation formation sector are based upon nascent behavioral economic theory and the pragmatic modeling conventions of system dynamics.

These additional assumptions are that producers make decisions based on information that is not perfect, and indeed can be significantly in error. In addition, a producer will have inherent delays in their ability to gather and utilize information concerning the financial implications of the biophysical processes resulting from a conservation practice. This simulation model attempts to formalize these decision-making processes by assuming an expectation formation process and an initial error in the estimation of biophysical effects by the producer. This error, Biophysical Estimation Error, affects the initial value or starting point of the expectation formation process. The producer gradually learns about the actual economic effects of CSP participation and subsequently modifies his or her perceptions and expectations concerning the net revenue that can be derived. The combination of significant error and expectation formation can produce considerably different short and long run expectations of net revenue, which is not predicted by traditional economic models assuming perfect information (USDA, Conservation Security Program Amendment to the Interim Final Rule Benefit Cost Assessment, 2005). These changing expectations can have subsequent effects on participation decisions.

The expectation formation sector uses three balancing loops, all exponential smoothing processes of their respective inputs. This formulation of perceptions and expectations is a modified version of the TREND function, which is a sophisticated version of extrapolative expectations (Sterman, 1987, 2000). These calculations can then be used as inputs to several different formulations of decisions rules. These decision-rules, formulated as binary choice of participation are varied to better understand farmer participation behavior under various regimes of farm management sophistication.

Representative Farm

The Conservation Security Program enrolled 202 watersheds in its 2005 Sign-Up. Among them is the Niagara River Watershed located at the western end of New State. It covers approximately 514,810 acres over five counties: Erie, Niagara, Genesee, Wyoming and a small part of Orleans. The watershed drains to Lake Ontario and also includes many small tributaries, which drain directly to the Niagara River, upstream of Niagara Falls. Eighty-three percent of the water flowing into Lake Ontario enters through the Niagara River (NRCS website—2005, <http://www.ny.nrcs.usda.gov/programs/programs/CSP/niagarawatershed>NRCS).
The Niagara River is one of the U.S.-Canadian International Joint Commissions 42 “Areas of Concern” throughout the Great Lakes Basin (NRCS website—2005,

<http://www.ny.nrcs.usda.gov/programs/programs/CSP/niagarawatershed>NRCS). Resource concerns center on water quality and soil erosion. The New York office of the Natural Resources Conservation Service states that non-point sources of pollution remain an area of concern and that nutrient, manure, and pest management conservation practices are particularly important in this watershed (NRCS website—2005, http://www.ny.nrcs.usda.gov/programs/programs/CSP/niagarawatershed). The climate is moderate due to the close proximity of Lake Erie and Lake Ontario, which allows for the production of a diverse variety of crops. As of 2000, there were 994 farms and 205,348 acres of farmland within the watershed. Important agricultural sectors include dairy, vegetable production, nursery stock, sod, greenhouse horticulture, vineyards and small fruit production (NRCS website—2005, <http://www.ny.nrcs.usda.gov/programs/programs/CSP/niagarawatershed).

Respondents to the 2004 Dairy Farm Business Summary (DFBS) in the western and central plain region of New York, which includes the Niagara River Watershed, had an average herd size of 487 cows and average farm size of 1,135 acres, of which, 1,001 were tillable. These dairy farms on average planted 414 acres of hay, 346 of corn silage, 87 of corn grain, put 17 acres into tillable pasture, and left 29 acres idle (Knoblauch, et al 2005). This simulation model utilizes a representative dairy farm based on these averages from the western and central plain region of New York and thus assumes a dairy farm of 487 cows, 1,100 acres, 1000 of which are tillable, and cropping ratios that are consistent with the farms in the DFBS. Other pertinent details assumed about the representative farm will be clarified in the appropriate section of this chapter.

Incentive Sector

The CSP incentive sector consists of the annual payments made to the representative farmer under the 2005 CSP Sign-Up payment levels for the Niagara Watershed in western New York. The simulation will calculate annual net revenue from a CSP Contract based on four separate payments: the stewardship (base) payment, existing practice payment, and two enhancement payments. The model will include the enhancement payments for the installation of riparian buffers and for cover crops, two conservation practices used in the Niagara watershed and available through the New York CSP sign-up. The calculation of net revenue from a CSP contract will subtract out the costs of implementation of these enhancements. The model equation (1) for Net Revenue derived from a CSP contract is provided below. The units for used for this equation are dollars per year.

(1) Actual Net Revenue = Base Payment + Change in Net Revenue from Cover Crop Enhancement + Change in Net Revenue from Riparian Buffer Enhancement
dollars/year

The new practice payments components of CSP, which are similar in design to existing EQIP payments, are not be included because of their low use in the 2004 Sign-Up and the expectation that the effects of their inclusion would be negligible. (USDA, 2005).

The stewardship (base) payment is calculated based on total acreage, the assigned rental rate (stewardship rate), a tier reduction factor, and a multiplication factor of 25%, representing the existing practices on the farm. See *Chapter Two* for details on the calculation of existing practice payments.

(2) Base Payment= (Total Enrolled Acres*Farmland rental rate*Tier Level Multiplier)*(1+Existing Practice Payment Proportion)
dollars/year

The stewardship rate is the estimated 2001 land rental rates calculated as a flat rate for the entire watershed. See *Chapter Two* for details on calculation of the stewardship rate. It has been designated at $40 for cropland and $19 for pastureland in the Niagara River Watershed (NRCS website—2005, http://www.ny.nrcs.usda.gov/programs/programs/CSP/niagarawatershed). The tier reduction factor, or Tier Level Multiplier, is based on the tier level at which the participant enters into the CSP contract. The tier reduction factors are 1.25% for tier I, 5% for tier II, and 11.25% for tier III.

(3) Tier Level Multiplier= Tier Multiplier fn (Tier Level)[1] *dimensionless*

The base model will consider the representative farm at tier level III, but will test the impact of participation at tier level II. This ensures a ten-year contract for the entire acreage of the farm. Incidental land can be included in the stewardship payments, therefore the entire 1,100 acres will be considered eligible for stewardship payments.

The model will simulate two enhancement payments, riparian buffers and cover crops, for the entire length of the contract. For the riparian buffer enhancement payment rate, the model will use the published CSP rate authorized specifically for the 2005 Niagara Watershed CSP Sign-up, that is, $100 for each acre of buffer created along water bodies or wetlands on the farm (NRCS website—2005, http://www.ny.nrcs.usda.gov/programs/CSP/niagarawatershed). The cover crop enhancement payment authorized in the CSP Sign-up was too low to induce new practices. Specifically, the CSP payment was $3 per acre, however national cost data and New York cost data showed that implementing cover crops cost significantly more, e.g. the NY Field Office Technical Guide (2005) showed average costs of $13.50. Indeed, the EQIP payment rate for cover crops in Erie County, NY for 2005 was $30 per ace. The low rate of payment can be attributed to lack of funding for CSP

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[1] The Tier Multiplier function allows the simulation of various tier levels of participation. The function has an output of: (1,1.25%), (2,5%), and (3,11.25%).

implementation (Knight—personal interview, 2006). Therefore, the model will not use actual CSP payment rates for cover crops, rather it will utilize the EQIP payment rate for the same practice in the same county. To receive this payment, a farm must protect 100% of all water bodies and wetlands within the farm boundary with a riparian buffer composed of grass or trees that has a minimum width of 100 feet. The total acreage used for the riparian buffer is assumed to be 30 acres for the representative farm. This is calculated as approximately the amount of acreage needed to provide a 100-foot border on each side of a watercourse that runs straight through a 1000-acre square farm.

The base model will use a flat payment rate for the enhancements as implemented in the 2004 Sign-Up. It will also test the variable rate payment scheme designated for the 2005 Sign-Up. These variable rate payments begin at 150% of the enhancement payment in year one, then dropping each year to 90%, 70%, 50%, 30%, 10%, and 0% respectively, for the remainder of the contract (NRCS, FY2005 CSP Sign-Up Announcement, 2005). This variable rate payment scheme is represented in the model by using a function called Variable Payment Rate, a function that uses "time" as an input and has an output that decreases enhancement payments using the reduction formula above. Finally, the model will respect all contract limitations including caps on the stewardship, enhancement, and total payments to an individual farmer.

Biophysical Sector

The purpose of the biophysical sector is to demonstrate the dynamic biophysical effects of conservation practices, which are often over-simplified in economic analyses, as well as provide a realistic net revenue input for the expectation formation sector. The biophysical sector of the model consists of the on-farm effects of both enhancement practices, that is, the riparian buffer and cover crop practice. There are many public benefits to these conservation practices such as increased water and air quality. Although some agricultural producers recognize these benefits, this model assumes that they are external, and thus not included in the calculus of the representative farmer's determination of net revenue. However, several model scenarios allow farmers to continue participation at varying degrees of net revenue loss, which can be interpreted as farmers valuing non-farm benefits in their participation decision. In addition to public benefits, several conservation practices have significant on-farm effects including short and long term implications for cropland productivity, implementation and management costs, and constraining the future use of land resources.

As initially conceived this research would analyze four separate conservation practices available for payments under the Conservation Security Program in the Niagara Watershed in the state of New York. These practices include 1) the development of a riparian buffer along all watercourses, 2) maintaining a cover crop (cereal rye), 3) adopting a conservation crop rotation, and 4) setting aside ten percent of crop acres in sixty foot strips for wildlife habitat. After initial modeling and consideration of the setting aside of crop acres for wildlife habitat, its effects were deemed similar to the practice of developing riparian buffers. Both practices take cropland out of production and yield effects on land not taken out of production were thought to be too minimal to include in this simulation model. Thus, both practices resulted in identical patterns of contract participation behavior. For this reason, the wildlife habitat practice is not simulated in this model.

In addition, the relevance of the conservation crop rotation practice for this simulation model depends upon its overall effect on producer net revenue for the representative New York dairy farm. If the financial impacts of a conservation crop rotation are substantially negative, it is unlikely that the representative farm would seriously consider a CSP contract with this practice. Thus, before development of a likely conservation crop rotation in the simulation model, a static partial budget exercise was carried out to examine the financial effects of this practice. In particular, the effect of a conservation crop rotation on the total nutrient needs of the representative dairy farm and the resulting change in cost of replacing lost nutrients was calculated. The resulting changes in net margin were considered too high for a hypothetical producer to consider switching to a conservation crop rotation, even in the presence of estimation error. However, this outcome should not be extrapolated to non-dairy crop producers, due to the unique nutrient needs of dairy producers, e.g. energy from corn silage. See Appendix B for a more detailed explanation of this partial budget exercise. Thus, the biophysical sector of this simulation model only considers two of the proposed conservation practices, which are: maintaining a cover crop of cereal rye and the development of riparian buffers.

The biophysical sector of this model considers two separate consequences of implementing these two conservation practices. The first consequence is the additional costs associated with implementing each of enhancement practices. The second effect is a change in annual crop yield, assumed to be corn silage, due to increased soil quality or other effect from the implementation of the conservation practices. The model calculates the financial impact of each conservation practice separately in order to distinguish their individual effect on participation decisions.

A riparian buffer is a strip of land covered in grass or trees adjacent to a body of water. Riparian is derived from the Latin word “ripa,” meaning “bank,” and generally describes something that is related to or situated on the bank of a river. A riparian buffer is a multi-purpose conservation practice designed to accomplish several objectives. Primarily, it is used as a strip that can filter out sediments, organic material, and pollutants before they enter a watercourse. The additional trees, shrubs, or other vegetation can also reduce stream bank erosion and sedimentation. It can also provide a source of cover necessary for fish and wildlife and create shade to lower water temperatures, which improves habitat for aquatic animals (NRCS electronic Field Office Technical Guide—2005, http://efotg.nrcs.usda.gov).

The riparian buffer enhancement is assumed to take 30 acres of cropland out of production from the 1000-acre representative farm, as explained above. This loss of productive land is the primary cost of implementing buffers and is the only one included in the model. Although riparian buffers have numerous environmental benefits, the biophysical effect on crop yields, for land not in riparian buffers, is considered negligible. There are no further additional costs or reductions to revenue. Therefore, for the purpose of the model, riparian buffers will have no other impact on net revenue other than the CSP enhancement payments for riparian buffers and the opportunity cost of the lost cropland, that is, the cost of replacing foregone corn silage.

(4) Change in Net Revenue from Riparian Buffer Enhancement = Program Payment for Riparian Buffer – Change in Costs from Riparian Buffer Enhancement *dollars/year*

(5) Change in Costs from Riparian Buffer Enhancement= Riparian Buffer Cost Rate*Enrolled Riparian Buffer Acreage *dollars/year*

Thus, the riparian buffer conservation practice is treated in this model in a similar fashion to other cost-benefit analyses of conservation practices. That is, the yield effects are considered negligible, however the opportunity costs can be substantial. This makes the riparian buffer enhancement a well-suited baseline enhancement practice with which to compare a more complicated conservation practice such as cover crops.

Growing a cover crop consists of growing a crop of grass, small grain, or legume primarily for seasonal protection and soil improvement (NRCS eFOTG—

2005, http://efotg.nrcs.usda.gov). For the purpose of this model, cover crops can be understood as the crops grown on traditional cropland when production of cash crops, such as corn, is not feasible, mainly during the late fall and early spring. These cover crops are not harvested, but rather incorporated into the soil or killed on the surface before they reach maturity. Usually high in nitrogen, they decompose rapidly in the soil and can be a supply of nutrients to the following crop (Magdoff, and van Es, 2000). Additionally, cover crops can have the effect of increasing organic matter, preventing erosion, suppressing weeds, breaking pest cycles, and increasing the water infiltration of the soil (NRCS eFOTG—2005, http://efotg.nrcs.usda.gov).

Three distinct terms are used to describe crops grown specifically to maintain soil fertility and productivity. These include green manures, cover crops, and catch crops. (Magdoff and van Es, 2000). Although sometimes used interchangeably, as seen in the NRCS literature, each term has a specific function from a producer's perspective. A "green manure" is usually grown to help maintain soil organic matter and increase nitrogen availability, thus implying the use of legumes such as hairy vetch or red clover. A "cover crop" is grown mainly to prevent soil erosion by covering the ground with living vegetation with roots that hold onto the soil and slow the action of moving water. A "catch crop," such as cereal rye, is grown to retrieve available nutrients in the soil following an economic cash crop in order to prevent nutrient leaching in the winter, (Magdoff and van Es, 2000). Usually, a producer's decision to grow a cover crop is based on accomplishing more than one of these objectives and therefore the term "cover crop" is often used to describe all three functions.

There are three general planting strategies available for effectively using a cover crop. First, is to plant a cover crop for an entire season and lose a season of income generating crop. This can be useful for the regeneration of very poor soils. A second strategy is to plant cover crops after the cash crop has been harvested, and kill it before the cash crop is planted for the next season. However, in northern areas where the growing season is short, it can be a problem to allow the cover crop enough time to grow in the fall. Thus, a third strategy is to overseed the cover crop onto the cash crop after it is off to a good start (Magdoff and van Es, 2000).

The model assumes that the representative farm's manure supply exceeds the nutrient needs for the farm's silage corn and hay rotation. In this situation, the producer would choose a cover crop that meets the following criteria: establishes itself effectively after a silage corn harvest, scavenges excess nitrogen in the fall, and provides additional organic material prior to planting in spring. For this scenario, cereal rye is an often recommended and commonly used cover crop (University of California SAREP: Cereal Rye—2005, http://www.sarep.ucdavis.edu/cgi-bin/CCrop.exe/show_crop_12).

Cereal or winter rye is very winter hardy and easy to establish. It germinates quickly and therefore can be planted later in the fall than most other species (Magdoff and van Es, 2000). Specific benefits of planting cereal rye include the tightening of the nutrient loop by scavenging and mining nutrients left over from the cash crop. Its deep root system and rapid growth promotes better drainage and reduced erosion. Cereal rye also provides plentiful organic matter. It can act as a natural weed suppressor by out competing light sensitive annuals and also through allelopathic (natural herbicide) effects (Managing Cover Crops Profitably, 1998).

Several results pertinent for this model are found in a study of the long-term effects of cover crops, specifically cereal rye, on corn silage production. The study of interest was undertaken in 1987 through 1995, in the Pacific Northwest, with the cereal rye being seeded each year in late September or early October after the corn harvest and incorporated into the soil in late April or early May. Conclusions indicate that although cereal rye was known to have several effects on subsequent crop production; "after 9 years of winter cover cropping, the effect of the cover crops on corn growth resulted primarily from their influence on soil N availability" (Kuo and Jellum, 2000).

Although cereal rye decreased corn silage yield in the short term, it increased soil organic nitrogen accumulation and gradually improved production over the long-term. Cereal rye has a long-term positive impact on soil organic nitrogen accumulation when grown continuously. A short-term decline in yields occurs due to nitrogen immobilization by the cereal rye, which temporarily reduces nitrogen availability to corn plants (Kuo and Jellum, 2000).

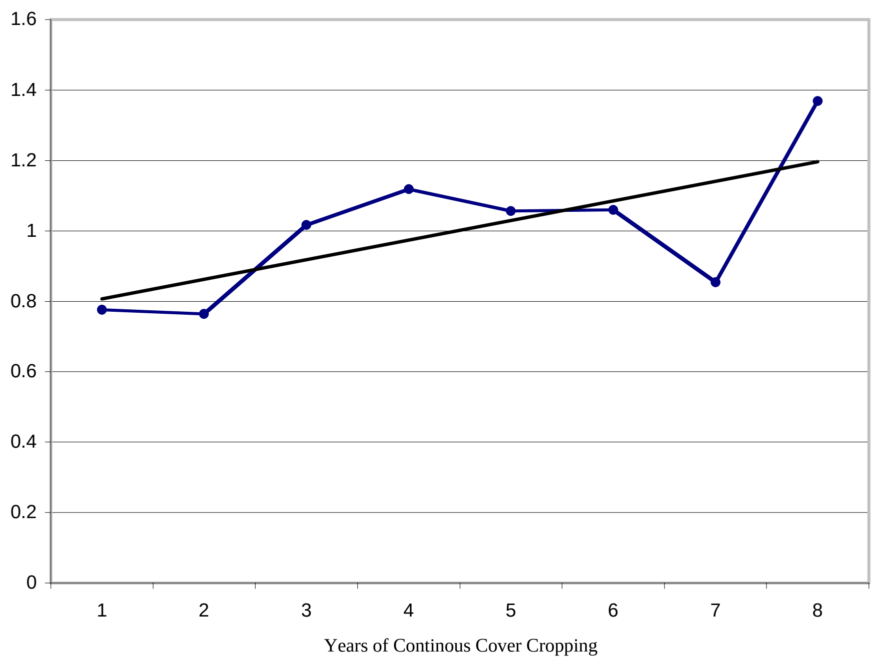


Figure 4.2 Multiplier Effect of Continuous Cover Cropping on Corn Silage Yields

Source: Kuo and Jellum, 2000

The above graph represents the effect of winter cover cropping with cereal rye on relative corn silage production where the x-axis is the year of consecutive cover cropping and the y-axis is the relative change in corn silage. This relationship provides an estimate of the initial negative yield effect due to nitrogen immobilization by the cereal rye. This effect, incidentally, provides some of the environmental benefits of using a cover crop, which is to tie up excess nutrients in the fall and winter. It also provides an estimate of the subsequent gradual increase in corn silage yield due to increased soil organic matter, which occurs slowly as the cover crop decomposes into states that are usable by the corn plants. The amount of nitrogen mineralized into the soil from cover crop depends on the Carbon and Nitrogen ratios of the cereal rye residue and environmental conditions such as temperature and soil water content. A further complexity is the effect of increased organic matter on the capacity of soil to hold nutrients (Magdoff and van Es, 2000). These factors contribute to the relatively low R-squared value of the correlation (Kuo and Jellum, 2000). For the purpose of this model, the complex yield effect is abstracted and assumed to be linear. As shown above, the yield effect begins with an initial decrease in relative yield and gradual improves yields to a point of an overall positive effect on corn silage yield between years four and five (Kuo and Jellum, 2000).

This biophysical sector of the model uses this linear relationship as a proxy for the much more complex biophysical processes briefly described above. The model uses this relationship, known as the Organic Matter EFFECT, as estimated by Kuo and Jellum (2000), to simulate the Additional Crop Yield, that is, the increase in average corn silage yields, measured in tons, on the representative farm under continuous use of cover crops. The model also tests the assumption of the linear approximation of Organic Matter EFFECT by comparing it to the actual function from Kuo and Jellum (2000). The Additional Crop Yield equation, seen below, only calculates the marginal contribution of cover crops and therefore subtracts out the expected, or normal, crop yield.

