PUBLIC BENEFITS OF PRIVATE LANDS CONSERVATION: EXPLORING ALTERNATIVE COMPENSATION MECHANISMS

September 2018

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AGRICULTURAL AND RESOURCE ECONOMICS
COLORADO STATE UNIVERSITY


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[2] Recommended citation: Andrew Seidl, Ryan Swartzentruber, Rebecca Hill. 2018. Public benefits of private lands conservation: Exploring alternative compensation mechanisms. College of Agricultural Sciences, Colorado State University. 25 pp.

[3] The authors would like to acknowledge with thanks the Lower Arkansas Valley Water Conservancy District for financial support of this project. All errors remain our responsibility.

EXECUTIVE SUMMARY

Conservation easements are a primary public policy tool to encourage stewardship of public benefits from private lands. The landowner can receive compensation for entering into an easement agreement up to the amount of economic loss suffered due to the restriction, also known as opportunity cost. Conservation programs will be more attractive to landowners if they can capture a greater share of the public good generated through the easement rather than merely cover their losses (opportunity cost). We explore the current appraisal system for evaluating conservation easement payments, as well as several alternative compensation mechanisms. Conservation easement payments array from opportunity cost recovery at the low end and public benefit of private lands conservation at the high end of compensation.

We use a benefit transfer approach to estimate the total value of the ecosystem services on private lands protected by conservation easements to Coloradoans. If we consider 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).

The subset of Southeast Colorado conserved land accounts for a third of total conserved lands in Colorado and contains more grassland on average compared to all of Colorado. An average acre of conserved land in Southeast Colorado generates slightly lower public benefits compared to the state, ranging from $814 to $921 per acre-year. Total annual benefits to Coloradoans provided by Southeast Colorado conservation easements range from $620 million to $702 million per year.

Over the lifetime of the easements, Coloradoans receive between $40 and $47 billion and an average conserved acre provides between $17,000 and $20,000 of benefits. Southeast Colorado provides a total of $12 billion to $14 billion of benefits, and an average acre of conserved land provides between $16,000 and $18,000. These ranges of public benefit values should provide the theoretical upper bound on what the public should be willing to pay annually to receive these benefits.

We take 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. 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. An average payment for a conserved acre in Southeast Colorado is $613, or about 93% of the appraised value of $655. These conservation easements generate between $16,000 and $18,000 per acre in public ecosystem service benefits.

In 2012, NRCS established GARCs with rate caps ranging from $170 per acre to $2,240 per acre-year depending on the easement type, the region and the land type conserved. The average GARC payment for a parcel in our dataset would have been $1,061 per acre-year conserved (2018 dollars). Estimated annual benefits provided by these easements fall between $4.4 million and $4.6 million. Under the GARC methodology, the payment would have been 4-15% more per acre than under the appraisal-based system.

Our results show that, regardless of payment methodology, private lands conservation using conservation easements provides positive benefits to the state of Colorado, and that these benefits far exceed the costs. Moving toward a public benefits valuation approach from the current opportunity cost approach has the potential for improved returns to taxpayer dollars due to attracting higher valued properties to the programs.

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INTRODUCTION

Private lands can provide valuable public benefits when managed for them. Conservation easements are a primary public policy tool to encourage stewardship of public benefits from private lands where private property rights are strong. A landowner voluntarily restricts his/her private property rights by removing the right to develop the land in an alternative use, typically residential or commercial development. In addition, the landowner agrees to a management plan that permits agricultural production and generates or conserves public benefits from the land. This deed restriction is an (agricultural) conservation easement (ACE or CE).

The landowner can receive compensation for entering into an easement agreement up to the amount of economic loss suffered due to the restriction, also known as opportunity cost. Fiscal responsibility requires the public enjoy benefits equal to or greater than the compensation to the landowner for the transaction. Program administrators entice landowners by compensating them for their opportunity cost of entering into the conservation easement, but also ensure that the public good generated exceeds the payment. Public program administrators are to ensure the funds put toward easements provide the greatest benefit to the public. Minimizing conservation easement payments per acre conserved should maximize the reach and fiscal responsibility of any publicly supported program. However, such an approach will also minimize the attractiveness of voluntary landowner participation in conservation easement programs and does not incentivize conservation of lands that provide high public benefits.

By rewarding landowners with parcels that provide the greatest public value to participate in a conservation easement program, the public will benefit most. Conservation programs will be more attractive to landowners if they can capture a greater share of the public good generated through the easement rather than merely cover their losses (opportunity cost). We explore the current appraisal system for evaluating conservation easement payments, as well as several alternative compensation mechanisms. Conservation easement payments array from opportunity cost recovery at the low end and public benefit of private lands conservation at the high end of compensation.

[4] See, for example: http://nationalaglawcenter.org/farmbills/conservation/; http://nationalaglawcenter.org/farmbills/

[5] NRCS ACEP-ALE homepage: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/acep/

[6] Soil and Water Resource Conservation Act (RCA) program reports: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/rca/ida/?cid=stelprdb1187042

[7] USDA Offers Assistance to Protect Privately-Owned Wetlands, Agricultural Lands and Grasslands. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/newsroom/releases/?cid=nrcseprd1365223

PUBLIC COSTS AND BENEFITS OF CONSERVATION EASEMENT PROGRAMS

Public Investments in Conservation Easements

Colorado is famous for its open landscapes, blue skies and Rocky Mountains. Colorado has prioritized conservation of the State's natural and agricultural lands as important to current and future generations of Coloradoans and has invested significant resources into land conservation efforts. The policy landscape for Colorado conservation easements can include local, state, federal and nonprofit actors and programs. Since 1995, Coloradoans protected more than 2.1 million acres of rural lands. The conservation easement tax credit program and financial support of Great Outdoors Colorado (GOCO), in collaboration with local and federal land conservation programs made this possible. In addition to conserving millions of acres in Colorado, these programs were able to target crucial wildlife habitat and have conserved some 1.5 million acres of the land identified as crucial wildlife habitat (Seidl et al, 2017b).

Several studies have demonstrated the public return to investments in private lands conservation in Colorado[4]. For example, Seidl et al. (2017b) found that each dollar invested by the state in conservation easements produced benefits between $4 and $12 for Coloradoans. While it is evident that Colorado conservation easement programs generated substantial public benefits for Coloradoans, it is possible that new valuation mechanisms could facilitate more landowner participation in conservation easement programs and increase benefits to the public. Valuation of conservation easements is a complex process, and the valuation of easements can have large effects on both the quantity and quality of lands conserved. We outline the current conservation easement valuation process and discuss alternatives to explore the potential to increase public benefits to Coloradoans.

Currently, Colorado private lands conservation programs evaluate conservation easements using an appraisal approach. The easement value is the difference in the appraised value of the land before and after enrollment in a conservation easement agreement. This appraisal process estimates the landowner's opportunity cost of entering into the conservation easement.

