Public returns to private lands conservation in Colorado: The Conservation Easement Tax Credit Program

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Executive summary

Colorado is famous for its iconic landscapes. These diverse lands constitute the natural and agricultural heritage of the state and fuel the economy through the sale of farm and ranch products, outdoor recreation, and tourism. Given the role these landscapes play in shaping the identity of the state, it is not surprising that Colorado has repeatedly identified conservation of the state's natural and agricultural resources as sound public policy and invested significant resources in conservation efforts to maintain these lands into the future. Conservation easements are among the primary tools to achieve this goal. Conservation easements are voluntary agreements that are legally enforceable. They are made between private landowners and either nonprofit land trusts or government bodies. The purpose of these agreements is to safeguard certain conservation values of a property. This includes protecting habitat for fish and wildlife, maintaining working farms and ranches, preserving scenic views, and ensuring spaces for outdoor education and recreational activities.

The state of Colorado has invested substantial financial resources assisting state agencies, local governments, and private nonprofit land trusts in the voluntary adoption of conservation easements from willing landowners. One of the state's principal efforts to incentivize the conveyance of conservation easements is the Conservation Easement Tax Credit program. This study examines the ecological and economic benefits to the public from the Conservation Easement Tax Credit program.

We used data on about 2.3 million acres of Colorado's lands with conservation easements that have received a state tax credit. To assess the ecological benefits, we calculated the acreage or miles of conserved lands that overlapped with mapped conservation values of priority to the State of Colorado. To assess the public economic benefits, we adopted a benefits transfer approach across 13 ecosystem types. The cost of the conservation easement was assumed to be captured in its entirety in the year the easement was conveyed and the benefits from the conservation easement were calculated to begin the year following the year of conveyance. We have included all easements for which complete data are available through 2022, have corrected dollars to 2022 values, and have used an annuity valuation to capture the flow of future benefits due to the permanence of all conservation easements. An important adjustment in the methodology is the treatment of recreation and tourism values. Recreation and tourism values may depend upon access. It was not immediately evident which easements provide recreational access. As a result, we chose to provide our public returns estimates with and without recreation and tourism values.

We estimate total cumulative public benefits of conservation easement credits to Colorado taxpayers is between $35 and $57 billion, or about $20 thousand per acre conserved. We find the value of public benefits between $31 and $49 associated with every dollar invested in the tax credit program using these conservative assumptions. For perspective, this is about 9-15% of state GDP. The public value of conservation easements in Colorado is driven by the protection and stewardship of our forests, wetlands, and grasslands. Using a 2% discount rate and our average benefit estimation yields a present value of some $217 billion of extending benefits for an additional 5 years and $2.3 trillion in perpetuity. These estimates may appear large, but due to the cumulative effects of investments made over two decades and the extension into perpetuity of these benefits, the estimates are appropriately scaled.

Conservation efforts on private and working lands target ecologically important areas, provide a significant economic stimulus to the Colorado economy, and tangible benefits to its residents. We find the public benefits of the tax credit program exceed the costs to Colorado taxpayers by good measure and is therefore a good investment of taxpayer dollars. The cost of making such investments is lower now than it will be in the future.


Photo by Michael Menefee

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Introduction

Conservation easements are voluntary agreements that are legally enforceable. They are made between private landowners and either nonprofit land trusts or government bodies. The purpose of these agreements is to safeguard certain conservation values of a property. This includes protecting habitat for fish and wildlife, maintaining working farms and ranches, preserving scenic views, and ensuring spaces for outdoor education and recreational activities. Conservation easements are typically permanent agreements that become part of the property's chain of title, yet the property itself remains in private ownership and management, and the underlying fee interest can be sold.

The state of Colorado has invested substantial financial resources assisting state agencies, local governments, and private nonprofit land trusts in the voluntary adoption of conservation easements from willing landowners. One of the state's principal efforts to incentivize the conveyance of conservation easements is the Conservation Easement Tax Credit program. This study examines the ecological and economic benefits to the public from the Conservation Easement Tax Credit program. The primary data source used for conservation easement data is the Colorado Ownership, Management and Protection database (COMaP).

In 2017 the Colorado Conservation Easement Tax Credit program and the state lottery division along with Great Outdoors Colorado funding for private conservation came under scrutiny due to sunset provisions in these programs. The state legislature and the land trust community were interested in understanding better the public return to Colorado taxpayers' investments in private lands conservation in the state. Colorado's land trust community, in consultation with the state legislature, commissioned a study from researchers at Colorado State University (CSU) to inform their discussions on the future of the two programs.

The CSU team found state investments in conservation easements had conserved nearly 1.5 million acres of identified crucial habitat, nearly 300,000 acres of prime farmland, 270,000 acres of elk severe winter range, 4,100 miles of stream, creek, or river frontage, and 19% of the Gunnison Sage-Grouse Production Areas that occur on private land.

CSU estimated Colorado residents had received an estimated $5.5-13.7 billion ($2017) of economic benefits from land conserved by conservation easements on investments of roughly $1.1 billion ($2017) since 1995. This represented roughly $4-12 of public benefits provided by private conserved land for each $1 invested in real 2017 dollars. In presenting their findings to the state legislature they concluded results suggested past and current land conservation efforts were sound economic investments benefiting current and future Colorado residents.

Subsequent work

Following the release of the 2017 study, the state legislature decided to extend both programs. To ensure the public and state has adequate information to evaluate the effectiveness of the Conservation Easement Tax Credit program, the state legislature also provided a one-time infusion of funds for COMaP.

The Colorado land trust community actively promoted the results of the 2017 study to state and federal elected officials and their staff. Interest was piqued among Colorado's representatives when the federal Farm Bill came up for reauthorization in 2018. An analysis by the CSU team of the economic impact of Farm Bill conservation easement programs provided approximately $80 million in economic stimulus to Colorado between 2008 and 2017. Planned ("pipeline") conservation easement projects in Colorado that would be supported by federal investment would create nearly $200 million in economic stimulus to Colorado's economy. More than 80% of that economic stimulus was focused on rural communities across Colorado. This work has been credited with increased investments in Federal Farm Bill conservation easement programs.

Members of the CSU team contributed to working groups investigating alternative means to value conservation easements to better reflect, prioritize, and incentivize the protection and stewardship of those properties with the greatest public values with scarce taxpayer dollars. Among the outcomes of the working groups was a recommendation and subsequent adoption of an increase in the percentage of conservation easement value that landowners can claim. Prior to 2021, the tax credit program had never exhausted its budgetary cap of $45 million. Since implementing the change (among other factors, potentially including increasing costs of borrowing and COVID effects on agricultural trade and supply chains) the program has far exceeded the budget cap and generated additional conservation gains across the state.


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Indeed, in 2023, the Division of Conservation has reserved the full $45 million budget cap[2], some $38 million in credits are reserved for 2024, $20 million for 2025. The full allowable 'waitlist' of $15 million has been reached for 2024, with an additional waitlist of $7 million for 2025. Current discussion surrounding the tax credit program include a potential increase in the budgetary cap, piloting alternative valuation approaches, potentially using a Colorado Conservation Index (CCI) of public benefits to private working lands conservation and addressing the orphan and fraudulent easement concerns considered in the working groups.

2 https://conservation.colorado.gov/tax-credit-certificates; https://conservation.colorado.gov/

Stakeholders clearly saw the potential value of a mapping tool to identify return on investments for any area of interest. The Colorado Natural Heritage Program (CNHP) launched Colorado's Conservation Data Explorer (CODEX) in 2021 which synthesizes conservation data from CNHP, Colorado Parks and Wildlife, Bird Conservancy of the Rockies, U.S. Fish and Wildlife Service and many other sources into a one-stop shopping website to view data and generate summary reports. This platform was a natural fit to host the return-on-investment algorithms from the 2017 study (adjusted to 2020 dollars). CNHP embedded these algorithms into a customized return-on-investment report so any area in Colorado can be evaluated. The return-on-investment report provides a low and high estimated total annual benefit of conserved ecosystem services for a user's area of interest.

Here we will narrow our focus to the tax credit program while employing a similar methodology to the 2017 report. It is important to note this analysis will not result in a return-on-investment per se, due to our narrowing of the financial investment to the tax credit program. The tax credit program is an important incentive for landowners to use conservation easements for private lands conservation and stewardship in Colorado, but several programs, policies and, importantly, sources of financial support may be employed in tandem across these conserved properties. As a result, our benefits estimates are best interpreted as the public value that tax credits are leveraging and enabling in the state, not that the program is uniquely responsible for generating.

In general, we will not replicate text from the 2017 report except for ease of understanding and to provide context for adjustments we have made to the methodology, analysis, and information base to improve and update our results and conclusions. Links to the 2017 report, other team publications of relevance, and methodological appendices are included at the end.


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The Colorado Conservation Easement Tax Credit Program

The Colorado legislature created the Conservation Easement Tax Credit program in 2000 [Section 39-22-522, C.R.S.]. The conservation easement must be established to meet one or more of four conservation purposes established in federal statute [26 USC 170(h)(4)]:

- the preservation of land for public outdoor recreation or education
- the protection of ecosystems or fish and wildlife habitat
- the preservation of open space (including farmland and forest land) for scenic enjoyment or pursuing governmental conservation policies
- the preservation of historically important land or structures.

Currently administered through the Colorado Division of Conservation, a landowner can choose to donate a conservation easement (CE) on their property, and in return, the landowner can claim a state tax credit – a dollar-for-dollar reduction of state income tax liability based on the appraised value of the donated portion of the easement and calculated using the formulae in Table 1. Uniquely, this tax credit certificate is transferable and can be sold in full or in part to a third party in a market transaction.

To the extent that total state income tax liability is reduced by this program, the tax revenue collected by the state is reduced relative to what it would otherwise be. This unrecovered potential tax revenue is the cost of the program to the state. The tax credit value is a proportion of the fair market value (FMV) of the donated CE up to a capped maximum value per CE donation. An annual program cap on the total value of tax credits issued was instituted in 2011. The specific proportion of the FMV, the credit cap per donation, and the annual program cap have changed several times since the program began (Table 1).

Table 1. Formulae and caps for Colorado's Conservation Easement Tax Credit Program.

Tax Year	Formula for calculating tax credit for the donated (uncompensated) portion of conservation easement	Tax Credit Cap Per donation	Annual Program Cap
2000-02	100% of FMV	$100,000	No cap
2003-06	100% of the first $100,000 of FMV, plus 40% of any remaining FMV	$260,000	No cap
2007-10	50% of FMV	$375,000	No cap
2011-12	50% of FMV	$375,000	$22,000,000
2013	50% of FMV	$375,000	$34,000,000
2014	50% of FMV	$375,000	$45,000,000
2015-16	75% of the first $100,000 of FMV, plus 50% of any remaining FMV	$1,500,000	$45,000,000
2017-20	75% of the first $100,000 of FMV, plus 50% of the next $4,900,000. The payments issued cannot exceed $1,500,000 per year, so more valuable easements are paid out in $1.5 m increments.	$5,000,000	$45,000,000
2021-present	90% of FMV up to a maximum of $5,000,000 per donation	$5,000,000	$45,000,000

Values through 2016 adapted from "Conservation Easement Tax Credit Program After Changes in 2014." https://leg.colorado.gov/sites/default/files/documents/audits/1561p_conservation_easement_tax_credit_program_0.pdf

Values through 2027 adapted from DORA. https://conservation.colorado.gov/

Approach

The 2017 study adopted a benefits transfer approach across 11 ecosystem types. The cost of the conservation easement was assumed to be captured in its entirety in the year of the conveyance and the benefits from the conservation easement were calculated to begin from year following the conveyance. The timeframe for the analysis was from 1995 to 2024 (observed from 1995 to 2017 and forecast from 2017 to 2024) with dollars expressed in 2017 values and present value calculations through 2024 assuming a 5% rate of discount and no income or population growth drivers of value change.

