THE IMPACT OF THE CHESAPEAKE BAY PROGRAM ON PENNSYLVANIA APPLICATION RATES FOR THE ENVIRONMENTAL QUALITY INCENTIVE PROGRAM

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ABSTRACT

The Impact of the Chesapeake Bay Program on Pennsylvania Application Rates for the Environmental Quality Incentive Program

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This paper presents an application of matching on propensity score to evaluate the impact of the Chesapeake Bay Program (CBP) on farmers' willingness to participate in the United States Department of Agriculture Environmental Quality Incentive Program (EQIP). One goal of the CBP is to reduce agricultural nutrient loadings to Chesapeake Bay. Achievement of this goal will require increased farm adoption of conservation practices to limit and reduce the levels of residual nutrients the bay.

One expectation of this investigation is that the CBP's agricultural related research and educational outreach programs directed to the farm community has a positive effect on farmers' willingness to enroll in conservation programs. Furthermore, the CBP funding to support county watershed technicians who assist farm operators with adoption of conservation practices is expected to also have a positive impact on farmers' willingness to enroll in EQIP. EQIP is the leading federal conservation program for cost-share funding for structural, vegetative, and land management practices to reduce agricultural non-point source pollution.

The study is limited in scope. The analysis is conducted over one state, Pennsylvania, and analyzes the impact of the CBP only on one program, EQIP. The study is not presented as a comprehensive evaluation of the CBP's impact on all farm conservation programs administered within the Chesapeake Bay watershed. However, the estimation method used for this study can be extended to other farm conservation programs.

To Kate, to Christopher

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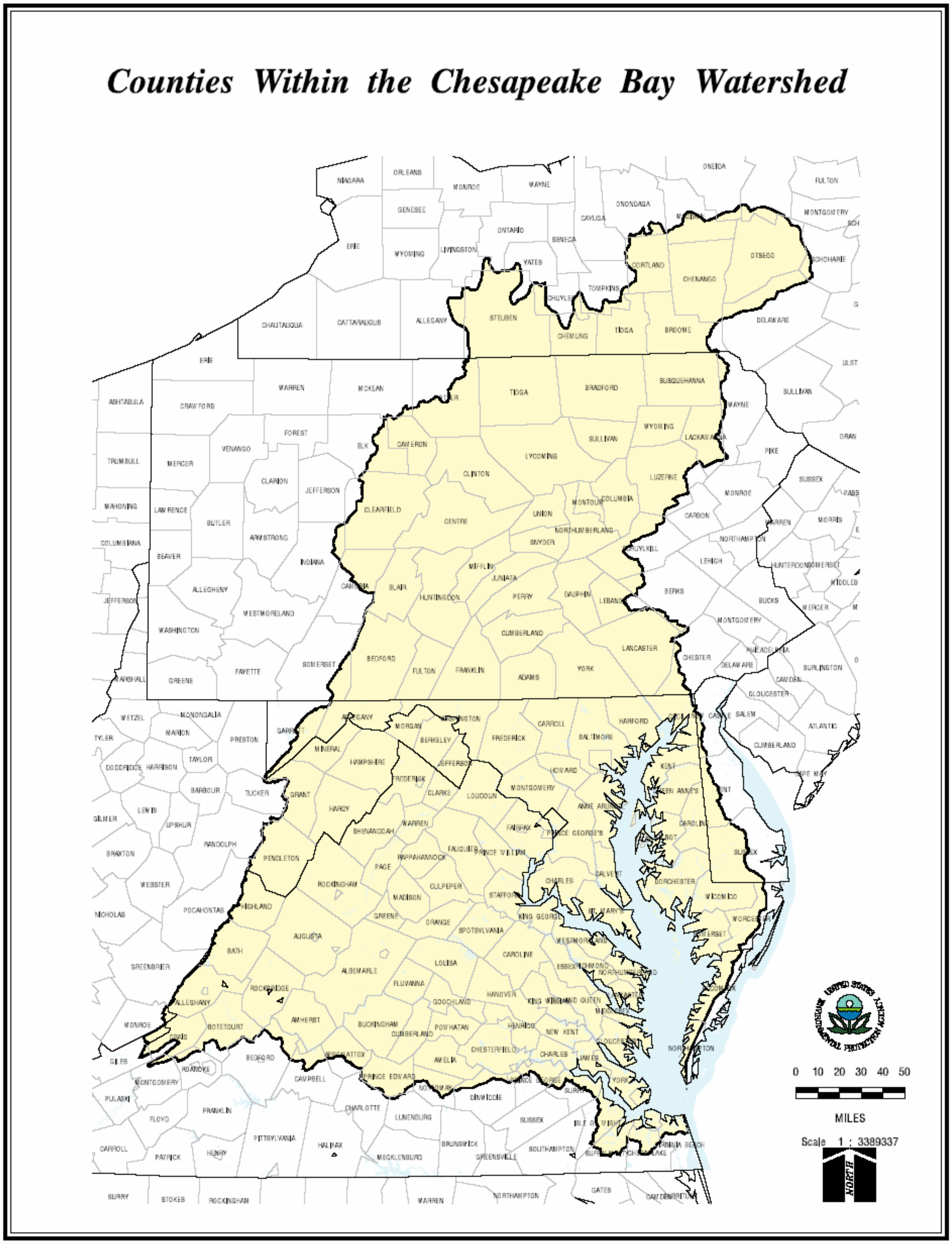
Chapter 1
Introduction

This paper contains results from the application of propensity score matching to evaluate the impact of the Chesapeake Bay Program (CBP) on farmers' willingness to participate in the United States Department of Agriculture Environmental Quality Incentive Program (EQIP).

The Chesapeake Bay Program is one of several large-scale watershed restoration programs in the nation. The program was established in 1983 to restore the water quality and ecological health of the Chesapeake Bay and the surrounding 64,000 square mile Chesapeake Bay watershed. The three signatory states to the Chesapeake Bay Agreement are Virginia, Maryland, and Pennsylvania. In addition, representatives for the District of Columbia, the United States Environmental Protection Agency (EPA), and the Chesapeake Bay Commission serve on the Chesapeake Bay Program Executive Council.

The watershed boundary and program area of the Chesapeake Bay Program is depicted in Figure 1. Although funding for the program comes from EPA, the agency has relinquished governance of the program to the Chesapeake Executive Council. The Council has no regulatory authority. The CBP uses a management structure primarily based on consensus and voluntary action. The regulatory measures enacted to restore the environmental health of the bay are accomplished through the individual state

Figure 1. Chesapeake Bay Watershed Boundary and CBP Program Area



legislative assemblies. The role of the states is demonstrated by the enactment of 58 environmental statutes pertaining to the Chesapeake Bay since the 1983 Agreement, of which 9 are federal laws, and 49 are state laws.

The CBP has evolved into a comprehensive basin-wide bay restoration program. The CBP has successfully expanded its realm of partnerships and sphere of influence to include a multitude of local and state agencies, four interstate commissions, and thirteen federal agencies with an office or program dedicated to the Chesapeake Bay. The CBP has more than 50 subcommittee and work groups. The CBP has cultivated partnerships with 11 university environmental research centers and has affiliation with more than 700 citizen and watershed stakeholder groups.

The CBP is a voluntary partnership among federal, state, and local governmental units, university research centers, and environmental, industrial, and agricultural interest groups. Although the CBP has no direct regulatory or enforcement powers, it establishes water quality restoration goals, identifies research priorities, coordinates watershed protection grants, and provides funding for environmental education programs. The Chesapeake Bay Program serves as the catalysts for a diverse array of environmental initiatives to restore the ecosystem of the Chesapeake Bay watershed. As a partnership of public and private organizations, the CBP does not have individual members. An assumption of this investigation is that the cumulative educational, research, and coordination activities of the CBP has a generalized "spill-over" effect on farmers' willingness to participate in farm conservation programs.

Farmers are exposed to the activities of the CBP via research and agricultural extension related out-reach activities of the land-grant universities which partner with the CBP. Agricultural interest groups and farm associations participate with the CBP in implementing demonstration projects designed to reduce agricultural non-point source pollution. Although farmers do not join or enroll in the CBP, individual farmers may choose to become members of local watershed organizations or regional environmental organizations which could be partners in the CBP. Farmers are also exposed to CBP environmental restoration initiatives via outlets for local and regional news.

1.1 Background

The Chesapeake Bay estuary is located along the mid-Atlantic seaboard of the United States. The Bay's water quality, ecology, and fisheries have exhibited significant degradation during the past 40 years. The Bay's current ecological productivity level is estimated as one-quarter of its historic level (Pierno 2004). Nutrient pollution is the greatest of all recognized threats to the ecological health of the bay (Cronin 1967; Boesch 2004).

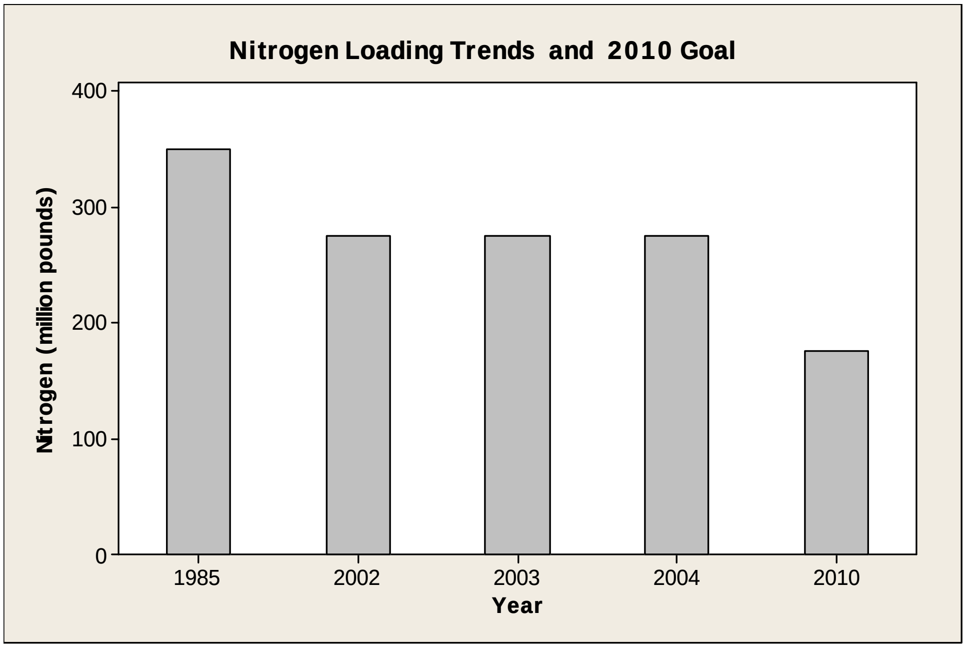
In response to the declining ecological health and corresponding economic loss emanating from the collapse of shellfish and fisheries industries, the Chesapeake Bay Program (CBP) was inaugurated in 1983 with the signing of the Chesapeake Bay Agreement by the states of Maryland, Pennsylvania, and Virginia, the District of Columbia, the Chesapeake Bay Commission, and the United States Environmental Protection Agency. The Agreement institutionalized a regional collaborative and voluntary approach to restoring and protecting the waters of the Chesapeake Bay and surrounding watershed. In 1999 the waters of the Chesapeake Bay were formally listed as impaired by the U.S. Environmental Protection Agency in compliance with Section303 (d) of the Clean Water Act.

The Chesapeake Bay Program is one of 28 large-scale eco-system restoration programs in the United States. The Chesapeake Bay watershed is 64,000 square miles and is the largest estuary drainage basin in the world. Sixteen million people reside in the basin. Eighty percent of the total basin area is located in the three states of Maryland, Pennsylvania, and Virginia. The remainder is located in the headwater states of New York, Delaware, and West Virginia. Agriculture accounts for 30 percent of total land use in the basin, and is the source for nearly 50 percent of total nutrient loadings to the Bay. The CBP established the goal of reducing total nutrient loadings to the Bay by 40 percent below the annual loadings of 1985 which was established as the base level for comparisons of future reductions. Achieving a 40 percent reduction below the 1985 nutrient loadings levels is necessary to restore the Bay's ecological health.