The financial offers for landowners to place conservation easements against their property seldom, if ever, reach 100% of the opportunity cost of the estimated productivity loss. Landowners can count as a donation the difference between the appraised value of the easement and the amount actually paid to the landowner under federal, and sometimes state, tax laws. These 'bargain sales' generate tax credits that can be used by the landowner or sometimes, such as in Colorado, they can be traded on a secondary market at a further discount.

Compensatory mechanisms create incentives for participants to manage for ecosystem services voluntarily in lieu of regulatory approaches, such as zoning, when market signals are inefficient. Incentives to encourage the provision of public benefits on private lands can include direct payments, but also tax credits, differential taxation and technology subsidies, for example. Policy makers recognize some lands create more public benefits than others create and have designed system requirements to target these high value lands. For example, for federal programs, the public benefits from the conservation easement must include one or more of the following: public outdoor recreation or education; protection of natural habitat; preservation of open space; and/or historic preservation. Due to additional leverage provided by federal tax policy and Farm Bill programs, many state and local efforts also will comply with federal standards.

The federal government has funded programs to conserve agricultural and sensitive lands since the Agriculture Act of 1956. Farm Bill programs that have featured land conservation objectives include: The Conservation Reserve Program (GRP), Wetland Reserve Program (WRP), Farm and Ranchland Protection Program (FRPP), and Grassland Reserve Program (GRP).

In 2014, the Agricultural Conservation Easement Program (ACEP) merged existing easement-type programs and changed rules to allocate federal conservation funds (Seidl et al., 2018). According to the USDA Natural Resource Conservation Service (NRCS), Colorado has 190,686 acres protected under ACEP, FRPP or GRP programs.[5]

In Colorado, ACEP ranks parcels proposed for enrollment based on land characteristics that connect to public benefits from conservation. This ranking takes into consideration some ecological characteristics of the lands, such as "special environmental significance," that will benefit from protection under the easement (Table 1).[6] However, ranking under this system is up to the discretion of the appraiser and explicit ecological considerations contribute a small portion of the ranking. An appraiser estimates the conservation easements' market value after the ranking system prioritizes the parcels proposed for inclusion. This appraisal is the opportunity cost of entering into the conservation easement agreement and considers, for example, development value and anticipated changes in agricultural productivity. The landowner can receive compensation up to the appraised value of their conservation easement through direct payments from federal, state or local programs, and tax credits used or sold in a secondary market.

Using an appraisal approach can lead to a compensation gap between the appraised value and the public benefits of conservation easements. Through exploring other valuation approaches and methods for estimating the public benefits from conserved lands, we can begin to frame evaluation strategies that reduce this compensation gap and maximize the public benefits from conservation programs.

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4 See, for example:

BBC. 2018. Economic impacts of the Colorado Lottery. April 2018. BBC Research and Consulting. 28 pp.

Cline, S. and A. Seidl. 2010. Combining non-market valuation and input-output analysis for community tourism planning: Open space and water quality values in Colorado, USA. Economic Systems Research. 22(4): 385-405.

Cline, S. and A. Seidl. 2009. Surf and Turf: Tourists' Values for Multifunctional Working Landscapes and Water Quality in Colorado. American Journal of Agricultural Economics. 91 (5): 1360-1367.

Coupal R. and A. Seidl. 2003. Rural Land Use and Your Taxes: The Fiscal Impact of Rural Residential Development in Colorado. Agricultural and Resource Policy Report, Department of Agricultural and Resource Economics, Colorado State University, APR03-02. http://dare.agsci.colostate.edu/csuagecon/extension/pubstools.htm#LandUse. 25 pp.

Ellingson, L. and A. Seidl. 2009. Tourists' and Residents' Values for Maintaining Working Landscapes of the 'Old West.' Journal of Rural Research & Policy. 4(1): 1-17.

Ellingson, L., Seidl, A., and J.B. Loomis. 2011. Comparing tourists' behavior and valuation of land use changes: A focus on ranchland open space in Colorado. Journal of Environmental Policy and Management. 54 (1): 55-69.

Glenn, E. 2014. An economic analysis of the effects of increasing Colorado's Conservation Easement Transaction Credit Cap. Thesis: Executive MBA-Economics. University of Denver.

Haefele, M, Loomis, J., and L. Blimes. 2016. Total economic value of US National Park Service estimated to be $92 billion: implications for policy. The George Wright Forum 33(3): 335-345.

Loomis, J., Seidl, A., Rollins, K., and V. Rameker. 2006. Alternate valuation strategies for public open space purchases: Stated versus market evidence. Economics and Contemporary Land Use Policy: Development and Conservation at the Rural-Urban Fringe. R.J. Johnston and S.K. Swallow, eds. Chapter 9, Pp 183-202. Resources for the Future: MA.

Magnan, N., Seidl, A. and J. Loomis. 2012. Is resident valuation of ranch open space robust in a growing rural community? Evidence from the Rocky Mountains. Society and Natural Resources 25(9): 852-867.

Orens, A. and A. Seidl. 2009. Working lands and winter tourists in the Rocky Mountain West: A travel cost, contingent behaviour and input-output analysis. Tourism Economics. 15(1): 215-242.

Sargent-Michaud, J. 2009. A return on investment: The economic value of Colorado's Conservation Easements. The Trust for Public Land.

Seidl, A., Ellingson, L., Mucklow, C.J. 2010. Castles or cattle? A regional analysis of working lands policy alternatives. Chapter 10 in New perspectives on agri-environmental policies; a multidisciplinary and transatlantic approach. Pp 156-174. Routledge: UK.

5 We assume that all easements that have been made are still active

6 ACEP-ALE ranking worksheet: https://www.nrcs.usda.gov/wps/portal/nrcs/main/co/programs/easements/acep/

TABLE 1: Current Criteria Used to Rank Parcels

NATIONAL RANKING CRITERIA
Percent of prime, unique, and important soils in the parcel
Percent of cropland, pastureland, grassland, and rangeland in the parcel
Ratio of total acres of land to average farm size in the county
Decrease in percentage of acreage of farm and ranch land in the county
Decrease in the percentage of acreage of permanent grassland, pasture and rangeland in county
Percent population growth in county
Population density
Existence of a farm or ranch succession plan
Proximity to other agricultural operations
Proximity of parcel to other protected land
Parcel ability to maximize protection of contiguous or proximal acres devoted to ag use
Parcel is a grassland of special environmental significance
Parcel currently enrolled in CRP in a contract that is set to expire within a year

STATE RANKING CRITERIA
The parcel is located in an area zoned for agricultural use
Eligible entity has demonstrated performance in managing and enforcing easements
Protecting parcel provides multifunctional benefits
Contains state specific factors for grasslands of special environmental significance
In a geographical region where enrollment achieves landscape, regional or other goals
Parcel will provide diversity of natural resource protections
Land evaluating indicates a viable agricultural area for parcel
Eligible entity will append or incorporate the NCRS minimum deed terms
Parcel contains habitat for at-risk species

The two leading alternative methods for evaluating conservation easement payments also are rooted in the opportunity cost approach and neither explicitly incorporates specific ecological benefits provided by parcels of land. The two leading approaches are:

Adjusted Assessed Land Value Analysis (AALV) – uses a multiplier to adjust the local tax authority's assessed land value. A statistical analysis measures the gap between the assessed value of a property and its market value. Primary challenges for state level programs of the AALV approach include data access and comparability across counties and the generators and holders of property assessment information.