(6) Change in Crop Yield= Enrolled Cover Crop Acreage*(normal crop yield*Organic Matter EFFECT)-(normal crop yield*Established Cover Crop Acreage) *tn/year*

The contribution to Actual Net Revenue from the cover cropping practice is calculated from the Change in Crop Yield as seen above, and the additional payments and costs of the cover crop enhancement.

(7) Change in Net Revenue from Cover Crop Enhancement= Change in Revenue due to Yields +Program Payment for Cover Crop – Change in Total Costs from Cover Crop Enhancement *dollars/year*

The change revenue from yields and payments are offset, however, by the operating costs of planting a cover crop such as machinery, labor, and seed costs. These costs are also included as inputs to the Actual Net Revenue from a CSP contract calculation seen in equation number one above.

(8) Change in Total Costs from Cover Crop Enhancement= Enrolled Cover Crop Acreage* Cover Crop Cost Rate *dollars/year*

Expectation Formation Sector Overview

This research assumes that farmers make participation decisions based on their expected costs and benefits of implementing conservation practices. Thus, modeling the expectation formation process of farmers is critical to understanding and predicting contract termination decisions. The purpose of the expectation formation sector is to apply descriptive behavioral decision-making concepts to the participation termination decision-making process. Descriptive elements of this process will go beyond those assumptions considered in traditional economic analyses such as profit-maximization under perfect information and rationality. Rather, this model considers decision-making processes that include assumptions of possible estimation error, learning, and adaptive expectations.

Perceived revenue and expected revenue are beliefs concerning present and future revenue streams and are modeled separately from actual revenue in this simulation model. Thus, the relaxation of the assumption of perfect information is a key aspect of this simulation model and leads to several non-trivial results. Perceptions and expectations are both modeled as adaptive processes that constantly update as new information is acquired, thus they are distinctly dynamic in nature.

In this model, perceived revenue is treated as an exponential smooth of actual revenue, and expected net revenue is modeled either as an exponential smooth of perceived revenue, that is, adaptive expectations, or as an extrapolative expectation based on perceived net revenue.

The expectation formation sector of this simulation model can be broken into four separate elements: biophysical estimation error, perception formation, expectation formulation, and extrapolative expectation formation. Although interconnected, each of these elements represents a distinct set of assumptions concerning the decision-making processes of the farmer. Each element will be discussed in turn, and the formulation and justification for each element will be provided. The stock and flow structure of the expectation formation sector is especially important because it represents the central concept that perceptions, expectations, and beliefs can be modeled as stocks in a system.

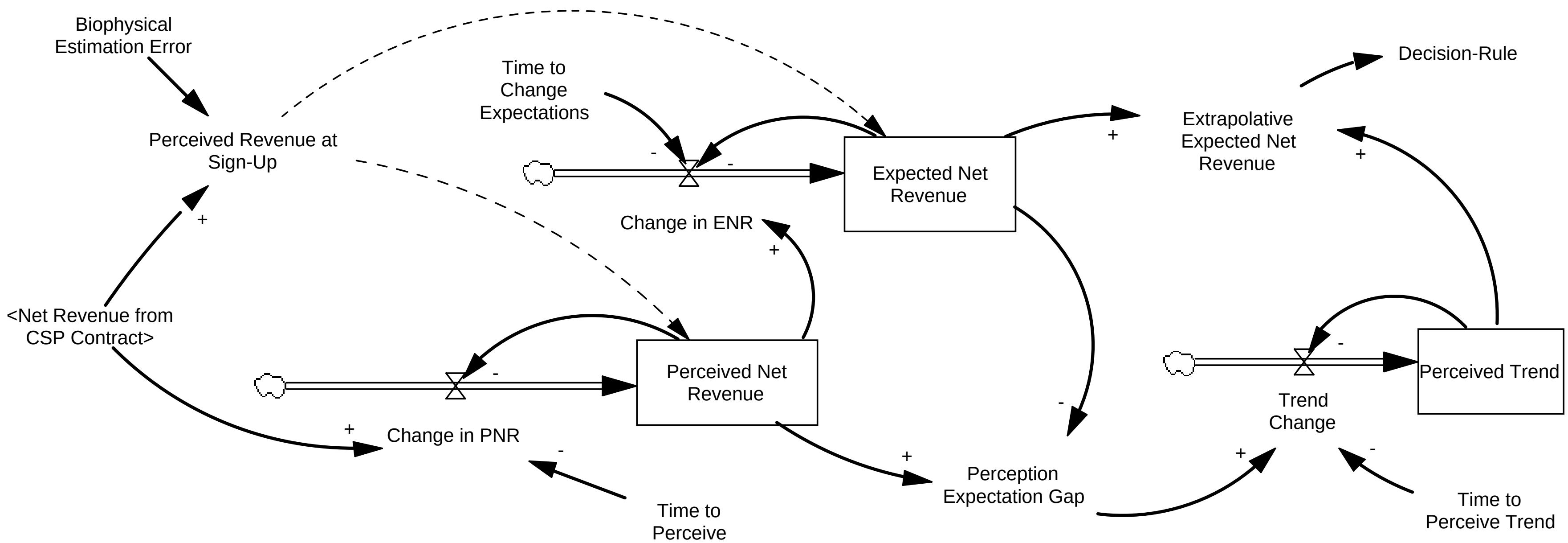


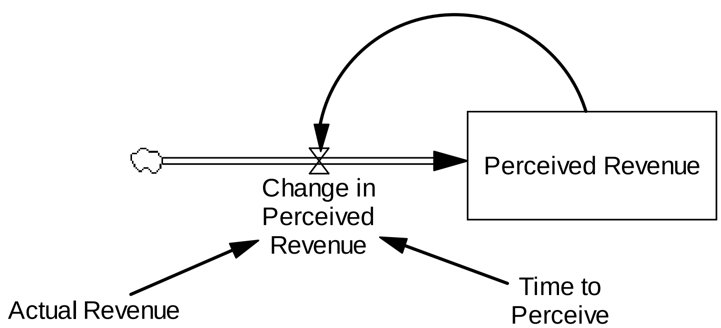
Figure 4.3 Expectation Formation Stock and Flow Diagram

Note: Dotted arrows indicate causal links for a stock's initial value.

Expectation Formation Sector Conceptual Foundation

Perceptions and expectations are represented as stocks because they are beliefs about the state of the system, in the farmer's case, the net revenue received from their participation in CSP. This belief will tend to remain the same unless new information is received, which is different, thus providing a reason to change previously held beliefs. Under this formulation, a belief changes when it is in error, that is, when the actual state of affairs differs from the current perceived state of affairs. The perceptions of a farmer, or any decision-maker, do not change instantly, however, when confronted with new information (Sterman, 2000). Therefore, perceptions and expectations are smoothed to represent the gradual adjustment of beliefs. These delays take the form of exponential smoothing processes.

An exponential smoothing process can be described mathematically and with the notation of system dynamics. For example, Figure 4.3 illustrates the stock and flow notation of a farmer's perceived revenue and its mathematical equivalent.



Perceived Revenue = INTEG (Actual Revenue-Perceived Revenue)/Time to Perceive

Figure 4.4 Exponential Smoothing Processes

In this example, Perceived Revenue is a stock variable, which is the integral, (INTEG) of the Actual Revenue minus Perceived Revenue, that is, Change in Perceived Revenue, all divided by the Time to Perceive.

If the currently held perceptions or expectations do not match the actual value, then they are gradually adjusted. The adjustment time, called Time to Perceive, determines how rapidly beliefs respond to error. The Perceived Revenue stock variable adjusts to the actual revenue in proportion to the size of the error between the two. Thus, the rate of change in the perception is proportional to the gap between the current actual value and the perceived value (Sterman, 2000). The rate at which errors in perceptions are corrected is formulated as the actual revenue minus the perceived revenue, divided by the adjustment time. Therefore, the adjustment rate is not constant; as the perceived state approaches the actual state, the remaining gap falls and therefore the adjustment rate is reduced (Sterman, 2000).

Although similar in construction, there are significant differences between a farmer’s perception of a current situation, and his or her expectation about a future situation. Expectations introduce a second and distinct information delay into the decision-making process of the farmer. Expectations are formed based on accumulated perceptions of the current state of the system, or Perceived Net Revenue in this simulation model. The delay is the process of forming beliefs about the future from current perceptions. As such, expectations are often modeled in system dynamics as adaptive learning processes or adaptive expectations (Sterman, 2000). Adaptive expectations are consistently updated and changed as farmers receive new information.

To illustrate the relevance of modeling adaptive expectations as an exponential smoothing process, it can be insightful to compare it to another commonly used estimate of expectations such as a moving average. It can be assumed that a moving average is a simplistic but reasonable proxy for a decision maker's expectation about the future (Sterman, 2000). For example, let us assume that a farmer uses a six-week moving average to generate expectations concerning revenue, which he or she then uses to make production decisions. In this case, each week's data represents one-sixth of the total beliefs held about actual revenue. Suppose actual revenue was constant over the past seven weeks, but dropped by fifty percent in the eighth week, and stayed at that the level for the foreseeable future. Without any further information concerning what caused the drop in revenue, the new information would be given the same weight as information received five weeks ago. Thus a moving average model would produce a linear decline for five straight weeks before reaching the actual level of revenue. See Figure 4.4 below illustrating the farmer's expectations under a moving average model.

A more appropriate model of decision-making would assume that recent data is more important than data received several weeks ago. The exponential smoothing process described above is a moving average where the weights of importance for each piece of information decline exponentially. The most recent values receive the most weight, while the older values receive progressively less. Thus, using adaptive expectations, that is, a process of continuous exponential smoothing, the same scenario produces a curved change in expectations. After a fifty-percent drop in revenue in week eight, expected revenue drops quickly at first, taking into account the large difference between the actual revenue and the expected revenue. However, the change in expectation slows as the difference between the actual revenue and expected revenue becomes less. Thus, after the first week, the farmer has significantly larger drop in expected revenue, compared to the six-week moving average. The adaptive expectations formulation assumes a two-week adjustment time or time to form expectations. The exponential smoothing process of adaptive expectations produces changes in expectations that are intuitively a more realistic representation of a farmer's expectation formation process. See the comparison between the adaptive expectations process, which uses an exponential smoothing process, and a simple moving average in the figure below.

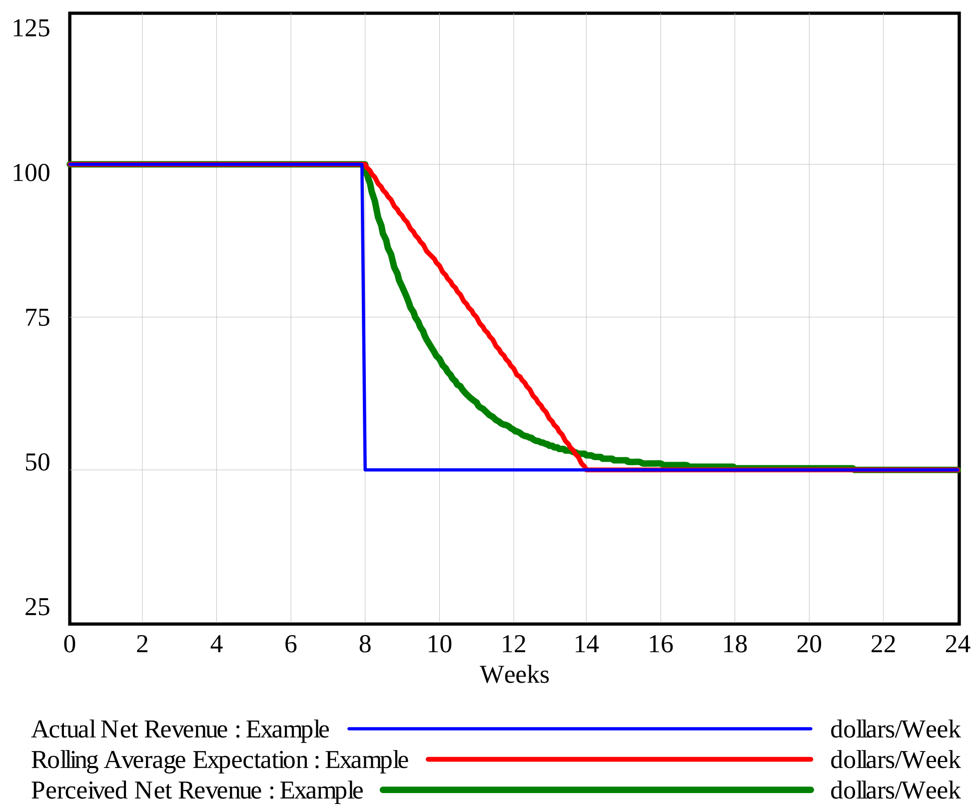


Figure 4.5 Comparison Of Expectation Formation

The modeling of perception and expectation formation as an exponential smoothing process is commonly used in system dynamics simulation models and is significantly buttressed by the research of Daniel Kahneman and Amos Tversky (Sterman, 2000). Both Kahneman and Tversky have published much research on the subject of behavioral decision-making alternatives to neoclassical economic assumptions (Plous, 1993). One of their first and most widely replicated findings is an effect called “anchoring and adjustment” (Sterman, 1987, 2000). This is the insufficient adjustment up or down from an original starting value or anchor. Tasks in which individuals must produce a numerical estimate are susceptible to an anchoring effect where the response is strongly biased toward any value, even if it is arbitrary, that the individual is induced to consider as a possible answer (Kanhneman, et al, 2000). Kahneman and Tversky’s original study (1974) documented an experiment where participants were asked to estimate the number of African countries in the United Nations after receiving a random value as an “anchor.” Significant differences were found between participants who were assigned higher versus lower anchors (Tversky and Kahneman, 1974). This research hypothesized that people often judge an unknown quantity by acknowledging a known reference point and then using additional information to adjust the base by some “stretch factor.” This cognitive heuristic has been replicated in the laboratory and has an intuitive appeal.

The effects of anchoring are pervasive and extremely robust, even when provided significant incentives to get the estimate correct (Plous, 1993). A common disadvantage of using “anchoring and adjustment” is that it has the common tendency to under predict changes, that is, to revise prior judgments too little in the face of new data (Sterman, 1987). The exponential smoothing process is appropriate to formally model the effect of “anchoring and adjustment” on the relationship between an initially held perception or expectation and the subsequent adjustment of that belief (Sterman, 1987, 2000). The specific formulations of farmers’ perceptions and expectations in this model are detailed in individual sections below.

Biophysical Estimation Error

The Biophysical Estimation Error is a structure in the model that reflects a specific assumption regarding a farmer’s imperfect information about the biophysical processes of conservation practices. Simply, it assumes that farmers have an initial error in estimating the biophysical effects of implementing conservation practice such as cover crops. This error leads to mistaken expectations regarding the revenue stream generated from participation in conservation programs such as CSP.

The cause of an individual farmer's Biophysical Estimation Error may be due to general lack of information, previous experience, heterogeneous farm characteristics, or externally introduced bias. The conceptual foundation for the Biophysical Estimation Error is grounded in the work of incomplete information in bidding games such as the "winner's curse" (Capen et al, 1971). This phenomenon, which has occurred in auctions and reproduced in economic experiments, such as Charness and Levin, 2005, originally described the bidding outcomes of auctions for petroleum drilling rights in the Gulf of Mexico. Successful bidders fall victim to "winners curse" when the average bid for an item is below the true value but the winning bid exceeds the true value of the item. This implies lack of perfect information, particularly an error in the estimation of the expected value of the item. The "winners curse" phenomenon further assumes that bidders will make errors in estimating the value of an item within an unknown distribution with mean 0. The assumption that farmers do not accurately perceive the actual biophysical effects of conservation practices is found in the benefit-cost analysis of CSP produced by NRCS. The NRCS aggregate participation model assumed that farmers only accounted for 25% of the on-farm benefits of conservation practices. However, their model did not account for subsequent learning about those effects (USDA, 2005).

The model assumes farmers have similarly distributed estimations of the economic benefits of conservation practices. These distributions are not known, however the model tests several levels of a representative decision-maker's error. This ranges from no estimation error, which considers the full financial impact of biophysical effects, to 100% error, which completely disregards financial impacts of biophysical effects. The estimation error is confined to the biophysical impacts of conservation practices on revenue because of their heterogeneous, dynamic, and often complex nature. The farmer is assumed to have full information concerning the costs of implementing each conservation practice and their respective enhancement payments made through CSP. Thus, if the Biophysical Estimation Error were zero, the farmer would begin the simulation perceiving the actual Net Revenue from CSP Contract. If error is 100%, then farmers will begin the simulation fully perceiving the costs of implementation, and CSP payments, but none of the financial impacts of the biophysical processes. Thus, the model equation for perceived revenue at the time of the CSP sign-up period can be written as:

(9) Perceived Revenue at Sign-Up= (Base Payment + Change in Net Revenue from Riparian Buffer Enhancement + Program Payment for Cover Crop - Change in Total Costs from Cover Crop Enhancement)+(1-Biophysical Information Uncertainty)*Change in Revenue due to Yields *dollars/year*

The Biophysical Estimation Error serves only as an adjustment to the starting point, or initial value, of a farmer’s Perceived Net Revenue and Expected Net Revenue. The process of perception formation allows for subsequent learning that adjusts Perceived Net Revenue towards a more accurate accounting of the actual net revenue.

Perceived Net Revenue Formation

The second element of the expectation formation sector is a delay in the perception of the costs and benefits of CSP participation. This information delay assumes that a fixed amount of time passes between the on-farm change in actual net revenue from participation in CSP and the perception of those changes. This delay could take many real world forms, including: management delays in collecting information, delays in processing the information for into useful forms, or deliberate postponement of planning until certain seasons of the year.

This delay is captured in an exponential smoothing process between the Net Revenue from CSP Contract and the stock variable Perceived Net Revenue. If the currently held perceptions do not match the actual value, then they are gradually adjusted. The adjustment time, called Time to Perceive, determines how rapidly beliefs respond to error. The Perceived Net Revenue adjusts to the actual input, in this case Net Revenue from CSP Contract, in proportion to the size of the error between the two. Mathematically, Perceived Net Revenue is a stock variable which is the integral, (INTEG) of the Change in Perceived Net Revenue, with an initial value of Perceived Revenue at Sign-Up

(9) Perceived Net Revenue= INTEG (Change in PNR, Perceived Revenue at Sign-Up) *dollars/year*

(10) Change in PNR= (Net Revenue from CSP Contract-Perceived Net Revenue)/Time to Perceive *(dollars/year)/year*

The Change in Perceived Net Revenue (PNR) is the difference between the Net Revenue from CSP Contract minus Perceived Net Revenue over the Time to Perceive. Thus, the rate of change in the perception is proportional to the gap between the current actual value and the perceived value (Sterman, 2000). This process of feedback and adjustment mimics a learning process where the farmer is continuously updating perceptions as new information becomes available. The farmer’s learning process concerning the actual financial impacts of biophysical effects versus the initially estimated biophysical effects is explicitly modeled through this exponential smoothing structure.

The adjustment time, or Time to Perceive, acts as a half-life for the time it takes a farmer to adjust his or her perceptions to a step change in actual net revenue. Therefore, after one adjustment time, 63% of the initial gap has been corrected, after two adjustment times, 86% of the gap is corrected, and after three adjustment times, the adjustment is 95% complete. Technically, the gap between perception and actual value is never fully closed. If there is constant growth or decline in net revenue from CSP participation, the formulation of this delay will create a steady state error between Perceived Net Revenue and the actual Net Revenue from CSP Contract (Sterman, 2000). This steady state error is easily represented graphically as Perceived Net Revenue will continue to lag Net Revenue from CSP Contract by a fixed amount. The average delay in perception, or Time to Perceive, for farmers is not known. However, a range of adjustment times are tested using different "types" of representative decision-makers who have differing rates at which they perceive changes in net revenue, which can represent management sophistication.

Expected Net Revenue Formation

In one set of scenarios, expected net revenue is modeled as adaptive expectations as illustrated in the overview to the expectation formation sector. Adaptive expectations are formally structured similarly to perceptions in the model, that is, as first-order exponential smoothing processes.