For the 2023 analysis we have included all easements for which complete data are available through 2022 (Figure 1), have corrected dollars to 2022 values, and have used an annuity valuation to capture the flow of future benefits due to the permanent nature of all conservation easements in the database.

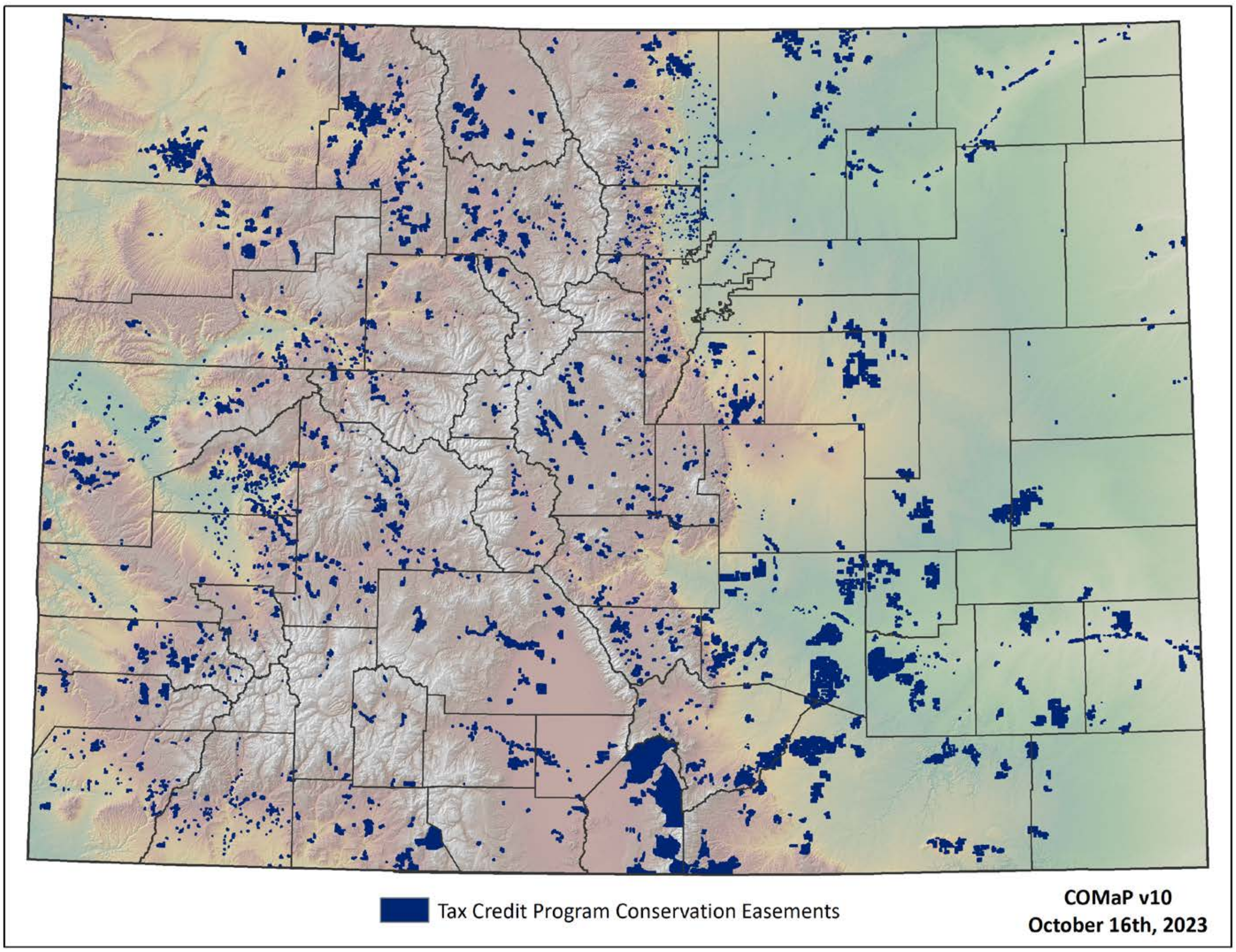

Figure 1: Tax credit program conservation easements

In addition, we have updated our benefits transfer values and categorization in view of the evolution of the field since 2017 and have considered four additional ecosystem service values (biological control, energy and raw materials, nutrient cycling, and soil formation) and two additional ecosystem categories (barren land/desert, pasture/hay) in this analysis in response to feedback from CODEX users (Tables 2 and 3).

Table 2: Classification and brief definition of ecosystem services included in this analysis (adapted from de Groot et al., 2002)	
Regulation Functions	Ecosystem processes and components
Aesthetic information	Attractive landscape features
Biological control	Population control through trophic-dynamic relations
Carbon sequestration and storage	Role of ecosystems in bio-geochemical cycles (e.g., $CO2/O2$ balance, ozone layer, etc.)
Energy and raw materials	Conversion of solar energy into biomass for human construction and other uses
Soil erosion control	Preserving the integrity and stability of the soil (e.g., vegetative cover)
Flood risk reduction	Attenuate floodwaters, enhance water absorption and provide natural buffers
Food/Grazing	Conversion of solar energy into edible plants animals
Habitat and nursery/ biodiversity	Providing suitable living and reproducing space for wild plant and animal species.
Nutrient cycling	Role of biota in storage and re-cycling of nutrients
Pollination	Role of biota in movement of floral gametes
Recreation and tourism	Variety in landscapes with (potential) recreational uses
Soil formation	Weathering of rock, accumulation of organic matter
Water quality	Biological interactions and sedimentation to promote filtration/stabilization of water
Water regulation	Role of land cover in regulating runoff & river
Water supply	Filtering, retention, and storage of fresh water (e.g., in aquifers)

Although there was some interest to include perennial snow and ice, industrial and commercial development, and recreation and tourism as eased land and value categories, we chose not to do so as directly attributing these values (or a specific proportion of them) to the easement and program was considered stretching the argument for causation too far.

Table 3: Ecosystems and ecosystems service value categories included in the 2017 vs 2023 analyses

	Developed - High Intensity Urban	Developed - Low Intensity Urban Green Space	**Barren/Desert**	Cultivated	**Pasture/Hay**	Grasslands/Herbaceous	Woody Wetlands	Emergent Herbaceous Wetlands	Shrub/Scrub	Evergreen Forests	Deciduous Forests	Mixed Forests	Open Water	Perennial Snow/Ice	Developed - il/Mine/Quarry
Aesthetic Information		**X**		X		**X**	X	X		*X*	X	X	**X**		
Biological Control				**X**	**X**					**X**	**X**	**X**			
Carbon Sequestration and Storage		X	**X**	X		**X**		**X**	X	X	X	X			
Energy and Raw Materials				**X**							**X**	**X**			
Soil Erosion Control				**X**	**X**	X				**X**	**X**	**X**			
Flood Risk Reduction		**X**					X	X		**X**	**X**	**X**			
Food/Grazing				X		X		**X**		X	*X*	X			
Habitat and Nursery/ Biodiversity				X	**X**	X	X	X	**X**	X	X	X	X		
Nutrient Cycling				**X**	**X**						**X**	**X**			
Pollination				X	**X**	**X**			**X**	**X**					
Recreation and Tourism					**X**	X	X	*X*	X		**X**	**X**			
Soil Formation				**X**	**X**										
Water Quality						*X*	**X**	**X**		**X**	**X**		**X**		
Water Regulation		X		**X**		X	**X**	**X**		**X**	**X**		X		
Water Supply							*X*	*X*							

X: Included in the 2017 ROI, NOT the 2023 ROI

X: Included in the 2017 ROI and the 2023 ROI

X: Included in the 2023 ROI, NOT the 2017 ROI

Perennial Snow/Ice NOT included

Developed - Oil/Mine/Quarry NOT included

Developed - High Intensity Urban NOT included

Recreation and Tourism NOT included. Listed as a reference to show potential increases in ROI for open access easements

An important adjustment in the methodology from 2017 to 2023 is the treatment of recreation and tourism values. Recreation and tourism values may depend upon access, particularly if aesthetic values are captured separately. It was not immediately evident which easements provide recreational access even if the ecosystem type would typically include such opportunities. We observe recreation and tourism values for eight of fifteen ecosystem service categories in the literature, in the range of $3.51 to $6.01 with an average of $4.76 of benefits per acre for every $1 spent. This could have important implications for benefits estimates in Colorado with high public participation in outdoor recreation and tourism as an important economic driver. As a result, we chose to provide our public returns estimates with and without recreation and tourism values.

As was the case on the benefit side of the calculations, a few challenges were encountered on the cost side calculations requiring some additional considerations. Colorado Department of Revenue reports the total value of gross conservation easement credits claimed on individual and corporate income tax returns annually through 2020 (see, for example, page 61 of the 2022 report here: https://cdor.colorado.gov/data-and-reports/cdor-annual-reports). However, there are some discrepancies in the annual values reported for the same year in different years of the annual report. The Division of Conservation reports the total value of conservation easement tax credits issued annually, although they are not necessarily claimed on tax returns in that year and publishes their tax credit cap data from 2011 to 2027, but not before. The figures reported in the Colorado Department of Revenue reports are also consistently lower than the Colorado Division of Conservation's tax credit cap data. As a result, we adopt the Department of Revenue figures from 2001 to 2010 and Division of Conservation from 2011 onward, corrected to 2022 dollars. Finally, conservation easement inscription dates are missing for some preserved acres, identified as 'unknown' in the calculations. Although unlikely to be true, the most conservative cost and benefit calculation would assume they closed in 2022.

Due to important differences in the approach, data analysis, data quality, and narrowing the focus to the tax credit program alone, the results of the 2017 report and the 2023 analysis are not strictly comparable, although they are quite similar conceptually. Distinct from the 2017 report, on the 'benefits' side we expand the number of ecosystem services accounted for, depend on the broader economic valuation literature, assume a lower discount rate according to current norms, and extend benefits in perpetuity. Since we focus on one of several potential sources of financial support, and do not include costs borne by the landowner or land trust that are not covered by the tax credit program, our 'cost' side calculations are partial. As a result, this is not a 'return-on-investment' calculation, strictly speaking. Our benefits estimates are best interpreted as the public value that tax credits are leveraging and enabling in the state, not that the program is uniquely responsible for generating.

