THESIS

THE ECONOMIC CONSEQUENCES OF PRIVATE LANDS CONSERVATION USING CONSERVATION EASEMENTS IN COLORADO

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ABSTRACT

THE ECONOMIC CONSEQUENCES OF PRIVATE LANDS CONSERVATION USING CONSERVATION EASEMENTS IN COLORADO

Conservation easements have been used across the United States to preserve natural amenities and compensate landowners for the public goods they provide. From the Farm and Ranch Land Protection Program to the Grassland Reserve Program, Colorado conserves 2.4 million acres of land (Colorado Natural Heritage Program and the Geospatial Centroid, 2018) This thesis explores the economic implications of Federal conservation easements through the Agricultural Conservation Easement Program in Colorado. Using Input-Output modeling I found that conservation easements contributed $176 million to Colorado's economic activity. Further Multi-Region Input-Output models showed that conservation easements support rural counties between $106 million and $112 million more than two counterfactuals I considered: decreasing federal income tax and a zero counterfactual. Further, using benefit transfer analysis, I estimated that all conservation easements in Colorado provide between $40 and $47 billion in ecosystem service benefits to Coloradoans. Using econometric meta-analysis techniques, I estimated that Coloradoans are willing to pay $4.3 billion for all the conserved lands in Colorado. I propose an alternative payment methodology that incentivizes landowners to enroll environmentally important lands rather than using development opportunity costs to determine payments.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1. INTRODUCTION

Conservation easements have been used to conserve private lands in federal programs since 1985 (Cain & Lovejoy, 2004). The state of Colorado allocates $45 million annually to fund conservation easements (Ray et al., 2016). Landowners permanently retire a subset of their private property rights when they enroll in a conservation easement program in exchange for payments and/or state and federal tax credits. I hypothesize that the benefits provided by conservation easements justify the costs to taxpayers and that an alternative payment mechanism could provide more ecological benefits for Colorado. I test this hypothesis by investigating the economic consequences of conservation easements in regards to the economic impact, the ecological benefits provided, Coloradoans' willingness to pay for conservation easements, and alternative payment mechanisms.

Colorado's awe-inspiring Rocky Mountains attract outdoor enthusiasts from all over the world. Since 71 percent of Coloradoans participate in outdoor recreation, it comes as no surprise that residents highly value their state's natural capital: from tourist attractions like jagged mountain peaks and sand dunes to an agricultural way of life in the eastern plains and fruit orchards on the western slopes (Outdoor Industry Association, 2018). Conservation easement programs aim to protect the ecological, cultural, and agricultural value of Colorado's natural capital through purchasing development and building rights from landowners. These easements can protect ecologically important habitat, ensure viable farmland for future generations, or provide open space and working landscapes. As of 2018, 2.4 million acres of private land have been protected through a conservation easement program (Colorado Natural Heritage Program and the Geospatial Centroid, 2018). Considering the importance of open space to Coloradoans

and the magnitude of Colorado's conservation programs, gaps still exist in the research literature in regards to the economic values and costs.[1] We are left asking the question: what are the economic consequences of private lands conservation using conservation easements in Colorado?

The goal of this thesis is to examine the effectiveness of conservation easements in Colorado. To do this, first, I explore the history of conservation easements in the United States and in Colorado specifically. I recall the accounts of fraudulent conservation easement claims which led to the cautious use of Colorado's budget for conservation easement programs. Next, I investigate the methods for conservation easement payments through the Agricultural Conservation Easement Program (ACEP). With the risk of fraudulent claims and additional costs to taxpayers, I consider if the economic consequences of conservation easements justify the risk and costs. I use a variety of metrics in my analysis. First, I focus on the economic impact of conservation easement payments in Colorado. Specifically, I look at the economic impact of ACEP funded conservation easement programs in rural Colorado counties. I compare these results to two counterfactual scenarios where federal dollars fund other national programs that have a negligible impact on Colorado or federal income tax decreases in Colorado. Next, I use econometric meta-analysis techniques to produce a Coloradoan willingness to pay for conserved lands. Then, I focus on the ecological benefits and costs of conservation easement programs. I estimate the value of ecosystem services provided by conservation easements using a benefit transfer methodology. I compare these estimates to the costs imposed on taxpayers. Lastly, I

[1] The following works concern conservation easements in Colorado specifically: Seidl et al., 2017; Wallace et al., 2008; Seidl, 2004, 2006; Orens et al., 2006; Magnan et al., 2005; Hoag et al., 1998; Ellingson & Seidl, 2009; Coupal & Seidl, 2003; Cline & Seidl, 2009, 2010.

propose an alternative payment methodology that creates a market for ecosystem services by incentivizing landowners to enroll more ecologically important lands.

The results of this thesis inform the current discussion in the Colorado House of Representatives after passing bill 18-1291 in 2018. This bill mandates an investigation into alternative payment mechanisms for conservation easements. Similarly, the U.S. Congress votes on the US Farm Bill approximately every five years. This research also informs Colorado's representatives of the benefits of the Farm Bill conservation easement program. Lastly, this research shows the need for further investigation of alternative payment mechanisms for conservation easements.

CHAPTER 2. BACKGROUND

Land conservation attempts to preserve certain aspects of land such as open space, wildlife, or agriculture while still allowing use of the land (Westover, 2016). Under this broad definition, land conservation takes many forms. Public land conservation requires the government to own the lands in order to conserve them. In contrast, in private land conservation, the government pays to place restrictions on the land without outright purchase. I focus on a particular type of private land conservation: conservation easements. Conservation easements impose restrictions on land uses that prevent commercial development on enrolled lands. A conservation easement for agricultural purposes additionally requires agricultural production to continue on the enrolled lands. Federal, state, and local conservation easement programs incentivize enrollment by compensating landowners for placing an easement on their land. Federal programs like the Agricultural Conservation Easement Program (ACEP), a subsection of the United States Farm Bill Conservation Title, offer a one-time payment to enrollees. To be eligible to enroll in a federal conservation easement program the parcel must demonstrate one or more of the following four criteria: contain at least 0% prime, unique, statewide or locally important farmland; contain historical or archeological resources, protect grazing uses and related conservation values, or further a state or local policy consistent with the purposes of the program (NRCS, 2019). State and local programs often leverage federal payments and credits by offering additional compensation (NRCS, 2019). For example, Colorado offers additional state tax credits to eligible conservation easement program participants (Foley, 2018). Landowners often work with local governments or Land Trust Organizations, private organizations that manage and monitor conservation easements, to enroll in these federal, state, and local programs.

Land Trusts, landowners, and governments come together to conserve land through conservation easements.

Farm Bill

According to Cain & Lovejoy (2004), since 1933 the United States Farm Bill has supported domestic agriculture through price supports and payments for idle land. The Farm Bill renews approximately every 5 years and has progressively incorporated support for more conservation practices and programs over the years. The first private land conservation program – the Conservation Reserve Program (CRP) – started in 1985. The CRP originally aimed to reduce soil, increase wildlife habitat, and improve water quality. To achieve these goals, private lands enrolled in the CRP were idled for the 30-year agreement, and cover crops were planted in these idled fields to mitigate soil erosion. In return, the federal government compensated landowners who participated in the CRP (Cain & Lovejoy, 2004).

The National Resources Conservation Services (2019) (NRCS) explained that later iterations of the Farm Bill replaced the CRP model with a working lands model. The Farm and Ranch Land Protection Program (FRPP) (1996-2014), Grassland Reserve Program (GRP) (2002-2014), and Wetland Reserve Program (WRP) (1990-2014).[2] These newer programs utilized the working lands conservation model, which aimed to achieve conservation benefits without requiring the landowner to stop production. In 2014, the Agricultural Conservation Easement Program (ACEP), which covers both Agricultural Land Easements (ALE) and Wetland Reserve Easements (WRE), replaced these programs for consolidation purposes (National Resources Conservation Services, 2019).

[2] For more information about the conservation easement program changes in the 2014 Farm Bill see for example Seidl & Villar (2014).

Landowners who participate in the ACEP relinquish some of their private property rights. According to the NRCS (2019), conservation easement lands cannot be sold for development and even private construction projects are limited. Conservation easement restrictions last in perpetuity, unless state legislation restricts enrollments to 30 years. ACEP participants also create a conservation plan in collaboration with the NRCS, which administers ACEP (National Resources Conservation Services, 2019). These restrictions and requirements attempt to ensure that conservation easements achieve ACEP's land conservation goals including slowing urban development and providing public environmental goods.

Although ACEP is a federally funded program, state legislation often dictates final details. Federal and state programs symbiotically create incentives for landowners to enroll land in a conservation easement. Federal programs set certain requirements for conservation easements such as evaluation of the easement and a conservation plan for the land. State programs leverage ACEP funding to achieve similar conservation goals. From our survey of a subset of conservation easements in Colorado, 65% of conservation easement payments came from state or local sources. Because of the state's role in shaping conservation easement programs, I now explore Colorado's history with conservation easements.

Conservation Easements in Colorado

Colorado's majestic Rocky Mountains and wide-open spaces attracted 80,000 new residents in 2018 (Tabachnik, 2018). Colorado is home of the iconic Rocky Mountain National Park and Pike's Peak, but many smaller parks and open spaces also see heavy use. It should be of no surprise that this culture of nature appreciation has resulted in 2.4 million acres of private lands conserved through conservation easements as of 2018 – not to mention other public space preservation (Colorado Natural Heritage Program and the Geospatial Centroid, 2018).

According to the NRCS (2019), Colorado conservation easements last in perpetuity and determines payments by fair market appraisal of the enrolled land. After an appraisal, an offer, which is a percentage of the difference between fair market value and the value in agriculture, is made to the landowner. Program participants often receive some percentage of the fair market value of their land depending on enrollment goals and prior year enrollment numbers (Foley, 2018; Ramsey, 2018; NRCS, 2019).

In 2000, Colorado was the first state to pass legislation allowing landowners to claim tax credits for enrolling their land in a conservation easement (Bleiberg, 2017). This legislation allowed participants to claim the difference between the fair market value and the conservation easement payment as a tax credit or sell those credits on a secondary market. Farmers, who often hold most of their wealth in land, took advantage of this program to convert a portion of that wealth into cash (Bleiberg, 2017; NRCS, 2019). Colorado legislation limits, or caps, the number of tax credits a landowner can claim for each parcel enrolled in the program (Bleiberg, 2017).

Migoya (2012), Rice (2016), Bleiberg (2017), and Lewis (2018) explained how others took advantage of the Colorado tax credit program in an unintended way. Starting in 2003, legislation increased the cap on tax credit amount per easement from $100,000 to $260,000 (Ray et al., 2016). Landowners could now claim more of the difference between the fair market value of their land and the actual conservation easement payment. The potential for additional earnings caused some bad actors to partition properties to claim more conservation easements and claim more tax credits on each conservation easement. They effectively found a way to circumvent the tax credit cap. Additionally, the fair market appraisals did not meet the requirements and standards of the program. This led to some individuals receiving approximately $37 million in tax credits through fraudulent appraisal claims. Colorado required all these participants to pay

back taxes because the appraisers did not meet the program standards. These scandals tarnished the name of Colorado's conservation easement programs and led to a series of lawsuits (Migoya, 2012; Rice, 2016; Bleiberg, 2017; Lewis, 2018).

Ray et al. (2016) and Bleiberg (2017) explained that in 2008 and 2013 Colorado passed additional legislation to redeem the program. This legislation established guidelines for appraisals, expanded oversight of the program, and introduced a cap for the annual budget of the conservation easement program at $45 million.[3] Since the reform, this budget cap has never been reached in part due to insufficient state approved appraisers (Ray et al., 2016; Bleiberg, 2017). These program corrections led to new issues including longer application review times and stricter requirements for state appraisers, as outlined by an audit conducted by the Colorado Office of the State Auditor found in Ray et al. (2016). Due to previous appraisal abuse, land must be appraised by a state-approved appraiser. From January 2014 to June 2016 there were only 21 state-approved appraisers, which is viewed by all parties as a constraint. Updated liability laws make appraisers hesitant to evaluate conservation easements. Currently, criticisms focus on application turnaround, with an average initial filing turnaround of 159 days in 2015. The program aims for an average time of 120 days, but applicants and conservation advocates have expressed frustration with the program's timeliness. Applications often come at the end of the calendar year, and the few certified appraisers cannot keep up with the seasonal influx. Issues with the administrative budget have been reported, with a mismatch between projected and actual applications. Since application fees cover the administrative budget, application fees are determined by projected enrollment and incorrect lower projections impose higher costs on applicants. These high transaction costs make an effective barrier to entry, with the 2016

[3] For more information about the evolution of the budget cap see Ray et al. (2016).

application fee being $12,675 for the tax credit certificate and a preliminary opinion for appraisal or conservation purpose. Additionally, if landowners request a second appraisal these additional costs could run up to $10,000 to $30,000 (Ray et al., 2016). These costs are large for small operation farmers and ranchers who might have ecologically important lands.

In 2018 the Colorado House of Representatives passed a new bill (18-1291), which provides more oversight to the conservation easement program to ease the burden on landowners while protecting from fraudulent applications (Winter et al., 2018). Despite the risks and costs of the conservation easement program, Colorado remains committed to providing this type of land conservation.

However, state tax credits only tell a portion of the story. Landowners also rely on federal programs like ACEP for compensation. State programs, such as Great Outdoors Colorado which helped secure the 2.4 million acres in Colorado, react to federal program requirements. State programs meet federal requirements so that participants can receive both federal and state compensation. Without both state and federal incentives working together, Colorado land conservation would have evolved differently. I now turn my attention to the federal methodology of conservation easement payments.

Federal and State Programs: Conservation Easement Payments

The Agricultural Conservation Easement Program tries to achieve two main objectives: controlling urban development of open space and providing public benefits to society. Land is prioritized for conservation based on a number of metrics that try to quantify the importance of both of these objectives (NRCS, 2015). If the primary goal of ACEP is to control the development of open spaces then paying landowners the conservation easement's opportunity cost would best accomplish this goal. However, if ACEP wishes to maximize the benefits

provided to society, they would prefer an alternative payment method, which compensates strictly based on those benefits. How does the current payment methodology achieve these two goals?

The NRCS (2015) and an interview with the Colorado NRCS Easements and Stewardship Coordinator Heather Foley (2018) explained the three different evaluation methods for determining conservation easement payments under the ALE subsection of ACEP. In each method, the value of the conservation easement is determined by the difference between the fair market value of the parcel with and without-easement, or opportunity cost of the easement.

Evaluations can be conducted through individual appraisals, Area-Wide Market Analysis (AWMA), or an alternative method approved by the NRCS. Most commonly, state-approved appraisers estimate the with and without-easement fair market value of the land in its best use. Under the AWMA method, analysts examine sales records of lands with and without easements in the same market area with the same land use. This analysis provides an average value of similar conservation easements in the area. With robust market data and a multitude of conservation easement applications, this method can be more time and cost effective. Colorado exclusively uses individual appraisals due to insufficient market data for the AWMA method and substantial variation across parcels to be evaluated (National Resource Conservation Services, 2015; Foley, 2018).

Lastly, ACEP allows for an alternative industry approved method, which gives flexibility for a new, more efficient method to be developed and the Wetland Reserve Easement division of ACEP provides an illustration of one potential alternative. The NRCS (2015) and an interview with the National Appraiser for the NRCS, Robert Ramsey (2018), explained the WRE allows for Geographic Area Rate Cap (GARC) estimates for easement value. GARC values categorize

conservation easements by land type and determine a fair market value for each land type in the geographic area by using an AWMA. The State Conservationist – the senior manager of NRCS conservation easements in the state – determines the market area boundaries and land use types included in the AWMA. From those base values, states have the freedom to adjust the percentage of the fair market value they will offer. For example, suppose Colorado's GARC values are 70% of the AWMA this year, but enrollment is below the target amount. Then the State Conservationist can raise the GARC value for next year to 80% of the AWMA to entice more enrollment. The WRE program will then offer the landowner the lowest of the three values: fair market appraisal value, GARC, and the voluntary landowner offer (National Resource Conservation Services, 2015; Robert Ramsey, 2018). The GARC methodology is currently used in the WRE subdivision, so there is precedent within ACEP to use this alternative method. I focus my analysis on the GARC method and an alternative method that I propose.

The GARC value is effectively the average opportunity cost of a land use in a market area. Economic theory suggests that this could induce the "lemons problem" first theorized by Akerlof (1970). The highest appraised lands will receive the average payment through GARC, so those landowners will not enroll in the program. However, the lowest appraised lands will also be valued at the average, which makes those landowners eager to enroll and receive higher compensation. This incentivizes low appraised lands to be enrolled and high appraised lands to refrain from enrollment (Akerlof, 1970). These appraisal values refer to the opportunity cost, so lands with high development potential would be considered high appraised lands. If the NRCS aims to protect land in areas of high development pressure, they would wish to enroll high opportunity cost lands and this methodology introduces the "lemons problem." Similarly, if the NRCS prioritizes conservation of the most acres for the least cost, they are overpaying for

conservation easements using the GARC method. However, if the NRCS wishes to provide the most public benefits with conservation easements, the "lemons problem" might not be of concern with this method. The NRCS recognizes these potential issues but believes wetlands to be homogenous enough in a region for the impact to be negligible (Robert Ramsey, 2018).

To illustrate how GARC values are created, I consider a simple case: the WRE program in Georgia. Easement specialist at the Georgia NRCS, Sharon Swagger (2018), explained in an interview how GARC values were created for the WRE program in Georgia. An internal economist at the Georgia NRCS office created 11 different market regions based on socioeconomic variables and land values. These market regions align unintentionally with the physiogeographic regions of Georgia. Next, the NRCS office analyzed previous wetland conservation easements in Georgia and identified two land use types from the pool of applications – forest land and agricultural land. These 11 market areas and two land types were given to Williams and Associates, a third-party appraisal company, who conducted an AWMA. An NRCS state committee decided that they would offer 80% of the AWMA value as the GARC value (Sharon Swagger, 2018).

Ramsey (2018) explained that due to the complex nature of conservation easement evaluations, landowners and NRCS offices want the process to be somewhat nuanced. Landowners who believe they have high-value land want higher compensation, and funders do not want to overcompensate low opportunity cost parcels. Methods like GARC work effectively for homogenous land, but the NRCS believes agricultural lands are too heterogenous. As such, NRCS believes that individual appraisals are in the best interest of both parties. Land Trust organizations push back on that rationale. They argue that the GARC methodology prevents small operation farmers or ranchers from conserving their land. The NRCS administration, Land

Trusts, and conservationists prioritize avoiding overcompensation, reducing complexity and transaction costs, and maximizing ecological benefits, respectively (Robert Ramsey, 2018). These potentially conflicting goals spark an interest in alternative compensation mechanisms.

Economic theory suggests that compensating for the opportunity cost of conservation easements would maximize the number of acres preserved for the minimum amount of compensation. Theoretically, the current method allows the government to protect the most land for the least cost to taxpayers. On the other hand, compensating landowners for the public benefits they provide would create a market for those benefits. These two theoretical viewpoints create bounds for conservation easement compensation. In between these two theoretical bounds exist infinitely many compensation mechanisms. I propose a hybrid mechanism that aims to compensate landowners for some ecological benefits at the expense of higher cost to taxpayers. This methodology would create a market for ecosystem services provided by agricultural land.

Colorado has taken advantage of the federal ACEP program to provide the public benefits of working landscapes. The complicated history of conservation easements in Colorado led to legislative reform and cautious use of state budget allocated for conservation easements. This legislative reform introduced additional requirements, which have created barriers for smaller landowners to consider enrollment in a conservation easement. This unintended consequence may not conflict with federal and state program goals, if they aim to provide the most conserved land for the least cost. The federal payment mechanisms suggest this might be the case as all methods rely on the fair market value of the land. However, alternative payment mechanisms could provide more benefits by creating a market for ecological benefits provided by conservation easements.