(11) Adaptive Expected Net Revenue= INTEG (Change in ENR, Perceived Revenue at Sign-Up)
dollars/year

(12) Change in ENR= (Perceived Net Revenue-Expected Net Revenue)/Time to Change Expectations *(dollars/year)/year*

Mathematically, Adaptive Expected Net Revenue is a stock variable which is the integral, (INTEG) of the Change in Expected Net Revenue, with an initial value of Perceived Revenue at Sign-Up. The Change in Expected Net Revenue (ENR) is the difference between the Perceived Net Revenue minus Expected Net Revenue over the Time to Change Expectations.

The mathematical structure of Adaptive Expected Net Revenue and Perceived Net Revenue are identical, although their respective inputs are different. Therefore, their properties are comparable. The delay between perception and expectation formation is captured in the exponential smoothing of Perceived Net Revenue into Adaptive Expected Net Revenue. Like perceptions, expectations will tend to remain the same unless new information is received. The resulting change is not instantaneous; rather it is a gradual correction of the error between the perceptions and expectations of net revenue. If the currently held expectations do not match the perceptions, then they are gradually adjusted. This formulation also leads to a steady state error between Adaptive Expected Net Revenue and Perceived Net Revenue when Perceived Net Revenue is growing or declining at a constant rate. The Extrapolative Expectation Formulation, however, will correct for this error as seen below.

The adjustment time, Time to Form Expectations, determines how rapidly beliefs are updated. Also like perception formation, the adjustment rate is not constant; as Adaptive Expected Net Revenue approaches Perceived Net Revenue, the remaining gap falls and therefore the adjustment rate is reduced. The average delay in forming expectations, or Time to Form Expectation, is not known. However, a range of adjustment times is tested using different “types” of representative decision-makers with various adjustment times representing how quickly they update their expectations of net revenue.

Alternatively, Adaptive Net Revenue can be modeled using extrapolative expectations. This formulation addresses the limitation of adaptive expectations, specifically, that it fails to allow for decision-makers to correct their expectations over time when faced with persistent perceived trend. Under adaptive expectations, a steady state error occurs whenever the input is steadily growing, which means the output will never equal the input even after sufficient time for transient adjustments has passed (Sterman, 2000).

By assuming extrapolative expectation behavior, the model allows farmers to correct their expectations for net revenue, if they are persistently different than perceived net revenue. Thus, where simple adaptive expectations will simply lag perceptions during linear growth, extrapolative expectations will perceive a trend and correct expectations to eventually coincide with perceptions.

This situation is often formulated in system dynamics models by using a TREND function (Sterman, 1987). The TREND function generates the expected rate of change in the input variable, expressed as a fraction of the input variable per time unit. However, Sterman’s TREND formulation generates percentage growth as an output, which is not needed for the representative farmer’s more simplistic net revenue calculation. In addition, the TREND function has difficulty dealing with raw inputs that cross or come close to zero. These characteristics make the TREND function unsuitable for modeling the expectations of the representative farmer. However, the fundamental concept underlying the TREND function correct and it can be easily modified to correct these shortcomings and provide a suitable replacement.

Extrapolative expectations uses the absolute difference between the Perceived Net Revenue and Expected Net Revenue, that is, the Perception Expectation Gap, to represent the error in expectations relative to perceptions.

(13) Perception Expectation Gap= Perceived Net Revenue- Adaptive Expected Net Revenue
dollars/year

This error can also be conceived of as a trend in Perceived Net Revenue. These errors are then exponential smoothed over an adjustment time, Time to Perceive Trend.

(14) Trend Change= (Expectation Gap-Perceived Trend)/Time to Perceive Trend *(dollars/year)/year*

Thus, the Perceived Trend is the exponentially smoothed accumulation of these past expectation errors.

(15) Perceived Trend= INTEG (Trend Change, 0) *dollars/year*

It is added back to the Adaptive Expected Net Revenue to create a corrected expectation called Extrapolative Expected Net Revenue.

(16) Extrapolative Expected Net Revenue= Adaptive Expected Net Revenue +Perceived Trend
dollars/year

This formulation has significant behavioral implications. It improves adaptive expectations by adding a perceived trend that can correct the steady state error seen with a linearly growing input. However, adjusting the expectation by adding a perceived trend will also lead to expectations that overshoot turning points in an input. Figure 4.6 illustrates the differences between modeling expectations as adaptive expectations, versus extrapolative expectations, given a situation where a producer's revenue increases permanently by fifty percent at week eight. In this hypothetical scenario, the overshooting aspect of extrapolative expectations is clearly demonstrated as the extrapolative expectations assumption corrects more quickly than adaptive expectations assumption, however it overshoots before correcting itself. Whereas, given the same inputs, adaptive expectations adjusts itself more gradually to the actual revenue without overshooting.

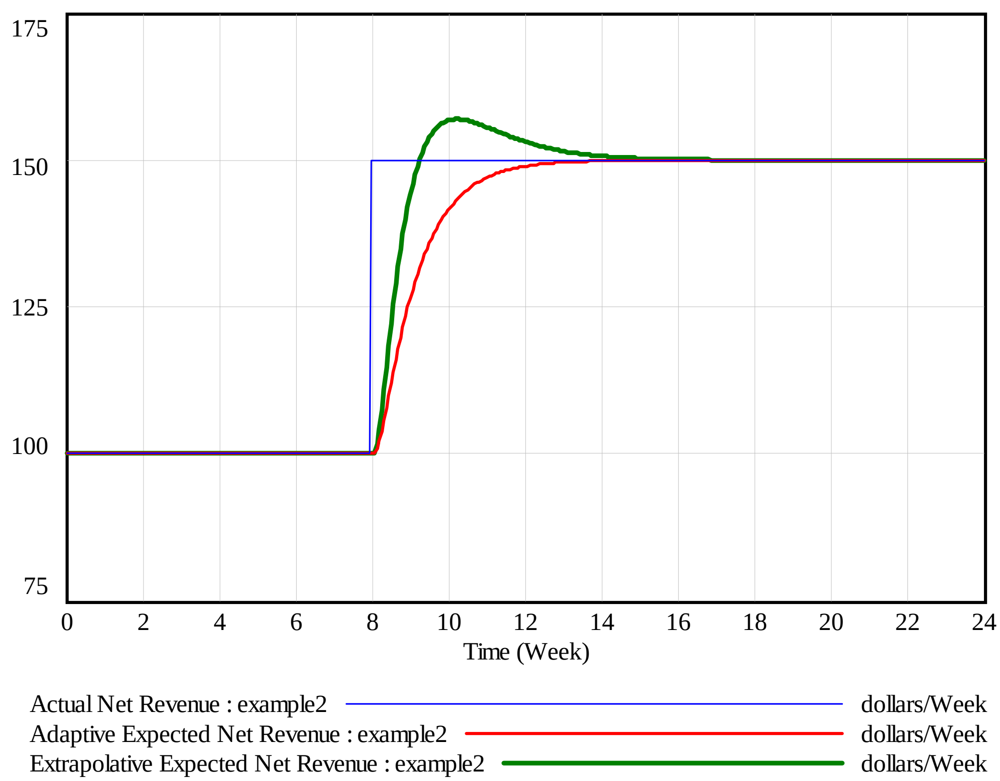


Figure 4.6 Expected Net Revenue With Adaptive Expectations Versus Extrapolative Expectations

Decision Rule Sector

The model thus includes assumptions of perception and expectation formation, must consider decision-rules that are appropriately matched to these perception and expectation processes. A decision-rule is the standard, heuristic, or rule that a farmer will use to determine continuing participation in CSP. Applied economic research most often uses Net Present Value (NPV) as the decision criterion.

Indeed, many commonly used farm management textbooks identify NPV as the optimal rule for decision-making (Kay, et al, 2004). The decision-rule sector of the model tests ten decision-rules ranging from traditional net present value to more descriptive decision-rules based on expected net revenue. All decision rules tested in this simulation use either Net Revenue from CSP Contract, Perceived Net Revenue, Adaptive Expected Net Revenue, or Extrapolative Expected Net Revenue as the sole input.

To approach these questions, this analysis will begin with the assumptions that producers have perfect information and use calculations of net present value as a decision-rule. Subsequently, it will examine the effects of alternative behavioral assumptions stemming from an assumption that producers will have pressure to terminate their CSP contract when facing revenues less than acceptable revenues or greater than acceptable losses. The simulation model could produce several different versions of decision-rules to determine participation in CSP. This model assumes a several possible reasonable decision rules and explores their implications. Accordingly, this analysis will test ten different decision-rules in order to better understand the dynamics of the participation decision model and provide of range of behavior, which policy-makers might expect from farmers. A table summarizing these ten decision-rules is provided below.

Table 4.1 Decision Rules

Name	*Description*	*Formulation*	*Reference*
Net Present Value with Perfect Information	This optimal decision rule assumes decision makers have perfect information regarding the actual future net revenue	=Net Revenue from CSP Contract/(1+Discount Rate)^Time	Kay, et al. 2004.
Myopic Perceived B/C Rule	Assumes decision makers do not have perfect information, but instead use a benefit cost rule based on current perceived net revenue	= IF THEN ELSE (Perceived Net Revenue<0, 0, 1)	Sterman, 2000
Myopic Adaptive Expectations B/C Rule	Assumes decision makers do not have perfect information, but instead use a benefit cost rule based on expected future net revenue	=IF THEN ELSE (Expected Net Revenue<0, 0, 1)	Sterman, 2000
Myopic Extrapolative Expectations B/C Rule with $0 threshold	Assumes decision makers do not have perfect information, but instead uses a benefit cost rule based on expected future net revenue adjusted with an extrapolated trend of the data	= IF THEN ELSE (Extrapolative Expected Net Revenue<0, 0, 1)	Kahneman and Tversky, 2000. & Plous, 1993
Myopic Extrapolative Expectations B/C Rule with $1,000 threshold	Adds a $1,000 threshold to account for absolute monetary losses and possible values for positive externalities of conservation practices	= IF THEN ELSE (Extrapolative Expected Net Revenue<-1000, 0, 1)	Kahneman and Tversky, 2000, & Plous, 1993
Myopic Extrapolative Expectations B/C Rule with $5,000 threshold	Increases the Extrapolative Expectation threshold up to $5,000	= IF THEN ELSE (Extrapolative Expected Net Revenue<-5000, 0, 1)	Kahneman and Tversky, 2000, & Plous, 1993
Myopic Extrapolative Expectations B/C Rule with $10,000 threshold	Increases the Extrapolative Expectation threshold up to $10,000	= IF THEN ELSE (Extrapolative Expected Net Revenue<-10000, 0, 1)	Kahneman and Tversky, 2000, & Plous, 1993
Relative Position Rule with $1,000 threshold	Assumes that decision makers will terminate based on a relative loss of revenue compared to a previous expected level of revenue ($1,000)	= IF THEN ELSE (Expectation Perception Gap<-1000, 0, 1)	Thaler, 1991.
Relative Position Rule with $5,000 threshold	Increases the Relative Position threshold up to $5,000	= IF THEN ELSE (Expectation Perception Gap<-5000, 0, 1)	Thaler, 1991.
Relative Position Rule with $10,000 threshold	Increases the Relative Position threshold up to $10,000	= IF THEN ELSE (Expectation Perception Gap<-10000, 0, 1)	Thaler, 1991.

Net Present Value with Perfect Information: the representative decision-maker initiates CSP participation if the net present value (NPV) of Net Revenue from CSP Contract is positive over the ten-year contract period.

(17) Net Present Value= INTEG (Change in Actual Net Revenue,0)
dollars/year

(18) Change in Actual Net Revenue =Net Revenue from CSP Contract/(1+Discount Rate)^Time
(dollars/year)/year

The NPV calculation assumes the representative decision-maker has perfect information regarding Net Revenue from CSP Contract. Therefore, termination of CSP participation is not an option for the decision-maker in this simulation model. The NPV calculation uses a 5% discount rate. NPV will be used as basis to compare other decision-rules using perceived and expected net revenue.

The term "myopic" characterizes decision-rules that are made with imperfect information, that is, only information currently available to decision makers at the time a decision is made. Rather, these decision-rules use the perceived, adaptive expected, and extrapolative expected net revenue as inputs, which are continuously updated through learning processes. The following decision-rules must rely upon myopic perceptions and expectations and thus are not subject to a standard NPV decision rule.

Myopic Perceptions Benefit/Cost Rule: the representative decision-maker initiates CSP participation if Perceived Net Revenue is greater than zero at the start of the simulation. The decision-maker terminates participation if Perceived Net Revenue falls below zero at any point during the simulation.

(19) Myopic Perceptions Benefit/Cost Rule= IF THEN ELSE(Perceived Net Revenue<0, 0, 1) *Dimensionless*

If decision-makers are constantly updating their perceptions of the Net Revenue from

CSP Contract, then this decision-rule assumes that decision-makers use their perceived net revenue rather than forming expectation about future costs and benefits.

Myopic Adaptive Expectations Benefit/Cost Rule: the representative decision-maker initiates CSP participation if Adaptive Expected Net Revenue is greater than zero at the start of the simulation. The decision-maker terminates participation if Adaptive Expected Net Revenue falls below zero at any point during the simulation.

(20) Myopic Expectations Benefit Cost Rule=IF THEN ELSE (Adaptive Expected Net Revenue<0, 0, 1)
Dimensionless

Expectation formation acts as a second information delay beyond Perceived Net Revenue. If perceptions are steadily growing or declining, this formulation will create a steady state error between expectations and perceptions.

Myopic Extrapolative Expectations Benefit/Cost Rule: the representative decision-maker initiates CSP participation if Extrapolative Expected Net Revenue is greater than zero at the start of the simulation. The decision-maker terminates participation if Extrapolative Expected Net Revenue falls below zero at any point during the simulation.

(21) Myopic Extrapolative Expectations Benefit/Cost Rule= IF THEN ELSE (Extrapolative Expected Net Revenue<0, 0, 1)
Dimensionless

Extrapolative expectations correct the steady state error seen in simple adaptive expectations. However, this formulation creates the possibility of decision-makers overshooting expectations when faced with a turning point in net revenue.

Myopic Extrapolative Expectations Benefit/Cost Rule with Threshold: the representative decision-maker initiates CSP participation if Extrapolative Expected Net Revenue is greater than zero. The decision-maker terminates participation if Extrapolative Expected Net Revenue falls below their threshold value at any point during the simulation. Threshold values will be tested at negative $1,000, $5,000, and $10,000.

(22) Myopic Extrapolative Expectations Benefit/Cost Rule with $1,000 Threshold= IF THEN ELSE(Extrapolative Expected Net Revenue<-1000, 0, 1) *Dimensionless*

(23) Myopic Extrapolative Expectations Benefit/Cost Rule with $5,000 Threshold= IF THEN ELSE(Extrapolative Expected Net Revenue<-5000, 0, 1) *Dimensionless*

(24) Myopic Extrapolative Expectations Benefit/Cost Rule with $10,000 Threshold= IF THEN ELSE(Extrapolative Expected Net Revenue<-10000, 0, 1) *Dimensionless*

This decision-rule is designed in accordance with emerging behavioral theories, such as Prospect Theory, proposed by Kahneman and Tversky (Plous, 1993). The threshold values allow the decision-maker to absorb a given amount of financial pressure before deciding to terminate participation. Although a break-even analysis is extremely useful as a normative rule, extrapolative expectations with varying thresholds might be a more accurate description of farmer decision-making. It can be instructive to understand the decision-making in terms of absolute monetary losses. The presence of threshold values can also indicate a decision-makers internalization of perceived positive externalities of conservation practices, that is, a conservation ethic or altruism.

Relative Position Rule: the representative decision-maker initiates CSP participation if the Perception Expectation Gap is below a given threshold. The decision-maker terminates participation when the Perception Expectation Gap is greater than the same threshold value. Threshold values will be tested at $1000, $5,000, and $10,000.

(25) Relative Position Decision Rule with $1,000 Threshold= IF THEN ELSE(Expectation Perception Gap<-1000, 0, 1) *Dimensionless*

(26) Relative Position Decision Rule with $5,000 Threshold= IF THEN ELSE(Expectation Perception Gap<-5000, 0, 1) *Dimensionless*

(27) Relative Position Decision Rule with $10,000 Threshold= IF THEN ELSE(Expectation Perception Gap<-10000, 0, 1) *Dimensionless*

This decision-rule is not predicted by traditional cost-benefit analysis, however it can be conceived as a realistic heuristic that could be used by farmers. Additionally, it is implied in the burgeoning literature on mental accounting and consumer choice that decision-makers might use this heuristic (Thaler, 1991). The relative position decision-rule does not reference the absolute value of the net revenue but rather the difference between the amount of revenue expected in a given year and the amount of revenue perceived. This decision rule provides for the real-world outcome of a farmer continuing to participate in CSP, even in a year that they expect to lose money. However, if the farmer perceives a greater loss than their threshold allows, a farmer might become disillusioned and seek to terminate participation.

Representative Decision-Makers

To facilitate a clearer understanding of the significant effects of unknown parameters in the simulation model, the model utilizes six "types" of representative decision-makers in order to consolidate and summarize important parameters. Using representative decision-makers does not preclude extensive sensitivity testing for the same parameters. Of particular interest are the decision-making parameters that relate to estimation error, learning, and expectation formation. These parameters are not readily available and formal survey methods for obtaining these estimates are beyond the scope of this research. These parameters include the Biophysical Estimation Error, Time to Perceive, Time to Form Expectations, and Time to Form Trends. Various combinations of the parameters are used to create six representative types of decision-maker.

Biophysical Estimation Error, designating the amount of knowledge a decision-maker has about the biophysical effects of the conservation practices, is distributed into three groups: 50%, 75%, and 100% error, labeled smart, average, and limited, respectively. No representative decision makers are given less than 50% error in estimating the biophysical effects because the model's perception and expectation functions depend on an initial change, thus little or no initial estimation error would render model output limited and uninteresting.

The second group of parameters represents the management characteristics of the decision-makers. Primarily, these parameters represent how quickly decision-makers perceive net revenue, form expectations about that revenue, and perceive trends in the net revenue from their participation in CSP. These types of decision-makers will be divided into two categories: sophisticated and naïve. These parameter settings for these two categories will affect Time to Perceive, Time to Form Expectations, and Time to Perceive Trend. These representative decision makers are summarized in Table 4.2.

Table 4.2 Representative Decision-Makers

Representative Decision-Makers	Biophysical Estimation Error	Time to Perceive (years)	Time to Form Expectation (years)	Time to Perceive Trend (years)
A. Smart Sophisticated	50%	1	2	2
B. Smart Naïve	50%	2	2	3
C. Average Sophisticated	75%	1	2	2
D. Average Naïve	75%	2	2	3
E. Limited Sophisticated	100%	1	2	2
F. Limited Naïve	100%	2	2	3

Model Testing

In order to build confidence in preparation for simulating the model, a battery of tests was conducted on the simulation model. This testing regime applied is summarized and recommended in Sterman (2000). A boundary adequacy test was conducted to determine the appropriateness of the model boundary including which models variables are included, considered exogenous inputs, or excluded from the model. For the stated purpose of informing policy-makers and practitioners of traditional applied economic models, the current model boundary is found to be appropriate.

A structural assessment considers the information provided by several test inputs and seeks to understand the behavior of the model under various conditions. These test inputs demonstrated appropriate behavior by the model. However, the question of the level of aggregation was considered to be important. A higher level of aggregation, for example, at the watershed or state level would allow several additional effects to be modeled. Word-of-mouth dynamics and other information flows between participants are not included in this individual farmer model. However, for the stated purpose of the model and for its intended audience, the system is modeled at an appropriate level of aggregation. Aside from aggregation issues, several partial model tests show that the structure of the model performs adequately and as expected. These partial model tests include separate calculations of the actual net revenue formulation, and several tests involving the appropriateness of the delay and smoothing structure associated with the formation of perceptions, expectations, and extrapolative expectations.

The model was tested for dimensional consistency. Except for calculations using time as an input, for example net present value, the model is dimensionally consistent.

A parameter assessment of this model highlights that fact that the parameters used in this model come from disparate sources have varying levels of accuracy and reliability. All parameters relating to the program payments, Tier Rates, and rental rates are the actual parameters used by the Natural Resources Conservation Service to determine the payments available to farmers located in the Niagara watershed near Buffalo, NY (NRCS website, April 2005). The key parameters in the expectation formation sector of the model including Time to Perceive, Time to Form Expectation, and Time to Form Trend, are educated guesses based on actual producer behavior. Extensive sensitivity testing, as shown in Chapter Five shows the ranges and associated behavior of these parameters.

