Hammerschlag LLC

Study Report:

Methow Valley Greenhouse Gas Inventory
Data Period January 1, 2019 – December 31, 2019

Prepared for: Methow Valley Citizens Council

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Inventory Definition and Overview

Inventory Boundary

The Methow Valley greenhouse gas (GHG) inventory is an inventory of GHG sources and sinks within Water Resources Inventory Area 48 (WRIA 48) as defined by the Washington State Department of Ecology under Washington Administrative Code 173-500-040. WRIA 48 consists of the watershed of the Methow River, and minor extensions northward to the Canadian border.

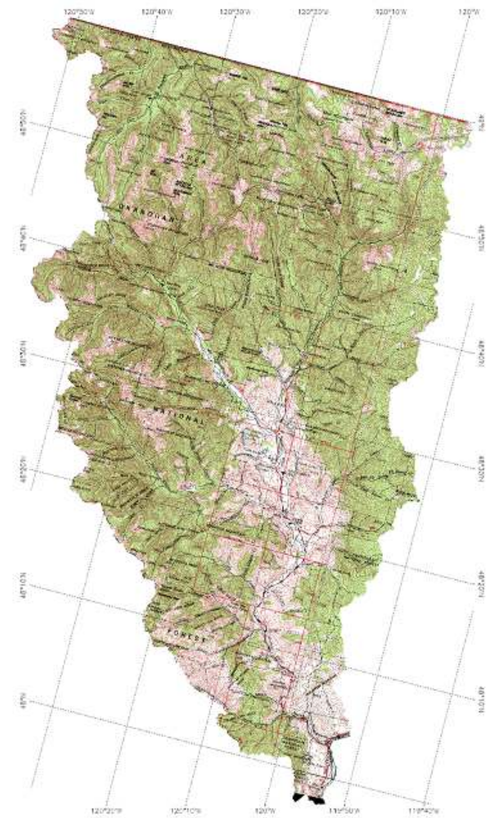

Figure 1 – Water Resources Inventory Area 48

Where data needs to be defined by federally-recognized boundaries, we used the following set of zip codes: 98814, 98833, 98834, 98846, 98856, and 98862.

The GHG inventory is disaggregated into three **Scopes**. Each Scope describes a different type of emissions source, as follows:

- **Scope 1** emission sources and sinks lie within the geographic boundary defined by WRIA 48.
- **Scope 2** emissions may occur anywhere, and are due to generation of electricity consumed inside WRIA 48.
- **Scope 3** emissions are from sources meeting neither the Scope 1 nor Scope 2 definition. Every entity that inventories its GHG emissions is free to include Scope 3 sources relating to activities that they may be able to influence, even though they are not producing emissions inside the geographic boundary. MVCC has chosen to include the following Scope 3 sources in its inventory: solid waste disposal; induced tourist travel; and seasonal residents' commute travel.

Inventoried Gases

The dominant GHG due to human activity is carbon dioxide. When biomass or fossil fuels are combusted, carbon dioxide is one of two primary combustion products (the other is water). This inventory does not include carbon dioxide from controlled combustion of biomass, under the assumption that firewood or other fuel biomass is sustainably harvested such that at any given moment emissions from combustion and sequestration from new growth are equal.[1]

This GHG inventory also includes methane associated with wastewater and solid waste. Methane has 28 times the global warming potential of carbon dioxide on a pound-for-pound basis, and hence is important to track in the anaerobic environments that create it. Combustion also produces very small quantities of methane, but even when weighted by its global warming potential methane constitutes perhaps one-tenth of one percent of total combustion-related GHGs. The inventory does not account emissions of nitrous oxides or fluorinated gases.

Inventory Overview

The Methow Valley GHG inventory can be organized in the framework of the three scopes defined above, or in the framework of primary economic sectors. Though the scopes framework is required for conformance with some GHG accounting standards like the Global Protocol for Communities,[2] the framework of primary economic sectors is more intuitive and can be more helpful toward identifying opportunities for GHG reduction.

The Methow Valley GHG inventory appears in the scopes framework in Table 1a. More than half of the 80,731 tCO_2e (metric tons of carbon dioxide-equivalent) emitted in 2019 are Scope 1 emissions, at 55,492 tCO_2e; with Scope 2 contributing 1,714 tCO_2e and Scope 3 23,525 tCO_2e. (Table 1a)

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[1] This assumption is coded into Washington State law (RCW 70A.45.020(3)) and many other jurisdictions' policies, but is not universally accepted. However, there is no universally accepted alternative, either.

[2] Wee Kean Fong et al., "Global Protocol for Community-Scale Greenhouse Gas Emission Inventories" (World Resources Institute, 2014).

	emissions tCO_2e
Scope 1	
buildings	1,567
transportation	52,576
waste & wastewater	1,350
SUBTOTAL	55,492
Scope 2	
buildings	1,409
irrigation	305
SUBTOTAL	1,714
Scope 3	
transportation	22,596
waste & wastewater	929
SUBTOTAL	23,525
TOTAL, all scopes	80,731

Table 1a – Methow Valley GHG emissions in 2019, by Scope. The economic sector *Waste & Wastewater* appears twice: Septic tanks and wastewater treatment plants emit GHGs in the Methow Valley under Scope 1, while solid waste shipped outside the Methow Valley decays to produce Scope 3 emissions.

	emissions tCO_2e
Buildings	
residential	1,581
commercial	1,395
SUBTOTAL	2,975
Transportation	
light vehicles	50,383
heavy trucks	1,473
seasonal residents	2,649
tourist vehicles	20,502
aviation	166
SUBTOTAL	75,172
Waste & Wastewater	
wastewater treatment plar	64
septic tanks	1,286
landfilled solid waste	929
SUBTOTAL	2,278
Irrigation	305
TOTAL, all sectors	80,731

Table 1b – Methow Valley GHG emissions in 2019, by economic sector.