CHAPTER 3. LITERATURE REVIEW

Legislative interest has turned to the benefits conservation easements provide to Colorado and potential alternative payment mechanisms (Ray et al., 2016). In order to address these economic consequences of conservation easements, I turn to the existing literature to determine the best practices for assessing the economic impact of conservation easement payments, estimating the willingness to pay for conservation easements in Colorado, and approximating the ecological benefits provided by conservation easements. The economic impact of ACEP has not been assessed previously, so I look at the CRP literature to understand the subtleties and assessment of the economic impact. Next, I look at the non-market valuation literature to understand how researchers estimate a willingness to pay for any non-market good and conservation easements in particular. Finally, I review how ecosystems provide services, how researchers estimate the value of those services, and techniques to use existing ecosystem service values to estimate the ecological benefits provided by conservation easements. Then I look at the ecological conservation literature to assess the validity of using these economic techniques as well as alternative conservation tools.

Economic Impact

Perhaps the most important yet under-explored question regarding conservation easement is the economic impact that they have. Although economic impact analysis has not been conducted on ACEP specifically, researchers have analyzed ACEP's ancestor, the CRP. These two conservation programs differ mechanically, as I will explore, but are similar enough to inform expectations and analysis. In addition to the economic impact of ACEP on Colorado, I emphasize the effect on rural Colorado. Previous research finds mixed outcomes regarding the

effect of conservation easement programs on rural communities (e.g., Devino, 1988; Mortensen, 1989; Myers, 1989; Broomhall, 1991; Hyberg et al., 1991; Martin, 1998). Lastly, I discuss reported survey results on conservation easement payment uses and how these expenditure profiles inform economic impact analyses.

The economic impact of the CRP has been well studied (e.g., Devino, 1988; Mortensen, 1989; Myers, 1989; Broomhall, 1991; Hyberg et al., 1991; Martin, 1998). The economic impact of the CRP occurred during three distinct phases. Initially, landowners received compensation and simultaneously idled agricultural lands which in turn decreased production resulting in both a positive and negative economic impact. Subsequently, cover crop establishment generated some economic activity as farmers purchased seeds and other inputs to maintain the crop cover. Lastly, landowners were faced with a decision to return the land to production or keep it idle. If the land did not return to production, then there were further negative long-term economic impacts. These economic phases are specific to the CRP due to program requirements. Most researchers found a negative economic impact of the CRP (Devino, 1988; Mortensen, 1989; Broomhall, 1991; Hyberg et al., 1991; Martin, 1998), with one study finding a positive economic impact (Myers, 1989).

In contrast, the short-term impacts of ACEP conservation easements consist of a one-time financial injection to landowners. Researchers have not evaluated monetarily additional long-term impacts of ACEP conservation easements. The CRP literature suggests ACEP should produce a positive economic impact. With the freedom to continue agricultural production, landowners receive additional money for retiring development rights.

While I expect the overall economic impact of ACEP to be positive, research shows that a larger scale of analysis might produce results inconsistent with smaller towns. Henderson

(1992) considered how the CRP might affect the number of businesses in rural communities of different sizes. Intuitively, residents of smaller communities travel to diverse shopping centers in larger communities. The CRP payments benefited businesses in larger communities and negatively affected smaller community businesses. Though a program might have a positive total economic impact, certain communities might experience growing pains as incentives shift (Henderson, 1992).

Even within the same county, communities will experience conservation programs differently. Hamilton (1998) found that at the county level the CRP did not affect economic well-being significantly as defined by median household income and percent in poverty. At the sub-county scale, the CRP negatively affected economic well-being, showing that specific communities will feel the economic effects while larger scales might not (Hamilton, 1998). Further, Martin (1988) considered the economic effect on three counties in Oregon and concluded different effects for each county. Martin attributed this difference to the composition of the counties' economies. One county containing an agricultural supply center suffered more due to the decrease in agricultural input expenditures (Martin, 1998). The scale of analysis affects the conclusions that are drawn, and even if a program has positive economic effects, an individual community may have a different experience. Although I don't expect any community to see a negative economic impact from ACEP, these CRP studies highlight the importance of understanding community-level differences and how recipients use their conservation easement payments. Purchasing goods in Denver will impact rural communities differently than purchasing local goods.

Researchers have recognized the importance of the expenditure profile when conducting an economic impact analysis (Martin, 1998). Unfortunately, expenditure categories for ACEP

payment uses vary across studies, but average percentages can still inform a priori expectations. Esseks et al. (2013) found that 69% of participants used a portion of the payment for personal or household expenditures and 84% of participants used a portion for agricultural improvements or inputs. Similarly, Duke et al. (2016) found that 64% of participants used the money for personal goods but found a much smaller proportion, 48%, of participants used the money for agricultural expenses. Clark (2010) found that 77% of participants used the payments toward savings or investment.

In addition to understanding conservation easement payment expenditures, previous research tries to understand changes in farming practices. Due to increased income or conservation practice requirements, farmers and ranchers might change their operation. Clark (2010) found that 17% of Ohio participants diversified their crops and 21% added farming businesses with their easement payments. Similarly, Esseks et al. (2013) found that 18% of surveyed participants diversified crops, 16% decreased diversification, and of those who added crops, 25% added specialty crops.

Since few researchers have analyzed ACEP easements, I turn to the broader conservation easement literature to guide my analysis. The literature shows the importance of incorporating surveyed expenditure profiles into the economic analysis. Previous research sets a priori expectations for the economic impact analysis results and potential discrepancies among specific communities.

Economic impact analysis, risks of fraudulent conservation easement claims, and costs to taxpayers help give some context to the discussion of conservation easements. However, if taxpayers are not willing to pay for conservation easements then these metrics become irrelevant.

Next, I discuss the theoretical basis for estimating Coloradoans' willingness to pay for conservation easements.

Willingness to Pay for Conservation Easements

How do we put a dollar amount on non-market goods such as open space or preserving a farm for future generations? Economists cannot directly value non-market goods, such as the bundle of goods that agricultural land conservation provide such as environmental benefits. Instead, researchers try to derive how much individuals theoretically would pay for the non-market good, or goods not traded in the market (Peterson, 2003). Accordingly, I conducted a meta-analysis to estimate this value from previous results in the literature. However, my estimate relies on the validity of other researchers' estimates. Thus, I turn to a discussion of the types of values people place on goods, how researchers try to estimate values of nonmarket goods, and estimated values of willingness to pay (WTP) for agricultural land.

The literature separates the total value of a good into different attributes. For example, a good can have use and nonuse values. For example, someone living in Colorado might regularly hike in Rocky Mountain National Park and put a value on the park as a place to hike. Alternatively, someone living in Washington, D.C. might never visit Rocky Mountain National Park but would place some value on the park's existence. Nonuse values can be further broken down into option value, bequest value, and existence value. People place some value on Rocky Mountain National Park because they have the option to visit someday. On the other hand, people place value on Rocky Mountain National Park because they want the park to be available to future generations. Lastly, people place some inherent value on the park knowing it exists even if they don't have the intention to visit. The differentiation between use and non-use values

complicate researchers' attempts to value non-market goods, but modern surveys and techniques can capture specific values or the total value.

Richter (1996), Boxall et al. (1996), and Loomis & Walsh (1997) outlined the two approaches to estimate values of non-market goods: stated preference and revealed preference. Stated preference methods ask people directly how much they are willing to pay (WTP) for the non-market good in question. This method allows researchers to survey participants and estimate non-use values such as option, bequest, and existence values. Revealed preference methods derive the good's value by observing people's actions rather than words. This second approach uses entrance fees and travel costs along with other methods to estimate use values. Revealed preference methods correct for respondents who might overstate how much they are willing to pay to show support for the certain good or program. However, stated preference methods have limitations of their own due to the hypothetical nature of the response elicitation (Richter, 1966; Boxall et al., 1996; Loomis & Walsh, 1997). Researchers utilize both methods to understand and decompose values according to their objectives. Since I derive a WTP estimate, I continue an in-depth exploration of stated preference methods.

Most commonly, researchers use the contingent valuation method (CVM) from a large number of stated preference methods. Contingent valuation surveys ask respondents directly how much they would pay for a certain quantity or level of the nonmarket good. The survey response values include all applicable use and nonuse values that the respondent might place on the good. In the context of conservation easements, CVM studies allow researchers to estimate the nonuse value respondents place on conservation easement programs. These responses estimate how much people would be theoretically willing to pay in taxes or other payment mechanisms to support the program. Other stated preference methods used in the conservation easement

literature include iterative bidding models (Halstead, 1984), conjoint analysis and similar choice experiments (Duke & Ilvento, 2004; Roe et al., 2004; Johnston & Duke, 2007b). All these stated preference methods elicit nonuse values for agricultural land.

Researchers also use other revealed preference methods such as hedonic pricing models, which compare housing prices with relative distance to a natural amenity, to elicit values for agricultural conservation easements. However, the literature debates the appropriate use of revealed preference models or hedonic pricing models in this context due to the inability to capture all nonuse values (Ready et al., 1997; Johnston et al., 2001; Johnston & Duke, 2007b). Revealed preference study results could not be incorporated into the meta-analysis.

Researchers have derived WTP for agricultural conservation easements and agricultural land generally through CVM surveys. Although researchers may use the same CVM techniques, small differences in study methodology confound comparisons. I considered the WTP for agricultural land preservation as the WTP for a conservation easement on that land. In this way, both types of CVM studies elicit similar WTP estimates. Researchers have studied various geographic areas from the ranches of Colorado to the farmland of Delaware (Bittner et al., 2006; Johnston & Duke, 2009). Studies also elicit responses from different scales, from a single city to an entire state. Johnston & Duke (2009) found that the spatial scale can be a driving factor of WTP estimates due to differences in attitude toward members of the same community versus the same state. Their results suggest that estimates of WTP per capita for a county in Delaware are more similar to a county in Connecticut than the state of Delaware.

Survey precision also affects WTP estimates. Ambiguous surveys fail to clarify if they estimated the marginal WTP for an additional acre of farmland or the WTP for all current farmland (Champ, 2003). Variations in research methods, geographic areas, and study scales

complicate comparisons across the CVM literature. After converting to 2018 dollars, WTP estimates range from less than a penny per household per acre per year for a sparsely populated, agricultural county in Colorado (Bittner et al., 2006) to $12.57 per household per acre per year for a small town in Massachusetts with very few acres of agricultural land (Halstead, 1984).

Coloradoans' willingness to pay for agricultural conservation easements gives context to the rest of my results. Their WTP captures all public nonuse values they might place on parcels protected by conservation easements. This implies that an estimate of this WTP would also estimate the maximum amount Coloradoans would pay for a conservation easement program. Though CVM studies vary methodologically, meta-analytic techniques address some sources of these variations and allow estimation of a WTP for Coloradoans. This WTP estimate gives greater context to the costs and benefit estimates of conservation easement programs in Colorado.

The primary public benefit of land conservation can be captured through ecosystem service valuation. I estimated the value of these benefits using a benefit transfer methodology, which uses estimates from the literature in the context of Colorado. Next, I explore ecosystem services and how researchers attempt to estimate monetary values for those services.

Ecosystem Services

Ecosystems provide many market and non-market services from aesthetic enjoyment to supporting wildlife habitat. The Millennium Ecosystem Assessment (2004) divided these services into four categories: provisioning, regulating, supporting, and cultural services. Provisioning services encompass consumable resources and provide many market goods. Cultural services are benefits provided directly to humans such as recreation and aesthetic views. Ecosystems provide supporting services, which encompass many non-market goods that

indirectly affect society such as erosion prevention, air quality, and climate regulation. These ecosystem services interact with society to produce benefits. Erosion prevention improves soil and water quality, which provides benefits to farmers by increasing productivity. No value would be produced without humans to benefit from these services. Changes to these ecosystems, such as development, result in valuable tradeoffs from these ecosystem services to an alternative use.

Researchers have estimated ecosystem service values for several decades. Farber et al. (2002) summarized relevant concepts and methodology for ecosystem service valuation studies. They argued that assigning economic values to ecological services might not align in a perfectly coherent manner. For instance, the economic value of resource harvesting might outweigh the ecological values of the ecosystem health. However, it is often argued that a value with some methodological issues is better than an implicit $0 value of ecosystems. Researchers conduct primary valuation studies using the following methods:

1. Avoided Cost (AC) – a value is assigned to the services based on the costs incurred in their absence.
2. Replacement Cost (RC) – a value is assigned to the services based on the costs to provide those services through other means.
3. Factor Income (FI) – a value is assigned based on increased income due to the presence or increase in ecosystem service.
4. Travel Cost (TC) – the demand for a service is deduced by the costs incurred by traveling to an ecosystem.
5. Hedonic Pricing (HP) – the value of a service is deduced by comparing housing prices to the relative proximity of a house to an ecosystem.

6. Contingent Valuation (CV) – willingness to pay (WTP) for services are deduced based on survey results of a hypothetical scenario.
7. Ecological Accounting (EA) – values for services are derived based on the natural energy required to provide such services

Researchers employ these methods to value a subset of ecosystem services or the total value of the ecosystem which encompasses all applicable services (Farber et al, 2002).

Ideally, an original study could be conducted measuring the ecosystem services provided by the specific study site and estimating a value of those services. However, due to budgetary and temporal constraints, policymakers often use benefit transfer methodologies. Benefit transfer analyses find ecosystem service values from similar study sites and apply them to the site of interest. Benefit transfers can be a function of site characteristics and population, a mix and match of service values from other sites, or some similar type of methodology. The accuracy, best practices, and criticisms of benefit transfers have been well studied. Proponents argue that a benefit transfer analysis can produce accurate results if it includes every detail of study site characteristics, but critics argue that benefit transfer is most often misused and values inappropriately applied to study sites with very different characteristics (e.g., Boyle and Bergstrom, 1992; Loomis, 1992; Downing and Ozuna, 1996; Plummer, 2009; Richardson et al., 2015).

Given these criticisms, researchers have since turned to meta-analyses of ecosystem service valuation studies to increase their accuracy of estimated benefits across a wider variety of contexts. Meta-analyses provide a method of summarizing a large database of values, and the result produces an ecosystem service value based on certain characteristics of the land. Nelson and Kennedy (2009) criticized some inappropriate uses of meta-analyses, but when used

correctly they outperform other benefit transfer methods (Rosenberger & Loomis, 2000). Wetlands are the most prevalent example of ecosystem service valuation meta-analyses due to the numerous primary research studies (Brouwer et al., 1999; Woodward and Wui, 2001; Brander et al., 2006; Ghermandi et al., 2010; Brander et al., 2012; Chaikumbung et al., 2016). Due to data constraints, meta-analyses have not been conducted with other ecosystems. Although previous research suggests a meta-analysis of ecosystem service valuations would be preferable to a benefit transfer, sufficient data relevant to Colorado does not exist to conduct such a study.

Conservation easements are well studied within the ecological conservation literature compared to other, newer conservation techniques. Conservationists are not as familiar with conservation tools other than conservation easements, so conservation easements are the most popular among land trusts and other conservationist groups (Bennett et al., 2018). However, conservation easements are not always the most appropriate land conservation tool across all contexts (Bennett et al., 2018). Research has also studied the efficacy of conservation easements in reaching ecological goals (e.g., Kiesecker et al., 2007; Wallace et al., 2008).

Ecologists have studied many of the assumptions that economists have made regarding ecosystem services as well. Research has found that ecosystem services are often closely intertwined (e.g., Brščić, 2006; Wolf et al., 2007; Kramer et al., 1997; Rickets et al., 2008; Engel et al., 2005; Hughes et al., 2005; Enfors et al., 2008; Clark et al., 1979; del-Val et al., 2006; Bennett et al., 2009). Programs that affect one ecosystem service might impact other services not specifically targeted (Barbier et al., 2008; Chan et al., 2006). Ecosystem services vary widely among the same ecosystem land cover type (Koch et al., 2009; Nelson et al., 2009; Naidoo et al., 2008; Egoh et al., 2008). Clearly ecological systems are more complicated than simply looking at a broad land cover definition and applying a number. However, I used this benefit transfer

methodology despite this fact because quantifying the value of ecosystem services is better than making the implicit assumption that there is no value.

Quantifying ecosystem service values captures most of the benefits of conservation easements. Along with costs, WTP estimates, and the economic impact in rural counties, these economic consequences contextualize the conservation easement program and justify the risks and costs.

In conclusion, the literature provides insight into the economic consequences of ACEP. Prior CRP studies outline the potential economic impacts of easement payments. Researchers use survey techniques to elicit willingness to pay values which can be used in a meta-analysis to estimate values in new contexts. Lastly, although better alternatives exist in theory, benefit transfer techniques can be used to estimate ecological benefits in the absence of other options. Next, I describe the methods I use to estimate the economic consequences of ACEP.

CHAPTER 4. METHODS

Economic Impact

I analyzed the economic impact of conservation easements in Colorado in two stages. First, I surveyed Colorado landowners who had received conservation payments to obtain an expenditure profile of how the conservation payments were used. Second, I used IMPLAN for a single region analysis of Colorado and a multi-region analysis of rural and urban Colorado to estimate the economic impacts of conservation easements from 2009 to 2017.

In Colorado, 122 parcels were enrolled in a federal agricultural conservation easement program between 2009 and 2017. I surveyed a sample of 67 landowners (of the total 122) of the easements held by my partners in the Colorado land trust community. Not all land trusts were interested in participating in this partnership, so I could not survey all landowners. This sample of 67 landowners represents all landowners who worked with my land trust partners. Easement holders include the Colorado Cattlemen's Agricultural Land Trust (CCALT), Colorado Open Lands (COL), The Nature Conservancy (TNC), Colorado West Land Trust (CWLT), Yampa Valley Land Trust (YVLT), and Palmer Land Trust (Palmer). This partnership with the land trusts allowed me to send the survey to conservation easement grantors from a known and trusted organization, potentially improving response rates. The survey consisted of ten questions, which captured how participants spent their easement payment, how their production practices changed, as well as new sources of income resulting from the easement payments. The survey instrument is found in Appendix B. The survey instrument was approved by the Colorado State University Research Integrity and Compliance Review Office (RICRO ID # 223-18H, Category 2 exempt). I distributed surveys according to the Dillman method, following the survey-postcard-survey

approach, and administered in partnership with the land trust holding the easement (Dillman et al., 2014).

Contact information was available for 65 of the 67 landowners. Of the 65 landowners surveyed, 43 surveys were returned with usable responses for an effective response rate of 66.15%. Survey results were combined with information related to the easement grantor contained in the land trust's database. Land trust data related to the easement included: county, year easement was recorded, federal funding amount, federal program, and match amount from other state and local level partners.

Although I had a high response rate of 66.15% of those sampled, non-response bias could affect the data. Easement grantors who did not respond might have certain characteristics compared to respondents (Champ, 2003). Since I have basic data for the sample of easements, I tested to see if non-respondents received a significantly different amount of federal funds as compared to respondents. I concluded that there is not a statistically significant difference between respondents and non-respondents with a p-value of 0.38. That is, the probability that the two groups are the same based on federal fund amounts is 38%, so I failed to reject the hypothesis that they are statistically the same. Similarly, I failed to reject that the two groups are the same based on the appraised value of the easement ($p=0.51$), number of acres enrolled in the easement ($p=0.89$), and the calendar year the land was enrolled ($p=0.77$).