There are three extreme value tests in which this model performs poorly. These include changing any of the adjustment times in perception or expectation formation to zero. Conceptually, this is a concern, however behaviorally it is acceptable because a delay can always be an assumed, no matter how small. The model fails to produce appropriate behavior when these values are zero. Specifically, the model fails to produce any behavior. This is due to the formulation of the adjustment times as they are the denominator of the flow structure. Thus, when these parameters go to zero the integration becomes incalculable.

Other extreme conditions tests of interest include changing Established Cover Crop, Normal Crop Yield, and Corn Silage Price. When each of these parameters goes to zero, the model responds appropriately. When Established Cover Crop goes to zero, the only revenue effect that remains is the base payment from CSP on the entire acreage of the farm. This could be a realistic situation if the farmer was performing other conservation practices and decided to drop out of only the cover crop practice but continue the others. When either the Normal Crop Yield or the Corn Silage Price goes to zero, the additional revenue generated by the cover crop goes to zero as well, however costs of implementing the practice are still modeled appropriately.

The model was tested for integration error. The simulation is currently being run with a time step of .0625, a change of time step to .015625 or .25; do not significantly affect behavior of the system.

Dynamic Participation Model Conclusion

This chapter explored the individual sectors of the dynamic participation decision simulation model. Various assumptions, specifically those relating to alternative expectation formation and decision-making, were proposed. Initial parameters and exogenous inputs can be found in Appendix A. The next chapter will describe the results of the simulation model for each of the representative decision-makers and various decision-rules.

CHAPTER FIVE

RESULTS OF INDIVIDUAL AND AGGREGATE SIMULATIONS

Introduction

This chapter describes the results of several simulations of the CSP decision-making model. It begins with a description and comparison of the base run of the simulation model. The base run provides for the single enhancement of riparian buffers. Then, the model is modified to account for combined cover crop and riparian buffer enhancements. As noted previously, early contract termination decisions are modeled as arising from the combination of perceptions and expectations about the net revenue effects of implementing conservation practices and the decision rules that use those net revenue effects as key information inputs. Four principal model variables will be used in the analyses throughout this chapter to illustrate the effects of changes in parameters on net revenue related variables. These revenue variables are Actual Net Revenue, Perceived Net Revenue, Adaptive Expected Net Revenue, and Extrapolative Expected Net Revenue.

Multi-parametric sensitivity analysis of the Biophysical Estimation Error and three time constants provides additional information concerning model behavior and the effects of uncertain model parameters. Next, the representative decision-makers described in Chapter Four will be used to better understand probable termination times under various decision rules. Using multiple simultaneous simulation runs with randomly assigned behavioral characteristics for a group of farm decision makers provides insights about likely aggregate cumulative termination rates under various decision rules. These simulations will also help analyze several important assumptions, including the organic matter effect from continuous cover cropping, the number of acres enrolled in cover crops, and the declining payment rate schedule that was implemented in the 2005 CSP sign-up, and potential policy "fixes" that can be used to improve participation.

The parameters and constants used for these simulation runs replicate the actual 2005 CSP Final Interim Rule as implemented in the Niagara Watershed in New York. Notable exceptions to this principle are the base payment rates for cover crops and riparian buffers, which are modeled after actual EQIP rates for the Niagara Watershed. (See Chapter Four for additional details on the calculation of enhancement payment rates.)

Base Model Results

Simulation modeling in the system dynamics tradition usually employs an iterative "what if" scenario analysis. Using this convention allows a better understanding of the dynamics at work in each scenario and the individual effects of assumption and parameters on termination decisions. In this case, results from the base simulation will allow better understanding of subsequent changes and sensitivity analyses. A description of the parameters and assumptions of the base simulation is therefore appropriate.

Key assumptions in the incentive sector of the simulation model are the agricultural producer's tier of participation, and the declining enhancement payment rate. The base model will assume the agricultural producer is participating in Tier III of CSP and thus receives 11.25% of the annual estimated rental rate for the entire farm. Tier II participation would receive 5% of the estimated rental rate (NRCS, CSP Amendment to Interim Final Rule, 2005). The base model also assumes a flat, rather than declining payment rate for all enhancements. The declining enhancement payment schedule was instituted by the sign-up announcement in 2005 and was not in effect during the 2004 sign-up (NRCS, FY2005 CSP Sign-Up Announcement, 2005).

Its effect is tested extensively and its results on decision making is reported later in this chapter.

In the biophysical sector of the model, the number of acres enrolled for each enhancement and the organic matter effect on corn yield are significant parameters. The base model will assume that four hundred acres of cover crops will be enrolled in CSP, corresponding to the assumed corn silage acreage on the eleven hundred acre farm. The riparian buffer enhancement will assume that thirty acres are enrolled. Chapter Four provides more details on the model formulation and assumptions for the enhancement practices. The base model will also use the linearized organic matter effect on corn yields, rather than the actual experimental results. The latter assumption, however, is tested later.

As explained in detail in Chapter Four, the expectation formation sector has four significant behavioral parameters. Although each of these parameters will be analyzed and reported later in the chapter, the following assumptions are made for the base run of the simulation model: Biophysical Information Uncertainty uses a value of one, denoting 100% error in perceiving the initial effect of cover cops on corn yields. Additionally, Time to Perceive, Time to Form Expectations, and Time to Perceive Trend all use an adjustment time of one year. Because the base run of the model is for the purposes of an initial examination of model behavior, it will not examine or report the results of the decision rule sector.

Four key model variables are useful for understanding the effects of changes in parameters on net revenue variables and termination decisions. These include Total Net Actual Revenue, Perceived Net Revenue, Adaptive Expected Net Revenue, and Extrapolative Net Revenue. Each of these variables represents the difference in actual, perceived, or expected revenue between participating in CSP under the assumed conditions and not participating in CSP. These variables are based on the behavioral parameters discussed above, which reflect assumptions about how farmers respond to new information. Conveniently, these key variables can be graphed together in order to better demonstrate their interrelatedness and the general behavior of the simulation model. These four variables are shown graphically in Figure 5.1 for the riparian buffer enhancement.

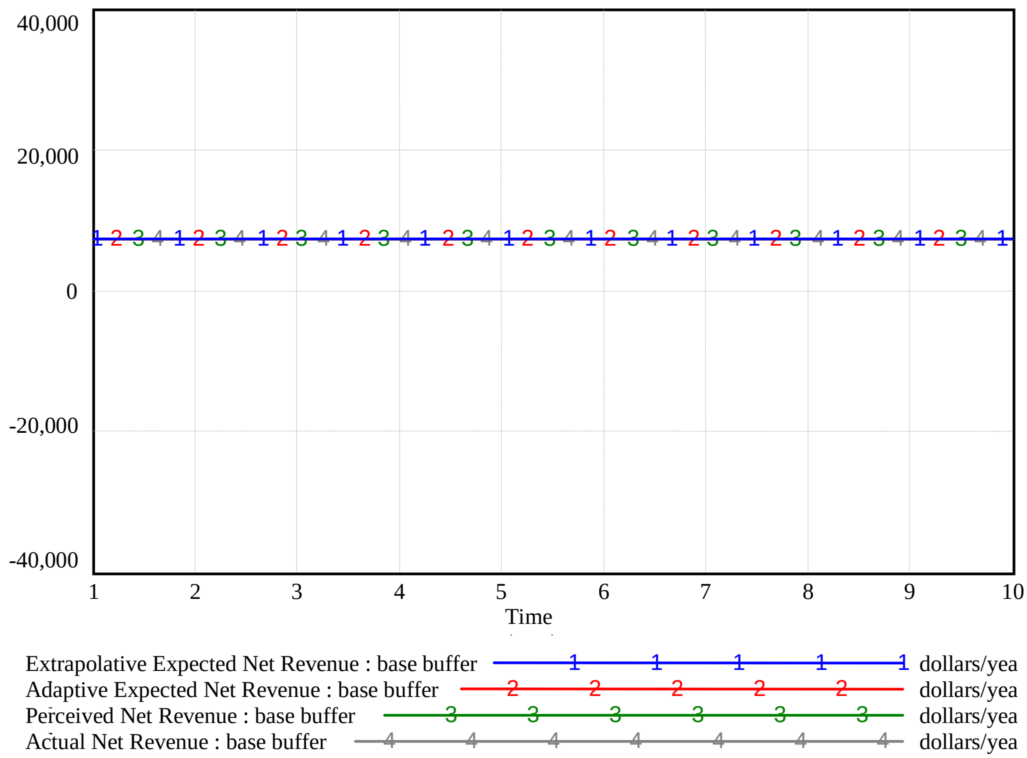


Figure 5.1 Base Simulation of Actual, Perceived, Adaptive Expected, and Extrapolative Expected Revenue For Riparian Buffer

As shown in Figure 5.1, a producer enrolling in CSP with only a riparian buffer enhancement of 30 acres receives $7,237 net revenue per year for the length of the CSP contract. This net amount is calculated by adding CSP base payments, existing practice payments, riparian buffer enhancement payments, and subtracting the costs to implement the riparian buffer, including the costs associated with the shortfall in corn silage production. Because this analysis assumes that the riparian buffer enhancement simply entails removing land from crop rotation, the producer faces no possibility of uncertainty in estimating that yield effect. This lack of estimation error leads to no initial difference between Actual Net Revenue and Perceived Net Revenue as is seen in Figure 5.1. Without this initial difference there is no correcting of perceptions or expectations, which leads to perceptions, adaptive expectations, and extrapolative expectations all track the Actual Net Revenue perfectly throughout the 10-year contract. Under all decision rules considered in this model, this producer would enter into a CSP contract and remain a participant throughout the life of the ten-year contract.

In reality, however, a producer's perception and expectation of the net revenue received from implementing a riparian buffer could vary from year to year and cause termination behavior. Causes of this variance include changes in the net revenue from corn silage production due to variation in yields or prices. Additionally, the on-farm demand for corn silage could change for the representative farm due to changes in livestock numbers, shifts in nutritional requirements, or both. Any of these exogenous changes could affect the farmer's perceived or actual value for the riparian buffer practice, most notably through the shadow price of corn silage. Although this analysis does not include those possible effects, it is important to note that more dynamic behavior for actual, perceived, and expected revenue, and thus termination decisions, are possible from implementing the riparian buffer.

Agreement to place 400 acres in the cover crop enhancement under a CSP contract results in dramatically different behavior of the key revenue variables. Figure 5.2 shows the revenue variables combining both riparian buffers and the cover crop enhancement.

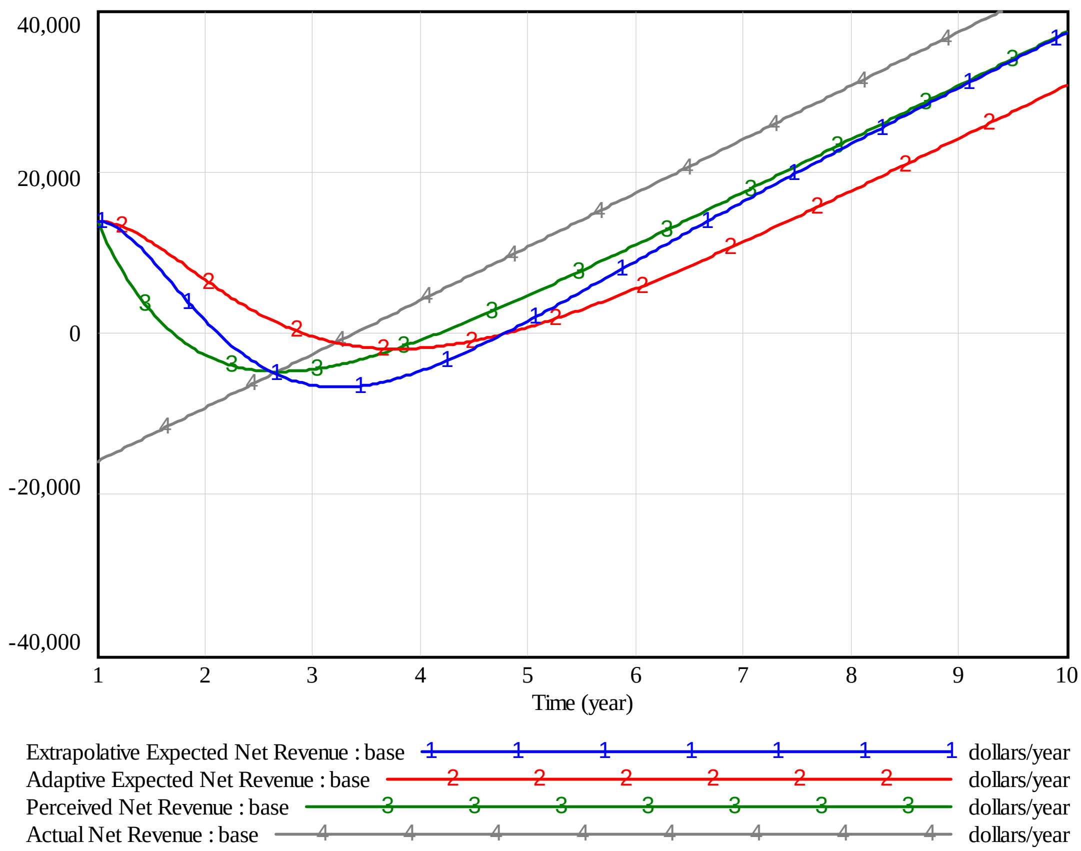


Figure 5.2 Base Simulation of Actual, Perceived, Adaptive Expected, and Extrapolative Expected Revenue For Cover Crop and Riparian Buffer

The figure shows Actual Net Revenue for the entire CSP contract (combined riparian buffer and cover crop enhancement) starting in year one at approximately negative $16,200. This negative return from participation in the CSP contract is due to the initial adverse effect of cover crops on yields. This yield impact is approximated at a 25 percent loss in year one, or 11.3 tons per acre compared to a normal yield of 15 tons per acre. This yield reduction results in a loss of approximately $30,000 worth of corn silage in year one. In contrast, the simulation model calculates the total payment from the CSP contract to be a positive $13,800, which is more than offset by the loss in corn silage production. Notably, $13,800 is also the starting value of Perceived Net Revenue because the base run assumes that the farmer's Biophysical Information

Uncertainty is 1, that is, the farmer initially perceives no yield affect from implementing cover crops. The base model shows Actual Net Revenue rising in a linear fashion due to the decreasing negative yield effect of crop crops. Actual Net Revenue crosses the break-even point at approximately 3.4 years after enrolling in CSP. The root cause of changes in the behavior of revenue expectations is changes in the yield effect from the cover crop enhancement.

Perceived Net Revenue, as well as Adaptive and Extrapolative Expected Net Revenue, begin to fall rapidly after the start of the simulation in the fashion of an exponential smoothing process, which is explained in Chapter Four. Perceived Net Revenue crosses the break-even point after approximately 1.7 years, however it comes from the opposite direction as Actual Net Revenue. The real world implication of this result is that in the early years of a CSP contract this farmer's perception of net revenue begins to decrease while the actual revenue is increasing. In short, the farmer's perception of revenue starts high and decreases while the actual revenue starts low and increases. This does not change until Perceived Net Revenue crosses the Actual Net Revenue between years 2 and 3.

Adaptive Expected Net Revenue consistently lags behind Perceived Net Revenue just as predicted and described in Chapter Four. Because there is constant growth in Perceived Net Revenue, the delay between Perceived and Adaptive Expected Revenue creates a steady state error. This gap is easily seen throughout the length of the simulation model. This steady state error, however, is corrected by the Extrapolative Expected Net Revenue, which identifies the magnitude of the gap and adjusts for the trend. Thus, it is easily seen that Extrapolative Expected Net Revenue decreases more quickly than Adaptive Expected Net Revenue, however it overshoots both Perceived and Adaptive Expected Net Revenue before correcting itself. This overshooting behavior is characteristic of Extrapolative Expected Revenue formulation and can be quantified be comparing the relative minimums of each revenue formulation. Adaptive Expected Net Revenue reaches a minimum of approximately negative $2,000 at 3.8 years, while Extrapolative Expected Net Revenue reaches a minimum of negative $6,700 at 3.2 years.

As seen in Figure 5.2, Extrapolative Expected Net Revenue does not correct for the steady state error that exists between Actual Net Revenue and Perceived Net Revenue. This gap represents the fixed amount of time that passes between the on-farm change in actual net revenue from participation in CSP and the perception of those changes. This delay could take many real world forms, including: management delays in collecting information, delays in processing the information for into useful forms, or deliberate postponement of planning until certain seasons of the year.

Parameter Sensitivity

Participation termination is a function of the key model parameters that act as inputs to the ten participation decision rules. Understanding the sensitivity of key model parameters is helpful determining causes of termination and developing policy recommendations that reduce terminations. At present, the values of these four parameters are unknown; therefore sensitivity testing is needed to better understand how different values can affect farmers' decision-making behavior.

The first of these parameters is the Biophysical Information Uncertainty parameter, which is used as an initial condition. This parameter indicates the degree to which producers initially perceive changes in corn yields. In the base run seen above, Biophysical Information Uncertainty takes a value of 1, implying 100% uncertainty about the biophysical effects. This implies that producers will ignore information about changes in revenue due to changes in yield when making their sign-up decision. Importantly however, producers begin to perceive information about the biophysical effects on yields after the simulation begins. The pattern of behavior is consistent with changing initial values. At the extreme values, zero and one, either no change in crop yields is perceived or all of the change in crop yields is perceived. Each series converges to the same numerical values, no matter the value of the initial error.

A significant characteristic when examining changes to Biophysical Information Uncertainty is the downward-sloping behavior of perceptions and expectations in scenarios that have higher initial error values. It is this initial error that gives rise to the important dynamics in the extrapolative expectation graph. This sensitivity analysis provides one insight into a producer's behavior. For example, if a producer uses any version of a myopic cost/benefit rule, where termination occurs whenever perceived or expected net revenue falls below zero, then uncertainty must be high enough at time zero, or the farmer will not sign up for the program. Practically, this means that a producer with a myopic benefit cost decision rule must have at least 50% Biophysical Information Uncertainty or signing up for CSP is seen as unprofitable and thus an unattractive option.

Sensitivity analysis is also relevant for the three constants used for adjustment times in the expectation formation sector. These include the Time to Perceive, Time to Form Expectations, and Time to Form Trend. Multi-parametric sensitivity analysis allows simultaneous varying of all three time constants. The constants are tested, using a range of 1 to 3, and assuming a random distribution with Biophysical Information Uncertainty held constant at 1. The variables of interest are Perceived Net Revenue, Adaptive Expected Net Revenue, and Extrapolative Expected Net Revenue. It is important to note the relationships between these parameters so as to better understand the dynamics at work. The Time to Perceive affects Perceived Net Revenue, however because Perceived Net Revenue is an input to both Expected Net Revenue and Extrapolative Net Revenue, Time to Perceive is important to their behavior as well.

However, Time to Form Expectations does not have the same relationship because it only affects Expectations and Extrapolative Expectations. Finally, Time to Form Trend does not affect either other variable except Extrapolative Expectations. It is in this way that the time constants build upon each other. Sensitivity analyses varied each of the time constants together at the same time in order to better understand their aggregate effect.