The relatively large contribution from Scope 3 demonstrates a strong willingness from community members to take responsibility for a broad range of emissions, including those outside the more conventional GHG inventory boundary limited to Scope 1 and Scope 2. Of the 23,525 tCO_2e in Scope 3 the vast majority, 20,502 tCO_2e, are ascribable to the round-trip emissions of vehicles driven by tourists.

The Methow Valley GHG inventory viewed through the economic sectors framework appears in Table 1b. The four primary economic sectors chosen are: Buildings, Transportation, Waste & Wastewater, and Irrigation. Viewed through this framework, the lion's share of the inventory falls in the Transportation sector, responsible for 75,172 tCO_2e of the 80,731 tCO_2e grand total. This outcome is driven in part by the very low GHG intensity of electricity in the Methow Valley, which causes the Buildings and Irrigation sectors to have much lower emissions.

The sectors-based Methow Valley GHG inventory is rendered visually in Figure 2.

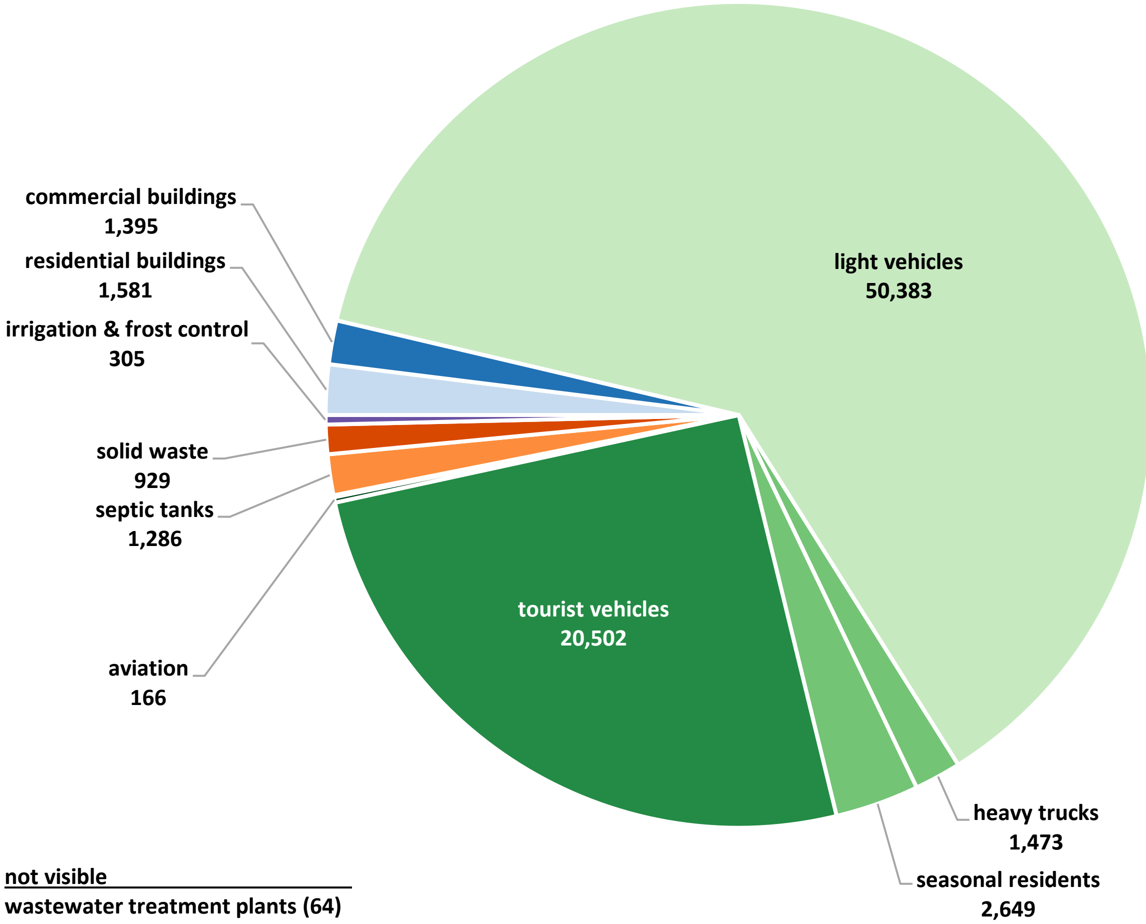

Figure 2 – Sectoral view of the Methow Valley GHG inventory. Units are tCO_2e. Buildings sector sources are blue; Transportation sector sources green; Waste & Wastewater red-brown; and Irrigation & Frost Control purple.

Documentation

All computations leading to tables and figures contained in this document are contained in supporting spreadsheet *MV-004e Methow Valley GHG inventory 2019.xlsb*. The supporting spreadsheet also contains all citations to quantitative sources.

Buildings

Activity and Emissions

Buildings are responsible for Scope 1 emissions when they combust propane or fuel oil on-site for space conditioning, domestic water heating, cooking or industrial processes. Buildings induce Scope 2 emissions when they consume electricity. All emissions ascribable to residential and commercial buildings are summarized in Table 2.

	activity		emissions	counts
	qty	*units*	*tCO_2e*	toward
residential buildings				
propane	120,822	gal	686	Scope 1
fuel oil	1,917	gal	20	Scope 1
electricity	52,093	MWh	875	Scope 2
SUBTOTAL			1,581	
commercial buildings				
propane	**	gal	842	Scope 1
fuel oil	1,917	gal	20	Scope 1
electricity	31,755	MWh	533	Scope 2
SUBTOTAL			1,395	
TOTAL, all buildings			2,975	

** Commercial propane consumption could not be computed from available data sources.

Table 2 – Activity levels and GHG emissions in the Buildings sector. See text for discussion of imputed propane emissions from commercial buildings.