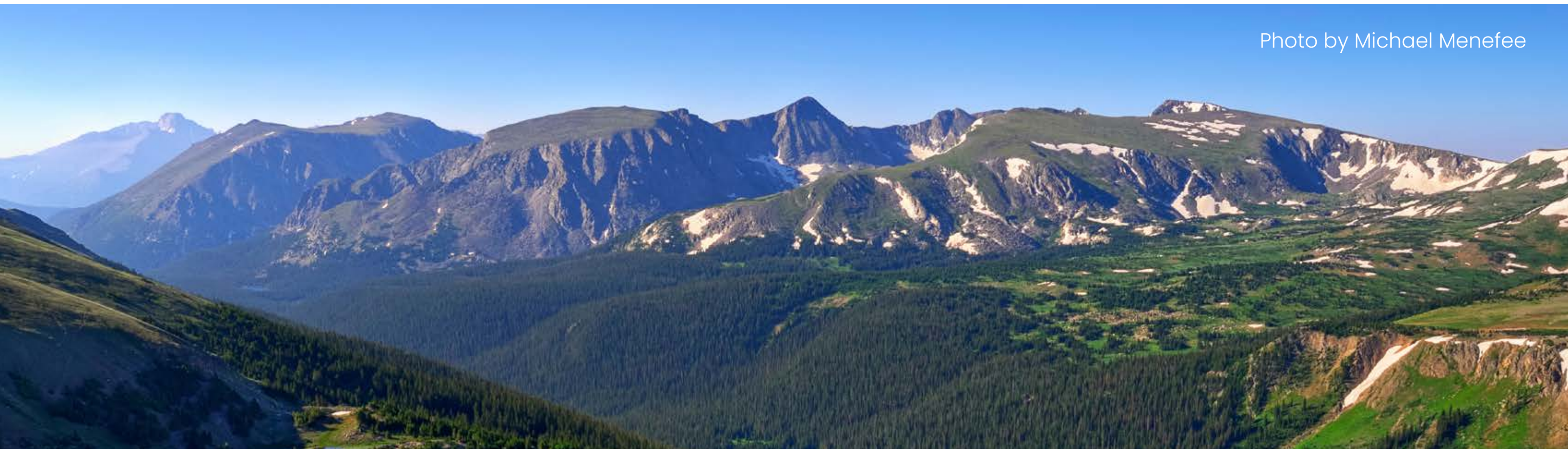

Photo by Michael Menefee

Results

Table 4 summarizes the distribution of ecosystems across almost 2.3 million acres (3.4% of total area) of Colorado private lands permanently protected by the conservation easement credit program since 2000. More than one third of private lands enrolled in the program are grasslands, followed by more than one-quarter in shrub or scrub land, about 14% in evergreen forest and 9% in deciduous forest ecosystems. The tax credit program has enrolled 17% of the state's wetlands and 9% of its hay ground. Benefit transfer estimates from the literature indicate that the state's wetlands generate the greatest public value per acre, followed by low intensity use open lands, likely due to their proximity to larger human populations which in turn drive per acre values (Table 4).

Table 4. Conservation Easement Tax Credit Program conservation in Colorado

Ecosystem (NLCD 2019)	Acres conserved	Acres in CO	Ratio of conserved to total acreage	Average value ($2022) by ecosystem/acre
1. Emergent Herbaceous Wetlands	72,318.29	714,849	10.12%	$7,052.98
2. Woody Wetlands	42,721.66	622,252	6.87%	$6,619.49
3. Developed, Low Intensity	3,471.57	504,040	0.69%	$5,905.39
4. Developed, Open Space	14,840.13	948,369	1.56%	$5,905.39
5. Deciduous Forest	194,817.11	4,345,388	4.48%	$3,586.74
6. Open Water	5,087.48	266,705	1.91%	$3,266.50
7. Cultivated Crops	90,907.76	8,275,088	1.10%	$3,048.34
8. Evergreen Forest	322,892.01	13,364,428	2.42%	$1,747.99
9. Mixed Forest	20,627.04	539,745	3.82%	$1,381.24
10. Grassland/Herbaceous	833,222.99	19,270,980	4.32%	$1,077.53
11. Hay/Pasture	65,165.88	761,261	8.56%	$574.60
12. Shrub/Scrub	615,019.82	15,975,290	3.85%	$222.24
13. Barren Land	8,698.49	501,711	1.73%	$1.37
14. Developed, High Intensity	95.63	115,420	0.08%	$0.00
15. Developed, Medium Intensity	785.50	355,756	0.22%	$0.00
16. Perennial Snow/Ice	19.79	57,662	0.03%	$0.00
Total	2,290,691.15	66,618,944	3.44%	

*Acreage for Perennial Snow/Ice is based on NLCD ecosystem types. A Comprehensive Valuation of the Ecosystem Services of the Arctic National Wildlife Refuge, Alaska, listed nine ecosystem services provided by protected Polar-alpine ecosystems with a total value of $368.22/acre. Since there are few acres identified by Colorado state data for the investment year, values are not included.

Table 5 provides for illustration of the conservation values of Colorado's lands protected by conservation easements using different criteria than ecosystems and the ecosystem services generated by them. Although 3.4% of Colorado lands are under protection of conservation easements supported by the tax credit program, some 13% of Colorado's gold medal streams are within 250 meters of conserved working landscapes that are protected. More generally, Table 5 demonstrates that investments in conservation easements have disproportionately favored ecologically important lands. More than 200,000 acres of private lands essential to the health of sage grouse and more than 1 million acres of seasonal ranges for elk and mule deer have been protected by the tax credit program and the landowners that manage them.

Table 5. Additional values protected through the Colorado Conservation Easement Tax Credit Program, 3.4% of Colorado land area.

Conservation Values	Acres Conserved*	Miles Conserved*	Percentage of total Conserved
CNHP Potential Conservation Areas (CNHP 2023)	748,820		4%
Prime Farmland (USDA 2023)	449,220		3%
FWS Critical Habitat (FWS 2023)	29,710		2%
Greater Sage-Grouse Priority & General Habitat (CPW 2022)	187,590		5%
Greater Sage-Grouse Production Areas (CPW 2022)	119,850		5%
Gunnison Sage-Grouse Production Areas (CPW 2022)	83,570		9%
Designated Scenic Byways within 250 meters of Conserved CEs (CDOT 2023)		230	9%
Gold Medal Streams within 250 meters of Conserved CEs (CPW 2023)		50	13%
Rivers, Streams, Canals and Ditches Mapped in the National Hydrography Dataset Plus High-Resolution National Release within 250 meters of Conserved CEs (USGS 2022)		15,800	6%
SB 181 High Priority Habitat (CPW 2022)	1,413,930		Not Calculated
Elk Winter Range (CPW 2022)	987,440		Not Calculated
Elk Severe Winter Range (CPW 2022)	325,250		Not Calculated
Mule Deer Winter Range (CPW 2022)	1,004,100		Not Calculated
Mule Deer Severe Winter Range (CPW 2022)	305,280		Not Calculated
Whitetail Deer Winter Range (CPW 2022)	194,330		Not Calculated
Black Bear Fall Concentration Range (CPW 2022)	622,910		Not Calculated
Pronghorn Winter Range (CPW 2022)	367,140		Not Calculated
Pronghorn Severe Winter Range (CPW 2022)	72,590		Not Calculated
Big Horn Sheep Winter Range (CPW 2022)	104,550		Not Calculated
Big Horn Sheep Severe Winter Range (CPW 2022)	10,320		Not Calculated

*Rounded to the nearest 10 acres or miles

Our analysis translates acres of private lands protected by conservation easement tax credits into ecosystem types, then ecosystem service categories, and finally ecosystem service values. Due to the state level analysis and the use of values transferred from the broader economic valuation literature to Colorado a range of values is appropriate to capture potential variation in site-to-site values.

Table 6 summarizes our main results highlighting 'low,' 'average,' and 'high' per acre ecosystem service values from the literature and scaling to the level of the Colorado tax credit program since 2000. Only those 13 ecosystem services that had positive values are included. Values are rounded to the nearest dollar per acre, except for those that have values below $3 per acre, and $1000 in total by category in part to signal our degree of precision in these estimates is certainly not to the level of parts of a dollar and is more likely in the tens of dollars at the per acre level for most value categories. Calculations are carried out using the more precise value.

Table 6: Public value of private lands conservation due to the Colorado conservation easement tax credit program

Ecosystem Service (ES)	Low value ecosystem/ ac	Avg value ecosystem/ ac	High value ecosystem/ ac	Low total	Average total	High total
($2022)				('000)		
Emergent Herbaceous Wetlands	6,492	7,053	7,614	6,252,017	6,792,731	7,333,445
Woody Wetlands	5,728	6,619	7,511	3,178,122	3,673,051	4,167,975
Developed, Low Intensity	3,997	5,905	7,814	166,433	245,888	325,349
Developed, Open Space	3,997	5,905	7,814	750,020	1,108,080	1,466,141
Deciduous Forest	3,522	3,587	3,651	8,459,751	8,615,181	8,770,636
Open Water	3,130	3,267	3,403	187,331	195,528	203,727
Cultivated Crops	635	3,048	5,462	758,379	3,641,888	6,525,409
Evergreen Forest	1,491	1,748	2,005	6,358,303	7,456,726	8,555,192
Mixed Forest	1,311	1,381	1,451	322,202	339,436	356,670
Grassland/Herbaceous	774	1,078	1,381	8,537,466	11,882,889	15,228,310
Hay/Pasture	573	575	576	483,335	485,049	486,298
Shrub/Scrub	2.53	222	442	18,956	1,665,152	3,311,348
Barren Land	1.37	1.37	1.37	170	170	170
	Total benefits			35,472,485	46,101,769	56,730,665
	Total costs			(1,156,149)	(1,156,149)	(1,156,149)
	Net benefit			34,316,336	44,945,620	55,574,516
	B/C ratio			31	40	49
	Benefits/acre conserved			15,485	20,126	24,766
	Costs/acre conserved			(505)	(505)	(505)
	Net benefits/acre conserved			14,981	19,621	24,261

All costs and benefits are in January 2022 dollars and assume that the program, its benefits and its costs, end in 2022. We estimate total cumulative public benefits of conservation easement credits to Colorado taxpayers is between $35 and $57 billion, or about $20 thousand per acre conserved (Table 6), and $43 and $74 billion if recreation and tourism benefits are included (about $25,500 per acre conserved) (Table 7). We find the value of public benefits between $31 and $49 associated with every dollar invested in the tax credit program using these conservative assumptions. If recreation and tourism values are included, our estimates increase to a range of $37-$64 on average across all currently enrolled acres in Colorado. For perspective, although they measure very different things, this is about 9-15% of state GDP. The public value of conservation easements in Colorado is driven by the protection and stewardship of our forests, wetlands, and grasslands. (Table 7).