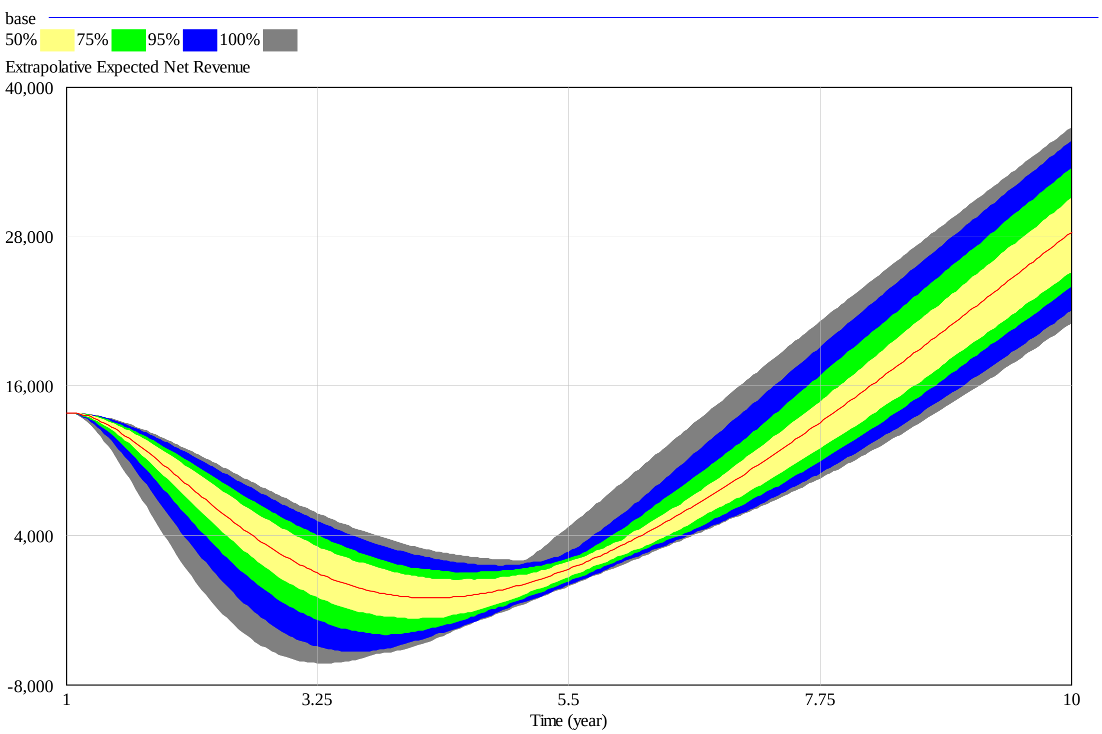


Figure 5.3 Sensitivity Analysis of Adjustment Times on Extrapolated Expected Net Revenue

Several outcomes are worth mentioning from the sensitivity analyses, of which Figure 5.3 is an example. First, for both perceived and expected revenue outputs, the basic pattern of behavior remains relatively constant. This behavior is characterized by sharply decreasing expectations until reaching a minimum and then increasing slowly to match the Actual Net Revenue.

In each of the sensitivity analyses, the upper and lower bounds of revenue expand at first and then contract significantly before expanding again. This "pinching" effect can be explained by the changing time of the inflection point, that is, the year when the minimum revenue is reached. When Time to Perceive, Time to Form Expectations, and Time to Form Trend are at relatively low adjustments times, e.g. 1, then the inflection point comes relatively soon in the lifespan of the simulation, that is 3.2 years for Extrapolative Expected Net Revenue. However, when those same parameters are relatively large, e.g. 3, then the inflection point comes later, that is, at 5.25 years. This is due to the adjustments happening more slowly and thus creating behavior that is more flat.

In numerical terms, the sensitivity analysis shows a moderately large range of values that each of these variables can take by using different time constants. In contrast however, the results of the model are not very behaviorally sensitive to changes in the time constants. Taken alone, this implies that there will be a distribution of termination dates, rather than one for all farmers. Without knowing the decision-making characteristics (time constants) or decision rules of individual farmers, this model is less useful for making point predictions of perceptions of profit or loss, or of specific expected dates of termination for individual farmers. However, by assuming ranges of decision-making characteristics for the entire population of farmers, this model can provide information about likely aggregate termination rates and distributions of termination times.

Viewed in this light, the model becomes a useful tool for illustrating potential termination decisions under various behavioral assumptions. Additionally, the model can predict the initial sign-up for CSP contracts that precede the termination decision. Because the goal of this research project is to demonstrate that termination could arise from conditions possible under CSP participation, not to make individual point prediction of termination times, the large range of numeric values for individual producers does not change the validity of the model, or the qualitative policy conclusions.

Termination Decisions

This decision-making model assumes that producers do not have perfect information, nor is it assumed that they use a traditional net present value calculation when making participation decisions. However, it is useful to compare the termination behavior resulting from alternative decision rules with the outcomes when a net present value decision-rule and perfect information are assumed.

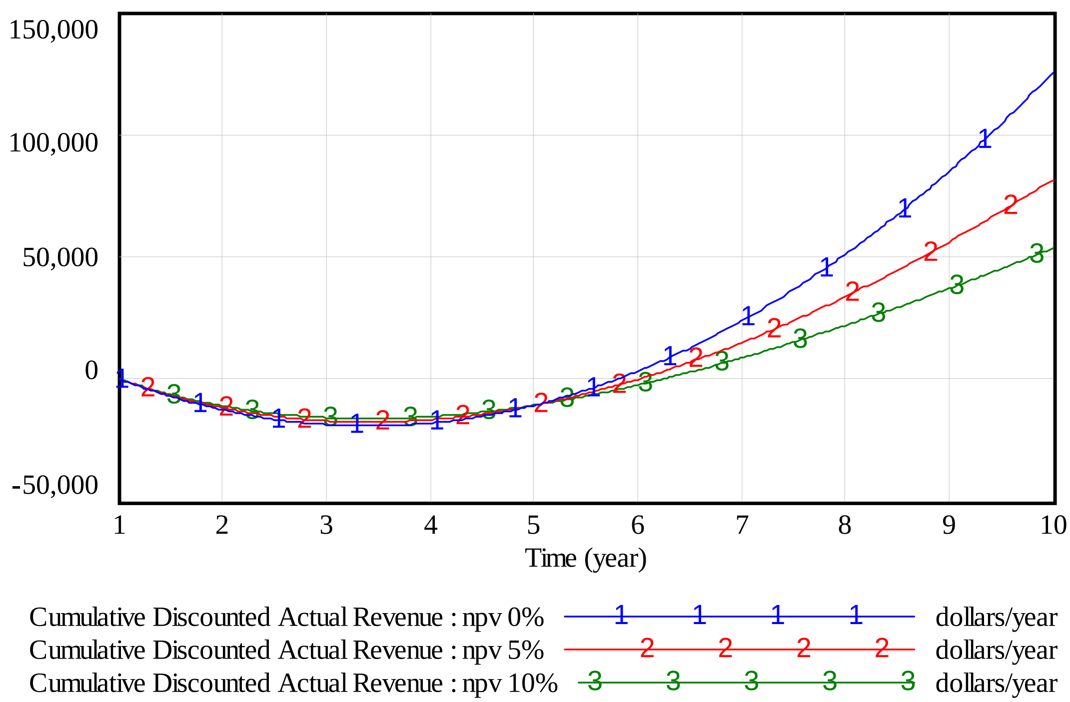


Figure 5.4 Varied Cumulative Discounted Net Revenues Under a CSP Contract

Assuming varying discount rates, a producer implementing the riparian buffer and cover crop enhancement will realize total revenue with a present value of $53,353 after ten years with a ten percent discount rate, $81,540 with a five percent discount rate, and $125,382 with no discounting. Under each of these scenarios, a producer would choose to participate in the CSP contract because of an expected positive return at the end of the ten-year contract and there would be no termination.

When perfect information and an NPV decision rule are not assumed, a set of alternative decision rules is necessary. This analysis assumes that producers are “myopic” decision makers, that is, they use decision-rules that are made with imperfect information. This is the information that is only available to decision makers at the time a decision is made. Furthermore, decision-makers will use a standard benefit cost calculation to determine participation and termination in a CSP contract. Threshold values are provided for several decision rules which can be interpreted as a tolerance for unmet expectations, or more practically, non-monetary reasons for CSP participation that are not represented in this simulation model. The most obvious example of this non-monetary reason would be a producer’s stewardship or conservation ethic. Table 5.1 displays simulated termination times, that is, the year in which a producer decides to terminate participation in CSP. This table utilizes the representative decision makers and examines nine separate decision rules (See Chapter Four for detailed descriptions of representative decision makers and decision rules.)

Table 5.1 Termination Times of Representative Decision-Makers (years)

Decision Rules	*Smart Sophisticated*	*Smart Naïve*	*Average Sophisticated*	*Average Naïve*	*Limited Sophisticated*	*Limited Naive*
Myopic Perceived B/C Rule	NP*	NP	1.38	1.78	1.72	2.88
Myopic Adaptive Expectations B/C Rule	NP	NP	2.88	4.38	NT	NT
Myopic Extrapolative Expectations B/C Rules						
• With $0 threshold	NP	NP	2.13	2.88	2.67	4.16
• With $1,000 threshold	NP	NP	2.25	3.19	2.78	NT
• With $5,000 threshold	2.13	3.06	3.09	NT	NT	NT
• With $10,000 threshold	NT	NT	NT	NT	NT	NT
Relative Position Decision Rules						
• With $1,000 threshold	1.09	1.16	1.06	1.09	1.06	1.09
• With $5,000 threshold	1.63	NT	1.31	1.72	1.22	1.44
• With $10,000 threshold	NT	NT	NT	NT	1.53	NT

Note: NP denotes that no participation occurs, NT denotes that no termination occurs

There are several key observations from the representative decision-makers and decision-rules analysis (Table 5.1). First, decision makers that perceive 50% of the effect of cover crops, that is, those representative farmers categorized as “smart”, have zero termination time for the first four decision rules. This implies that these decision makers do not sign-up for a CSP contract using any decision-rule that has a threshold of $1,000 or less. This is predicted because the starting value for perceived, adaptive expected, and extrapolative expected is a negative $1,048. Therefore, producers who have a low threshold, and who are making a benefit cost calculation will not sign-up under this scenario.

A second key observation is that decision-makers with a $10,000 threshold for unmet expectations using extrapolative expectations do not terminate contracts under any scenario. Under a $5,000 threshold, decision-makers terminate contracts under half of the representative decision-maker assumptions. Specifically, the lower the estimation error, the more likely the producer is to terminate the CSP contract. As seen under the $1,000 threshold, only the decision maker with the highest error and the slowest updating did not terminate the CSP contract.

A third key observation is that the relative position decision rule results in different termination behavior than the other rules. Under a relative position decision rule, a producer decides to terminate their CSP contract when the gap between expected revenue becomes much larger than what is being perceived at the same time. Therefore, a producer might still have positive net revenue, but if it is significantly less than what was expected, the producer will terminate participation. The threshold values determine what value of difference is actually significant. The relative position decision rule, although unorthodox in neoclassical economics, provides insight into the decision making model.

As seen in Table 5.1, under a $1,000 threshold, the producer terminates participation under all scenarios after close to one year. However, under the $5,000 threshold, the Smart Naïve representative decision-make does not terminate participation. It can therefore be understood that the Smart Naïve formulation creates the smallest gap between Perceived Net Revenue and Adaptive Expected Net Revenue. This is not surprising because the Smart Naïve representative decision-maker has the least changes in expectations. This producer starts with low estimation error and updates perceptions and expectations relatively slowly. Alternatively, it should also be true that the opposite should produce a large gap between perceptions and expectations. This premise is confirmed by the termination of the Limited

Sophisticated decision-maker under the $10,000 threshold for the relative position decision rule. In this case, all decision makers do not terminate participation, except for the decision maker with the highest estimation error and the fastest updating of perceptions and expectations, the mirror opposite of the Smart Naïve decision maker.

Aggregate Termination Rates

The analysis using representative decision makers provides a perspective on the effect of assumptions concerning individual decision-makers' unknown behavioral characteristics. An alternative analysis using aggregated decision-makers with randomly selected behavioral characteristics can provide a more robust foundation for determining policy implications and recommendations. In this analysis, 100 model simulations using farmers with randomly assigned behavioral characteristics were aggregated for each of the ten decision rules. (This aggregate analysis is analogous to agent-based models except for the lack of interaction among agents.) Other than behavioral characteristics, all other farm and CSP contract parameters were assumed to be the same for all farmers. The ranges in parameters for the behavioral characteristics ranges included: Biophysical Information Uncertainty, 50% to 100% error; Time to Perceive, 1 to 3 years; Time to Form Expectations, 1 to 3 years; and Time to Perceive Trend, 1 to 3 years. Figure 5.5 shows aggregate termination rates for selected decision rules.

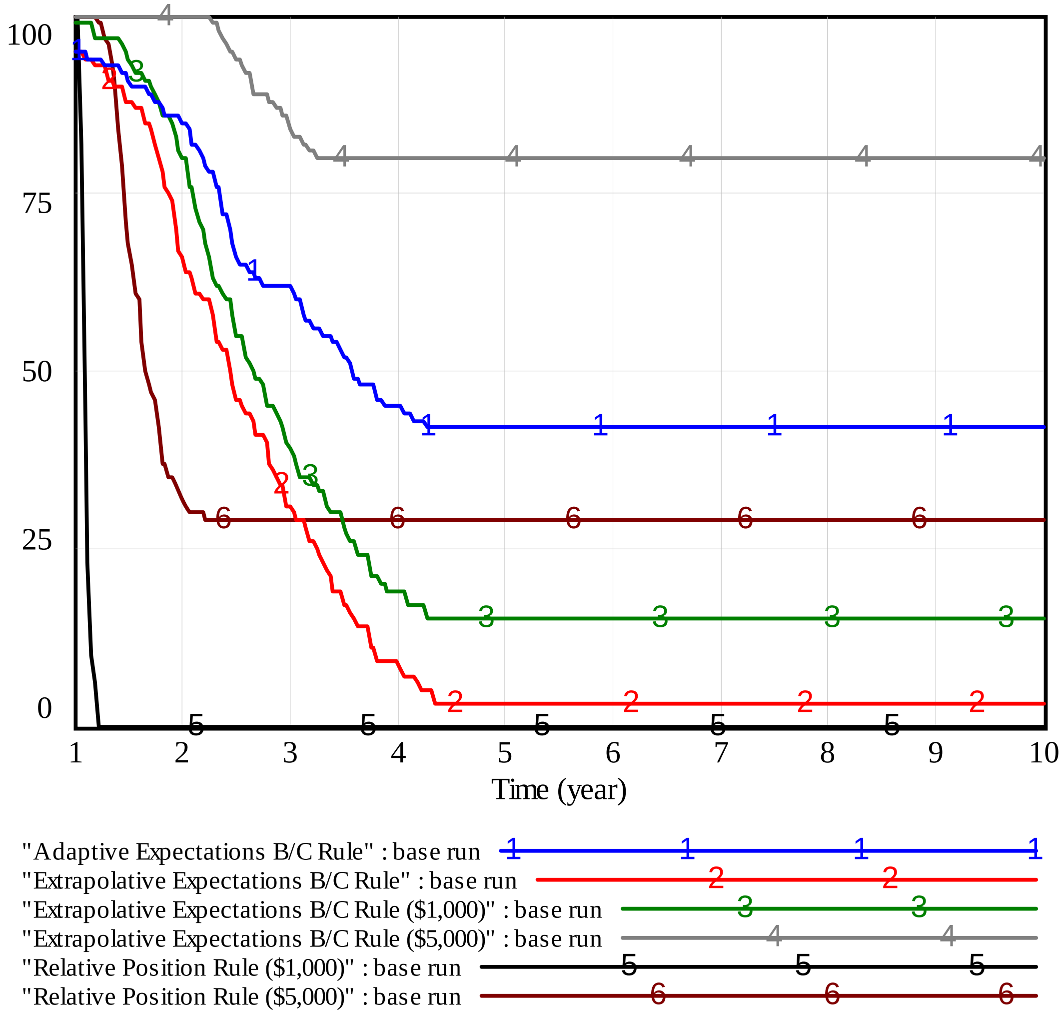


Figure 5.5 Cumulative Participation Rates for Aggregate Decision Makers Under Select Decision Rules

The starting position of each cumulative participation rate signifies the number, and, because the population of farmers is 100, also the percentage of farmers who initially sign-up for a CSP contract. For example, the Adaptive Expectation Benefit/Cost Rule begins with a participation rate of 95, that is, 5, or 5% of farmers do not expect that signing-up for a CSP contract is a profitable proposition. Each decision rule shows a cumulative decline of participation, or conversely an increase in terminations, until a point at which participation stabilizes and terminations cease. Thus, of those 95% of farmers who signed up for CSP under the Adaptive Expectations decision rule, 56% decided to terminate participation. Table 5.2 summarizes the percentage of farmers not participating at sign-up, the cumulative termination rate, and termination ending time for each of the myopic decision rules.

Table 5.2 Cumulative Termination Rates for Aggregate Decision Makers Under Alternative Decision Rules

Decision Rules	*Not Participating*	*Cumulative Termination Rate*	*Termination Ending Time*
Myopic Perceived B/C Rule	5%	100%	3.09
Myopic Adaptive Expectations B/C Rule	5%	56%	4.23
Myopic Extrapolative Expectations B/C Rules			
With $0 threshold	5%	97%	4.34
With $1,000 threshold	1%	87%	4.3
With $5,000 threshold	0%	20%	3.25
With $10,000 threshold	0%	0%	N/A
Relative Position Decision Rules			
With $1,000 threshold	0%	100%	1.19
With $5,000 threshold	0%	71%	2.22
With $10,000 threshold	0%	2%	1.97

The cumulative termination rates in the table show significantly different rates between decision rules, and between threshold levels within a decision rule category. The Perceived B/C rule, Extrapolative Expectations B/C ($0) rule, and Relative Position ($1,000) rule have the highest cumulative termination rates. This seems to suggest that a $0 to $1,000 threshold is not large enough to prevent terminations. An interesting exception is the Adaptive Expectations B/C rule, which uses an implicit threshold of $0. The threshold levels for each of these decision rules play a significant role in determining termination. A $10,000 threshold seems to be the upward bound for both Extrapolative Expectations B/C rule and for the Relative Position B/C rule as almost no farmers termination participation. Threshold values between $0 and $10,000 seem to be in sensitive to changes in policy and change significantly in later policy analyses.

Organic Matter Effect

A significant factor driving the behavior of the decision-making model is the organic matter effect of continuous cover cropping on corn silage yields. Unfortunately, the empirical evidence on these effects is exceedingly limited. The base model selected for this thesis uses a linearized version of a study conducted by Kuo and Jellum (See Chapter Four). Figure 5.6 illustrates the key variables of Actual Net Revenue, Adaptive Expected Net Revenue, and Extrapolative Expected Net Revenue under the actual, rather than linear yield relationship analyzed previously. This analysis is also illustrative of other impacts due to variations in crop and livestock production systems that are not explicitly modeled.

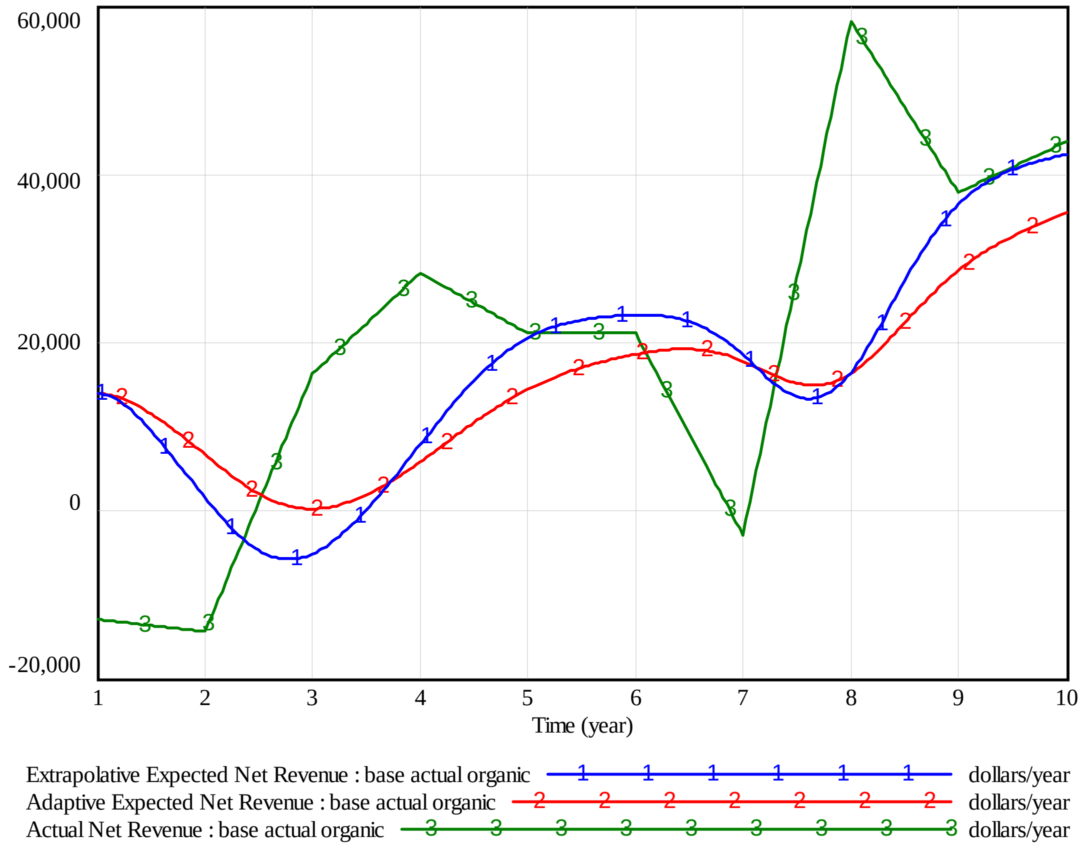


Figure 5.6 Actual, Adaptive Expected, and Extrapolative Expected Net Revenue Using the Actual Organic Matter Effect of Continuous Cover Crops

Using the actual organic matter effect introduces much more variability into Actual Net Revenue. In this case, Actual Net Revenue is below zero in the first, second, and seventh year. Both Adaptive and Extrapolative Expected Net Revenue lag changes in Actual Net Revenue with Extrapolative Net Revenue characteristically overshooting the maximum and minimum points.