Emissions from wood combusted for home heating are excluded from the inventory because they are biogenic: there is new, future firewood growing and sequestering carbon at presumably the same rate users of firewood are emitting carbon.[3] The quantity of biogenic emissions from wood combustion are reported in Optional Information below, for reference.

We were unable to assess the quantity of propane consumed in the commercial sector, but could impute the GHG emissions associated with its use, 842 tCO_2e, according to the methodology described below.

Methodologies

The quantity of residential households is from the American Community Survey (ACS), 2018 5-year values. The ACS disaggregates several of its datasets down to census county divisions (CCDs) that include two covering most of WRIA 48: Methow Valley CCD and Early Winters CCD.

[3] This practice complies with published community greenhouse gas inventory protocols, *e.g.* Fong et al., 39.

Estimated numbers of households utilizing each fuel were simply sums of the two values reported for the two CCDs.

Liquid petroleum gas (LPG) is a common heating fuel in the Methow Valley. Most LPG users know it by the name "propane" but the ACS survey form does not utilize this term, likely causing confusion for survey respondents and ambiguity in the meaning of ACS reports. In the Methow Valley CCD an estimated 55 households were reported as using "utility gas" even though there is no utility gas service in the Methow Valley; these "utility gas" households were also included in the LPG totals. See Appendix A for additional discussion.

The use rate of LPG per household was drawn from the U.S. Energy Information Administration's 2015 Residential Energy Consumption Survey (RECS), as assigned to the RECS climate region "Cold" that includes the Methow Valley.

There is no federal tally of commercial floorspace sufficiently disaggregated to identify a total for the Methow Valley. So we estimated this by retrieving the employed population from the American Community Survey, multiplying this by 40% to represent our estimate of the fraction occupying a commercial building during their work hours, and multiplying this by the mean floorspace per worker reported in the U.S. Energy Information Administration's 2012 Commercial Buildings Energy Consumption Survey (CBECS). The result was 0.54 million square feet of commercial floorspace in the Methow Valley.

LPG usage intensity is not reported in CBECS so we worked with the assumption that, since natural gas is not available in the Methow Valley, any business that would otherwise be connected to utility gas is instead consuming LPG. CBECS reports that in the Pacific census division, 54% of commercial buildings utilize natural gas as their primary space heating fuel. Those buildings consume natural gas at the rate of about 47,000 Btu/GSF (British thermal units per gross square foot), so we assumed the same rate of consumption for LPG.

Fuel oil consumption was reported directly by the primary provider, Cascade King's. Cascade King's does not separately track residential and commercial deliveries, but staff estimated that the two are approximately equal. There may be one or more additional suppliers of fuel oil to the Methow Valley, but these were agreed to be *de minimis* by project advisors.

Electricity consumption was reported directly for each subsector (residential and commercial) by each of the two utilities in the region, Okanogan County PUD and Okanogan County Electric Co-op. Washington State law requires utilities to report their generating fuel mixes; neither utility owns or has power purchase agreements with fossil fuel resources, but both utilities do receive a small quantity of unspecified mix from the grid, which causes each utility to have an emission factor of .017 tCO_2e/MWh. This is still extremely low – for example a relatively clean, natural gas-fired generator will emit approximately 0.4 tCO_2e/MWh.

Transportation

Activity and Emissions

Transportation emissions occur largely in Scope 1, from the tailpipes of vehicles registered in, and driven in, the Methow Valley. These Scope 1 emissions are detailed in Table 3.

	activity		emissions	counts
	qty	*units*	*tCO_2e*	toward
locally-registered light vehicles				
cars	3,358,251	gal	29,485	Scope 1
light trucks	2,266,813	gal	19,903	Scope 1
motorcycles	113,305	gal	995	Scope 1
SUBTOTAL			50,383	
locally-registered heavy trucks	144,294	gal	1,473	Scope 1
seasonal residents				
commute travel	15,608	visits	2,094	Scope 3
local travel	1,560,800	mi	554	Scope 1
SUBTOTAL			2,649	
tourist vehicles	152,781	visits	20,502	Scope 3
aviation	19,954	gal	166	Scope 1
TOTAL, all transportation			75,172	

Table 3 – Activity levels and GHG emissions in the Transportation sector.

The aviation emissions shown in Table 3 are associated with fuel consumption at Methow Valley State Airport only; fuel consumption data at Twisp Municipal Airport and Lost River Resort was unavailable. The correlation between fuel delivered at an airport and combustion emissions in the surrounding region is approximate, but representative. A disproportionate quantity of fuel combustion occurs during landing and takeoff; and the combustion of fuel loaded at Methow Valley State Airport after leaving Methow Valley airspace, is balanced by combustion of fuel loaded elsewhere, in arriving aircraft.

The Methow Valley GHG inventory takes responsibility for emissions associated with tourism, the bulk of which are due to tourists' use of road vehicles to travel to and from the Methow Valley. Most tourists to the region are assumed to originate from the greater Seattle area, so a large fraction of these emissions occur outside the geographic boundary and are therefore tabulated under Scope 3.[4] Seasonal residents also contribute Scope 3 emissions in a similar fashion, though their relative contribution is far smaller than nonresident tourists.

[4] To achieve perfect compliance with some GHG inventory protocols, the tourist travel emissions would need to be split into two portions: that occurring within the WRIA 48 geographic boundary (Scope 1), and that occurring outside it (Scope 3). To simplify accounting in this inventory, all tourist travel emissions are reported in Scope 3.

