Island County 2021 Climate Action Plan

Update to 2011 Plan

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This document contains the results of a Geographic Greenhouse Gas Emissions Inventory for Island County for 2010 and 2019. The inventory includes data for the Community as well as the Island County Municipal Operations. This is an addendum to the 2010 GHG Emissions Inventory and Resource Conservation Plan dated 12/5/2011.

Acknowledgements

I would like to acknowledge and thank many people and organizations for their help in making this project possible.

- The Northwest Clean Air Agency for the grant funding to support this project. Also, for their overall leadership in Climate mitigation work in our tri-county region.
- ICLEI – Local Governments for Sustainability, specifically Tom Herrod, who provided the protocols, tools, technical guidance, and support throughout the project.
- The Island County Commissioners for their leadership in reducing Greenhouse Gas emissions as seen in the application for the NWCAA grant as well as support and guidance throughout the project.
- Jennifer Johnson, Dept. of Natural Resources Manager, Island County Public Health, and Island Local Integrating Organization Coordinator who is my key point of contact from Island County and acting as project manager.
- Larry Van Horn, Director Island County Facilities and Fleet Management for his leadership throughout the project and into the future to carry out the recommended actions.
- Previous Island County employees, Hannah Rae Liss and Lori Clark for their guidance and leadership on Milestone 1 and 2.
- To the rest of the Island County Staff who tirelessly responded to my requests for information.
- Puget Sound Energy, Snohomish County PUD and Cascade Natural Gas for providing community and consumption information. Also, for their already successful energy efficiency and renewable energy projects that are currently making a positive impact on the GHG emissions in our county.

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Executive Summary

The impacts of climate change are being felt today and are expected to become more intensified in coming years. Climate changes pose risks to our ecosystem, infrastructure as well as quality of life for those who live, work, and play in Island County. Island County must do its part to reduce overall climate emissions to avert the worst climate change impacts as well as adapt to climate change by building resilience in our ecosystem, infrastructure, and agricultural practices. The impacts of climate change being seen today in our region include:

- hotter and dryer summers,
- heavier winter rains,
- seriously degraded air quality due to massive wildfires,
- record-breaking heat waves,
- sea-level rise, increased storm surges and high tide flooding, and
- ocean acidification, increasing ocean temperatures and harmful algae blooms.

Whatcom County hired Cascadia Consulting Group, to prepare a report, "Climate Trends and Projected Impacts". Although Island County has different microclimates and ecosystems than Whatcom County, the trends and projected impacts are a very good place to start when determining the critical importance of acting on climate change.

Achieving the emission reduction targets laid out in this plan and adapting to climate change requires actions across a broad spectrum of areas and multiple levels of government and community leaders. It includes how we power our lives, our transportation choices, the way we build and heat / cool our buildings, how we manage forest health and other critical ecosystems. Not included in this plan but very critical in overall climate change reduction and adaptation is building more sustainable agricultural systems.

The report starts by defining a Science Based Emission Target for Island County and then lays out the High Impact Actions (HIA) required to achieve the targets. Lastly there is a separate section addressing Climate Resilience and Adaptation. It is important to note that implementing the High Impact Actions will not only reduce carbon emissions but also build our climate resilience and provide our infrastructure, ecosystems, and humans with adaptation capacity.

Supporting this plan are various regulations, new building codes and programs from the State of Washington including but not limited to, the Clean Energy Transformation Act, Clean Buildings Standards, HB 1287 Preparing for zero emissions vehicles and the Climate Commitment Act. In addition, federal funding, and other incentives through the recently passed 2021 Infrastructure bill as well as the anticipated Build Back Better bill will provide important funds for accelerating these projects.

This plan has been developed with strong partnership and support from ICLEI, Local Governments for Sustainability, Commissioner St. Clair, Jennifer Johnson, Dept of Natural Resources Manager, and many other Island County government and community leaders including the NW Clean Air Agency, Whidbey Camano Land Trust, Opportunity Council, Whidbey Island Conservation District, Sherman-Bishop Farms, Sweetwater Farm and Shire, PSE, SnoPUD, etc. I would like to thank them for their tireless support and invaluable contributions.

Science Based Targets (SBT) and Emission Goals

2030 per Capita Emission Reductions From 2019 Baseline	2030 Absolute Emission Reductions From 2019 baseline	2019 Baseline Scope 1 and Scope 2 (MT CO2e)	2030 Targets Scope 1 and Scope 2 (MT CO2e)
63%	63%	602,589	223,432

Table 1: Science Based Targets (SBT) and Emission Goals (MT, metric tons)

ICLEI's team of technical experts worked in collaboration with Island County to develop the Science Based Targets and Emission Goals. Science-based targets are climate goals in line with the latest climate science. They represent Island County's fair share of the ambition necessary to meet the Paris Climate Agreement commitment of keeping warming below 1.5°C. To achieve this goal, the Intergovernmental Panel on Climate Change (IPCC) states that we must reduce global emissions by 50% by 2030 and achieve climate neutrality by 2050. Equitably reducing global emissions by 50% requires that high-emitting, wealthy nations reduce their emissions by more than 50%.

Growth Rates

Commercial, Residential, Growth (conservative, based on population)	On-Road Vehicles Growth (conservative, based on population)	Industrial Growth (conservative estimate)	Grid Decarbonization Use Moderate BAU estimate
5%	5%	2.5%	85%

Table 2: Growth rates applied to forecast 2030 Business-as-Usual (BAU) emissions.

Island County's 2016 comprehensive plan forecasted population to be 87,917 by 2036 but already we know this is a low forecast. IC population forecast for 2021 is 86,969 with growth of just over 1% per year for the past 4 years. A conservative estimate for population growth and corresponding growth in commercial, residential, vehicle-miles-traveled (VMT) and industrial areas has been applied.

Baseline, Forecasted Emissions and Modeled Emissions (after HIA)

	Baseline and Forecasted Emissions			Modeled Emissions after HIA	
Sectors	**2019 Baseline Emission MT CO2e**	**% of Total**	**2030 Forecast BAU Emission MT CO2e**	**2030 Forecasted Emission MT CO2e**	**Percentage Change**
Fuels Commercial	14,264	2%	14,977	13,752	-3.6%
Electric Commercial	116,709	18%	18,567	18,653	-84.0%
Fuels Residential	65,759	10%	69,047	58,794	-10.6%
Electric Residential	190,113	30%	30,245	33,247	-82.5%
Fuels Industrial	26	0%	27	27	3.8%
Electric Industrial	1,879	0%	292	292	-84.5%
On-Road	212,615	33%	179,043	97,578	-54.1%
Total; Primary Sectors	601,365	94%	312,198	222,343	-63.0%
Ferries	11,419	2%	3284	3284	0%
Inventory Total	638,164	100%			

Table 3: 2019 Baseline and 2030 BAU Forecasted Emissions, Modeled Emissions after HIA applied

High Impact Actions (HIA) to meet Island County's Science Based Targets

This Climate Action Plan (CAP) outlines High level Actions (HIA) across multiple different sectors that together will lead to achieving the Island County Science Based Targets (SBT). With climate change impacts already upon us, it is important to incorporate climate adaptation to build resilience into Island County's planning. Executing on the HIA will not only decarbonize our county but it will also work to build resilience in infrastructure and ecosystems.

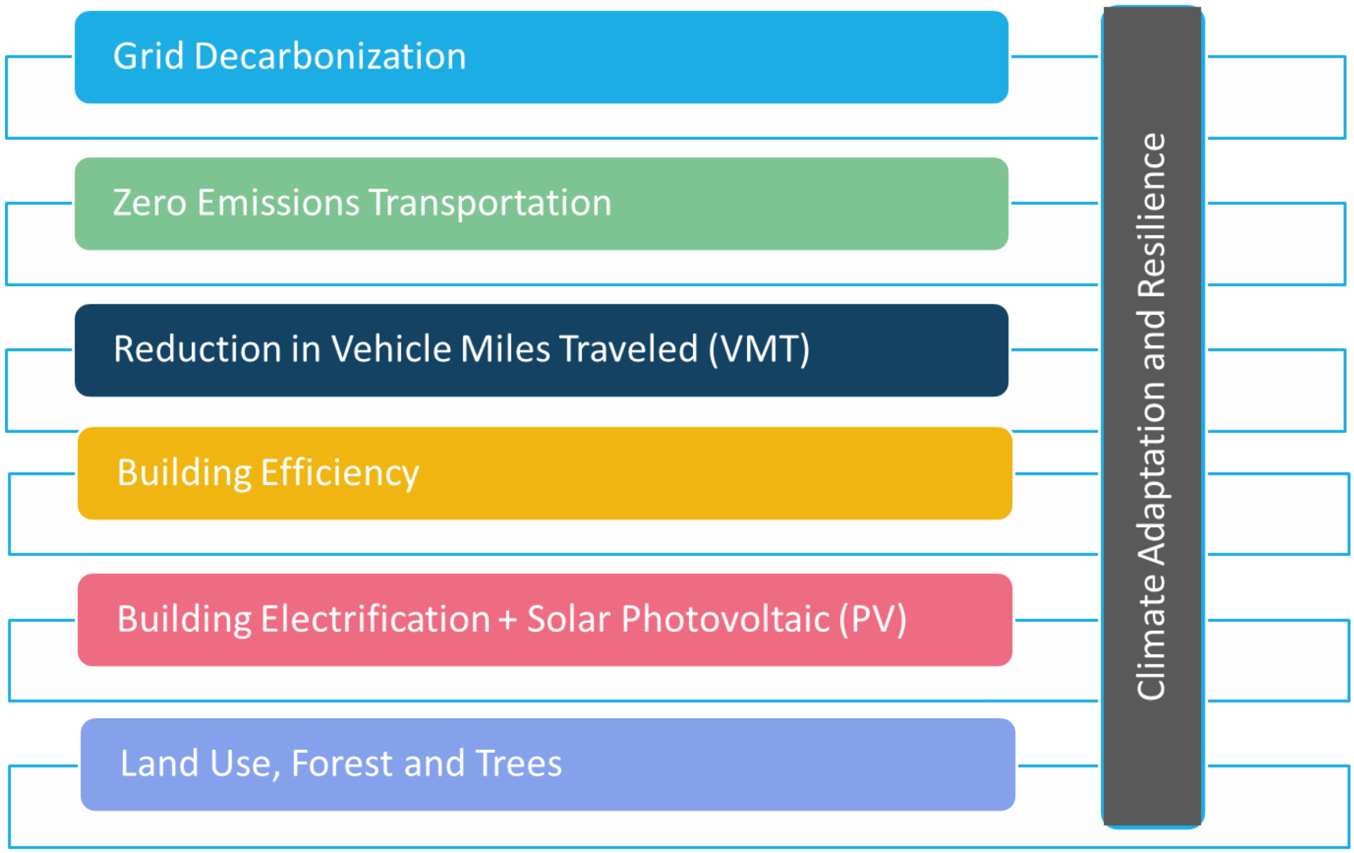


Figure 1: HIA Actions Overview

Overarching recommendations, shown in table below, are critical starting points to achieving goals outlined in the Climate Action Plan. The actions in order of priority related to importance of leverage and available funding.

Recommendations	Critical Details	Resources Required	Timing and Dependencies
• IC Vehicle Electrification of fleet.	Leverage outside consultants to capture maximum funding resources.	DKS Consulting – Vehicle Electrification, Municipal Fleet Electrification Plans range between $50 to $80K. funding resources. (see Heather Bickford for details).	Q1 2022
• IC to Hire a Sustainability Manager.	Own execution of CAP, collaborate with PSE and SnoPUD on decarbonizing grid, be on top of funding opportunities, work collaboratively across county departments and neighboring counties.	Salary: The middle 50% of Environmental Sustainability Managers makes between $111,040 and $113,000, with the top 75% making $187,200.	Q1 to Q2 2022
• IC to Set up Climate Action Committee.	Work in collaboration with Sustainability Mgr. to drive CAP HIA. Recommend requirements for participants to have energy, utility, transportation, climate, planning and/or communication backgrounds.	Sustainability manager to oversee. Whatcom County as possible model, Jefferson County, Thurston County, City of Langley as potential models.	Q2 2022 Dependent on Sustainability Manager to be in place.
• IC to hire grant writer and/or retain grant writer.	Requirement across IC departments.	Joining Vision and Action (JVA) as potential solution. Service details with Jennifer Johnson.	Q1 2022
• Island County (IC) to lead the way.	Execute HIA on IC Vehicle fleets, facilities, and lands.	Facilities, DNR Dept. Mgr., and Sustainability Manager to lead after hired.	Starting in Q1 2022 through 2030

Table 4: Overarching Climate Action recommendations

HIA: Grid Decarbonization

This is a critical component of the Climate Action Plan and achieving the 63% SBT. Although Island County is not directly responsible for this HIA, Island County stands to benefit from the Utility's Clean Energy Plans. It is important to note that PSE supplies 75% of the total electricity to Island County and represents 96% of total emissions from electricity so will be the major focus of the actions listed below.

High Impact Action			
Type	**Target**	**Net Reduction (MT CO2e)**	**Description**
Electric Grid Decarbonization	Moderate BAU (85%)	274,985	Moderate estimate of 85% total reduction in carbon intensity (MT CO2/MWH) from the baseline year to 2030.

Table 5: Targets for Grid Decarbonization HIA

Recommendations	Critical Details	Resources Required	Timing and Dependencies
• Invite PSE and SnoPUD to present Clean Energy Plans.	Understand how plan impacts / benefits IC and best path to participate.	PSE:Carryn.VandeGriend@pse.com SnoPUD: Marr, Garrison GBMarr@snopud.com	Dec 2021 / Jan 2022
• Collaborate with PSE and SnoPUD on Clean Energy Plan.	Work on Island County's behalf to guide implementation and achieve maximum local benefits.	IC Sustainability Manager	Q2 2022
• Focus on building grid resilience.	Work with PSE and SnoPUD (microgrids, efficiency, demand response, distributed solar PV).	IC Sustainability Manager	Q2 2022
• Educate IC unincorporated residents & business.	Offer support on how residents and business can participate and benefit.	IC Citizen Action Committee, NWCAA Outreach, PSE Community partners	Q2 2022 and beyond

Table 6: Recommendations for Grid Decarbonization HIA.

On May 7, 2019, Governor Jay Inslee signed into law the Clean Energy Transformation Act (CETA) (SB 5116, 2019), which commits Washington to an electricity supply free of greenhouse gas emissions by 2045. CETA applies to all electric utilities serving retail customers in Washington and sets specific milestones to reach the required 100% clean electricity supply. The law requires utilities to phase out coal-fired electricity from their state portfolios by 2025. By 2030, their portfolios must be greenhouse gas emissions neutral, which means they may use limited amounts of electricity generated from natural gas if it is offset by other actions. By 2045, utilities must supply Washington customers with electricity that is 100% renewable or non-emitting, with no provision for offsets.

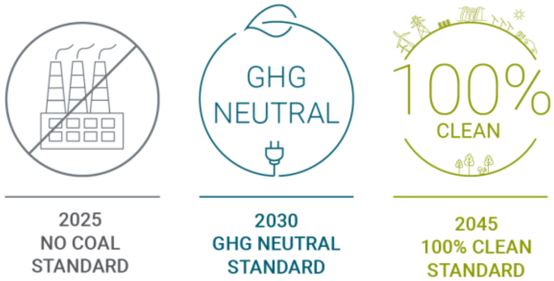


Figure 2: Clean Energy Transformation Act (CETA) targets.

Puget Sound Energy's high-level plans to achieve these targets are as follows.

- significant investments in renewable resources
- accelerated acquisition of energy conservation
- increased use of demand response
- integration of distributed energy resources like residential solar and battery energy storage
- reduced reliance on short-term market purchases in response to the changing western energy market
- inclusion of alternative fuels to operate new generating plants

Island County can benefit from this plan in multiple ways. A key recommendation in the Climate Action Plan is to hire a Sustainability Manager to be an Island County voice at the table to support a reliable and equitable clean energy transformation.

Utilities may adopt a slower transition path necessary to avoid rate shock. The law also provides for short-term waivers of the clean if energy standards if needed to protect reliability. It is highly likely that SnoPUD will achieve these targets as their energy mix is almost carbon free today. PSE's plan is more aggressive which is the reason for setting a moderate target.

It is important to note that Cascade Natural Gas (CNG) is not required to comply with CETA standards. They will be required to participate in the WA State Climate Commitment Act (CCA) but at this point it is not clear what the overall impacts will be. CNG today focuses on demand management including conservation and direct use. This is modeled into commercial and residential reductions through building efficiency.

Other Community Benefits

- <u>Cost Reduction</u>: Reduction in overall energy use and therefore cost through electrification, efficiency, and other distributed energy resource programs.
- <u>Energy Security and Resilience</u>: Decrease in frequency and duration of outages through increased system reliability based on growth in non-wire alternatives to meeting demand which include locally distributed energy resources as well as microgrids.