Geographic Area Rate Caps (GARC) – provides a flat rate payment based on location, and can incorporate different values for different land types, as different land types provide different public benefits. GARC approaches can be found across the U.S. and can provide an improvement to standard appraisal approaches by recognizing the different public values created from different land types, but still have limitations for incentivizing the conservation of parcels that provide the greatest public benefits. We provide a detailed discussion on GARC payments compared to other payment schemes in the results section of this report.

PUBLIC BENEFITS OF CONSERVATION EASEMENTS: VALUATION OF ECOSYSTEM SERVICES AND BENEFIT TRANSFER

Alternatively, programs could incorporate public ecosystem service benefits generated by the parcel into conservation easement compensation calculations. Such an approach could serve to maximize the public benefit of payments by increasing the emphasis on the public values generated from conservation easements, rather than focusing on the cost of their provision. A focus on ecosystem benefits would shift conservation payment evaluation from cost effectiveness toward prioritization based on maximizing gross public benefits or, potentially, net benefits (benefits less costs; 'efficiency').

Here, we evaluate the ecosystem benefits to facilitate parcel ranking and easement payments to follow public benefits rather than an appraisal of opportunities lost to the landowner due to the easement. Under this approach, we recognize that each parcel of conserved land preserves a different portfolio of ecosystems and ecosystem services. We explore the evaluation of each parcel based on ecosystem service values, which would enable taxpayers to capture the greatest ecosystem service benefits from federal, state and local conservation easement dollars.[7]

Benefit transfer is a common approach used by policy makers to estimate the value of ecosystem services. Benefit transfer is popular due to budgetary and temporal constraints commonly faced by decision makers and policy analysts. Benefit transfer studies take ecosystem service values from other 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 (Boyle and Bergstrom, 1992; Loomis, 1992; Downing and Ozuna, 1996; Plummer, 2009; Richardson et al., 2015).

For our benefits transfer analysis, we consider the seven main land types found in Colorado, based on the National Land Cover Database (NLCD)[8] classification system: open water, woody wetland, emergent herbaceous wetland, forest, agriculture, grassland, and shrub/scrub. We exclude certain land cover types that do not provide significant ecosystem service values: barren land, permanent ice, and the four NLCD classifications of developed land. We 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 (see Appendix 2 for additional detail).

Estimation Methods

We identified 141 studies from the Envalue[9], Environmental Valuation Reference Inventory (EVRI)[10], and The Economics of Ecosystems and Biodiversity (TEEB)[11] databases or studies referenced from in the initially identified studies that appeared to be potentially relevant for our study sites in Colorado. We excluded several outlier values from study locations in the eastern United States, as inappropriate to the Colorado case. We converted contingent valuation studies[12] that gave results in dollars per person-year to household values, using census data for Colorado (census.gov). We scaled these values to the Colorado population and converted to dollars per acre.

7 For a full list of the theoretical methods for the economic valuation of ecosystem services, please refer to Appendix 1.

8 NLCD fact sheet: https://pubs.usgs.gov/fs/2012/3020/

9 http://www.environment.nsw.gov.au/envalueapp/

10 http://www.evri.ca/en

11 http://www.teebweb.org/publication/tthe-economics-of-ecosystems-and-biodiversity-valuation-database-manual/

12 Contingent valuation studies estimate the value a person places on a good by directly asking them to report their willingness-to-pay for the good or willingness-to-accept to give up a good

We eliminated any benefit transfer studies and retained only original valuation results for inclusion in our benefit transfer analysis. We screened these studies for the specific ecosystems in Colorado, eliminating any coastal or saltwater ecosystems. Finally, we eliminated studies that did not provide sufficient detail to derive an annual dollar per acre or annual dollar per household per acre value. This left 35 original valuation studies that were applicable for our 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.

Due to the lack of studies with original valuation of grassland and shrubland, three additional studies were included that did not conduct original research. Costanza et al. (1997) provides values for grassland, but they arrive at this value by a combination of original research and benefit transfer. Wilson (2010) provides values for pollination in both grassland and shrubland. We modify their estimates by taking the value of pollination in the United States and converting to a per acre value for grassland, forest, and shrubland. Further, Earth Economics (2013) provides a value of air quality from shrubland adopted from Costanza et al. (1997). We converted all values to dollars per acre per year adjusted to May 2018 dollars.

We identify values for the ecosystem services listed in Table 2, where an X signifies that a value for that ecosystem service found in the literature. We report ecosystem service values for each land cover type in Table 3.

TABLE 2: Public Ecosystem Service Values Available by Land Type

	OPEN WATER	FOREST	SHRUB/ SCRUB	GRASS-LANDS	AGRI-CULTURE	WOODY WETLANDS	EMERGENT HERBACEOUS WETLANDS
Provisioning Services							
Food				X			
Water	X	X				X	X
Raw materials							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
Nutrient cycling		X		X			X
Pollination		X	X	X	X		
Biological control		X				X	X
Habitat services							
Nursery service							
Genetic diversity	X	X	X	X	X	X	X
Cultural services							
Esthetic information							X
Recreation			X		X		
Inspiration							
Neighborhood Effect		X					

TABLE 3: Annual Ecosystem Service Values from the Literature, 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 (2010)
	Genetic Diversity	80.26	115.76	Scott, et al. (1998)
	Recreation	9.26	115.76	Scott, et al. (1998)
TOTAL		**458.19**	**622.60**	
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 (2010)
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 (2010)
	Genetic Diversity	29.66	29.66	Hansen (2007)
	Recreation	47.33	47.33	Knoche & Lupi (2007)
TOTAL		**251.94**	**272.54**	

Continued ▸

TABLE 3, CON'T.: Annual Ecosystem Service Values from the Literature, per Acre

ECOSYSTEM	SERVICE	MIN VALUE	MAX VALUE	STUDY
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**	
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, we used InVEST[13], a benefit transfer tool from Natural Capital Project, to estimate carbon storage and sequestration values. We assume 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). We 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. We use a conservative estimate of $20 per tonne to estimate carbon sequestration values. Applying this tool to our conserved lands of interest in Colorado, we were able to derive

13 https://www.naturalcapitalproject.org/invest/

estimates for metric tons (1 tonne = 2200 lbs.) of carbon stored and sequestered for an acre of each land cover type. We estimated carbon storage and sequestration ecosystem service value applying our 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.[14] To ignore these values would be to discount substantially important ecological values. However, due to the magnitude of these carbon sequestration and storage values, we compare the minimum and maximum values with and without carbon (Table 3). We calculate the minimum and maximum values by summing the ecosystem service values, approaching the total public value of the ecosystem. Following Costanza (1997), we assume 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 us to sum across all relevant ecosystem services to provide a final estimate.