Methodologies

Local vehicle registrations were acquired from the Washington State Department of Licensing (DOL). The DOL assigns one of 27 available vehicle use classes to each registered vehicle, and we grouped these into four vehicle analysis groups to simplify both analysis and interpretation. Our assignment of vehicle use classes to vehicle analysis groups was as shown in Table 3a.

vehicle analysis group			
car	**light truck**	**motorcycle**	**heavy truck**
Passenger	Truck	Motorcycle	Combination (Non-Farm Use
Antique Vehicle	Commercial		Combination (Farm Use)
For Hire	Farm Use		Logging
			Fixed Load Vehicle
			Tow Truck

Table 3a – Assignment of state vehicle use classes to the four vehicle analysis groups *car*, *light truck*, *motorcycle* and *heavy truck*. Fifteen additional, less-relevant, state vehicle use classes were unused in the data analysis.

Table 3a includes only twelve of the vehicle use classes; the remaining 15 are either irrelevant or cause *de minimis* emissions.[5] DOL also collects model year for each registration, which allowed us to create a matrix of vehicle analysis group × model year values for fuel economy, using fuel-economy-by-model-year arrays published in the Oak Ridge National Laboratory *Transportation Energy Data Book*. From here we could compute the fuel consumption for each model year in each analysis group, by counting the number of vehicles registered in that matrix cell, dividing by fuel economy, and multiplying by the national average use (13,476 vehicle miles) for each vehicle analysis group.[6]

We assumed all fuel combusted by cars, light trucks and motorcycles is gasoline;[7] and assumed all fuel combusted by heavy trucks is diesel. The two fuels have slightly different GHG emission factors (8.8 $kgCO_2$/gal for gasoline and 10.2 $kgCO_2$/gal for diesel), and using these assumptions we computed the emissions shown in Table 3.

Aviation emissions are computed directly from the quantity of aviation fuel sold at the airport.

Tourist vehicle emissions are computed from tourist counts prepared for an independent study expected to be published in the near future. The study estimates 458,342 overnight guests per year. At the recommendation of inventory advisors we assumed an average of three guests per

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[5] *Snowmobile, Farm Exempt, Camper, All Terrain Vehicle (WATV), Moped, Intermittent Use Trailer, Exempt (State/County/Local/Tribal), Snowmobile (Vintage), Mobile Home, Motorhome, Antique Travel Trailer, Neighborhood Electric Vehicle, Off Road Vehicle, Travel Trailer*, and *Private Use Trailer*.

[6] Except *Antique Vehicles*, each of which contributed 5,000 miles to the *car* analysis group.

[7] The fleet does include some diesel-fueled cars and light trucks, but this will have a negligible impact relative to the assumption because equivalent diesel and gasoline vehicles emit approximately the same quantity of greenhouse gases per mile traveled. *See* International Council on Clean Transportation, "Gasoline vs. Diesel: Comparing CO2 Emission Levels of a Modern Medium Size Car Model under Laboratory and On-Road Testing Conditions" (ICCT, May 2019).

vehicle, and assigned each vehicle a round-trip distance equal to the centroid distance between Seattle and Winthrop (378 miles, or 189 miles each way). Using a U.S. fleet-average vehicle emissions factor of 0.355 kgCO_2e/mi, we computed a total of 20,502 tCO_2e emissions ascribable to tourist travel.

The same study estimates 1,951 part-time residential homes in the region. We assumed eight vehicle round trips per year per home, and assigned each trip the same round-trip distance and vehicle emission factor as used for tourist vehicles, yielding the result 2,094 tCO_2e.

Waste and Wastewater

Activity and Emissions

In anaerobic environments, such as under water or inside a landfill, the bacteria that consume biomass produce methane as a byproduct. Methane is a powerful greenhouse gas, causing about 28 times as much global warming as an equal mass of carbon dioxide. In the open air, different species of bacteria cause the decomposition, and produce carbon dioxide as the primary waste product.

A primary focus of wastewater treatment is keeping the decay process aerobic, therefore limiting GHGs to the less potent carbon dioxide. Twisp and Winthrop both operate centralized wastewater treatment plants. In Twisp wastewater is mechanically aerated, while Winthrop utilizes facultative lagoons. The two plants together serve about 1,460 of the Methow Valley's year-round residents, and the remainder rely on household-scale methods for wastewater management. For the purpose of the GHG inventory, we assume that all household methods emit methane at the same rate as a septic system. Since the majority of the population relies on household-scale treatment, and the wastewater treatment plants are effective at inducing decay to carbon dioxide, the vast majority of wastewater emissions, 1,286 tCO_2e, are associated with the distributed households versus only 64 tCO_2e associated with the treatment plants. (Table 4)

	activity		emissions	counts
	qty	*units*	*tCO_2e*	toward
wastewater treatment plans				
Winthrop	460	capita	48	Scope 1
Twisp	1,000	capita	16	Scope 1
SUBTOTAL			64	
septic tanks	4,931	capita	1,286	Scope 1
landfilled solid waste	2,600	ton	929	Scope 3
TOTAL, waste and wastewater			2,278	

Table 4 – Activity levels and GHG emissions in the Waste & Wastewater sector.

A large fraction of a typical community's solid waste stream consists of organic materials. This organic material, too, will decay to methane in an anaerobic environment. Solid waste from the Methow Valley is sent to the Central Landfill near the city of Okanogan, where it will decay primarily to methane. The portion of methane escaping the landfill's methane collection system contributes 929 tCO_2e to the Scope 3 GHG inventory.

Landfill decay of a given article of waste can take many years to complete. Landfill gas emissions are unique among community GHG inventory sources, insofar that they occur throughout a long period that extends many years beyond the time period covered by the inventory. Landfill emissions are computed as the emissions *commitment* associated with garbage disposed of during the inventory year, rather than as actual emissions during the inventory year.