Rural-Urban Continuum Codes (RUCC) classify counties based on their population and geographic location near urban centers. A RUCC score of 1 signifies a metro county with a population greater than 1 million while a score of 9 signifies a county not adjacent to a metro county with less than a 2,500 urban population. Unsurprisingly, the survey found that more easements are in rural areas (Figure 4.1), with 62% of all easements located in a county with a

RUCC score of 7 or greater. Further, 60% of acres under federally supported easements are in these rural counties, and 81% of federal easement money goes to these counties. Only three of the conservation easements were located in counties with a RUCC score of less than 3. This finding supports the contention that federally supported agricultural conservation easement funds are used in Colorado for the environmental public good ecosystem services generated from agricultural lands in rural counties, rather than as an urban planning or growth management tool.

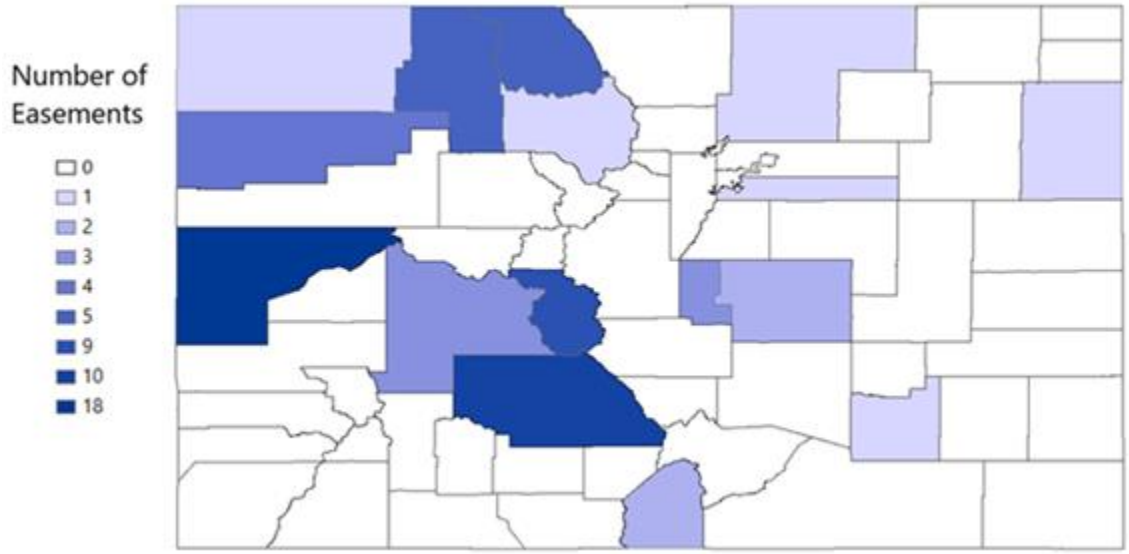

Figure 4.1. Colorado Conservation Easement Sample Map

Responses were used to construct proportions of conservation easement payments spent in eight different categories: reinvested in agricultural production, invested in non-agricultural enterprise, agricultural expansion, savings, family education, debt, non-business goods, and other. Survey respondents reported the percentage of conservation easement compensation in the eight categories found in Table 4.1. All expenditures were assumed to occur locally in the same county as the conservation easement.

Table 4.1. Survey Expenditure Categories	
Category	Description
Invested in Agriculture	the proportion of their easement payment invested back into their agricultural operation. This can come in the form of the purchase of inputs such as livestock, labor, equipment or other infrastructure such as irrigation equipment.
Diversification	the proportion of their easement payment invested in non-farmland based enterprise diversification. This can take the form of adding agritourism, hunting/fishing or other outdoor recreation activities to their operation.
Land Purchase/Real Estate	the proportion of their easement compensation invested in the purchase or lease of additional land to expand their agricultural operation.
Education	the proportion of their easement compensation used toward the post-high school education of a family member.
Savings	the proportion of their easement payment invested in savings, which could include retirement funds, the stock market as well as savings accounts.
Debt	the proportion of their easement compensation used to pay down debt.
Purchase of non-business related goods	the proportion of their easement payment spent on retail goods such as recreational vehicles, vacations or a second home.
Other	Respondents were asked to indicate what their other expenditures were if this category was selected and responded with expenses such as charitable giving, daily expenses, and attorneys.

I extrapolated to the entire population of conservation easements in Colorado. I did not have data on the 55 conservation easements outside of the sample and could not conduct more rigorous tests to check for differences between the two groups. Since I found no evidence that respondents differed from non-respondents in the sample, I concluded that the sample is representative of the entire population. As such, I assumed that the entire $80.8 million federal conservation easement dollars were spent in the same manner as the sample of $36.5 million in order to get a state level estimate of the economic impact. The sample comprised 55% of all conservation easements, 62% of acres enrolled, and 45% of federal easement dollars. A comparison of data from the population of Colorado conservation easements and the sample is found in Tables 4.2 - 4.5.

Table 4.2. Comparison of Conservation Easement Population and Sample (Total)						
Year	Total easements		Acres		Nominal Federal dollars	
	Population	Sample	Population	Sample	Population	Sample
2009	27	2	12488	1896	$5,563,500	$1,047,084
2010	10	6	26013	2436	$6,515,900	$1,809,649
2011	35	14	48687	2664	$8,484,000	$4,671,087
2012	6	13	15294	12541	$7,172,800	$3,481,337
2013	9	7	2465	10712	$16,049,700	$2,253,616
2014	7	4	5182	4308	$4,182,000	$1,823,525
2015	9	10	3184	22047	$4,353,200	$8,803,452
2016	10	3	6185	2028	$12,962,500	$1,449,120
2017	9	4	9213	6346	$9,198,900	$5,924,000
2018	0	4	0	14736	$0	$2,562,500
Total	122	67	128710	79714	$74,482,500	$33,825,370

Table 4.3. Comparison of Conservation Easement Population and Sample (FRPP)						
Year	FRPP easements		FRPP acres		FRPP dollars	
	Population	Sample	Population	Sample	Population	Sample
2009	26	2	7012	1896	$5,541,100	$1,047,084
2010	6	6	13152	2436	$6,451,900	$1,809,649
2011	34	14	36483	2664	$8,394,700	$4,671,087
2012	5	12	14267	4663	$7,134,400	$3,193,337
2013	2	6	1007	3038	$16,036,900	$1,853,616
2014	0	4	0	4308	$9,800	$1,823,525
2015	0	8	0	21870	$396,600	$8,398,000
2016	0	1	0	1727	$0	$600,000
2017	0	1	0	1573	$0	$800,000
2018	0	1	0	186	$0	$762,500
Total	73	55	71920	44361	$43,965,400	$24,958,798

Table 4.4. Comparison of Conservation Easement Population and Sample (GRP)						
Year	GRP easements		GRP acres		GRP dollars	
	Population	Sample	Population	Sample	Population	Sample
2009	1	0	5476	0	$22,400	$0
2010	4	0	12862	0	$64,000	$0
2011	1	0	12203	0	$89,300	$0
2012	1	1	1028	7878	$38,400	$288,000
2013	7	1	1458	7674	$12,800	$400,000
2014	0	0	0	0	$174,700	$0
2015	0	0	0	0	$0	$0
2016	0	0	0	0	$13,500	$0
2017	0	0	0	0	$22,500	$0
2018	0	0	0	0	$0	$0
Total	14	2	33027	15552	$437,600	$688,000

Table 4.5. Comparison of Conservation Easement Population and Sample (ACEP)						
Year	ACEP easements		ACEP acres		ACEP dollars	
	Population	Sample	Population	Sample	Population	Sample
2009	0	0	0	0	$0	$0
2010	0	0	0	0	$0	$0
2011	0	0	0	0	$0	$0
2012	0	0	0	0	$0	$0
2013	0	0	0	0	$0	$0
2014	7	0	5182	0	$3,997,500	$0
2015	9	2	3184	177	$3,956,600	$405,452
2016	10	2	6185	301	$12,949,000	$849,120
2017	9	3	9213	4773	$9,176,400	$5,124,000
2018	0	3	0	14550	$0	$1,800,000
Total	35	10	23763	19801	$30,079,500	$8,178,572

Sample data were reported at the time the landowner received the federal payment. Population data were obtained from the NRCS and were reported at the time the financial obligation was made. Due to time lags, these may not be the same date, and as such the same conservation easement may be recorded in different fiscal years based on the data source.

I used Economic Impact Analysis for Planning (IMPLAN) data and software to assess the economic impact of conservation easements in Colorado from 2009 to 2017. IMPLAN uses data from industries concerning what commodities they purchase (IMPLAN, 2004). This allows

IMPLAN to track how an increase in an industry's demand will affect other related industries. For example, an increase in local agricultural demand will translate into an increase in demand for agricultural support goods such as tractors. The total economic impact will be composed of direct, indirect, and induced effects. The direct effect is defined as the initial increase in demand. The indirect effect is the increase in demand for related industries. The induced effect captures the increase in output due to increased wages in the region. For example, the increase in agricultural demand might cause farmers and ranchers to hire temporary labor which increases the income for those laborers. That additional income is reintroduced into the economy as demand for other goods and services. Economists define this as the induced effect (IMPLAN, 2004).

General Input-Output modeling, such as IMPLAN, analyzes the effect of outside money on a regional economy. For example, the effect of conservation easements funded by Colorado tax dollars would not have an economic impact on Colorado by definition. Such a program is simply transferring dollars within the economy from taxpayers to conservation easement holders. A transfer introduces no additional money into the economy. As such, I restrict my IMPLAN analysis to federally funded conservation easements. Note that these easements leverage state dollars and state tax credits; however, I only considered the federal portion of compensation to conservation easement holders.

IMPLAN data describe county-level industry transactions and allow for basic analyses. An advantage of using IMPLAN is the timeliness and ease with which an economic impact can be estimated. Other Input-Output modeling, such as Computable General Equilibrium, can allow for greater data accuracy and dynamic modeling flexibility, but model building is time intensive.

Table 4.6. Total Direct Expenditures by Category	
Expenditure Category	Total Direct Expenditures
Investment in Agriculture	$12,214,544
Diversification	$891,519
Land Purchase/Real estate	$10,681,438
Savings and Debt	$55,811,421
Non-Business related goods	$849,809
Education	$172,149
Other/Charity	$198,466

I used the direct expenditure profile shown in Table 4.6 to 'shock' each expenditure category in the Input-Output model and determine the multiplier (indirect and induced) effects of the spending. The IMPLAN Input-Output model contains 529 different sectors of the economy, which is more detailed than the survey of easement grantors was able to capture. To create the expenditure categories in IMPLAN, I aggregated existing IMPLAN sectors to create categories for each of the types of expenditures included in the survey. Table 4.7 lists the IMPLAN sectors included in each expenditure category.

Table 4.7. Crosswalk Between Survey Responses and IMPLAN Sectors			
Survey category	Aggregate Sector Name	Code	Description
"Invested back into the ag operation through purchases of inputs (including restocking livestock herds), labor, equipment or other infrastructure (including irrigation infrastructure)"	Reinvest in Agriculture	2	Grain farming
		4	Fruit farming
		11	Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming
		19	Support activities for agriculture and forestry
		262	Farm machinery and equipment manufacturing
"Purchase of non-business related goods (e.g., recreational vehicle, vacation, second home)" or "Other"	Retail	396	Retail - Motor vehicle and parts dealers
		397	Retail - Furniture and home furnishings stores
		398	Retail - Electronics and appliance stores
		399	Retail - Building material and garden equipment and supplies stores
		400	Retail - Food and beverage stores
		401	Retail - Health and personal care stores
		402	Retail - Gasoline stores
		403	Retail - Clothing and clothing accessories stores
		404	Retail - Sporting goods, hobby, musical instrument and book stores
		405	Retail - General merchandise stores
		406	Retail - Miscellaneous store retailers
		407	Retail - Nonstore retailers

"Invested in savings (could include retirement fund or stock market investment as well as savings accounts)" and "Pay down farm debt"	Banking Sector	433	Monetary authorities and depository credit intermediation
		434	Nondepository credit intermediation and related activities
		435	Securities and commodity contracts intermediation and brokerage
		436	Other financial investment activities
"Invested in post-high-school education of a family member"	Education	472	Elementary and secondary schools
		473	Junior colleges, colleges, universities, and professional schools
		474	Other educational services
"Invested in non-farm land-based enterprise diversification (e.g., agritourism, hunting/fishing, outdoor recreation)"	Nonfarm Enterprise	496	Other amusement and recreation industries
		500	Other accommodations
"Charitable donations"	Charity	513	Religious organizations
		514	Grantmaking, giving, and social advocacy organizations
"Invested in the purchase or lease of additional land to expand the ag operation"	Real Estate	440	Real Estate

The analysis goes further by comparing the impact of these federal dollars on rural and urban counties separately. I used the Economic Research Service's (ERS) RUCC definitions of metro and non-metro counties to identify rural and urban counties. Urban counties are defined as counties with one or more urban center with a population of 50,000 or more or 25% of the workforce in a county commutes to a neighboring urban county. This definition corresponds to Rural-Urban Continuum Codes of 1-3. I checked the robustness of this by adjusting the limit. The data contain no counties with a RUCC score of 4 or 5 and one county with a RUCC score of

6. This provides a clear image of the divide between urban and rural and does not change the results.

I conducted a Multi-Regional Input-Output (MRIO) analysis through the IMPLAN software. This analysis captures feedback, or economic spillovers, from one region to another. The MRIO analysis considers two regions: the primary region where the initial shock occurs and the periphery region where economic impact occurs only due to spillover effects. For example, consider a shock to rural counties in Colorado. A portion of that shock creates demand in urban counties or the periphery region. Similarly, that new demand in urban counties creates demand in rural counties. This feedback loop continues indefinitely, with each impact shrinking in magnitude. MRIO analysis captures this economic impact by including inter-regional trading.

Multi-region analysis through the IMPLAN software does not allow for shocking aggregated sectors. I disaggregated and shocked individual sectors in IMPLAN to find the key sectors driving the aggregated results. Analysis was required to show which sectors best represented the single region IMPLAN results. I used these sectors that most closely match the original total output results as reported later in the results. The MRIO model used these representative sectors of the original categories. I could have used another criterion to determine the representative sectors, such as employment, but the primary analysis focuses on total output. This choice means I do not expect other results, such as changes in employment, to match the initial single region analysis.

Spillover coefficients measure the impact on the periphery region when shocking the primary region. Often when conducting Multi-Region Input-Output analysis researchers provide spillover coefficients to describe the connections of the involved regions (Hughes & Litz, 1996). Sectors in rural regions tend to have stronger ties to urban regions than vice versa. I define the

Urban model as the IMPLAN model where urban counties are the primary region and rural counties are the peripheral region. I define the Rural model in the corresponding way, where the rural counties are the primary region.

I calculated and report spillover coefficients for both regions of the MRIO analysis. Spillover coefficients provide a measure of how much the direct impact in the primary region spills over to the periphery or secondary region. I calculated the spillover coefficients for each sector that will be shocked later in the analysis. To calculate the spillover coefficients, I shocked the sectors and found the magnitude of impacts in both the primary and periphery regions relative to the direct injection. Next, I took the proportion of the impact in the periphery region to the sum of the impact in the periphery region and the impact in the primary region less the direct impact of the primary region. The following equation is used to calculate spillover coefficients:

$$Spillover\ Coefficient = \frac{Total_{periphery}}{Total_{periphery} + Total_{primary} - Direct_{primary}}$$

Where Total refers to the total impact from the shock in the primary region and Direct refers to the direct impact of the shock, or the amount of the initial shock, in the primary region.

This MRIO model assessed the impact the federally funded conservation easements had on rural counties in Colorado. However, we also need to consider the opportunity cost to federal spending. Instead of using those dollars to fund conservation easements, they could have funded another program. To better capture the effect of ACEP, I constructed counterfactuals, which attempt to capture the opportunity cost of the payments, or what might have been the situation had there been no injection of federal funds into private lands conservation in Colorado.

Suppose that Colorado had decided that they would not participate in the ACEP program, ceteris paribus. I considered two counterfactual scenarios. First, Colorado's voluntary boycott of the program allowed federal funds to be used in other government programs. Coloradoans still

paid the same federal income tax, so the analysis does not alter Coloradoans' income or behaviors. I assume the federal money is used elsewhere outside of Colorado. This implies a negligible positive economic impact on Colorado relative to baseline, so I refer to this scenario as the zero counterfactual. Second, I considered a counterfactual scenario where voluntary nonparticipation in ACEP resulted in Coloradoans paying lower income tax. Rather than federal funds being used elsewhere in the government, Coloradoans would never have paid those taxes in the first place, so their income is increased relative to baseline. The federal government would not likely lower taxes based on voluntary nonparticipation, but this scenario represents the best plausible case for Coloradoans. These two counterfactual scenarios create upper and lower bounds on the MRIO results. The best Colorado could hope for is lower taxes and the worst is the government using those funds elsewhere.

Lower federal income tax can be simulated in the MRIO model by increasing household income. I assumed the decrease in taxes would be the same magnitude as the amount of ACEP payments to Colorado and that the distribution of dollars is proportional to the amount of income tax paid. I estimated the economic impact of the tax decrease by injecting the ACEP payments to the corresponding households in rural and urban counties using IMPLAN.

IMPLAN differentiates households by income category, so I differentiated households according to household income brackets. York (2018) of the Tax Foundation summarized Internal Revenue Service (IRS) national federal income tax data from 2015. The US Census reported the number of Colorado households in household income brackets by county in 2015 (United States Census Bureau, 2015). I reconciled the household income thresholds defined by the IRS with the US Census income brackets to estimate the total amount of federal income tax paid by each household income bracket in each county. I aggregated federal income tax by

income bracket based on the ERS rural and urban county classification. I calculated the percentage of total federal income tax paid by each bracket in both rural and urban counties and then allocated the $80.8 million ACEP payments to households.

Household income bracket definitions differed slightly between data sources. US Census data definitions align with IMPLAN's income brackets with one exception. IMPLAN defines an annual household income bracket for $50,000 to $75,000 and the following bracket as $75,000 to $100,000. The US Census provides data for $50,000 to $70,000 and $70,000 to $100,000. I assumed that households earning between $70,000 and $75,000 consume in a manner comparable to the $75,000 to $100,000 bracket defined in IMPLAN.

The IRS reported taxes paid based on income percentiles (York, 2018). Using this data, I calculated the effective tax rate and created income tax brackets based on percentile thresholds. Table 4.8 reports the total income, federal taxes paid, and effective tax rate for each income bracket. I assumed that taxpayers in Colorado do not diverge from national averages in terms of effective tax rate by income bracket.

Table 4.8. National Federal Income Tax Profile by Household Income Brackets, 2015

	Annual Household Income Bracket (2015$)					
	< 39,275	39,275 - 79,655	79,655 - 138,031	138,031 - 195,778	195,778 - 480,930	>480,930
Income Tax Paid (in million)	$41,125	$153,502	$233,097	$160,154	$298,750	$567,697
Adjusted Gross Income (in millions)	$1,144,545	$2,000,338	$2,194,410	$1,144,771	$1,563,650	$2,094,906
Effective Tax Rate	4%	8%	11%	14%	19%	27%

Original data taken from York (2018).

Median household income varies across urban and rural counties. I aggregated data for all rural and urban counties for comparison. Table 4.9 shows the detailed breakdown of the percentage of households in each income bracket for 2017 and the total percentage of households in rural and urban counties. Unsurprisingly, 87% of Colorado households live in urban counties according to US Census data. These results also show that 11% of Colorado households earn less than $15,000 annually and that the majority of these households live in urban counties. These details show the economic profile of rural and urban counties are not the same. This suggests that urban and rural counties will not have the same expenditure profiles when simulating a decrease in federal income tax. I estimated the total amount of federal income tax paid by each household category in rural and urban counties and apply this percentage to the total ACEP federal dollars spent on conservation easements in Colorado. Table 4.10 shows the resulting MRIO IMPLAN injections to households.