By assuming varying discount rates and perfect information the actual organic matter effect can be compared to the net present value of the linearized effect. Under the actual organic effect a producer will realize $48,930 versus $53,353 total revenue under the linearized effect after ten years with a ten percent discount rate, $74,734 versus $81,540 with a five percent discount rate, and $114,551 versus $125,382 with no discounting. Under each of these scenarios, a producer would choose to participate in the CSP contract because of an expected positive return at the end of the ten-year contract. However, because of differences in the magnitude and timing of revenue received, the gains would be somewhat less under the actual organic effect than under the linear effect. Figure 5.7 shows the cumulative participation rates for the select decision rules comparing the actual organic matter effect and the linear organic matter effect.

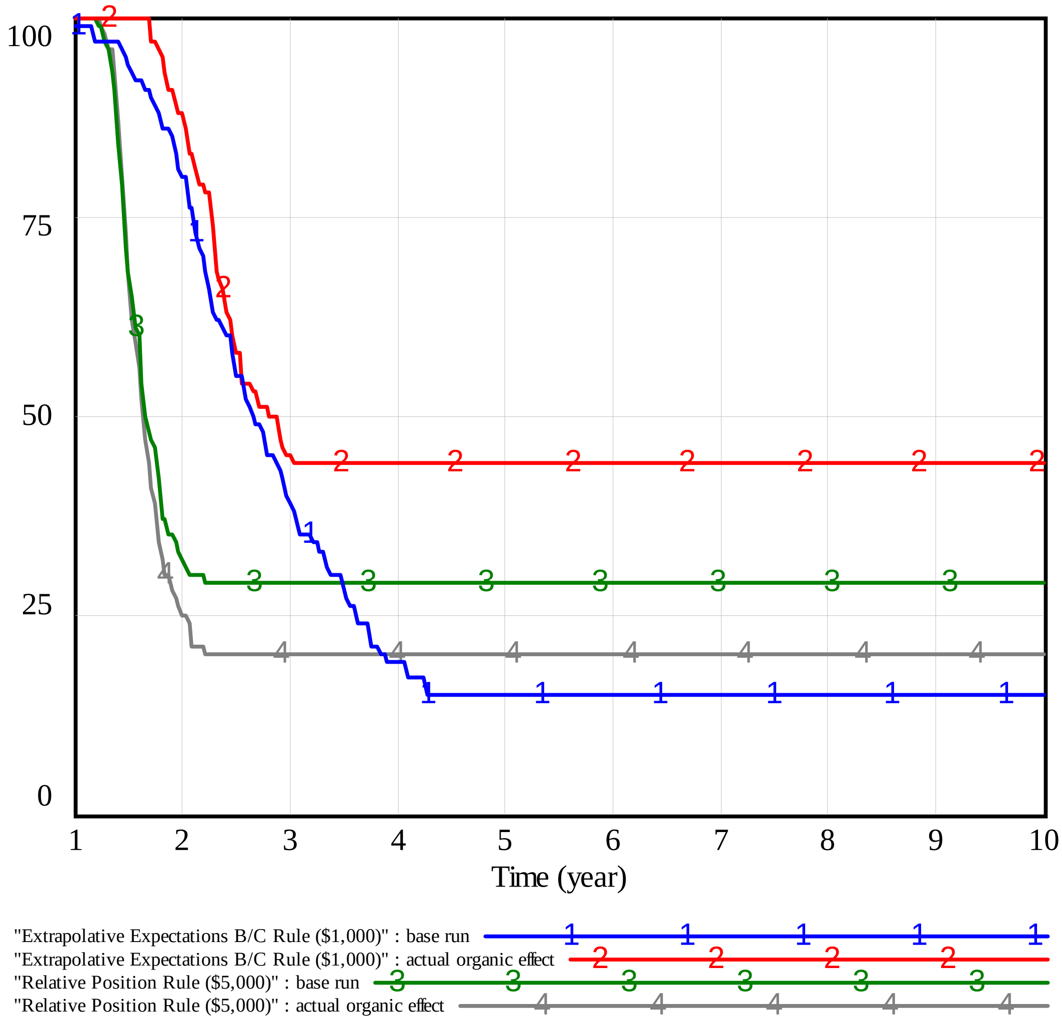


Figure 5.7 Cumulative Participating Rates for Aggregate Decision Makers For Extrapolative Expectation ($1,000) And Relative Position ($5,000) Decision Rules Under Actual And Linear Organic Effect

The cumulative participation rates shown in Figure 5.7 show differing effects of assuming an actual organic matter effect compared to a linear effect. As shown in the figure, cumulative participation under the Extrapolative Expectations ($1,000) decision rule is significantly higher under the actual organic matter effect, whereas the participation for the Relative Position ($5,000) is somewhat lower. Thus, the impact of the actual organic matter effect (or variations in the effect more generally) differs in direction and magnitude under different decision rules.

Table 5.3 shows the initial participation and cumulative termination rates for each of the decision rules and compares them to the linear organic matter effect assumed in the base simulation of the model. Notably, initial participation rates are higher under the actual organic effect because net revenue in year one is higher. Additionally, the actual organic matter effect significantly decreases terminations, or conversely increases participation, under the myopic perceived, adaptive, and extrapolative expected decision rules. The opposite effect however is seen under the relative position decision rules, which increase termination rates. Causes of this behavior can be tracked to increased variability between perceptions and expectations under the actual organic matter effect. It is clear from the comparison of cumulative termination rates between the linear and actual organic effect that the assumptions regarding changes in corn yield significantly drive participation behavior.

Table 5.3 Cumulative Termination Rates: Actual Versus Linear Organic Effect Using Alternative Decision Rules

Decision Rules	*Not Participating*	*Change from Linear*	*Cumulative Termination Rate*	*Change from Linear*
Myopic Perceived B/C Rule	0%	-5%	81%	-19%
Myopic Adaptive Expectations B/C Rule	0%	-5%	33%	-23%
Myopic Extrapolative Expectations B/C Rules				
• With $0 threshold	0%	-5%	65%	-32%
• With $1,000 threshold	0%	-1%	56%	-31%
• With $5,000 threshold	0%	0	9%	-11%
• With $10,000 threshold	0%	0	0%	0%
Relative Position Decision Rules				
• With $1,000 threshold	0%	0	100%	0%
• With $5,000 threshold	0%	0	80%	+9%
• With $10,000 threshold	0%	0	6%	+4%

Effect of CSP Contracts Design

The decision-making model makes four assumptions concerning the design and implementation of the CSP contract. These assumptions are that the producer participates at Tier III, enrolls 400 acres of cover crops annually, enrolls 30 acres of riparian buffer annually, and the enhancement payments are made on a flat rather than declining payment schedule. Of these assumptions, the tier level and the acres enrolled as a riparian buffer were tested and result in no changes in the dynamic behavior of the model. However, both assumptions affect the initial profitability of a CSP contract. Fewer acres in a riparian buffer and a shifting to a tier two contract would substantially decrease the actual net revenue received from the CSP contract. However, aside from a downward shift for perceived and expected revenue, there is no other effect.

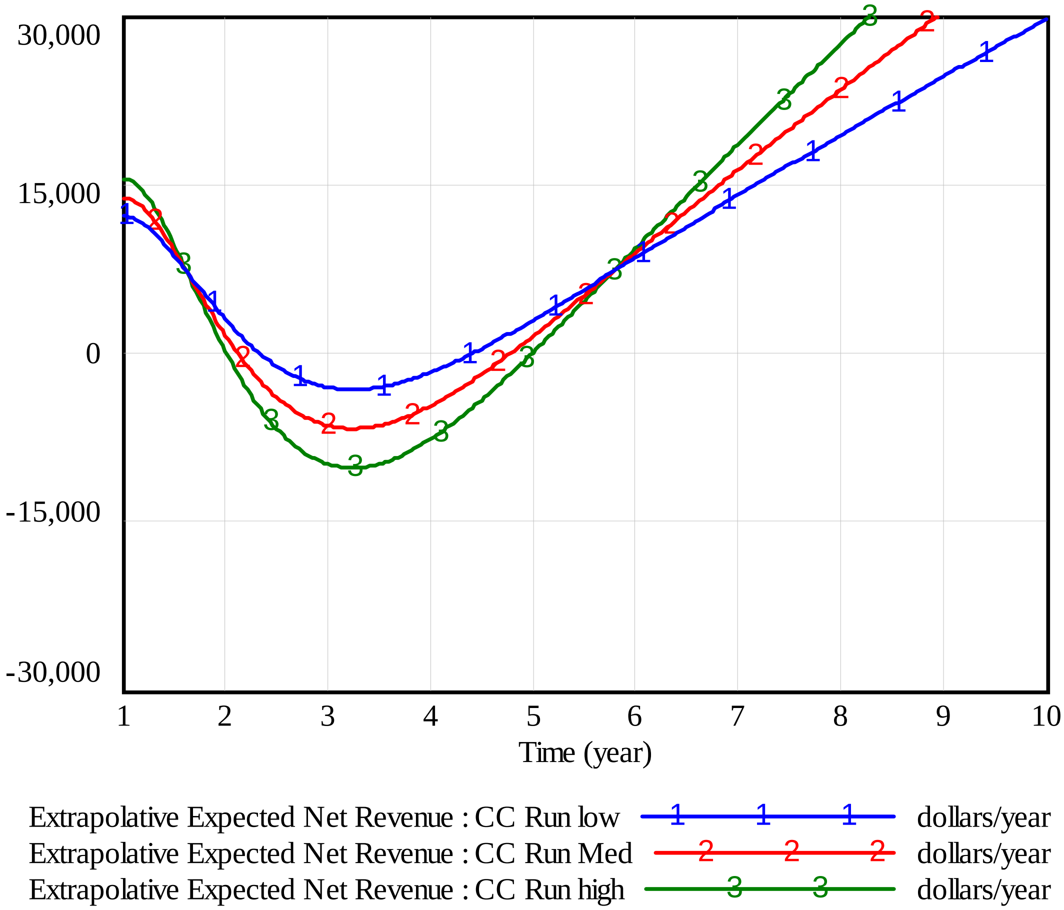


Figure 5.8 Changing Dynamics of Extrapolative Expected Net Revenue Due to Changes in Cover Crop Acreage

In contrast, the number of acres enrolled in cover crops does have a substantial effect on the dynamic behavior of the net revenue variables in the model. An increase in cover crop acreage significantly increases the fluctuation in expectations, that is, it deepens the trough and raises the peak. Although more cover crop acreage eventually leads to greater cumulative net revenue, in the short term, decreased corn silage yields create the conditions for higher termination rates under all myopic decision rules. Figure 5.8 illustrates the increased variability of Extrapolated Expected Net Revenue when cover crop acreage is increased and decreased by one hundred acres.

The assumption of a flat versus declining payment schedule also significantly affects the dynamics of the decision-making model. As stated in Chapter Two, the declining payment schedule for enhancement payments was implemented for the 2005 sign-up. It states that participants must take a variable payment rate for all enhancements. This rate begins at 150% of the enhancement payment in year one, then decreases each year to 90%, 70%, 50%, 30%, 10%, and 0% respectively, for the remainder of the contract (NRCS, FY2005 CSP Sign-Up Announcement, 2005). The rationale for this variable payment rate, cited by NRCS, is to provide capacity to add additional enhancements in the out-years and to encourage participants to make continuous improvements to their operation by adding additional enhancements throughout the life of the contract. An unsaid, but often acknowledged factor in the declining payment scheme was federal budget constraints (See Chapter Three).

A comparison of Extrapolative Expected Net Revenue under both scenarios is shown in Figure 5.12. Also displayed is the Actual Net Revenue under the declining payment scenario.

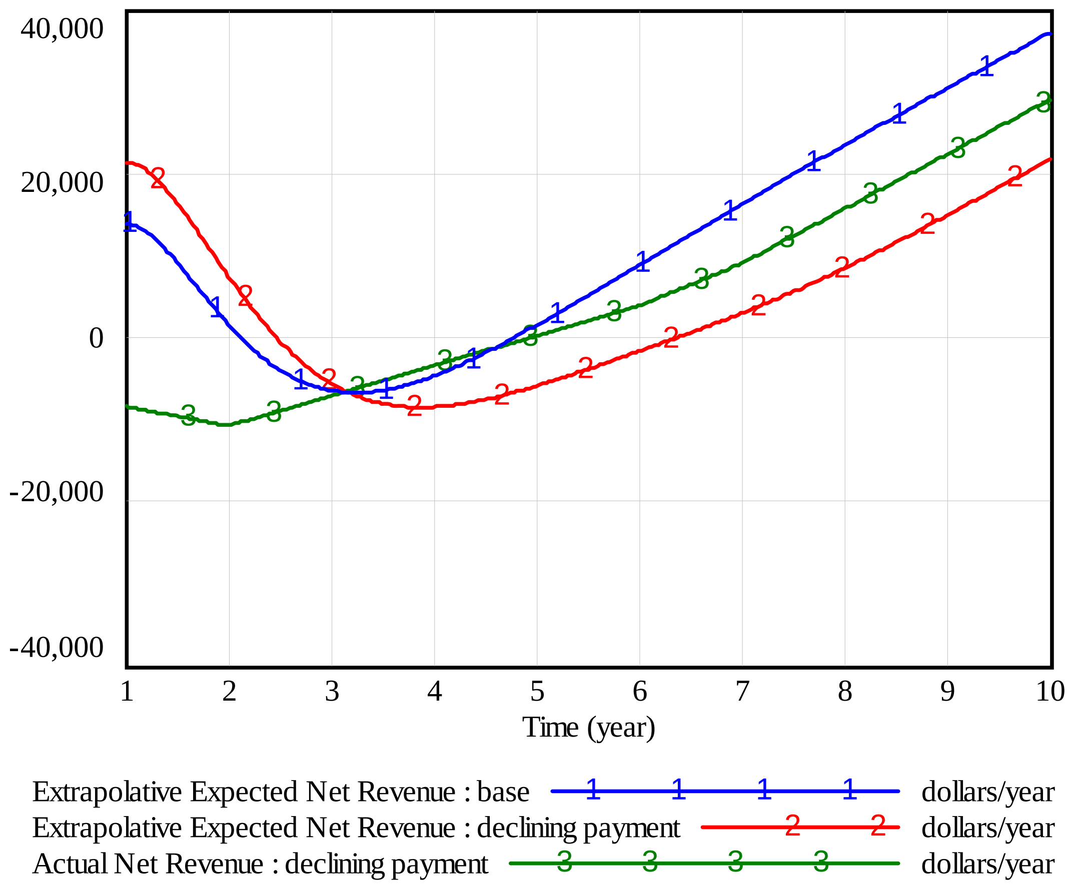


Figure 5.9 Extrapolative Expected Net Revenue Under Declining Versus Flat Payment Schedules

Extrapolative Expected Net Revenue under the declining payment schedule scenario starts at a higher level of revenue, however expectations decline even more rapidly because Actual Net Revenue declines in the second year rather than increasing. This second year decline is creates a situation where expectations fall even more quickly than under a flat payment schedule. In addition, cumulative revenue is lower under the declining payment schedule, which not surprising since one of its purposes was to reduce government expenditures. The effect of the declining payment schedule would be to increase the initial sign-up rate by enhancing the attractiveness of CSP contracts. However, perceptions and expectations of net revenue quickly fall under a declining payment rate scenario and drop below those in the flat payment schedule.

An alternative analysis using aggregated decision-makers can provide a more robust policy analysis for better understanding the effect of the declining payment rate on termination decisions. Using the same simulation approach of 100 aggregated farmers possessing randomly selected behavioral characteristics, Figure 5.10 and Table 5.4 indicate the percentage of farmers not signing-up for CSP and the cumulative termination rate over the entire 10-year contract. Additionally, this is contrasted with the same calculations made for farmers using a flat payment schedule for enhancement payments.

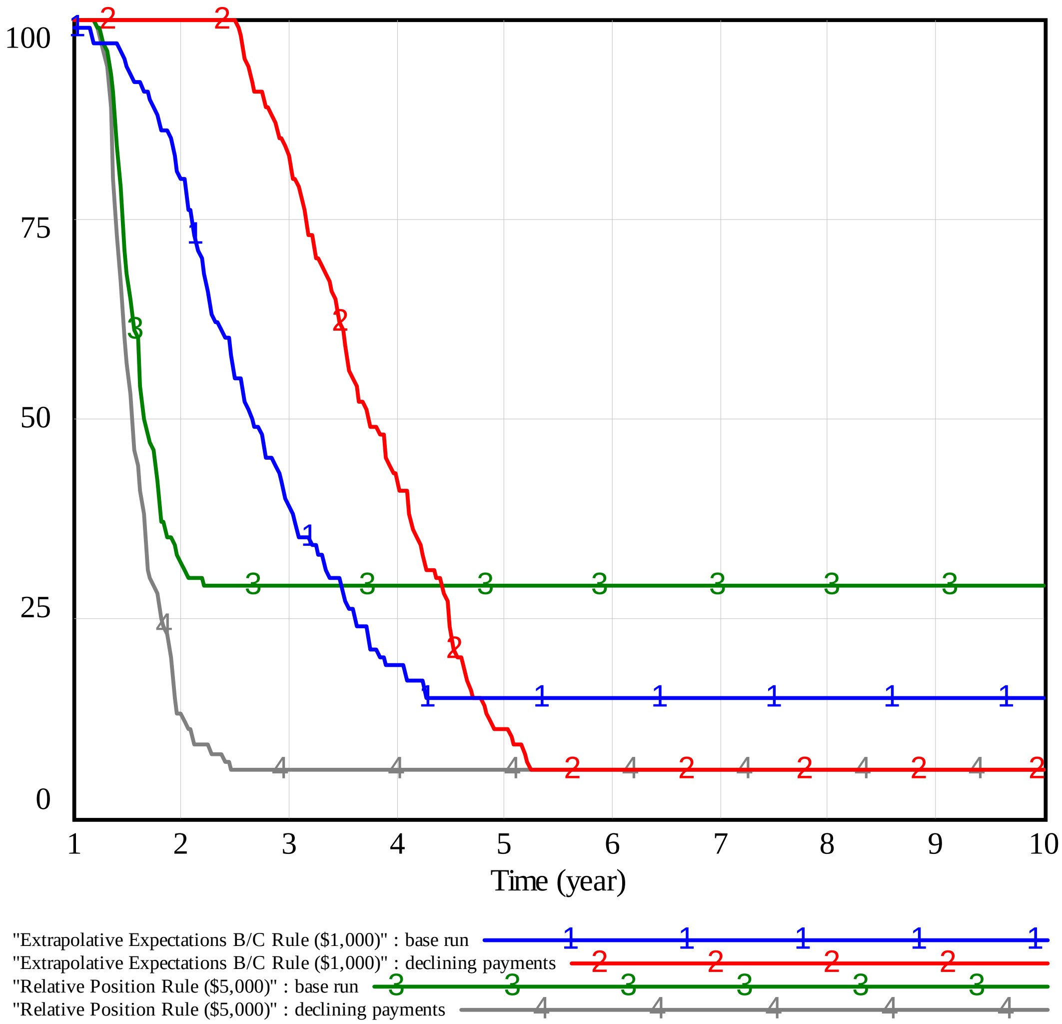


Figure 5.10 Cumulative Participation Rates For Aggregate Farmers For Select Decision Rules Under Declining Versus Flat Payment Rates

This aggregate participation analysis of the Extrapolative Expectations ($1,000) decision rule and the Relative Position ($5,000) decision rule show that the declining payment schedule produces significantly higher terminations under both scenarios. Table 5.4 shows the initial participation rates and cumulative termination rates for all decision rules and compares them to the flat payment schedule assumed in the base simulation run. Thus, the adjustments to the payment schedule made for the 2005 sign-ups are likely to increase contract termination rates over what they would have been if the flat payment schedule used in 2004 were to be continued.

