LOPEZ ISLAND 2025

sustainable transformations for resilience

Prepared for
Lopez Island, WA

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EXECUTIVE SUMMARY

Lopez Island, a small community of around 2,800 permanent residents in Puget Sound, stands at a crossroads. The changes it sets in motion and implements between now and 2025 will set the island on a sustainable, stable trajectory, or one marked by turbulence and uncertainty. With an aging population, income disparity, rising fuel prices, and other critical risk factors already shaping many discussions on Lopez Island, the time has come to turn some of these conversations into action.

After presenting an overview of the current practices in several of the island's key systems, we highlight some potential risk areas for the island and then suggest potential solutions to help Lopezians bring about sustainable transformations for resilience – so called because they exist at the intersection of environmental sustainability, resilience and adaptability, and cultural acceptability. We use this novel and innovative framework to analyze each potential solution and determine its merit. Our analysis stems from extensive background research and an intensive research trip to Lopez Island, and many of the solutions we present come directly from ideas gathered in interviews and conversations with Lopezians and local experts.

We organize our research around four key systems on Lopez Island: **transportation; agriculture and water; waste;** and **electricity and heating**. Within these subject areas, we identified 17 potential solutions that Lopezians should begin to implement between now and 2025 to set the island on a sustainable and resilient trajectory. In order of combined score for environmental sustainability, resilience and adaptability, and cultural acceptability, the 17 solutions are:

1) *Host seasonal community events to promote local agriculture*
2) *Localize the waste collection system*
3) *Collect and distribute treated sewage water from the Fisherman Bay sewage district for use in select crop irrigation*
4) *Create an energy interest group*
5) *Create a value-add communal industrial kitchen*
6) *Conduct a transportation infrastructure climate change vulnerability assessment*
7) *Implement "Lopez Rocks & Rolls" – an informal rideshare program*
8) *Improve bicycling infrastructure*
9) *Promote local farmers through educational campaigns*
10) *Participate in OPALCO's MORE program*
11) *Conduct a solar resource site assessment*
12) *Take advantage of Energy Efficiency Snapshots from OPALCO*
13) *Use available financing for energy efficiency improvements*
14) *Build a co-op greenhouse*
15) *Conserve energy and shift usage away from peak hours*
16) *Increase the share of hybrid vehicles on the island*
17) *Form a local agriculture advisory committee*

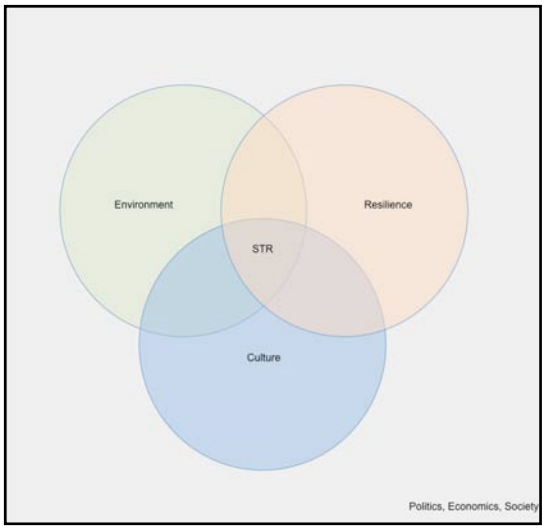
Recognizing some important limitations to our study like limited time, geographic distance, and lack of technical expertise, we believe that other island communities and city planners and strategists will find our potential solutions and risk assessments applicable to their work. Perhaps most importantly, we see our framework of analysis – using environmental sustainability, resilience and adaptability, and cultural acceptability as metrics by which to assess potential solutions – replicable in a variety of circumstances and locations

KEY DEFINITIONS

Sustainable Transformations for Resilience

As island communities around the world consider their future in the context of global paradigm shifts, successful growth trajectories will require leveraging synergies between environmental sustainability, resilience and adaptability to shocks and change, and unique culture, heritage and tradition. We call the changes needed to achieve such growth trajectories sustainable transformations for resilience. These island-scale transformations – in personal behavior, infrastructure, social and economic systems, and in other areas – protect the environment while meeting the needs of current and future generations and they complement the island's culture, heritage, and tradition. They promote resilience in that they improve the island's ability to adapt to or recover from external shocks and broader economic and environmental changes. The image to the right depicts visually how sustainable transformations for resilience (STR in the diagram) at the intersection of the three overlapping circles can simultaneously promote three different areas that are of critical importance to islands. As the grey box surrounding the diagram below suggests, planning strategies must also be feasible within the island's political, economic, and social constraints.