HIA: Zero Emissions Transportation (including Electrification)

High Impact Action			
Type	**Target**	**Net Reduction (MT CO2e)**	**Description**
On-Road Vehicle Electrification and other zero emissions tech.	California + (9% Annual Growth)	67,712	Represents a 40.5% reduction in total Internal Combustion Engine VMT. This action influences an increase in Residential & Commercial buildings electricity emissions.

Table 7: On-Road Vehicle Electrification targets

Recommendations	Critical Details	Resources Required	Timing and Dependencies
• Develop Plan to Electrify IC fleet. • Integrate EV First Procurement & Use policies.	Expect funding through Federal Infrastructure bill. Leverage Consultant (DKS consultant) to accelerate and maximize funding.	IC Transportation Director and Facilities Manager. Fleet Electrification Plan estimated cost \$50 to \$80K.	Q2 2022
• EV Charging Infrastructure across Island County.	Develop Plan, ensure funding and partners to build out. Leverage consulting partners.	IC Transportation Director and IRTPO,	2022 - 2025
• Adopt EV Ready building codes for commercial, residential, & multi-family.	Required to support EV adoption. Cost is lower if done during construction. Resources: City of Seattle Codes, SWEEP EV codes here. TOC has policy in place for commercial.	IC Planning Department. (Supporting WA State codes: HB 1257 (2019), HB1287)	Q3 2022
• Island Transit Fleet decarbonization (electric, green hydrogen) Targets TBD.	Funding sources; Federal Infrastructure bill, etc. Note: south-end transit station critical to plan, 2019 Fleet Emissions = 2856 MT CO2e.	Island Transit Board, IC Transportation Director.	Complete the Zero Emissions Bus (ZEB) pilot in 2022, targets to be set post pilot.
• School Bus fleet electrification.	Funding available through Federal Infrastructure bill (\$6B in total).	School transportation Managers.	2022 to 2025

Table 8: Recommendations to achieve on-road vehicle electrification targets.

The target is an aggressive goal reflecting the growth we have already seen in the State of Washington and forecast to continue through 2030. This is the target set for most cities and counties in WA, CA and OR.

Washington State Enabling Legislation

Washington State HB 1287 was passed in May of 2021 which lays the groundwork for a strong increase in EV sales and penetration in the State of WA. SB 5192 set requirements for standardization of public electric vehicle charging stations.

The HB 1287 has several key components.

1. Legislation requires Washington's electric utilities to include modeled estimates for new load from electric vehicle charging in their Integrated Resource Plans.

2. These load forecasts should be coordinated with the utilities' electrification of transportation plans that are required under the Clean Energy Transformation Act; the statute enacted in 2019 that requires utilities to transition to 100% non-emitting generation by 2045

3. The legislation requires the Washington Department of Transportation to developing a mapping and forecasting tool that will predict where electric vehicle charging infrastructure will be built, how fast electric vehicle adoption will occur, traffic flows, electric demand for vehicle charging, and other factors to aid utilities and agencies of government in planning for electrification of the transportation system.

4. The legislation requires building codes to be updated to require buildings with parking facilities to be constructed with wiring that will accommodate Level 2 (240-volt, 40 amp) charging stations for at least ten percent of parking spaces. The rules must be adopted by July 1, 2021, except that rule for high-density residential housing must be implemented by July 1, 2024.

Funding and Tax Incentives for EVs

At the time of this report, there are federal credits (up to $7500 tax credit) and state tax incentives (sales and use tax exempt) for the purchase and lease of certain plug-in electric passenger, light duty trucks, and medium duty passenger vehicles. The federal tax credits are expected to increase in amount and eligibility with the Build Back Better Act which has yet to pass.

In the recently passed Federal Infrastructure bill there is allocated $7.5 billion for electric vehicles and EV charging infrastructure, $7.5B for zero emissions busses and ferries. $6B for battery material processing grants and battery manufacturing and recycling grants. It is strongly recommended to prioritize planning for vehicle electrification in the Island County fleet as well as Island County community and leverage the support of outside consultants to maximize funding potential.

Electric Vehicles Environmental Impact

As with any change the question must be asked, what is the net environmental impact of the change. In particular, the concerns mainly stem around the Electric Vehicle batteries. The Union of Concerned Scientists (UCS), a science-based non-profit organization working for a healthier environment and a safer world, researched this topic and summarized this in a technical report titled "Electric Vehicle Batteries, Addressing Questions about Critical Materials and Recycling" (see Appendix E for full report).

> Highlights from the report:
> Electric vehicles are critical to reducing transportation pollution and solving the climate crisis but manufacturing them at the necessary scale will require significantly increasing production of the batteries that power them. How batteries are made, what they are made of, and whether they are reused or recycled

affect the sustainability of this crucial component. Even though batteries last many years, they eventually reach the end of their useful life for powering electric vehicles. Policies and incentives for recycling and reusing batteries, including strong health and labor standards, will further lessen the impacts of EVs.

As highlighted in the UCS report the key to lowering the environmental impact is strong policies and incentives for recycling. The US Department of Energy has been hosting a "contest" to come up with the most innovative way to recycle batteries. Phase II winners were selected in Feb of 2021 with Phase III winners soon to be announced. Program overview can be found at this website. In addition, the $6B in the infrastructure bill to address recycling and battery material processing supports the path towards a low environmental impact EV transition.

Other Community Benefits

- Reduce overall cost of ownership of vehicles for residents and support their transition to EVs
- Improve local air quality, especially important where there is congestion, and for children and transit riders
- Continue to be a desirable tourist destination as they adopt EVs.

Ferry Electrification

High Impact Action			
Type	**Name**	**Net Reduction (MT CO2e)**	**Description**
Ferry Electrification	BAU	5367	Hybrid-Electric vessels planned in 0 to 5 years for Mukilteo-Clinton Ferries, Coupeville Ferries by 2040. Use overall target of 53% reduction by 2030

Table 9: Ferry Electrification targets

Recommendations	Critical Details	Resources Required	Timing and Dependencies
• IC to work closely with WA DOT and Federal Govt to coordinate investments in our Ferry systems.	Dependent on building a reliable (and low carbon) charging infrastructure in Clinton.	IRTPO – Transportation Director.	By 2026 for Mukilteo / Clinton By 2040 for Coupeville Ferries
• Create long-term parking capacity at Mukilteo Ferry and new Island Transit South Whidbey Center.	Decrease ferry congestion to maximize the growth in use of the ferries without increase in VMT.	IRTPO – working in collaboration with neighboring counties.	Before 2026

Table 10: Recommendations to achieve targets for Ferry Electrification

Washington State Ferries (WSF) burns more than 18 million gallons of diesel fuel a year, making the system Washington State's largest consumer. Within the state transportation system, ferries generate the most carbon and other greenhouse gas emissions. The WSF is working on several projects to meet the goals of Executive Order 20-01, which directs WSF to move toward a zero emissions fleet.

Although Island County will not have direct control over this project it is important to collaborate on the infrastructure planning and execution. The plan is to place the charging infrastructure at the Clinton terminal. Transmission of power from PSE comes by way of the north end of the Island and therefore the Clinton Ferry Charging terminal will be at the end of the "line". It will be critical to ensure the power for this charging station is sufficient, reliable, and carbon free. Also, it would be prudent to coordinate this project with the development of the South End Transit station and corresponding electric vehicle charging infrastructure for busses and vehicles.

HIA: Vehicle Miles Traveled (VMT) Reduction

High Impact Action			
Type	**Name**	**Net Reduction (MT CO2e)**	**Description**
High Level VMT Reduction	Moderate (5%)	8,952	This represents 10% reduction in in-bound and out-bound VMT. Overall, it is a 5% reduction in total VMT

Table 11: High Level VMT Reduction Targets

Recommendations	Critical Details	Resources Required	Timing and Dependencies
• Create long-term parking capacity at Mukilteo Ferry and new Island Transit South Whidbey Center.	Necessary to increase walk-on ferry usage	IRTPO leadership to coordinate with State of WA and neighboring counties to implement.	2022 to 2023
• Set up shuttle service from ferries to Langley and to Coupeville.	Target tourism first, available for commuters and travelers secondary, incorporate bike racks.	Langley and Coupeville leaders (Chamber, City staff)	Q3 2022 Long-term parking as first step.
• Continue to execute on IC's 2018 Non-Motorized Trails Plan.	2018 plan allows for new priorities to be weighed and evaluated.	Transportation Director, IRTPO, Tourism director.	202 through 2030
• Increase Island Transit ridership Rebuild ridership that was severely impacted by COVID.	Target for 2022 (over 2021): Vanpool ridership increase of 4.22%, a paratransit ridership increases of 4.22%, and a fixed route ridership increase of 7.93% for Whidbey and 10.76% for Camano Island.	IC Transportation Director, Island Transit Board / staff (part of TDP plan)	2022 through 2026

Table 12: Recommendations to achieve High Level VMT targets.

Reducing emissions from transportation starts with reducing the number of miles traveled in personal vehicles (VMT). This is critical to reduce congestion. This plan names a few of the high impact actions our county can execute to achieve these targets.

Other Community Benefits

- Reduce congestion / wait times at Mukilteo/Clinton Ferry with multiple benefits including improved <u>local air quality</u>, <u>workforce productivity</u>, <u>maintaining desirability of Island county to live, work and play (tourism)</u>.
- Increase options for people who commute on and off the Island for work

Building Efficiency and Electrification

Executive Summary

Building efficiency and electrification is critical to not only meeting Island County's climate targets but also improving climate resilience. The Electric Utilities cannot cost effectively achieve the target reductions in carbon emissions while meeting the growth in building and vehicle electrification without a strong growth in building energy efficiency. This is a critical part of PSE's plan to decarbonize the grid and is foundational for Island County's CAP.

The Opportunity Council is a strategic partner in achieving residential, multi-family and commercial, building efficiency and electrification goals in Island County. One of the leaders at the Opportunity Council, Mark Schofield Community Energy Challenge Manager, provides context for why building efficiency and electrification is critical and the multiple benefits it provides our IC residents. This has been summarized in the following two paragraphs.

In recent years, our region has experienced seriously degraded air quality due to massive wildfires, as well as excessive, record-breaking heat waves. Both situations are exacerbated and made more likely because of human-induced climate change. The dome of high pressure that settled over the Pacific Northwest in June 2021 sent temperatures soaring above 100 degrees, resulted in hundreds of deaths and exposed the dangers facing many vulnerable people in our communities. The relatively old housing stock in our area combined with a general lack of air conditioning in buildings make these types of events dangerous and unbearable for many.

It's reasonable to expect that energy prices will continue to rise in the future and climate change-driven extreme weather events will become more common. Efforts to upgrade energy efficiency in homes and other buildings will become increasingly important in terms of both climate change adaption and mitigation. Weatherizing existing homes, as well as converting space and water heating to highly efficient electric heat pump technology, will reduce energy expenses while improving home comfort and safety. For example, during periods of excessive heat and poor air quality due to wildfire smoke, these upgraded homes will be able to maintain a moderate temperature and reduce indoor air pollution by leaving windows closed and using an efficient cooling source. Energy efficiency retrofits in homes and commercial buildings will also significantly reduce overall carbon pollution, as the building sector is one of the largest contributors to greenhouse gas emissions. In the process of making these upgrades, we'll boost local economic development.

Building and Energy Codes

Island County follows the Washington State Building Code. The Washington State Building Code is comprised of several different codes including the state energy code. Most are national model codes adopted by reference and amended at the state level. Others, such as the Washington State Energy Code (WSEC), are state-written state-specific codes. The 2018 WSEC, which is a combination of the 2018 International Energy Conservation Code (IECC) and the 2015 (WSEC), has now been divided into commercial and residential provisions. Targets modeled in this report for Residential and Commercial Building efficiency are based on IECC 2018 standards which is a very good approximation for these purposes.

A 2021 Energy Strategy provides a blueprint for how, by 2050, the state of WA can nearly eliminate the use of fossil fuels with the least societal costs. A key recommendation is changing the energy code to require all-electric buildings no later than the 2027, with incremental improvements each code cycle from 2021 to 2027. Heat pump technology for space heating, cooling and water heating are ideal for our climate zone, 1229 more contractors are familiar with this technology and the energy codes today provide some incentives to use all-electric. With these factors in mind the target for building electrification in residential and commercial has been set to moderate target of 50% of new buildings.

HIA: Residential Building Efficiency

High Impact Action			
Type	**Target**	**Net Reduction (MT CO2e)**	**Description**
Residential Building Efficiency	IECC 2018	1,229	All new buildings including 1% of existing Sq FT (renovations and turnover) will meet IECC 2018 (37% reduction in building EUI)

Table 13: Residential Building Efficiency target

Recommendations	Critical Details	Resources Required	Timing and Dependencies
• Opportunity Council Low-income weatherization program.	Successful program already in place, need to expand through education and outreach. Additional funding may become available to expand programs.	IC Staff (TBD) for outreach and education to unincorporated areas through IC, NWCAA, Citizen Climate Committee, Utility outreach, etc.	Q2 2022
• Community Energy Challenge (CEC) for all residents (Opportunity Council Program).	Successful program already in place, need to expand through education and outreach.	IC staff for outreach and education to unincorporated areas, NWCAA, Citizen Climate Committee, Utility outreach, etc.	Q3 2022
• Education and outreach to IC unincorporated residents.	Collaborate with key partners; Opportunity Council, PSE, SnoPUD, NWCAA, IC Permits, Heat Pump & Building Contractors.	Sustainability Manager or another leader (perhaps through Citizen Action Committee).	Q2 2022

Table 14: Recommendations to achieve Residential Building Efficiency targets.

Other Community Benefits

- Reduction in energy costs for the building owner
- Improved comfort and indoor air quality
- Increase resilience and adaptation to changing climate (hotter, more smoke events, etc.)

HIA: Commercial Building Efficiency

High Impact Action			
Type	**Target**	**Net Reduction (MT CO2e)**	**Description**
Commercial Building Efficiency	IECC 2018	1,045	All new buildings including 1% of existing Sq FT (renovations and turnover) will meet IECC 2018 (37 % reduction in building EUI)

Table 15: Commercial Building Efficiency target

Recommendations	Critical Details	Resources Required	Timing and Dependencies
• IC to carry out Clean Buildings Standard on required buildings (base). Implement on all buildings (stretch goal)	WA State Clean Buildings Standard, WAC 194-50, Dept of Commerce Notifications should have gone out in 2021 summer, incentives for early compliance.	Facilities Manager and possible consultant and/or IC Sustainability Mgr. with required background.	Q1 2022 understand compliance laws and timing 2026 to 2028
• WA Clean Buildings Standard- all qualified buildings (>50,000 sq feet) in Island County.	WAC 194-50, Notifications should have gone out in 2021 summer, incentives for early compliance	Facilities Managers for specific buildings and/or organizations	Q1 2022 understand compliance laws, timing 2026 to 28
• Community Energy Challenge (CEC) for all business (Opportunity Council program)	Successful program already in place, need to expand through education and outreach.	IC staff for outreach & education to unincorporated areas, NWCAA, Citizen Climate Committee.	Q3 2022
• Education and Outreach to IC unincorporated business	Collaborate with key partners; Opportunity Council, PSE, SnoPUD, NWCAA, IC Permits, Heat Pump & Building Contractors	Sustainability Manager or another leader (perhaps through Citizen Action Committee)	Q2 2022
• C-PACER implement for commercial, nonprofit, & multifamily	Commercial Property Assessed Clean Energy & Resilience (C-PACER) Financing **(details)** and **FAQ** Couples well with CEC.	pacer@shiftzero.org, King County C-PACER program,	2023

Table 16: Recommendations to achieve Commercial Building Efficiency Targets.

Other Community Benefits

- Reduction in energy costs for building owner
- Improve comfort and indoor air quality
- Increase resilience and adaptation to changing climate (hotter, more smoke events, etc.)
- Growth in business increase for Island County heat pump contractors

HIA: Residential Building Electrification

High Impact Action			
Type	**Target**	**Net Reduction (MT CO2e)**	**Description**
Residential Building Electrification	50% new buildings all electric	9,168	50% of new buildings & 2% Existing Sq FT per year are electrified (starting in 2023). Represents a 15% reduction in residential MMBTU.

Table 17: Residential Building Electrification Targets

Recommendations	Critical Details	Resources Required	Timing and Dependencies
• IC to plan for significant changes to Building Codes	Follow the WA State Building Codes, expect all Electric by 2027 with code updates each year	Permitting Dept	2022 to 20230
• Opportunity Council Low-income weatherization program	Successful program already in place, expand through education & outreach.	IC Staff (TBD) for outreach and education to unincorporated areas, NWCAA, Citizen Climate Committee, Utility outreach, etc.	Q2 2022
• Community Energy Challenge (CEC) for all residents (Opportunity Council program)	Successful program already in place, need to expand through education and outreach.	IC staff for outreach and education to unincorporated areas, NWCAA, Citizen Climate Committee, Utility outreach, etc.	Q3 2022
• Education & Outreach to IC unincorporated business	Collaborate with key partners; Opportunity Council, PSE, SnoPUD, NWCAA, IC Permits, Heat Pump & Building Contractors	Sustainability Manager or another leader (perhaps through Citizen Action Committee)	Q2 2022

Table 18: Recommendations for achieving Residential Building Electrification Targets

Other Community Benefits

- Reduction in energy costs for building occupant
- Improve comfort and indoor air quality
- Growth in business increase for Island County heat pump contractors
- Increase resilience and adaptation to changing climate (hotter, more smoke events, etc.)