1.2 Problem Statement

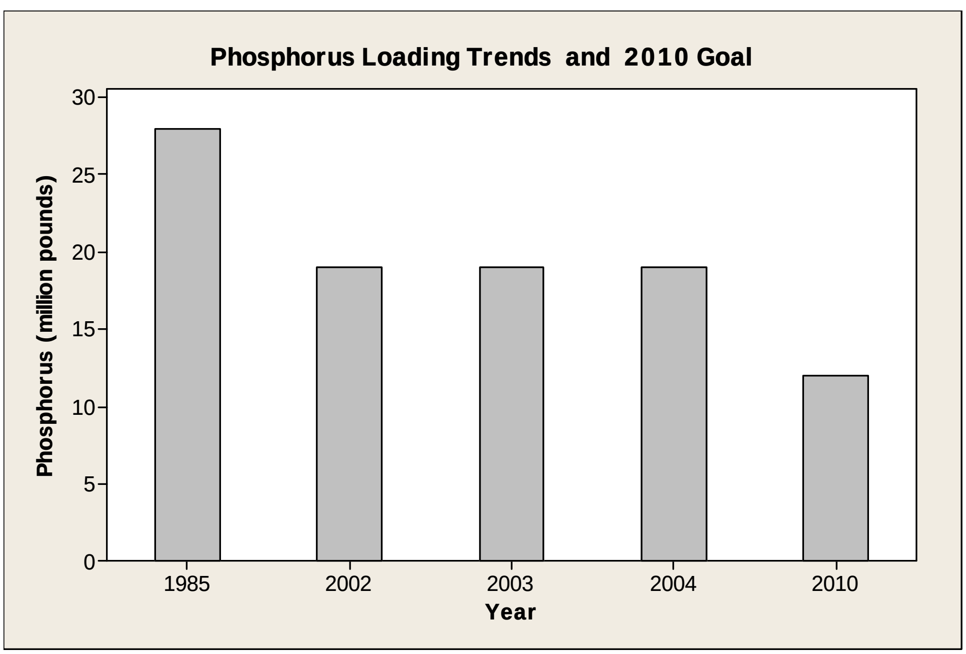
The Chesapeake Bay Program is operating under a court agreement to achieve its goal of nutrient reductions by 2010. If the goals are not achieved, the EPA may be required to enforce new regulations to reduce nutrient loadings from non-point pollution sources. This direction might include new regulations of agricultural production to reduce nutrient enrichment. Although the CBP was successful in reducing nutrient loadings to the bay during the period 1990 – 2000, Figures 2 and 3 illustrate that during recent years, the efforts of the CBP have failed to result in sustained reductions in nutrient loadings.

Figure 2. Nitrogen Loadings 1985 – 2004 and CBP Goal



Source: Bay Journal 2006

Figure 3. Phosphorus Loadings 1985 – 2004 and CBP Goal



Source: Bay Journal 2006

A challenge confronting the Chesapeake Bay Program is the necessity to reduce agricultural nutrient enrichment and maintain caps on future loadings once target reduction levels are obtained. One assumption for this paper is reduction of residual agricultural nutrients is positively correlated with implementation of agricultural conservation practices. The strength of the positive correlation varies significantly due to variation in an array of random variables such as level of conservation effort, frequency of program participation, and type of adopted conservation practice. Evaluating environmental outcomes attributed to adoption of conservation practices is extremely challenging due to the complexities of aggregating individual loadings from multiple nonpoint sources, changing land use patterns, changes in management practices, and perhaps most significant of all, is the variability of climate conditions.

Reaching the target nutrient reduction goals of 175 million pounds of nitrogen and 12.9 million pounds of phosphorus by 2010 will require the active participation and on-going commitment of the agricultural sector. Recruiting voluntary participation in farm conservation programs requires sustained CBP expenditures to support educational out-reach programs.

Knowing if the CBP affects participation rates in farm conservation programs is useful information for designing future CBP programs. There is increasing interest in the potential gains in nutrient reductions from implementing nutrient trading programs between point-source and non-point source contributors.

This analysis is limited to a farmer's willingness to enroll in the Environmental Quality Incentive Program (EQIP). The Environmental Quality Incentive Program is one of 20 farm conservation programs administered nationwide by the United States Department of Agriculture Natural Resources Conservation Service (NRCS). EQIP is a voluntary program. The purpose of the program is to promote agricultural production and concurrently reduce environmental problems attributed to agriculture. This goal is partially accomplished by providing cost-share payments and technical assistance to participating farmers for the planning and implementation of structural, vegetative, and land management practices on eligible land to promote soil and water conservation practices. Under the 2002 Farm Bill, EQIP was authorized at an unprecedented funding level of $6.1 billion over 5 years. EQIP is the major source of cost-share funds for addressing environmental problems attributed to agricultural production and has widespread support among the farm community (Zinn 2005).

The Pennsylvania Department of Environmental Protection (DEP) and the United Stated Geological Survey (USGS) estimated reductions in nitrogen and phosphorus loadings to the Chesapeake Bay Watershed which could be attributed to different state and federal programs. The estimates were calculated using the Chesapeake Bay Watershed computer model. For the 4 state and 3 federal programs, conservation practices funded under EQIP accounted for 50 percent of total nitrogen reductions from agriculture and 60 percent of total phosphorus reduction from agriculture during calendar year 2000 (Pennsylvania Department of Environmental Protection 2002). The total agricultural related reduction was estimated at 10.6 million pounds of nitrogen and 319,229 pounds of phosphorus. However, the estimates from the Chesapeake Bay Watershed Model were criticized in a General Accounting Office Report for over-stating the level of nutrient reduction attributed to best-management practices (GAO 2005). Although the above estimates may over-state the extent of nutrient reductions, EQIP likely accounts for the highest percentage of nutrient reductions of all state or federal agricultural conservation programs.

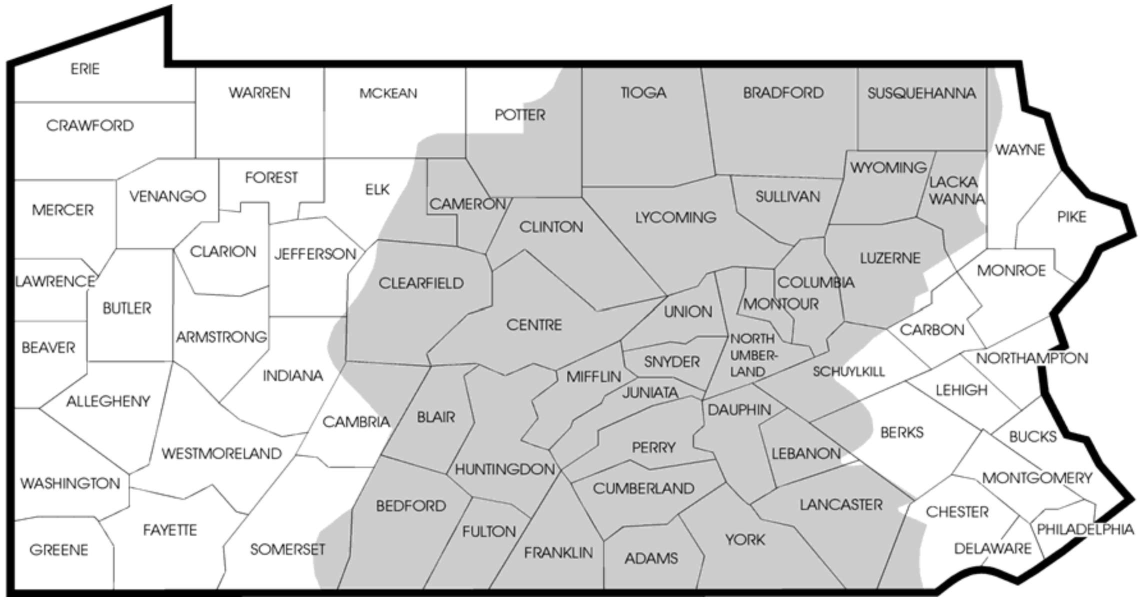
To be eligible to enroll in EQIP, an applicant must be an agricultural producer and be in compliance with the highly erodable and wetland conservation requirements of the 1985 Farm Bill (Natural Resources and Conservation Service 2002). Applications are submitted to the Natural Resources and Conservation Service (NRCS). There is no limit to the number of applications NRCS will accept. However, budget constraints limit the number of application selected for funding. For FY2004 NRCS received approximately 600 applications state-wide in Pennsylvania, and funded 300.

A farm operator is eligible to enroll in a multiple of conservation programs such as the Conservation Reserve Program (CRP), the Conservation Reserve Enhancement Program (CREP), Wetlands Reserve Program, and the Wildlife Habitat Incentive Program (WHIP). However, this initial study is limited to EQIP to avoid double-counting multiple applications from the same farm operator as a measure of willingness to participate in conservation programs.

1.3 Study Area

The state of Pennsylvania is the pilot-study area. Of the 67 counties located in Pennsylvania, 36 counties participate in the Pennsylvania Department of Environmental Program (DEP) Chesapeake Bay Program. Figure 2 shows the location of the Chesapeake Bay basin and program area of the Chesapeake Bay Program in Pennsylvania. Approximately 30 percent of the surface area of the Chesapeake Bay watershed is located in Pennsylvania.

Figure 4. Study Area: State of Pennsylvania and In-basin Counties.



Source: Pennsylvania Department of Environmental Protection Chesapeake Bay Program. Shaded area illustrates the Chesapeake Bay watershed.

Table 1 lists the counties and corresponding land area in the Chesapeake Bay watershed. For the balance of this paper, the Chesapeake Bay watershed will be referred to as the basin. Of the 67 counties located in Pennsylvania, 43 counties have a portion of their land area in the basin. 33 of the 67 counties have 50 percent or more of their land areas in the basin, and 31 of the 67 counties have 75 percent of land area in the basin.

The area of the Chesapeake Bay watershed located in Pennsylvania is referred to as the Susquehanna River Basin. The Susquehanna River is the largest of the nine major Bay tributaries and flows 450 miles through New York and Pennsylvania to the Chesapeake Bay. This study was limited to the one state so that the counties to be used for matching were from a set that were subject to similar economic conditions and similar state regulations (Smith 2006).

Table 1: Percentage of County Land Area in the Chesapeake Bay Watershed 2006

	County	Actual %	If County has portion of land area in basin T=1	If county has 50% or more of its land area in basin T=1	If county has 75% or more of its land area in basin T=1
1	Adams	100	1	1	1
2	Bedford	100	1	1	1
3	Berks	7.1	1	0	0
4	Blair	100	1	1	1
5	Bradford	100	1	1	1
6	Cambria	42.3	1	0	0
7	Cameron	100	1	1	1
8	Carbon	1	1	0	0
9	Centre	100	1	1	1
10	Chester	18.5	1	0	0
11	Clearfield	90.7	1	1	1
12	Clinton	100	1	1	1
13	Columbia	100	1	1	1
14	Cumberland	100	1	1	1
15	Dauphin	100	1	1	1
16	Elk	32.4	1	0	0
17	Franklin	100	1	1	1
18	Fulton	100	1	1	1
19	Huntingdon	100	1	1	1
20	Indiana	7.5	1	0	0
21	Jefferson	1	1	0	0
22	Juniata	100	1	1	1
23	Lackawanna	84.7	1	1	1
24	Lancaster	99.6	1	1	1
25	Lebanon	85.3	1	1	1
26	Luzerne	85.3	1	1	1
27	Lycoming	100	1	1	1
28	McKean	2.2	1	0	0
29	Mifflin	100	1	1	1
30	Montour	100	1	1	1
31	Northumberland	100	1	1	1
32	Perry	100	1	1	1
33	Potter	62.8	1	1	0
34	Schuylkill	51	1	1	0
35	Snyder	100	1	1	1
36	Somerset	13.6	1	0	0
37	Sullivan	100	1	1	1
38	Susquehanna	100	1	1	1
39	Tioga	100	1	1	1
40	Union	100	1	1	1
41	Wayne	7.9	1	0	0
42	Wyoming	100	1	1	1
43	York	100	1	1	1
Total			43	33	31

Source: Natural Resources Conservation Service

The river delivers 50 percent of the freshwater flow to the Bay and accounts for sixty percent of the total nitrogen load and 34 percent of the total phosphorus loads to the Bay. The Susquehanna River is the largest tributary source of nutrient and sediment loadings. Approximately 75 percent of the 27,500 square mile Susquehanna River basin area is located in Pennsylvania. Land use in the Susquehanna basin consists of forest at 60 percent and agriculture at 30 percent.

Thirty-six counties located in the Chesapeake Bay watershed choose to participate in the Pennsylvania Department of Environmental Protection (DEP) Chesapeake Bay Program in 2003-2004. Each county that participates in the program receives funding for a watershed technician. Four participating counties received funding to support 2 or more watershed technicians. To maintain a "comparable level of treatment effect" across participants only those counties with 1 technician will be included in the set of participants. Maintaining a comparable level of treatment effect implies that for estimating the impact of a county having a CBP watershed technician on its EQIP application rates , only counties with similar number of technicians are compared. The assumption is that each CBP watershed technician exhibits a comparable level of work effort in promoting enrollment in farm conservation programs. Although there are methods to conduct matching for multiple treatment effects, this study limited the analysis to counties with 1 CBP technician.

The 4 counties with 2 or more watershed technicians will be omitted from the initial analysis. The four counties are Bradford, Dauphin, Lancaster, and York. All four counties are leading counties in Pennsylvania's agricultural production. Bradford County also displayed an unusual outcome of submitting 85 unfunded applications in 2004. This outcome is three times greater than any other county and the observation is treated as an outlier.

Five non-participant counties were omitted from the analysis. The EQIP application rate for Cameron County is 8.6 percent. The next highest rate for non-participant counties is 4 percent. The 8 percent EQIP application rate was calculated from a total of 3 applications and a total of 35 farms in the county. This observation significantly influenced the mean non-participant rate. However, in light of there only be a total of 35 farms in the county, the observation was omitted from the analysis.