Methodologies

Biological oxygen demand (BOD) entering each of the two wastewater treatment plants was estimated from the U.S. average per-capita production of 85 g/person-day reported by the Intergovernmental Panel on Climate Change Emissions (IPCC).[8] Annual BOD load was computed for Winthrop as 14,281 kg based on a population of 460 served; and for Twisp as 31,045 kg based on a population of 1,000 served.

Finally, each of the two plants was assigned an IPCC emission factor consistent with its technology; 0.12 $kgCH_4/kgBOD$ for Winthrop, and 0.018 $kgCH_4/kgBOD$ for Twisp.

We assumed that the balance of the Methow Valley population, 4,931 persons, utilized septic systems which were assigned IPCC emission factor 0.3 $kgCH_4/kgBOD$.

We computed the emissions commitment of solid waste utilizing the U.S. EPA's Waste Reduction Model ("WARM"), version 15. The model was set to use national-average assumptions for methane generation and landfill gas capture rates.

[8] Intergovernmental Panel on Climate Change, "2019 Refinement to the 2006 IPCC Guidelnes for National Greenhouse Gas Inventories, Volume 5: Waste" (IPCC, 2019).

Irrigation

Activity and Emissions

Pumps and associated equipment for irrigation and frost protection induce substantive electric loads that are metered separately by the electric utilities. The quantities of electricity and emissions ascribable to these activities are shown in Table 5.

	activity		emissions	counts
	qty	*units*	*tCO_2e*	toward
irrigation & frost control	18,186	MWh	305	Scope 2
TOTAL irrigation & frost control			305	

Table 5 – Activity levels and GHG emissions in the Irrigation sector.

Irrigation and frost control together induce 305 tCO_2e, making agriculture an important source of Scope 2 emissions about one fifth the size of all commercial buildings taken together.

Methodologies

Electricity consumption was reported directly by the two utilities described in *Methodologies* under the Buildings sector.

Optional Information

Landscape

Relationship of the Landscape to the GHG Inventory

Growing trees sequester carbon, and therefore can be treated as a GHG sink. Likewise, trees lost to harvest, fire, or disease are a GHG source.[9] Over the WRIA 48 watershed as a whole, CO_2 is being emitted and lost by the landscape at various rates to create a net sink or emission, depending on the balance between the various influences.

Tree boles and crowns make up a large fraction of the landscape biomass, and provide the most powerful available lever over GHG sequestration on land. As of 2017, the most recent data year available, live tree boles and crowns in WRIA 48 have a mass of approximately 31.9 million metric tons representing 51.5 million tCO_2e, over 600 times the size of the entire community inventory. Statistical fluctuations in weather, fire frequency, commercial logging intervals, or tree disease can easily induce changes in the stock of trees that implicate emissions swamping the community inventory. Furthermore, a large fraction of the landscape is out of the local community's direct control – some 86% of WRIA 48 is either state or federal land.[10] For these reasons, GHG emissions associated with the landscape are treated under Optional Information, rather than under Scope 1.

GHG Balance of Changes in Forest Cover

Figure 3 shows the change to living forest biomass in WRIA 48 between the years 2012 and 2017. In the figure, brown colors are negative values, which indicate a loss of living biomass that induces carbon emissions to the atmosphere. Blue-green colors are positive values, indicating sequestration of atmospheric carbon in biomass. The figure's color scale is quantified on an average-per-year basis for three reasons: (1) this simplifies comparison to the emission rates computed in the GHG inventory; (2) timber surveys that provide the quantitative anchors for the dataset are relatively infrequent; and (3) the program supplying the datasets releases a new issue approximately once per five years. This is yet another reason for reporting landscape emissions in Optional Information: there will likely be no new data available to adjust this value for approximately five years.

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[9] Only a portion of live biomass lost to fire or disease enters the atmosphere at the time of death. Typically the great majority of biomass is slowly lost in ensuing years when the damaged boles decay through biological processes. Harvested wood returns to the atmosphere at varying rates – from nearly immediately in the case of fuelwood, to a century or more when used in long-lived construction.

[10] Methow Basin Planning Unit, "Methow Basin (WRIA 48) Watershed Plan" (Okanogan County, June 20, 2005), https://www.methowwatershed.com/methow-plan.