HIA: Commercial Building Electrification

High Impact Action			
Type	**Target**	**Net Reduction (MT CO_2e)**	**Description**
Commercial Building Electrification	50% new buildings all electric	1,054	50% of new buildings & 1% Existing Sq FT per year are electrified (starting in 2023). Represents an 8.2% reduction in Commercial MMBtu

Table 19: Commercial Building Electrification Targets

Recommendations	Critical Details	Resources Required	Timing and Dependencies
• IC to plan for significant changes to Building Codes	Follow the WA State Building Codes, expect all Electric by 2027 with code updates each year	Permitting Dept	2022 to 2030
• IC to carry out Clean Buildings Standard on required buildings (base). Implement on all buildings (stretch)	WA State Clean Buildings Standard, WAC 194-50, Dept of Commerce, notifications should have gone out in 2021 summer, incentives for early compliance.	Facilities Manager and possible consultant and/or IC Sustainability Mgr. with required background.	Q1 2022 understand compliance laws, timing 2026 -2028
• WA Clean Buildings Standard- all qualified buildings (>50,000 sq feet) in Island County.	WAC 194-50, notifications should have gone out in 2021 summer, incentives for early compliance	Facilities Managers for specific buildings and/or organizations	Q1 2022 understand compliance laws, timing 2026 -2028
• Community Energy Challenge (CEC) for all business (Opportunity Council program)	Successful program already in place, need to expand through education and outreach.	IC staff for outreach and education to unincorporated areas, NWCAA, Citizen Climate Committee, Utilities	Q3 2022
• Education & Outreach to IC unincorporated business	Collaborate with key partners; Opportunity Council, PSE, SnoPUD, NWCAA, IC Permits, Heat Pump & Building Contractors	Sustainability Manager or another leader (perhaps through Citizen Action Committee)	Q2 2022

• C-PACER implement for commercial, nonprofit, & multifamily	Commercial Property Assessed Clean Energy & Resilience (C-PACER) Financing **(details)** and **FAQ**, Couples well with CEC.	pacer@shiftzero.org, King County C-PACER program, Whatcom & Spokane County	2023

Table 20: Recommendations for Commercial Building electrification targets

Other Community Benefits

- Energy Costs reduction for building occupant
- Increase resilience and adaptation to changing climate (hotter, more smoke events, etc.)
- Improve comfort and indoor air quality
- Growth in business increase for Island County heat pump contractors

HIA: Solar Photovoltaic (PV)

Increasing the amount of locally installed Solar PV is a critical component of PSE's plan to decarbonizing the grid and build the needed capacity and grid resilience. In addition, Island County has seen significant growth in locally installed solar PV over the past 10 years and expect this to continue.

Recommendations	Critical Details	Resources Required	Timing and Dependencies
• Streamline Solar PV permitting to reduce lead times, paperwork, costs.	Leverage best practice process of over the counter permitting (Langley, Anacortes, Edmonds, Skagit County, etc.)	Planning Dept	2022 - 2023
• IC to install Solar PV on buildings and land (where appropriate)	Hire ESCO (or other consultant) to evaluate best possible options and cost and funding opportunities.	IC Facilities Manager, IC Sustainability Manager	2022 - 2030
• Island Transit Solar PV	100 kW Coupeville facility, 10kW Camano Island facility	Island Transit staff	2022: Funding secured,
• Maintain and expand Net metering program	Net metering program is critical to ensure continued growth and success of solar PV in Island County. Lobby and Leverage key partners.	IC Sustainability Manager	2022 – 2030 Dependent on hiring Sustainability Manager.
• Education and outreach to IC unincorporated areas	Expand the education and outreach to citizens and business. Leverage key partners; PSE, WSW,	IC staff (tbd.), leverage key partners; Whidbey Sun and Wind, PSE, SnoPUD, Citizen Climate Committee	2022 - 2030

Table 21: Recommendations for Solar PV HIA

Other Community Benefits

- Energy Costs reduction
- Increase resilience for community (major component of grid decarbonization + resilience)
- Improve comfort and indoor air quality
- Growth in business increase for Island County heat pump contractors

HIA: Land Use, Forests and Trees

Net Greenhouse Gas Emission removals from Island County's forest lands and trees is significant at -452,022 (T CO2e/year) based the ICLEI report (see Appendix F). In addition, the annual ecosystem services value provided by our forest is between $1.4 and $1.5 Billion per year, based on a report prepared by Earth Economics (see Appendix G.) Both reports are using forest and tree data from 2016 data bases and therefore you can expect these values to be reduced with the additional forest removal between 2016 and 2021.

Equally important is building resilience to the changing climate. Island County is seeing hotter, dryer summers and heavier winter rains compared to historic conditions, and this is expected to further intensify. These changes will be difficult for many plants and animals to adapt to, and many species won't be able to disperse - without assistance - as fast as climate is changing. Weakened forests will also be more susceptible to pests and disease, resulting in mortality and increased risk of wildfires, that will release more carbon dioxide back into the atmosphere. Combined with increased land conversion and more homes, these changes will diminish groundwater aquifer levels and quality, including increased risk of saltwater intrusion. Healthy and diverse forests will better adapt to climate change and provide an important overall component to building Island County's climate resilience.

Key partners in maintaining and improving Island County forests are the WSU Extension Forestry Management program, both Snohomish Conservation District and Whidbey Island Conservation District, and the Whidbey Camano Land Trust. They provide Island County residents with education and support in the development, execution and maintenance of Forest Management plans and conservation programs.

There have been several Island County residents engaged on the issue of encouraging healthy forests mainly working through the Island Local Integrating Organization (ILIO). The ILIO builds upon the knowledge of existing committees and watershed groups that are collectively responsible for actions related to the implementation of ecosystem recovery focused programs and projects in Island County. This citizen group submitted to the ILIO a list of recommended actions Island County can take to encourage healthy forests. These recommendations have been reviewed and condensed into actions that are currently planned for 2022 and ones that are recommended to be in place in 2023 – 2030.

Recommendation	Resources	Timeline
Updates to the Island County Public Benefits Rating System (PBRS) program. Goal is to reduce the rate of conversions and "after the fact" conversions under non-conversion permits, and reforestation of under-utilized areas.	Planning Department	On workplan for 2022
Revise the criteria for allowing the lifting of the six-year development moratorium for properties with non-conversion forest permits	Public Works	On work plan for 2022
Improve communication with WA DNR on forest permits	All applicable IC departments	Immediately
Work in collaboration with WSU extension Forestry and Whidbey Island Conservation District (WICD) to promote and expand education and outreach on local, regional, and state programs, resources, and forest management information i.e., Designated Forest Land (DFL), Small Forest Land (SFL). Identify lands (and owners) that are at risk to conversion – target education and outreach.	Department of Natural Resources (DNR)	On work plan for 2022
Review and update the Conservations Futures Funds (CFF) program to evaluate all aspects of forest management and stewardship benefits. Ensure that CFF is Fully funded under the RCW.	Department of Natural Resources (DNR)	On work plan for 2022
Collaborate with SCD and WICD to research the effectiveness and applicability of utilizing USDA NRCS programs in Island County, such as the Conservation Stewardship Program and/or EQIP Program (Environmental Quality Incentives Program), to provide incentive-based opportunities to enhance soil health, water quality, and to enhance healthy habit areas for wildlife	Department of Natural Resources (DNR)	On work plan for 2022
Continue to support key partners; WICD and WSU Extension Forest Management program	Island County Commissioners	Ongoing
Establish an Island County Forest Management Plan	All IC Dept.	TBD
Potential clarifications or revisions: • Define critical area regulations to better align with forest management practices and regulations • Create plan for review of mitigation after one year to assure it meets the requirements and intent of section D. • Evaluate implementing conditional use permits for conversation of forest lands greater than one acre in the Rural Zone	Planning Department	TBD

Climate Resilience and Adaptation

As highlighted in previous sections in this report climate change is already impacting Island County and our region. The recommendations provided in this Climate Action Plan provide both carbon reduction as well as increased climate resilience benefits. It is recommended that all actions are evaluated with both a climate mitigation as well climate resilience and adaptation lens. Additional recommendations are shown below.

Recommendation	Resources	Timeline
Put in place Sea Level Rise Monitoring Plan. Framework is finalized and work to begin in 2022.	Planning Dept (Jonathon Lange)	2022 Plan
Applied for Dept of Ecology Grant to provide education and outreach to shoreline communities as well as execution of the Sea Level Rise Monitoring Plan. Execute on this if awarded grant.	Planning Dept, (Nicholas Reibel), DNR and MRC	2022 Plan (if awarded grant)
Integrate climate adaptation into the next Comprehensive Plan (due in 2025 but working on incremental updates yearly). Leverage TOC 2022 Comp Plan and Puget sound resource guide.	Planning Department (with commissioners' approval)	Final report to be due in 2025

Table 22: Climate Resilience and Adaptation Recommendations

Appendix A; Data Sources, Contacts and Resources for HIA

Key Resources and Contacts High Level

Name/Title	Contact	Comments
ICLEI, Senior Program Manager	Tom Harrod tom.herrod@iclei.org	Guidance on protocols, Clear Path and overall approach to inventory and Climate Action Planning.
Dept. of Natural Resources Manager, Island County Public Health Island Local Integrating Organization Coordinator	Jennifer Johnson jenifer.johnson@islandcountywa.gov	Assigned to be my main point of contact from Island County
Commissioner	Janet St. Clair J.StClair@islandcountywa.gov	Leading Commissioner on project
Director of Facilities and Fleets	Larry Van Horn l.vanhorn@islandcountywa.gov	A significant amount of the actions from the CAP are in facilities and fleets.

Key Data Sources, Resources, Contacts for High Level Actions

Name/Title	Contact	Other Resources
Climate Change Impacts		
Climate Trends and Projected Impacts (Whatcom County)	**Whatcom County Climate Advisory committee**	https://www.whatcomcounty.us/DocumentCenter/View/53837/Whatcom-County-Climate-Science-Summary-2020?bidId=
High Level Resources		
Grant Writing and funding research	**Joint Vision in Action (JVA)** 2246 Irving St. Denver, CO 80211	Katalin Wishart, Senior Managing Associate, Business Development & Client Relations, (720) 407-8399 (direct) , katalin@joiningvisionandaction.com Outline of services (see Jennifer Johnson)

Grid Decarbonization		
Electric Utilities Clean Energy Plans	PSE: Carryn Vande Griend Carryn.VandeGriend@pse.com SnoPUD: Garrison Marr GBMarr@snopud.com	PSE Clean Energy Plan https://cleanenergyplan.pse.com/ceip-documents SnoPUD Clean energy Plan:https://www.snopud.com/wp-content/uploads/2021/11/Draft_2021_CEIP.pdf
Washington State Clean Energy Transformation Act (CETA)	Applies to Electric Utilities: No Coal by 2025, Net Zero by 2030, Zero Emissions by 2045.	CETA: https://www.commerce.wa.gov/growing-the-economy/energy/ceta/
Washington State Climate Commitment Act (CCA)	Beginning in 2023, caps and reduces GHG emissions from largest emitting sources. Cascade Natural Gas will be required to comply.	CCA: https://ecology.wa.gov/Air-Climate/Climate-change/Reducing-greenhouse-gases/Climate-Commitment-Act
On-Road Vehicle Electrification Adoption		
Vehicle Electrification Consulting Services	DKS Consulting Services (see Heather Bickford)	Mike Usen, AICP | Electromobility and Resiliency Lead Direct: 206.436.0557 | Cell: 206.288.3174 | mike.usen@dksassociates.com
Forecasting Tools	ICLEI Source for forecasts	https://evadoption.com/ev-sales/ev-sales-forecasts/
IC Electric Vehicles Planning webpage	Planning reference for Electric Vehicles	https://www.islandcountywa.gov/PublicWorks/Roads/Planning/Pages/electric_vehicles.aspx
WA State Legislation HB 1287	Concerning Preparedness for a Zero Emissions Transportation Future.	https://app.leg.wa.gov/billsummary?BillNumber=1287&Year=2021&Initiative=false
EV Infrastructure Building Codes:	Adoption Toolkit	https://www.swenergy.org/transportation/electric-vehicles/building-codes
PSE Vehicle Electrification	Resources for consumers related to owning and operating an EV	https://www.pse.com/en/pages/electric-cars
WA State Legislation HB 1257	HB 1257 (2019), adopted provisions in IBC Section 429	https://app.leg.wa.gov/WAC/default.aspx?cite=51-50-0429

WA State Department of Commerce	Updates on latest news; Links to partners, statewide initiatives, etc.	https://www.commerce.wa.gov/growing-the-economy/energy/electric-vehicles/
VMT Reduction		
Motorized Trail Plan (2018)	Public Works / Transportation Director	https://www.islandcountywa.gov/PublicWorks/Roads/Transportation-Planning/Documents/Island%20County%20NMTP%202018-03-02%20Low%20Res.pdf
Island Transit, 2021 to 2026 Transit Development Plan (TDP)	Island Transit	https://www.islandtransit.org/Transit-Development-Plan
Residential Buildings Efficiency and Electrification		
Low Income Weatherization, Opportunity Council	Kyle White, kyle_white@oppco.org	https://www.oppco.org/weatherization-and-home-repair/
Community Energy Challenge, Opportunity Council	Mark Schofield, Manager mark_schofield@oppco.org	https://sustainableconnections.org/community-energy-challenge/
Building and Energy Codes	WA State Building Council	https://sbcc.wa.gov/state-codes-regulations-guidelines/state-building-code/energy-code
Building and Energy Codes	Building Industry Association of WA (BIAW)	https://www.biaw.com/building-codes/
WA State 2021 Energy Strategy	WA State Department of commerce	https://www.commerce.wa.gov/wp-content/uploads/2021/01/WA_2021SES_-Executive-Summary.pdf
Commercial Buildings Efficiency and Electrification		
Clean Buildings Standards	WA Dept of Commerce	https://www.commerce.wa.gov/growing-the-economy/energy/buildings/clean-buildings-standards/
Clean Buildings Standards	WA State Hospital Association (excellent overview of program)	https://www.wsha.org/articles/new-clean-buildings-standard-start-planning-for-compliance/

Community Energy Challenge, Opportunity Council	Mark Schofield, Manager mark_schofield@oppco.org	https://sustainableconnections.org/community-energy-challenge/
C-PACER	Shift Zero (resource to support implementation)	https://shiftzero.org/pace/
Solar PV		
Over the Counter Permitting Process	Leverage Over the counter streamline permitting process	Langley, Edmonds, Skagit County, Anacortes, Bellevue, Kirkland, Seattle, etc.
Ferry Electrification		
Ferry System Electrification	Washington State Department of Transportation	https://wsdot.wa.gov/construction-planning/major-projects/ferry-system-electrification
Climate Resilience / Adaptation		
Comprehensive Planning	Guide for Puget Sound Regions	https://www.cakex.org/documents/climate-change-adaptation-through-local-comprehensive-planning-guidance-puget-sound-communities
IC Sea Level Rise Monitoring Plan	Island County data to inform Comp Plan, etc.	https://www.islandcountywa.gov/Planning/Documents/PlanningCommission/19-07221-000_IC-SLR-MonPlan_20210315%20(1).pdf
Whatcom County: Summary of Observed Trends and Expected Climate Change impacts	Report to feed into their Climate Action Plan, Prepared by Cascadia Consulting Group	https://www.whatcomcounty.us/DocumentCenter/View/53837/Whatcom-County-Climate-Science-Summary-2020?bidId=

Data Sources for Government Operations Inventory.