Four additional non-participant counties were omitted because the likelihood of the counties choosing to participate in EQIP was deemed to be nearly zero. Two counties, Philadelphia and Pike have 9 and 50 farms respectively and have no acreage in the EQIP program or prior EQIP applications. Two counties, Forest and Elk have neither EQIP applications nor acreage enrolled in EQIP for prior years. Furthermore, both counties have 90 percent or more forest cover. They are predominately forested with no agriculture. The dataset for this study consists of a total of 58 observations. Thirty-two counties participating in the CBP and 26 counties as non-participants

An estimated 26,800 farms are located in "participant" counties, and 20,750 farms are located in nonparticipating counties. To estimate if the CBP impacts farmers' willingness to enroll in EQIP, the EQIP application rate for the 26 non-participant counties will be used as a control to estimate the missing counterfactual. The missing counterfactual is defined as the expected EQIP application rate for CBP participants if the CBP did not exist. The nonparticipating counties provide a means to estimate what EQIP application rates would be for counties located in the basin absent the CBP.

CBP funding is allocated to a county conservation district to support a watershed technician for the purpose of working with farm operators to design and implement farm conservation practices. Approximately 2 million dollars is allocated annually to participating conservation districts located within the basin. Separate CBP funds to cost-share implementation of farm conservation practices have decreased during the past 10 years. However, the decrease in CBP cost-share funds for farm conservation projects has been off-set by a significant increase in USDA funding for farm conservation programs. For example, the actual EQIP expenditures increased from 2.5 million dollars in FY2002 to 9.8 million dollars in FY2005. The number of contracts increased from 51 in FY2002 to 324 in FY2004. The average obligation per contract decreased from approximately $50,000 in FY 2002 to $30,000 in FY 2004.

The selection of using total number of EQIP application received by NRCS as a measure of the CBP effect on farmers' willingness to enroll in EQIP instead of using only the number of funded applications was to avoid the influence of NRCS budget constraints on the number of application that can be funded. However, it should also be recognized that an increase in the total number of applications received does not necessarily lead to increased adoption of farm conservation.

While the EQIP program is administered by the Natural Resources and Conservation Service (NRCS), the CBP watershed technicians commonly assist farmers with completing enrollment applications for conservation cost-share funding for multiple programs (Chesapeake Bay Cost-share Program, Environmental Quality Incentive Program (EQIP), the Conservations Reserve Program (CRP), the Wetland Reserve Program, and the Conservation Reserve Enhancement Program (CREP)).

Limiting the selection of the outcome variable to only total EQIP application omits capturing the potential impact of the CBP on other farm conservation programs. EQIP was selected because it is the primary farm conservation program for cost-share funding for structural, vegetative, and land-management practices.

A potential measure of the CBP impact could be observed higher program application rates from farmers located in "participant" counties with a CBP watershed technician compared to EQIP application rates from "non-participant" counties which do not have a CBP watershed technician.

Although counties apply annually to participate in the PDEP CBP program, all the counties that participated in 2004 participated in the previous year. It was assumed each county had a watershed technician working with farmers throughout the period 2004.

The use of a control model to estimate program impact uses a framework consisting of three categories: a treatment, individuals, and an outcome variable (Caliendo 2005).

In this paper, treatment is defined as the program and educational out-reach initiatives of the Chesapeake Bay Program and the presence of a CBP watershed technician in participating counties. The effort of the CBP watershed technicians is intended to increase the conservation behavior of farm operators located in the counties of the Chesapeake Bay watershed. Counties located in the basin who have applied for a CBP watershed technician are labeled as "participant" (D_i=1), and counties without a CBP technician are labeled as "non-participant" (D_i=0). All data for this study is at the county level.

The outcome variable is EQIP application rates by county for FY2004. EQIP application rate is calculated by dividing the total number of EQIP applications received by NRCS per county by the total number of farms per county. Total applications consist of the sum of funded applications plus unfunded applications.

Farmers' willingness to participate in EQIP is demonstrated by submission of an enrollment application. If county participation in the CBP could be randomly assigned, then there would be a randomized control group for use in estimating the effect of treatment on the participating counties. A randomized control group is created by “forcibly” but randomly excluding potential participants from the treatment (Smith 2006). When assignment to treatment and non-treatment is randomized, then two groups are created that share similar distribution of observable and non-observable attributes that influence the outcome variable. Calculation of an unbiased estimate of the treatment effect can be made by analyzing the differences in the mean outcomes for each group.

However, when a randomized group is not available, as is the case in this study which relies on observational data, one evaluation method which can be used to estimate treatment effects for purposes of comparing outcomes with treatment (i.e. participating in the CBP) and without treatment (i.e. not participating in the CBP) is referred to as matching (Winship 2004; Dehejia 1998; Rosenbaum and Rubin 1983).

The use of matching as a method to reduce bias in the estimation of treatment effects with observational datasets have become increasingly popular in medical trails and in the evaluation of economic policy intervention (Becker 2006; Wooldridge 2002). In the environmental economics literature matching has recently been extended to evaluation of environmental programs (Greenstone 2002; List 2002; Frondel 2001).

1.4 Conceptual Framework

This section provides the motivation for use of a control model to evaluate the impact of the CBP on farmers’ willingness to enroll in EQIP. The reasons why farmers’ willingness to enroll in EQIP may be affected by the CBP are discussed, as well as several reasons why there may be no effect.

As previously described, the claim of this investigation is that the CBP is expected to have a positive impact on EQIP application rates. The analysis is confined to the study as described in Section 1.3, and is not applicable to CBP counties located in the other signatory sates. The reasons the CBP is hypothesized to have an impact on EQIP application rates are:

1. Counties located in the Chesapeake Bay watershed that choose to participate in the Pennsylvania Department of Environmental Protection (PDEP) Chesapeake Bay Program obtain funding to support a CBP watershed technician. The county CBP watershed technician works directly with farmers to identify agricultural related environmental problems, and assist farmers with enrolling in farm conservation programs.

2. EQIP is administered by the Natural Resources and Conservation Service. While the CBP watershed technician is not a NRCS employee, the technicians have a cooperative working relationship with NRCS. Often CBP watershed technicians are physically located in the same county conservation district office as the regional NRCS EQIP program staff. Thus the premise to this study is that the work of CBP watershed technicians augments the work of NRCS staff in promoting enrollment in EQIP.

3. Although the CBP participant counties apply annually to PDEP, county participation in CBP has been on-going for multiple years. In some instances counties have been participants in the CBP since inception of the CBP in the 1980s. It is expected that the CBP watershed technicians have developed working relationships with members of the farm community. Communication between farm operator and resource agencies, and development of trust between farm operators and resource agencies have demonstrated to have a favorable effect on farmer willingness to enroll in conservation programs (Vollmer-Sanders 2006).

4. In addition to the education outreach work of the CBP watershed technicians, farm operators in counties located in the Chesapeake Bay watershed are exposed to the efforts of CBP partner organizations. CBP partner organizations include universities, agricultural interest groups, environmental organizations, and local citizen watershed protection groups. The work of these groups related to promoting agricultural conservation practices to protect water resources is expected to also have a positive impact on farmers' willingness to enroll in EQIP.

Reasons why the CBP may not have an impact on farmers' willingness to enroll in EQIP are:

1. One reason CBP may not impact farmers' willingness to enroll in EQIP is the possible reluctance of farmers' to enroll in any conservation programs. Farmers may not adopt conservation practices that are may potentially result in loss of farm income and/or ability to "self regulate" their farm operation. "There is an inherent incompatibility between agricultural and natural systems" (Batie 1990). Thus if farmers' are unwilling to enroll in EQIP, the CBP may be not be able to overcome this reluctance.

2. A factor that may also diminish the impact of the CBP on farmers' willingness to enroll in EQIP is the physical distance of CBP participant counties from the Chesapeake Bay. While the CBP is a watershed protection program, the CBP is primarily focused on the bay. Farmers in CBP participant counties which are located hundreds of miles from the bay are unlikely to have a strong affinity for Chesapeake Bay. In light of this, CBP watershed technicians have altered their emphasis from promoting protection for Chesapeake Bay to one of promoting protection for local watershed and the Susquehanna River basin.

3. An additional confounding factor that may lessen the impact of the CBP on EQIP application rates for participant counties relative to EQIP rates for non-participant counties is the nature of the state of Pennsylvania's role as a partner to the CBP. When Pennsylvania enacts legislation in response to meeting CBP initiatives and goals (i.e reduce agricultural nutrient loadings), the state actions are implemented state-wide. Pennsylvania does not enact measures that are unique to or targeted to only counties located in the Chesapeake Bay watershed. To the extent that state legislation may influence enrollment in EQIP (i.e. state requirements for nutrient management plans), the impact is state-wide.

4. The Pennsylvania Department of Environmental Protection budgets $1.6 million in funding to support CBP 34 CBP watershed technicians in participant counties. The size of the program may be too small for its impact to be discernable. There are other farm conservation programs in addition to EQIP, and it is possible that enrollment in EQIP is not impacted by the CBP because farmers choose to enroll in other programs. Further more it is also possible that the CBP has an impact on farmers adopting conservation practices, but such measures are done privately without enrollment in a public conservation program. Pennsylvania is the nation's leading state in terms of acreage enrolled and contracts signed for the federal Conservation Reserve Enhancement Program (CREP) (Zinn 2005). It may be that enrollment in CREP is having a "crowding" out effect on applications to EQIP.

EQIP is a federal farm conservation program administered by the Natural Resources and Conservation Service (NRCS). The program was created by the 1996 Farm Bill and was authorized at a total of $1 billion over the period 1997 - 2002. The 2002 Farm Bill re-authorized EQIP at a total of $6 billion for the 5 year period 2003 - 2007. This six-fold increase in authorization was attributed to the backlog of EQIP applications that were not funded due to budget constraints.

Total EQIP allocations increased from nearly $400 million in 2002 to $900 million in 2004. For Pennsylvania, EQIP allocations increased from $4.7 million to nearly $10 million in 2004 (NRCS 2006). EQIP is a voluntary program and is the principle source of cost-sharing assistance for farm operators willing to adopt soil and water conservation practices. If a farmer's application for EQIP enrollment is selected for funding, the farmer enters into a 10 to 15 year contract to implement and maintain the proposed conservation practice. USDA cost-shares 75 percent of the projected cost of each conservation practice up to a maximum of $450,000 total payments to a farmer during the five year period of the Farm Bill. Sixty percent of EQIP funds are targeted to livestock producers (Zinn 2005).

To estimate farmers' willingness to enroll in EQIP at the county level, this study relied on data from the NRCS state office in Harrisburg, Pennsylvania. Estimating total number of applications submitted required knowing the number of applications funded and the number of applications not funded. County level data for 2003 and prior years are of poor quality. Because of changes to NRCS record keeping practices and electronic data base systems in 2003, county level data for total number of applications not funded at the county level is reliable and available for 2004 and 2005.

In 2004, the Pennsylvania State office of NRCS obligated $9.9 million to a total of 324 EQIP contracts. Although the legislation authorizing the EQIP program requires a minimum of 60 percent of EQIP funds be targeted to livestock operations, nearly 95 percent of Pennsylvania's EQIP funds were obligated to conservation contracts for livestock operations. When EQIP contract obligations are analyzed by farm type, dairy farms accounted for 75 percent of Pennsylvania EQIP cost-share payments to livestock operations, and beef farms nearly 25 percent of payments. $485,000 of the $9.9 million in EQIP cost-share payments went to non-livestock operations. This amount is 5 percent of total EQIP payments.

When counties are ranked from highest to lowest in terms of milk production, the top ten Pennsylvania counties in milk production are all located in the Chesapeake Bay watershed and all are participants in the CBP. Even if the CBP has no effect on EQIP application rates it is likely participant counties will have higher EQIP applications rates because of the concentration of livestock farms in participant counties, and the targeting of EQIP funds to livestock operations.

This outcome reveals why a control model is necessary to estimate the impact of the CBP on EQIP application rates. One approach to estimating this impact would be to use the mean difference EQIP application rates between CBP participant counties and non-participant counties as an estimate of the program impact. However, this estimator does not take into account the outcome that even in absence of the CBP, it is likely EQIP application rates may be higher for participants due to the concentration of livestock operations in the participant counties and the priority of EQIP funding targeted to livestock operations. The simple difference in mean estimator would be biased upwards, and attribute a greater impact to the program than warranted.

A control model is used to estimate program impact when assignment to participate in a program is not randomized. In this study, county participation in the

Chesapeake Bay program is not randomly assigned. Counties located in the Chesapeake Bay watershed self select whether to participate in CBP.

The benefit of randomization of participation is that the set of counties randomly selected for participation, and the set of counties randomly removed from participation will share the same distribution of characteristics (i.e. number of livestock farms) that may affect the outcome variable, EQIP application rates. If participation could be randomly assigned, then the simple mean difference between participant county outcome and non-participant outcome is one measure of the program impact.