Table 7: Public value of private lands conservation due to the Colorado conservation easement tax credit program, including outdoor recreation and tourism values

Ecosystem Service (ES)	**Low value of ecosystem/ ac**	**Avg value of ecosystem/ ac**	**High value of ecosystem/ ac**	**Low total**	**Average total**	**High total**
($2022)				('000)		
Emergent Herbaceous Wetlands	7,029	8,009	8,989	6,769,954	7,713,398	8,656,832
Woody Wetlands	6,614	7,546	8,477	3,669,971	4,186,901	4,703,837
Developed, Low Intensity	3,997	5,905	7,814	166,433	245,888	325,344
Developed, Open Space	3,997	5,905	7,814	750,020	1,108,080	1,466,141
Deciduous Forest	3,758	3,885	4,011	9,027,620	9,331,468	9,635,315
Open Water	6,025	6,320	6,616	360,625	378,315	396,005
Cultivated Crops	635	3,048	5,462	758,379	3,641,888	6,525,409
Evergreen Forest	2,665	3,154	3,644	11,366,795	13,454,861	15,542,884
Mixed Forest	1,508	1,578	1,648	370,575	387,809	405,043
Grassland/ Herbaceous	780	1,083	1,387	8,599,663	11,945,086	15,290,508
Hay/Pasture	573	575	576	483,360	485,074	486,332
Shrub/Scrub	131	757	1,383	982,802	5,670,613	10,358,499
Barren Land	1.37	1.37	1.37	169	169	169
	Total benefits			43,306,369	58,549,551	73,792,319
	Total costs			(1,156,149)	(1,156,149)	(1,156,149)
	Net benefit			42,150,220	57,393,402	72,636,170
	B/C ratio			37	51	64
	Benefits/acre conserved			18,905	25,560	32,214
	Costs/acre conserved			(505)	(505)	(505)
	Net benefits/acre conserved			18,401	25,055	31,709

However, conservation easements are in perpetuity and once the public investment has been made, the public can be expected to benefit into the foreseeable future. If we fix the level of benefits at the end of 2022 and extend them annually, without any additional acreage, the benefits accruing to taxpayers can be viewed as an annuity. Since the number of acres in the state is fixed and the population and income of Colorado taxpayers is increasing, this value should also increase annually, but this invites unnecessary complications to the calculations.

Recent guidance (Whitehouse.gov, 2023) suggests a 2% discount rate, lower than the traditional 3-5% rate assigned in the 2017 calculation and adopted by many regulatory impact assessments which has the effect of increasing today's value of future benefits and costs. Using a 2% discount rate and our average benefit estimation without outdoor recreation and tourism benefits yields a present value of almost $217 billion of extending benefits for an additional 5 years and $2.3 trillion in perpetuity. A 5% discount rate would yield a present value of about $200 billion by extending benefits for 5 years, or $920 billion if benefits extend into perpetuity. These estimates may appear large, but due to the cumulative effects of investments made over two decades and the extension into perpetuity of these benefits, the estimates are appropriately scaled.

Photo by Michael Menefee

Photo by Michael Menefee

Conclusions

In this report we provide an update and somewhat narrower take on our 2017 analysis entitled Investing in Colorado: Colorado's Return on Investments in Conservation Easements: Conservation Easement Tax Credit Program and Great Outdoors Colorado. Here we focus on Colorado's Conservation Easement Tax Credit program, taking into account changes in the program since 2017, additions to the number of conservation easements inscribed through the program and entered into COMaP since our last analysis, and improvements in the meta-analysis and benefits transfer literature surrounding categorization and valuation of ecosystem services on Colorado's working landscapes. Although our approach generally parallels the 2017 analysis, our results are not strictly comparable due to the adjustments we have made in the analysis and the narrowing of its scope.

Conservation efforts on private and working lands target ecologically important areas, provide a significant economic stimulus to the Colorado economy, and tangible benefits to its residents. We find, as we found in 2017, that the public benefits of the tax credit program exceed the costs to Colorado taxpayers by good measure and is therefore a good investment of taxpayer dollars, even with some very conservative assumptions. The cost of making such investments is lower now than it will be in the future. With more likely or realistic assumptions it is clear public policy to conserve Colorado's working landscapes is a very good investment in our future.

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Appendices

Appendix A: Additional resources

The 2017 Analysis:

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

CSU-team related resources since publication of the 2017 analysis:

Blake A., Cossitt-Glesner, I., Funk, A., Seidl, A., and Thomason, G., 2021. Preserving Agricultural Lands for Colorado's Future. Colorado Food Systems Advisory Council Issue Brief. July 2021.https://cofoodsystemscouncil.org/wp-content/uploads/2021/08/PreservingAgLands_Brief_v2.pdf

Colorado Conservation Data Explorer (CODEX), 2021. Database and simulation tool created for 2017 study on return on investment to conservation easements updated to 2020 values. https://cnhp.colostate.edu/maps/codex/

Seidl, A., 2020. Economic impact of future federal conservation easement payments on (rural) Colorado communities. June 2020. 7 pp. REDI Report. https://csuredi.org/redi_reports/economic-impact-of-future-federal-conservation-easement-investments-on-rural-colorado-communities/

Seidl, A., Hill, R., and Mangus, L., 2020. Alternative methods for substantiating payments for conservation easements in Colorado. October 2020. https://api.mountainscholar.org/server/api/core/bitstreams/b3917596-c9d6-4902-a2a0-a8921f4ed141/content

Seidl, A., Hill, R., and Mangus, L., 2020. Alternative methods for substantiating payments for conservation easements in Colorado: Report summary. October 2020. https://www.libarts.colostate.edu/redi/wp-content/uploads/sites/50/2020/09/REDI-Report-Alt-Val-Easments-Summary-Oct-2020.pdf

Seidl, A., Swartzentruber, R., Hill, R., 2018. Public benefits of private lands conservation: Summarizing alternative compensation mechanisms. September 2018. 2 pp. https://api.mountainscholar.org/server/api/core/bitstreams/e3f26365-cc71-4d0f-838e-f66ac45bcaa0/content

Seidl, A., Swartzentruber, R., Hill, R., 2018. Public benefits of private lands conservation: Exploring alternative compensation mechanisms. September 2018. 25 pp. https://mountainscholar.org/items/0537b648-02f9-49df-9e4c-427294d2a263

Seidl, A., Swartzentruber, R., Hill, R., 2018. Estimated Economic Impact of Federal Agricultural Conservation Easement Programs (ACEP) on Colorado, 2009-2017: Summary. July 2018. 2 pp. https://api.mountainscholar.org/server/api/core/bitstreams/3e95b806-15de-4897-9af2-cfa9d56fea6d/content

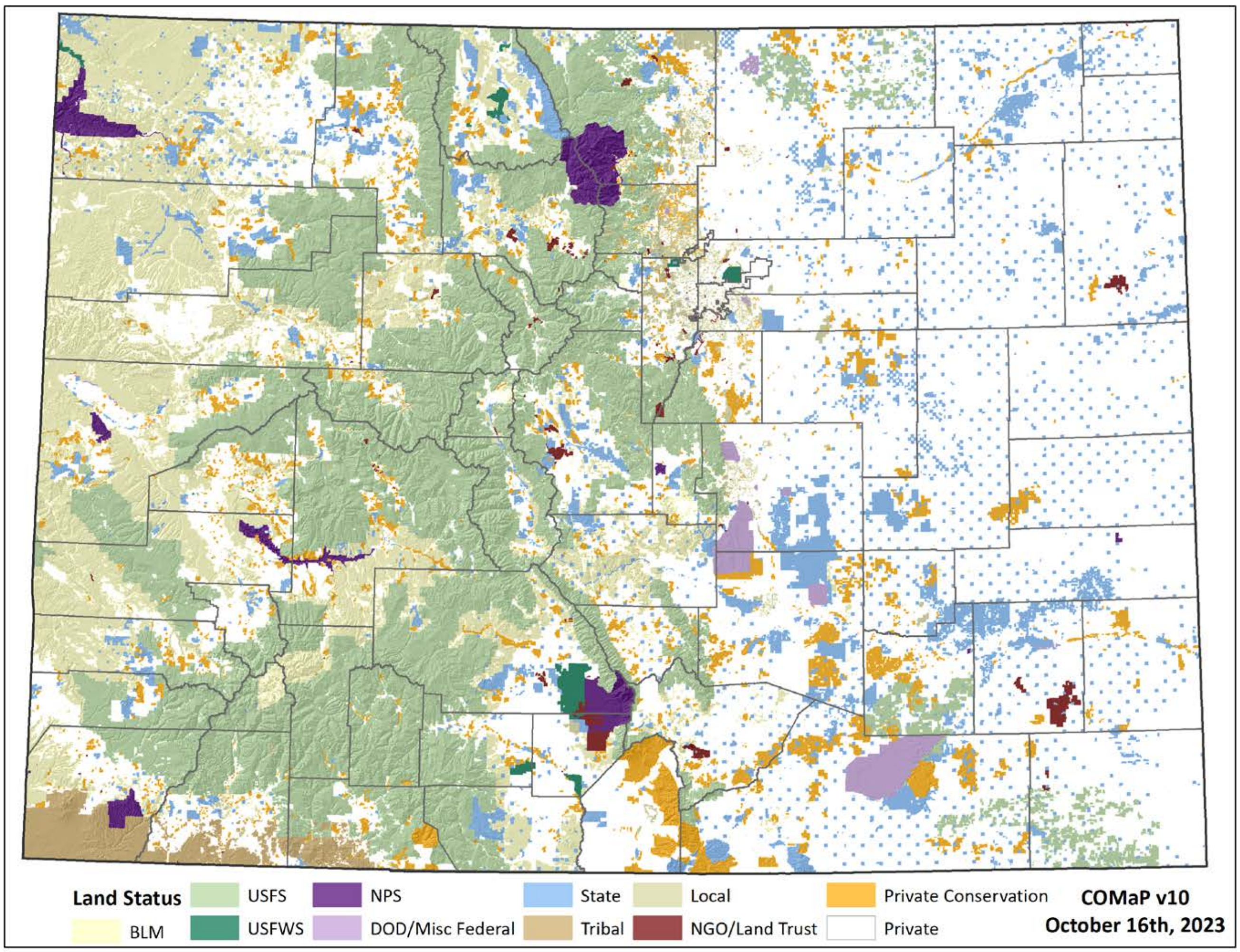
Seidl, A., Swartzentruber, R., Hill, R., 2018. Estimated Economic Impact of Federal Agricultural Conservation Easement Programs (ACEP) on Colorado, 2009-2017. July 2018. 32 pp. https://api.mountainscholar.org/server/api/core/bitstreams/4d17eb79-b9db-41eb-b6fa-41bee188a8ea/content

Appendix B. Spatial Datasets and Selection Criteria

Several spatial datasets were central to our analysis and are described in more detail below.

Colorado Ownership, Management and Protection database

The Colorado Ownership, Management and Protection database (COMaP) is a map product managed by the Colorado Natural Heritage Program at Colorado State University. The conservation easement data used in this study were derived from COMaP. Currently in its 10th version, COMaP integrates protected lands from over 300 data sources into one seamless map (Appendix Figure 1). Source polygons are adjusted, or edge-matched, to create a topologically correct map with no overlaps or gaps. The scale of the data varies by source and is documented in the attribute table. Other attributes include landowner, land manager, conservation easement holder, reception number, protection mechanism, public access, state tax credit information, and more. To learn more about COMaP, visit https://comap.cnhp.colostate.edu



Appendix Figure 1. Protected areas and public ownership data provided through COMaP.

A call for data preceded this report and many organizations responded with current data submissions to support our goal of a robust and comprehensive map. We also received a list of conservation easements from 2011 to the present from the Colorado Division of Conservation of CEs that applied for a state tax credit. State tax credit reporting requirements were implemented in 2011. There was no reporting from 2000, the onset of the program, through 2010. This analysis used the October 16, 2023 version of COMaP. The selection criteria are described below.