Sector	Contact	Comments
Buildings and Facilities and Vehicle Fleets	Larry VanHorn l.vanhorn@islandcountywa.gov Laura Beard l.beard@islandcountywa.gov Karen Hossfeld km.hossfeld@islandcountywa.gov Donna Rollag DonnaR@islandcountywa.gov> Colleen Jokinen ColleenJ@islandcountywa.gov Markell Egelston, MarkellE@islandcountywa.gov Andreana McKelvey, A.McKelvey@islandcountywa.gov Amie Weatherford, A.Weatherford@islandcountywa.gov Tami Davis, TM.Davis@islandcountywa.gov	Facilities and Fleet Manager Fleet Service Coordinator Office Manager Facilities OH Courthouse, Accts Payable PW, Finance Director PW, Accounting Supervisor PW, Accounting Fleet Solid Waste, Accts Payable PW, Accts Payable Traffic
Waste	Jeff Hegedus J.Hegedus@islandcountywa.gov	Solid Waste Director
Transportation	Heather Bickford H.bickford@islandcountywa.gov	Transportation Planner

Data Sources for Community Inventory

Sector	Contact	Comments
Electricity – Puget Sound Energy (PSE)	Nicholas.Hartrich@pse.com, Carryn.VandeGriend@pse.com	Supply electricity to Whidbey Island, emission factors provided by tom.herrod@iclei.org
Electricity – Snohomish County PUD (SnoPUD)	Garrison Marr <GBMarr@snopud.com>	Supplies electricity to Camano Island, provided electricity usage as well as emission factors.
Natural Gas – Cascade Natural Gas (CNG)	Monica.Cowlishaw@cngc.com and Kris.Forck@cngc.com	Supplies Natural Gas to Camano Island and Oak Harbor. Does not include use by Navy Operations
Propane and Fuel Oil	Census Data provided by tom.herrod@iclei.org	Data extrapolated from the census data for residential sector.
Transportation	Data from Google's Environmental Insight Explorer (EIA) provided by tom.herrod@iclei.org Ferry diesel fuel usage was provided by Kevin	Different methodology for tracking VMT between 2010 and 2019. 2010 used AADT (count-based traffic

	Bartoy <BartoyK@wsdot.wa.gov>	data). Also included ferry fuel use in 2019.
Solid Waste	Data from new Solid Waste Director, Jeff Hegedus< J.Hegedus@islandcountywa.gov>	Data and the waste mix for 2010 was inaccurately applied when corrected resulted in a significant increase in overall emissions.
Water and Wastewater	Septic System data provided by Susan Wagner SusanW@islandcountywa.gov, Oak Harbor WWTP data from Phil Matthews; pmatthews@oakharbor.org Langley WWTP data from Randi Perry; langleyutilities@whidbey.com Coupeville WWTP data from Joe Grogan; utilities1@townofcoupeville.org.	

Appendix B; Glossary of Terms

Glossary of Terms	
Annual	A frequency of once a year; unless otherwise noted, annual events such as reporting requirements will be based on the calendar year.
Base year	A specific year against which an entity's emissions are tracked over time.
Base year emissions	GHG emissions in the base year.
Boundaries	GHG accounting and reporting boundaries can have several dimensions, i.e., organizational, operational and geographic. These boundaries determine which emissions are accounted for and reported by the entity.
British thermal unit (Btu)	The quantity of heat required to raise the temperature of one pound of water by one degree Fahrenheit at about 39.2 degrees Fahrenheit. MBTU or MMBTU both stand for one Million BTUs.
Carbon dioxide (CO_2)	The most common of the six primary GHGs, consisting of a single carbon atom and two oxygen atoms, and providing the reference point for the GWP of other gases. (Thus, the GWP of CO_2 is equal to 1.)
Carbon stock	The carbon embodied in a biological system, such as oceans, trees and the atmosphere. A carbon stock that is taking up carbon is called a "sink" and one that is releasing carbon is called a "source".
CO_2 equivalent (CO_2e)	The universal unit for comparing emissions of different GHGs expressed in terms of the GWP of one unit of carbon dioxide
Direct emissions	Emissions from sources within the reporting entity's organizational boundaries that are owned or controlled by the reporting entity, including stationary combustion emissions, mobile combustion emissions, process emissions, and fugitive emissions. All direct emissions are Scope 1 emissions, with the exception of biogenic CO_2 emissions from biomass combustion.
Double counting	Two or more reporting entities taking ownership of the same emissions or reductions.
EV - Electric Vehicles	Electric vehicles (EVs) have a battery instead of a gasoline tank, and an electric motor instead of an internal combustion engine.
Emission factor	A unique value for determining an amount of a GHG emitted on a per unit activity basis (for example, metric tons of CO_2 emitted per million Btus of coal combusted, or metric tons of CO_2 emitted per kWh of electricity consumed).
Facility	Any property, plant, building, structure, stationary source, stationary equipment or grouping of stationary equipment or stationary sources located on one or more contiguous or adjacent properties, in actual physical contact or separated solely by a public roadway or other public right-of way, and under common operational or financial control, that emits or may emit any greenhouse gas.
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Fugitive emissions	Emissions that are not physically controlled but result from the intentional or unintentional release of GHGs. They commonly arise from the production, processing, transmission, storage and use of fuels or other substances, often through joints, seals, packing, gaskets, etc. Examples include HFCs from refrigeration leaks, SF_6 from electrical power distributors, and CH_4 from solid

	waste landfills.
Global warming potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one mass-based unit of a given GHG compared to one equivalent unit of carbon dioxide (CO_2) over a given period of time.
Greenhouse gases (GHGs)	For the purposes of this Protocol, GHGs are the six gases identified in the Kyoto Protocol: carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).
Greenhouse gas sink	Any physical unit or process that stores GHGs; usually refers to forests and underground/deep sea reservoirs of CO_2.
Greenhouse gas source	Any physical unit or process which releases GHG into the atmosphere.
Green power	A generic term for renewable energy sources and specific clean energy technologies that emit fewer GHG emissions relative to other sources of energy that supply the electric grid. Includes solar photovoltaic panels, solar thermal energy, geothermal energy, landfill gas, low-impact hydropower, and wind turbines.
Hydrofluorocarbons (HFCs)	One of the six primary GHGs, a group of manmade chemicals with various commercial uses (e.g., refrigerants) composed of one or two carbon atoms and varying numbers of hydrogen and fluorine atoms. Most HFCs are highly potent GHGs with 100-year GWPs in the thousands.
Indirect emissions	Emissions that are a consequence of activities that take place within the organizational boundaries of the reporting entity, but that occur at sources owned or controlled by another entity. For example, emissions of electricity used by a manufacturing entity that occur at a power plant represent the manufacturer's indirect emissions.
Intergovernmental Panel on Climate Change (IPCC)	International body of climate change scientists. The role of the IPCC is to assess the scientific, technical and socio-economic information relevant to the understanding of the risk of human-induced climate change (www.ipcc.ch).
Inventory	A comprehensive, quantified list of an organization's GHG emissions and sources.
Inventory boundary	An imaginary line that encompasses the direct and indirect emissions included in the inventory. It results from the chosen organizational and operational boundaries.
Kilowatt hour (KWh)	The electrical energy unit of measure equal to one thousand watts of power supplied to, or taken from, an electric circuit steadily for one hour. (A Watt is the unit of electrical power equal to one ampere under a pressure of one volt, or 1/746 horsepower.)
Kyoto Protocol	A protocol to the United Nations Framework Convention on Climate Change (UNFCCC). Ratified in 2005, it requires countries listed in its Annex B (developed nations) to meet reduction targets of GHG emissions relative to their 1990 levels during the period of 2008–12.

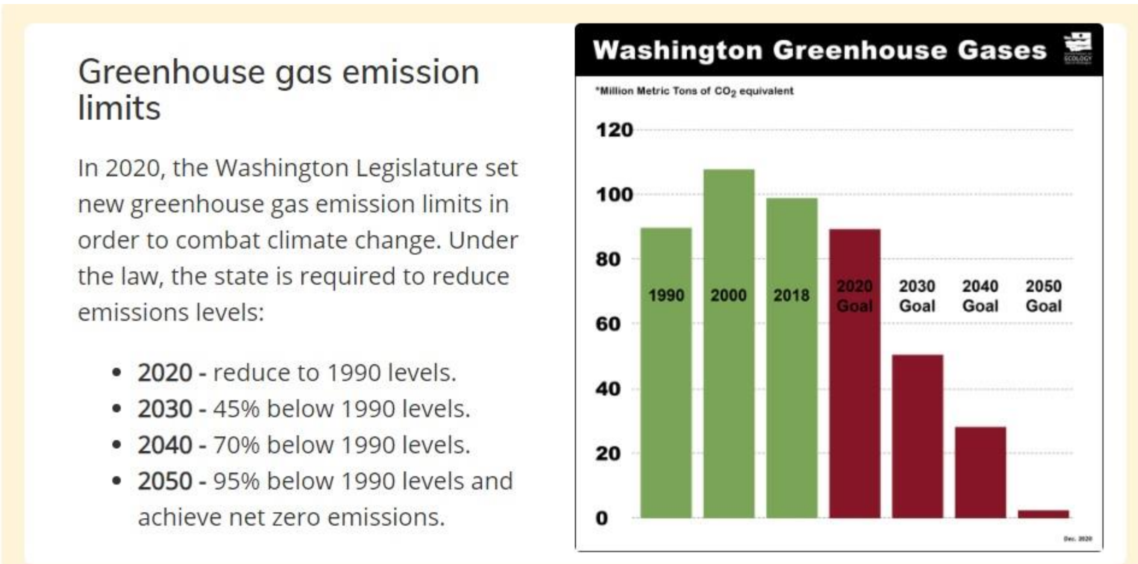
Life Cycle Analysis	Assessment of the sum of a product's effects (e.g. GHG emissions) at each step in its life cycle, including resource extraction, production, use and waste disposal.
Methane (CH_4)	One of the six primary GHGs, consisting of a single carbon atom and four hydrogen atoms, possessing a GWP of 28, and produced through the anaerobic decomposition of waste in landfills, animal digestion, decomposition of animal wastes, production and distribution of natural gas and petroleum, coal production, and incomplete fossil fuel combustion.
Metric ton (MT, tonne)	Common international measurement for the quantity of GHG emissions, equivalent to about 2,204.6 pounds or 1.1 short tons.
Mobile combustion	Emissions from the combustion of fuels in transportation sources (e.g., cars, trucks, buses, trains, airplanes, and marine vessels) and emissions from non-road equipment such as equipment used in construction, agriculture, and forestry. A piece of equipment that cannot move under its own power but that is transported from site to site (e.g., an emergency generator) is a stationary, not a mobile, combustion source.
Natural gas	A naturally occurring mixture of hydrocarbons (e.g., methane, ethane, or propane) produced in geological formations beneath the earth's surface that maintains a gaseous state at standard atmospheric temperature and pressure under ordinary conditions.
Nitrous oxide (N_2O)	One of the six primary GHGs, consisting of two nitrogen atoms and a single oxygen atom, possessing a GWP of 310, and typically generated as a result of soil cultivation practices, particularly the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production, and biomass burning.
Operational boundaries	The boundaries that determine the direct and indirect emissions associated with operations within the entity's organizational boundaries.
Process emissions	Emissions from physical or chemical processing rather than from fuel combustion. Examples include emissions from manufacturing cement, aluminum, adipic acid, ammonia, etc.
Propane	A normally straight chain hydrocarbon that boils at -43.67 degrees Fahrenheit and is represented by the chemical formula C_3H_8.
SBT or Science Based Target	Science-based targets are climate goals in line with the latest climate science. They represent your community's fair share of the ambition necessary to meet the Paris Agreement commitment of keeping warming below 1.5°C.
Scope	Defines the operational boundaries in relation to indirect and direct GHG emissions.
Scope 1	All direct GHG emissions, except for direct CO_2 emissions from biogenic sources
Scope 2	Indirect GHG emissions associated with the consumption of purchased or acquired electricity, heating, cooling, or steam.

Scope 3	All indirect emissions not covered in Scope 2. Examples include upstream and downstream emissions, emissions resulting from the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, use of sold products and services, outsourced activities, recycling of used products, waste disposal, etc.
Short ton (ton)	Common measurement for a ton in the U.S. and equivalent to 2,000 pounds or about 0.907 metric tons.
Therm	A measure of one hundred thousand (10^5) Btu.
United Nations Framework Convention on Climate Change (UNFCCC)	Signed in 1992 at the Rio Earth Summit, the UNFCCC is a milestone Convention on Climate Change treaty that provides an overall framework for international efforts to mitigate climate change. The Kyoto Protocol is a protocol to the UNFCCC.
VMT – Vehicle Miles Traveled	A measurement of total miles vehicles traveled in Island County applied to an EPA average vehicle type and MPG on the roads to estimate the total carbon emissions from the transportation sector.

Appendix C: Washington State GHG Emissions limits Legislation

Mitigating and adapting to the impacts of climate change have become a much higher priority since 2010 for the State of Washington. The impacts are being felt today in terms of the frequency of more extreme weather events such as wildfires and floods, overall water supply, sea level rise and ocean acidification.

In 2020 Washington State set new limits to GHG emissions.   Island County does not have a 1990 baseline so cannot directly assess how we are doing against these goals, but we can use the same targets as below utilizing the 2010 baseline.



Appendix E: Electric Vehicle Batteries, Addressing Questions and Concerns about Critical Materials and Recycling. By the Union of Concerned Scientists.

Union of Concerned Scientists

FACT SHEET

Electric Vehicle Batteries

Addressing Questions about Critical Materials and Recycling

HIGHLIGHTS

Electric vehicles are critical to reducing transportation pollution and solving the climate crisis, but manufacturing them at the necessary scale will require significantly increasing production of the batteries that power them. How batteries are made, what they are made of, and whether they are reused or recycled affect the sustainability of this crucial component. Even though batteries last many years, they eventually reach the end of their useful life for powering electric vehicles. Policies and incentives for recycling and reusing batteries, including strong health and labor standards, will further lessen the impacts of electric vehicles.

Battery electric vehicles (BEVs) are a key strategy for reducing air pollution and global warming emissions. They have zero tailpipe emissions, and even when powered by today's sources of electricity, their life cycle global warming emissions are significantly lower than those for vehicles fueled with gasoline or diesel (O'Dea 2019; Reichmuth 2020). However, the increased adoption of BEVs raises important questions about the availability, recyclability, and sustainability of battery materials.

Scaling up BEV manufacturing will mean increasing the production and processing of several materials used in today's lithium-ion batteries. Fortunately, strategies for recycling lithium-ion batteries offer the possibility of a sustainable, long-term supply of such materials, supporting the continued deployment of electric vehicles (EVs). However, implementing those strategies will require addressing a number of technical, economic, logistic, and regulatory barriers.

Courtesy of Li-Cycle

Recycling the cobalt, lithium, and other critical materials in electric vehicle batteries will help meet increased demand for materials as vehicle sales grow in future years and reduce the need to mine new materials. Recycling facilities are currently few and far between—Li-Cycle (shown above) is one of just 10 or so in the world operating today—underscoring the need for policies to help promote increased recycling.

Battery Materials and Their Availability

Battery packs in EVs contain hundreds, even thousands, of individual lithium-ion batteries, typically referred to as cells and often similar in size to AA alkaline batteries. Cells consist of two electrodes: the anode (the negative terminal of a battery in use) and the cathode (the positive terminal). When the battery is operating (discharging), lithium ions move from the anode to the cathode through an electrolyte (often a liquid) and a plastic separator that prevents the anode and cathode from coming into contact and short circuiting the cell. Electrons flow around the separator from the anode to the cathode through the device powered by the battery.

To facilitate smooth charging and discharging, battery packs consist of multiple cells bundled into modules. Combining several modules with additional packaging and thermal management systems creates the finished battery pack used in EVs.

Of the materials used in lithium-ion battery cells, the US government deems many to be “critical” (Box 1) (DOI 2018). These elements are crucial to battery performance, yet their supply is at risk, whether due to material shortages or because supplies are concentrated or processed in a single country (Bauer et al. 2010).

Different types of lithium-ion batteries are distinguished by the metals that make up the cathode. The choice of materials affects important battery characteristics such as longevity, cost, and energy density (the amount of energy a certain size battery stores). The choice also affects other battery components, such as thermal and power management systems.

The cathode, which accounts for roughly one-quarter of the cost of a battery, combines lithium with nickel, manganese, cobalt, aluminum, or iron. Aluminum is also used as the cathode’s current collector and in packaging for the cell and module. The anode typically consists of graphite and a copper current collector.

Early lithium-ion battery cathodes relied heavily on cobalt. Today’s batteries use less cobalt per kilowatt-hour (kWh) of energy capacity, although it is still commonly used because it contributes to a battery’s energy density and chemical stability. Both the high price of cobalt and negative impacts of mining it motivate efforts to reduce the amount of cobalt in batteries. In 2018, lithium-ion batteries averaged 28 kilograms of cobalt per 100 kWh across all battery end uses and chemistries. This amount is expected to decrease by 60 percent by 2035 (Figure 1, p. 3).

New and low-cobalt cathode chemistries can offer improved battery performance through higher energy densities. Battery cathodes using less cobalt include nickel-cobalt-aluminum oxide (“NCA”) and some nickel-manganese-cobalt oxide (“NMC”) compositions. In addition, major manufacturers of light- and heavy-duty BEVs widely use cobalt-free cathodes based on lithium iron phosphate (“LFP”).[1]

Still, even with significant reductions in the amount of cobalt or other critical materials, overall consumption will rise as more EVs are produced and the capacity of each vehicle’s battery increases. More than 60 gigawatt-hours (GWh)[2] of lithium-ion battery capacity has been deployed in roughly 1 million BEVs in the United States since 2010. EVs sold in 2019 alone accounted for more than one-quarter of the total battery capacity deployed (16 GWh) (Ambrose et al. 2020). The significant role of BEVs in reducing emissions from the transportation sector will continue this rising demand for materials.