Table 4.9. Household Income Profile for Rural and Urban Counties in Colorado, 2017

Region	Percentage of Households in Annual Household Income Bracket (in Thousands of Dollars)									
	<15	15-30	30-40	40-50	50-75	75-100	100-150	150-200	>200	Total
Rural	1.63	2.17	1.36	1.33	2.48	1.53	1.29	0.39	0.37	12.55
Urban	9.33	12.13	8.18	8.03	16.76	11.68	12.76	4.58	4.01	87.45

Original data taken from United States Census Bureau (2015).

Table 4.10. Counterfactual Household Injection		
Household Income Bracket (Annual, in Thousands of Dollars)	Rural Injection Amount	Urban Injection Amount
<15	$43,955	$251,317
15-30	$175,182	$979,831
30-40	$171,399	$1,027,977
40-50	$459,630	$2,770,245
50-75	$1,189,230	$8,033,606
75-100	$1,416,785	$10,846,220
100-150	$2,260,336	$22,297,287
150-200	$961,580	$11,211,120
>200	$1,395,089	$15,328,558
Total Injection Amount	$8,073,185	$72,746,162

I used the MRIO model to simulate the counterfactual by increasing rural and urban household income by the respective amount. I compared the economic impact of conservation easement payments on rural and urban counties to these counterfactual scenarios. These counterfactuals create bounds on the most likely alternative use to ACEP conservation easement money. The comparison between the impact of ACEP and the zero counterfactual creates an upper bound of the best approximation for the economic impact of ACEP. The comparison between the impact of ACEP and the impact of decreased federal income tax creates a lower bound on the best approximation for the economic impact of ACEP.

Willingness to Pay for Conservation Easements

I conducted a meta-analysis of studies estimating WTP for agricultural lands and conservation easements in the United States to estimate WTP for conservation easements in Colorado. The conservation easements analyzed in this study are a special subset of agricultural land, so I combined both types of studies in the meta-analysis. Searches through Google Scholar, Academic Search Premier database, and citations from summary articles (Kashian & Skidmore, 2002; Brander & Koetse, 2011) produced 26 potential studies that estimate willingness to pay for

agricultural land. I excluded estimates that could not be converted to annual WTP per acre per household. The final data consisted of 18 unique studies that contained 56 different WTP estimates.

Following Brander and Koetse (2011), I included the area of farmland/conservation easements in the study area, population density, median household income, and the year the survey was conducted. Additionally, I followed the wetland meta-analysis literature (Brouwer et al., 1999; Woodward & Wui, 2001; Brander et al., 2006; Brander et al., 2012) and controlled for the quality of the paper by including a dummy variable signifying that the estimate appeared in a peer-reviewed journal. Lastly, I controlled for the scale of the study estimate. As mentioned above, survey results in WTP per acre are conditional on the size of the study area. If respondents considered local agricultural land in their own community, they may have a higher WTP than if they considered less familiar state-wide agricultural land. I controlled for the scale of the study by specifying if the study was as the city, county, or state scale.

Meta-analysis combines data from the study results, the geographic study area, and the study itself. Studies provided varying levels of data about the socioeconomic characteristics of the study area. As such, median annual household income, population density per square mile, and acres of farmland/conservation easements were estimated with data from the US Census or the USDA Census of Agriculture. Annual data were not always available from these sources, in which case I used the nearest available data or a linear estimate. Often authors calculated an aggregate WTP for the agricultural land/conservation easements, and in doing so they estimated population with the most recent census data. In these cases, the source cited by the author was used in the calculations, but otherwise, I calculated a linear estimate for the missing data. Appendix C contains more details.

Data often need transformation when estimating a meta-analysis econometric model. All dollar amounts were converted to May 2018 dollars using Consumer Price Index data from the Bureau of Labor Statistics (Bureau of Labor Statistics, 2019). Following Brander and Koetse (2011), I took the natural logarithm of income. Additionally, I transformed the WTP per acre per household per year, the area of conserved agricultural land, and population density by taking the natural logarithm to help with potential outliers. This gives the final model equation:

$$\ln(WTP) = \beta_0 + \beta_1 * \ln(Area) + \beta_2 * \ln(Popdensity) + \beta_3 * \ln(Hhinc) +$$

$$\beta_4 * Published + \beta_5 * State + \beta_6 * City + \beta_7 * Year + \beta_8 * Samplesize + \epsilon$$

Where WTP is the willingness to pay in dollars per acre per year for agricultural land conservation; Area is the number of acres of conserved agricultural land in the study region; Popdensity is the population density per square mile in the study region; Hhinc is the median household annual income in the study region; Published is a dummy variable signifying if the study was published in a peer-reviewed journal; State and City are dummy variables showing if the study region was at the state or city scale; Year is the year the respondents were surveyed; and Samplesize is the sample size of the original study. Since the model includes two dummy variables for the city and state scale, the constant coefficient implicitly captures the county level scale and the estimates for β_5 and β_6 capture the differences in relation to county level studies.

Many meta-analyses suffer from homoskedastic data due to multiple observations from a single study. Brander and Koetse (2011) ran a weighted least squares model with the sample size of the study serving as the weight. Excluding interaction terms with dummy variables due to collinearity, I tested for homoskedasticity using White's test and find that there is significant evidence that the data do suffer from heteroskedasticity (P=0.0007). Since meta-analyses frequently suffer from homoskedasticity with respect to the number of observations, I conducted

a Breusch-Pagan test with the sample size and sample size squared. The results of this test show that the data suffer from homoskedasticity with respect to the number of observations (P=0.0153).

I also tested for collinearity to ensure that the dummy variables provide enough unique information to be included in the model. The Variance Inflation Factor (VIF) numbers range from 2.18 for the state variable to 4.5 for the city variable. Table 4.11 lists the VIF numbers for all variables. I conclude that collinearity is not a problem with the data.

Table 4.11. Variance Inflation Numbers for OLS Regression

Variable	VIF
City	4.5
Popdensity	3.25
Hhinc	2.9
Area	2.81
Samplesize	2.67
Published	2.62
Year	2.39
State	2.18

I report the Ordinary Least Squares estimates since they are consistent in the presence of heteroskedasticity along with White's correct standard errors. Since the estimates are consistent, I used the OLS model to predict the willingness to pay for conserved agricultural land in Colorado. Further, I report a WLS model which attempts to control for the heteroskedasticity using the number of observations as weights. This secondary model allows for more accurate conclusions regarding the driving factors of WTP for conservation easements.

After finding model estimates, I predicted the WTP for conservation easements in Colorado using the OLS model. According to COMAP, Colorado has 2,385,007 acres of land conserved (Colorado Natural Heritage Program and the Geospatial Centroid, 2018). According

to the 2013-2017 American Community Survey 5-Year Estimates, median household income in Colorado is $67,185.25 (in 2018$). According to the US Census' 2017 Population Estimates, the population of Colorado in 2017 was 5,607,154. Given that Colorado has a total area of 104,094 square miles, this translates into an estimated 53.87 people per square mile. I compared the estimated WTP to current payment amounts. This comparison shows whether Coloradoans are willing to pay more for conservation easements than is currently allocated.

Benefit Transfer

I identified 141 potentially relevant studies from the ENVALUE (a searchable environmental value database from the New South Wales government), Environmental Valuation Reference Inventory (EVRI), and The Economics of Ecosystems and Biodiversity (TEEB) databases or other studies referenced for the analysis in Colorado. I eliminated any benefit transfer studies retaining only original valuation. I screened these studies for the specific ecosystems in Colorado, eliminating any coastal or saltwater ecosystems. Finally, I eliminated studies that did not provide sufficient detail to derive an annual dollar per acre or annual dollar per household per acre value. Thirty-five original valuation studies remained that could be used in the benefit transfer. Of these 35 valuation studies, 5 applied to forests, 13 to wetlands, 5 to open water, 9 to agriculture, 2 to grassland, and 1 to shrubland.

I considered nine main land types, based on the National Land Cover Database (NLCD) classification system, that are found in Colorado: open water, woody wetland, emergent herbaceous wetland, deciduous forest, evergreen forest, mixed forest, agriculture, grassland, and shrub/scrub (Homer et al., 2012). I combined pasture and cropland cover types into an agriculture category and the three different forest types in NLCD into a single forest category due to data constraints.

Due to the lack of data for grassland and shrubland, I included 3 additional studies that did not conduct original research. Costanza et al. (1997) provided values for grassland, but they arrived at this value by a combination of original research and benefit transfer. Wilson (2014) provided values for pollination in both grassland and shrubland. I modified their estimates by taking the value of pollination in the United States and converting to a per acre value for grassland, forest, and shrubland. Finally, Batker et al. (2013) provided a value of air quality from shrubland taken from Costanza et al. (1997). I converted all values to dollars per acre per year adjusted to May 2018. Outlier values were eliminated since certain estimates from East Coast studies do not apply to Colorado.

I identified values for the ecosystem services listed in Table 4.12, where an "X" signifies that the literature provided a value for that ecosystem service. I classified ecosystem service types from de Groot et al. (2002) into the four Millennium Ecosystem Assessment (2004) categories which appear in Table 4.5. I report ecosystem service values for each land cover type in Table 4.13.

Table 4.12. Public Ecosystem Service Values Available by Land Type							
	Open Water	Forest	Shrub/ Scrub	Grassland	Agriculture	Woody Wetland	Emergent Herbaceous Wetlands
Provisioning Services							
Food				X			
Water	X	X				X	X
Raw materials							
Genetic resources	X	X	X	X	X	X	X
Regulating Services							
Air quality		X	X				
Climate regulation		X	X	X	X	X	X
Disturbance moderation		X				X	X
Waste treatment	X			X			
Erosion prevention		X		X	X	X	X
Biological control		X				X	X
Supporting Service							
Nutrient cycling		X		X			X
Pollination		X	X	X	X		
Cultural services							
Esthetic information							X
Recreation			X		X		
Inspiration							
Neighborhood Effect*		X					
* Neighborhood Effects refer to the increase of housing values due to relative proximity to an ecosystem. The typical ecosystem service types do not capture increases in housing values.							

Table 4.13. Annual Ecosystem Service Values from the Literature, 2018$ per Acre				
Ecosystem	Service	Min Value	Max Value	Study
Open Water	Water Supply	147.35	147.35	Roberts & Leitch (1997)
	Waste Treatment	350.89	350.89	Bouwes & Schneider (1979)
	Habitat Value	32.92	32.92	Roberts & Leitch (1997)
		327.34	327.34	Gupta & Foster (1975)
TOTAL		531.16	825.59	
Forest	Water Supply	10.63	60.58	Campbell & Tilley (2014)
	Air Quality	10.63	71.20	Campbell & Tilley (2014)
	Climate Regulation	29.29	30.71	Lewis, et al. (1996)
	Carbon	1822.00	1822.00	InVEST
	Disturbance Moderation	18.07	100.96	Campbell & Tilley (2014)
	Erosion Prevention	29.76	46.76	Campbell & Tilley (2014)
	Nutrient Cycling	6.38	14.88	Campbell & Tilley (2014)
	Pollination	0.05	0.33	Campbell & Tilley (2014)
	Biological Control	13.32	13.32	Pimentel, et al. (1995)
	Genetic Diversity	15.94	37.20	Campbell & Tilley (2014)
	Neighborhood effects	0.12	0.15	Hand, et al. (2008)
TOTAL		1956.18	2198.08	
Shrub/Scrub	Air Quality	6.94	8.76	Batker, et al. (2013)
	Carbon	356.00	356.00	InVEST
	Pollination	5.72	26.32	Wilson (2014)
	Genetic Diversity	80.26	115.76	Scott, et al. (1998)
	Recreation	9.26	115.76	Scott, et al. (1998)
TOTAL		458.19	622.60	
Ecosystem	Service	Min Value	Max Value	Study
Grassland	Food, Climate Regulation, Waste Treatment, Nutrient Cycling, Genetic Diversity, Recreation	112.91	112.91	Costanza, et al. (1997)

	Carbon	276.00	276.00	InVEST
	Erosion Prevention	63.44	63.44	Pimentel, et al. (1995)
	Pollination	5.72	26.32	Wilson (2014)
TOTAL		458.07	478.66	
Agriculture	Carbon	146.00	146.00	InVEST
	Erosion Prevention	23.23	23.23	Hansen (2007)
	Pollination	5.72	26.32	Wilson (2014)
	Genetic Diversity	29.66	29.66	Hansen (2007)
	Recreation	47.33	47.33	Knoche & Lupi (2007)
TOTAL		251.94	272.54	
Woody Wetlands	Water Supply	147.35	147.35	Roberts & Leitch (1997)
	Carbon	295.00	295.00	InVEST
	Disturbance Moderation	7.34	7.34	Watson, et al. (2016)
		46.75	65.75	Zavaleta (2000)
		374.11	374.11	Gupta & Foster (1975)
		689.71	689.71	Roberts & Leitch (1997)
	Erosion Prevention	72.49	72.49	Rein (1999)
	Biological Control	662.27	686.50	Jenkins, et al. (2010)
	Genetic Diversity	32.92	32.92	Roberts & Leitch (1997)
		327.34	327.34	Gupta & Foster (1975)
TOTAL		1217.36	2218.39	
Ecosystem	Service	Min Value	Max Value	Study
Emergent Herbaceous Wetland	Water Supply	147.35	147.35	Roberts & Leitch (1997)
	Carbon	295.00	295.00	InVEST
	Disturbance Moderation	4.53	11.88	Hovde & Leitch (1994)
		46.75	65.75	Zavaleta (2000)
		374.11	374.11	Gupta & Foster (1975)
		689.71	689.71	Roberts & Leitch (1997)

	Erosion Prevention	72.49	72.49	Rein (1999)
	Nutrient Cycling	0.29	1.10	Hovde & Leitch (1994)
	Biological Control	662.27	686.50	Jenkins, et al. (2010)
	Genetic Diversity	2.43	14.31	Hovde & Leitch (1994)
		32.92	32.92	Roberts & Leitch (1997)
		327.34	327.34	Gupta & Foster (1975)
	Esthetic Information	0.10	0.56	Hovde & Leitch (1994)
TOTAL		1184.45	2220.05	

Rather than the valuation literature, I used Integrating Valuation of Ecosystem Services and Tradeoffs (InVEST), a benefit transfer tool from the Natural Capital Project, to estimate carbon storage and sequestration values. I assumed that carbon, as a global public good, should have the same value worldwide. InVEST has been used recently in the literature to facilitate ecosystem service studies in a variety of ways (Isely, et al., 2010; Choi & Lee, 2018; Moreira, et al., 2018). I only utilized InVEST's ability to estimate carbon storage and sequestration amounts based on land cover types and then apply a price of carbon. In their meta-analysis of social cost of carbon estimates, Tol (2008) compared their estimated median of $20 per tonne of carbon using 3% discount rate to the European Union's cost of carbon permits at $160 per tonne of carbon. Using 3% discount rates, Nordhaus (2017) found a social cost of carbon to be $87 per tonne compared to the US Interagency Working Group's estimates of an average of $45 per tonne. I used a conservative estimate of $20 per tonne to estimate carbon sequestration values. Applying this tool to the conserved lands in Colorado, I derived estimates for metric tons (1 tonne = 2200 lbs.) of carbon stored and sequestered for an acre of each land cover type. I estimated carbon storage and sequestration ecosystem service value applying the conservative estimate of $20 per metric ton for carbon.

As carbon reporting and offsetting more often becomes a mandatory component of climate adaptation and mitigation plans, the market price of carbon will rise, as has been observed in the European Union in 2018 (Twidale, 2018). To ignore these values would be to discount substantially important ecological values. However, due to the magnitude of these carbon sequestration and storage values, I compare the minimum and maximum values with and without carbon (Table 4.14). I calculated the minimum and maximum values by summing the ecosystem service values, approaching the total public value of the ecosystem. Following Costanza et al. (1997, 2014), I assumed that ecosystem services are non-rival and that no ecosystem services is an intermediate product to another final product ecosystem services. The assumption that an ecosystem can provide one service independent of all others allows summing across all relevant ecosystem services to provide a final estimate. As mentioned before, experts debate this assumption and it is an area of improvement for benefit transfer analyses (e.g., Barbier et al., 2008).

Table 4.14 illustrates not all land parcels provide the same public benefits, with maximum annual per acre benefits ranging from $2,220 dollars for emergent herbaceous wetlands to $273 for agricultural land. If the goal is to maximize the public benefits from taxpayer investments in conservation easements, the land type of the conserved land is important to the evaluation of the conservation easement payment.

Table 4.14. Annual Ecosystem Service Value Estimates with and without InVEST Carbon Estimates, per Acre, 2018$				
	Min with Carbon	Max with Carbon	Min without Carbon	Max without Carbon
Forest	1,956	2,198	134	376
Emergent Herbaceous Wetland	1,184	2,220	889	1,925
Wooded Wetland	1,217	2,218	922	1,923
Open Water	531	826	531	826
Agriculture	252	273	106	127
Grassland	458	479	458	479
Scrub/Shrub	458	623	102	267

To better understand the public benefits provided by conservation easements in Colorado, I explore the land types that are currently under easement in Colorado. Colorado Natural Heritage Program has mapped all conserved lands in Colorado, made accessible through the Colorado Ownership, Management and Protection (COMaP) service (Colorado Natural Heritage Program and the Geospatial Centroid, 2018). COMaP provides data on many kinds of conserved lands, so I filtered out public and non-conservation easement lands. Using COMaP, I overlaid land cover data from the Multi-Resolution Land Characteristics Consortium (MRLC, 2019). The National Land Cover Database (NLCD) maps land covers for the entire United States based on 20 different categories. I excluded four categories found only in Alaska and four developed land categories. I found the acreage of each land cover type, applied the estimated ecological benefits from the survey of the literature, and estimated the value of benefits provided by these conserved lands.

The estimate of ecosystem service values gives insight into the public value of conservation easements in Colorado. These benefits come at a cost to or an investment by taxpayers. Next, I discuss how I analyze federal ACEP payment methods and propose a new methodology.

ACEP Payment Methods

Lastly, I compare the various value estimates for ACEP conserved agricultural land in Colorado. I compare actual cost, estimated environmental benefits, the rental value of the land, proposed Geographic Area Rate Cap values, and my own calculated value based on rental value and estimated benefits. Actual conservation easement payments are included in the available data, and estimated environmental benefits come from the previous section using benefit transfer methods. I expand the analysis to include rental value, previously suggested Colorado GARC values, and my own proposed compensation calculation.

The National Agricultural Statistics Service provides rental data for agricultural parcels. They report county level, as well as Agricultural District, rental rates for irrigated and non-irrigated cropland and pastures annually from 2009 to 2017 except for 2015. I converted these dollar per acre values to 2018 dollars. In cases where counties are too small to protect individual privacy, rental rates are aggregated with other counties. I estimated missing data by using the average rental rate for the Agricultural District when possible or by averaging the previous and following year that data are available. To find the rental value of conservation easement lands, I applied the rental rates to conservation easements with available land use profiles. I aggregated survey data and additional conservation easement data in Southeast Colorado from 2009 to 2017. Land use of conservation easements is estimated from survey responses of without-easement lands and is reported for Southeast Colorado easements. I categorized these land uses into irrigated cropland, non-irrigated cropland, and pastureland and apply the correct annual rental rate. I converted the annual rental rate to a value in perpetuity. I followed the Environmental Protection Agency's recommendation of using a 3%, 5%, or 7% interest rate (Environmental

Protection Agency, 2010). I used a 5% discount rate throughout the analysis. Converting annual rental amounts gives the rental value estimates for conserved agricultural land.