A control model is used to estimate program impact when the analysis is conducted using observational data. The fundamental idea of the control model is to identify non-participant counties that can be used as a "control" observation for use in estimating the difference in EQIP application rates between participant and non-participant counties that are attributed to the impact of the CBP. A non-participant county selected as a control will possess the same distribution of characteristics that influence EQIP application rates as the participant county. The control model is formally introduced in the next section.

Chapter 2

Control Model

This section uses the exposition and notation by Dahajia (1998), Wooldridge (2002), Frondel (2001), and Smith (2006) to describe the estimators and assumptions of matching methods. The notation for estimating a potential outcome was first introduced by Neyman (1923) and Fisher (1935) for the analysis of random events, and renewed by Rubin (1974, 1977, and 1978). The theoretical model used to estimate treatment effects is commonly referred to as a counter-factual model (Dahajia 1998, Winship and Sobel 2004, Wooldridge 2002). This paper refers to the model as a control model. The model is used to estimate the missing counter-factual of the participant observations, and the result is used as a control variable for calculating the treatment effect. The control model is presented in the context of estimating the effect of the Chesapeake Bay Program (treatment) on county EQIP application rates (outcome).

There is an extensive literature devoted to the philosophical concepts and definitions of what constituents a cause and effect relationship, and the necessary conditions under which a relationship can be deemed casual (Winship and Sobel 2004). During the 1980s, an explicit model of causal inference based on the counterfactual account of a casual relation was developed by statisticians and econometricians (Rosenbaum and Rubin 1983; Heckman 1989; Manski 1995; Heckman, Ichimura, and Todd 1997). The work has resulted in an extension of causal inference based on controlled experimental design methods. In the social sciences, randomized assignment to a treatment group and control group often is not feasible or practical. The counter-factual model is premised on the metaphor of an experiment where the goal is to estimate the effect of a particular 'treatment' (Winship and Sobel 2004) and treatment is often interpreted broadly (Wooldridge 2002).

For purposes of this paper treatment is defined as the work of a CBP watershed technician in a participant county conducting educational out-reach for the purpose of increasing farmer' adoption of conservation practices. The unit of observation is a county. The outcome variable is the EQIP application rate.

The notation commonly used for the counter-factual model is as follows:

Let *i* index the counties in the study area, with *i* = 1, 2, 3…67

Di = (0,1) indicator of the treatment actually received by unit i

Di = 0 if no participation in CBP;
County does not apply for CBP funds for watershed technician.

Di = 1 if participant in CBP
County does apply for CBP funds for watershed technician.

Yi = EQIP application rate for county i

= [(Total number of EQIP applications by county i) / (number of farms in county i)]*100

Symbolically, the evaluation problem can be represented as:

Y_{i0} = outcome of county i if non-participant.

Y_{i1} = outcome of unit i if participant.

The causal effect for unit i = $\Delta i = Y_{i1} - Y_{i0}$

$Y_i = DY_{i1} + (1 - D)Y_{i0} \rightarrow$ the actually observed outcome of unit i

Let X $\rightarrow$ observable county characteristics that simultaneously influence the participation decision and the outcome variable and are unaffected by the outcome variable.

When participation is voluntary, one treatment effect that is of interest to policy makers is the expected treatment effect over the treated population (ATET), which is the mean effect of those units actually treated by the CBP.

$$\text{ATET} \equiv \quad \Delta \mid_{D=1} \quad = E(\Delta i \mid D=1)$$

$$= E(Y_{i1} - Y_{i0} \mid D=1)$$

$$= E(Y_{i1} \mid D=1) - E(Y_{i0} \mid D = 1)$$

The missing data problem of the counterfactual model is that only $E(Y_{i1} \mid D=1)$ is observed, while the term $E(Y_{i0} \mid D = 1)$ is the counterfactual which can not be observed and thus must be estimated. Either Y_{i1} or Y_{i0} is observed for each county but not both; one cannot observe the nonparticipant outcome for participants, and one cannot observe participant outcome for nonparticipant. For this paper, a county is treated by the CBP if it is a participant in the Pennsylvania Department of Environmental Protection (DEP) Chesapeake Bay Program during 2004. The educational outreach (treatment) is conducted by the CBP watershed technician.

While $E(Y_{i1} \mid D=1)$ and $E(Y_{i0} \mid D=0)$ is observed, $E(Y_{i0} \mid D = 1)$ is not. If $E(Y_{i0} \mid D=0)$ is substituted for $E(Y_{i0} \mid D = 1)$, bias is equal to the difference between the two estimatates $E(Y_{i0} \mid D = 1) - E(Y_{i0} \mid D=0)$.

As a thought experiment, if counties were randomly assigned to treatment

$$Y_{i1}, Y_{i0} \perp\!\!\!\perp D_i$$

Implies $E(Y_{i0} \mid D_i = 0) = E(Y_{i0} \mid D_i = 1) = E(Y_i \mid D_i = 0)$

Thus $E(Y_{i0} \mid D = 1) - E(Y_{i0} \mid D=0) = 0$

Where, $Y_i = DY_{i1} + (1 - D)Y_{i0}$ is the observed outcome, and $\perp\!\!\!\perp$ is the symbol for independence between random variables (Dahajia 1998). In randomized experiments, use of the observed outcome for non-participants as an estimate of the control does not introduce bias in the estimator.

> "In an experimental approach, individuals in a population are randomly assigned between participation and non-participation to a program, and the outcome of interest is compared between those groups. Random assignment should generate two groups, participants and nonparticipant, where each group has the same average characteristics for both observable and non-observable attributes.

> Randomization tends to make treated and control groups comparable in terms of all observed and unobserved covariates" (Rosenbaum 1995).

Random assignment solves the evaluation problem by direct construction of the unobserved counterfactual. If counties could be randomly assigned to participation in the CBP, then the non-participants' EQIP application rates could be substituted for the participants' unobserved "outcome had they not participated" without introducing bias.

Matching addresses the evaluation problem by assuming that the choice of participation (D_i =1 or D_i = 0) is independent of the non-participant outcome when the outcome is conditioned on a set of observable variables X (Smith 2006). This primary assumption is referred to as conditional independence assumption (CIA) or "ignorable treatment assignment" (Dahajia 1998, Rosenbaum and Rubin 1983). This assumption is expressed mathematically as:

$$Y_{i1}, Y_{i0} \perp\!\!\!\perp Di \mid X_i, \text{ for all i.}$$

Where the two potential outcomes are independent of assignment to treatment when conditioned on a set of attributes X.

> "Matching uses data on non-participants to estimate the participant's outcome as if they had not participated in the program. The term 'matching' is used since the comparison is made conditional on a set of observable variables, X, that affect both the outcome and likelihood of participation, yet are unaffected by participation (Borland 2005)."

The average treatment effect on the treated using a matching estimator is:

$$E(\Delta \mid D{=}1, X_i) = E(Y_{i1} \mid D{=}1, X_i) - E(Y_{i0} \mid D{=}0, X_i)$$

For this estimator to be unbiased requires that $E(Y_{i0} \mid D{=}1, X_i) = E(Y_{i0} \mid D{=}0, X_i)$. The interpretation of the above formula is that an unbiased estimate of the treatment effect can be obtained by substituting the observed outcome for a non-participant for the unobserved outcome of the participant's missing counter-factual.

In application, what is being proposed is the following: if county A participates in the CBP, only the county's outcome as a participant is observed ($Y_{i1} \mid D=1$). To estimate county A's outcome had the county not participated ($Y_{i0} \mid D=1$), one wants to identify a non-participant county B with outcome designated as ($Y_{i0} \mid D= 0$), which possesses all the similar attributes as possible as county A that influence the decision to participate and the outcome variable EQIP application rate.

By conditioning on a set of county attributes, the conditional independence assumption implies that the observed outcomes are independent of assignment to treatment, which is the same as assignment to treatment being effectively random for the two groups, participant, and non-participant (Borland 2005). Intuitively, the CIA requires that a county' decision to participate in the CBP is unrelated to what their outcome would have been in the absence of program participation.

An additional requirement is that the outcome of unit i is independent of unit j. This assumption is referred to as the stable unit treatment value assumption (SUTVA). This study proceeds to conduct an estimation of average treatment effect on the treated premised on the conditional independence assumption and the stable unit treatment assumption being fulfilled. There is not formal test of the CIA.

> "The CIA is satisfied if the vector of covariates includes all of the variables that affect both participation and outcomes" (Smith 2006).

The work of Rosenbaum and Rubin extended this estimation to non-experimental settings when randomization of treatment is not possible, as in the current situation.

One type of matching method is exact matching. As an example to illustrate exact matching, consider classifying each participant and non-participant county into "cells" based on their characteristics. For example, if counties were classified according to number of farms and number of non-farm businesses and each category was constructed as a binary variable; less than 300 farms and more than 300 farms and less than 500 businesses and more than 500 businesses, the following table could be used to match counties:

	Less than 300 farms	More than 300 farms
Less than 500 businesses		
More than 500 businesses		

Each observation could be placed into one of the four cells, and each cell would contain participant and non-participant counties with the corresponding attributes. Thus matching on two variables (i.e. farms and businesses) with only two discrete outcomes results in four cells, or 2^n, where n is the number of variables being used for matching. If one has 5 variables each with 3 values, then exact matching produces 3^5 = 243 cells. The number of cells increases exponentially as the number of matching variables increase, and in matching is referred to as "the curse of dimensionality" (Smith 2006, Borland 2005). As the number of variables used for matching increase and the number of cells increase exponentially, the probability of finding exact matches for participant and non-participant counties decreases (Dahajia 1998). Thus exact matching quickly becomes unmanageable.

Rosenbaum and Rubin demonstrated that matching on a set of covariates could be reduced to matching on a propensity score. Proofs are contained in Rosenbaum and Rubin (1983). The use of a propensity score reduces the dimensionality of the matching problem, and allows for matching on a scalar (Dehejia 1998).

In the context of this study, the propensity score is interpreted as the probability of a county choosing to participate in the CBP conditioned on a set of observable county attributes (Caliendo 2005). County participation is defined as a county submitting an application to the Pennsylvania Department of Environmental Protection and receiving funding to support a CBP watershed technician. All counties in the basin that enroll in the CBP receive funding designated for a watershed technician. As described above, the propensity score is a scalar with a range between 0 and 1. The county attributes which could be used for directly matching participant counties to non-participant counties are instead used to estimate the propensity score using logit regression. Logit regression is used when the dependent variable is binary. The dependent variable is defined as D=1 if county applied for CBP participation, and D=0 if the county is not a participant.

Chapter 4
Empirical Estimation

To estimate the CBP impact on participant counties, one estimator of interest to policy makers is the average treatment effect on the treated (ATET). The ATET is the difference in mean outcome for participants minus the mean outcome for participants if they had not participated in the program. Let N_1 be the number of counties that choose to participate and N_0 the number of non-participant counties.

To estimates the program impact one would like to calculate:

$$ATET = \frac{1}{N_1}\sum_i Y_{i1} - \frac{1}{N_1}\sum_i Y_{i0} \qquad (4.1)$$

Y_{i1} in the left-side term is the outcome variable (i.e. EQIP application rate) for participant counties with a set of covariates X. Y_{i0} is the unobserved EQIP application rate for participants absent any treatment.

As stated previously when discussing the population parameter, Y_{i0} is not observable for participants, and thus $\frac{1}{N_1}\sum_i Yi_0$ is unknown. This undetectable mean has to be replaced by an observable average (Frondel 2001).

Categories of estimators include before-after comparisons, cross-section estimators, and difference-in-difference estimators. Because this analysis is limited to one year, this paper employed the cross-section estimator where the mean of the observed outcome of non-participant counties is used to replace the mean of the unobservable Yi_0 for participants. The impact estimator of the average treatment effect on the treated is:

$$ATET = \frac{1}{N_1}\sum_i Y_{i1} - \frac{1}{N_0}\sum_j Y_{j0} \qquad (4.2)$$

The right-hand term is the observed outcome of non-participant counties that have been matched to participant counties based on the propensity score. The propensity score is the probability of a county participating in the CBP conditioned on a set of county characteristics. The notation P(x) is used to represent the propensity score. The propensity score is defined mathematically as a conditional probability that the assignment to treatment indicator variable $D_i = 1$ given a set of covariates **x.**

$$P(x) = \text{probability } (D=1|\ x) = \frac{pr(D=1)\ pr(x|\ D=1)}{pr(D=1)pr(x|\ D=1) + pr(D=0)pr(x|\ D=0)}$$

The above formula is an application of Bayes' rule for a conditional probability, where P(x) is the propensity score, probability (D=1| x) is the conditional probability of participation given set of county attributes, pr(x| D=1) is the conditional probability of a set of county attributes given county is a participant, and pr(x| D=0) is conditional probability of county attributes given county is non-participant. An assumption of equation 4.2 is that the expected outcome of a participant county absent the CBP is equal to the expected outcome of a non-participant county when conditioned on the propensity scores, expressed as: $E(Y_{i0} \mid D=1, P(x)) = E (Y_{i0} \mid D=0, P(x))$, where P(x) is the propensity score.