In the 10 years since manufacturers deployed the first modern BEVs, the capacity of battery packs in passenger

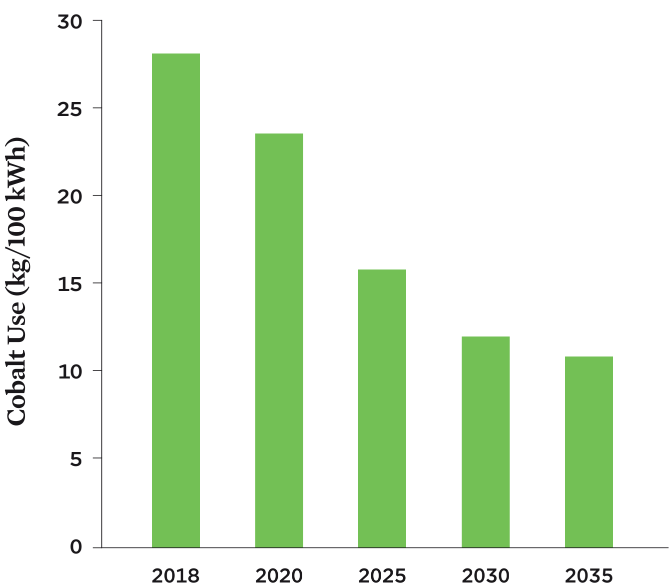
BOX 1.

Rare, Precious, or Critical?

While often used interchangeably, the terms “rare earth metals,” “precious metals,” and “critical minerals” refer to different things. Despite their name, rare earth minerals, a group of metals on the periodic table, are not the rarest elements in Earth’s crust (Haxel, Hedrick, and Orris 2002). However, they are considered critical due to their importance in many technologies (e.g., lighting, displays) and the potential for disruptions in their supply. While rare earth minerals are used in electric vehicle motors, they are not components of lithium-ion batteries. Precious metals, such as platinum, gold, and silver, are generally the rarest elements in the earth’s crust. They, too, are considered critical given their importance in technologies (e.g., catalytic converters in diesel and gasoline vehicles) and limited availability.

Several materials in lithium-ion batteries are critical, but they are neither rare-earth nor precious metals. These materials include lithium, nickel, manganese, cobalt, aluminum, copper, and graphite. Some are used primarily in other industries. For example, the production of stainless steel accounts for nearly 80 percent of global production of nickel. However, batteries consume more than half of the global production of lithium and cobalt (Miller and Moores 2019).

FIGURE 1. Reducing the Cobalt in Batteries



The high price of cobalt, the negative impacts of mining it, and higher-performing alternatives motivate efforts to use less of it in batteries.

Note: The amount of cobalt used per 100 kWh of battery capacity is based on actual (2018) and projected (2020–2035) global market shares of lithium-ion battery cathode chemistries and estimates of material demands for those chemistries.

SOURCES: NELSON ET AL. 2020; OLIVETTI ET AL. 2017; BENCHMARK MINERAL INTELLIGENCE 2019.

vehicles has increased while costs have decreased. Battery pack capacity in the first Nissan Leaf, released in 2010, was 24 kWh; the 2020 Tesla Model 3 has up to 75 kWh in capacity. With improved chemistries and larger energy capacities, the range of a passenger BEV has reached 400 miles on a single charge (Baldwin 2020). Meanwhile, between 2010 and 2020, the average price of battery packs decreased from $1,200 per kWh to $137 per kWh (Boudway 2020).

While deposits of minerals used in lithium-ion batteries are distributed widely around the world, a few countries account for most of the known "reserves"—deposits that are technically, economically, and legally feasible to extract (Figure 2, p. 4). In 2019, the global production of cobalt, nickel, and manganese each exceeded 2 percent of today's total reserves (e.g., a 50-year supply for current reserves and demand) and of lithium and graphite, less than 1 percent. As demand has grown, so have reserves with improved extraction methods and the discovery of new mineral deposits. Reserves that are more difficult to extract, however, could exacerbate the negative impacts of mining.

Extractive industries have earned a reputation for frequently violating human rights and degrading the environment. Cobalt mining in the Democratic Republic of Congo, a country with 70 percent of the world's existing cobalt production and more than 50 percent of cobalt reserves, has well-documented negative impacts on the environment, community health, and human rights (NMIS, n.d.a; Amnesty International 2016). Public attention to issues surrounding cobalt mining has led to commitments by several automakers and battery suppliers to improve conditions through supply chain sourcing, although much more needs to be done (WEF 2020).

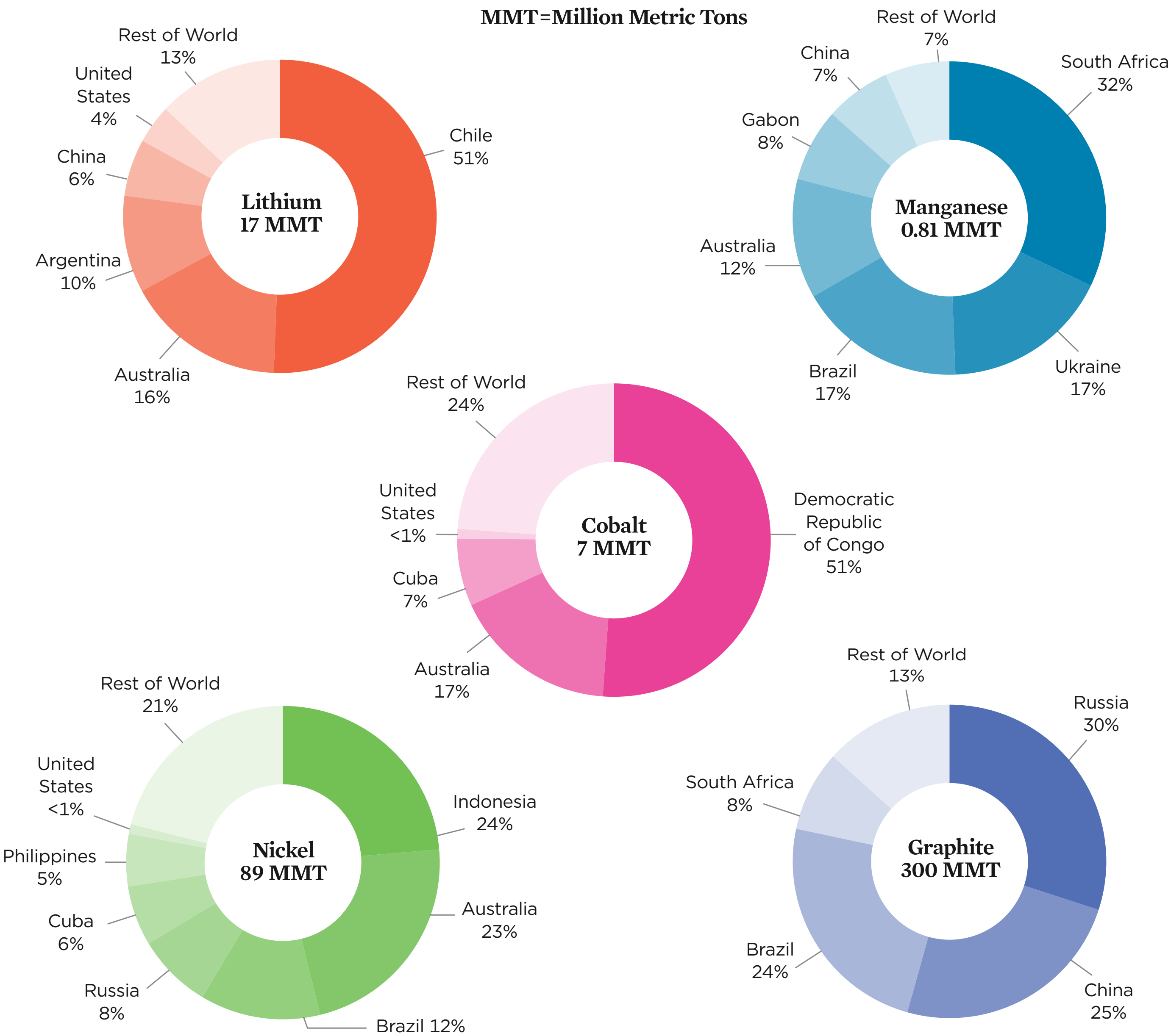
Demand for Battery Materials and the Role of Recycling

The electrification of cars and trucks will need to accelerate to avoid the most severe impacts of global warming. By one estimate, the number of passenger BEVs on US roads could increase from roughly 1 million today to 43 million by 2035 and globally from 5 million to 245 million (BNEF 2019).[3] Such growth will significantly increase demand for the minerals used in batteries. Accounting for projected changes in battery chemistry, global production of lithium, nickel, manganese, cobalt, and graphite for lithium-ion batteries across all end uses could increase five- to seventeen-fold over the next 20 years, depending on the material (Figure 3, p. 5). This could strain the availability of these materials at today's levels of economically recoverable resources and manufacturing capacity.

While producing many more BEVs will require new raw materials in the near term, recycled materials from used batteries could meet a significant portion of new demand in the future. Widespread battery recycling can create a more stable domestic source of materials for battery production, reduce the demand for raw materials, and minimize the risks of geopolitical disruptions of the supply chain. Assuming 95 percent collection and recovery of the relevant metals as an upper bound, as well as a shift toward low-cobalt and no-cobalt chemistries, the United States could meet about 30 to 40 percent of the anticipated material demand for lithium, nickel, manganese, cobalt, and graphite in passenger BEVs with recycled battery materials by 2035 (Figure 4, p. 6).[4]

[*Recycled materials from used batteries could meet a significant portion of new EV battery demand.*]

FIGURE 2. Reserves of Materials Used in Lithium-Ion Batteries, by Country



Reserves of minerals currently used in lithium-ion batteries are distributed around the world, but individual minerals are concentrated in a few countries.

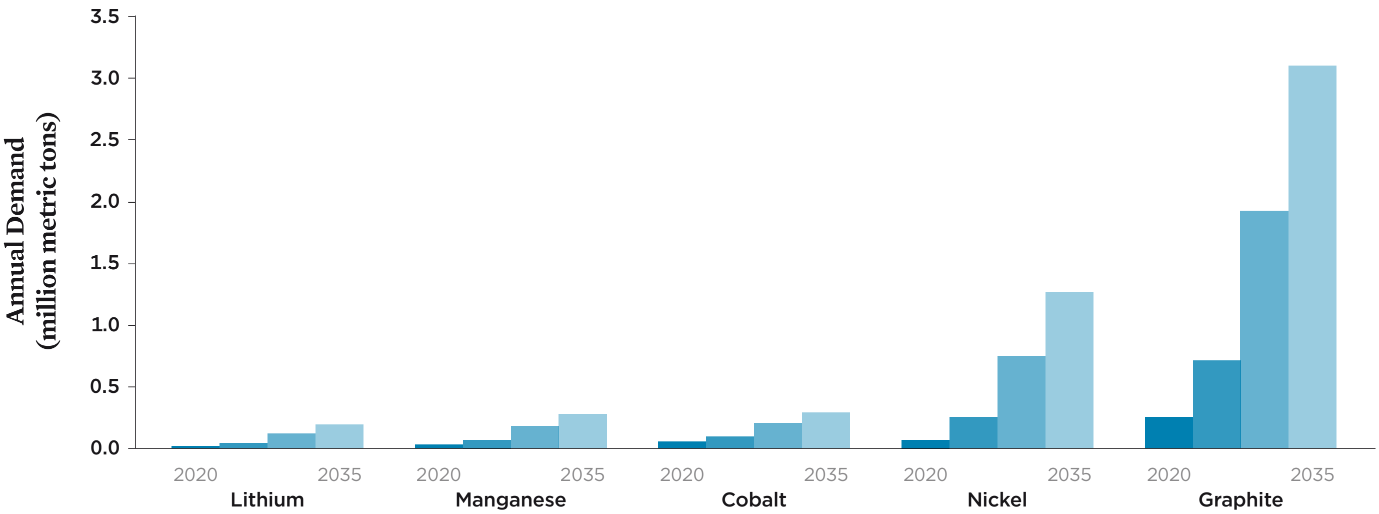
SOURCE: NMIS, N.D.B.

The Role of Batteries in Electric Vehicle Emissions

For conventional vehicles, their operation represents their largest contribution to global warming emissions. Roughly 90 percent of global warming emissions from combustion vehicles occur at the tailpipe. In contrast, all global warming emissions associated with BEVs occur "upstream." That is, they come from manufacturing vehicles and generating electricity to power them.

Work by the Union of Concerned Scientists and others has found that, based on today's average sources of electricity

FIGURE 3. Projected Annual Global Demand for Battery Materials



Meeting the expected demand for lithium-ion batteries across all sectors will significantly increase demand for minerals.

Notes: Global demand for lithium-ion batteries reflect projected changes in the market share of different battery chemistries. Material demand is based on an estimate that passenger EVs comprise 55 percent of total battery demand in 2020 (2.2 million annual EV sales), increasing to 72 percent in 2035 (35 million annual EV sales). A 50 kWh capacity is used for EVs along with a 3 percent annual increase in battery gravimetric energy density (beginning with 150 watt-hours per kilogram in 2020). Estimates of global demand include an upstream materials efficiency of 90 percent to account for loss of material during refining and processing steps.

SOURCES: NELSON ET AL. 2020; OLIVETTI ET AL. 2017; BENCHMARK MINERAL INTELLIGENCE 2019; BNEF 2019.

in the United States, the total global warming emissions associated with BEVs are about 55 percent lower than those of gasoline vehicles. In parts of the country with higher levels of renewable energy—California, for example—BEVs reduce emissions by more than 70 percent. And the emissions associated with BEVs will continue to decline as the nation derives more of its electricity from renewable resources (Reichmuth 2020; Ambrose et al. 2020; Needell et al. 2016).

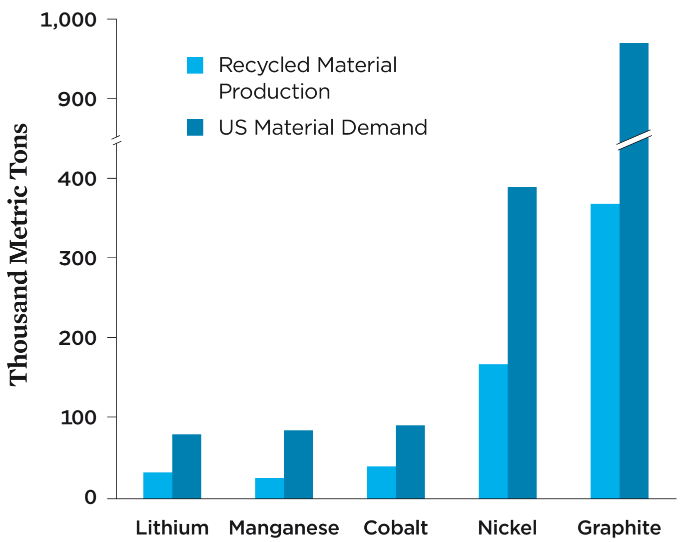
Upstream emissions from extracting and refining fuels and raw materials are also important considerations. For example, producing and processing crude oil into gasoline contributes an average of 24 percent of the fuel's overall life cycle global warming emissions in the United States, depending on the source of the oil (Gordon et al. 2015; Cooney et al. 2017).

For BEVs, battery and vehicle manufacturing can contribute 14 percent to 24 percent of a BEV's life cycle global warming emissions depending on where and how batteries are manufactured, as well as on the sources of raw materials (Ambrose et al. 2020). Overall, manufacturing a BEV contributes about 70 grams of carbon dioxide–equivalent emissions per mile (g CO_2e/mile) compared with 40 grams for a comparably sized gasoline vehicle. But because a BEV's operating-related emissions (i.e., vehicle charging) are relatively low, the total global warming emissions for BEVs on the average grid in the United States are less than half those for gasoline vehicles (200 g CO_2e/mile vs. 450 g CO_2e/mile).

Increasing the efficiency of battery manufacturing while also increasing the share of renewable energy used in assembling battery cells could reduce the global warming emissions associated with battery manufacturing by more than 40 percent (Figure 5, p. 7). Because recycling batteries reduces the need for extracting, refining, and transporting new minerals, it reduces not only emissions but also other impacts associated with these processes. Increasing the amount of renewable energy used to charge an electric vehicle, however, results in the most significant reductions in global warming emissions over the life cycle of an EV.

[***Recycling batteries reduces the need for extracting, refining, and transporting new minerals.***]

FIGURE 4. Meeting US Passenger EV Battery Demand with Recycled Materials, 2035



A significant portion of demand for battery materials could be met by recycling, transitioning to low-cobalt cathode formulations, and high levels of material recovery.

Note: Material supply and demand is based on the weighted average of US passenger EV sales and cathode market shares. The analysis is based on an on-road passenger BEV population of roughly 1 million today, increasing to 43 million in 2035, and assumes 95 percent of metals from retired batteries are recovered.