According to the National Agricultural Statistics Service, in 2017 the rental value for irrigated cropland ranged from $26.68 to $217.59 per acre (in 2018$). Taking an unweighted average, meaning each county where data are available contributes equally regardless of how many acres of land were rented, the average rental value for irrigated cropland in Colorado was $105.71 per acre. Non-irrigated cropland ranged from $10.78 to $43.11 per acre with an unweighted mean of $24.46. Pasture land ranged from $1.74 to $17.45 per acre with an unweighted mean of $6.17. Supply, demand, productivity, and transportation distances cause these wide ranges in rental rates. Not all irrigated cropland – let alone agricultural land generally – in Colorado is the same.

At the 2012 NRCS Colorado State Technical Committee Meeting, Dawn Jackson proposed GARC values for certain regions in Colorado. As discussed, GARC values are a mixture of compensating landowners for the public value of their property and limiting enrollment for ACEP budgetary constraints. Agricultural GARC values are seldom used due to large variations in land values. Even across the state of Colorado agricultural land changes dramatically, from the fruit orchards of the western slopes to the ranches of the eastern plains. In addition, Colorado is reluctant to use agricultural GARC values due to concerns about fraudulent transactions in the conservation easement system (Ramsey, 2018). With these caveats in mind, I calculated the proposed GARC values for illustration and comparison.

In order to apply GARC and rental rate values, I classified the aggregated data of both survey results and additional conservation easements into the three rental rate categories: irrigated cropland, non-irrigated cropland, and pasture. Table 4.15 shows what land uses were

mapped to which rental categories. The conservation easement data consist of 18,369 acres of irrigated cropland, 750 acres of non-irrigated cropland, and 76,692 acres of pasture.

Table 4.15. Crosswalk Between Land Uses and Rental Category	
Land Use	Rental Category
Flood Irrigated	Irrigated Cropland
Mechanized Irrigated	Irrigated Cropland
Irrigated Cropland	Irrigated Cropland
Fallow	Non-irrigated Cropland
Fruit Production	Non-irrigated Cropland
Idle	Non-irrigated Cropland
Cropland	Non-irrigated Cropland
Livestock Grazing	Pasture
Meadows	Pasture
Irrigated Meadow	Pasture
Mountain Meadows	Pasture
Native Range	Pasture
Native Grass	Pasture
Range	Pasture
Mountain Native Range	Pasture

Lastly, I calculated a proposed estimate of the value of conservation easements in Colorado. I used previously estimated agricultural rental rate values from the National Agricultural Statistics Service and actual conservation easement payment amounts. Actual conservation easement payments are to defray a percentage of the estimated current and future value given up by the landowner. Agricultural rental rates are directly related to the productivity of the land in agriculture. If development potential drives the fair market value of land, then value in agricultural production and the opportunity cost for development will diverge. From the sample data, I calculated the proportion of opportunity cost (Opportunity) to rental value (Rental). This method assumes that the proportion of opportunity cost to agricultural rental rate will remain constant for every parcel of agricultural land in Colorado, which likely is not the case. I estimated the opportunity cost of a hypothetical parcel of land using this proportion and

multiply it by 0.75 to reflect a typical GARC percentage. Next, I added a tenth of the estimated environmental benefits to encourage land stewardship for public values of private lands. I conducted additional robustness checks on the coefficients in front of the estimated opportunity cost and environmental values. This method attempts to replace some of the compensation based on the developmental value of the land with the environmental benefits the land provides. This gives the following equation:

$$Proposed = 0.75 * Rental * \left(\frac{Sample\ Opportunity}{Sample\ Rental}\right) + 0.1 * Environmental$$

The counterfactual of enrolling land into conservation easements varies with the location, but I do not claim that the alternative land use would not provide any environmental benefits. As such, By means of illustration, I propose compensating landowners one-tenth of the estimated environmental benefits they provide. Additional data would improve the precision of this estimate, but the proposal at least compensates landowners for the benefits they provide in addition to the lost value of their land due to easement restrictions. This proposed methodological change incentivizes land enrollments of more environmentally beneficial lands.

CHAPTER 5. RESULTS

Survey Results

Survey responses show that the majority of federal conservation easement compensation was invested in debt payments (52.1%), followed by saving (16.6%), and re-investment in production agriculture (16.1%) (Figure 5.1). Debt repayment is the most frequently reported investment category, with 63.6% of easement holders reporting using some portion of their easement payment on debt reduction. Some 52.3% of respondents indicated that they reinvested at least some of their easement compensation back into their agricultural operation, and 36.4% indicated that they put some of the money into savings. The average response and standard deviation are also reported in Table 5.1.

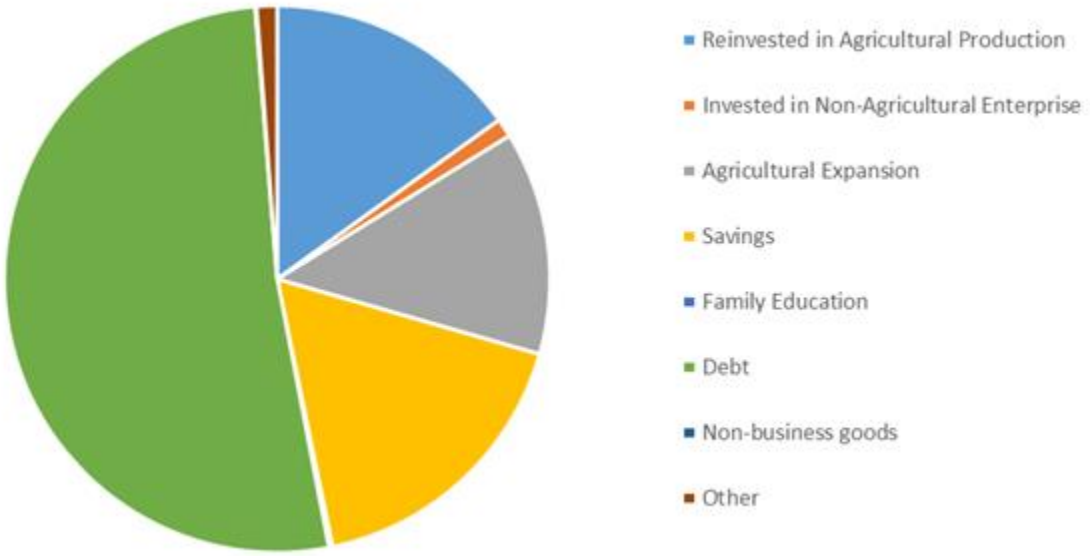

Figure 5.1. Proportion of Surveyed Expenditures by Category

Table 5.1. Reported Agricultural Conservation Easement Payment Use				
Expenditure Category	Percentage of respondents reporting use	Percentage of total expenditures	Average percentage of payment use	Standard deviation of percentage of payment use
Investment in Agriculture	53.49	15.11	27.0	17.6
Diversification	6.98	1.1	6.3	1.5
Land Purchase/Real estate	27.91	13.22	24.6	10.8
Savings	37.21	17.32	32.7	19.9
Debt	58.14	51.74	40.1	34.7
Non-Business related goods	4.65	0.09	1.8	0.4
Education	4.65	0.21	3.1	0.7
Other/Charity	6.98	1.2	24.1	14.4

The published literature notes a wide range of investment strategies for conservation easement payments, and the results from this survey are in line with results from previous literature. Duke & Ilvento (2004) found that 54.2% of easement owners reported putting some proportion toward savings and Clark (2010) found that in Ohio 52% of easement payment went toward investment and savings. In contrast, Lynch (2007) found that only 28% of respondents put money toward savings. My survey results follow Duke & Ilvento (2004) and Clark (2010) more closely with 47.7% of easement owners surveyed putting some proportion of their easement payment toward savings.

The literature also reports a range of results related to the proportion of respondents using the payments to pay down debt. Clark (2010) found 35% of easement payment dollars went to debt repayment while Lynch (2007) found this in 35% of respondents. Esseks (2006) reported 55% of respondents put some of their payment toward debt relief. Some 63.3% of the survey respondents indicated that 52.1% of the funds went toward debt repayment, indicating that the respondents allocated a greater proportion of their easement payment towards debt repayment than past studies have shown.

In addition to basic expenditure patterns, the survey provided insight into conservation easement practices, demographics, and additional impacts above simple expenditures. In Colorado, the average federal conservation easement payment was $540,932, with an average of 1,357 acres enrolled or $399 per acre. The average non-federal match was $1,070,082, indicating federal funds are leveraged at 2:1 in Colorado, ignoring potential state and federal tax credit program participation. The majority of agricultural conservation easements in the state (58) were administered through the FRPP, while 8 were administered through ACEP/ALE, and 2 through GRP.

The survey results also show 41.9% of federal conservation easement participants in Colorado changed their agricultural practices in some way due to the easement payment. Some commonly reported changes include improved irrigation (32.5%), increased acreage (14%), and changes in crop mix and rotation (2.3%). Perhaps in part due to these changes in practices, 6.8% of survey respondents indicated an improvement in their yields attributable to participation in the federal program; however, no one reported a decrease in yields. The survey found 11.4% of respondents indicated that they added outdoor recreation opportunities to their operations, for a total reported increase of 255 recreation days. This strategy has the potential to diversify farm incomes and support rural communities in low yield years.

Other survey results illustrate some of the non-market benefits that could not be captured in the Input-Output analysis. One respondent indicated that the easement money helped them get through difficult years of drought. Another respondent mentioned more elk grazing on their property. Another respondent revitalized an older orchard with easement money, which should create economic returns for decades. Agricultural conservation easement payments allowed others to build vacation rental units, invest in river projects to provide fishing recreation, assist in

a company sale, and lease federal land for grazing. These reported effects of ACEP were not captured in the following economic impact results.

Economic Impact

First, I present the economic impact of the conservation program on the state of Colorado, focusing on the sectors driving economic activity. Next, I used an MRIO model in IMPLAN to separate impacts into urban and rural counties. I also report spillover coefficients for the primary sectors in the MRIO model. Finally, I compare the results to two counterfactual analyses: the zero counterfactual and a decrease in federal income tax for Coloradoans.

Single Region IMPLAN Analysis

I analyzed federal conservation easement payments in Colorado from 2009 to 2017, which accounted for a total of $36,551,003 (in 2018 dollars) in payments to Colorado agricultural landowners (Table 5.2). I used IMPLAN to understand how these payments were spent in Colorado's economy and impacted the state directly and indirectly. The expenditure profiles outlined in Table 5.2 shows how the easement payment dollars were spent within the Colorado economy. Figure 5.2 illustrates the distribution of easement dollars over the 9-year period and the source of easement funding. All the Colorado easement payments were from FRPP, until 2012 when GRP first became part of the easement portfolio (Figure 5.2). ACEP succeeded the FRPP and GRP programs in 2014**.** Figure 5.2 also illustrates that easement payments are not constant from year-to-year with spikes in Colorado easement payment receipts in 2010, 2014 and 2017.

Table 5.2. Sample Federal Conservation Easement Payments, 2018$					
Year	Nominal Federal Amount	Real Federal Amount	FRPP Real Federal Amount	GRP Real Federal Amount	ACEP Real Federal Amount
2009	$1,047,084	$1,227,918	$1,227,918	$0	$0
2010	$1,809,649	$2,106,170	$2,106,170	$0	$0
2011	$4,671,087	$5,366,388	$5,366,388	$0	$0
2012	$3,481,337	$3,834,569	$3,518,980	$315,589	$0
2013	$2,253,616	$2,447,872	$2,015,881	$431,990	$0
2014	$1,823,525	$1,967,924	$1,967,924	$0	$0
2015	$8,803,452	$9,353,192	$8,922,562	$0	$430,630
2016	$1,449,120	$1,519,044	$628,952	$0	$890,092
2017	$5,924,000	$6,097,810	$838,602	$0	$5,259,207
2018	$2,562,500	$2,630,117	$782,620	$0	$1,847,497
TOTAL	$33,825,370	$36,551,003	$27,375,997	$747,579	$8,427,426

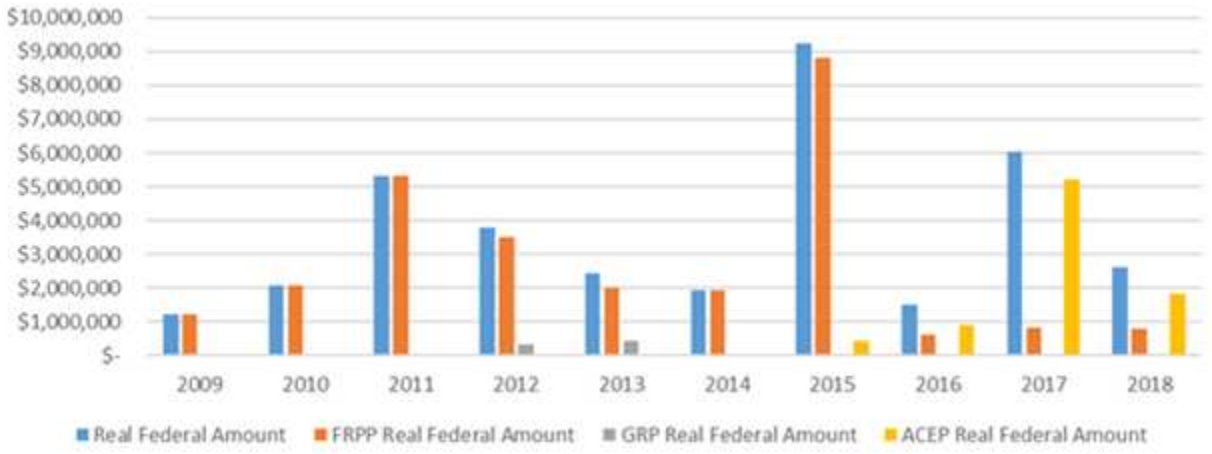

Figure 5.2. Sample Federal Agricultural Conservation Easement Payments to Colorado, 2009-18

Table 5.2 shows Colorado federal easement payments by year. The first column shows that the total Colorado federal easement payments during the period was $33,825,370. Converted to 2018 dollars, the total real federal easement value is $36,551,003. Some $27,375,997 of these easement dollars came from the FRPP program, $8,427,426 from the ACEP program and $747,579 from the GRP program.

Table 5.3. Single Region Economic Impacts of Federal Conservation Easement Payments on Colorado, 2018$				
Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	497	$23,914,000	$35,989,000	$80,249,000*
Indirect Effect	342	$19,353,000	$28,749,000	$55,595,000
Induced Effect	283	$13,089,000	$23,089,000	$40,217,000
Total Effect	1122	$56,356,000	$87,827,000	$176,061,000
*Note that this value is slightly lower than the total easement payments due to margining in the retail sectors				

Table 5.3 shows the summary results from the IMPLAN analysis. The analysis shows that $80.8 million in federal agricultural conservation easement program spending created over $176 million dollars in new economic activity to the state of Colorado over the past nine years (2009 – 2017). The $176 million in new economic activity created 1,122 new jobs and $88 million dollars in value-added in Colorado over the period.

The generated economic activity is associated with a Colorado total output multiplier of 2.18 for financial injections from federal agricultural conservation easements. This means that for every dollar of federal conservation easement payments in the state, $2.18 dollars of direct, indirect and induced economic activity is generated in Colorado. This multiplier is larger than typically expected due to the large economic multipliers associated with the banking sector. Respondents spent over $55.8 million dollars in the form of payment of debt and contributions to savings which stimulated the banking sector.

Table 5.4 illustrates in more granular detail the sectors of the Colorado economy that are most affected by the $80.8 million in federal conservation easement payments. Payments affected the banking sector most, which is unsurprising as the survey found that paying down debt and investing in saving accounted for 71% of all conservation easement expenditures. Other sectors associated with direct spending, such as agricultural reinvestment and retail sectors, also rank in the top ten. Due to the multiplier effects of the easement payment spending, many of the

sectors in the top ten are not areas where direct payment expenditures occurred. The industrial sectors that experience relatively large effects all have linkages to the banking sector and include wholesale trade, management of companies and data processing.

Table 5.4. Top Ten Colorado Industries Affected by Agricultural Conservation Easement Compensation

Description	Employment	Labor Income	Value Added	Output
Banking Sector*	398	$24,776,000	$31,081,000	$70,863,000
Real Estate*	101	$1,856,000	$12,637,000	$18,594,000
Reinvest in Agriculture*	115	$2,822,000	$3,430,000	$14,407,000
Owner-occupied dwellings	0	$0	$3,056,000	$4,712,000
Retail*	56	$1,797,000	$2,912,000	$3,996,000
Insurance agencies, brokerages, and related activities	22	$1,267,000	$1,584,000	$3,640,000
Wholesale trade	15	$1,286,000	$2,210,000	$3,404,000
Management of companies and enterprises	12	$1,616,000	$1,917,000	$3,081,000
Insurance carriers	6	$587,000	$1,096,000	$2,317,000
Data processing, hosting, and related services	8	$813,000	$858,000	$2,205,000
*custom aggregated sector, for details on the industries in these sectors refer to Table 5.5				

The previous aggregation of IMPLAN sectors makes implicit assumptions about how money is spent within those aggregated sectors. I shocked each aggregated sector in isolation and attempted to replicate the results by shocking just one IMPLAN sector. These results show which sectors are driving the results and allows for evaluation. For example, the custom sector "Reinvest in Agriculture" might give results driven by the IMPLAN sector "Fruit farming." Although the data include fruit farming operations, it would be unreasonable to presume that most of the money spent on investing in agriculture would be invested in fruit farming. Table 5.5 shows the single IMPLAN sectors that best replicate the aggregated sectors according to total output and total employment along with the percentage of error. Both employment and output criteria result in single sectors that seem reasonable given the specific survey data**.**

Table 5.5. IMPLAN Sectors Which Replicate Aggregated Sectors				
Aggregated Sector	Sector with Smallest Total Output Error	Percent Error	Sector with Smallest Total Employment Error	Percent Error
Reinvest in Agriculture	Grain Farming	5.56	Beef cattle ranching and farming	13.04
Banking Sector	Nondepository credit intermediation and related activities	-8.60	Securities and commodity contracts intermediation and brokerage	7.11
Charity	Grantmaking, giving and social advocacy organizations	-10.24	Grantmaking, giving and social advocacy organizations	-57.02
Education	Other educational services	-0.60	Elementary and secondary schools	-3.54
Nonfarm Enterprise	Other amusement and recreation industries	-0.57	Other amusement and recreation industries	-5.00
Retail	Retail- Health and personal care stores	-0.82	Retail- Miscellaneous store retailers	9.32
Model Total		-5.46		6.89

Multi-Region IMPLAN Analysis

I hope to isolate the economic impact on rural counties in Colorado that cannot be seen from the state level analysis. Using the ERS definition of metro and non-metro counties I categorized each county into urban and rural, respectively. Due to limitations with IMPLAN, the multi-region model cannot use custom aggregated sectors in the analysis. From the results in Table 5.5, I used representative sectors to conduct the analysis. The representative sectors change when using different criteria of employment or total output. I chose to focus the analysis on total output and used representative sectors based on that criterion. In the results, I report the changes in employment but caution the reader that I do not expect these numbers to map directly to the state level impact analysis.

I allocated conservation easement payments to urban and rural counties based on the survey data assuming expenditures occurred in the same county as the conservation easement. The survey shows 20% of conservation easement payment dollars went to landowners in urban counties. Additionally, 40% of the surveyed conservation easements and 32.3% of conserved acres are in urban counties. I used the expenditure profiles listed in Table 5.1 which were derived from the survey results to allocate money to economic sectors. Table 5.6 shows the amounts allocated to specific sectors in the urban and rural regions. The proportion allocated to each sector is the same for both urban and rural, but the total amount reflecting the differences in total conservation easement compensation to urban and rural counties.