Island-specific culture, tradition, and heritage, along with resilience and adaptability and environmental sustainability, constitute the three pillars of our sustainable transformations for resilience. We deploy these three concepts in our report in the following manner:



Culture, Heritage, and Tradition

We learned a great deal about Lopez Island's rich history, traditions, and cultural heritage, as well as its current social norms and its many other unique characteristics during our many conversations and interviews with island residents. The analysis and potential solutions that follow in this report are rooted in and address these aspects of Lopez that give the island its personality.

Resilience and Adaptability

Throughout this report, we use resilience to mean the capacity to which a society, community, geographic location, ecosystem, or other system can spring back or recover from shocks to that entity's normal mode of functioning. Adaptability for us entails the ability of a system, based on its unique characteristics, to transform itself to succeed within a new set of demands, constraints, opportunities, and challenges.

Environmental Sustainability

For the purposes of this report, we use the US Environmental Protection Agency's definition of environmental sustainability: Environmental "sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations."

INTRODUCTION

AN ISLAND FOCUS...

While even a quick online image search will reveal the natural beauty of Lopez Island – something tourists and residents alike see firsthand – what may not appear to nonresidents and outside observers is everything else that makes Lopez unique among the world's thousands of inhabited islands. We firmly root our report in a consideration for Lopez Island's unique demographics, strengths and weaknesses, risks, history and culture, aspirations and concerns. Indeed, this report sets out to support the island's efforts to build sustainability and resilience into its strategic planning and growth trajectory – and it could not do so without first developing an understanding of what makes Lopez, Lopez.

With a land area of about 30 square miles (roughly equal to the size of Manhattan), Lopez Island is the third largest in San Juan County – a collection of islands in Puget Sound in the northwest corner of Washington state. During the summer months, tourists, particularly bicycle enthusiasts, flock to Lopez due to its relatively flat topography and scenic beauty. The island is mostly rural and residential, with a small downtown area consisting of shops, restaurants, and other professional services companies [1].

Lopez has a population of almost 2,800 that can swell to over 5,500 during peak tourist periods like those around the 4th of July. Accounting for 16 percent of San Juan County's population, Lopez's population will grow by over 20 percent to surpass 3,400 by 2025 [2]. Lopez's median age of 56.8 years is nearly a generation older than the national median age of 37.2 [3]. The population pyramid in Figure 1 illustrates older adults comprising a relatively large proportion of Lopez's population. Figure 2 compares the percentage of population for the age categories of under 50, age 50 to 59, and age 60 and over, for Lopez, San Juan County, Washington State, and nationally. Demographers expect San Juan County's seniors aged 65 and older to account for 38 percent of the county population by 2020, roughly 2.5 times higher than the expected state percentage [4]. Seniors occupy an even larger

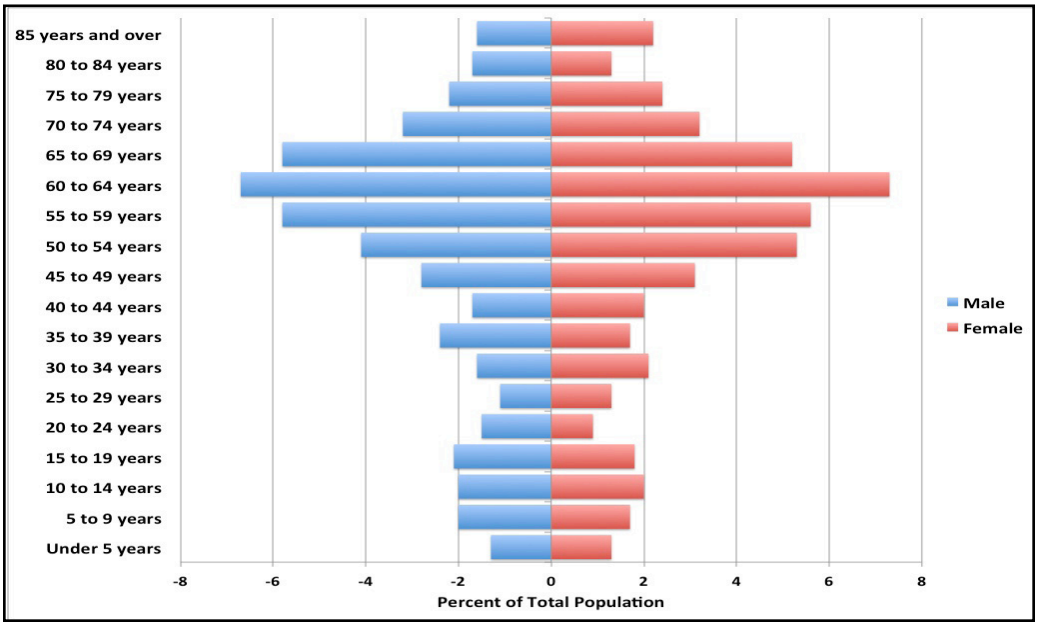


Figure 1:
Age profile of Lopex Island.