Table 5.4 Cumulative Termination Rates: Declining Versus Flat Payments

Decision Rules	*Not Participating*	*Change from Flat*	*Cumulative Termination Rate*	*Change from Flat*
Myopic Perceived B/C Rule	0%	-5%	90%	-10%
Myopic Adaptive Expectations B/C Rule	0%	-5%	48%	-6%
Myopic Extrapolative Expectations B/C Rules				
• With $0 threshold	0%	-5%	100%	+3%
• With $1,000 threshold	0%	-1%	94%	+7%
• With $5,000 threshold	0%	0	28%	+8%
• With $10,000 threshold	0%	0	0%	0%
Relative Position Decision Rules				
• With $1,000 threshold	0%	0	100%	0%
• With $5,000 threshold	0%	0	76%	+5%
• With $10,000 threshold	0%	0	24%	+22%

Payment Rate Policy Analysis

A more instructive policy analysis of the termination decision needs to address alternatives for decreasing the rate at which producers terminate participation in CSP. Any policy "fix" should be robust over variations in behavioral characteristics and for multiple decision rules. For example, decreasing the Biophysical Information Uncertainty parameter, holding all other parameters constant, will decrease program termination under relative positions decision rules, however producers using the myopic cost benefit rules would continue to terminate and, fewer producers would sign-up. In addition, producers would increasingly not sign up for the program in the first place under myopic decision rules. Thus, alternative formulations for policy "fixes" must be explored.

An administratively realistic approach would be to address the issue of payment levels. For example, a straightforward, but costly, policy of increasing the payment rate for cover crops from $30 per acre to $50 per acre would satisfy all of the myopic cost benefit analysis decision rules by substantially raising net revenue. In this case, the payment rates are increased so that even with the rapid downturn of expectations, a farmer would still not expect to take a loss or reach negative revenue in any given year. This policy fix however, still allows farmers who use a relative position decision rule to drop out at the same time as with a lower payment rate for cover crops. Thus, simply increasing payments rates may be an ineffective and costly mechanism for lowering termination rates, despite its intuitive appeal.

A more robust policy solution would be to vary payment rates to compensate for the model-predicted downturn in farmer perceptions and expectations. Under this policy change, dynamic enhancement payment policy would provide a changing amount of money to farmers based on predicted average changes in crop yields based on the organic matter effect of cover crop practices. This, of course, is greatly limited by the difficulty of "knowing" the heterogeneous nature of the organic effect on additional corn silage yields. This information would be very difficult to customize to each individual producer. However, such fine-tuning of payment rates might be possible on a watershed basis depending on the quality of soil information and the predictive value of corn yield models.

In the case of cover crops, the payments would start at a higher level in the first two years to ensure that farmers are signing up for the program based on a correct cost benefit analysis of the program. Systemic evaluation of a number of dynamic payment schedules indicated that there are a variety of possible schedules that can increase initial participation rates and decrease termination rates. (A cost-minimizing payment schedule that also minimizes terminations could be derived, but was not undertaken for this analysis.) One such payment schedule would start enhancement payments high in the first year at $18,000 rather than $12,000, and then balloon payments to $27,000 rather than $18,000 in the second year in order to compensate for the loss in yields. Payment rates would then slowly decrease to $0 in year six and beyond as yields return to normal and subsequently higher than normal levels. Thus, one reasonable dynamic payment rate scenario for the cover crop enhancement would look like the following schedule from year one through year ten: 150%, 225%, 150%, 100%, 50%, 0%, 0%, 0%, 0%, 0%.

Figure 5.11 shows the Actual Net Revenue and Extrapolative Expected Net Revenue for both the base simulation run and for a simulation assuming the dynamic payment described above. As illustrated, the significant increase of cover crop enhancement payments in year two keep expectations high until the positive yield effect becomes a significant positive influence on Actual Net Revenue. Also noteworthy is the cost savings achieved by the government illustrated by the difference between the base simulation and dynamic payment Actual Net Revenue in years six through ten. This dynamic payment schedule for the cover crop enhancement changes government spending from $120,000 to $81,000, in effect saving $39,000 over the life of the CSP contract.

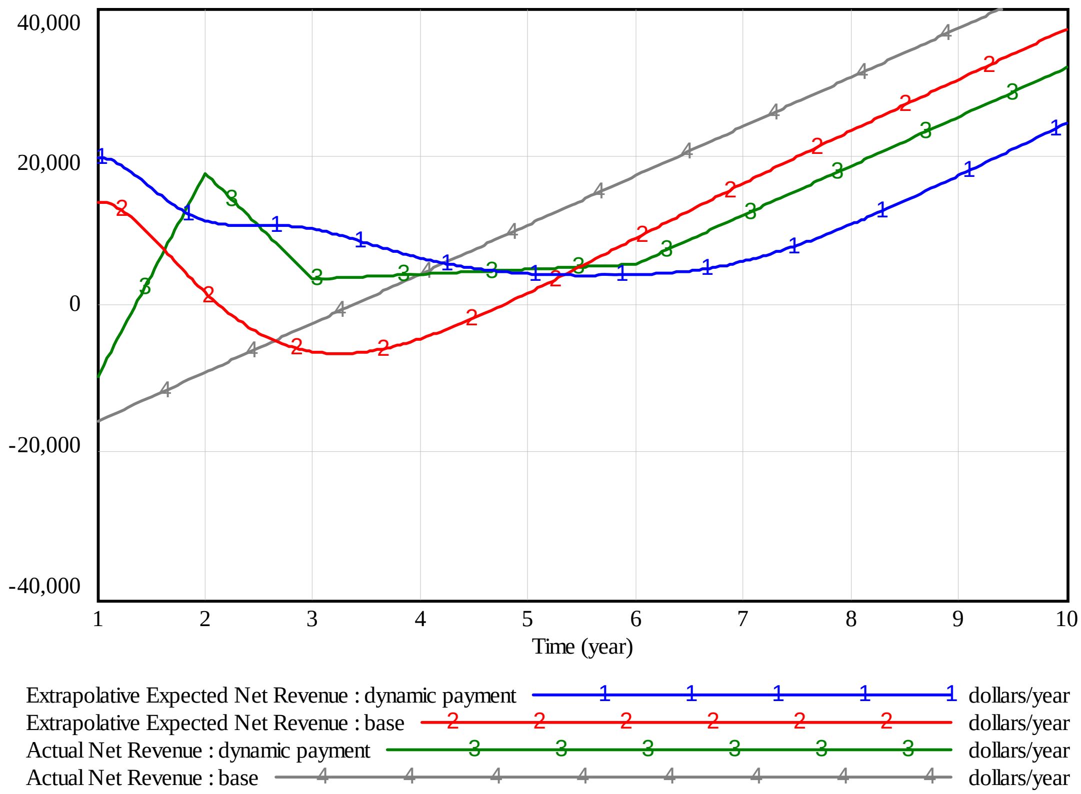


Figure 5.11 Actual and Extrapolative Expected Net Revenue Under Dynamic Enhancement Payments

The dynamic enhancement payments increase participation through higher initial sign-ups and fewer terminations. The 50% increase in payments in year one provides a greater incentive for farmers to sign up in the first place for CSP. The significant increase in year two maintains perceived and expected revenue at a high level which prevents myopic benefit cost decision makers from dropping out, as well as increasing the likelihood that relative decision makers stay above their threshold value. Figure 5.12 shows the effect of the dynamic payment rate on an aggregate population of farmers under select decision rules.

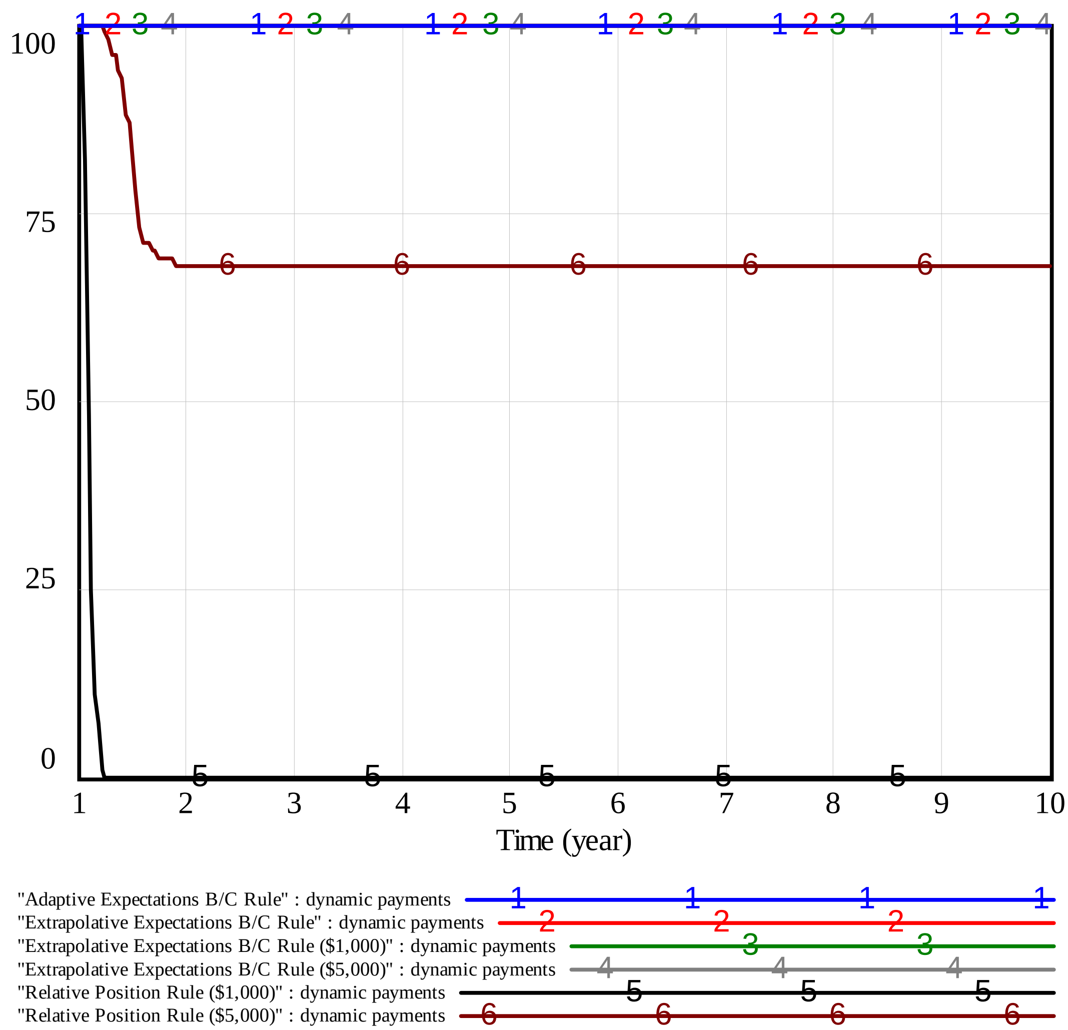


Figure 5.12 Cumulative Participation Rates for Aggregate Farmers Under Select Decision Rules Under Dynamic Enhancement Payments

As seen in Figure 5.12 the Myopic Perceived, Adaptive, and Extrapolative Expected Revenue all have a termination rate of zero under the dynamic enhancement payment schedule. The relative position decision rules continue to show termination decisions, but fewer than under the flat payment rate scenario as is shown in Table 5.5, except when the threshold is $1,000 which continues to terminate at a rate of 100%.

Table 5.5 Effect Of Dynamic Payments On Cumulative Termination Rates

Decision Rules	*Not Participating*	*Change from Flat*	*Cumulative Termination Rate*	*Change from Flat*
Myopic Perceived B/C Rule	0%	-5%	0%	-100%
Myopic Adaptive Expectations B/C Rule	0%	-5%	0%	-56%
Myopic Extrapolative Expectations B/C Rules				
• With $0 threshold	0%	-5%	0%	-97%
• With $1,000 threshold	0%	-1%	0%	-87%
• With $5,000 threshold	0%	0	0%	-20%
• With $10,000 threshold	0%	0	0%	0%
Relative Position Decision Rules				
• With $1,000 threshold	0%	0	100%	0%
• With $5,000 threshold	0%	0	19%	-52%
• With $10,000 threshold	0%	0	0%	-2%

This policy remedies the situation faced by myopic decision makers but does not completely solve the problem of terminations by relative position decision-makers with relatively low thresholds. Thus, it is also necessary to find ways to reduce the Biophysical Information Uncertainty for farmers who make decisions based on their perceived versus actual relative financial positions. In this specific case, education concerning the dynamic nutrient effects of cover crops would decrease the farmer's initial estimation error. Because this variable is actually a proxy for informed and knowledgeable farmers, this could require educational programs through various governmental or quasi-governmental agencies.

Conclusion

Chapter Five provides graphical and numerical results of several simulations of this CSP decision-making model. In this simulation model of a representative northeastern dairy farm, the riparian buffer enhancement alone does not create the conditions that would allow for termination. This result is due to the lack of unexpected changes in net revenue coming from implementation of a riparian buffer. In contrast, the cover crop enhancement has a biophysical effect on the corn yields over the life of the CSP contract. If this effect is unexpected, which implies that the farmer has an initial estimation error, then termination of the CSP contract becomes possible. Furthermore, using representative decision makers, Chapter Five explores the behavioral characteristics of decision making that make this termination decision more or less likely.

Additionally, 100 aggregated decision-makers with randomly selected behavioral characteristics are used to provide a more robust analysis of policy and model assumptions. Although the total number of possible combinations of behavioral characteristics and policy scenarios is prohibitively high to simulate each, this analysis captures the general effects of each assumption and policy change. In particular, the threshold levels for each decision rule are a significant determinant of termination time and for cumulative termination rates. Additionally, the use of actual versus linear organic matter effect on corn yields due to continuous cover cropping had a significant effect on termination rates, although the direction of this effect differs depending on which decision rule is used.

A key policy implication is that the declining payment schedule for enhancement practices results in a higher sign-up rate but also a higher termination rate for many of the decision rules. A prescriptive policy change, which modifies the payment schedule, offsets declining perceptions and expectations of net revenue in situations where there is significant initial estimation error. This dynamic enhancement payment schedule increases participation at sign-up, eliminates termination for all but the relative position decision rules (although it reduces their rates of termination), and provides the opportunity to reduce government expenditures on the program.

CHAPTER SIX

CONCLUSIONS

Overview and Summary

The Conservation Security Program was authorized by Congress in the 2002 Farm Bill and is hailed by many observers as the first true "green payments" program for working lands in the United States. Federal conservation programs are voluntary and often involve a multiyear commitment to install and operate conservation practices. These commitments typically contain few restrictions on terminating participation. Anecdotal evidence and previous analysis of similar agri-environmental programs for working lands shows that premature termination of contracts is a persistent issue. This type of producer behavior is not easily explained using the standard assumptions of neoclassical economics, that is, profit-maximization under perfect information and perfect rationality. Rather, this unexpected termination behavior demonstrates the need for analyses that take into account biophysical complexities and alternative decision-making assumptions. An alternative set of behavioral assumptions is explored in this research that employ descriptive rather than normative participation decision rules.

Significant research efforts are focused on modeling the integrated biophysical and economic aspects of conservation programs (See Chapter Three). However, review of the accumulated research shows that there is far less focus on the complex processes of participation decisions in these programs. This research addresses that concern with the objective of exploring the impact of alternative behavioral assumptions and dynamic biophysical effects of conservation practices on the participation and termination decisions of New York dairy producers. A simulation model was constructed to represent the effects of selected biophysical processes on farm profitability, producers' ability to gather and utilize this information, and finally their decisions to participate in the program. The results of this model provide insights concerning unexpected participation behavior and suggestions for policy design and implementation.

Key Results

The results of the dynamic participation decision model indicate that premature termination of CSP contracts is possible and even probable under certain conditions. These conditions include the complex biophysical effects of conservation practices, behavioral characteristics of decision makers, and payment schedules of the Conservation Security Program. These are all significant factors affecting if and when farmers decide to terminate a CSP contract.

Termination decisions, in this model, are posited to be a result of learning processes, that is, the farmer's realization of new information concerning the profitability, or net revenue from participating in the Conservation Security Program. Further, this learning only occurs under specific circumstances, namely when conservation practices have complex biophysical impacts on crop yields. This study, centered on a single representative dairy farm in western New York, assumes, based on selected empirical evidence (Kuo and Jellum, 2000), that one of the prescribed conservation practices, continuous cover cropping, can have a deleterious effect on corn yields during the first few years of implementation. Specifically, cereal rye, when used as a cover crop, will absorb nutrients early in the first few years, which decreases yields. However, this effect is counterbalanced in later years by increasing organic matter, which increases corn yields. Nonetheless, if unexpected, this biophysical effect could substantially change a farmer's realized net revenue after deciding to participate in a CSP contract. It is this biophysical effect that is the impetus for learning processes.

A useful illustration of this learning phenomenon is seen in a comparison of both enhancement practices—riparian buffers and cover crops—as simulated in this model. As discussed in Chapter Four, two additional enhancement practices, the wildlife habitat and conservation crop rotation, are not explicitly simulated in this model. It is shown that a producer entering into a CSP contract with only a riparian buffer enhancement will not experience a change in yields, and hence net revenue, due biophysical effects. In contrast however, the cover crop enhancement has a biophysical effect on corn yields over the life of the CSP contract. If the decision maker is unaware of this yield effect, that is, there is an initial estimation error, then it is possible that the farmer begins participation in a CSP contract expecting a higher level of net revenue than will actually occur. A farmer's perceptions and expectations of net revenue begin to fall immediately after sign-up. The subsequent "learning" process in which the farmer perceives and comes to expect a lower level of net revenue might trigger a termination decision depending on the decision rule that is used by the farmer. Furthermore, a farmer's expectations of net revenue, if the farmer uses an extrapolative expectation formation process, are likely to overshoot the actual net revenue. This phenomenon of overshooting can exacerbate the conditions under which termination decisions are made.

The behavioral characteristics of the decision maker play a significant role in shaping the producer's learning process and the formation of expectations of net revenue from the CSP contract. Most important is the magnitude of the farmer's initial estimation error. A greater initial error estimating the biophysical effects of conservation practices on corn yields indicates a larger the gap between actual net revenue and expected net revenue. This results in greater learning over a shorter amount of time. If the farmer uses a relative position decision rule that compares the current perceived revenue with the current expected revenue, then a larger initial estimation error could increase termination decisions.

Three additional significant decision making characteristics modeled in this study assume that farmers have delays in updating their perceptions and expectations of net revenue, and thus determine a farmer's adjustment times for perceiving new information and the incorporation of that learning into new expectations about net revenue. These adjustment times for perceiving, forming expectations, and forming trends also have a significant effect on the timing of a termination decision. The expectation formation process can further encourage farmers to terminate their CSP contracts by creating greater amounts of volatility in expectations. In addition, these adjustment times can create a greater or lesser magnitude of overshooting when extrapolative expectations are of concern.

The type of decision rule used by the farmer is also of significance when determining if or when a farmer might terminate participation in CSP. This analysis examined ten alternative decision rules. The first decision rule was a benefit-cost rule using a net present value calculation that assumes perfect rationality and perfect information. Under this decision rule, 100% of farmers entered into a CSP contract and continued to participate without termination. The analysis also tested decision rules that only incorporated a farmer's perceived net revenue or adaptive expected net revenue. Both of these decision rules assumed that farmers made myopic benefit cost decisions, that is, the farmers made decisions based on information that was only available to them at the time of the decision. If net revenue was above $0, then the farmer continued participation, if below, then the farmer terminated participation. In all cases, cumulative termination rates for farmers using an adaptive expectations decision rule were lower than for farmers using a perceptions decision rule. This effect was a result of most farmers' adaptive expectations of revenue being less volatile than their perceptions of revenue.

The extrapolative expectations decision rule is an intuitively more realistic formulation of a decision rule for farmers. This decision rule, like the two mentioned above, used a myopic benefit-cost rule. However, the extrapolative expectations decision rule was tested at several thresholds, that is, $0, $1,000, $5,000, and $10,000. These thresholds provided leeway or tolerance for extrapolative expectations to drop below zero, and represent a farmer's non-monetary reasons for participating in CSP, such as a conservation or stewardship ethic. These threshold values were significant in determining when and if farmers would terminate participation, generating 97%, 87%, 20%, and 0% cumulative participation rates respectively.