Table 5.6. MRIO Direct Expenditures

Sector	Rural Direct Expenditure	Urban Direct Expenditure
Reinvest in Agriculture	$9,775,439.90	$2,439,103.94
Real Estate	$8,548,478.02	$2,132,960.42
Banking Sector	$44,666,522.00	$11,144,898.93
Charity	$158,834.50	$39,631.35
Education	$137,773.14	$34,376.25
Nonfarm Enterprise	$713,493.11	$178,026.14
Retail	$680,111.98	$169,697.10
Total	$64,680,652.65	$16,138,694.13

I calculated spillover coefficients from urban counties to rural counties and from rural counties to urban counties (Table 5.7). The Rural spillover coefficients to the urban region range from 0.38 for Charity to 0.00 for Reinvest in Agriculture. The Urban spillover coefficients vary from 0.23 for Reinvest in Agriculture to 0.02 for Nonfarm Enterprises, Real Estate, and Education. These calculated results match similar studies in the literature (Hamilton et al., 1991; Hughes & Litz, 1996). Agricultural sectors have greater spillover from urban regions to rural ones, but overall rural regions have greater spillovers to urban regions.

Table 5.7. Spillover Coefficients		
Sector	To Urban Counties	To Rural Counties
Reinvest in Agriculture	0.00	0.23
Real Estate	0.22	0.02
Banking Sector	0.29	0.03
Charity	0.38	0.04
Education	0.25	0.02
Nonfarm Enterprises	0.24	0.02
Retail	0.27	0.04

First, I ran the analysis on the Rural model and examine the spillover effect into urban counties. Scaling the survey results to the entire $80.8 million federal dollars received as payment for conservation easements, I injected $64,680,653 into the Rural model (Table 5.6). This $64.7 million injection resulted in an economic impact of $111.8 million dollars within rural counties and $19 million dollars of impact in urban counties (Tables 5.8 and 5.9).

Table 5.8. Rural Model Economic Impact on Rural Counties, 2018$				
Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	396	$21,292,000	$27,960,000	$64,219,000*
Indirect Effect	238	$8,862,000	$13,807,000	$30,233,000
Induced Effect	137	$4,976,000	$9,714,000	$17,362,000
Total Effect	771	$35,130,000	$51,481,000	$111,814,000
*Note that this value is slightly lower than the total easement payments due to margining in the retail sectors				

Table 5.9. Rural Model Economic Impact on Urban Counties, 2018$				
Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect*	$0	$0	$0	$0
Indirect Effect	$4,813,000	$6,705,000	$12,069,000	$4,813,000
Induced Effect	$2,367,000	$3,965,000	$6,949,000	$2,367,000
Total Effect	$7,180,000	$10,670,000	$19,018,000	$7,180,000
*Note that the Direct Effect will always be 0 for periphery regions				

Next, I ran the analysis on the Urban model, with interest in the spillover effect into rural counties. Using the same methodology as the Rural model, I injected $16,138,694 into the Urban model (Table 5.6). This $16.1 million generated an economic impact of $34.8 million dollars

within urban counties and $272 thousand dollars of impact in rural counties (Tables 5.10 and 5.11).

Table 5.10. Urban Model Economic Impact on Urban Counties, 2018$				
Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	90	$6,322,000	$7,952,000	$16,023,000*
Indirect Effect	65	$3,515,000	$5,215,000	$9,564,000
Induced Effect	64	$3,030,000	$5,333,000	$9,232,000
Total Effect	219	$12,867,000	$18,500,000	$34,820,000
*Note that this value is slightly lower than the total easement payments due to margining in the retail sectors				

Table 5.11. Urban Model Economic Impact on Rural Counties, 2018$				
Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect*	0	$0	$0	$0
Indirect Effect	1	$45,000	$72,000	$180,000
Induced Effect	1	$23,000	$44,000	$93,000
Total Effect	2	$68,000	$116,000	$272,000
*Note that the Direct Effect will always be 0 for periphery regions				

Since I disaggregated the sectors, I compare the results with the original single region analysis. The total impact of rural counties is $112.1 million, and the urban impact is $53.8 million. The total impact on the Colorado economy with MRIO modeling is then $166 million compared to the original result of $176 million. This 5.7% discrepancy could be caused by mapping injections to different representative sectors. Alternatively, the original analysis could have overstated the impact due to aggregating injections to both urban and rural counties. In other words, the MRIO analysis correctly attributes injections to rural counties with smaller economic multipliers whereas the original analysis overestimates how much money is injected into urban areas with larger multipliers. I cannot definitively identify the source of the discrepancy. However, a 5.7% difference in results does not indicate any serious problems with the MRIO modeling procedure.

In both the Rural and Urban models, the most affected industries in the primary region look almost identical. The top three industries include banking, real estate, and grain farming. Since these three sectors received a portion of the direct impact of spending, it comes as no surprise that they appear in the most affected. The rest of the top ten industries impacted include industries closely tied to banking (5.12 and 5.13). These results mirror the previous single region results.

The most affected industries in the peripheral regions in these models do not share many similarities. In the Rural model, the top affected industries in the peripheral region primarily consist of banking or real estate related industries. Interestingly, other support sectors such as Air Transportation and Advertising show up as well. In the Urban model, the top affected industries in the peripheral region still include some banking and real estate-related sectors. In contrast to the previous results, four of the top ten industries are agricultural related and three of the top ten industries are energy related. These linkages show that urban regions demand more energy and agricultural related goods from rural regions. In contrast, rural regions demand more specialized services from urban regions (Tables 5.14 and 5.15).

Table 5.12. Top Ten Industries Affected in Primary Region of Rural Model				
Description	Employment	Labor Income	Value Added	Output
Banking Sector	305	$19,057,000	$20,413,000	$45,487,000
Real Estate	76	$1,407,000	$8,896,000	$13,361,000
Reinvest in Agriculture	27	$1,023,000	$1,176,000	$10,092,000
Insurance agencies, brokerages, and related activities	54	$2,249,000	$2,741,000	$7,762,000
Monetary authorities and depository credit intermediation	13	$845,000	$1,598,000	$2,830,000
Owner-occupied dwellings	0	$0	$1,825,000	$2,813,000
Other financial investment activities	15	$211,000	$253,000	$2,102,000
Support activities for agriculture and forestry	24	$742,000	$768,000	$1,064,000
Limited-service restaurants	11	$258,000	$641,000	$1,054,000
Wholesale trade	6	$311,000	$560,000	$1,031,000

Table 5.13. Top Ten Industries Affected in Primary Region of Urban Model				
Description	Employment	Labor Income	Value Added	Output
Banking Sector	65	$6,050,000	$6,334,000	$11,728,000
Real Estate	20	$372,000	$2,569,000	$3,766,000
Reinvest in Agriculture	12	$251,000	$288,000	$2,470,000
Insurance agencies, brokerages, and related activities	8	$471,000	$590,000	$1,337,000
Owner-occupied dwellings	0	$0	$701,000	$1,081,000
Other financial investment activities	5	$175,000	$206,000	$807,000
Wholesale trade	3	$284,000	$486,000	$741,000
Monetary authorities and depository credit intermediation	3	$210,000	$391,000	$619,000
Insurance carriers	2	$156,000	$291,000	$615,000
Management of companies and enterprises	2	$321,000	$380,000	$599,000

Table 5.14. Top Ten Industries Affected in Periphery Region of Rural Model (Spillover to Urban)				
Description	Employment	Labor Income	Value Added	Output
Banking Sector	305	$19,057,000	$20,413,000	$45,487,000
Real Estate	8	$144,000	$991,000	$1,453,000
Management of companies and enterprises	5	$748,000	$887,000	$1,398,000
Banking Sector	7	$690,000	$723,000	$1,339,000
Other financial investment activities	7	$264,000	$311,000	$1,219,000
Wholesale trade	4	$329,000	$564,000	$859,000
Wired telecommunications carriers	1	$127,000	$312,000	$614,000
Owner-occupied dwellings	0	$0	$391,000	$603,000
Advertising, public relations, and related services	2	$124,000	$288,000	$453,000
Air transportation	1	$101,000	$208,000	$413,000

Table 5.15. Top Ten Industries Affected in Periphery Region of Urban Model (Spillover to Rural)				
Description	Employment	Labor Income	Value Added	Output
Reinvest in Agriculture	0	$3,000	$4,000	$30,000
Insurance agencies, brokerages, and related activities	0	$7,000	$9,000	$24,000
Real Estate	0	$2,000	$16,000	$24,000
Wireless telecommunications carriers (except satellite)	0	$0	$4,000	$12,000
Support activities for agriculture and forestry	0	$8,000	$8,000	$12,000
Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming	0	$1,000	$2,000	$10,000
Electric power generation - Fossil fuel	0	$1,000	$3,000	$9,000
Electric power generation - Wind	0	$0	$6,000	$7,000
All other crop farming	0	$3,000	$3,000	$7,000
Extraction of natural gas and crude petroleum	0	$3,000	$3,000	$6,000

The multi-region analysis shows that 67.5% of the total economic impact from federal conservation easement dollars occurred in rural counties. Although 80% of the direct payments go to rural counties, concentration of businesses in urban areas mean that spending more often occurs in these places – even by rural inhabitants. In other words, linkages are stronger from rural-to-urban than urban-to-rural and can be seen in the spillover coefficients that explicitly show spillover effects to urban counties are stronger than to rural counties with the one exception of grain farming. Although these results uncover more of the story than a single region analysis, to tell the whole story the analysis must include a counterfactual use of conservation easement monies.

Counterfactual IMPLAN Analysis

In place of ACEP funding conservation easements in Colorado I considered reducing federal income tax. I allocated ACEP dollars by estimating the proportion of federal income tax paid by each household bracket in rural and urban counties. I estimated the economic impact of this tax decrease using the MRIO model. This creates a lower bound on the actual economic impact of ACEP funding in Colorado.

The Rural model counterfactual analysis shows that lowering federal income tax resulted in a total economic impact of $5.3 million in rural counties and $0.7 million spillover to urban counties. In the Urban model, I estimated an economic impact in urban counties of $78.4 million and spillover to rural counties of $0.6 million. This results in a total impact in rural counties of $5.8 million and an impact of $79.1 million in urban counties (Table 5.16). In the counterfactual model, the majority of the money went to urban households as they pay a higher percentage of

total federal income tax. The results reflect this with 93% of the total economic impact occurring in urban counties.

Table 5.16. Counterfactual Summary Results				
Model and Region	Employment	Labor Income	Total Value Added	Output
Rural Primary	42	$1,511,000	$2,954,000	$5,276,000
Rural Periphery	4	$270,000	$414,000	$743,000
Urban Primary	542	$25,720,000	$45,275,000	$78,392,000
Urban Periphery	3	$132,000	$251,000	$567,000
Total Impact on Rural	45	$1,643,000	$3,205,000	$5,843,000
Total Impact on Urban	547	$25,990,000	$45,689,000	$79,135,000

Tables 5.17 – 5.20 break down the industries most affected in both the primary and periphery regions of the Rural and Urban models. The most affected industries in the primary regions share many similarities. Owner-occupied dwellings, real estate, hospitals, and other essential support industries make up the top 10 industries affected. Like the previous multi-region analysis, the peripheral regions' top affected industries do not share similarities. The spillover effect from the Urban model includes agricultural and energy-related industries in the rural counties top affected regions. The rural model's spillover effect to urban counties includes similar industries as the primary region but some more specialized additions such as architectural services and management services.

Table 5.17. Top Ten Industries Affected in Primary Region of Counterfactual Rural Model				
Description	Employment	Labor Income	Value Added	Output
Owner-occupied dwellings	0	$0	$565,000	$871,000
Real estate	3	$48,000	$304,000	$457,000
Hospitals	2	$130,000	$145,000	$255,000
Limited-service restaurants	2	$52,000	$129,000	$212,000
Wholesale trade	1	$45,000	$82,000	$150,000
Monetary authorities and depository credit intermediation	1	$44,000	$84,000	$149,000
Other financial investment activities	1	$14,000	$17,000	$138,000
Offices of physicians	1	$86,000	$83,000	$132,000
Full-service restaurants	3	$64,000	$71,000	$131,000
Electric power transmission and distribution	0	$10,000	$40,000	$116,000

Table 5.18. Top Ten Industries Affected in Periphery Region of Counterfactual Rural Model (Spillover to Urban)				
Description	Employment	Labor Income	Value Added	Output
Real estate	0	$7,000	$49,000	$71,000
Management of companies and enterprises	0	$26,000	$31,000	$49,000
Other financial investment activities	0	$10,000	$12,000	$46,000
Wholesale trade	0	$15,000	$25,000	$39,000
Nondepository credit intermediation and related activities	0	$17,000	$18,000	$33,000
Wired telecommunications carriers	0	$5,000	$13,000	$26,000
Owner-occupied dwellings	0	$0	$15,000	$23,000
Management consulting services	0	$13,000	$12,000	$20,000
Architectural, engineering, and related services	0	$10,000	$10,000	$18,000
Data processing, hosting, and related services	0	$7,000	$7,000	$18,000

Table 5.19. Top Ten Industries Affected in Primary Region of Counterfactual Urban Model				
Description	Employment	Labor Income	Value Added	Output
Owner-occupied dwellings	0	$0	$6,001,000	$9,252,000
Real estate	32	$581,000	$4,014,000	$5,885,000
Wholesale trade	16	$1,405,000	$2,410,000	$3,671,000
Hospitals	19	$1,462,000	$1,632,000	$2,894,000
Insurance carriers	6	$624,000	$1,164,000	$2,457,000
Limited-service restaurants	27	$546,000	$1,382,000	$2,387,000
Other financial investment activities	13	$493,000	$579,000	$2,270,000
Offices of physicians	13	$1,411,000	$1,364,000	$1,989,000
Full-service restaurants	29	$730,000	$810,000	$1,492,000
Wired telecommunications carriers	3	$301,000	$741,000	$1,456,000

Table 5.20. Top Ten Industries Affected in Periphery Region of Counterfactual Urban Model (Spillover to Rural)				
Description	Employment	Labor Income	Value Added	Output
Real estate	0	$6,000	$36,000	$54,000
Beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming	0	$6,000	$8,000	$40,000
Electric power generation - Fossil fuel	0	$3,000	$12,000	$33,000
Electric power generation - Wind	0	$2,000	$23,000	$27,000
Insurance agencies, brokerages, and related activities	0	$6,000	$8,000	$22,000
Animal, except poultry, slaughtering	0	$2,000	$3,000	$22,000
Wireless telecommunications carriers (except satellite)	0	$0	$6,000	$20,000
Extraction of natural gas and crude petroleum	0	$8,000	$9,000	$19,000
Electric power transmission and distribution	0	$1,000	$5,000	$14,000
Scenic and sightseeing transportation and support activities for transportation	0	$8,000	$8,000	$14,000

The counterfactual analysis explains the full story of how conservation easement monies affect rural and urban communities. With conservation easement payments, rural counties received $112.1 million in economic impact compared to our counterfactual impact of $5.8

million. Alternatively, urban counties received $53.8 million in economic impact from conservation easements and $79.1 million from decreased federal income tax (Table 5.21). Note that the total economic impact of conservation easements is greater than the counterfactual of lowering federal income tax. Decreased federal income tax is modeled as a direct injection to households – who save a portion of this money – whereas conservation easements are modeled as direct expenditures according to the results of the survey data.

Table 5.21. Model Summary Results for Comparison				
Model and Region	Employment	Labor Income	Total Value Added	Output
MRIO Impact on Rural	773	$35,198,000	$51,598,000	$112,087,000
MRIO Impact on Urban	339	$20,047,000	$29,171,000	$53,838,000
Counterfactual Impact on Rural	45	$1,643,000	$3,205,000	$5,843,000
Counterfactual Impact on Urban	547	$25,990,000	$45,689,000	$79,135,000
Single Region Impact	1,122	$56,356,000	$87,827,000	$176,061,000
Aggregate MRIO Impact	1,112	$55,245,000	$80,768,000	$165,924,000
Aggregate Counterfactual Impact	688	$31,859,000	$56,109,000	$97,850,000

I proposed two likely counterfactual scenarios: the zero counterfactual and a decrease in federal income tax. The zero counterfactual provides an upper bound on the best approximation for the impact of conservation easement payments: $112.1 million to rural counties and $53.8 million to urban counties. The decrease in federal income tax provides the lower bound of the best approximation for the impact: $106.2 million to rural counties and a negative impact of $25.3 million in urban counties. These results show that conservation easement payments stimulate the economy more than decreasing federal income tax, and that conservation easement programs function as a transfer of wealth from urban to rural communities. ACEP, as part of the larger Farm Bill, helps accomplish the goal of supporting rural agricultural communities.

Willingness to Pay for Conservation Easements

The 18 identified studies provided a total of 56 values which were used in the meta-analysis. The number of values provided from a single study range from 1 to 18 with an average of 3.11 studies. Studies published in peer-reviewed journals composed 11 out of these 18 studies. Household income, population, and area in square miles were not always available in the original study. In these cases, another source provided an estimate as outlined in Appendix C. Table 5.22 provides summary information about the studies included in the meta-analysis.

Table 5.22. WTP Studies Summary

Author	Number of Observations	Year*	Scale	Published
Beasley et al. (1986)	1	1986	city	Y
Bergstrom et al. (1985)	4	1981	county	Y
Bittner et al. (2006)	1	2001	county	N
Bowker & Didychuk (1994)	4	1994	city	Y
Cho et al. (2005)	1	2003	county	Y
Duke & Ilvento (2004b)	1	2001	state	Y
Duke et al. (2007)	18	2005	city	N
Fleischer & Tsur (2009)	2	2002	county	Y
Halstead (1984)	3	1984	city	Y
Johnston & Duke (2007a)	4	2005	city	Y
Johnston et al. (2001)	1	1995	county	Y
Kashian (2000)	1	1998	city	N
Krieger (1999)	1	1997	county	N
Mcleod et al. (2002)	1	1998	county	N
Ozdemir (2003)	4	2002	state	N
Ready et al. (1997)	4	1990	county	Y
Rosenberger & Walsh (1997)	4	1996	county	Y
Waddington (1990)	1	1990	county	N

*Note that the year column indicates the year the data were collected not the year of publication.

Previous testing shows that there is significant evidence that heteroskedasticity is present in the model. Even if the model suffers from heteroskedasticity, the coefficient estimates will remain consistent and estimating the WTP for agricultural land conservation in Colorado with

OLS results will not cause any problems. Heteroskedasticity in the model will make the estimates inefficient, so I report White's heteroskedastic corrected standard errors as they will be correct with the presence of heteroskedasticity (Table 5.23).

Table 5.23. OLS WTP Meta-Analysis Regression Results

VARIABLES	COEFFICIENT
Area	-1.065***
	(0.0508)
Samplesize	-0.00189***
	(0.000638)
Popdensity	0.114
	(0.217)
Hhinc	2.213*
	(1.251)
Year	-0.00157
	(0.0356)
Published	-0.936**
	(0.371)
City	-1.034
	(0.651)
State	-0.480
	(0.738)
Constant	-17.56
	(14.34)
Observations	54
R-squared	0.903

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The coefficient estimates for Area, Popdensity, and Hhinc match the a priori expectations. The greater the area of land already conserved the less valuable another acre will be, so theory suggests the coefficient for Area should be negative. Higher population density suggests open space should be more valuable, so I expected the coefficient on Popdensity to be

positive. Finally, higher income households have higher WTP for agricultural land, so I expected the coefficient on Hhinc to be positive as well.