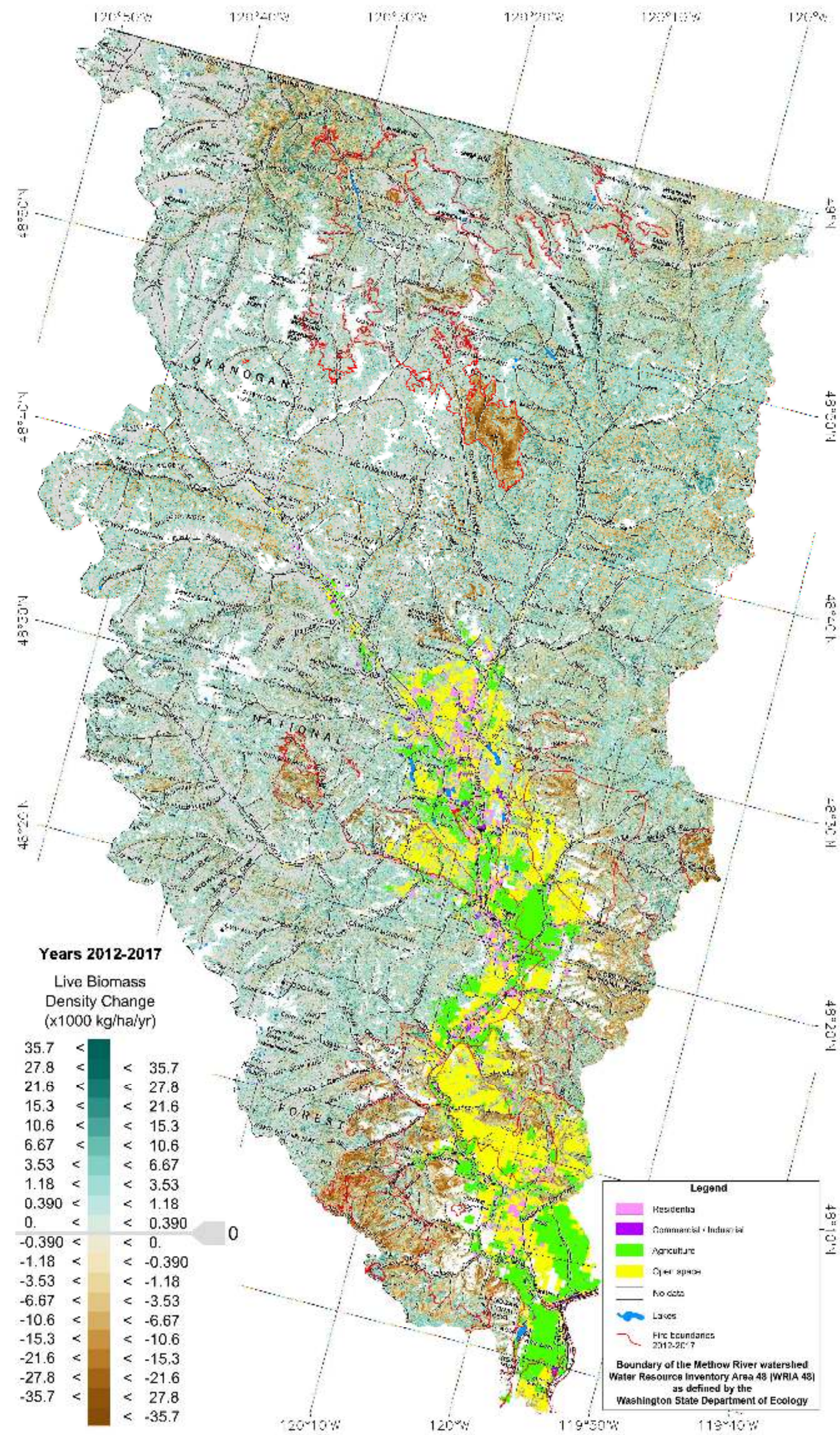

Figure 3 – Biomass flux from and to forests between 2012 to 2017. Negative numbers (brown) indicate losses of live biomass leading to emissions, and positive numbers (blue-green) indicate tree growth leading to sequestration. Additional, saturated colors are used to indicate nonforest land use according to Washington State Department of Revenue land use codes recorded by the Okanogan County Assessor's office as of 2020. Red lines are the boundaries of fires catalogued in the federal Monitoring Trends in Burn Severity (MTBS) program from 2012 to 2017.

We computed forest biomass in Figure 3 from data supplied by the Landscape Ecology, Modeling, Mapping, and Analysis (LEMMA) collaboration between the USDA Forest Service's Pacific Northwest Research Station, and Oregon State University's Department of Forest Ecosystems and Society. The dataset was computed utilizing a gradient nearest neighbor (GNN) imputation method, which combines the accuracy of ground-surveyed plots with the broad coverage of remote sensing and other spatial data.[11] LEMMA's GNN method provided us with fine-resolution estimates of biomass in live trees throughout WRIA 48, in each of the two endpoint years 2012 and 2017. The map shows computed, annual-average gain or loss in live biomass, by subtracting the live biomass in 2012 from live biomass in 2017, and dividing by five to yield an annual average (Table 6).

	activity		emissions commitment
	qty	*units*	*tCO_2e*
live biomass total, 2012	34,066,838	metric ton	
live biomass total, 2017	31,922,530	metric ton	
change, 2017-2012	-2,144,307	metric ton	
average change, 2017-2012	-428,861	metric ton	691,959

Table 6 – Activity levels and GHG emissions on the WRIA 48 landscape.

The annual change in living biomass leads to a corresponding commitment to GHG sinks and sources.[12] Tree growth during a given year corresponds to carbon dioxide sequestration in the same year. Tree loss during a given year means a commitment to GHG emissions over some time period beginning at the tree's loss. That time period can extend over many additional years. For example a very large snag might slowly decay to carbon dioxide in the open air for decades after a crown fire; or harvested wood might reside in a durable piece of construction for half a century and then slowly decay to methane in a future landfill.

The GNN dataset reported live biomass of 34.07 million metric tons in 2012 and 31.92 million metric tons in 2017, meaning 2.14 million metric tons were lost during the five year period, or an average of 429,000 metric tons per year. The corresponding, net emissions commitment of the landscape each year was 692,000 tCO_2e.

Nonforest Land Use

Where the LEMMA dataset indicated no forest cover, we assessed potentials for GHG sequestration in soil or tree growth consistent with values published by the Intergovernmental Panel on Climate Change (IPCC). To do so, we obtained parcel boundaries and Washington

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[11] https://lemma.forestry.oregonstate.edu/methods/methods

[12] The term emissions *commitment* is used here in the same sense as for solid waste sent to a landfill. In both cases, an event during the inventory year (disposal of trash, or loss of a living tree) induces a precisely calculable quantity of future emissions, but with only an imprecisely known schedule for their release.