SOURCE: BNEF 2019; DUNN ET AL., FORTHCOMING.

Reusing and Recycling Batteries

When an electric vehicle comes off the road, whether due to its age or an accident, its battery must be processed in some way. Potential end-of-life pathways include reusing the battery in other applications ("second life"), recycling the battery's materials, and disposal. Even if a battery is reused, eventually its materials need to be recycled or disposed of. Most interest in battery recycling focuses on the cathode, which contains the highest-value materials (Box 2, p. 8). Understanding the opportunities for and barriers to recycling is critical to reducing the amount of mining needed for battery materials.

When an EV battery pack reaches the end of its useful life in a vehicle, it is still likely to retain more than two-thirds of its initial energy storage capacity—for example, the range of a BEV decreasing from 300 to 200 miles (Hossain et al. 2019). In some cases, such batteries could be refurbished for use in another vehicle or in a lower-power, stationary application. For example, a market could emerge for using second-life batteries for low-cost energy storage for utilities and electricity consumers (Mobility House 2018; Mobility House 2016). With the growing use of BEVs, the economic potential for reusing their batteries could further decrease the cost of new EVs and increase the value of used EVs.

Globally, fewer than a dozen facilities recycle EV batteries today, with a combined material processing capacity of less than 100,000 metric tons annually. For 50 kWh batteries with a gravimetric energy density of 150 watt-hours per kilogram, this recycling capacity corresponds to 300,000 EV batteries per year, or roughly 10 percent of global annual EV sales today, but 1 percent of expected annual sales in the early 2030s (BNEF 2019). In the United States, such facilities are especially limited in both number and processing capacity. One key to enabling greater recycling capacity in the United States will be increasing the domestic manufacturing of batteries.

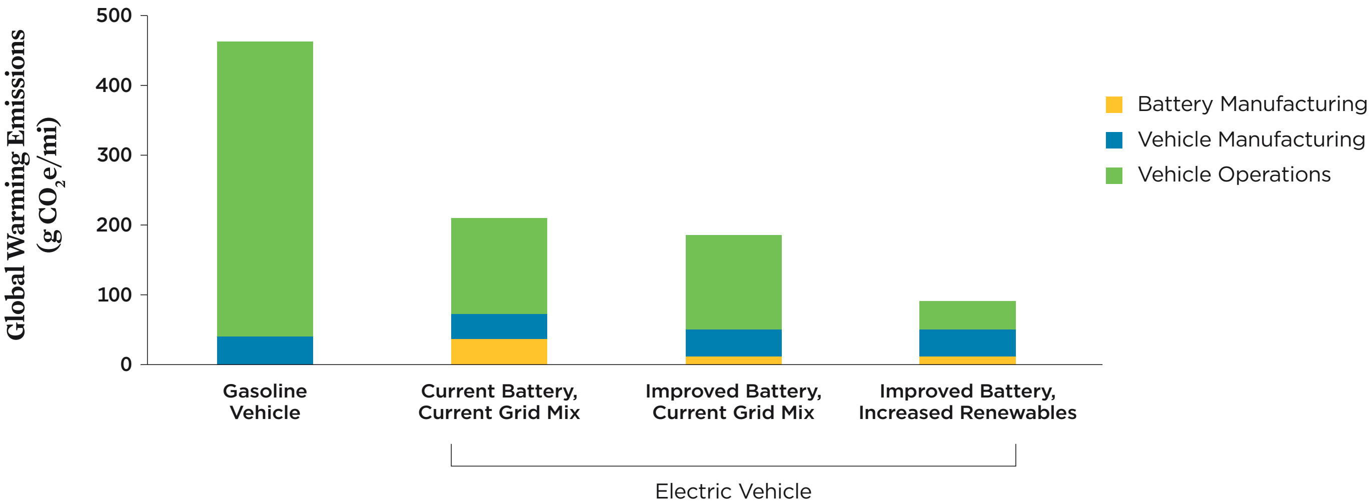
Public Policy for Responsible Battery Management

Public policy will play an important role in enabling the widespread reuse of EV batteries and promoting the recycling of their constituent materials. Currently, national and regional policies for waste management and recycling do not consider the impact of large flows of EV batteries primarily because the BEV market did not exist when such policies went into place.

Lessons learned from recycling policies targeting consumer electronics and other automotive components can inform material handling and recycling policies for EV batteries. In addition, the United States can draw on the experience of other countries with major BEV markets, some of which are beginning to consider policies to address these issues. For example, China recently enacted extensive policy and guidelines for recycling EV batteries and promoting second-life uses (MIIT 2018). The policy directs manufacturers to design batteries that enable easier recycling and to provide technical information on proper storage and management. China also places responsibility for recycling on the vehicle manufacturer, a mechanism known as "extended producer responsibility." The European Commission recently proposed extensive measures that would require collection of used batteries and set standards for recycled content in new batteries (EC 2020).

On a global level, the World Economic Forum has organized corporations, governments, and public interest groups around the world with the aim of solving key data transparency challenges related to EV batteries (WEF, n.d.). This consortium is developing standards for labeling batteries and sharing data, with the goal of providing access to critical information about battery chemistry and condition. Such information, mostly unavailable today, is critical for second-life and recycling

FIGURE 5. Mine-to-Wheel Life Cycle Global Warming Emissions of Different Passenger Vehicle Types



The total global warming emissions of EVs are far below those of vehicles powered by internal combustion engines. With increased use of renewable energy for battery manufacturing and vehicle charging, the benefits of EVs will become even more dramatic.

Notes: All scenarios assume average US vehicle lifetime mileage (155,000 miles), fuel economy (28 mpg), and electrical grid. They also assume a BEV with a 250-mile all-electric range, 60 kWh battery pack, and today's EV life cycle battery emissions of 85 kg CO_2e/kWh. The "improved battery" scenario assumes reductions in cathode cobalt content, changes in the sourcing of battery materials (e.g., nickel), using 100 percent renewable energy for battery assembly processes, and 100 percent "direct recycling" of cathode materials. The "increased renewables" scenario assumes electricity sourced primarily from renewables (73 percent), a reasonable and achievable target based on the estimated makeup of California's sources of electricity in 2030.

SOURCES: AMBROSE ET AL. 2020; CIEZ AND WHITACRE 2019; DAI ET AL. 2019; EIA 2019.

applications and would enable the tracing of batteries' properties (e.g., chemical make-up, capacity, cycle/charging history) through the chain of ownership.

As the transition to a low-carbon, electric transportation system continues, battery recycling and reuse will become an increasingly important strategy for mitigating the potential adverse impacts of producing raw materials, disposing of waste, and securing more reliable, less damaging sources of battery materials. Such a strategy should aim at securing several essential outcomes:

- Ensuring a resilient supply of future battery materials and avoiding the need for additional development of new raw material resources;
- Planning the infrastructure needed to recycle and repurpose batteries;
- Sharing information to ensure that owners, reusers, and recyclers can access important information about battery systems;
- Encouraging battery reuse and responsible logistics to maximize the useful life of batteries and ensure the safe handling of used batteries; and
- Providing incentives and establishing requirements for sustainable practices "from mine to wheel."

Several state, national, and global policy actions would provide the necessary framework to achieve greater reuse and recycling of battery materials:

- Set content targets for incorporating recycled materials into new battery cells as a strategy for closing the loop on the EV battery life cycle and increasing recycling.
- Set guidelines for facility permitting and land use to enable the safe transportation, storage, and recycling of used batteries.
- Set standards to label batteries with their cell chemistry and provide access to battery cycle and history data.
- Develop a waste designation for EV batteries that enables collection, responsible third-party reuse, and recycling for material recovery.
- Adopt and enforce international environmental and labor standards for mining and material processing and utilize independent third-party auditors to oversee mandatory compliance for battery suppliers.

With the growth of the BEV market, it is time for federal and state governments and international bodies to set requirements for the collection of used batteries, revise policies governing the classification and transport of used batteries, and set standards to ensure that batteries are recycled using

BOX 2.

The Stages of Battery Recycling

Battery recycling has three general stages:

- Pretreatment primarily consists of mechanically shredding and sorting plastic and metal materials.
- Secondary treatment involves separating the highest-value materials in the cathode from the aluminum collector foil with a chemical solvent.
- The final step is separating the cathode materials through leaching chemicals ("hydrometallurgy"), electrolytic reactions, and/or heat treatment ("pyrometallurgy" or "smelting").

safe and responsible methods. As the number of BEVs increases, so too will opportunities to make batteries from recycled materials. Realizing this future demands action today as we move forward on reducing transportation pollution and solving the climate crisis.

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ENDNOTES

1 *NCA batteries have 0.12 kg cobalt per kWh. Depending on the ratio of nickel to cobalt, NMC batteries have 0.08 kg to 0.25 kg cobalt per kWh (Nelson et al. 2020).*
2 *One GWh (one million kilowatt-hours) is equivalent to the annual electricity demand of approximately 90 single-family homes (EIA, n.d.).*
3 *Estimate includes only full battery electric vehicles.*
4 *Recycling rates for lead-acid batteries have exceeded 97 percent in the United States since the 1990s (Turner 2015). However, lead-acid battery recycling at an Exide facility in Southern California has resulted in the contamination of 7,500 homes (Barboza and Poston 2018).*

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Appendix F: Summary Report, GHG Inventory for Forests and Trees Outside of Forests, 2011 to 2016, Island County WA

Summary Report

GHG Inventory for Forests and Trees Outside Forests, 2011 to 2016
Island County, Washington

Summary

Forests and trees play a key role in mitigating climate change, yet they are often not included in local greenhouse gas (GHG) inventories or climate action plans. Island County, Washington has taken the first step towards understanding how local changes in land use and tree canopy have contributed to the county's net greenhouse gas profile. Unlike other sectors, land use (in this case, forests and trees) not only emit GHGs, they also remove CO2 from the atmosphere through photosynthesis, and play a critical role in regulating the planet's climate. The information contained in this summary report can be useful when designing climate actions that reduce GHG emissions and/or increase removals of GHGs from the atmosphere.

Key findings:

- Over the period 2011 to 2016, emissions from forests and trees were 57,051 t CO2e per year.

- Over the period 2011 to 2016, the Net GHG balance of forests and trees was -452,023 t CO2e per year.

- Roughly 47% of Island County's total land base of 54,940 hectares (135,760 acres) is forest. Many areas outside of forests are also covered by trees, including an average of nearly 16.6 percent tree canopy on lands outside of forest areas

- Over the same period, annual CO2 removals from forests and trees were -435,395 t CO2e per year. (Carbon removals are represented by negative values.)

- Total GHG emissions for Island County across all sectors could be reduced if additional forests/trees were added to its land base, and/or if losses of trees were reduced further.

Table 1. Island county's GHG fluxes from forests and trees for inventory period 2011 – 2016, all values reported in t CO2e per year

	Removals(t CO2e/yr)	Emissions(t CO2e/yr)
Undisturbed Forest	-376,593	
Forest Disturbances		37,543
Non-Forest to Forest	-9,807	
Forest to Settlement		1,383
Forest to Grassland		15,110
Forest to other non-forest lands		321
Trees outside of forests	-48,995	2,695
Harvested Wood Products	-73,679	
TOTAL	-509,074	57,051
Net GHG balance	-452,023	

Data Inputs

Data used as inputs into the GHG emission and removal calculations are described below.

Land and Forest Cover

GHG inventories for lands are reported in six "land use" categories which were defined by data on land cover—forest land, grassland, cropland, wetland, settlement and other land (barren, snow, ice). Island County's total land base is approximately 54,940 hectares (135,760 acres), with nearly 22.9% Settlement (i.e. developed areas of varying intensity), around 47.3% forest, 21.5% Grassland (which includes hay/pasture, shrub/scrub and other herbaceous cover), 1% cropland, 5.3% wetland and 1.9% other land.

Figure 1. Land cover in Island from the National Land Cover Database, 2016

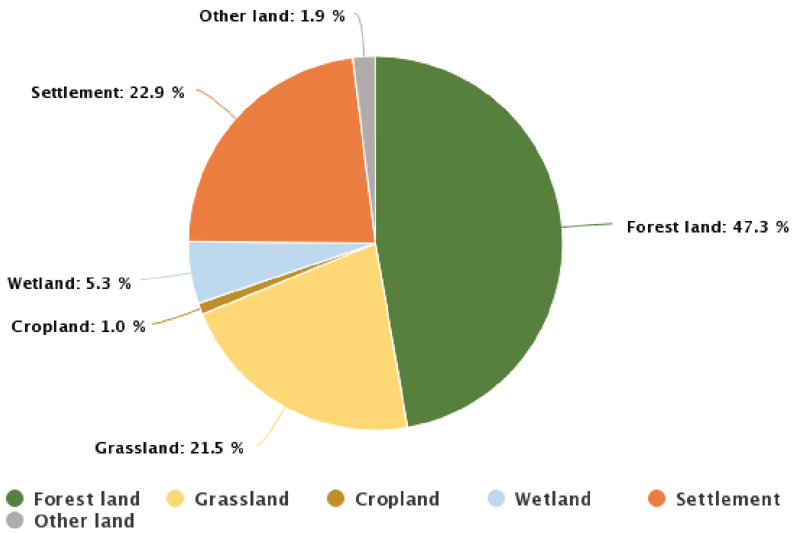
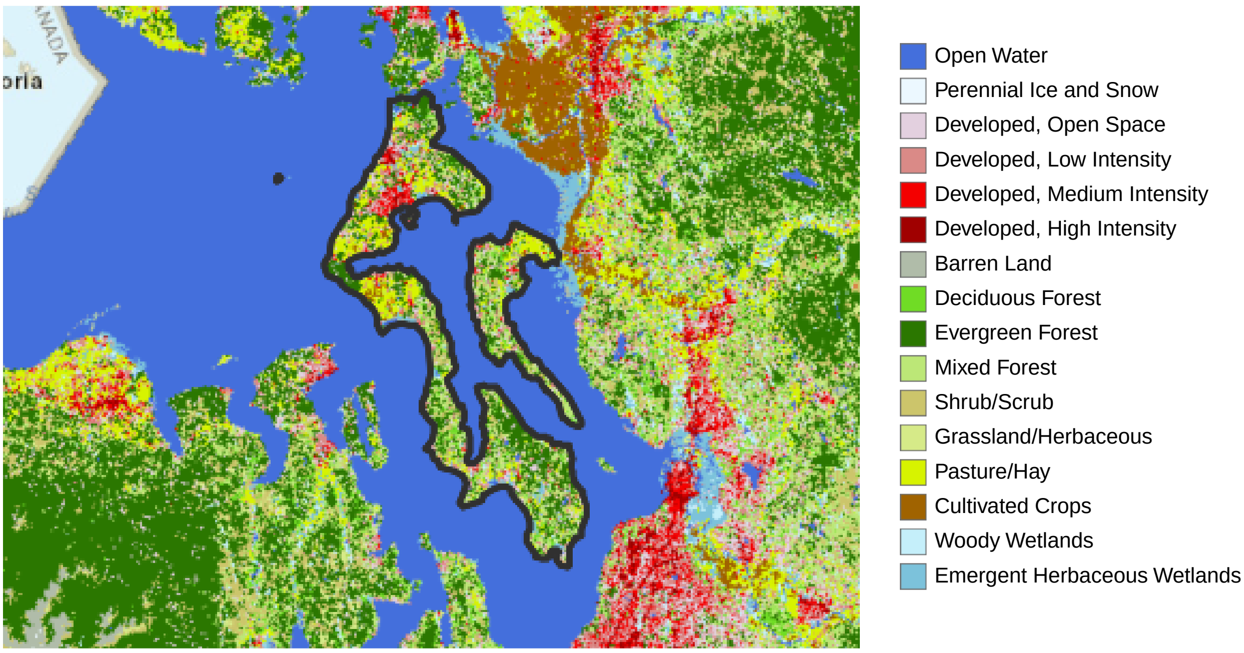


Figure 2. Land cover in Island from the National Land Cover Database, 2016

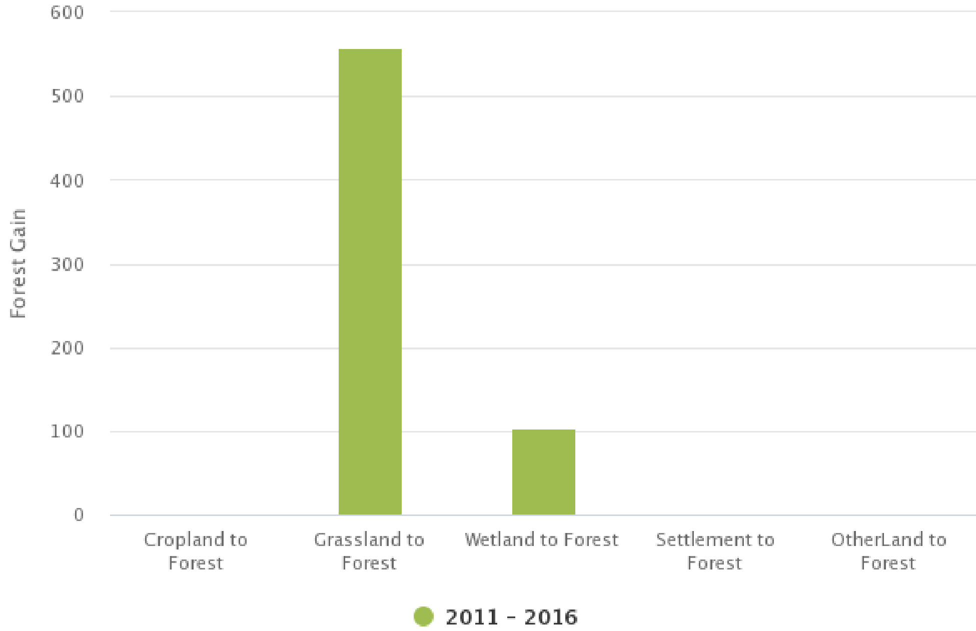


Forest Cover Change

Generating GHG estimates requires data not just on areas of land use, but also data on how land use has changed over time. Between 2011 and 2016, the county lost around 426 hectares (1,052 acres) of forest land, largely conversion to Grassland. Over the same period, the county gained around 662 hectares (1,636 acres) of forest land, largely from Grassland.