After matching on the propensity score, and satisfying the balancing requirements of the covariates, the above estimator is the difference of the simple average of the outcome variable (i.e. EQIP application rate) for the matched participant counties minus the simple or weighted average of the matched non-participants.

4.1 Data and Variable Selection

All data used for this analysis is county-level data. There are 43 counties with a portion of their land surface located in the Chesapeake Bay watershed. Thirty-six counties choose to participate in the Pennsylvania Department of Environmental Protection (DEP) Chesapeake Bay Program. All counties choosing to participate in the CBP received funding to support a watershed technician to work directly with farm operators. Technicians promote conservation practices and inform farm operators regarding opportunities to obtain cost-share funds to implement best management practices. The work of a watershed technician augments the educational out-reach efforts of conservation districts. It is expected that the work of a CBP watershed technician is positively correlated with farmers' willingness to enroll in farm conservation programs. This effect is consistent with the variable of communication and trust identified as a potential determinant of farmers' willingness to adopt conservation practices listed in the literature review.

The outcome variable for the study is EQIP application rate by county. The variable is calculated by dividing total EQIP applications from each county by the total number of farms per county. Estimates of farms by county were obtained from the U.S. 2002 Agricultural Census and are defined as any place from which $1,000 or more of agricultural products were produced and sold, or normally would have been sold, during the census year. The use of EQIP application rates as a proxy for farmers' willingness to participate in conservation program does not include farmers who are willing to participate but did not submit an application. EQIP is funded over the five-year duration of the 2002 Farm Bill 2002-2007. Although applications are accepted on a continuing basis, NRCS encourages EQIP applicants to submit one application that will address multiple environmental concerns to avoid the practice of submitting applications each year. Data was not available to identify what percentage of applicants received prior EQIP funding. The Natural Resources and Conservation Service (NRCS) provided the count of total EQIP applications for 2004.

The set of covariates used to estimate the propensity score were selected from the categories of farm characteristics, physical county attributes, and county level social and economic indicators. Appendix A contains the list and source for 79 variables assembled for consideration of being used as a covariate for estimating the propensity score.

The conditional independence assumption (CIA) requires the outcome variable to be independent of treatment conditional on the propensity score. Only variables that simultaneously influence the decision to participate (binary Di=0 or Di=1) and the outcome variable (EQIP application rates) should be included in the logit model to estimate the propensity score. Furthermore only variables that are unaffected by the participation decision should be included.

The logit model is: $$\Pr(D=1 \mid x) = \frac{\exp[\mathbf{x\beta}]}{1 + \exp[\mathbf{x\beta}]}$$

Where **x** is a vector of county covariates and **β** is a vector of corresponding coefficients estimated using logit regression. As a first step in selecting covariates, the correlation coefficient for the 79 county attributes and each of the two variables, Treatment and EQIP rates were calculated. From this list, 15 were identified as having higher correlation for both Treatment and EQIP rate relative to the other 64 variables. The selected variables are listed in Table2. Inspection reveals that the correlation is weak for most variables with rates near 0.20. These 15 variables were selected from the list of 79 variables because they have a higher correlation coefficient for both the Treatment variable, and the EQIP Application Rate than the 64 other county attributes.

Table 2. Selected Variables and Correlation with Treatment (D=1, D=0) and EQIP Application Rate

	Variable		Correlation Coefficient Treatment	EQIPRate
1	Farms with 500 to 999 acres		0.217	0.229
		p-value	0.102	0.083
2	Net Farm Income		0.551	0.208
		p-value	0	0.117
3	Percent county planted in crop		0.296	0.23
		p-value	0.024	0.083
4	Percent of county planted in corn crop		0.316	0.237
		p-value	0.016	0.074
5	Mean value equipment per farm		0.186	0.237
		p-value	0.162	0.073
6	Population 2000		-0.294	-0.175
		p-value	0.025	0.188
7	Number of Non-farm establishments with paid employees		-0.293	-0.171
		p-value	0.026	0.199
8	Percent of population with only high school degree		0.189	0.203
		p-value	0.155	0.127
9	Percent republican vote in 2004 presidential vote		0.471	0.259
		p-value	0	0.049
10	Number of hunting licenses		-0.25	-0.213
		p-value	0.058	0.108
11	ERS rural code		0.27	0.279
		p-value	0.041	0.034
12	Percent agricultural land within 150 feet of stream		0.267	0.221
		p-value	0.043	0.095
13	Number of acreage covered by nutrient management plans		0.48	0.184
		p-value	0	0.167
14	Number of EQIP contracts prior to 2004		0.212	0.29
		p-value	0.111	0.027
15	Number of housing units		-0.294	-0.174
		p-value	0.025	0.191

Economic theory, previous research, and information about the institutional settings should guide the researcher in building up the model (Caliendo 2005). An extensive review of the propensity score matching literature did not reveal prior empirical application to evaluating watershed protection programs. The selected variables for this study that have relatively higher correlation coefficient and correspond to conservation determinants identified in the agricultural econometrics literature include:

1. The number of farms with 500 to 999 acres.
   Positive correlation.
   Larger farms are likely to participate in working-land conservation programs such as EQIP than smaller "part-time" or "retiree farms'. (Lambert 2006)

2. Net farm income.
   Positive correlation.
   Higher farm income shifts budget constraints to adopt conservation practices. (Lambert 2006, Vollmer-Sanders 2006

3. Percent of agricultural land within 150 feet of waterway.
   Positive correlation.
   Lambert (2006) reports farm location next to a stream as a statistical significant determinant for working-farms to participate in conservation programs.

4. Number of Non-farm establishments with paid employees
   Negative correlation
   Increased opportunity for off farm employment associated with fewer enrollments in conservation programs. (Norris and Batie 1987)

5. Number of housing units
   Negative correlation
   The higher the number of housing units may be associated with increased opportunity for land development and subsequent reduced farm enrollment in conservation programs (Vollmer-Sanders 2006). However, increased housing stock may also increase societal pressure on farm operators to adopt conservation to reduce negative spillover effects.

Given the small sample size (58 observations) a parsimonious logit model was used to calculate propensity scores using only four variables. There is high correlation between the variable Farms with 500 to 999 acres and net farm income.

Also there was high correlation between number of non-farm establishments and number of housing units in a county. Number of farms with 500 -999 acres and number of non-farm establishments were selected for inclusion in the model. The percent of agricultural land within 150 feet of a stream, and the total number of EQIP funded applications prior to 2004 were also included. The variable, percent of Republican vote in 2004 presidential election, has the highest correlation coefficient with the participation variable and the EQIP rate variable of all the variables listed in Appendix A. Further investigation is warranted regarding the effect of this variable. Although this variable consistently is statistically significant in all model specifications using different covariates, it was not included in the model given the uncertainty of its role in explaining the participation decision and outcome variable. Descriptive statistics for the four covariates are listed in Table 3.

Table 3. Descriptive Statistics for Selected Covariates

Variable	Mean for Non-participants	Mean for Participants	P-value for two-sided t-test of difference in means Pr(|T| > |t|) =	Definition and Source
Farm 500-999 acres	40.4 (30.9) n=26	54.8 (34.1) n=32	0.098	Number of farms with 500 to 999 acres *Agricultural 2002 Census*
Number of Firms	6119 (8365) n=26	2520 (2712) n=32	0.044	Number of non-farm establishments with paid employees *Current Business Patterns*
Percent agriculture within 150 feet of stream	7.44 (2.67) n=26	8.95 (2.83) n=32	0.042	Percentage of agricultural lands within 150 feet of waterway *Pennsylvania Conservation Commission*
Number of EQIP Applications prior to 2004	3.96 (3.08) n=26	5.75 (4.89) n=32	0.096	Total number of EQIP applications (funded and unfunded) prior to FY2004 *Natural Resources Conservation Service*
Standard Deviations in parentheses				

4.2 Estimation

Dehejia (1998) present the following algorithm for estimating the propensity score:

1. Start with a parsimonious logit function to estimate the score
2. Sort data according to estimated propensity score (ranking from lowest to highest).
3. Stratify all observations such that estimated propensity scores within a stratum for treated and control units are close (no significant difference); e.g. start by dividing observations in blocks of equal score range (0-0.2…0.8-1).
4. Statistical test: for all covariates, differences-in-means across treated and control units within each block are not significantly different from zero.
   1. If covariates are balanced between treated and control observations for all blocks, stop.
   2. If covariate i is not balanced for some blocks, divide block into finer blocks and re-evaluate.
   3. If covariate i is not balanced for all blocks, modify the logit by adding interaction terms and/or higher-order terms of the covariate i and re-evaluate.

The propensity score matching values were estimated using Stata 9.1 Software. The software program uses a similar algorithm as described above to balance the propensity scores. The term balance is used to imply that the average propensity score for participant and non-participant observations do not differ within blocks (Becker 2002), and the differences in covariate means for participants and non-participants are not statistically significant at conventional significance levels. In Step 3 of the above algorithm, stratify is defined as initially subdividing the propensity scores into quintiles, and checking if the balancing conditions are met. If conditions are met, then the propensity scores remain stratified into quintiles, where each interval 0– 0.2, 0.2-0.4, 0.4-0.6, 0.6-0.8, and 0.8 – 1.0 is referred to as a "block". If the balancing conditions are not met, then the propensity scores are stratified into six blocks, and the balancing condition is checked. This process continues until the balancing condition is satisfied. As noted in step 4.3, if a covariate is not balanced for all blocks, the logit model is re-specified by adding interaction terms and/or high-order terms of the covariates to estimate a new set of propensity scores, and the stratification process is repeated to check for the balancing conditions.

The statistical test for balancing covariates requires that within each interval, the results from t-tests of mean differences for each of the covariates used in the logit regression reveals that the mean of the covariate does not differ between in-basin and out-basin counties.

To satisfy the balancing property, observations with the same propensity score must have the same distribution of characteristics independent of treatment status. To test if this condition is satisfied, a 2-sample t-test is used to verify that the differences in mean across treated and control units within each interval are not significantly different from zero (Chen 2004).

Upon completion of estimating propensity score for each county, Stata Software was used to estimate average treatment effects on the treated by matching on propensity scores (Becker and Ichino 2002). A propensity score was calculated for each county using a logit regression. The propensity score ranges from 0 to 1, and is the likelihood of a county participating in the CBP program given the selected county attributes. The counties are ranked highest to lowest according to their propensity score. After the propensity score is calculated and ranked from highest to lowest, the next step in the calculation of ATET is to match a non-participant county to a participant county based on propensity score.

There are many methods in the evaluation literature for purposes of matching. This study presents results for two types of matching methods, nearest neighbor matching and radius matching (Becker 2002). Matching on propensity scores is restricted to a common support, and as such the estimates of average treatment effect on the treated is defined only for those participants with a propensity score within the common support.

Borlan, 2005 defines common support as the requirement that for each program participant, there is some observation with the same (or sufficiently similar) characteristic that does not participate, and hence can be used as the matched comparison observation.

Common support implies omitting all observations of participant county propensity scores that are above the maximum propensity score for the non-participant counties, and omitting all observations for non-participant county propensity scores that are below the minimum propensity score for the participant counties. Matching on a common support makes it evident whether or not comparable non-participant units are available for each participant unit. In the matching literature, the benefit of matching on common support is contrasted to regression analysis when observations of participant and non-participants are clustered into two distinct groups and effects are estimated "solely by projection into regions where there are no data points (Smith 2006)."

The trade-off associated with matching on common support is loss of observations due to observations which lie outside the common support interval being discarded. One problem of establishing the common support using 'minima and maxima comparisons' is that potentially good matches for participant observations could have a propensity score that is very close to the bound and yet still be discarded (Smith 2006, Caliendo 2006).

4.3 Results

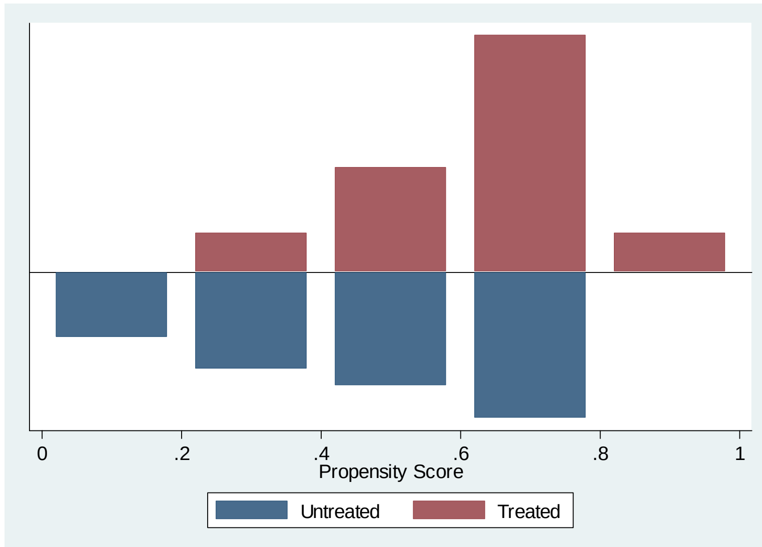
A logit regression model was used to estimate county propensity scores. The dependent variable is binary, with participation designated as D=1, and non-participation D=0. Table 4 lists the logit model results. The coefficients have the expected signs. The number of funded EQIP applications is positively associated with the likelihood that a county will choose to participate in the CBP. This may partially be attributed to the occurrence that if there is a prior track-record of farmers being successful obtaining cost-share funds for adoption of conservation practices there is support in the agricultural community for a county to participate in the CBP to obtain funding for a watershed technician to assist in developing applications for enrollment in farm conservation programs.