Department of Revenue land use codes (DOR codes) held by the Okanogan County Assessor's office. These parcels represent non-federal non-state lands or, equivalently, land owned by private entities or local government. Each parcel carries exactly one DOR code. For each of the 57 unique DOR codes appearing in the Assessor's database, we summed the areas of all parcels carrying that code. The 57 resulting area values were then grouped and summed into one of four meta-categories: residential, commercial/industrial, agricultural or open space. (Table 7)

	area	GHG red. potential, tCO_2e/yr	
	hectares	*most likely*	*max*
residental	14,146	--	--
commercial/industrial	1,453	--	--
agricultural	137,811	10,193	18,557
open space	26,660		
retained as open space		3,466	21,061
if allowed to reforest		94,110	197,284
TOTALS	180,069	107,769	236,902

Table 7 – Nonforest land use and GHG sequestration potentials.

Agricultural lands were assigned GHG mitigation potentials according to the wide range of potentials IPCC collected under the classification "agronomy," which includes virtually all carbon-positive agricultural practices other than direct displacement of nitrogen fertilizers. Open space was assessed according to two different classifications offered by IPCC: "grazing/pastureland" and "restoration of degraded lands." In Table 7 these are referred to as "retained as open space" and "allowed to reforest," respectively, to more intuitively reflect the collections of carbon-positive treatments IPCC includes in each.

Residential and commercial/industrial coded lands were not assessed for GHG mitigation potential. That GHG mitigation potential is equivalent to the potential to reforest ("plant trees") on residential and commercial/industrial parcels. Estimating this requires knowing the fraction of each parcel that is available for reforestation, data that was not available at the time of this GHG inventory.

The GHG reduction potentials shown in Table 7 should be considered as order-of-magnitude scale markers only. In particular reforestation is a powerful mitigation tool quantitatively speaking, but only a portion of open space can be realistically considered a candidate for reforestation. That said, it is clear that land management offers mitigation opportunities meaningful at the scale of the GHG inventory. However, measuring and tracking land use-based GHG emissions in the Methow Valley requires a data gathering and monitoring system much more sophisticated than what is currently available.

Biogenic Emissions from Wood Heat

Fuelwood combusted by Methow Valley residents that originates inside the boundary of WRIA 48 is included in the forest cover change emissions computed above. Presumably the vast majority of fuelwood consumed originates inside WRIA 48, but even so community policymakers may like to know what contribution fuelwood combustion makes to the total.

	activity		emissions	counts
	qty	*units*	*tCO_2e*	toward
wood heat (biogenic)	80,238	mmBtu	7,526	O.I.
TOTAL wood heat (biogenic)			7,526	

Table 8 – Biogenic emissions from wood heat.

Table 8 shows the energy value and emissions of fuelwood combustion for residential heat. The energy value was computed by multiplying the number of wood-heated households reported in the 2018 ACS 5-year values, by the average annual fuel use per wood-heated, rural household reported by the 2015 RECS. The product, 80,238 mmBtu, is roughly equivalent to 2,600 cords of stacked firewood. The CO_2 emission rate of fuelwood was duplicated from U.S. EPA standard emission factors.

The Table 8 total, 7,526 tCO_2e, represents the maximum GHG equivalency assignable to wood combustion. There is currently no consensus methodology for measuring and attributing partial GHG equivalency to biogenic emissions from fuelwood. If such a methodology were to be developed, it could result in Methow Valley fuelwood being assigned a quantity of Scope 1 emissions that is between zero and this maximum value. If this is done, then caution needs to be taken with regards to double counting emissions from wood harvested within WRIA 48.

Location-Based Scope 2 Emissions

In 2015 the World Resources Institute issued additional guidance on the reporting of Scope 2 emissions ("Guidance").[13] The Guidance distinguished between "market-based" and "location-based" methods of determining electricity emission factors. Utility-specific emission factors, such as those we are using in this inventory, are considered market-based. The Guidance requires that when market-based emission factors are used, Scope 2 emissions following the location-based method be provided in Optional Information.

The location-based method requires the reporter to utilize grid-average emission factors associated with their location; in the United States, grid-average emission factors are supplied by the U.S. EPA eGRID reports. The Methow Valley lies in the Northwest Power Pool subregion defined in eGRID and shows an average grid emission factor of 0.414 tCO_2e/MWh, far higher

[13] Mary Sotos, "GHG Protocol Scope 2 Guidance" (World Resources Institute, 2015).

than the emission factors of the local utilities. A comparison of Scope 2 emissions calculated using the two different approaches appears in Table 9.

	consumption *MWh*	market-based emissions *tCO_2e*	location-based emissions *tCO_2e*
Buildings (residential)	52,093	875	21,583
Buildings (commercial)	31,755	533	13,157
Irrigation	18,186	305	7,535
TOTALS	102,034	1,714	42,275

Table 9 – Scope 2 emissions computed with the market-based and location-based methods.

The Methow Valley GHG inventory includes a total of 1,714 tCO_2e Scope 2 emissions, but this number would inflate to 42,275 tCO_2e under the location-based method, or 40,561 tCO_2e above the market-based value. This increment is roughly half of the entire inventory.

We do not recommend assigning meaning to the location-based emissions, because:

1. The eGRID subregion is too large to accurately represent which generating resources are contributing to electricity delivered in the Methow Valley; and
2. Doing so removes an appropriate sense of collaboration between the community and its local utilities.

Consumption-Based Emissions

With the exception of electricity, this inventory excludes upstream emissions due to manufacture and transport of goods consumed within the Methow Valley but produced elsewhere. A **consumption-based** emissions inventory includes upstream emissions, but is extremely difficult to compile and has a relatively low precision. However, we can estimate the values in a consumption-based inventory for the Methow Valley, by scaling an existing consumption-based inventory in a similar economy. The highest-quality such inventory available in the Pacific Northwest is that undertaken by the State of Oregon for calendar year 2015.[14]

[14] Department of Environmental Quality, "Oregon's Greenhouse Gas Emissions through 2015: An Assessment of Oregon's Sector-Based and Consumption-Based Greenhouse Gas Emissions" (State of Oregon, May 2018), https://www.oregon.gov/deq/aq/programs/Pages/GHG-Oregon-Emissions.aspx.