TABLE 4: 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

Table 4 clearly illustrates not all land parcels provide the same public benefits, with maximum annual per acre benefits ranging from $2,220 dollars on the high end for emergent herbaceous wetlands to $273 on the low end 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.

To understand better the public benefits provided from conservation easements in Colorado, we need to understand the land types that are currently under easement in Colorado. Colorado Natural Heritage Program has a mapped all conserved lands in Colorado, made accessible through the Colorado Ownership, Management and Protection (COMaP) service. COMaP provides data on many kinds of conserved lands, so we filtered out public and non-conservation easement lands. Using COMaP, we overlaid land cover data from the Multi-Resolution Land Characteristics Consortium.[15] The National Land Cover Database (NLCD) maps land covers for the entire United States based on 20 different categories. We excluded four categories found only in Alaska and four developed land categories. We overlaid the NLCD dataset onto COMaP to find the acreage of each land cover type. We then applied the estimated ecological benefits from our survey of the literature to find the value of benefits provided by these conserved lands.

[14] Analysts raise EU carbon price forecasts on emissions rise: https://www.reuters.com/article/us-eu-carbon-survey/analysts-raise-eu-carbon-price-forecasts-on-emissions-rise-uk-brevity-clarity-idUSKBN1HI1LR

[15] MRLC National Land Cover Database: https://www.mrlc.gov/nlcd11_data.php

For this application, we are particularly interested in the results from southeastern Colorado relative to the rest of the state, so we report both Colorado acres and Southeast Colorado acres (Table 5). We define southeastern Colorado using the Economic Development Regions from the Colorado Office of Economic Development and International Trade.[16] We define Southeast Colorado as economic regions 6, 7, and 14, comprising Baca, Bent, Crowley, Huerfano, Kiowa, Las Animas, Otero, Pueblo, and Prowers counties. Colorado and Southeast Colorado have all seven land cover types represented in currently conserved land. Differences in the land type portfolios of Colorado and the sub-region of Southeast Colorado do exist and these differences have important implications for the ecosystem benefits from conservation easements in these areas.

TABLE 5: Acres of Land Cover Type in Conservation Easement

LAND COVER	COLORADO	% OF ACRES	SOUTHEAST COLORADO	% OF ACRES
Open Water	5,799	0.24	713	0.09
Forest	611,188	25.20	178,768	23.17
Scrub/Shrub	567,663	23.41	116,320	15.08
Grassland	907,360	37.41	435,041	56.39
Agriculture	212,293	8.75	21,038	2.73
Woody Wetlands	50,177	2.07	5,768	0.75
Herbaceous Wetlands	30,527	1.26	4,104	0.53
TOTAL	**2,385,007**	**98.34**[17]	**761,752**	**98.74**[18]

Results

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. The ecosystem services stemming from the 0.8 million acres of conserved private lands in Southeast Colorado tend to differ from the state as a whole, where an average acre of conserved land contains 56% grassland, 23% forest, and 15% shrubland (Table 5).

We use a benefit transfer approach to estimate the total value of the ecosystem services on private lands protected by conservation easements to Coloradoans. If we consider 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).

The subset of Southeast Colorado conserved land accounts for a third of total conserved lands in Colorado and contains more grassland on average compared to all of Colorado. An average acre of conserved land in Southeast Colorado generates slightly lower public benefits compared to the state, ranging from $814 to $921 per acre-year. Total annual benefits to Coloradoans provided by Southeast Colorado conservation easements range from $620 million to $702 million per year. Estimated per acre values are lower in the Southeast Region due to the increased proportion of grassland, which provides relatively lower public ecosystem services benefits per acre (Table 6).

16 https://choosecolorado.com/doing-business/regions/

17 The remaining 1.66 percent of land is classified as barren, permanent ice, or developed according to the NLCD and therefore excluded.

18 The remaining 1.26 percent of land is classified as barren, permanent ice, or developed according to the NLCD and therefore excluded.

Colorado generates slightly lower public benefits compared to the state, ranging from $814 to $921 per acre-year. Total annual benefits to Coloradoans provided by Southeast Colorado conservation easements range from $620 million to $702 million per year. Estimated per acre values are lower in the Southeast Region due to the increased proportion of grassland, which provides relatively lower public ecosystem services benefits per acre (Table 6).

TABLE 6: Total Annual Benefits Provided by Land Cover Type, $2018

LAND COVER	STATE MIN	STATE MAX	SE CO MIN	SE CO MAX
Open Water	3,080,401	4,787,896	378,895	588,919
Forest	1,195,594,756	1,343,443,452	349,703,117	392,947,829
Scrub/Shrub	260,095,447	353,426,963	53,296,095	72,420,633
Grassland	415,631,271	434,321,556	199,277,785	208,238,994
Agriculture	53,485,339	57,858,269	5,300,249	5,733,594
Woody Wetlands	61,083,470	111,312,253	7,021,480	12,795,226
Herbaceous Wetlands	36,158,232	67,772,353	4,861,099	9,111,290
TOTAL	**2,025,128,917**	**2,372,922,742**	**619,838,720**	**701,836,485**
Average Per Acre	**849**	**995**	**814**	**921**

It is important that the estimated average values per acre are per year values and conservation easements protect lands, and in turn, the ecosystem benefits that they provide, for a much longer timeframe than one year. To better estimate the ecosystem benefits that accrue from the conservation of lands we need to estimate the benefits over the life of the conservation easement.

For this analysis, we assume that conservation easements are perpetual as required by the law. The Environmental Protection Agency suggests using 3, 5, or 7 percent discount rates to assess the value of future benefits and costs in cost benefit analyses.[19] We convert these annual perpetual benefits into a 2018 dollar value, or present value, using a 5% discount rate. Over the lifetime of the easements, Coloradoans receive between $40 and $47 billion and an average conserved acre provides between $17,000 and $20,000 of benefits. Southeast Colorado provides a total of $12 billion to $14 billion of benefits, and an average acre of conserved land provides between $16,000 and $18,000 (Table 7).

These ranges of public benefit values should provide the theoretical upper bound on what the public should 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 7).