Colorado Conservation Easement Tax Credit Program List: If we definitively knew whether a tax credit was claimed, we honored that information. Otherwise, we assumed that qualifying conservation easements received a tax credit and applied the following filters to identify qualifying conservation easements:

Included

- Conservation easements from 2011 through 2022 that were identified by the Colorado Division of Conservation as applying for a state tax credit.
    - Selected from GIS field TAXCREDIT
- Privately owned conservation easements from 2000, the onset of the program, through 2010. (conservation easements with unknown dates were included, assuming most privately owned conservation easements have been established since 2000)
    - Selected from GIS fields OWNER, PROTECTION_MECHANISM, and DATE_ESTABLISHED

Excluded

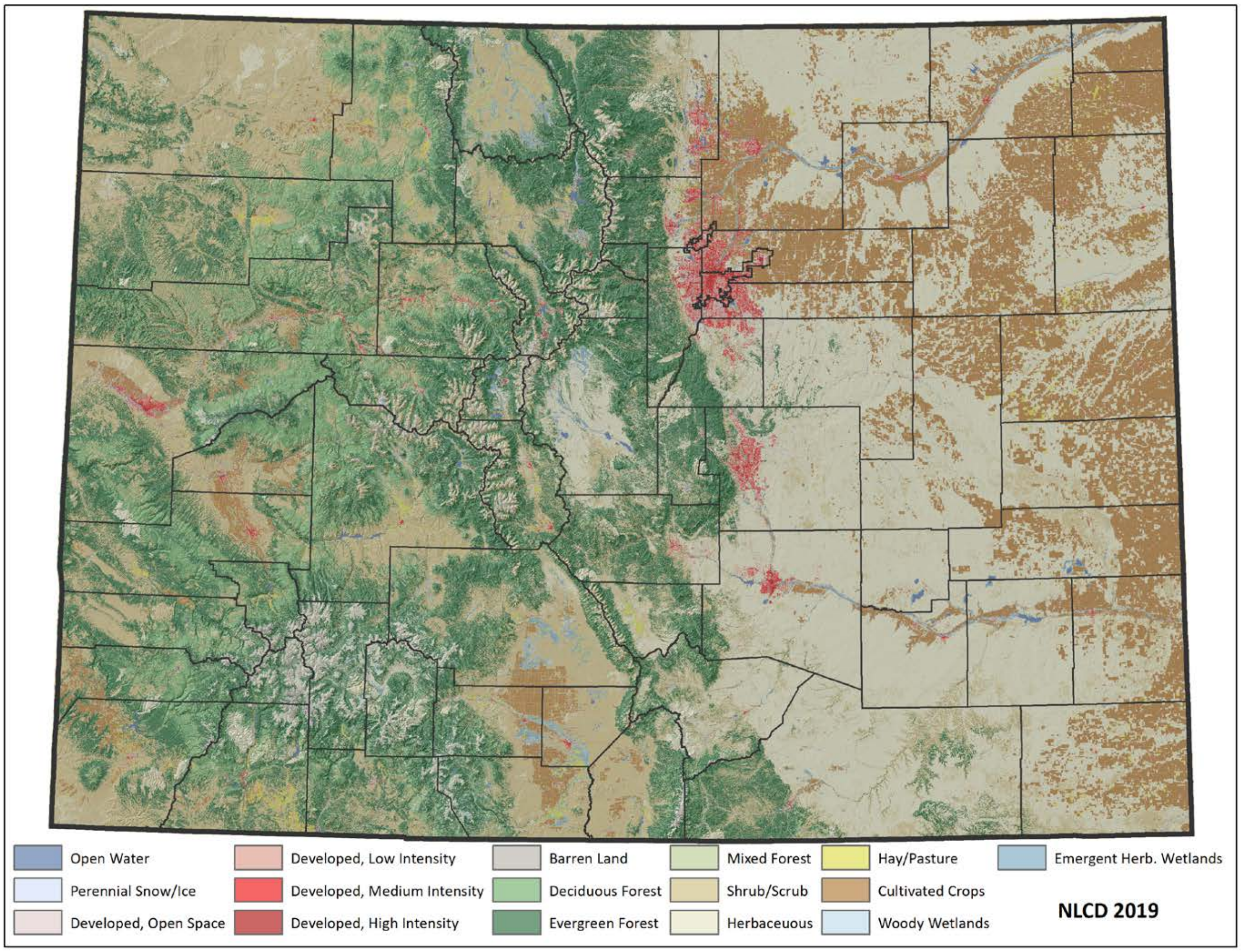
- Conservation easements in public ownership.
- Term (i.e., less-than-perpetual) conservation easements.
- Any "quid pro quo" conservation easement, if known.
- Any conservation easement established prior to 2000, the onset of the state tax credit program.

Limitations

- Reporting requirements for the state tax credit program were implemented in 2011. We assumed qualifying conservation easements from 2000 -2010 applied for a tax credit.
- Approximately 10% of the acreage used in the analysis included conservation easements with unknown dates. It's possible some of these were established prior to 2000. This uncertainty also affected the economic analysis. Conservative assumptions were used and all undated easements were assigned 2022 closure dates.
- Phased conservation easements, those that increase in acreage over time by a willing landowner, may or may not be represented in COMaP for the 2000-2010 conservation easements. This can affect the closure dates, an attribute used in the economic analysis.
- It is unknown if counties and municipalities are labeling all "quid pro quo" conservation easements when they submit data. These conservation easements do not qualify for tax credits. It's possible that some of the 2000 – 2010 conservation easements held by local governments are "quid pro quo" but were not labeled as such.

National Land Cover Database

The National Land Cover Database (NLCD) is a nationwide dataset developed by a consortium of federal agencies. We used the 2019 version of the NLCD to identify ecosystems in Colorado (Appendix Figure 2). The NLCD is derived primarily from Landsat mosaics and is available at a spatial resolution of 30 meters. To learn more about the NLCD, visit https://www.usgs.gov/centers/eros/science/national-land-cover-database



Appendix Figure 2. National Land Cover Database 2019.

Conservation easement polygons were overlaid with the NLCD raster in GIS to report the square meters of each ecosystem type within conservation easements by year established. Square meters were converted to acres using Microsoft Excel conversion tools.

Colorado Parks and Wildlife Species Activity Mapping

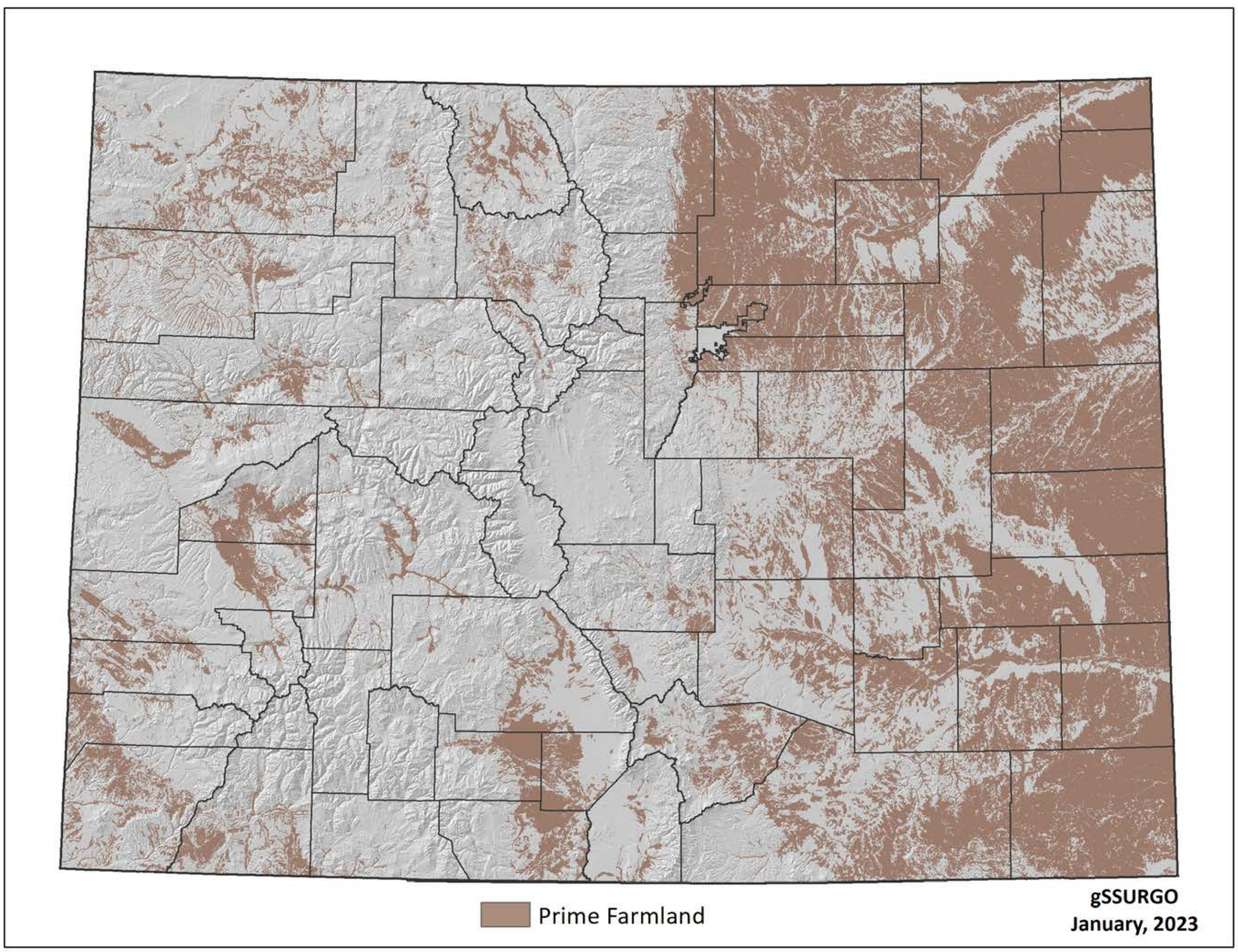
The Species Activity Mapping (SAM) provides information on wildlife distributions to public and private agencies and individuals, for environmental assessment, land management resource planning and general scientific reference. This is a layer package created by the Colorado Parks and Wildlife GIS Unit in July 2023 for distributing Colorado wildlife GIS data in shapefile format for public distribution. The layers in the 2023 package were last updated in December 2022. This information was used extensively in Table 5 to illustrate other conservation priorities conserved through the Conservation Easement Tax Credit Program.

Gridded Soil Survey Geographic (gSSURGO) Database

Gridded SSURGO (gSSURGO) from January 2023 was used for calculating Prime Farmland acres. USDA provides the following description:

The gridded SSURGO (gSSURGO) dataset was created for use in national, regional, and statewide resource planning and analysis of soils data. The raster map layer data can be readily combined with other national, regional, and local raster layers, including the National Land Cover Database (NLCD), the National Agricultural Statistics Service (NASS) Crop Data Layer (CDL), and the National Elevation Dataset (NED).

The gSSURGO Database is derived from the official Soil Survey Geographic (SSURGO) Database. SSURGO generally has the most detailed level of soil geographic data developed by the National Cooperative Soil Survey (NCSS) in accordance with NCSS mapping standards. The tabular data represent the soil attributes and are derived from properties and characteristics stored in the National Soil Information System (NASIS).



Appendix Figure 3. Prime Farmland from gSSURGO 2023.