Relative position decision rules assume that farmers make participation decisions based on the difference between what net revenue is currently perceived and the net revenue that is expected. Farmers using these decision rules are particularly sensitive to fluctuations in changing net revenue. Thus, increased volatility in actual net revenue, either from using the actual observed organic matter effect of continuous cover cropping, or by introducing price and yield variation, creates higher levels of termination for these farmers. Threshold values for relative position decision rules are also of significance. The relative position threshold values were $1,000, $5,000, and $10,000, and had cumulative termination rates of 100%, 71%, and 2%, respectively.

Thus, a farmer's participation decision rule, particularly the threshold value for that decision rule, are highly significant for determining when and if the farmer will terminate participation in the CSP contract. Although this simulation model demonstrates termination behavior under several different circumstances and under several decision rules, the exact nature and timing of these terminations are difficult to predict given high variability concerning actual biophysical processes, and uncertainty surrounding the actual behavioral characteristics of farmers eligible for CSP participation.

Policy Implications

This analysis has several implications for pragmatic policy solutions to the problem of premature termination of CSP contracts. Policy makers who design incentive structures, that is, payment schedules and rates, for conservation programs, should look beyond typical cost/benefit models of decision-making. Assuming rational economic behavior, perfect information, and the use of a net present value calculation as a decision rule, is likely to lead to inefficient policy design. Taking into account alternative decision-making behavior, this research recommends an alternative payment schedule to what was implemented in the 2005 CSP sign-up. In addition, decreasing the initial estimation error of agricultural producers that is represented by the biophysical information uncertainty parameter in the simulation model can reduce termination rates for some types of decision makers.

From a policy design perspective, schedules of payment rates can be an important leverage to either increase or decrease termination rates of program participants. An important example is the significantly different termination rates resulting from the current use of declining payment schedule for enhancements in CSP and the proposed dynamic payment rate (see Chapter Five).

The declining enhancement payment schedule increases initial sign-up rates but significantly decreases final participation rates. All decision rules, except for those incorporating adaptive expectations and perceptions, show increased contract termination rates compared to a flat payment schedule. However, if the policy objective of implementing the declining payment schedule is simply to decrease government expenditures, then it has been successful, because the declining payment schedule decreases cumulative farm-level revenue over the ten-year contract.

A more intriguing policy option, however, is one that decreases government expenditure and decreases cumulative termination rates at the same time. Correspondingly, a more robust policy would be to vary the payment rates to compensate for the expected downturn in farmer perceptions and expectations. Given the specific biophysical effects of cover crops, dynamic payments would start at a higher level in early years to ensure that farmers are signing up for the program based on a correct cost benefit analysis of the program. Payments would begin to decline in later years as the increased revenue from corn yields increase total revenue. These dynamic payment rate schedules must be designed to compensate for dramatic changes in farmers' perceived and expected revenue for specific enhancement practices.

Evaluation of several dynamic payment schedules indicated that there are a variety of possible schedules that can increase initial sign-up rates, decrease termination rates, and decrease government expenditures simultaneously. The simulated dynamic payment schedule, described in Chapter Five, maintains participation rates at 100% for all but the relative position decision rules with $1,000 and $5,000 thresholds. Additionally, the dynamic payment rates increase the initial sign-up to 100% for all decision rules. Finally, the dynamic payment rate significantly decreases government spending by 33% over the ten-year contract. This policy "fix" is robust over variations in behavioral characteristics and for multiple decision rules.

However, a significant limitation of the dynamic payment schedule is the high level of information needed to construct such as payment. For example, policy designers must be able to identify the unique yield effects of each conservation practice on each producer's agricultural operation. In this way, payment rates can be designed to compensate for the change in revenue. This information requirement is high and but could be developed by implementing more sophisticated bio-economic soil and crop models.

Additional bio-economic soil and crop models, coupled with aggressive educational campaigns, can also be a useful mechanism for reducing the initial estimation error of producers regarding the biophysical effects of conservation practices. Improving the breadth and depth of education and technical assistance will also have the effect of shifting farmers' decision rules from myopic expectations to ones more closely aligned with net present value calculations. Both of these dimensions are good reasons to improve and increase the educational components of conservation programs.

Limitations and Future Research

Although this research is an initial exploration of hypotheses regarding termination decisions, there are numerous opportunities for future researchers to assess its underlying assumptions and extend its breadth and depth. It is important to distinguish, however, between limitations that prevent this research from producing realistic point predictions of termination rates and times and limitations that reduce the validity of the policy implications. Important limitations of this research are described below. These include: the lack of a reference data set for CSP contract terminations, limited representation of the biophysical effects of cover crops, inadequate differentiation between continuous and discrete timing of financial and biophysical events, uncertain behavioral characteristics of decision makers, and finally the narrow scope of the representative farm type and conservation practices modeled. Each of these shortcomings are elaborated on below.

First, this research did not have access to a reference data set for available for comparison and verification of results. Ideally, termination rates for current CSP contracts would be available to compare aggregate rates. Termination rates for specific practices or enhancements such as the cover crop enhancement would have allowed a direct comparison and of this model to actual data. Assuming that this model uses a correct formulation of the biophysical organic matter effect for cover crops, comparison of termination data would allow better specification of behavioral decision making characteristics and decision rules for participating producers. Thus, the model could provide a more general test of the underlying assumptions about the decision rules.

The collection, analysis, and dissemination of conservation contract terminations could be a significant contribution to further research into termination decisions. By combining aggregate contract termination data with additional farm-level economic and biophysical characteristics, results of this research could be evaluated. More importantly, the uncertain behavioral characteristics of decision makers, which are assessed with sensitivity analysis in this research, could be specifically calibrated with empirical data.

Second, the biophysical effect of continuous cover cropping plays a critical role in the termination decision, regardless of behavioral assumptions or decision rules. This model uses a study of cereal rye on corn production in the Northwestern United States, which has a very different agronomic environment compared to that faced by New York farmers. It is conceivable that yield response could differ enough between the two regions to dramatically influence the results reported here. Additionally, this model assumes that farmers are not aware of the organic matter effect of cover cropping and thus do not proactively counter the nutrient depletion effect of cover crops with added fertilizer in the first few years. Studies of actual usage and practices regarding cover crops in the New York would significantly strengthen the credibility of the cover crop organic matter effect and its consequences for perceived and expected revenue, and ultimately for termination decisions. Given the critical role of the organic matter effect upon termination rates, this effect needs to be modeled more appropriately for the New York dairy farm environment.

There is tremendous opportunity for the application of simulation models to the bio-economic effects of conservation practices. Integrated models, developed from a pragmatic policy design perspective, can be used educate practitioners and policy makers and ultimately be used to better design agri-environmental programs. There are several examples of integrated bio-economic modeling referenced in Chapter Three. These studies need to be expanded to a greater set of conservation practices and replicated for multiple regions of the country. The systematic development of integrated bio-economic models on a watershed basis could be successfully coordinated with current policy design efforts ongoing at the Natural Resources Conservation Service.

Third, this model does not adequately distinguish between continuous and discrete timing of financial and biophysical events. Due to the mathematical formulation of this simulation model, in particular the use of differential equations to model perceptions and expectations of revenue, all inputs and calculations are based on continuous rather than discrete time periods. For example, CSP enhancement payments are modeled as being paid out to the farmer continuously over annual periods. In reality, however, a farmer would receive the enhancement payment once annually. This is true for all CSP payments, revenue received from crops, and costs of implementing the CSP contract. This modeling assumption has the most impact on events that increase or decline over time, for example the change in yields due to biophysical effect of cover crops and the declining enhancement payments. In these situations, the decline is modeled as a continuous linear function rather than a stepwise function at yearly intervals. In reality, all payments, revenue, and costs, would actually come at discrete and likely separate times, thus creating more complex variations in actual, perceived, and expected net revenue. Although these increased variations would not change the general tendencies and behaviors described in Chapter Five, it is possible that the timing and rate of terminations could be significantly affected if decision rules were not properly adjusted to reflect the discrete nature of financial events.

Fourth, uncertainty about which behavioral assumptions are appropriate lessens confidence in the model predictions. However, sensitivity analysis indicates that the policy conclusions, in particular, are robust across multiple values for behavioral characteristics and across decision rules. Experimental economics has made significant advances in behavioral decision making in the past thirty years. The construction of this dynamic participation decision model should be confirmed with well-developed experimental economics laboratory techniques and should examine the assumptions and parameters of initial estimation error, the adjustment times for forming perceptions and expectations, and the various decision rules that are or could have been used to represent farmers termination decisions.

Simulation models that move away from net present value calculations and assumptions of perfect rationality and perfect information can provide insights that are useful for pragmatic policy analysis. Added practicality comes at the cost, however, of highly uncertain decision rules. Nine alternative decision rules were tested in this analysis. At present, little is known about the proportion of farmers who use these rules, or if there are other rules which should be examined. If the general approach to modeling decision making in this research is appropriate, it is in principle possible to find combinations of dynamic payment schedules and educational efforts to modify the value of the biophysical information uncertainty that minimize termination rates for given aggregate government expenditures, regardless of the distribution of farmer decision rules. However, if dynamic simulation models are to become more useful to policy-makers, more research needs to be done in order to better understand the decision rules employed by individual farmers in a world where error, time lags, and learning are necessary processes. In particular, the specification of learning as additional information perceived by a decision maker after an initial estimation error could be validated using techniques of experimental economics and behavioral decision theory. The modeling conventions of system dynamics, which specify expectations as lagging perceptions, are also fertile ground for further research in the fields of experimental and behavioral economics.

Lastly, the narrow scope of the representative farm type and conservation practices modeled limits the ability of the results to be generalized beyond the narrow confines of a New York Dairy Farm and for a limited number of conservation practices. The Conservation Security Program in applicable to a diverse range of agricultural systems including cropland, pasture, and rangeland in watersheds in every state of the United States. The range and number of enhancement practices available are determined individually by states, but range into the hundreds. Thus, the biophysical effects of conservation practices and resulting termination behavior should be examined for a much broader range of conservation practices across a diverse set of agronomic environments. Extensive research into these important biophysical effects and participation behaviors will allow more robust policy analysis and ultimately, more sound policy design for conservation programs in the future.

APPENDIX A

MODEL PARAMETERS

This appendix provides a complete list of parameters and exogenous inputs used in the dynamic participation decision model presented in *Chapter Four*.

Model Parameters

Biophysical Estimation Error= 1.0, .75, .50 for “limited,” “average,” and “smart” representative farmers respectively.

Dimensionless

BIU is variable underlying the assumption that farmer does not have perfect information of the biophysical processes of cover crops or other conservation practices. This parameter has no available data associated with it and will need extensive sensitivity testing.

Corn Silage Price= 20 *dollars/tn*

Corn silage can be valued in many different experts, Edwards suggests using a combination of relative corn grain prices, hay prices, and substitute feed costs. Others knowledgeable about the industry use a rule-of-thumb, which states that the price of corn silage is seven times the price of corn.
Source: Personal Interview, William Joslin, August 16, 2005.

Cover Crop Payment Rate= 30 *dollars/acre/year*

Cover Crop payment rate is per acre/year amount of money assumed to be paid through the CSP for implementing Cover Crops in the Niagara Watershed.
Source: NRCS website-2005 EQIP rates for Erie County

Cover Crop Cost Rate=13.5 *dollars/year/acre*

NY NRCS Field Office Technical Guide, ERS EQIP Northern Crescent Cost Estimates

Discount Rate= 0, 0.05, 0.1 *Dimensionless*

Decision-maker’s internal discount rate as used in net present value calculation. This is a commonly used discount rate for relatively short-term decision-making.
Source: Kay, et al, 2004.

Enrolled Riparian Buffer Acreage= 30 *acre*

The total acreage needed to create a 100-ft riparian corridor on a 1000-acre representative farm with a straight watercourse running through it.

Existing Practice Payment= 0.25 *Dimensionless*

25% of the stewardship rate is the standard rate for all CSP contracts.
Source: NRCS FY2005 Sign-Up Announcement, 2005.

Farmland rental rate= 40 *dollars/acre/year*

Each acre of farmland in a given watershed is given a base rental rate from which the base payments are derived. The $40 dollar payment rate is a combination of many factors ultimately determined by NRCS staff.
Source: NRCS website-2005,
http://www.ny.nrcs.usda.gov/programs/programs/ CSP/niagarawatershed

Riparian Buffer Cost Rate = 65 *dollars/acre/year*

The opportunity cost (average rental rate) for an acre of productive agricultural land in northwest NY state. Source: Knoblauch, et al. 2003.

Riparian Buffer Payment Rate= 100 *dollars/acre/year*

Source: NRCS website-2005,
http://www.ny.nrcs.usda.gov/programs/programs/ CSP/niagarawatershed

Tier Level= 3 *Dimensionless*

Participants are placed in a Tier at the start of their enrollment in CSP. The tier is determined by previous environmental performance and willingness to take on at least two additional conservation practices on the entire farm.
Source: NRCS FY2005 Sign-Up Announcement, 2005.

Time to Form Expectations= 1, 2, for “sophisticated” and “naïve” representative farmers respectively. *year*

The parameter is the adjustment time for a farmer to form an expectation based on Perceived Net Revenue. This parameter has no available data associated with it and will need extensive sensitivity testing.

Time to Perceive= 1, 2, “sophisticated” and “naïve” representative farmers respectively. *year*

This parameter represents the adjustment time for a farmer to perceive information regarding the actual Net Revenue from CSP Contract. This parameter has no available data associated with it and will need extensive sensitivity testing.

Time to Perceive Trend= 2, 3, for “sophisticated” and “naïve” representative farmers respectively. *year*

The average adjustment time needed for a farmer to recognize a trend in the

Perceived Net Revenue. This parameter has no available data associated with it and will need extensive sensitivity testing.

Total Enrolled Acres= 1100 *acre*

The representative NY Dairy Farm is assumed to have 1000 eligible acres of cropland. The average dairy farm responding to the Dairy Farm Business Summary in the Western and Central Plain Region was 1,088 acres.
Source: Knoblauch, et al. 2005.

Variable Rate Enhancement Payments Switch= 1 *Dimensionless*

This is a binary switch for activating the variable rate payment plan. The base simulation assumes that the variable rate payment plan is activated.

Enrolled Cover Crop Acreage=300 *acre*

This is the assumed total amount of corn acreage put under cover crops for the duration of the CSP contract. Approximates the average acreage devoted to cropland in Dairy Farm Business Summary in the Western and Central Plain Region.
Source: Knoblauch, et al. 2003.

Normal Crop Yield= 15 *tn/acre*

This is the corn silage yield for the average dairy farm responding to the Dairy Farm Business Summary in the Western and Central Plain Region.
Source: Knoblauch, et al. 2005.

Simulation Control Parameters

FINAL TIME = 10 *year*
The final time for the simulation.

INITIAL TIME = 0 *year*

The initial time for the simulation.

SAVE PER = TIME STEP *year*

TIME STEP = 0.03125 *year*

Model Exogenous Inputs

Organic Matter EFFECT= 0.8074+RAMP(0.0555, 0, 10) *Dimensionless*

This is the linear estimated effect of continuous cover cropping on corn silage average yields. This input is equivalent to a linear equation with a .8074 intercept and .0555 slope.

Source: Kuo and Jellum, 2000.

Variable Rate Enhancement EFFECT([(0,0)-(10,2)],(1,1.5),(2,0.9),(3,0.7),(4,0.5),(5,0.3),(6,0.1),(7,0),(8,0),(9,0),(10,0)) *Dimensionless*

This input is the equivalent of imposing the variable rate enhancement payment plan.

Source: NRCS FY2005 Sign-Up Announcement, 2005.

Tier Multiplier fn([(0,0)-(4,0.2)],(0,0),(1,0.0125),(2,0.05),(3,0.1125)) *Dimensionless*

This input is equivalent to the tier multiplier and tier reduction factor applied to the stewardship payments.

Source: NRCS FY2005 Sign-Up Announcement, 2005.

APPENDIX B

COST ANALYSIS OF CONSERVATION CROP ROTATION

The conservation crop rotation conservation enhancement was examined separately from the cover crop and riparian buffer enhancements, which were simulated using the dynamic participation decision model described in *Chapter Four*. A separate analysis was conducted to better understand the complexities of changing crop rotations and the subsequent cost effects on a rebalanced ration for a New York dairy farm. After an initial benefit/cost analysis using Cornell's Net Carbohydrate model, the conservation crop rotation enhancement was found to be too costly to be considered practicable for a NY dairy producer was thus left out of the dynamic simulation modeling. The description below describes the conservation crop rotation and the benefit/cost analysis associated with the representative dairy operation's additional nutrient needs.

As defined by the Natural Resources Conservation Service, a conservation crop rotation is practice means growing various crops on the same piece of land in a planned sequence. This sequence may involve growing high residue producing crops such as corn or wheat in rotation with low residue producing crops such as vegetables or soybeans. The rotation may also involve growing forage crops in rotation with various field crops. Benefits include reduced runoff and erosion, increased organic matter, improved pest management, and improved wildlife habitat. The CSP enhancement payment is $2 per acre annually for implementing a conservation crop rotation. Specifically, the CSP contracts requires that a farmer use a minimum of three different crops in rotation and never grow the same crop two years in row on the same acreage (NRCS website 2005, http://www.ny.nrcs.usda.gov/programs/programs/CSP/niagarawatershed).

The ratio of dedicated corn silage and hay crop acres found in the Dairy Farm Business Summary (Knoblauch, et al., 2005), as well a interviews with state and federal employees familiar with the area, indicate that many dairy farmers of the size of the representative farm use a crop rotation of three years of corn silage followed by three or four years of alfalfa hay. The alfalfa is valuable as forage for feeding purposes but also as a legume to replace soil nitrogen levels.

This analysis is an attempt to understand the effects of changing from a traditional CCCAAA crop rotation to a CSP subsidized CO/AAAA conservation crop rotation on a 900 acre NY dairy farm. The objective is to examine the financial impact of changing the supply of nutrients to a dairy farm, assuming that the ration will need to be revised. This analysis assumes the current crop rotation and ration and then formulates a new ration based on the supply of nutrients from a conservation crop rotation. Lastly, an analysis of the net change in cost is performed.

The representative farm used for this analysis has 900 tillable acres, 450 cows, and 277 heifers. The traditional ration was calculated using Cornell's Net Carbohydrate Model, which was used to balance a ration that used most of the grown alfalfa and corn silage while reaching the same level of average milk production seen in the Dairy Farm Business Summary. A ration was produced for lactating cows, dry cows, and heifers. The total nutrient needs were adjusted for feeding losses and then compared to the supply of available on the farm. The supply of nutrients was calculated using average yields from the DFBS and adjusted for harvest and storage losses. All losses adjustments were taken from Knoblauch and Milligan (1977). The ration was balanced so as to use all of the supplied corn silage and alfalfa, however an additional 574 tons of soybean meal and 724 tons of corn grain are needed in order to balance the rations.

The supply of nutrients was then calculated based on the yields from a conservation crop rotation. This rotation resulted in more alfalfa, oat silage, and significantly less corn silage. The ration was then reformulated to reflect these changes. The ration was again balanced so as to use most of the supplied corn silage and alfalfa. Additionally, 524 tons of soybean meal and 1280 tons of corn grain are needed to balance the rations. Changing from a traditional crop rotation to a conservation crop rotation results in the following marginal changes: increase corn silage use by 6.92 tons, decrease alfalfa use by 217 tons, decrease purchased soybean meal by 49 tons, and increase purchased corn grain by 556 tons.

New York NASS survey data was used to determine the marginal financial impact resulting from a change to a conservation crop rotation. This analysis shows that the representative farmer’s corn silage costs increase by $180, alfalfa revenues increase by $23,410, there is $9,843 in cost savings from soybean meal, and there is an additional cost of $49,647 for purchased corn grain. This results in a net loss of $16,573, but with $1800 from the CSP contract, that loss is reduced to $14,773 on average per year. Although this analysis uses ten-year average NY NASS prices, the outcomes are highly sensitive to the price of corn grain. Although this analysis does not account for fixed costs, such as machinery, it is likely that a farmer might do a similar estimate and determine that adopting a the conservation crop rotation enhancement is not in the financial interest of the dairy farm. Thus, the omission of the conservation crop rotation enhancement is justified in the previous dynamic participation decision model.

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