TABLE 7: Cost and Benefits of Conservation Easements in Perpetuity, r= 0.05, 2018$

	MIN FOR CO	MAX FOR CO	MIN FOR SE CO	MAX FOR SE CO
Total Benefits	40,502,578,335	47,458,454,846	12,396,774,406	14,036,729,694
Average Benefits Per Acre	16,982	19,899	16,274	18,427
Average Easement Compensation Per Acre	899		613	
Average Easement Appraisal Value Per Acre	1,151		655	

[19] EPA Discounting Future Benefits: https://www.epa.gov/sites/production/files/2017-09/documents/ee-0568-06.pdf

The benefits generated from conservation do not come without a cost, however. Since conservation easement programs wish to minimize taxpayer burden, we report state-funded compensation paid to landowners, which excludes tax credit programs, as a lower bound of the cost to Colorado tax payers. However, CE programs require voluntary participation of landowners, so we also report appraisal value, which serves as an estimate of opportunity cost of participation to landowners. Using actual conservation easement transaction data from the Colorado land trust community, we find 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 appraisal value of the easement.

We take 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.

Appraisal method payments for conservation easements in Southeast Colorado mirror our previous results of slightly lower benefits than for the State of Colorado. An average payment for a conserved acre in Southeast Colorado is $613, or about 93% of the appraised value of $655. Although it appears the current appraisal methodology might adjust for ecosystem types, market forces, such as population and income, may explain this variation better. These conservation easements generate between $16,000 and $18,000 per acre in public ecosystem service benefits. This translates into an average return on investment of $24 -$29 in the form of ecosystem services for every $1 invested in conservation easements in Southeast Colorado, a greater estimated return on investment than the state average.

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. A methodology that incentivizes land conservation based on the ecosystem values generated from the specific land type has potential to provide an even larger return on investment in the future.

We also can compare payments under a GARC payment methodology to the current appraisal method payments and to ecosystem benefits generated. Due to data constraints, we were not able to compare GARC values with existing appraisal values statewide. Instead, we had to compare using a subset of Colorado conservation easements with which we had the data needed for comparison.

Data from Seidl, et al. (2018b) and additional conservation easement data from the Lower Arkansas Valley Water Conservancy District allowed us to compare appraisal payments, benefits provided, and potential GARC payments. The useable dataset contained 43 conservation easements in Southeast Colorado that received $10 million in onetime payments for a total of 11,200 acres conserved.

In 2012, NRCS established GARCs for the Grassland Reserve Program (GRP) and Wetland Reserve Program (WRP) with rate caps ranging from $170 per acre to $2,240 per acre-year depending on the easement type, the region and the land type conserved. For illustration, looking specifically at the Southeast region of Colorado and our dataset of conserved lands, the average GARC payment would have been $1,061 per acre-year conserved (2018 dollars). (Table 8)

Estimated annual benefits provided by these easements fall between $4.4 million and $4.6 million. Even if we exclude carbon values, estimated annual benefits range from $3.7 million to $3.9 million. Assuming all conservation easements are in perpetuity, we calculate the benefits accrued by this subset of easements. The annualized benefits including carbon storage and sequestration in perpetuity provide $88 -$93 million, using a 5% discount rate. (Table 8)

In Table 8, we compare the GARC payment values to the current appraisal method as well as the benefits that the public receives from these conserved lands, based on our benefit transfer results. Interestingly, under the GARC methodology, the payment would have been over 15 percent more per acre than under the appraisal-based system, if we do not consider tax credits. Assuming each landowner receives tax credits and other direct and indirect payments up to the appraised value of the land, the GARC payment would have been 4% more per acre. Navigating and applying for tax credits and completing an appraisal represent real transaction costs for landowners in the form of time and money. This suggests that landowner participation under GARC could be expected to increase in the region. (Table 9)

In addition, the GARC methodology incentivizes the conservation of certain land types with greater payments per acre. With greater payments per acre and more acres enrolled, the cost of the policy will increase, but it is possible that the GARC methodology would also have changed the land type mix conserved in the region in such a way that would have generated increased ecosystem benefits to the public beyond just the increase in acres. However, our benefit transfer results suggest that forest and wetland ecosystems provide the highest value in terms of ecosystem services. The GARC payment method does not differentiate between these ecosystems but lumps them together into Non-Ag Bottomland. To maximize benefits per taxpayer dollar a valuation methodology would benefit from incorporating more ecosystem differentiation. In all cases, public benefits far outweigh the conservation easement costs regardless of compensation methodology (Table 9).

TABLE 8: GARC payments by land type, Southeast Region, 2018$

	GARC PAYMENT PER ACRE	APPRAISED VALUE, AVERAGE PER ACRE	APPRAISED VALUE, COMPENSATION RECEIVED, AVERAGE PER ACRE	ACRES
Irrigated Crop	1,918	2,006	1,841	3970
Non-irrigated Crop	400	-	-	0
Grassland	394	445	359	7156
Non-Ag Bottomland	833	4,756	3,805	58

TABLE 9: Results for Southeast Region by valuation method, 2018$

	GARC PAYMENT PER ACRE	APPRAISED VALUE, AVERAGE PER ACRE
	Total Value	**Per Acre Value**
Appraisal Method, compensation received	10,099,650	903
GARC	11,870,405	1,061
Minimum Annual Ecosystem Benefits in Perpetuity	87,834,821	7,854
Maximum Annual Ecosystem Benefits in Perpetuity	92,699,280	8,289

Average payment values are important when comparing a new valuation method to the existing method. However, different land types have different ecosystem values and the compensation differences across valuation methods is more divergent for some land types. Using annual benefits as an illustrative proxy for an ecosystem payment method, conservation easements that contain agricultural, wooded wetlands, emergent herbaceous wetlands and forests would benefit the most from an alternative to the appraisal method.

Conclusion

Conservation easements are an important land preservation tool and provide positive economic values to Colorado residents. The current system for valuing conservation easements can be costly and time consuming, among other potential complications. The Colorado legislature values current conservation easement programs and is proactively exploring potential alternatives for improving the efficacy of their delivery. Currently conservation easements are valued through an opportunity cost approach that evaluates the cost to the landowner (in terms of decreased land values) of entering a conservation easement agreement.

We estimated public ecosystem benefits generated because of conservation easements in Colorado. Using a benefit transfer approach, we find that current appraisal-based approach for valuing conservation easement has a return on investment of $13-$21 per dollar invested in Colorado, and that this return on investment is even greater in Southeast Colorado, $24-$29.

While it is clear that current conservation easements are providing public benefits that exceed public costs, it is possible that a greater emphasis on the ecosystem benefits that parcels provide could create a system that generates an even greater return on investment for conservation easements. We find that on average Colorado conservation easements provide between $17,000 and $19,900 (2018$) per acre in ecosystem benefits to the public. We also find that different land types provide substantially different ecosystem benefits, regardless of the opportunity cost of entering into the conservation easement. An easement payment evaluation method that recognizes the ecosystem benefits that certain land types provide has the potential to increase the return on investment from conservation easements.