For the purposes of this study we included the following categories of Prime Farmland from gSSURGO (Appendix Figure 3):

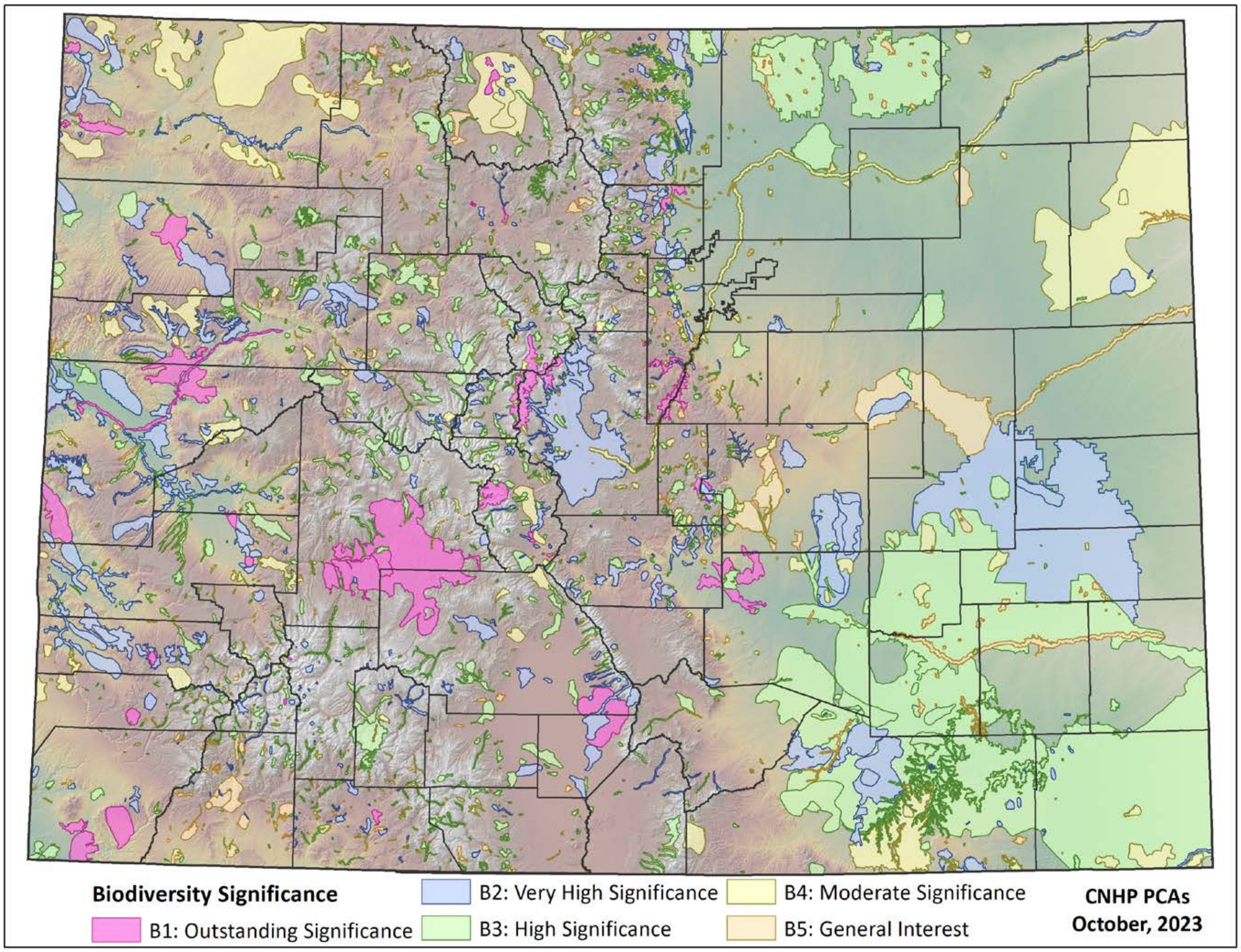
- All areas are prime farmland
- Farmland of local importance
- Farmland of statewide importance
- Farmland of statewide importance, if warm enough, and either drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of unique importance
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if protected from flooding or not frequently flooded during the growing season

Colorado Natural Heritage Program Potential Conservation Areas

The Potential Conservation Areas (PCA) map shows CNHP's best estimate of the primary area required to support the long-term survival of targeted rare species or natural communities (Appendix Figure 4).

To successfully protect populations or occurrences of rare and imperiled species, it is necessary to delineate conservation areas. These potential conservation areas focus on capturing the ecological processes that are necessary to support the continued existence of a particular element of natural heritage significance (species, subspecies or significant plant community). Potential conservation areas may include a single occurrence of a rare element or a suite of rare elements or significant features.

The intent is to identify a land area that can provide the habitat and ecological processes upon which a particular element or suite of elements depends for their continued existence. The best available knowledge of each species' life history is used in conjunction with information about topographic, geomorphic, and hydrologic features, vegetative cover, as well as current and potential land uses. The proposed boundary does not automatically exclude all activity. It is hypothesized that some activities will cause degradation to the element or the processes on which they depend, while others will not. Consideration of specific activities or land use changes proposed within or adjacent to the preliminary conservation planning boundary should be carefully considered and evaluated for their consequences to rare and imperiled species.



Appendix Figure 4. Colorado Natural Heritage Program Potential Conservation Areas.

Appendix C: Compiled ecosystem service values (ESV) (including recreation values, low, high, and mean values)							
Land Cover	**Ecosystem Service**	**Author**	**Year of Study**	**Location**	**Low**	**High**	**Average**
					$2022/Ac/Yr		
Cultivated	Food	Faux, J.	1999	Oregon	22.72	285.26	153.99
		Piper, S.	1977	Black Hills South Dakota & Wyoming	55.73	55.73	55.73
		Sanshu, H.S., Wratten, S.D., Cullen, R., Case, B.	2008	Canterbury, New Zealand	678.00	11,142.78	5,910.39
					495.23	8,253.92	4,374.58
		Zhou, X., et al.	2009	Iowa	26.83	132.04	79.43
					255.70	3,973.95	2,114.82
	Water Regulation	Sanshu, H.S., Wratten, S.D., Cullen, R., Case, B.	2008	Canterbury, New Zealand	59.91	59.91	59.91
					30.23	30.23	30.23
					45.07	45.07	45.07
	Habitat and Nursery	Sanshu, H.S., Wratten, S.D., Cullen, R., Case, B.	2008	Canterbury, New Zealand	-	278.27	139.13
					-	363.77	181.88
					31.24	48.35	39.80
					10.41	230.13	120.27
	Soil Erosion Control	Moore, W.B.	1987	Oregon	31.84	43.04	37.44
		Pimentel, D., et al.	1995	USA	160.74	160.74	160.74
					145.99	145.99	145.99
		Wilson, S. J.	2008	Ontario, Canada	2.90	2.90	2.90
					85.37	88.17	86.77
	Aesthetic Information	Bergstorm et al.	1985	South Carolina	42.04	107.15	74.60
	Nutrient Cycling	Wilson, S. J.	2008	Ontario, Canada	12.21	12.21	12.21
	Soil Formation	Pimentel, D.	1998	Maryland	8.60	8.60	8.60
		Sanshu, H.S., Wratten, S.D., Cullen, R., Case, B.	2008	Canterbury, New Zealand	-	54.24	27.12
					17.69	205.75	111.72
					15.32	250.56	132.94
					0.41	6.49	3.45
					1.18	5.31	3.25
		Wilson, S. J.	2008	Ontario, Canada	3.15	3.15	3.15
					6.62	76.30	41.46
	Biological Control	Cleveland, C.J., et al.	2006	South-central Texas	17.28	246.21	131.74
		Pimentel, D.	1998	Maryland	100.55	100.55	100.55
					69.22	69.22	69.22
		Pimentel, D., et al.	1995	USA	37.71	37.71	37.71
		Sanshu, H.S., Wratten, S.D., Cullen, R., Case, B.	2008	Canterbury, New Zealand	-	58.96	29.48
					44.95	102.53	73.74
	Energy and Raw Materials	Sanshu, H.S., Wratten, S.D., Cullen, R., Case, B.	2008	Canterbury, New Zealand	-	132.07	66.03
					-	175.69	87.85
					-	153.88	76.94
	Carbon Sequestration and Storage	Canadian Urban Institute.	2006	Ontario, Canada	122.77	122.77	122.77
		Sanshu, H.S., Wratten, S.D., Cullen, R., Case, B.	2008	Canterbury, New Zealand	-	123.81	61.90
					61.38	123.29	92.34
	Pollination	Costanza, R., et al.	1997	Global	3.39	17.07	10.23
		Pimentel, D.	1998	Maryland	125.77	125.77	125.77
		Ricketts, T.H., et al.	2004	Costa Rica	239.38	239.38	239.38
		Sanshu, H.S., Wratten, S.D., Cullen, R., Case, B.	2008	Canterbury, New Zealand	-	258.23	129.11
					-	268.25	134.13
		Winfree et al.	2011	New Jersey & Pennsylvania	57.51	2,386.69	1,222.10
					71.01	549.23	310.12

Appendix C: Compiled ecosystem service values (ESV) (including recreation values, low, high, and mean values)							
Land Cover	**Ecosystem Service**	**Author**	**Year of Study**	**Location**	**Low**	**High**	**Average**
Cultivated Total					634.78	5,461.91	3,048.34
Deciduous Forest	Recreation and Tourism	Prince, R. & Ahmed, E.	1989	Unknown	**52.09**	**66.16**	**59.13**
		Shafer, E. L., et al.	1993	Pennsylvania	**694.11**	**694.11**	**694.11**
		Willis, K G.	1991	Great Britain	**1.50**	**671.28**	**336.39**
		Briceno, Tania et al.	2023	Wyoming	**260.51**	**260.51**	**260.51**
		Bennett, R., et al.	1995	Windsor Forest, England	**237.60**	**237.60**	**237.60**
		Maxwell, S.	1994	Marston Vale Community Forest, Bedfordshire, England	**172.72**	**230.28**	**201.50**
					236.42	**359.99**	**298.20**
	Aesthetic Information	Standiford, R., Huntsinger, L.	2012	California Oak Woodlands	601.22	601.22	601.22
		Walsh, et al.	1990	Colorado	108.40	108.40	108.40
					354.81	354.81	354.81
	Biological Control	Krieger, D.J.	2001	US Forests	12.63	12.63	12.63
	Energy and Raw Materials	Pimentel, D.	1998	Ithaca, NY	5.31	5.31	5.31
					36.77	36.77	36.77
					21.04	21.04	21.04
	Carbon Sequestration and Storage	Mates. W., Reyes, J.	2004	New Jersey	74.94	330.91	202.93
		E. T. Campbell	2018	Maryland	60.69	60.69	60.69
					67.82	195.80	131.81
	Water Regulation	E. T. Campbell	2018	Maryland	1,164.50	1,164.50	1,164.50
	Water Quality	Zhongwei, L.	2006	Little Miami River watershed, Ohio	349.33	350.79	350.06
	Nutrient Cycling	E.T. Campbell	2018	Maryland	176.39	176.39	176.39
	Soil Erosion Control	E. T. Campbell	2018	Maryland	5.52	5.52	5.52
	Habitat & Nursery	E.T. Campbell	2018	Maryland	1,222.94	1,222.94	1,222.94
	Flood Risk Reduction	E. T. Campbell	2018	Maryland	147.05	147.05	147.05
Deciduous Forest Total					3,522.03	3,651.46	3,586.74
Deciduous Forest Total with Recreation					**3,758.45**	**4,011.45**	**3,884.95**
Desert							
	Carbon Sequestration & Storage	Delfino, K., et al.	2007	Mojave Desert	1.37	1.37	1.37
Desert Total					1.37	1.37	1.37
Emergent Herbaceous Wetland	Food	Allen, J et al.	1992	Oakland, California	432.97	432.97	432.97
	Water Regulation	Brander, L.M, et al.	2006	Global	3,211.98	3,211.98	3,211.98
					123.76	123.76	123.76
					1,442.28	1,442.28	1,442.28
					826.86	826.86	826.86
		E. T. Campbell	2018	Maryland	1,533.98	1,533.98	1,533.98
					1,427.77	1,427.77	1,427.77
	Habitat & Nursery	Everard, M.	2009	United Kingdom	16.62	16.62	16.62
		Gren, I.M. & Soderqvist, T.	1994	Sweeden	21.87	21.87	21.87
		Loomis, J	1991	San Joaquin Valley, California	7,254.77	7,254.77	7,254.77
		Pearce, D. & Moran, D.	1994	Global	5,254.02	5,254.02	5,254.02
					350.10	350.10	350.10
		Woodward, R., & Wui, Y.	2001	Global	206.67	2,134.11	1,170.39
		E. T. Campbell	2018	Maryland	1,222.94	1,222.94	1,222.94
					2,046.71	2,322.06	2,184.39