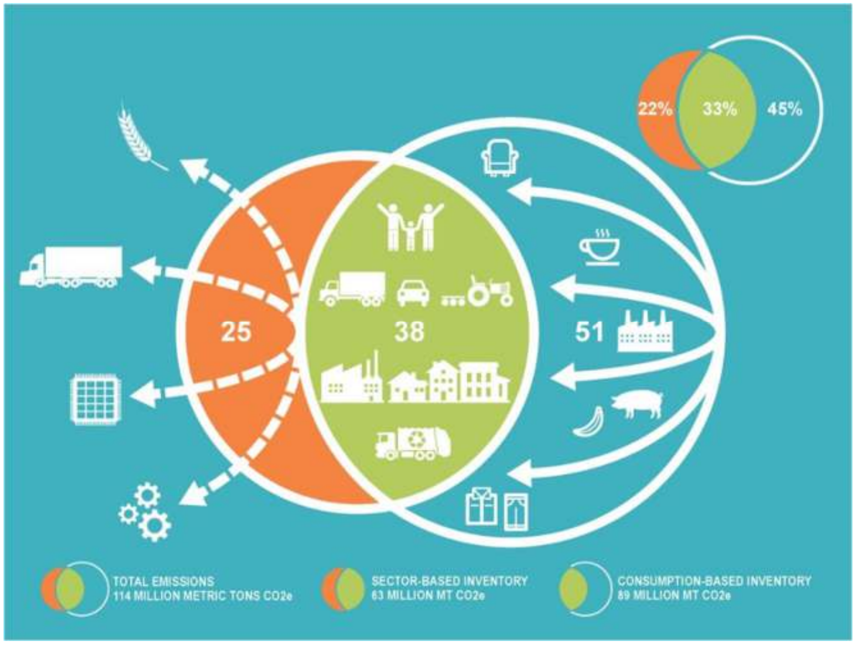

Figure 4 – Comparison of Oregon's 2015 consumption-based inventory (larger circle) and sector-based inventory (smaller circle), in millions of tCO_2e. From Oregon Department of Environmental Quality 2018, p.4.

In Figure 4 the larger circle on the right represents Oregon's consumption-based inventory and the smaller circle on the left is Oregon's conventional Scope 1+2 inventory. The green intersection represents emissions sources shared by both inventories; the orange area represents Scope 1+2 manufacturing and transport emissions for products exported from Oregon and therefore excluded from the consumption-based inventory.

Of Oregon's 89 million tCO_2e consumption-based inventory, 51 million tCO_2e are specifically upstream emissions due to imported products (the uncolored area in Figure 4). Comparing to Oregon's conventional Scope 1+2 inventory of 63 million tCO_2e, the upstream emissions are about 81% (51 million tCO_2e/63 million tCO_2e) the size of the Scope 1+2 inventory.

The Methow Valley's Scope 1+2 inventory is about 57,000 tCO_2e (from Table 1a). If the behavior of Methow Valley's consumers resembles that of Oregon's, we would expect the upstream emissions to be approximately 81% of this, or 46,000 tCO_2e. The comparison of the Methow Valley to the State of Oregon is of course conjectural at best, so this estimate of upstream emissions should be considered order-of-magnitude only.

Value of Recycling

Recycling waste can avoid the production of new materials. Often, the GHG emissions of manufacturing a material from recycled waste are lower than the GHG emissions of manufacturing the same material from virgin feedstocks. In this case, recycling appears to create emissions reductions due to the displacement of the manufacturing from virgin feedstocks. However, these emissions reductions cannot be reported in a conventional

Scope 1+2 inventory, since the baseline manufacturing emissions are upstream, outside the inventory boundary.

In the absence of a consumption-basis GHG inventory, we can still report the benefit of recycling as Optional Information. Materials recycled from the Methow Valley waste stream in 2019 were as shown in Table 10.

WARM material classification	quantity *ton*	benefit of recycling *tCO_2e*
Corrugated Containers	263.40	-825.85
Magazines/Third-class Mail	15.33	-47.06
Newspaper	14.62	-39.59
Office Paper	14.08	-40.32
HDPE	9.25	-7.89
PET	3.07	-3.53
Mixed Electronics	6.70	-5.29
Aluminum Cans	10.77	-98.30
Steel Cans	9.90	-18.14
Mixed Metals	101.12	-444.03
Mixed Recyclables	200.00	-569.28
TOTALS	648.24	-2,099.28

Table 10 – Recycling in the Methow Valley, allotted to WARM materials classifications.

The materials were assigned classifications according to the taxonomy offered by WARM version 15; Table 10 reports the associated recycling benefits computed by WARM. The recycling benefit of -2,100 tCO_2e could lower Methow Valley's estimated, upstream emissions of 46,000 tCO_2e by about 4.6%.

Appendix A

Household liquid petroleum gas (LPG) use was determined based on American Community Survey (ACS) 2018, 5-year average results in the Methow Valley and Early Winters census county divisions. A portion of 2018 ACS questionnaire page 6, including the question regarding home heating fuel, is duplicated here with our annotations in yellow. This question was worded identically in all five years (2014-2018) contributing to the 2018 5-year average.

LPG is a common heating fuel in the Methow Valley. Most LPG users know it by the name "propane," but the ACS survey form does not utilize the word propane, likely causing confusion for survey respondents and ambiguity in the meaning of ACS reports.