We compare payments under the appraisal method to what payments would have been under an alternative GARC payment method. The GARC method would result in greater per acre payments for easements in our sample and potentially decrease transaction costs for receiving maximum compensation, which could entice more landowners into participation. In addition, this method has some differentiation across land types, but still lumps land types with wildly different ecosystem service benefits into a single category. While this method has potential to increase landowner involvement and positively influence the land types conserved, the effect this system would have on the return on investment in conservation easement programs to Coloradoans remains unclear. The appraisal and GARC methods do not provide strong incentives to enroll particularly high public value lands. Using an alternative method that bases landowner compensation on different ecosystem types has the potential to entice landowners to enroll the highest value lands and provide the most benefits for taxpayer dollars.

Our results show that, regardless of payment methodology, private lands conservation using conservation easements provides positive benefits to the state of Colorado, and that these benefits far exceed the costs. Moving toward a public benefits valuation approach from the current opportunity cost approach has the potential for improved returns to taxpayer dollars due to attracting higher valued properties to the programs. We discuss the substantial ecosystem service benefits conservation easement programs provide using a benefit transfer analysis. Further research to frame the details of a public benefits valuation approach and the potential implications it would have for the mix of land conserved, the payments individual landowners would receive, and the public benefits generated from conservation easements is a logical and needed next step.

REFERENCES

Batker, D., Christin, Z., Schmidt, R., & de la Torre, I. (2013). The economic impact of the 2013 Rim Fire on natural lands. Earth Economics, Tacoma, WA.

Bell, F.W. (1997) The economic valuation of saltwater marsh supporting marine recreational fishing in the southeastern United States. Ecological Economics 21(3): 243-254.

Bennett, D., Nielsen-Pincus, M., Ellison, A., Pomeroy, A., Burright, H., Gosnell, H. Moseley, C. and Gwin,l. 2014. Barriers and Opportunities for Increasing Landowner Participation in Conservation Programs in the Interior Northwest. Ecosystem Workforce Program Working Paper, Number 49.

Bergstrom, J. C., Dillman, B. L., & Stoll, J. R. (1985). Public environmental amenity benefits of private land: the case of prime agricultural land. *Journal of Agricultural and Applied Economics,* 17(1), 139-149.

Bouwes, N. W., & Schneider, R. (1979). Procedures in estimating benefits of water quality change. *American Journal of Agricultural Economics*, 61(3), 535-539.

Boyle, K. J., & Bergstrom, J. C. (1992). Benefit transfer studies: myths, pragmatism, and idealism. *Water Resources Research*, 28(3), 657-663.

Campbell, E. T., & Tilley, D. R. (2014). Valuing ecosystem services from Maryland forests using environmental accounting. *Ecosystem Services*, 7, 141-151.

Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'neill, R.V., Paruelo, J. and Raskin, R.G. (1997). The value of the world's ecosystem services and natural capital. *Nature*, 387(6630), 253.

Choi, J., & Lee, S. (2018). An Analysis of the Carbon Fixation Change according to the Greenbelt Deregulation Using InVEST Model–In Case of Anyang and Gwacheon City. *In IOP Conference Series: Earth and Environmental Science* (Vol. 167, No. 1, p. 012043). IOP Publishing.

de Groot, R., Brander, L., van der Ploeg, S., Costanza, R., Bernard, F., Braat, L., … van Beukering, P. (2012). Global estimates of the value of ecosystems and their services in monetary units. *Ecosystem Services*, 1(1), 50–61. https://doi.org/10.1016/j.ecoser.2012.07.005

Downing, M., & Ozuna, J., Teofilo. (1996). Testing the Reliability of the Benefit Function Transfer Approach. *Journal of Environmental Economics and Management*, 30(3), 316–322. https://doi.org/10.1006/jeem.1996.0021

Farber, S. C., Costanza, R., & Wilson, M. A. (2002). Economic and ecological concepts for valuing ecosystem services. *Ecological Economics*, 41(3), 375–392. https://doi.org/10.1016/S0921-8009(02)00088-5

Hand, M. S., Thacher, J. A., McCollum, D. W., & Berrens, R. P. (2008). Forest amenities and location choice in the Southwest. *Journal of Agricultural and Resource Economics*, 232-253.

Hansen, L. (2007). Conservation reserve program: environmental benefits update. *Agricultural and Resource Economics Review*, 36(2), 267-280.

Hovde, B., & Leitch, J. A. (1994). Valuing prairie potholes: Five case studies. Department of Agricultural Economics, Agricultural Experiment Station, North Dakota State University.

Gupta, T. R., & Foster, J. H. (1975). Economic criteria for freshwater wetland policy in Massachusetts. *American Journal of Agricultural Economics*, 57(1), 40-45.

Howe, C., Suich, H., Vira, B., & Mace, G. M. (2014). Creating win-wins from trade-offs? Ecosystem services for human well-being: A meta-analysis of ecosystem service trade-offs and synergies in the real world. *Global Environmental Change*, 28, 263–275. https://doi.org/10.1016/j.gloenvcha.2014.07.005

Isely, E. S., Isely, P., Seedang, S., Mulder, K., Thompson, K., & Steinman, A. D. (2010). Addressing the information gaps associated with valuing green infrastructure in west Michigan: Integrated Valuation of Ecosystem Services Tool (INVEST). *Journal of Great Lakes Research*, 36(3), 448-457.

Jenkins, W. A., Murray, B. C., Kramer, R. A., & Faulkner, S. P. (2010). Valuing ecosystem services from wetlands restoration in the Mississippi Alluvial Valley. *Ecological Economics*, 69(5), 1051-1061.

Johnston, R. J., & Duke, J. M. (2007). Is willingness to pay for farmland preservation transferable across states? Evidence from a choice experiment. In *American Agricultural Economics Association (AAEA) Annual Meeting, Portland, OR*.

Knoche, S., & Lupi, F. (2007). Valuing deer hunting ecosystem services from farm landscapes. *Ecological Economics*, 64(2), 313-320.

Lewis, D. K., Turner, D. P., & Winjum, J. K. (1996). An inventory-based procedure to estimate economic costs of forest management on a regional scale to conserve and sequester atmospheric carbon. *Ecological Economics*, 16(1), 35-49.

Loomis, J. B. (1987). Expanding Contingent Value Sample Estimates to Aggregate Benefit Estimates: Current Practices and Proposed Solutions. *Land Economics*, 63(4), 396–402. https://doi.org/10.2307/3146296

Loomis, J. B. (1992). The evolution of a more rigorous approach to benefit transfer: benefit function transfer. *Water Resources Research*, 28(3), 701-705.

Moeltner, K., & Woodward, R. (2009). Meta-Functional Benefit Transfer for Wetland Valuation: Making the Most of Small Samples. *Environmental and Resource Economics*, 42(1), 89–108. https://doi.org/10.1007/s10640-008-9205-0

Moreira, M., Fonseca, C., Vergílio, M., Calado, H., & Gil, A. (2018). Spatial assessment of habitat conservation status in a Macaronesian island based on the InVEST model: a case study of Pico Island (Azores, Portugal). *Land Use Policy*, 78, 637-649.