Figure 3. Loss of forest to other land use types between 2011 and 2016 (ha)

Figure 4. Gain of forest from other land use types between 2011 and 2016 (ha)



Forest Disturbances

Over the inventory period 2011 to 2016, forest disturbance from harvests/other disturbance was the most significant in Island County, affecting 337 hectares (833 acres), followed by insects, which affected 321.2 hectares (794 acres) and fires, which affected 0 hectares (0 acres).

Trees Outside Forests

Figure 5 shows tree canopy captured by the NLCD tree canopy data. (Note that some areas with high tree canopy in Figure 5 overlap with the NLCD forest class shown in Figure 2.)

This data are available only for the years 2011 and 2016. Over this time period, Island County had an average of 4,734 hectares (11,698 acres) of tree canopy outside forests. Between 2011 and 2016, 8 hectares per year of tree canopy were lost, for a total of 38 hectares (95 acres) of tree canopy loss over the 5 year period. Most of this loss occurred within the Grassland class.

Figure 5. Tree canopy 2016 (Source: National Land Cover Database)

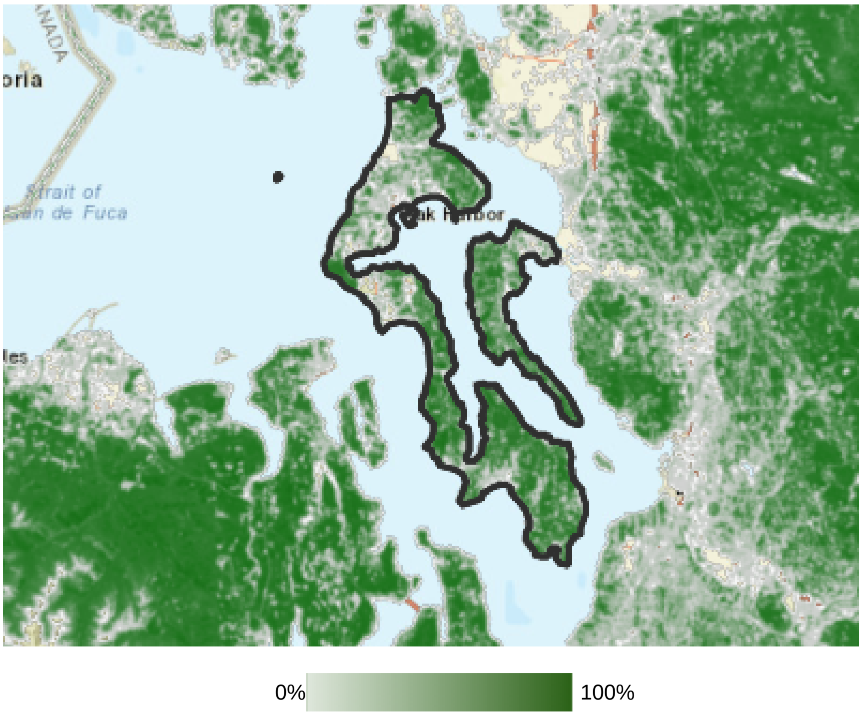


Figure 6: Average tree canopy (in hectares) and % tree canopy in different non-forest land use categories in Island County for the period 2011-2016. Note: bars relate to tree canopy area (left vertical-axis, hectares) and dots are the % tree cover per land use category (right vertical-axis). “Other” category not shown due to very low area.

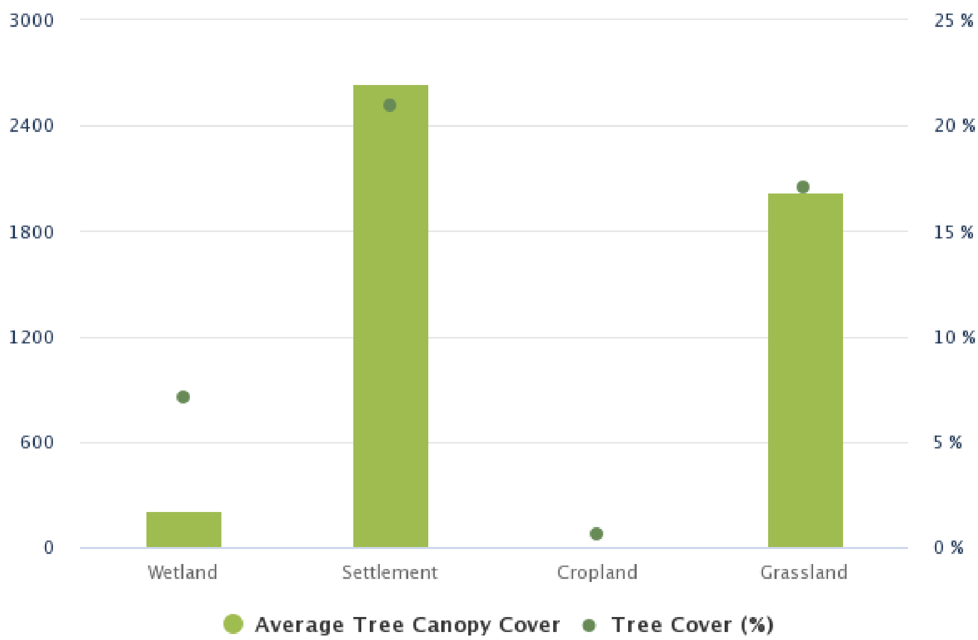
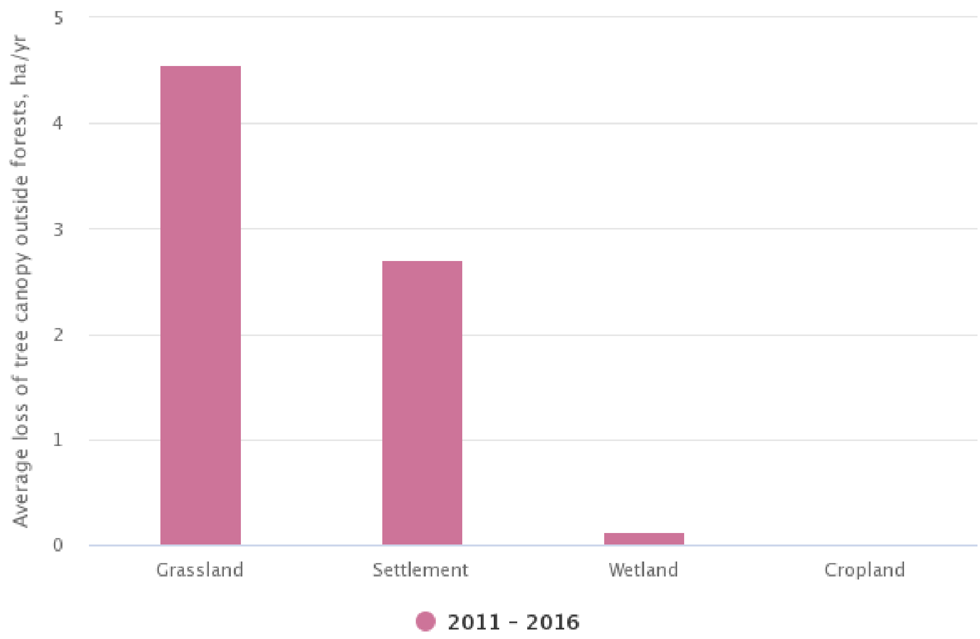


Figure 7: Average area of tree canopy loss in different non-forest land use categories in Island County over the period 2011 to 2016 (hectares per year). Note: other category not shown due to very low area.



Land Cover Change Matrix

Table 2. Full NLCD land cover change matrix for 2011 to 2016. All areas are in hectares.

2016: Top 2011: Left	Deciduous Forest	Evergreen Forest	Mixed Forest	Woody Wetlands	Cultivated Crops	Pasture/Hay	Grassland/Herbaceous	Shrub/Scrub	Open Water	Emergent Herbaceous Wetlands	Developed, Open Space	Developed, Low Intensity	Developed, Medium Intensity	Developed, High Intensity	Barren Land	Perennial Ice/Snow	Total
Deciduous Forest	2,755	3	3	0	0	0	6	7	0.3	0	0.3	0.5	0.2	0.1	0	0	2,776
Evergreen Forest	1	14,626	11	0	0	0.9	199	78	2	0.2	6	4	5	0.4	0	0	14,933
Mixed Forest	2	12	7,465	0	0	0.6	39	71	0	0	0.2	0.2	0.3	0	0.3	0	7,591
Woody Wetlands	0	0	0	431	0	0	0	0	1	2	0.1	0	0	0	0	0	435
Cultivated Crops	0	0	0	0	469	0	0	0	0	0	0	0	0.1	0	0	0	469
Pasture/Hay	0	2	1	0.3	69	7,814	11	10	3	0.6	2	2	3	1	0.6	0	7,919
Grassland/Herbaceous	1	28	6	0.2	0	1	1,018	146	0.6	0.5	0.5	2	2	0	5	0	1,212
Shrub/Scrub	28	311	180	0.1	0	3	63	2,353	0.1	0.1	0.5	0.7	0.5	0	0.5	0	2,940
Open Water	2	84	11	3	0	0	9	5	800	128	0.1	0	0.2	0	38	0	1,080
Emergent Herbaceous Wetlands	0	0	0	3	0	0	0.2	0	6	1,944	0.9	0	0.1	0	4	0	1,957
Developed, Open Space	0	0	0	0	0	0	0	0	0	0	4,595	4	11	1	0	0	4,611
Developed, Low Intensity	0	0	0	0	0	0	0	0	0	0	0	5,658	0	0	0	0	5,658
Developed, Medium Intensity	0	0	0	0	0	0	0	0	0	0	0	0	1,831	0	0	0	1,831
Developed, High Intensity	0	0	0	0	0	0	0	0	0	0	0	0	0	461	0	0	461
Barren Land	0.5	0.5	0.3	0	0	0.5	0.8	0.8	1	50	0.5	0.5	1	0.4	1,013	0	1,071
Perennial Ice/Snow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**2,789**	**15,067**	**7,678**	**437**	**538**	**7,820**	**1,346**	**2,671**	**815**	**2,125**	**4,606**	**5,672**	**1,854**	**464**	**1,061**	**0**	**0**

Table 3. Simplified land cover change matrix for 2011 to 2016.All areas are in hectares.

2016: Top 2011: Left	Forest Land	Cropland	Grassland	Wetland	Settlement	Other Land	Total
Forest Land	25,309	0	402	6	17	0.3	**25,735**
Cropland	0	469	0	0	0.1	0	**469**
Grassland	558	69	11,419	5	14	6	**12,071**
Wetland	103	0	14	2,877	1	42	**3,037**
Settlement	0	0	0	0	12,561	0	**12,561**
Other Land	1	0	2	52	3	1,013	**1,071**
Total	**25,971**	**538**	**11,837**	**2,940**	**12,596**	**1,061**	**0**

Emission and Removal Factors

A summary of the emission and removal factors used in the calculations is provided in Table 4.

	Emission Factor (t C/ha)	Removal Factor (t C/ha/yr)
Forest Change		
Deforestation		
To Cropland	0.00	
To Grassland	51.19	
To Settlement	113.15	
To Wetland	65.07	
To Other	100.41	
Reforestation (Non-Forest to Forest)		-4.04
Forest Remaining Forest		
Undisturbed		-4.16
Disturbed		
Fire	0	
Insect/Disease	-24.51	
Harvest/Other	175.13	
Trees Outside Forest		
Tree canopy loss	95.90	
Canopy maintained/gained		-2.82

Harvested Wood Products

Harvested wood products (HWP) temporarily store carbon from the forest ecosystem as the wood goes through a series of production processes and end-uses, with eventual disposal (and emission to the atmosphere). The delay represents a net benefit to the atmosphere. The period of storage varies from long-lived solid wood products that remain in use for long periods of time to products that are quickly disposed of in landfills.

In the web tool, the HWP Calculator tracks carbon in harvested wood through four different "fates," from harvest to timber products to primary wood products to end-use to disposal, applying best estimates for product ratios and half-lives at each stage. Based on user inputs entered about annual harvest volumes in Island County, the change in the harvested wood pool over the inventory period 2011 to 2016 is estimated as 73679 t CO2e per year.

Caveats

Information presented here represents a snapshot in time of the net GHG balance and many of the factors contributing to that balance. The estimates can help identify where policies may be designed to reduce net GHG emissions. This inventory currently uses a simplifying assumption that a loss of forest or trees results in immediate emissions to the atmosphere (rather than delayed emissions in the case of various use cases from long-term storage to shorter decay timelines if sent to landfills). In general, it is important to consider that these estimates represent a relatively short period of time compared with the long-term consequences of policy decisions and land management actions. For example, a forest converted to settlement represents a permanent loss of removal capacity. Over the long term, maintaining forests will sustain a higher rate of carbon removal, depending on age-related growth rates and occurrence of disturbances.

There are significant uncertainties in the estimates. Although not quantified here, typical greenhouse gas inventories of forests using similar approaches, including the national GHG inventory, report uncertainties in the net GHG balance that can be as high as ±45% (with 95% confidence). In the results presented here, the most uncertain estimates involve emissions from land-use change which are based on well-documented remote-sensing products, but relatively few field observations from a statistical sampling of county forests. While uncertainties can be high, the estimates can still provide useful information on the relative magnitude and importance of such GHGs; subsequent analyses can also provide information on the directionality of emissions and removals from land management.

Finally, it is recommended that additional analyses be done using models that project impacts of alternatives over coming decades. Such models are available and have been used in other studies at county scale. The GHG inventory presented here is only the first step to providing science-based information to support policy decisions. To more fully explore the potential impacts of alternate policies, projection models can be used to compare long-term results among the alternatives which typically include a “business as usual” (i.e. no change in policy) alternative. This feature may be added into the web tool in the future.

Appendix G: Ecosystem Services Value of County Forests, Earth Economics

NATURE'S VALUE IN ISLAND COUNTY

The Ecosystem Services Value of Island County Forests

NOVEMBER 2021

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EARTH ECONOMICS

1. INTRODUCTION

The lands and waters of Water Resource Inventory Area (WRIA) 6—a.k.a. Island County and its surrounding waters in the Puget Sound—are important to food production, employment, and recreational opportunities, and provide indirect benefits, such as water and air filtration, disaster risk reduction, and fish and wildlife habitat. To help stakeholders appreciate the value of protecting and restoring Island County ecosystems, Earth Economics conducted an aquatic and land cover-based *Ecosystem Services Valuation* (ESV) of the non-market value provided by ecosystems throughout the region and how the value changed with land cover over a 24-year period.

Forests are important sites for outdoor recreation and food production (e.g., foraging), also providing less direct benefits such as water and air filtration, disaster risk reduction, and fish and wildlife habitat. Yet forests and other ecosystems are also threatened by pollution, development pressures, and unsustainable land management. This summary was produced as part of a larger effort to communicate the value of protecting and restoring both terrestrial and aquatic ecosystems throughout the Salish Sea basin—especially those impacting quality of waters surrounding WRIA 6—which includes a valuation of the non-market ecosystem services benefits provided throughout the basin.

Ecosystem Services and Non-Market Benefits

Ecosystem services are the benefits provided by nature to people. Despite this, nature contributes substantial value to economic life: providing essential resources, protecting infrastructure, providing wildlife habitat, and other benefits that provide a foundation for human wellbeing. In recent decades, economists have developed ways to estimate the value of these "non-market benefits" so that they may be included in decision-making processes. Because the non-market value provided by ecosystem services is rarely captured in market prices, such benefits are often overlooked until their loss results in much greater costs, whether through natural disasters, diminished aesthetics, or the need to replace natural benefits with built infrastructure, such as water treatment plants. Ecosystem services are the benefits provided by nature to people. Because few ecosystem services are traded in markets, they are somewhat difficult to value.