I used the OLS results to obtain an estimate for the WTP of agricultural land conservation in Colorado. The estimated 2018 WTP value for all conservation easements in Colorado at the state level is $0.000043 per acre per household per year. I am 95% confident that the true value is between $0.00001 and $0.00018. Converting these estimates to annual dollars per year, on average households would be willing to pay $102.09 annually for the current level of Colorado conserved lands with 95% confidence that the true value falls between $24.06 and $433.23 per household per year. The 2013-2017 American Community Survey 5-Year Estimates states that there were 2,082,531 households in Colorado. Accordingly, I estimate that Coloradoans are willing to pay $212.6 million dollars annually for the current amount of conserved land or using a 5% discount rate $4.25 billion in a one-time payment. Table 5.24 shows a comparison of the Colorado estimate with other values found in the literature at the state level analysis. Although the estimated value is smaller than others, those estimates come from the East Coast. States like Delaware and Connecticut are socio-geographically different than Colorado. Given the level of conservation in Colorado and the smaller population density, the estimate is reasonable.

Table 5.24. WTP Per Acre-Household Estimate Compared with Literature

Author	Year	WTP Estimate	State	Published
OLS Estimate	2018	0.00004	Colorado	-
Ozdemir (2003)	2002	0.00069	Maine	N
Ozdemir (2003)	2002	0.00096	Maine	N
Ozdemir (2003)	2002	0.00373	Maine	N
Johnston & Duke (2007a)	2005	0.00500	Connecticut	Y
Johnston & Duke (2007a)	2005	0.00600	Delaware	Y
Ozdemir (2003)	2002	0.00646	Maine	N
Duke & Ilvento (2004b)	2001	0.03000	Delaware	Y

The meta-analysis literature has studied best practices to address heteroskedasticity (Nelson & Kennedy, 2009). Since there is significant evidence that the data suffer from heteroskedasticity and the literature provides simple solutions, I ran a Weighted Least Squares regression using the sample size of the original study (Samplesize) as the weight (Table 5.25). As expected, none of the coefficient estimates changed significantly, but the standard errors changed.

The WLS model should present more accurate standard errors which allow a more precise discussion of the importance of variables. Area, sample size, household income, and publication status are all highly significant. Economic theory suggests that area and household income should be important factors in determining WTP. The meta-analysis literature also discusses the importance of sample size and publication status (Woodward & Wui, 2001; Brander et al., 2006; Nelson & Kennedy, 2009; Ghermandi et al., 2010). Population density, year, and scale of study are not significantly different from zero. Although preferences for agricultural land conservation may change over the years, the results support Magnan et al. (2012) who found robust willingness to pay for agricultural land over time. Surprisingly population density is not statistically significant; however, population density may be confounded with the scale of the study. Overall the results match the a priori expectations based on economic theory and the meta-analysis literature.

Table 5.25. WLS WTP Meta-Analysis Regression Results

VARIABLES	COEFFICIENT
Area	-1.056***
	(0.124)
Samplesize	-0.00213***
	(0.000699)
Popdensity	0.120
	(0.185)
Hhinc	2.670***
	(0.899)
Year	0.0215
	(0.0392)
Published	-0.886**
	(0.410)
City	-1.299*
	(0.745)
State	-1.137*
	(0.653)
Constant	-22.73**
	(10.52)
Observations	54
R-squared	0.910

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results show that a one percent increase in the area of land already conserved decreases the annual WTP per household per acre by 1.056 percent (or a decrease of $2 million in perpetuity in the case of the entire state of Colorado). In contrast, a one percent increase in the median household income increases annual WTP per household per acre by 2.67 percent (or an increase of $5 million in perpetuity in the case of Colorado). Interestingly, county-level estimates are statistically higher than state and city level estimates at the 0.1 threshold. City and state estimates are not significantly different than one another.

Benefit Transfer

Across the diverse ecosystems of Colorado, conservation easements on private lands account for 2.4 million acres. An average acre of conserved land in Colorado contains 37% grassland, 25% forest, and 23% shrubland. Colorado's diverse natural landscape cause variations in this average depending on geographic region. For example, a conserved acre in Southeast Colorado, which includes Baca, Bent, Crowley, Huerfano, Kiowa, Las Animas, Otero, Pueblo, and Prowers counties, contains an average of 56% grassland, 23% forest, and 15% shrubland.

I used a benefit transfer approach to estimate the total value of the ecosystem services on private lands protected by conservation easements to Coloradoans. Considering an average acre of conserved land in Colorado, annual ecosystem service benefits per acre range from $849 (using minimum values) and $995 (using maximum values) per acre per year and in the range of $2-2.3 billion in total value per year (2018 dollars). Table 5.26 shows the annual estimated benefits provided in Colorado by land cover type.

Table 5.26. Total Annual Benefits Provided by Land Cover Type, 2018$

Land Cover	State Min	State Max
Open Water	3,080,000	4,788,000
Forest	1,195,595,000	1,343,443,000
Scrub/Shrub	260,095,000	353,427,000
Grassland	415,631,000	434,322,000
Agriculture	53,485,000	57,858,000
Woody Wetlands	61,083,000	111,312,000
Herbaceous Wetlands	36,158,000	67,772,000
Total	2,025,129,000	2,372,923,000
Average Per Acre	849	995

Note that the estimated average values per acre are annual values. However, conservation easements protect lands and provide ecosystem benefits for longer than one year. To better estimate the ecosystem benefits that accrue from the conservation of lands I estimated the benefits over the life of the conservation easement. Over the lifetime of the easements,

Coloradoans receive between $40 and $47 billion and an average conserved acre provides between $17,000 and $19,900 of benefits (Table 5.27).

Table 5.27. Cost and Benefits of Conservation Easements in Perpetuity, r = 0.05, 2018$		
	Min for CO	Max for CO
Total Benefits	40,502,578,000	47,458,455,000
Average Benefits Per Acre	17,000	19,900
Average Easement Compensation Per Acre	899	
Average Easement Appraisal Value Per Acre	1,151	

These ranges of public benefit values should provide the theoretical upper bound on what the public would be willing to pay annually to receive these benefits. If this were the annual public rental rate in exchange for these ecosystem service benefits, then the public purchase price for such a parcel would be $17,000 - $19,900 per acre, in addition to its remaining value in production agriculture, using a 5% discount rate (Table 5.27).

The benefits generated from conservation do not come without a cost, however. Since conservation easement programs wish to minimize taxpayer burden, I also report state-funded compensation paid to landowners, which excludes tax credit programs, as a lower bound of the cost to Colorado taxpayers. However, conservation easement programs require voluntary participation of landowners, so I also report appraisal value, which serves as an estimate of the opportunity cost of participation to landowners. Using actual conservation easement transaction data from the Colorado land trust community, I found an average state-funded payment of $899 per acre conserved or about 78% of the appraised value. Additional compensation comes in the form of participation in tax credit programs for the value of the donated portion of the easement up to the total appraised value of the easement.

I used state-funded conservation easement payments as the lower bound cost to taxpayers and appraisal value as the upper bound. Private land conservation, which costs on average

between $899 (without tax credits) and $1,151 (with maximum tax credits, federal match, etc) per acre to conserve through an easement purchase, generates between $17,000 and $19,900 per acre in public ecosystem service benefits. This translates into an average return on investment of $13 – $21 in the form of public ecosystem services for every $1 invested in conservation easements in the state of Colorado.

ACEP Payment

I applied the rental rate for the corresponding category and year to the aggregated dataset of conservation easements, and I obtained the annual rental value of the sample of conservation easements. Since the total value of the land is of interest, I assumed the rental value is in perpetuity using a 5% interest rate. I calculated the total rental value of the land and report the results in Table 5.28. Although irrigated cropland is only one-quarter of the acreage of pastures, the higher rental rate results in the highest contribution of $34.3 million to the total rental value in perpetuity of $44.4 million.

Table 5.28. Rental Value of Conservation Easement Lands

Category	Annual Rental Value	Total Value in Perpetuity, r=0.05
Irrigated Cropland	$1,717,158	$34,343,160
Non-irrigated Cropland	$21,448	$428,964
Pasture	$482,635	$9,652,706
Total	$2,221,241	$44,424,820

I estimated the proposed compensation as three-quarters of the rental value of the land multiplied by the proportion of the opportunity cost to the rental value of the sample plus a tenth of the estimated minimum environmental benefits provided. I used the following equation in the calculations:

$$Proposed = 0.75 * Rental * \left(\frac{Sample\ Opportunity}{Sample\ Rental}\right) + 0.1 * Environmental$$

The rental value of the sample is $44.4 million as seen in Table 5.36. The federal and nonfederal amount of conservation easement compensation to landowners totaled to $113 million for the sample. This gives a proportion of opportunity cost to rental values of 2.55. This means that for every dollar of rental value there is an estimated $2.55 of opportunity cost in the form of development. Using this proposed compensation equation, the total proposed payments for the conservation easement sample is $169.5 million dollars compared to the current $113.3 million dollars spent.

I performed a sensitivity analysis because the existing literature does not suggest how opportunity cost and environmental benefits should be weighted. I report the proposed compensation for the sample in Colorado after I changed one coefficient by +/- 0.05 while keeping the other coefficient constant. I included the values of increasing and decreasing both coefficients by 0.05 as well. Lastly, I report the coefficients values that achieved the estimated WTP for the sample keeping the other coefficient value constant. Table 5.29 shows the results of this analysis. Since estimated benefits are much larger than estimated opportunity cost, a 0.05 change in the benefit coefficient caused a much larger change in the proposed compensation. Note that all proposed compensation results exceed the current payment amount and most remain under the estimated WTP. This analysis shows that the proposed coefficient values illustrate an alternative payment mechanism that balances both opportunity cost and benefits while remaining under the estimated WTP of Coloradoans for those conservation easements.

Table 5.29. Proposed Compensation Coefficients Sensitivity Analysis, Entire Colorado Sample				
Opportunity Coefficient	Benefit Coefficient	Proposed Compensation for Sample	Change Relative to Proposed Coefficient Values (%)	Comparison to WTP Estimate
0.75	0.1	$169,459,000	0.00	Under
0.8	0.1	$175,123,000	3.34	Under
0.7	0.1	$163,794,000	-3.34	Under
0.75	0.05	$127,211,000	-24.93	Under
0.75	0.15	$211,707,000	24.93	Over
0.7	0.05	$121,546,000	-28.27	Under
0.8	0.15	$206,043,000	21.59	Over
0.75	0.11	$180,497,000	6.51	Equal
0.85	0.1	$180,497,000	6.51	Equal

Due to data constraints, first I compare payment schemes for a smaller subset of conservation easements in Southeast Colorado defined as the following counties: Baca, Bent, Crowley, Huerfano, Kiowa, Las Animas, Otero, Pueblo, and Prowers. Proposed GARC values for Southeast Colorado are shown in Table 5.30. I present the proposed GARC values, estimated benefits, actual conservation easement compensation, estimated productive value, and proposed compensation of the subset of 20 conservation easements in Southeast Colorado (Table 5.31).

Table 5.30. Proposed GARC Payments for Southeast Colorado	
Land Use	GARC Payment per Acre
Irrigated Crop	$1,918
Non-irrigated Crop	$400
Grassland	$394
Non-Ag Bottomland	$833

Table 5.31. Comparison of Conservation Easement Values for Southeast Subset	
Method	Value
GARC	$6,317,700
Minimum Benefits with Carbon	$20,583,200
Maximum Benefits with Carbon	$22,100,800
Actual Compensation	$5,431,500
Rental Value	$6,907,400
Proposed Compensation	$15,268,600

The proposed GARC value closely matches both actual compensation and the rental value of the land in Southeast Colorado. Since development potential in Southeast Colorado is not as close to the average development potential in Colorado as a whole, the proposed compensation overstates the value of conservation easements in Southeast Colorado.

I considered an illustrative example of 100 acres of grassland in Otero County in Southeastern Colorado. The estimated ecosystem service benefits would be between $916,000 and $958,000 in perpetuity. Coloradoans' willingness to pay for a conservation easement on the parcel is $166,600 in perpetuity. The rental value would be $5,400 and the GARC payment value would be $39,400. The proposed payment value would be $105,000 (Table 5.32). As noted previously, the values change drastically with a specific parcel and scaling values such as willingness to pay to a specific parcel can produce inaccurate values. These estimations can provide insight into larger scales, but with highly heterogenous land these values might not be applicable to a given parcel.

Table 5.32. Values for Hypothetical Grassland in Otero County, r=0.05, 2018$	
Minimum Benefits with Carbon	$916,000
Maximum Benefits with Carbon	$958,000
Willingness to Pay	$166,600
Rental Value	$5,400
GARC Value	$39,400
Proposed Compensation	$105,000

I scaled the analysis to the entire sample of conservation easements and compare estimated benefits, actual compensation, productive value, and proposed compensation (Table 5.33). As I aggregate, the actual compensation diverges from productive value. This reflects the fact that conservation easement payments are based on development potential, and land with lower rental values might have more development potential in more urban areas. Estimated benefits still far exceed actual or proposed compensation. The proposed compensation

compensates landowners more than actual compensation, but this reflects the large difference between payments and benefits. Since benefits are taken into consideration the proposed compensation exceeds the current compensation method. While this might be worrisome for taxpayers, this gives landowners incentive to enroll land that provides more environmental benefits rather than land with high development potential. I calculated the estimated WTP for the conservation easement sample and convert it from annual to perpetuity using a 5% discount rate. While the proposed compensation does increase the total cost of the sample of conservation easements in Colorado, it does capture more of the public's willingness to pay for those conserved lands without exceeding it.

Table 5.33. Comparison of Conservation Easement Value for Entire Sample	
Method	Value
Minimum Benefits with Carbon	$844,961,700
Maximum Benefits with Carbon	$892,570,200
Actual Compensation	$113,282,500
Rental Value	$44,424,800
Proposed Compensation	$169,458,600
Estimated WTP	$180,497,000

CHAPTER 6. LIMITATIONS AND FUTURE RESEARCH

The economic consequences of conservation easements appear to justify the costs and risks. However, the analysis could be improved upon in future research. I outline the limitations of the economic impact analysis, benefit transfer values, and alternative payment mechanisms.

Economic Impact

Economic Impact Analysis can only be applied to the federal contribution to conservation easement payments. State matching programs in the available data for Colorado account for $69.8 million in conservation easement payments; however, this money serves as a transfer to conservation easement holders from the state government, and therefore primarily Colorado resident taxpayers. As such no new economic activity can be determined in our economic impact analysis at the state level as it is a transfer within the state. These transfers may have real impacts on individuals and potentially even specific counties or communities. Since the source of state match monies cannot be identified, I cannot say with certainty what this redistribution might look like.

The survey failed to specify where expenditures occurred. Although this would impose a large burden on the surveyed landowners, more granular detail of the exact expenditures, as well as the location, would increase the accuracy of the multi-regional economic impact analysis on rural vs urban Coloradoans. Future surveys could collect data to address some of these uncertainties in the model.

The analysis does not evaluate the potentially significant investment effects that may come from conservation easement payments. The Input-Output model treats the conservation easement payments as a one-time influx of dollars into the Colorado economy, which under-

estimates the positive economic outcomes stemming from the conservation easement payment. For example, if the easement payment is used to invest in better technology, that improved technology may have lasting positive effects on the economy that are not captured in the analysis. The analysis cannot capture other non-expenditure effects that were reported such as increased elk grazing, building rental homes, increased outdoor recreation, and supplementing income through rough years. As a result, the economic impact results are a conservative estimate of the economic activity generated over 2009 to 2017 from federal agricultural conservation easement payments in Colorado.

The IMPLAN software does not allow for aggregation of sectors in a Multi-Region Input-Output model. Future work could construct an MRIO model outside of the software in order to aggregate the sectors and more accurately reflect the survey responses.

Benefit Transfer

Benefit transfer methods can provide accurate results if used appropriately. Although values from the literature were screened, some values applied to land types in Colorado may not be entirely appropriate. Values from Eastern United States may not be applicable to Colorado. Future research could collect primary data on the ecosystem services provided by conservation easements in Colorado and estimate the value of those services. Alternatively, with a growing database of primary ecosystem service valuation studies, a meta-analysis could be conducted to estimate ecosystem service values for Colorado in particular which would improve upon a simple benefit transfer method.

The results show that the per acre benefits make it clear that the payments received are considerably lower than the lifetime ecosystem benefits generated from the easement and are similar to the average annual ecosystem benefits stemming from land conservation. This does not

account for alternative use of the land. That is, land development provides some amount of ecosystem service values which were not accounted for in this analysis and as such the values are over estimated. Future research could account for the benefits provided by an alternative land use by surveying landowners to determine the most probable alternative use of the land in the absence of the conservation easement.

Alternative Payment Mechanisms

The heterogeneity of agricultural land in Colorado makes a simple conservation easement payment mechanism impossible. The results of this thesis show that the opportunity cost of agricultural land in Southeast Colorado differs from all of Colorado, so any payment mechanism based on the opportunity cost of the land will vary drastically across counties. If the program shifts focus and tries to maximize ecological benefits, then a payment mechanism based on ecosystem services could be applied across county lines. However, given the limitations of this benefit transfer study, a better methodology would be warranted to estimate the ecosystem service values. All payment mechanisms would incur tradeoffs between costs and benefits. The results of this thesis show that Coloradoans are willing to pay for conservation easements and the estimated benefits are worth the costs. As such, future research could investigate alternative payment mechanisms in greater depth.

Additional research could explore different aspects of the program aside from the payment mechanisms. For example, incentivizing landowners to apply earlier in the year could reduce demand of the state approved appraisers. Similarly, changing liability legislation could entice more appraisers to become state certified. I do not consider any of these aspects of the program in my analysis, but additional research in these areas could provide further insight into these issues.

CHAPTER 7. CONCLUSION

To have a better grasp of the economic implications of the Agricultural Conservation Easement Program in Colorado, I have explored a wide range of metrics in the analysis. Conservation easements have been a source of contention in Colorado after early cases of misuse. This has led the Colorado government to pursue more oversight and implementing more cautionary measures. This, in turn, led to a surplus of state budget earmarked for conservation easements. While caution is warranted, I explored some of the economic implications of conservation easements to understand the costs and benefits of ACEP in Colorado. I explored the economic impact to the state and then disaggregated the impacts between rural and urban areas in Colorado. I then compared this with a counterfactual to understand what an alternative use of those federal dollars might look like. I investigated the willingness to pay for agricultural land literature and estimated how much Coloradoans are willing to pay for conservation easements. I quantified some of the ecosystem service benefits of conservation easements through a benefit transfer methodology. Lastly, I compared all of the results to understand how the current costs compare to benefits and Coloradoans' willingness to pay. I proposed an alternative payment system that compensates landowners directly for environmental benefits and captures more of the publics' willingness to pay for those benefits.

The single area Input-Output analysis showed that conservation easement payments in Colorado generated $176 million in economic activity. I improve upon this initial analysis by conducting a Multi-Region Input-Output analysis with rural and urban counties. This analysis showed that of the total estimated impact in the MRIO analysis of $166 million, $112 million of the economic activity occurred in rural counties, while $54 million occurred in urban counties. I

further improved upon this analysis by conducting a counterfactual analysis. I considered two counterfactual scenarios. The first assumed that the federal dollars used to fund ACEP would be used by another government program with a negligible economic impact on Colorado. The second assumed that Coloradoans received a decrease in federal income tax because of voluntary nonparticipation in ACEP. These counterfactuals serve as bounds for the best approximation of the economic impact of ACEP in Colorado. The second counterfactual analysis effectively injected federal dollars to households and examines the increased economic activity. Of the total $85 million of increased economic activity in the second counterfactual, only $6 million occurred in rural counties while $79 million occurred in urban counties. First, note that conservation easement payments generated $81 million more in economic activity than the counterfactual federal income tax decrease. Further, the distribution of the impact shows that rural communities received $106 million more in economic impact through conservation easement payments than the counterfactual. Urban communities received $25 million less in economic impact through conservation easement payments than the counterfactual. I estimate the best approximation for the economic impact of conservation easements on rural counties to be between $106 million and $112 million. One objective of the Farm Bill throughout the years has been to support rural communities. The results show that in Colorado conservation easements have been an effective way of achieving that goal.