Nelson, J. P., & Kennedy, P. E. (2009). The Use (and Abuse) of Meta-Analysis in Environmental and Natural Resource Economics: An Assessment. *Environmental and Resource Economics*, 42(3), 345–377. https://doi.org/10.1007/s10640-008-9253-5

Nordhaus, W. D. (2017). Revisiting the social cost of carbon. *Proceedings of the National Academy of Sciences*, 201609244.

Pimentel, D., C. Harvey, P. Resosudarmo, K. Sinclair, D. Kurz, M. McNair, S. Crist, P. Sphpritz, L. Fitton, R. Saffouri and R. Blair. (1995). Environmental and economic costs of soil erosion and conservation benefits. *Science* 267: 1117-1123.

Plummer, M. L. (2009). Assessing benefit transfer for the valuation of ecosystem services. *Frontiers in Ecology and the Environment*, 7(1), 38–45. https://doi.org/10.1890/080091

Rein, F. A. (1999). An economic analysis of vegetative buffer strip implementation. Case study: Elkhorn Slough, Monterey Bay, California. *Coastal Management*, 27(4), 377-390.

Richardson, L., Loomis, J., Kroeger, T., & Casey, F. (2015). The role of benefit transfer in ecosystem service valuation. *Ecological Economics*, 115, 51–58. https://doi.org/10.1016/j.ecolecon.2014.02.018

Roberts, L. A., & Leitch, J. A. (1997). Economic valuation of some wetland outputs of Mud Lake, Minnesota-South Dakota.

Rosenberger, R. S., & Loomis, J. B. (2000). Using meta-analysis for benefit transfer: In-sample convergent validity tests of an outdoor recreation database. *Water Resources Research*, 36(4), 1097-1107.

Scott, M. J., Bilyard, G. R., Link, S. O., Ulibarri, C. A., Westerdahl, H. E., Ricci, P. F., & Seely, H. E. (1998). Valuation of ecological resources and functions. *Environmental Management*, 22(1), 49-68.

Seidl, A., Swartzentruber, R., & Hill, R. (2018a). Estimated Economic Impact of Federal Agricultural Conservation Easement Programs (ACEP) on Colorado, 2009-2017: Summary. 2 pp. July 2018.

Seidl, A., Swartzentruber, R., & Hill, R. (2018b). Estimated Economic Impact of Federal Agricultural Conservation Easement Programs (ACEP) on Colorado, 2009-2017. 32 pp. July 2018.

Seidl, A., Anderson, D., Bennett, D., Greenwell, A., and Menefee, M. (2017a). Colorado's Return on Investments in Conservation Easements: Conservation Easement Tax Credit Program and Great Outdoors Colorado: Executive Summary. Colorado State University, Fort Collins, CO. https://warnercnr.colostate.edu/wp-content/uploads/sites/2/2017/07/ColoradoStateU_CE-ROI-study_web.pdf

Seidl, A., Anderson, D., Bennett, D., Greenwell, A., and Menefee, M. (2017b). Colorado's Return on Investments in Conservation Easements: Conservation Easement Tax Credit Program and Great Outdoors Colorado. Colorado State University, Fort Collins, Colorado. https://warnercnr.colostate.edu/wp-content/uploads/sites/2/2017/07/ColoradoStateU_CE-ROI-study_web.pdf

Sharp, R., Tallis, H.T., Ricketts, T., Guerry, A.D., Wood, S.A., Chaplin-Kramer, R., Nelson, E., Ennaanay, D., Wolny, S., Olwero, N., Vigerstol, K., Pennington, D., Mendoza, G., Aukema, J., Foster, J., Forrest, J., Cameron, D., Arkema, K., Lonsdorf, E., Kennedy, C., Verutes, G., Kim, C.K., Guannel, G., Papenfus, M., Toft, J., Marsik, M., Bernhardt, J., Griffin, R., Glowinski, K., Chaumont, N., Perelman, A., Lacayo, M. Mandle, L., Hamel, P., Vogl, A.L., Rogers, L., Bierbower, W., Denu, D., and Douglass, J. (2018). InVEST +version+ user's guide. The Natural Capital Project, Stanford University, University of Minnesota, The Nature Conservancy, and World Wildlife Fund.

Tol, Richard S. J. (2008). The Social Cost of Carbon: Trends, Outliers and Catastrophes, Economics: The Open-Access, Open-Assessment E-Journal, Kiel Institute for the World Economy (IfW), Kiel, Vol. 2, Iss. 2008-25, pp. 1-22, http://dx.doi.org/10.5018/economics-ejournal.ja.2008-25

Walsh, R.G., J.B. Loomis & Gillman, R.A. (1984). Valuing option, existence, and bequest demand for wilderness. *Land Economics*, 60(1): 14-29.

Watson, K. B., Ricketts, T., Galford, G., Polasky, S., & O'Niel-Dunne, J. (2016). Quantifying flood mitigation services: The economic value of Otter Creek wetlands and floodplains to Middlebury, VT. *Ecological Economics*, 130, 16-24.

Zavaleta, E. (2000). The economic value of controlling an invasive shrub. *AMBIO: a Journal of the Human Environment*, 29(8), 462-467.

APPENDIX 1: ECONOMIC APPROACHES TO THE VALUATION OF ECOSYSTEM SERVICES

The Millennium Ecosystem Assessment (2003) defined an ecosystem services framework consisting of four categories of services contributing to human wellbeing: Provisioning Services: Goods or products produced by ecosystems; Regulating Services: Natural processes regulated by ecosystems; Cultural Services: Intangible and recreational benefits obtained from ecosystems; Supporting Services: Functions that maintain all other services. Provisioning services include consumable resources and most market goods. Regulating services include many non-market goods that indirectly affect society such as erosion prevention, air quality, and climate regulation. Cultural services include recreation, inspiration for religion, folklore, and music, and inspiring views. People implicitly or explicitly value and tradeoff these ecosystem services through their individual and collective behavior in markets and other exchanges, policies, institutions and culture.

Techniques to value natural capital and ecosystem services have been evolving for about 30 yrs. Farber et al. (2002) summarize relevant concepts and methodology for ecosystem service valuation studies. They argue that assigning economic values to ecological services might not align perfectly. For instance, the economic value of resource harvesting might outweigh the ecological values of the ecosystem health. However, a value with some methodological issues is an improvement over an implicit zero value of ecosystems. Researchers conduct primary valuation studies using the following methods:

1. Avoided Cost (AC) – assigns a value to the services based on the costs incurred in their absence. (Hovde & Leitch, 1994; Roberts & Leitch, 1997)

2. Replacement Cost (RC) – assigns a value to the services based on the costs to provide those services through other means. (Scott, et al., 1998)

3. Factor Income (FI) – assigns a value based on increased income due to the presence or increase in ecosystem service. (Bell, 1997)

4. Travel Cost (TC) – deduces the demand for a service by the costs incurred travelling to an ecosystem. (Knoche & Lupi, 2007)

5. Hedonic Pricing (HP) – deduces the value of a service by comparing housing prices to the relative proximity of a house to an ecosystem. (Hand, et al., 2008)

6. Contingent Valuation (CV) – deduces the willingness to pay (WTP) for services based on survey results of a hypothetical scenario. (Walsh, et al., 1984; Bergstrom, et al., 1985)

7. Ecological Accounting (EA) – derives values for services based on the natural energy required to provide such services. (Campbell & Tilley, 2014)

Researchers have utilized these methods to value a subset of ecosystem services or the total economic value of the ecosystem that encompasses all applicable services.