Table 4. Logit Estimates of the Coefficients of Participation

Independent Variable	Coefficient	SE Coefficient	P-value
Constant	-1.00486	1.12749	0.373
Farm500-999	0.0095844	0.0197394	0.6270
NumFirms	-0.0001782	0.0001129	0.114
PerAgStream	0.106273	0.116379	0.361
EQIPfy02-03	0.145102	0.0853441	0.089

Figure 5 is a histogram of propensity scores with the number of counties measured along the vertical axis and propensity scores measured on the horizontal axis. The interval of common support is [.28674648, .91886112]. Non-participants are counties labeled as untreated, and participant counties are labeled as treated. In light of the small sample size, the histogram shows a reasonably good mix of participant and non-participant scores for matching. Table 5 lists the distribution of propensity scores.

Figure 5. Histogram of Propensity Scores



Frequency of participants (treated) is top segment of bar graph
Frequency of non-participants (untreated) is bottom segment of bar graph
The region of common support is [.28674648, .91886112]

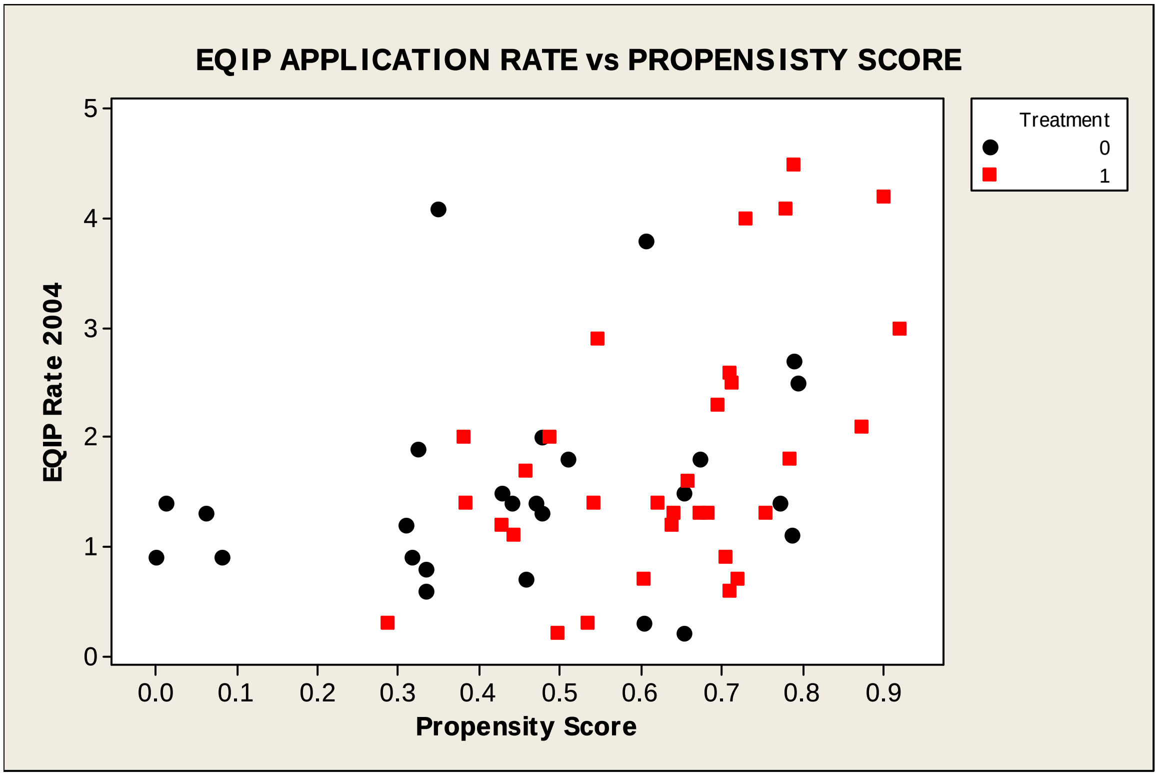
Table 5. Estimated Distribution of Propensity Scores

Propensity Score	Non-participant	Participant	Total	Common Support Total
0.0 – 0.2	4	0	4	0
0.2 – 0.4	6	3	9	9
0.4 – 0.6	7	8	15	15
0.6 – 0.8	9	18	27	27
0.8 – 1.0	0	3	3	3
Total	26	32	58	54

Balancing property for all covariates for each block has been satisfied.

The four non-participant counties with propensity scores below the lower bound of the common support interval are: Bucks, Delaware, Montgomery, and Allegheny with corresponding propensity scores of 0.08, 0.06, 0.02, and 0.001. The distribution of EQIP application rate for 2004 and the propensity scores for the participants (D=1, squares) and non-participants (D=0, circles) are shown in the following scatter-plot in Figure 6. The pattern illustrates a mix of participant and non-participant observations within the interval of 0.28 and 0.91. There is a cluster of 4 non-participant observations in the interval of 0 – 0.1 that are omitted from the calculation of ATET.

Figure 6. EQIP Application Rate and Propensity Scores



The matching process can be visualized as a search for a non-participant observation that has a propensity score closest to a participant observation. Thus, by drawing a vertical line through a participant observation one is searching for a non-participant observation which lies on the vertical line or closest either to the right or left of the line.

4.4 Assessing the Matching Quality

Table 6 lists the p-scores from a standard t-test for testing if the difference in means of propensity scores is statistically different from zero for non-participants and participants and whether the difference in means for non-participant and participant county covariates are statistically significant. The testing is conducted with quintiles of the propensity scores which correspond to blocks 1 – 5. The balancing condition for matching requires that the mean value of the propensity score and mean value for each of the county attributes for the non-participant counties be similar to the propensity score and mean value of the county attributes for the participant counties.

> "The basic intuition of the support problem is that if you are going to estimate the counterfactual for a given person by someone matched to that person, then you need to have someone similar to the person in the counterfactual state (Smith 2006)."

Whereas in Table 3, the difference in covariate means was statistically significant at the 0.1 significance level, the p-values listed in Table 6 indicate that the difference in covariate means are no longer statistically significant within blocks.

As stated previously, if county participation in the CBP could be randomly assigned, then randomization assures that the distribution of observable and unobservable county covariates would be similar for participants and non-participants. In matching, the balancing condition tests whether the participants and non-participants display similar distributions of propensity score and selected county attributes.

Inspection of Table 6 reveals results that are consistent with the balancing requirement. After matching, the difference in propensity score means and the covariates for the participants and non-participants are not statistically significant (Dehejia and Wahba 1998).

Table 6 Balancing on Propensity Scores

Covariate	Block	Mean for Non-participant	Mean for Participant	P-value for two-sided t-test of difference in means Pr(|T| >|t|)=
Propensity score	1	n=0	n=0	
Farm500-999	1	n=0	n=0	
NumFirms	1	n=0	n=0	
PerAgStream	1	n=0	n=0	
EQIPfy02-03	1	n=0	n=0	
Propensity Score	2	.3278005 (.0137141) n=6	.350545 (.055284) n=3	0.3446
Farm500-999	2	21.16667 (14.5522) n= 6	27.66667 (34.77547) n=3	0.6924
NumFirms	2	4928.5 (2569.635) n=6	5401.333 (2806.503) n=3	0.8073
PerAgStream	2	5.634667 (1.511095) n=6	6.512333 (.682916) n=3	0.3812
EQIPfy02-03	2	2.5 (3.016621) n=6	2.666667 (2.081666) n=3	0.9348
Propensity Score	3	.4660982 (.0267882) n=7	.491824 (.0462998) n=8	0.2196
Farm500-999	3	23.14286 (5.984106) n=7	20.125 (5.984106) n=8	0.4497
NumFirms	3	2902.571 (2760.091) n=7	2321.25 (2359.044) n=8	0.6671
PerAgStream	3	6.663286 (1.634976) n=7	6.9555 (2.357865) n=8	0.7879
EQIPfy02-03	3	3.142857 (1.9518) n=7	3.125 (3.226564) n=8	0.9900
Propensity Score	4	.703255 (.0807809) n=9	.700214 (.05493) n=18	0.9088
Farm500-999	4	30.55556 (18.6421) n=9	32.55556 (16.40022) n=18	0.7775
NumFirms	4	1898.778 (1417.052) n=9	2297.389 (1417.052) n=18	0.7024
PerAgStream	4	9.927667 (2.760862) n=9	10.28933 (2.760862) n=18	0.7468
EQIPfy02-03	4	6.111111 (2.934469)	6 (4.537426)	0.9475

		n=9	n=18	
Covariate	Block	Mean for Non-participant	Mean for Participant	P-value for two-sided t-test of difference in means Pr(|T| >|t|)=
Propensity Score	5	n=0	n=3	
Farm500-999	5	n=0	n=3	
NumFirms	5	n=0	n=3	
PerAgStream	5	n=0	n=3	
EQIPfy02-03	5	n=0	n=3	

Caliendo (2005) identifies several methods to assess the matching quality of selected covariates to check if the matching procedure is able to balance the distribution of the relevant variables in both the participant and non-participant groups. The basic idea is to compare the situation before and after matching and check if there remain differences after conditioning on the propensity score.

Sianesi (2004) suggests re-estimating the propensity score on the matched sample and comparing the pseudo-R^2's before and after matching. The pseudo-R^2 indicates how well the regression covariates explain the participation probability. After matching there should be no systematic differences in the distribution of covariates between participants and non-participants. Therefore, the pseudo-R^2 should be fairly low. The pseudo-R^2 associated with the logit regression prior to matching is 0.15, and after matching, the logit regression using the matched observations is 0.02. Therefore, after matching the covariates are balanced within groups (participants and non-participants) and explain little of the probability of participation.

An F-test for the joint significance of the covariates prior to matching has a p-value of 0.017, and after matching the F-test for joint significance has a p-value of 0.84. One wants the F-test to be significant when the initial propensity scores are estimated using the logit regression because participants and non-participants differ in their attributes. The coefficients reflect these differences and for a model constructed to explain the probability of participation one wants to reject the hypothesis that all coefficients are zero. After selecting those participants and non-participants who are similar in terms of the selected covariates, differences should no longer be present. If the logit model is re-estimated using the reduced sample of matched observations, there are no differences in the two groups, and the regression coefficients should not be significant corresponding to a higher p-value.

The results from the t-tests for differences in propensity score means and the covariates, the comparison of pseudo-R^2, and the comparison of F-tests are consistent with the model being estimated with a balanced set of covariates.

Table 7 lists the counties by propensity score within blocks. A small data set allows for direct comparison of matched participant and non-participant counties. Randomization of participation and non-participation to a program results in independent and identical distributions of observable and non-observables for participants and non-participants. It is this outcome that allows for the direct estimation of program impact by calculating the difference in mean outcome for participants and non-participants to be an unbiased estimator of the program impact.

Estimation by matching on propensity scores attempts to emulate this outcome by construction of distributions that are similar for the observable attributes for participants and non-participants. It is the similarity of these distributions that allows for the substitution of non-participants outcomes for the expected outcome of participants as if they did not participate in the programs, which is the missing counter-factual. This substitution is premised on the assumption that the decision to participate is not influenced by unobservable county attributes.