Conservation easement payments support rural communities; however, a comparison must be made with the costs. The greatest burden lies with taxpayers and if they are not willing to pay the costs then the government might be misrepresenting the people. I examined the willingness to pay literature and estimated how much Coloradoans are willing to pay for the current amount of conserved lands. I searched the literature and constructed a meta-analysis

regression to find that Coloradoans are willing to pay $0.00004 per acre per household per year. I determined that this is a reasonable estimate compared to other values in the literature considering the differences between Colorado and the East Coast. For the sample of conservation easement data, this results in a total willingness to pay of $180 million compared to the actual payments of $113 million. This shows that Coloradoans are willing to pay more than the current amount of compensation to conservation easement holders.

Coloradoans are willing to pay the current cost of conservation easements, but what benefits do they receive from this land conservation? I used a benefit transfer methodology to estimate the ecosystem service values from conservation easements. I found a range of values in the literature which would apply to ecosystem services in Colorado. For the sample of conservation easement data, I estimated that public ecosystem benefits range from $845 million to $893 million. The estimated ecosystem benefits are more than 7 times the amount of actual payments and over 4 times what Coloradoans would be willing to pay. This shows that conservation easements provide a considerable amount of non-consumptive use benefits to the state of Colorado.

The proposed alternate payment method compensates landowners for the real loss in value due to forgone development rights but also encourages enrollment of lands that provide more ecological benefits. One can easily find rental rates for the county of the potential easement and calculate the estimated value of the foregone development rights. I multiplied this by three quarters and added one-tenth of the estimated minimum ecosystem service values of the potential easement. This not only creates incentives to enroll ecologically valuable land but allows compensation estimates based on the type of land and county location. For the sample of conservation easements, the proposed methodology would have paid conservation easement

holders $169 million. This is more than the $113 million under the current method but is still lower Coloradoans' willingness to pay of $180 million. This proposed method allows landowners to capture more of the willingness to pay for the public benefits that they provide through conservation easements.

The proposed method does not solve every issue with current conservation easement payments. It does not capture enough heterogeneity across regions as seen in the results for a subsample of conservation easements in Southeast Colorado. State actors will still require individual appraisals to account for this heterogeneity. However, this imposes real barriers to entry for landowners considering enrolling their land in a conservation easement. As the results show, Colorado and its citizens would benefit from using all $45 million annual of the state budget to increase the number of conservation easements. A federally approved alternative payment mechanism that could estimate the value of the conservation easement without an individual appraisal could increase the number of conservation easements. This alternative method would increase enrollment of smaller parcels of land which previously would not enroll due to initial appraisal costs.

The Agricultural Conservation Easement Program succeeds in supporting rural counties in Colorado and providing many ecosystem services to the residents of Colorado. The analysis shows that these benefits and outcomes are greater than both the cost of the program as well as Coloradoans' stated willingness to pay for the program. Although there are reasons to continue requiring individual appraisals to value potential land for enrollment in the program, I show that alternative methods can remove barriers to entry for landowners, encourage enrollment of more environmentally valuable land, remain within Coloradoans' willingness to pay, and potentially increase the overall acreage of conserved lands. The proposed method comes with challenges,

but the analysis showed that conservation easements are worthwhile investments for Colorado. Colorado should dedicate more resources for developing an alternative methodology to lessen the initial barriers to entry and increase conservation easement enrollment.

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APPENDICES

Appendix A: Survey As Seen By Respondents

[land trust letterhead]

[date]

Dear **[insert name]**,

The Colorado Land Trust Community is partnering with researchers at Colorado State University's Department of Agricultural and Resource Economics (DARE) to better understand the economic impact of federal conservation easement programs on Colorado communities. Participants include all Colorado landowners who received payments from these federal programs since 2007. The results of this research will be used to help inform funding decisions for these types of producer programs in the future.

We at **[insert organization]** request that you complete and return the enclosed survey within the next two weeks. Participation will take approximately 10-15 minutes. Your participation in this research is voluntary. If you decide to participate in the study, you may withdraw your consent and stop participation at any time without penalty.

This survey is designed to help researchers estimate the economic impact of these programs on Colorado communities. We will keep your identity strictly confidential and all data analysis and reporting protocols will be followed closely. When we report and share the data with others, we will combine the data from all participants.

While there is no known direct benefit to you, we hope to gain important insights that will help inform funding decisions for conservation programs in the future. It is not possible to identify all potential risk in research procedures, but the researchers have taken reasonable safeguards to minimize any known and potential (but unknown) risks. Completing the survey and returning it in the enclosed stamped envelope is your consent to participate.

If you have any questions about the research, please contact Professor Andy Seidl at Andrew.Seidl@colostate.edu or Research Scientist Rebecca Hill at rebec.hill@colostate.edu and refer to Federal Conservation Easement Payment Recipient Survey in the subject line of your message. If you have any questions about your rights as a volunteer in this research, please contact the CSU IRB at: RICRO_IRB@mail.colostate.edu; 970-491-1553.

[land trust director salutation, name and address/contact]

Federal Conservation Easement Payment Recipient Survey

The Colorado Land Trust Community[4] is partnering with researchers at Colorado State University's Department of Agricultural and Resource Economics (DARE) to better understand the economic impact of federal conservation easement programs[5] on Colorado communities. Participants include all Colorado landowners who received payments from these federal programs since 2007. The results of this research will be used to help inform funding decisions for these types of producer programs in the future.

In **[insert date of easement closing]** you received payments in the amount of **[insert $$ number]** for conveying a conservation easement to **[insert organization]**. This survey is designed to help researchers estimate the economic impact of these programs on Colorado communities. For the easement payment described above, please respond to each question fully and to the best of your ability. If you have entered into more than one easement agreement on your operation since 2007, you will need to complete the survey for EACH easement agreement separately. Participation will take approximately 10-15 minutes.

Your participation in this survey is voluntary and strictly confidential. If you decide to participate in this survey, you may withdraw your consent and stop participation at any time without penalty. We will keep your identity strictly confidential and all data analysis and reporting protocols will be followed closely. When we report and share the data with others, we will combine the data from all participants. While there is no known direct benefit to you, we hope to gain important insights that will help inform funding decisions for conservation programs in the future. It is not possible to identify all potential risk in research procedures, but the researchers have taken reasonable safeguards to minimize any known and potential (but unknown) risks. To indicate your consent to participate in this research please select "Yes" below and continue with the survey. If you do not consent, please select "No" and return the survey using the self-addressed stamped envelope.

○ Yes

○ No

[4] *The Colorado Cattlemen's Land Trust (CCLT), Colorado Open Lands (COL), The Nature Conservancy (TNC), Mesa Land Trust (Mesa), Rio Grande Headwaters Land Trust (RiGHT), the Gunnison Ranchland Conservancy Legacy (GRCL), Yampa Valley Land Trust (YVLT), Aspen Valley Land Trust (AVLT), San Isabel Land Protection Trust (SILTP), Palmer Land Trust (Palmer), and Headwaters Conservancy.*

[5] *Farm and Ranch Land Protection Program (FRPP), Grassland Reserve Program (GRP), Agricultural Conservation Easement Program (ACEP), Agricultural Land Easements (ALE).*

1. As a result of this easement have you added hunting/fishing or other outdoor recreation activities to your operation?

- ○ Yes
- ○ No

2. If you answered "Yes" to question 1:

a) What were the estimated gross revenues from these activities: $_____/yr.

b) What are the estimated number of visitor-days from these activities: _____/yr.

c) If you added employees, please indicate the number of full time equivalent employees hired to support these activities: _____FTE.

3. In completing the table below, please round to the nearest acre:

	Immediately Before Entering into Easement	Directly Following Entrance into Easement (1 - 3 years post easement)
Total Farmed (Ranched) Acres	acres	acres
Acres Irrigated with Flood Irrigation	acres	acres
Acres Irrigated through Mechanized Means (roller, drip, center pivot)	acres	acres

4. How many acres are in production of the following (Please round to the nearest acre):

	Immediately Before Entering into Easement	Directly Following Entrance into Easement (1 - 3 years post easement)
Livestock Grazing	acres	acres
Fallow	acres	acres
Fruit Production	acres	acres
Row Crop Production (e.g., corn, wheat, alfalfa, sugar beets)	acres	acres
Idle	acres	acres
Other	acres	acres

If Other, please describe: _____

5. For the operation on which this easement is placed I:

- ○ Am the primary operator
- ○ Am a co-operator
- ○ Lease out the land

6. Have you noticed any change in your yields or stocking rates as a result of adopting the conservation practices required by the easement?

- ○ Yes
- ○ No

7. If you answered "Yes" to question 6, please indicate by what percentage your yield or stocking rates changed due to conservation easement practices:

	Baseline yield or stocking rate per acre	Estimated yield or stocking rate change due to easement practices (% change) (please circle one)
Livestock Grazing	/acre	-50 -40 -30 -20 -10 0 (no change) +10 +20 +30 +40 +50
Fruit Production	/acre	-50 -40 -30 -20 -10 0 (no change) +10 +20 +30 +40 +50
Row Crop Production (e.g., corn, wheat, alfalfa, sugar beets)	/acre	-50 -40 -30 -20 -10 0 (no change) +10 +20 +30 +40 +50
Other	/acre	-50 -40 -30 -20 -10 0 (no change) +10 +20 +30 +40 +50

If Other, please describe: _____

_____

8. Did you change your farming operation in any way due to this easement? (Select all that apply)

- ☐ Changed Crop Mix/Rotation
- ☐ Increased Acreage Farmed (acres ranched or number of livestock/stocking rate)
- ☐ Decreased Acreage Farmed (acres ranched or number of livestock/stocking rate)
- ☐ Improve Irrigation Practices
- ☐ Other (Please Describe)

_____

9. If you changed your farming/ranching operation due to this easement, please use the space below to describe how has your operation changed because of your enrollment in the easement program:

_____

_____

_____

_____

_____

_____

10. In the list below please indicate what proportion of your total conservation payment went to each of the following (they should sum to 100%):

Invested back into the ag operation through purchases of inputs (including restocking livestock herds), labor, equipment or other infrastructure (including irrigation infrastructure)	%
Invested in non-farm land-based enterprise diversification (e.g., agritourism, hunting/fishing, outdoor recreation)	_____%
Invested in the purchase or lease of additional land to expand the ag operation	%
Invested in savings (could include retirement fund or stock market investment as well as savings accounts)	_____%
Invested in post-high-school education of a family member	_____%
Pay down farm debt	%
Purchase of non-business related goods (e.g., recreational vehicle, vacation, second home)	%
Other	_____%
	100%

If Other, please describe: _____

Thank you for taking the time to fill out this survey. Please use the space provided below to provide any other information or feedback that you think might be helpful to our understanding and analysis.

_____
_____

_____

We anticipate the results of this survey will be available in May 2018. If you would like a copy of the results, to hear from us when the results will be presented in your community, have questions, comments or other feedback, please contact: Professor Andrew Seidl (Andrew.Seidl@colostate.edu) at your Colorado State University

<This survey is complete. Thank you for your participation.>

Appendix B: Methodology for Filling in Missing Meta-Analysis Data

In some cases, I was not able to obtain all the necessary data from the study itself. In these cases, I consulted additional outside data sources. The most common of these sources was the US Census and the USDA Census of Agriculture. Table B.1 lists the data sources consulted for each study. Most frequently I consulted outside sources to find the population, area, or household income for a study area. For Ready et al. (1997), I used Nutt et al. (2011) to find the average acreage of a horse farm in Kentucky. I was then able to include Ready et al. (1997) by converting the proposed number of horse farms conserved into acres. Bittner et al. (2006) do not report the number of acres of agricultural land in Moffat County, Colorado, so I used the USDA Census of Agriculture to provide an estimate of the existing acreage of agricultural land. For the study conducted by Cho et al. (2005), I assumed that the 1100 acres cited in the study was the current level of protection.

Table B.1. Data Sources for Missing Willingness to Pay Data		
Study	Data Source	Data Type
Beasley et al. (1986)	US Census	Population, Household Income, Area
Bergstrom et al. (1985)	US Census	Population, Household Income
Bittner et al. (2006)	USDA Census of Agriculture	Population, Area, Area of Agricultural Land
Bowker & Didychuk (1994)	Statistics Canada	Population, Area
Cho et al. (2005)	US Census	Population, Number of Households
Duke & Ilvento (2004b)	US Census	Population, Area
Duke et al. (2007)	US Census	Population, Household Income, Area, Average Household Size
Halstead (1984)	US Census	Population
Johnston & Duke (2007a)	US Census	Population
Kashian (2000)	US Census	Population
Krieger (1999)	US Census	Population, Area
Mcleod et al. (2002)	US Census	Population, Area
Mcleod et al. (2002)	USDA Census of Agriculture	Area of Agricultural Land
Ozdemir (2003)	US Census	Population, Area, Average Household Size
Ready et al. (1997)	Nutt et al. (2011)	Average Area of Horse Farms
Ready et al. (1997)	US Census	Population, Household Income
Rosenberger & Walsh (1997)	US Census	Population, Household Income
Waddington (1990)	US Census	Population, Area, Average Household Size
Waddington (1990)	USDA Census of Agriculture	Area of Agricultural Land

Appendix C: Conservation Easement Parcels

While there are a variety of conserved lands, I only examined conservation easement parcels. Using COMaP, I filtered PROTECTION_MECHANISM to include any values containing "CE" in order to select conservation easements. I also filtered OWNER to include only Land Trust, Private, and NGO in order to exclude publicly owned conservation easements. When referring to all conservation easements in Colorado, I am referring to these parcels.

Only permanent conservation easements are eligible for federal programs. However, term (say, 20 or 30 yrs.) conservation easements do exist in COMaP. In the sort of the available data, I

assumed that easements are in effect in 2018, unless I have information confirming the parcel does not remain protected. A total of roughly 2.4 million acres included in the analysis (Figure C.1).

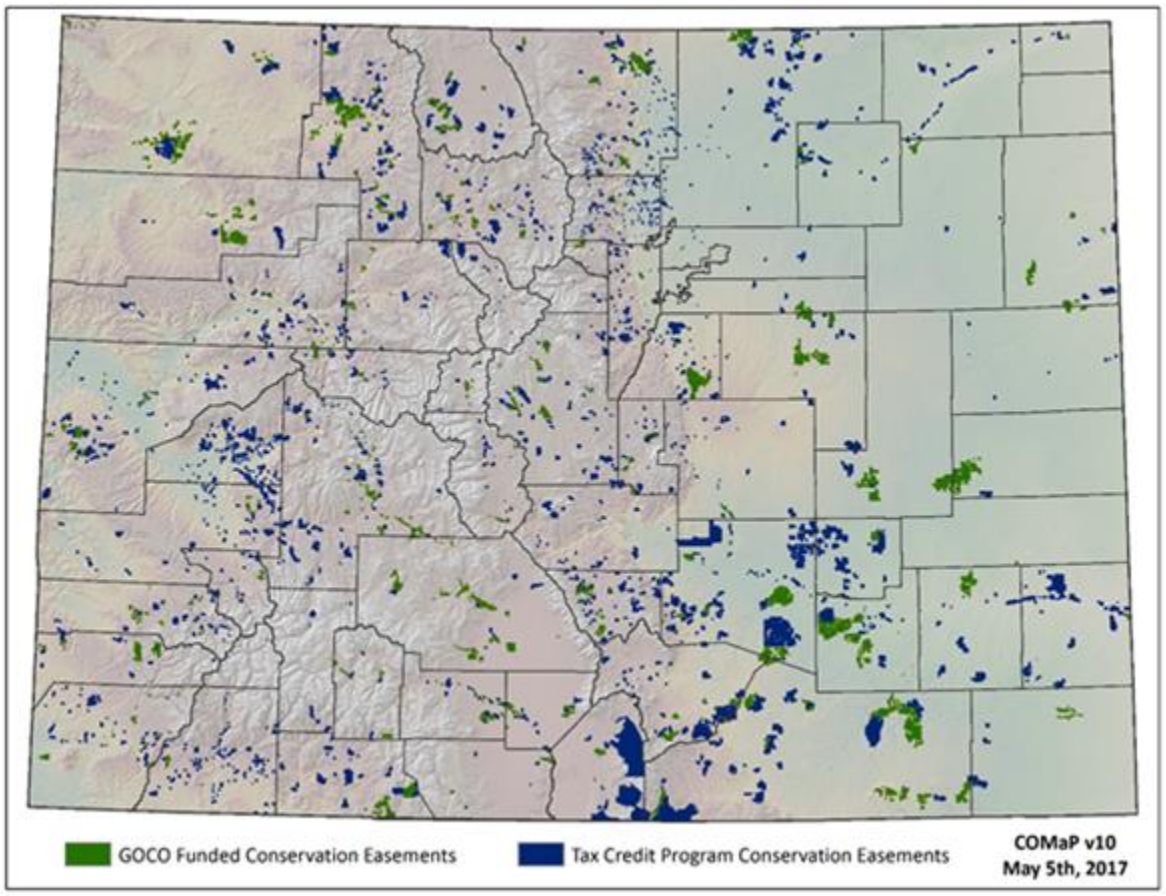

Figure C.1. Locations of Conservation Easements Included in Analysis of Entire State

The ecosystem service values from the literature separated into benefit transfer categories differ slightly from NLCD land cover types. Table C.1 shows how benefit transfer values apply to the corresponding NLCD land cover type.

Table C.1. Land Cover Crosswalk	
Benefit Transfer Category	NLCD
Open Water	Open Water
Not Evaluated	Perennial Ice/Snow
Not Evaluated	Developed, Open Space
Not Evaluated	Developed, low
Not Evaluated	Developed, medium
Not Evaluated	Developed, High
Not Evaluated	Barren
Forest	Deciduous Forest
Forest	Evergreen Forest
Forest	Mixed Forest
Scrub/Shrub	Scrub/Shrub
Grassland	Grassland
Agriculture	Pasture
Agriculture	Crops
Woody Wetlands	Woody Wetlands
Emergent Herbaceous Wetlands	Emergent Herbaceous Wetlands

The data for the subset of conservation easements in South East Colorado specified the general ecosystem conserved and I mapped them into NLCD categories. Acreage assigned to multiple ecosystems were divided evenly among those ecosystems. For example, an easement assigned to forest and grassland was allocated 50% of total acreage to forest and 50% to grassland.

LIST OF ABBREVIATIONS

ACEP – Agricultural Conservation Easement Program
ALE – Agricultural Land Easement
AWMA – Area Wide Market Analysis
CoMAP – Colorado Ownership, Management and Protection
CRP – Conservation Reserve Program
CVM – Contingent Valuation Method
ERS – Economic Research Service
EVRI – Environmental Valuation Reference Inventory
FRPP – Farm and Ranch Lands Protection Program
GARC – Geographic Area Rate Cap
GRP – Grassland Reserve Program
IMPLAN – Economic Impact Analysis for Planning
InVEST – Integrated Valuation of Ecosystem Services and Tradeoffs
IRS – Internal Revenue Service
MRIO – Multi-Region Input-Output
NLCD – National Land Cover Database
NRCS – National Resource Conservation Service
OLS – Ordinary Least Squares
RUCC – Rural-Urban Continuum Code
TEEB – The Economics of Ecosystems and Biodiversity
WLS – Weighted Least Squares
WRE – Wetland Reserve Easement
WRP – Wetland Reserve Program
WTP – Willingness to Pay