Researchers have since turned to meta-analyses to increase the accuracy of transferring the results of earlier studies across a wider variety of contexts. While benefit transfer studies take a few values from similar sites, meta-analyses include as many values as possible and then statistically control for characteristics such as ecosystem type, size, location, and surrounding demographics. Entering the characteristics of the study site into the meta-analysis equation generates estimated ecosystem service benefits that transfer across sites. The resulting values tend to be more accurate since meta-analyses include a range of values and use statistical methods to control for important variables. Nelson and Kennedy (2009) criticize some inappropriate uses of meta-analyses, but when used correctly, they outperform other benefit transfer methods (Rosenberger & Loomis, 2000).

Wetlands are the most common subject of ecosystem service valuation meta-analyses, due to the large number of primary research studies available (Brouwer et al., 1999; Woodward and Wui, 2001; Brander et al., 2006; Ghermandi et al., 2010; Brander et al., 2012; Chaikumbung et al., 2016). We did not conduct meta-analyses with other ecosystems due to a lack of data. Although previous research suggests meta-analysis would be preferable, sufficient data relevant to Colorado do not exist for us to conduct such a study.

Primary ecosystem service valuation studies examine a specific site and estimate the value using these methods. The ecosystem of the site may provide services very specific to that location. For example, Plummer (2009) criticized use of benefit transfers that take recreation values from a tourism destination in Costa Rica and apply them to all rain forest ecosystems. Likely those recreation values are not accurate for each acre of rain forest. To improve benefit transfer studies, researchers should only include values that are reasonable for the specific study site. Due to data limitations, researchers frequently assign ecosystem services to broad ecosystem types. Researchers take values for those services from the literature and apply them to all relevant ecosystems. Costanza, et al. (1997) were the first to assign values to broad ecosystem types, recognizing 16 different ecosystem biomes in the world.

APPENDIX 2: CONSERVED LANDS

While there are a variety of conserved lands, we only examined conservation easement parcels. Using COMaP, we filtered PROTECTION_MECHANISM to include any values containing "CE" in order to select conservation easements. We also filtered OWNER to include only Land Trust, Private, and NGO in order to exclude publicly owned conservation easements. When referring to conservation easements in Colorado, we are 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 our sort of the available data, we assume that easements are in effect in 2018, unless we have information confirming the parcel does not remain protected. A total of roughly 2.4 million acres included in the analysis (Figure 1).

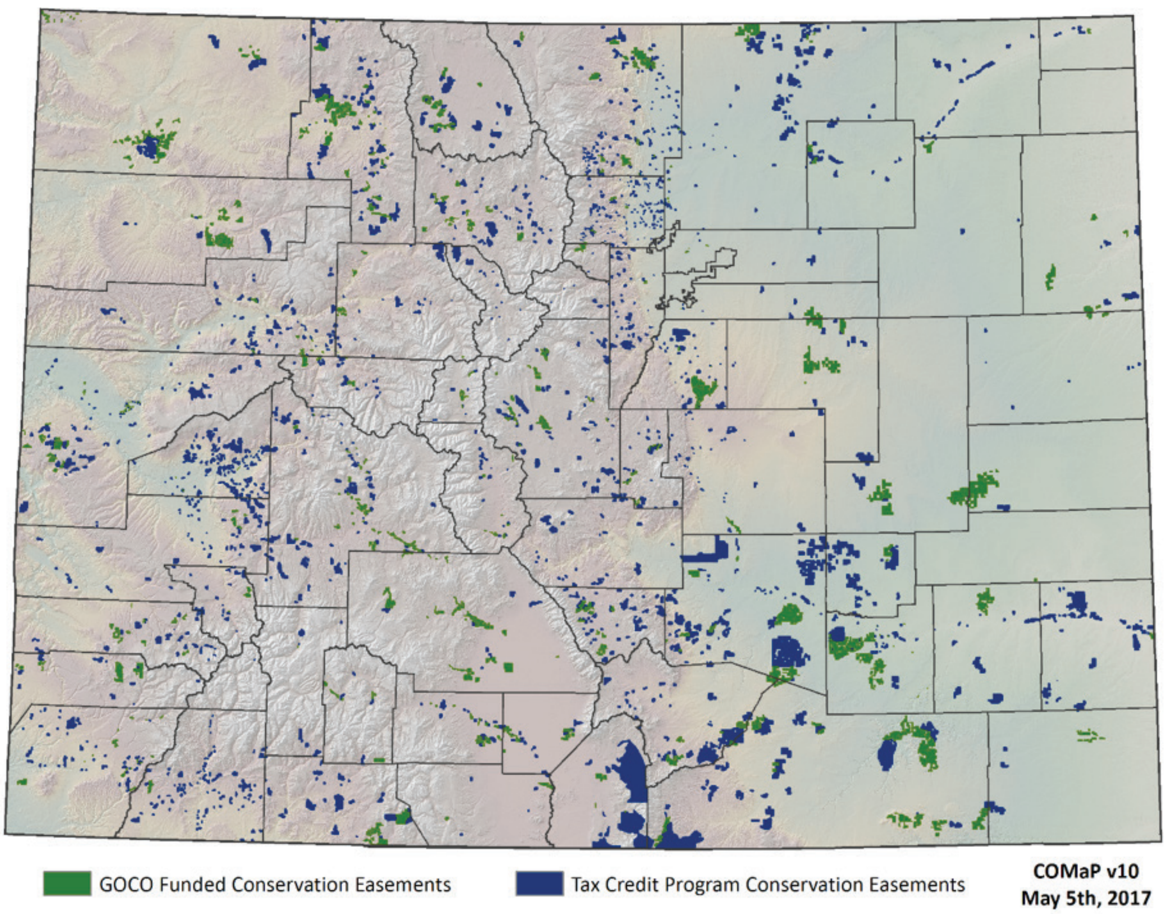

Figure 1. Locations of conservation easements included in the analysis.

The ecosystem service values from the literature separated into benefit transfer categories differ slightly from NLCD land cover types. Table 10 shows how benefit transfer values apply to the corresponding NLCD land cover type.

TABLE 10: 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

We were unable to break out the 43 conservation easements in Southeast Colorado from the state-level conservation easement information using NLCD land cover data due to data constraints. Our data specified the general ecosystem conserved and we 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.

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