Table 7. Propensity Scores within Common Support by Block by County

	code	county	treatment	Rate04	PS1	match	block	comsup	weight
1	58	SUSQUEHANNA	1	3	0.918861	1	5	1	
2	49	NORTHUMBERLAND	1	4.2	0.898891	1	5	1	
3	56	SOMERSET	1	2.1	0.873308	1	5	1	
4	20	CRAWFORD	0	2.5	0.792762	1	4	1	3
5	29	FULTON	1	4.5	0.789106	1	4	1	
6	59	TIOGA	0	2.7	0.787744	1	4	1	1
7	63	WASHINGTON	0	1.1	0.787231	1	4	1	1
8	55	SNYDER	1	1.8	0.783845	1	4	1	
9	53	POTTER	1	4.1	0.779303	1	4	1	
10	30	GREENE	0	1.4	0.772073	1	4	1	3
11	1	ADAMS	1	1.3	0.753913	1	4	1	
12	7	BLAIR	1	4	0.72902	1	4	1	
13	5	BEDFORD	1	0.7	0.719946	1	4	1	
14	28	FRANKLIN	1	2.5	0.711235	1	4	1	
15	31	HUNTINGDON	1	0.6	0.710117	1	4	1	
16	18	CLINTON	1	2.6	0.709527	1	4	1	
17	50	PERRY	1	0.9	0.705211	1	4	1	
18	15	CHESTER	1	2.3	0.694436	1	4	1	
19	32	INDIANA	1	1.3	0.682954	1	4	1	
20	64	WAYNE	0	1.8	0.67347	1	4	1	8
21	47	MONTOUR	1	1.3	0.67337	1	4	1	
22	21	CUMBERLAND	1	1.6	0.657171	1	4	1	
23	62	WARREN	0	0.2	0.653515	1	4	1	1
24	42	MCKEAN	0	1.5	0.652683	1	4	1	2
25	11	CAMBRIA	1	1.3	0.640881	1	4	1	
26	14	CENTRE	1	1.2	0.6387	1	4	1	
27	34	JUNIATA	1	1.4	0.620738	1	4	1	
28	3	ARMSTRONG	0	3.8	0.606295	1	4	1	1
29	44	MIFFLIN	1	0.7	0.604382	1	4	1	
30	4	BEAVER	0	0.3	0.603522	1	4	1	1
31	57	SULLIVAN	1	2.9	0.546776	1	3	1	
32	66	WYOMING	1	1.4	0.541326	1	3	1	
33	41	LYCOMING	1	0.3	0.533112	1	3	1	
34	43	MERCER	0	1.8	0.510245	1	3	1	4
35	60	UNION	1	0.2	0.497592	1	3	1	
36	19	COLUMBIA	1	2	0.488517	1	3	1	
37	33	JEFFERSON	0	2	0.478397	1	3	1	1
38	61	VENANGO	0	1.3	0.476548	0	3	1	0
39	26	FAYETTE	0	1.4	0.469124	0	3	1	0
40	16	CLARION	0	0.7	0.45881	1	3	1	1
41	17	CLEARFIELD	1	1.7	0.457955	1	3	1	
42	40	LUZERNE	1	1.1	0.441843	1	3	1	
43	37	LAWRENCE	0	1.4	0.440807	1	3	1	1
44	65	WESTMORELAND	0	1.5	0.428757	1	3	1	1
45	54	SCHUYLKILL	1	1.2	0.42747	1	3	1	
46	38	LEBANON	1	1.4	0.384352	1	2	1	
47	6	BERKS	1	2	0.380536	1	2	1	
48	48	NORTHAMPTON	0	4.1	0.348769	1	2	1	2
49	39	LEHIGH	0	0.8	0.333262	0	2	1	0
50	25	ERIE	0	0.6	0.33303	0	2	1	0
51	13	CARBON	0	1.9	0.324649	0	2	1	0
52	10	BUTLER	0	0.9	0.317238	0	2	1	0
53	45	MONROE	0	1.2	0.309856	1	2	1	1
54	35	LACKAWANNA	1	0.3	0.286747	1	2	1	

In the matching literature using propensity scores, there are several algorithms for selecting pairs of participant and non-participant propensity scores for purposes of matching the outcome variable (Becker 2002). The two method used for this paper consists of nearest neighbor matching with replacement and radius matching. Nearest neighbor matching sets

$$C(i) = \min_{j} \| p_i - p_j \| \qquad (4.3)$$

Where:

$\| p_i - pj \|$ is the absolute value of the difference between the propensity score for a participant county p_i and the propensity score for a non-participant county p_j

C(i) = the set of control units matched to the treated unit i with an estimated propensity score of p_i.

C(i) is a singleton, unless there are multiple nearest neighbors.

Radius matching is defined as:

$$C(i) = \{ p_j \mid \| p_i - p_j \| < r\} \qquad (4.4)$$

All the control units with estimated propensity scores falling within a radius r from p_i are matched to the treated unit i. Depending on the specification of r, radius matching can be used to increase the number of control units used, especially when the data set is small.

The formula for both types of matching estimators can be written as:

$$\text{ATET}= \frac{1}{N}\sum_{i \in T} Yi - \frac{1}{N}\sum_{j \in C} wjYj \qquad (4.5)$$

Where the weights w_j are defined by $w_j = \sum_i wij$. The weight assigned to a unit is the frequency the control unit was used as a match. This value for nearest neighbor matching was calculated by inspection and is listed in Table 7.

Table 8 contains the descriptive statistics for the absolute value propensity-score difference between participants and non-participants. The average difference in matched propensity scores is 0.026. The maximum difference between a matched pair is 0.12 which is relatively large and is due to the small sample set.

Table 8. Average Absolute Propensity Score Difference Between Participant and Non-participant

Variable	Observations	Mean	Std Deviations	Min	Max
Propensity Score	32	0.0267	0.0296	0.00009	0.12

Estimates of the average treatment effect on the treated (ATET) are listed in Table 9. Depending on the selection of matching algorithm the ATET values range from -0.047 to 0.219. The ATET is interpreted as the impact the CBP has on EQIP application rates for counties that participate in the CBP. The hypothesis for this study is that the CBP has a positive impact on farmers' willingness to enroll in EQIP. The null hypothesis that the difference in means is different from zero cannot be rejected for any of the three ATET estimates. Thus, there is no empirical evidence given the design of this study, that the CBP is impacting farmers' willingness to enroll in EQIP. Given the common support criteria for selecting observations for matching, the estimate of ATET is limited to those participant counties with propensity scores with the interval [.28674648, .91886112].

The formulas to analytically calculate the standard errors of the mean participant and non-participant EQIP rate are contained in Becker and Ichino 2002. The Stata software program for estimating ATET (Stata command: attnd) includes options for estimating standard errors using boot-strapping. The estimate of ATET standard error using boot-strapping with nearest neighbor matching and 100 replications is 0.448. This result compares closely to the analytically calculated standard error of 0.422.

Table 9. Estimates of Average Treatment Effect on Treated

Nearest Neighbor							
	Observations	Weight	Mean	Std. Deviations	Min	Max	t
Participant Rate	32		1.809	1.16	0.2	4.4	
Non-participant Rate	16	32	1.85	0.90	0.2	4.1	
ATET			**-0.047**	0.422			-0.111

Radius Matching with r = 0.01							
	Observations	Weight	Mean	Std. Deviations	Min	Max	t
Participant Rate	10		1.93	1.291898	0.7	4.5	
Non-participant Rate	12	10	1.711111	0.96162	0.2	3.8	
ATET			**0.219**	0.528			0.415

Radius Matching with r = 0.05							
	Observations	Weight	Mean	Std. Deviations	Min	Max	t
Participant Rate	29		1.675862	1.103778	0.2	4.5	
Non-participant Rate	22	29	1.532979	0.904747	0.2	4.1	
ATET			**0.14**3	0.317			0.451

Radius Matching with r = 0.10							
	Observations	Weight	Mean	Std. Deviations	Min	Max	t
Participant Rate	30		1.69	1.087341	0.2	4.5	
Non-participant Rate	22	30	1.609453	0.980282	0.2	4.1	
ATET			**0.081**	0.303			0.265

Chapter 5

Concluding Remarks

This final section interprets the results, addresses the policy implications of the results and identifies potential areas for further research.

The selected set of covariates for estimating the propensity score using a logit model resulted in estimated coefficients with signs that are consistent with expected outcomes. The number of farms with 500 to 999 acres in a county and the percentage of county agricultural land within 150 feet of a waterway were associated with a positive effect on the probability of a county choosing to participate in the Chesapeake Bay Program. The number of non-farm establishments with paid employees is negatively associated with likelihood of participation. This may partially be attributed to the possibility that the greater the number of non-farm employment establishments in a county, the lower the perceived benefit of have a CBP watershed technician to work with farm operators.

The total number of funded EQIP applications in a county for the years prior to 2004 had a positive effect, and was statistically significant at a significance level of 0.05. Cumulative performance of EQIP in terms of total applications funded positively influences the probability of a county choosing to participate in the CBP. Because the estimation of CBP impact was limited to the one year, 2004, this variable was included as a lagged covariate.

A total of 58 observations were included in the unmatched sample which was comprised of 32 participant counties and 26 non-participant counties. The mean EQIP rate for the two groups in the unmatched sample is 1.8 percent for participant counties, and 1.5 percent for non-participant counties. After matching on propensity scores, the mean rate for participant counties remains the same, 1.8 (i.e. all 32 participant county observations were matched), however, the mean EQIP application rate for non-participants after matching is 1.85 percent. The increase in the mean EQIP application rate for the non-participant counties after matching is attributed to omitting non-participant observations with propensity scores which were below the lower bound for the common support interval, and not all non-participant county observations were used for matching. Only 16 of the 22 non-participant observations were used for matching.

The choice of matching algorithm significantly influences the estimation of mean effect for the control units. When matching is conducted using radius matching with r = 0.01, only those control observations (non-participants) with a propensity score within an absolute distance of 0.01 of a participant observation propensity score are included in the matched sample set. Multiple control counties can be matched to the same participant county. Thus while radius matching can be used to improve the quality of matches by selecting a small value for r, it results in smaller matched sample size. In this study, when r is 0.01, 10 participant observations and 12 non-participant observations are included in the estimation of average treatment effect on the treated. The mean EQIP rate for participants is 1.93 percent, and the mean EQIP rate for non-participants is 1.71 percent. The average treatment effect on the treated is the difference of 0.2 percent. The impact of the CBP on participating counties is to increase the average county EQIP application rate by 2 tenths of a percent. The result is small in magnitude and statistically significant with an estimated t-statistic of 0.44

Although within the matching literature (Caliendo 2006), there are proposed tests to evaluate the sensitivity of ATET estimates to unobserved differences between participants and non-participants, no evaluation was conducted in this study in light of the results not being statistically significant.

The following discussion of policy implications is presented with the assumption these results are consistent with future findings to evaluate the impact of the CBP on EQIP application rates. In light of the limited scope of this study, the recommendations are directed to the Pennsylvania Department of Environmental Protection (DEP) Chesapeake Bay Program.

This investigation did not find a positive impact of the DEP CBP on EQIP applications rates as hypothesized. The result has important implications for the CBP's goal of reducing agricultural nutrient enrichment.

Prior to 2002, Pennsylvania experienced success in reducing phosphorus loads to the bay via its tributaries. Over a 15 year period, annual phosphorus loads were reduced by nearly 793,000 pounds. Nitrogen loads were reduced by 5.7 million pounds per year. DEP credits many programs for contributing to the decline in nutrient loads, including its Chesapeake Bay Program, Nutrient Management Act Program, key federal programs such as EQIP, Conservation Reserve Program, and Conservation Reserve Enhancement Program. Also during this time Pennsylvania enacted a phosphate detergent ban in 1990, and increased nutrient removal efficiencies at wastewater treatment plant. Sixty-five percent of the phosphorus reduction is attributed to point source programs, and 21 percent is attributed to EQIP. Conservation practices funded under EQIP accounted for 58 percent of total nitrogen reductions. Point sources resulted in a net increase of nitrogen loadings of 1.4 million pounds per year (Pennsylvania Department of Environmental Protection 2002). Future policies to reduce nutrient loadings are expected to increasingly focus on agricultural related nutrient loading sources.

The increasing priority given to reducing agricultural nutrient enrichment will necessitate the need for improved understanding of the CBP's impact on farmers' willingness to enroll in conservation programs, especially if the CBP is going to continue to relay on a voluntary approach to adoption of farm conservation practices in contrast to its regulatory approach of the Nutrient Management Act Program.

The first recommendation of this study is for the Pennsylvania DEP to better document the impact of its programs on agriculture. EQIP is the primary conservation program for reducing nutrient enrichment from production agriculture. The CBP has an extensive network of partner organizations with scientific and educational expertise related to agricultural production and farm conservation. Improved documentation of its program impact on agriculture will bring forth improved definition of measurable outcomes. This recommendation is consistent with an identified need described by the Scientific and Technical Advisory Committee of the Chesapeake Bay Program, which stated “there is a need to better quantify the effectiveness of existing strategies and to develop new strategies to meet the challenges of new, more aggressive nutrient reduction goals while maintaining and enhancing farm profitability (Scientific and Technical Advisory Committee 2004).

A second recommendation of this study is for the Pennsylvania DEP to develop a monitoring system for its Chesapeake Bay Program. If one of the goals of the program is to reduce agricultural nutrient enrichment from production agriculture, the Pennsylvania DEP should work with NRCS and representatives of farm groups to improve coordination among county CBP watershed technicians and NRCS EQIP program specialists. DEP should produce a biennial report documenting the accomplishments of its state administered CBP.

Documenting the impact of the CBP could be expanded to include other conservation programs, beginning with the Conservation Reserve Program (CRP), and the Conservation Reserve Enhancement Program (CREP). It may be that CBP watershed technicians are successful motivating farmers to enroll in these programs. As noted earlier in Section 1.4, Pennsylvania is the nation's leading state in contracts and dollars obligated under CREP. However, these programs were credited with contributing less than 1 percent toward phosphorus reductions, and less than 5 percent of nitrogen reductions as of 2002 (Pennsylvania Department of Environmental Protection 2002).Both programs result in removing crop lands from production and placing the land in a conservation reserve status with resource conserving planting (Zinn 2005).