Appendix C: Compiled ecosystem service values (ESV) (including recreation values, low, high, and mean values)							
Land Cover	**Ecosystem Service**	**Author**	**Year of Study**	**Location**	**Low**	**High**	**Average**
	Recreation & Tourism	Brander, L.M., et al.	2006	Global	**34.89**	**1,046.72**	**540.81**
		Cooper J. & Loomis, J.	1991	San Joaquin Valley, California	**17.30**	**411.75**	**214.52**
		Farber & Costanza	1987	Louisiana	**151.24**	**316.75**	**234.00**
		Gren, I.M. & Soderqvist, T.	1994	USA, Europe, & Asia	**268.27**	**268.27**	**268.27**
					294.48	**294.48**	**294.48**
					3,832.29	**3,832.29**	**3,832.29**
		Kreutzwiser, R.	1981	Lake Erie	**257.36**	**257.36**	**257.36**
		Lant, C.L., & Roberts, R.S.	1990	Iowa & Illinois	**251.44**	**251.44**	**251.44**
		Stoll et al.	1989	Louisiana	**756.49**	**756.49**	**756.49**
		Whitehead	1990	Clear Creek, Kentucky	**1,186.06**	**7,685.22**	**4,435.64**
		Willis, K.G.	1991	United Kingdom	**43.66**	**48.03**	**45.85**
					148.46	**148.46**	**148.46**
		Wilson, S. J.	2008	Ontario, Canada	**157.21**	**157.21**	**157.21**
		Woodward, R., & Wui, Y.	2001	Global	**2.17**	**30.45**	**16.31**
					54.39	**428.56**	**241.47**
					1,148.63	**6,052.07**	**3,600.35**
					537.77	**1,374.10**	**955.93**
	Aesthetic Information	Mahan, B. L., et al.	2000	Portland, Oregon	48.81	48.81	48.81
	Water Quality	de Groot, D.,	1992	Unknown	19,106.94	19,106.94	19,106.94
		Gren, I.M. & Soderqvist, T.	1994	Sweeden	516.37	516.37	516.37
					327.83	327.83	327.83
		Grossman, M.	2012	Czechia, Germany	12.88	15.14	14.01
		Lant, C.L., & Roberts, R.S.	1990	Iowa & Illinois	251.44	251.44	251.44
		Meyerhoff, J., & Dehnhardt, A.	2007	Czechia, Germany	394.08	1,177.73	785.91
		Olewiler, N.	2004	Canada	395.84	1,112.20	754.02
		Wilson, S. J.	2008	Ontario, Canada	1,622.27	1,622.27	1,622.27
					254.86	254.86	254.86
		Woodward, R., & Wui, Y.	2001	Global	274.11	274.11	274.11
					449.96	616.88	533.42
	Flood Risk Reduction	Brander, L.M., et al.	2006	Global	19.54	19.54	19.54
		Costanza, R., et al.	1997	Global	2,594.24	2,594.95	2,594.60
		Gupta, T.R., & Foster, J.H.	1975	Massachusetts	67.99	543.92	305.96
		U.S. Army Corps of Engineers	1976	Massachusetts	561.40	561.40	561.40
		Woodward, R., & Wui, Y.	2001	Global	193.61	3,800.50	1,997.05
		E.T. Campbell	2018	Maryland	523.36	523.36	523.36
					660.03	1,340.61	1,000.32
	Nutrient Cycling	E.T. Campbell	2018	Maryland	1,305.64	1,305.64	1,305.64
	Soil Erosion Control	E.T. Campbell	2018	Maryland	18.50	18.50	18.50
	Carbon Sequestration & Storage	E.T. Campbell	2018	Maryland	101.16	101.16	101.16
Emergent Herbaceous Wetland Total					6,491.55	7,614.41	7,052.98
Emergent Herbaceous Wetland Total with Recreation					**7,029.33**	**8,988.50**	**8,008.92**

Appendix C: Compiled ecosystem service values (ESV) (including recreation values, low, high, and mean values)							
Land Cover	**Ecosystem Service**	**Author**	**Year of Study**	**Location**	**Low**	**High**	**Average**
Evergreen Forest	Food	Lampietti, J.A., & Dixon, J.A.	1995	Global	38.71	38.71	38.71
	Water Regulation	Adger, W.N., et al.	1995	Mexico	0.10	0.10	0.10
	Habitat & Nursery	Costanza, R., et al.	1997	Global	1.59	817.95	409.77
		Haener, M. K. & Adamowicz, W. L.	1998	Alberta, Canada	1.18	8.08	4.63
					1.38	413.01	207.20
	Recreation & Tourism	Barrick, K., et al.	1990	Wyoming	**7,864.10**	**7,864.10**	**7,864.10**
		Boxall, P. C., et al.	1996	Alberta, Canada	**0.27**	**0.27**	**0.27**
		Costanza, R., et al.	1997	Global	**0.54**	**3,248.21**	**1,624.38**
		Haener, M. K. & Adamowicz, W. L.	1998	Alberta, Canada	**0.01**	**0.07**	**0.04**
		Hanley N.D.	1989	UK	**145.58**	**145.58**	**145.58**
		Walsh et al.	1978	South Platte River Basin, Colorado	**51.00**	**51.00**	**51.00**
		Wilson, S. J.	2008	Ontario, Canada	**157.08**	**157.08**	**157.08**
					1,174.08	**1,638.04**	**1,406.06**
	Soil Erosion Control	Moore, W.B.	1987	Willamette Valley, Oregon	1.00	1.00	1.00
	Water Quality	Olewiler, N.	2004	Canada	41.08	41.08	41.08
		Wilson, S. J.	2008	Ontario, Canada	254.86	254.86	254.86
					98.98	98.98	98.98
	Biological Control	Wilson, S. J.	2008	Ontario, Canada	13.97	13.97	13.97
	Energy & Raw Materials	Haener, M. K. & Adamowicz, W. L.	1998	Alberta, Canada	4.75	4.75	4.75
	Flood Risk Reduction	Wilson, S. J.	2008	Ontario, Canada	830.82	830.82	**830.82**
	Carbon Sequestration & Storage	Wilson, S. J.	2008	Ontario, Canada	202.50	202.50	**202.50**
	Pollination	Costanza, R., et al.	1997	Global	88.80	398.88	243.84
		Wilson, S. J.	2008	Ontario, Canada	520.34	520.34	520.34
					288.75	288.75	288.75
					299.30	402.66	350.98
Evergreen Forest Total					1,490.50	2,005.49	1,747.99
Evergreen Forest Total with Recreation					**2,664.58**	**3,643.53**	**3,154.06**
Mixed Forests	Aesthetic Information	Briceno, T., et al.	2023	Wyoming	222.24	222.24	222.24
	Carbon Sequestration & Storage	Briceno, T., et al.	2023	Wyoming	0.06	82.99	41.53
		Briceno, T., et al.	2023	Wyoming	1,303.20	1,303.20	1,303.20
					651.63	693.09	672.36
	Biological Control	Briceno, T., et al.	2023	Wyoming	11.51	11.51	11.51
	Energy & Raw Materials	Briceno, T., et al.	2023	Wyoming	18.26	45.54	31.90
	Flood Risk Reduction	Briceno, T., et al.	2023	Wyoming	385.44	385.44	385.44
	Food	Briceno, T., et al.	2023	Wyoming	0.74	1.42	1.08
	Recreation & Tourism	Briceno, T., et al.	2023	Wyoming	**196.84**	**196.84**	**196.84**
	Soil Erosion Control	Briceno, T., et al.	2023	Wyoming	6.57	6.57	6.57
	Habitat & Nursery	Briceno, T., et al.	2023	Wyoming	1.17	30.54	15.85
	Nutrient Cycling	Briceno, T., et al.	2023	Wyoming	13.56	55.02	34.29
Mixed Forests Total					1,311.11	1,451.37	1,381.24
Mixed Forests Total with Recreation					**1,507.95**	**1,648.21**	**1,578.08**