While many consider nature to be truly priceless and resist placing dollar values on nature, conversations about land use and related decisions are usually spoken in the language of budgets, costs, and returns on investment. When the economic value provided by non-market ecosystem services is omitted, such benefits are effectively treated as having zero value, and the resulting decisions reflect that. Nature is valued in many ways by many people, but we know economic approaches can be critical when it comes to including nature in the decision-making process.

Approach

To ensure that the broadest range of benefits are included in this ESV, Earth Economics applied Benefit Transfer Methods, in which ecosystem service benefits are generalized by ecosystem type and relevant contextual variables (e.g., location, climate) as a means of rapidly generating reasonable value estimates at a much lower cost than would be necessary to conduct primary research of such scale. These per-acre, per-year estimates were then scaled by the extent of each ecosystem type (in context) to estimate the total value provided by nature across the entire basin each year.

Aside from improving understanding of the overall contribution of the region's ecosystems to human wellbeing, the ESV established a baseline by which to assess the value gained, protected, or lost through restoration, zoning, land cover change, or environmental degradation. These estimates can help decision makers achieve their restoration goals. By comparing differences in the value of ecosystem services across land cover types (e.g., forest vs. agriculture, grasslands vs. urban development), one can gain a sense of the relative gains and losses from specific patterns of land cover change. For example, the change resulting from converting forest to cropland can be estimated as the value produced by the new land cover (cropland) minus that produced by the former land cover (forest). This simple framework can support detailed comparisons of land cover change, zoning policy, growth projections, and other factors at multiple scales. It is especially effective at communicating the tradeoffs involved in changing land cover and land use, in both unit terms (per-acre conversions), and at the scale of observed or expected changes.

To demonstrate this approach, Earth Economics analyzed the ecosystem services impacts of land cover change in Island County (WRIA 6), the surrounding waters (Skagit Bay, North-Central Puget Sound, Rosario Strait, Strait of Juan de Fuca), and the watersheds contributing to those waters between 1992-2016. However, this report focuses on only those within WRIA 6. The case study reflects the complex challenges of addressing forest loss within Island County while promoting a better understanding of the economic and social benefits provided by ecologically important lands and helping decision makers to identify and rank policies by their cumulative impact on those public goods.

2. RESULTS SUMMARY

Island County has over 140 thousand acres of forests—which is about 40% of all land in the county—that are both culturally and economically important to residents. Earth Economics estimates that **Island County forests provide between $1.4 billion and $1.5 billion in non-market benefits every year** (Table 1).

Forests also play a critical role in climate change mitigation by sequestering and storing carbon from the atmosphere. Carbon storage of the county's forests was estimated using a study by Smith et al. (2006)[i] that fully accounts for all carbon stored throughout the lifetime of forests and forest products. The U.S. government values the *Social Cost of Carbon* (SCC) at $51 per ton of CO_2, a measure of the global impacts of every additional ton of atmospheric carbon, including damages to agriculture, public health, and property.[ii] This means Island County forests provide over $22 million in climate stability benefits each year.

Table 1. Annual ecosystem services value (thousand $ per year, 2019 USD) of 142,000 acres of forest in Island County in 2016.

WRIA 6	Low Estimate	High Estimate	Average Estimate
Aesthetic Information	1,269,630	1,269,640	1,269,640
Air Quality	22,310	22,310	22,310
Climate Stability	21,410	130,060	75,730
Cultural Value	2,520	2,520	2,520
Disaster Risk Reduction	29,010	29,010	29,010
Food	3	2,050	640
Habitat	32,990	32,990	32,990
Recreation & Tourism	10	1,270	640
Science & Education	250	250	250
Soil Retention	290	290	290
Water Capture, Conveyance, & Supply	230	1,080	420
Water Quality	1,690	4,800	2,830
Total	*1,380,343*	*1,496,270*	*1,437,270*

The second phase of this project used estimates similar to those presented in Table 1 (with the addition of other terrestrial and aquatic ecosystem types) as a baseline to explore changes in land cover and associated net annual ecosystem services benefits produced in Island County since 1992. The figures below show the estimated change in ecosystem services benefits due to conversion of forests to cropland and developed land cover within Island County (Figure 1), and the locations where such losses occurred (Figure 2).

Figure 1. Average loss of ecosystem services value (total, 2019 USD) over time associated with forest land cover types converted to cropland and developed land cover in Island County.

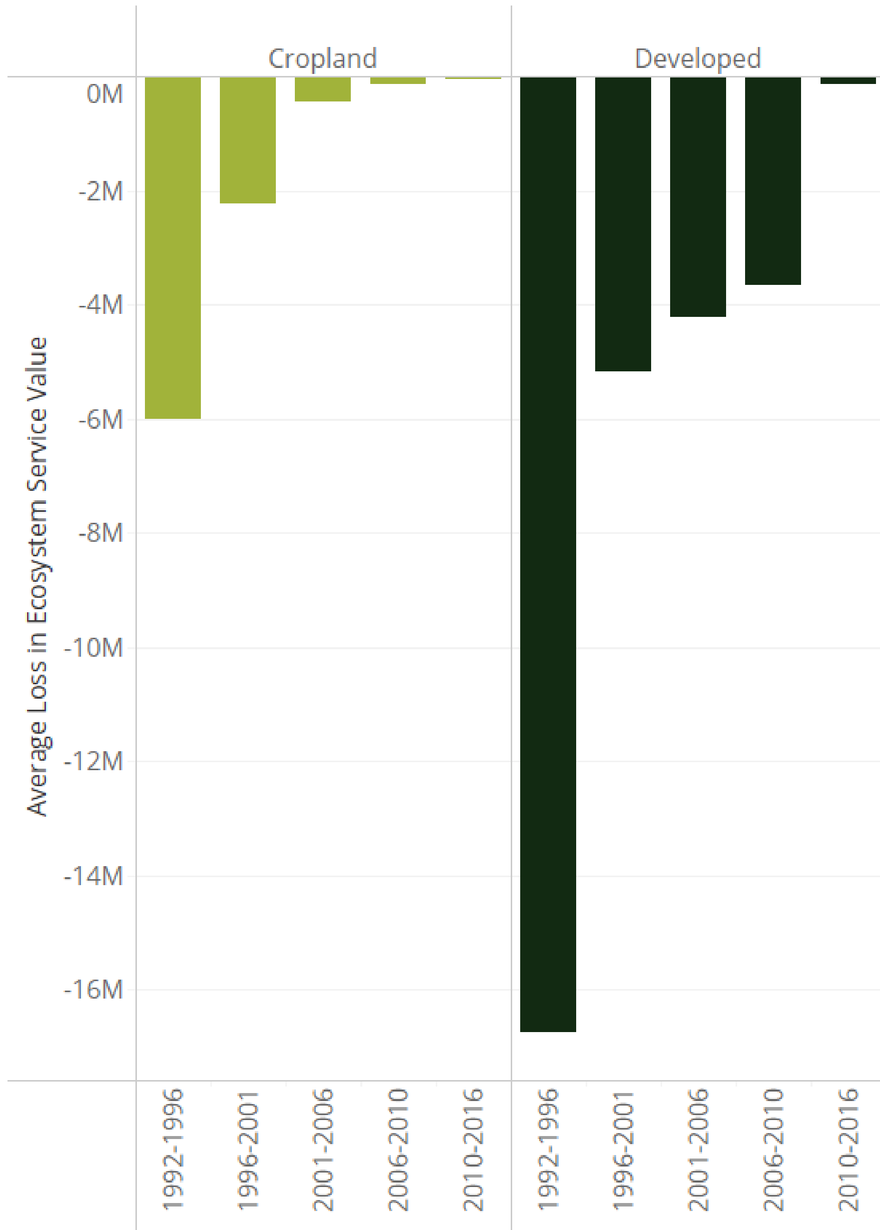
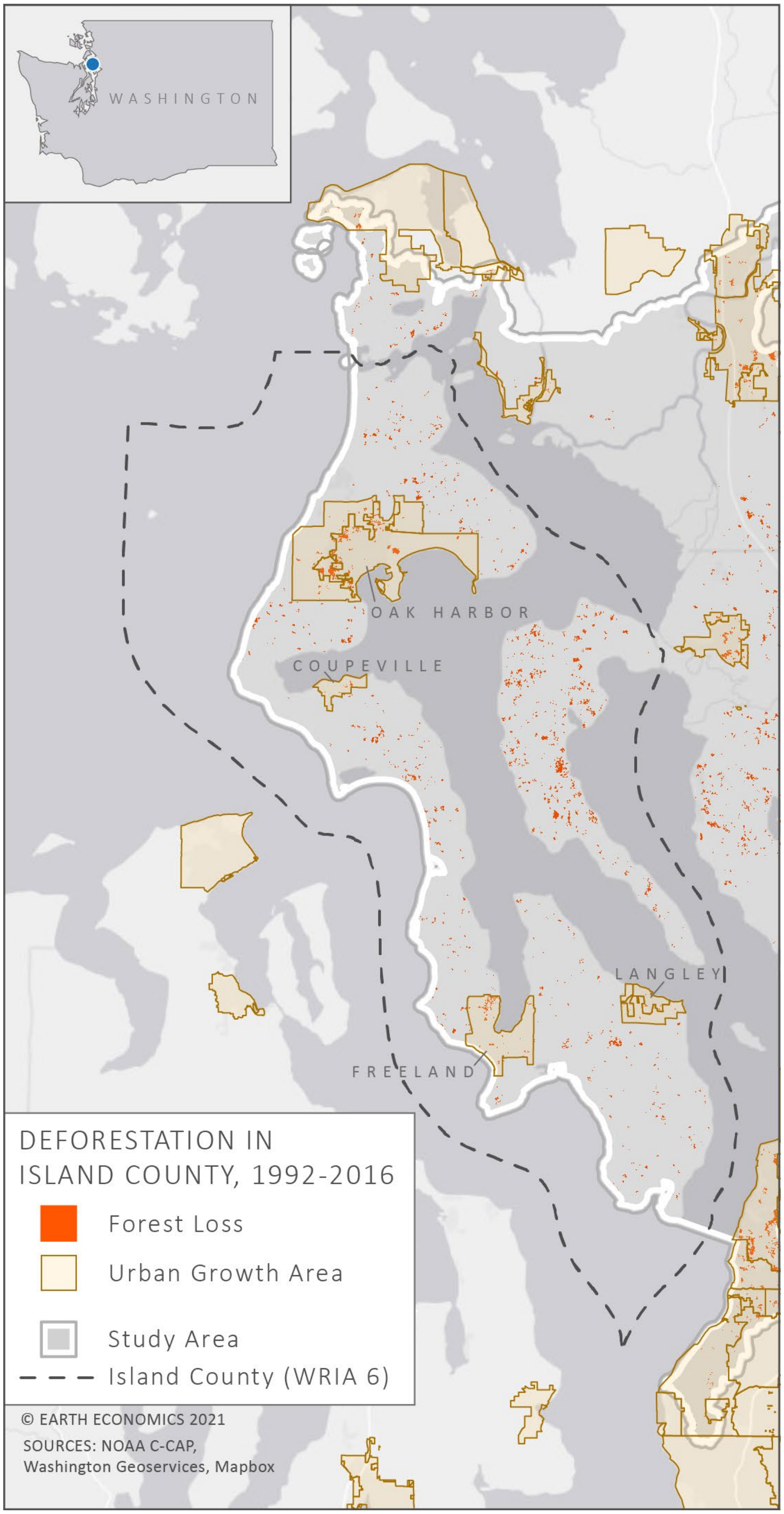


Figure 2. Loss of forest to cropland and development in Island County between 1992-2016. An interactive version of this map can be found at: https://arcg.is/0e9r8i. Forest loss data source: NOAA C-CAP.[iii]



Limitations of Ecosystem Services Valuation

This analysis was based on NOAA's Coastal Change Analysis Program (C-CAP) land cover data set,[iii] which is produced at 30-meter resolution (approximately 1/5th of an acre). Changes in land cover below that scale may not be reflected in those data. Moreover, because C-CAP (and similar) land cover data are updated once every five years, annual changes to land cover may not be fully apparent.

Tree Removal in Island County: A High-Resolution Analysis

Earth Economics identified high resolution spatial data from the Washington Department of Fish and Wildlife that captures changes in tree cover and impervious surface with the source of change (or "change agent"), including anthropogenic causes like development and logging (a.k.a. forestry), and natural causes, from 2006-2017. [iv] This data was not used in the valuation, but it was combined with current zoning maps of Island County in an interactive web map[1] to identify where tree loss occurred. This analysis focused primarily on change agents identified as forestry, development, and tree removal (Table 2). Areas designated with a change agent of only "tree removal" means that trees were removed by humans, but the researchers could not conclude it was for the purpose of commercial forestry, development, or other activities.

Table 2. Acres of tree loss in Island County from 2006-2017, by change agent.

Change Agent	2006-2009	2009-2011	2011-2013	2013-2015	2015-2017	*Total*
Development	328	52	31	108	55	573
Forestry	125	0	463	239	0	827
Tree Removal	744	356	240	660	1,360	3,360

When trees are removed and impervious surfaces – like concrete – are added for development, it's reasonably assumed that the change is permanent. In other words, once the land is developed, it's not likely to be returned to forest in the foreseeable future. Therefore, areas where these activities occur together can be useful in identifying permanent changes by zoning types (e.g., urban, rural). Between 2006-2017, trees were removed from over 550 acres in urban and rural areas for the purpose of development, with 400 acres of that development in rural zones. However, that only makes up 0.4 percent of all area in the county designated as rural (about 108,000 acres), whereas tree removal accounted for 2% of all urban areas (about 6,400 acres).

Rather than looking at just the sum of acres that experienced any change, also consider how much of an area's trees are cut down or replaced with impervious surface (i.e., the true acreage of tree loss). Table 3 presents weighted results (in acres) based on multiplying the percent of tree decrease or percent impervious increase by the acreage of the area it occurred within. For example, if an area of 10 acres had 100% tree removal, it would remain as 10 acres in the weighted results, but if it experienced 50% tree removal, it would be 5 acres. This gives a more accurate representation of acres of trees removed or acres of impervious surface added.

[1] Tree loss web map in high resolution: https://arcg.is/evnSG0

Table 3. Acres in Island County changed by Development that experienced both a decrease in tree cover and increase in impervious surface between 2006 and 2017, weighted by percent change.

Description	2006-2009	2009-2011	2011-2013	2013-2015	2015-2017	*Total*
Developed acres, weighted by tree decrease						*377*
RAID	39	5	3	5	11	*64*
Rural	145	29	18	39	38	*270*
Urban	20	4	1	16	2	*43*
Developed acres, weighted by impervious surface increase						*198*
RAID	19	3	1	2	9	*34*
Rural	56	15	13	16	24	*123*
Urban	25	6	1	6	2	*41*
				GRAND TOTAL		*575*

3. CONCLUSION

Forests in Island County contribute substantial non-market benefits to residents, especially in terms of climate change mitigation.

Productive forest ecosystems in Island County build and protect soils, absorb rain to recharge groundwater, gradually releasing water for downstream needs while limiting flooding. Forests managed for greater biodiversity, especially riparian forests, provide and protect critical habitat for fish, amphibians, mammals, birds, insects, and invertebrates. Trees convert atmospheric carbon to wood fiber through photosynthesis, while producing oxygen and improving air quality. Even more, forests provide substantial aesthetic value, supporting higher prices for real estate within their view shed, and offering a broad range of recreational opportunities, from hunting and fishing, to hiking, wildlife viewing, and sightseeing.

Earth Economics estimates that the forest ecosystems that exist in Island County provide between $1.4 billion and $1.5 billion in ecosystem services value every year. This valuation establishes the fact that forests in the county provide a broad range of benefits, supporting the economic and social wellbeing of both forest owners and communities nearby, downstream, and beyond. And while forests tend to be managed for the production of wood and paper products, it is possible, and even necessary, to manage for other ecosystem functions as well.

Only by understanding the immense value of ecosystem services provided by these lands can landowners, elected officials, and other stakeholders manage and regulate the stewardship of forests to maximize the economic, social, and environmental benefits they provide—benefits on which all rely.

ENDNOTES

[i] Smith, J.E., Heath, L.S., Skog, K.E., Birdsey, R.A. 2006. Methods for calculating forest ecosystem and harvested carbon with standard estimates for forest types of the United States. USDA Forest Service Northeastern Research Station, General technical report NE-343.

[ii] Interagency Working Group on the Social Cost of Greenhouse Gases. 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990.

[iii] National Oceanic and Atmospheric Administration, Office for Coastal Management. “C-CAP Regional Land Cover and Change.” Coastal Change Analysis Program (C-CAP) Regional Land Cover. Charleston, SC: NOAA Office for Coastal Management. Available at www.coast.noaa.gov/htdata/raster1/landcover/bulkdownload/30m_lc/.

[iv] Washington Department of Fish and Wildlife, 2017. High Resolution Change Detection (HRCD). Available at http://www.pshrcd.com/#/data.

EARTH ECONOMICS

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