Areas for future research include increasing the sample size via using panel data and extending the study are to the entire Chesapeake Bay basin. Both measures introduce new challenges to estimation. Within the three signatory states of Pennsylvania, Maryland, and Virginia there are approximately 180 counties of which 140 have a portion of their land area in the basin. The ratio of non-participant counties to participant counties becomes smaller when the study is expanded to the entire basin. This presents challenges for using matching estimators. Furthermore, variables to control for differences in state programs would be needed because each state participates in the CBP uniquely with its own set of state regulations and programs.

The selection of an outcome variable warrants further research. Analysis could be conducted using total dollars obligated or total acreage enrolled in EQIP. The investigation could include the impact of the CBP on other conservation programs such as Conservation Reserve Program, Wetlands Reserve Program, or the Conservation Reserve Enhancement Program.

The count of farms by county used for this study includes multiple farms owned by a single farm operator. The county count also includes farm operators who belong to the Amish and Mennonite communities, who typically choose not to participate in federally funded conservation programs. The count also includes operators of very small farms who commonly do not participate in EQIP. Further research is warranted to better define the subset of farm operators likely to participate in EQIP.

This study is an initial attempt to empirically estimate the impact of the Pennsylvania CBP on participation in EQIP. Although, policy recommendations must be viewed in light of the limitation's of the study, the results indicate a need for the Pennsylvania DEP to re-evaluate its initiatives and programs intended to influence farm adoption of conservation practices.

Restoring the ecological health of the Chesapeake Bay requires reducing agricultural nutrient enrichment. This requirement was first articulated in the early 1970s, became a focus of the CBP in the 1990s, was re-affirmed in the 2002 Chesapeake Bay Agreement and continues to be a leading priority of the signatory states.

If the CBP is to be successful reducing agricultural nutrient enrichment, a clearer understanding of its impact on farm behavior and adoption of conservation practices is needed. After 15 years of focusing on reducing agricultural nutrient enrichment, the CBP would benefit from re-allocating resources to support additional research and analysis to evaluate its impact on the agricultural sector.

APPENDIX A

List of Variables Considered as County Covariates for Matching

	Variable	Treatment Correlation	EQIPRate Correlation	Data Source
1	Conservation Reserve Payments (dollars)	0.631	0.074	3
2	Net Farm Income (dollars)	0.538	0.112	1
3	Phosphorus source transport index	0.534	0.077	4
4	Percent Dairy Farms	0.493	0.149	1
5	Acres covered by nutrient management plans	0.482	0.154	4
6	Animal Equivalent Units (AEU) per acre	0.474	-0.043	4
7	**Percent Republican Presidential Vote 2004**	**0.441**	**0.303**	**10**
8	Mean soil phosphorus level (ppm)	0.439	-0.154	4
9	Percent county land used for crop production	0.433	0.102	1
10	Acres treated with manure	0.419	0.065	1
11	Percent county land used for corn production	0.418	0.076	1
12	Farm Operating loans (dollars)	0.415	0.09	3
13	Number of nutrient management plans	0.405	0.047	4
14	Percent agricultural land	0.382	0.011	4
15	Percent of soil samples exceeding 50ppm phosphorus	0.369	-0.158	4
16	Number of farms applying manure	0.358	0.026	1
17	**Number of farms 500 to 999 acres**	**0.355**	**0.286**	**1**
18	**Number of EQIP contracts FY2002 and FY2003**	**0.349**	**0.179**	**6**
19	Percent of Farms with farming primary occupation	0.341	-0.013	1
20	Number of cattle	0.34	0.075	1
21	Farms with sales exceeding 1000 (thousands dollars)	0.332	-0.001	1
22	Number of poultry	0.33	-0.045	1
23	Number of acres irrigated	0.313	-0.113	1
24	Number of hogs	0.307	-0.016	1
25	Number of dairy farms	0.301	0.026	1
26	Farm acreage	0.291	0.079	1
27	**EQIP Obligations FY2002 and FY2003**	**0.29**	**0.18**	**6**
28	**Average soil phosphorus levels**	**0.282**	**-0.188**	**4**
29	**Number of farms 180 to 499 acres**	**0.281**	**0.177**	**1**
30	Number of acres covered by farm conservation easement	0.281	-0.086	4
31	Number of farms with farming primary occupation	0.275	-0.034	1
32	Number of farms with 1000 acres or more	0.27	0.108	1
33	**Percent of agricultural land within 150 feet of stream**	**0.264**	**0.323**	**4**
34	**Number of acres covered by EQIP as of FY2003**	**0.263**	**0.243**	**6**
35	Mean value of equipment per farm (dollars)	0.26	0.137	1
36	Number of farms	0.254	-0.047	1
37	Farms with sales 500 to 999 (thousands dollars)	0.253	-0.018	1
38	Farms with sales 250 to 499 (thousands dollars)	0.248	-0.049	1
39	Percent change in housing stock	0.236	-0.069	2
40	Farms with 1 to 9 acres	0.235	-0.069	1
41	Farms with sales 100 to 249 (thousands dollars)	0.234	-0.067	1
42	Number of poultry farms	0.234	-0.054	1
43	Number of farm conservation easements	0.23	-0.089	4
44	Number of cattle farms	0.222	0.001	1

	Variable	Treatment Correlation	Rate Correlation	
45	Farms with 10 to 49 acres	0.217	-0.124	1
46	Farms with 50 to 179 acres	0.21	-0.058	1
47	Number of hog farms	0.196	-0.041	1
48	Percent of cattle farms	0.162	0.147	1
49	Percent soil samples exceeding 300ppm phosphorus	0.157	-0.163	4
50	Percent soil samples exceeding 200ppm phosphorus	0.149	-0.192	4
51	Farms with less than 10,000 sales revenue	0.143	-0.065	1
52	Farm Operating loans (dollars)	0.134	0.077	3
53	Farms with sales 50 to 99 (thousand dollars)	0.129	-0.094	1
54	Farms with sales 25 to 49 (thousands dollars)	0.103	-0.058	1
55	Percent of population with only high school degree	0.1	0.23	9
56	Federal highway grants (dollars)	0.065	-0.151	3
57	Percent change in population 2000 - 2004	0.04	-0.172	2
58	Median income as a percent of state median	0.027	-0.122	2
59	Median income	0.024	-0.12	2
60	Number of dairy farms	-0.004	0.032	1
61	Number of beef cows	-0.006	0.033	1
62	Number of hunting licenses	-0.018	-0.196	11
63	Housing construction permits	-0.032	-0.143	2
64	Number of beef farms	-0.043	-0.004	1
65	Percent of hog farms	-0.052	0.092	1
66	Percent of poultry farms	-0.055	-0.086	1
67	Percent of population with college degrees	-0.062	-0.171	9
68	Percent of livestock farms	-0.064	0.139	1
69	Industrial groundwater withdrawal	-0.108	0.014	8
70	Percent of forest cover	-0.137	0.129	5
71	Water land ratio	-0.142	-0.111	11
72	Total direct federal expenditure	-0.177	-0.222	3
73	**Density**	**-0.186**	**-0.178**	**1**
74	**Population 2004**	**-0.192**	**-0.226**	**7**
75	**Population 2000**	**-0.194**	**-0.227**	**7**
76	Unemployment rate	-0.197	0.067	9
77	**Number of firms**	**-0.203**	**-0.21**	**2**
78	**Number of housing units**	**-0.233**	**-0.228**	**7**
79	Percent of beef farms	-0.32	0.101	1

Source:

1. U.S. 2002 Agricultural Census
2. County Business Patterns U.S. Bureau of Census
3. Federal, State, and Local Governments Consolidated Federal Funds Report
4. Pennsylvania State Conservation Commission
5. Pennsylvania Bureau of Forestry
6. Natural Resources and Conservation Service
7. U.S. Census Bureau
8. United States Geological Survey
9. Economic Research Service
10. Wilkes University Pennsylvania Election Statistics
11. Pennsylvania State Data Center

APPENDIX B

DATA SET

Code	County	Treatment	EQIP App04	Farms	Eqip Rate	Farm 500to999	NumFirm	PerAgStream	EQIP contracts FY0203
1	ADAMS	1	17	1261	1.35	63	1911	9.321	6
2	ALLEGHENY	0	4	464	0.86	2	34819	6.07	0
3	ARMSTRONG	0	28	739	3.79	34	1496	7.499	4
4	BEAVER	0	2	645	0.31	8	3476	6.228	9
5	BEDFORD	1	8	1093	0.73	50	1081	14.278	1
6	BERKS	1	36	1791	2.01	67	8210	5.768	5
7	BLAIR	1	20	504	3.97	28	3235	13.475	6
8	BRADFORD	1	97	1495	6.49	107	1321	9.08	9
9	BUCKS	0	8	917	0.87	21	18032	5.588	7
10	BUTLER	0	10	1174	0.85	34	4294	6.377	0
11	CAMBRIA	1	8	634	1.26	27	3520	7.45	8
12	CAMERON	0	3	35	8.57	0	140	11.43	1
13	CARBON	0	4	206	1.94	5	1114	3.98	0
14	CENTRE	1	15	1213	1.24	38	3163	8.501	6
15	CHESTER	1	44	1918	2.29	37	12399	5.962	21
16	CLARION	0	4	591	0.68	29	1067	5.71	1
17	CLEARFIELD	1	8	468	1.71	12	1922	3.183	5
18	CLINTON	1	11	420	2.62	15	742	8.193	7
19	COLUMBIA	1	18	884	2.04	27	1499	6.371	2
20	CRAWFORD	0	35	1416	2.47	50	2152	8.891	9
21	CUMBERLAND	1	18	1116	1.61	43	5587	6.05	11
22	DAUPHIN	1	7	852	0.82	16	6573	9.352	9
23	DELAWARE	0	1	76	1.32	0	13214	6.29	0
24	ELK	0	0	226	0.00	0	990	5.703	1
25	ERIE	0	8	1283	0.62	38	6994	7.125	3
26	FAYETTE	0	14	978	1.43	24	2753	8.013	2
27	FOREST	0	0	59	0.00	1	146	2.587	0
28	FRANKLIN	1	35	1418	2.47	70	2804	12.23	3
29	FULTON	1	25	561	4.46	31	290	14.101	4
30	GREENE	0	12	881	1.36	24	668	14.43	4
31	HUNTINGDON	1	5	848	0.59	40	826	12.933	2
32	INDIANA	1	12	903	1.33	30	1984	7.74	7
33	JEFFERSON	0	11	548	2.01	15	1185	5.18	3
34	JUNIATA	1	9	644	1.40	15	501	10.848	2
35	LACKAWANNA	1	1	289	0.35	1	5397	7.11	2
36	LANCASTER	1	59	5293	1.11	53	11524	6.334	20
37	LAWRENCE	0	10	703	1.42	23	2163	6.039	2
38	LEBANON	1	16	1104	1.45	15	2597	6.659	1
39	LEHIGH	0	5	618	0.81	16	8190	5.663	7
40	LUZERNE	1	6	548	1.09	13	7580	5.141	10
41	LYCOMING	1	4	1323	0.30	30	2825	8.639	3
42	MCKEAN	0	4	265	1.51	12	1116	13.45	2
43	MERCER	0	22	1239	1.78	28	2938	6.781	4
44	MIFFLIN	1	5	752	0.66	17	924	9.363	3
45	MONROE	0	4	324	1.23	5	3312	7.023	0
46	MONTGOMERY	0	10	729	1.37	10	26051	5.689	4
47	MONTOUR	1	4	304	1.32	12	355	11.68	3
48	NORTHAMPTON	0	20	487	4.11	29	5667	3.64	5
49	NORTHUMBERLAND	1	30	719	4.17	22	1765	9.145	16
50	PERRY	1	7	752	0.93	31	753	9.303	5

51	PHILADELPHIA	0	0	9	0.00	0	25621	0	0
52	PIKE	0	0	51	0.00	3	732	7.86	0
53	POTTER	1	14	343	4.08	24	438	13.07	5
54	SCHUYLKILL	1	10	838	1.19	33	3086	6.174	2
55	SNYDER	1	14	784	1.79	15	840	10.71	8
56	SOMERSET	1	25	1194	2.09	65	1935	7.254	13
57	SULLIVAN	1	5	170	2.94	12	170	10.424	0
58	SUSQUEHANNA	1	34	1116	3.05	56	817	9.497	14
59	TIOGA	0	26	973	2.67	63	859	10.727	5
60	UNION	1	1	521	0.19	17	853	9.262	0
61	VENANGO	0	6	473	1.27	15	1291	5.288	3
62	WARREN	0	1	499	0.20	14	982	7.618	6
63	WASHINGTON	0	28	2506	1.12	43	4912	11.106	11
64	WAYNE	0	12	661	1.82	27	1428	9.4	5
65	WESTMORELAND	0	20	1353	1.48	28	8921	9.632	7
66	WYOMING	1	5	358	1.40	17	635	6.45	3
67	YORK	1	19	2546	0.75	50	8234	6.369	9

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