Appendix C: Compiled ecosystem service values (ESV) (including recreation values, low, high, and mean values)							
Land Cover	**Ecosystem Service**	**Author**	**Year of Study**	**Location**	**Low**	**High**	**Average**
Grasslands	Food	US Dept of Comm	1995	USA	44.25	44.25	44.25
	Water Regulation	Jones, O.R., et al.	1985	Southern High Plains, USA	1.98	1.98	1.98
	Recreation & Tourism	Butler, L.D., & Workman, J.P.	1993	Texas	**5.64**	**5.64**	**5.64**
	Pollination	Wilson, S. J.	2008	Ontario, Canada	520.34	520.34	520.34
	Habitat & Nursery	Gascoigne, W.R., et al.	2011	North & South Dakota	43.05	43.05	43.05
	Soil Erosion Control	Gascoigne, W.R., et al.	2011	North & South Dakota	8.87	8.87	8.87
	Aesthetic Information	Ready, R.C., et al.	1997	Kentucky	0.01	0.01	0.01
		Qiu, Z., et al.	1998	Goodwater creek watershed, Missouri	311.26	1,524.70	917.98
					155.64	762.35	458.99
	Carbon Sequestration & Storage	Gopalakrishnan, Varsha, et al.	2018	Colorado	0.05	0.05	0.05
Grasslands Total					774.17	1,380.89	1,077.53
Grasslands Total with Recreation					**779.81**	**1,386.53**	**1,083.17**
Shrub	Habitat & Nursery	Costanza, R., et al.	1997	Global	0.79	433.37	217.08
	Recreation & Tourism	Bennett, R., et al.	1995	Windsor Forest, England	**237.60**	**237.60**	**237.60**
		Costanza, R., et al.	1997	Global	**19.68**	**1,643.50**	**831.59**
					128.64	**940.55**	**534.59**
	Carbon Sequestration & Storage	Gopalakrishnan, Varsha, et al.	2018	Colorado	0.05	0.05	0.05
	Pollination	Costanza, R., et al.	1997	Global	1.70	8.54	5.12
Shrub Total					2.53	441.95	222.24
Shrub Total with Recreation					**131.17**	**1,382.50**	**756.84**
Woody Wetlands	Water Regulation	Brander, L.M., et al.	2006	Global	417.31	417.31	417.31
					1,305.77	1,305.77	1,305.77
					861.54	861.54	861.54
	Habitat & Nursery	Brander, L.M., et al.	2006	Global	47.45	1,325.85	686.65
		van Kooten, G. C. & Schmitz, A.	1992	Canada	3.09	21.18	12.13
					48.84	48.84	48.84
		Loomis, J. & Ekstrand, E.	1998	Four Corners, USA	0.68	2.72	1.70
		Wilson, S. J.	2008	Ontario, Canada	3,135.31	3,135.31	3,135.31
					647.07	906.78	776.93
	Recreation & Tourism	Gupta, T.R., & Foster, J.H.	1975	Massachusetts	**237.97**	**475.93**	**356.95**
		van Vuuren, W. & Roy, P.	1993	Lake St. Clair, Ontario, Canada	**1,758.00**	**1,758.00**	**1,758.00**
		Kozak J., et al.	2011	Illinois	**663.22**	**663.22**	**663.22**
					886.40	**965.72**	**926.06**
	Aesthetic Information	van Vuuren, W. & Roy, P.	1993	Lake St. Clair, Ontario, Canada	1,758.00	1,758.00	1,758.00
		Daniel A. Revollo-Fernández	2015	Xochimilco, UNESCO World Heritage Site, Mexico	1,456.87	1,796.81	1,626.84
					1,607.43	1,777.40	1,692.42
	Water Quality	Grossman, M.	2012	Czechia, Germany	10.02	11.77	10.89
		Jenkins, WA., et al.	2010	Mississippi Alluvial Valley	666.69	710.99	688.84
					338.35	361.38	349.87
	Flood Risk Reduction	Brander, L.M., et al.	2007	Global	3,841.84	3,841.84	3,841.84
		Leschine, T.M., et al.	1997	Washington, USA	2,440.95	7,765.69	5,103.32
		Streiner, C., Loomis,J.	1995	Contra Costa, Santa Cruz, & Solano, California	638.35	638.35	638.35
		Wilson, S. J.	2008	Ontario, Canada	2,171.43	2,171.43	2,171.43
					2,273.14	3,604.33	2,938.74
Woody Wetlands Total					5,727.54	7,511.43	6,619.49

Appendix C: Compiled ecosystem service values (ESV) (including recreation values, low, high, and mean values)							
Land Cover	**Ecosystem Service**	**Author**	**Year of Study**	**Location**	**Low**	**High**	**Average**
Pasture/Hay	Habitat & Nursery	Bastian, C.T., et al.	2001	Wyoming	2.37	5.88	4.39
	Recreation & Tourism	Boxall, P. C.	1995	Alberta, Canada	**0.04**	**0.04**	**0.04**
	Soil Erosion Control	Canadian Urban Institute	2006	Ontario Canada	7.59	7.59	7.59
		Wilson, S. J.	2008	Ontario, Canada	2.90	2.90	2.90
					5.25	5.25	5.25
	Aesthetic Information	Bastian, C.T., et al.	2001	Wyoming	6.34	6.34	6.34
	Nutrient Cycling	Canadian Urban Institute	2006	Ontario Canada	29.11	29.11	29.11
		Wilson, S. J.	2008	Ontario, Canada	12.21	12.21	12.21
					15.89	15.89	15.89
	Soil Formation	Canadian Urban Institute	2006	Southern Ontario Canada	7.59	7.59	7.59
		Pimentel, D., et al.	1995	USA & Global	9.43	9.43	9.43
		Wilson, S. J.	2008	Ontario, Canada	3.15	3.15	3.15
					6.72	6.72	6.72
	Biological Control	Pimentel, D., et al.	1997	USA & Global	22.63	22.63	22.63
		Wilson, S. J.	2008	Ontario, Canada	21.37	21.37	21.37
					22.00	22.00	22.00
	Pollination	Wilson, S. J.	2008	Ontario, Canada	520.34	520.34	520.34
Pasture/Hay Total					572.57	576.08	574.60
Pasture/Hay Total with Recreation					**572.60**	**576.12**	**574.63**
Urban Green Space (Low & High Intensity)	Aesthetic Information	Bolitzer & Netusil	2000	Portland, Oregon	48.44	48.44	48.44
		McPherson, G. & Simpson	2002	Modesto & Santa Monica California	430.97	2,694.80	1,562.88
		Nowak, D.J., et al. USFS	2002	New York, Atlanta, Baltimore, Philadelphia, Boston, Oakland, Syracuse, Jersey City	5,255.41	7,858.07	6,556.74
					6,318.44	8,981.96	7,650.20
					7,193.21	10,600.52	8,896.86
					-	11,328.90	5,664.45
					7,578.40	11,168.17	9,373.28
					9,116.82	13,435.32	11,276.07
					14,785.53	21,789.22	18,287.38
		Qiu, Z., et al.	2006	Missouri	1,249.01	1,641.64	1,445.33
		Breffle, William S., et al.	1998	Boulder, Colorado	-	365.26	182.63
					2.25	372.34	187.30
					44.41	414.18	229.30
		Thompson, R., et al.	1999	Lake Tahoe, California	164.88	13,895.89	7,030.38
					3,727.70	7,471.05	5,599.37
	Carbon Sequestration and Storage	McPherson, E.G., et al.	1998	Sacramento, California	38.98	38.98	38.98
					255.99	255.99	255.99
					256.15	256.15	256.15
		Gopalakrishnan, Varsha, et al.	2018	Colorado	2.72	2.72	2.72
		McPherson, G. & Simpson	2002	Modesto & Santa Monica, California	97.39	209.97	153.68
					130.25	152.76	141.50
	Water Regulation	Chen, S., et al.	2020	Guangzhou, China	27.69	32.31	30.00
	Flood Risk Reduction	McPherson, G. & Simpson	2002	Modesto & Santa Monica, California	111.52	157.51	134.52
Urban Green Space Total					3,997.15	7,813.64	5,905.39

Appendix C: Compiled ecosystem service values (ESV) (including recreation values, low, high, and mean values)							
Land Cover	**Ecosystem Service**	**Author**	**Year of Study**	**Location**	**Low**	**High**	**Average**
Lake & Riparian (Open Water)	Aesthetic Information	Berman, M.A., et al.	2013	Matanuska-Susitna, Alaska	302.08	302.08	302.08
		Corrigan, J. R., et al.	2009	Clear Lake, Iowa	491.42	583.03	537.22
					526.78	1,226.79	876.78
					440.09	703.97	572.03
	Water Quality	Bouwes, N. W. & Scheider, R.	1979	Pike Lake, Wisconsin	1,865.58	1,865.58	1,865.58
		Hampson, D. I., et al.	2017	River Yare, Norwich, England	0.00	0.17	0.08
					0.01	0.42	0.21
					621.86	622.05	621.96
	Habitat & Nursery	Amigues, J. P., et al.	2002	Garonne River, Toulouse, France	216.54	216.54	216.54
					329.23	329.23	329.23
		Berrens, R. P., et al.	1996	Rio Grande, New Mexico	2.70	8.39	5.55
		Haener, M. K. & Adamowicz, W. L.	1998	Alberta, Canada	2.76	18.89	10.82
		Wu, J. & Skelton-Groth, K.	2002	Pacific Northwest Camp Creek	-	2.58	1.29
				Deardorff Creek	-	11.75	5.88
				Fields Creek	6.07	12.59	9.33
				Granite Creek	42.62	92.80	67.71
				Mountain Creek	-	4.30	2.15
				Murderers Creek	8.23	25.33	16.78
				Reynolds Creek	-	3.53	1.76
				Rock Creek	1.74	18.98	10.36
				Service Creek	5.28	11.14	8.21
				South Fork John Day River	-	3.25	1.63
					43.94	54.23	49.09
	Recreation & Tourism	Cordell, H. K. & Bergstrom, J.C.	1993	North Carolina	**1,232.11**	**2,425.29**	**1,828.70**
		Costanza, R., et al.	1997	Global	**2.17**	**2,460.48**	**1,231.33**
		Ward, F. A., et al.	1996	Sacramento, California	**5,800.25**	**5,800.25**	**5,800.25**
		Everard, M.	2009		**19.14**	**19.14**	**19.14**
					1,763.42	**2,676.29**	**2,219.85**
Lake & Riparian Total					1,105.90	1,380.25	1,243.08
Lake & Riparian Total with Recreation					**2,869.31**	**4,056.54**	**3,462.93**

Appendix C: Compiled ecosystem service values (ESV) (including recreation values, low, high, and mean values)							
Land Cover	**Ecosystem Service**	**Author**	**Year of Study**	**Location**	**Low**	**High**	**Average**
River (Open Water)	Water Regulation	Gibbons, D. C.	1986	USA	3,475.74	3,475.74	3,475.74
					1,481.85	1,481.85	1,481.85
					899.97	899.97	899.97
					2,831.79	2,831.79	2,831.79
					2,172.34	2,172.34	2,172.34
	Aesthetic Information	Berman et al.	2013	Matanuska-Susitna, Alaska	618.88	618.88	618.88
		Kulshreshtha, S. N. & Gillies, J. A.	1993	Saskatchewan, Canada	38.09	1,051.82	544.96
		Rich, P. R. & Moffitt, L. J.	1982	Housatonic River, Massachusetts	9.91	9.91	9.91
		Sanders, L. D., et al.	1990	Rocky Mountains, Colorado	0.69	1.04	0.86
					166.89	420.41	293.65
	Recreation & Tourism	Loomis, John B., et al.	1991	San Joaquin Valley, California	**22.59**	**28.06**	**25.33**
					94.34	**242.90**	**168.62**
		Shafer, E. L., et al.	1993	Pennsylvania	**5,720.65**	**5,720.65**	**5,720.65**
					21,849.66	**21,849.66**	**21,849.66**
					6,921.81	**6,960.32**	**6,941.07**
	Habitat & Nursery	Weber & Stewart	2009	Middle Rio Grande, N. Mexico	155.20	247.87	201.53
					205.52	482.12	343.82
River Total					2,377.86	2,654.46	2,516.16
River Total with Recreation					**9,299.67**	**9,614.78**	**9,457.22**
	Aesthetic Information				283.98	541.94	412.96
	Habitat & Nursery				51.36	67.14	59.25
	Water Quality				621.86	622.05	621.96
	Water Regulation				2,172.34	2,172.34	2,172.34
	Recreation & Tourism				**2,895.08**	**3,212.20**	**3,053.64**
Open Water Total					3,129.54	3,403.47	3,266.50
Open Water Total with Recreation					**6,024.61**	**6,615.67**	**6,320.14**
*Many of these sources come from an Earth Economics database referenced by Earth Economics Colorado River Basin ESV and updated to USD Jan 2022. Some sources are from the ESVD and other literature-searching methods.							

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