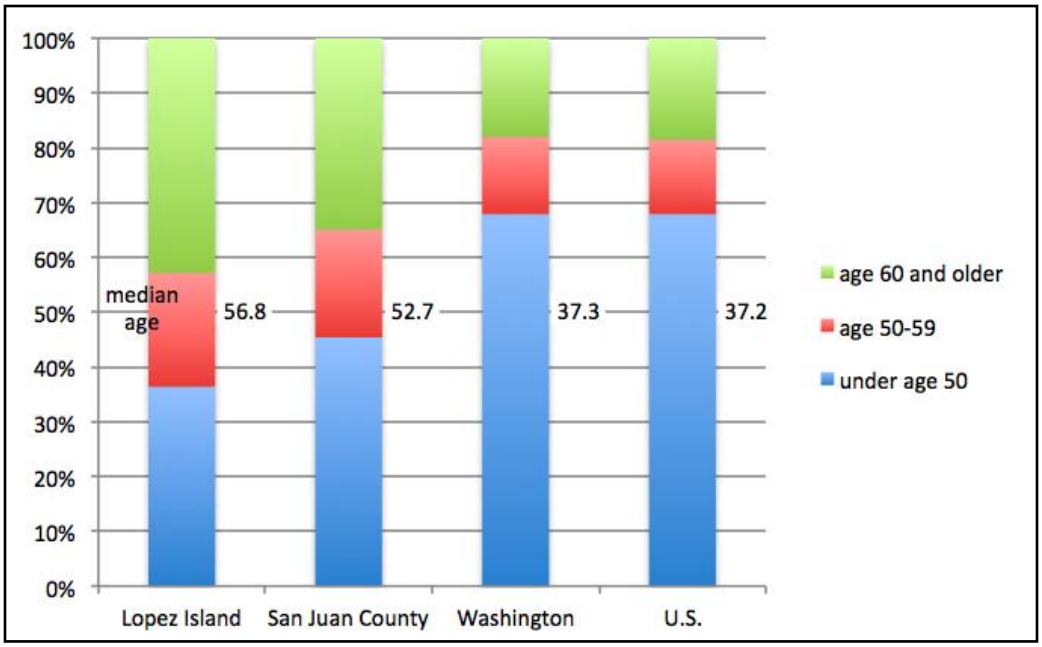


Figure 2:
Age Category Comparison.

proportion of the population on Lopez, highlighting the challenges Lopez will face meeting the needs of a large growing senior population.

According to the 2010 decadal US Census, Lopez Island had 3,249 housing units, more than half of which (1,673) were seasonally vacant. By comparison, only 3 percent of all housing units in Washington state were seasonally vacant in 2010. The average permanent resident household size is just under two individuals. Owner-occupied residences make up about 75 percent of permanent residences on the island, while renter-occupied units account for the other 25 percent ([3] and [4]).

Median household income on Lopez Island in 2010 was $52,600, almost $5,000 less per household than the statewide figure of $57,200 [5]. A relatively high cost of living compared to the rest of the state weighs additionally on Lopezian's already relatively low household income. For example, the median home sales price on Lopez Island during the first quarter of 2012 was just over $350,000 [6], while the median home sales price for the state during the same time was $208,300 [7]. In addition, Lopez Island residents regularly pay about $0.50 more per gallon of gasoline on the island than they would on the mainland. Lopez Island may not be poor by many measures, but neither is it free of poverty [1]. According to the 2010 census, 21 percent of Lopez Island families with children under the age of 18 live below the US Census' poverty level (between about $15,000 and $20,000 per year per family, depending on family size), compared to 15 percent in Washington ([5] and [8]). Perhaps even more surprising, 51 percent of elementary school students on Lopez Island qualify for free or reduced lunch [9].

The island's age profile, depicted in Figure 1, plays a significant role in determining income and wealth on the island. One quarter of the population earns income through non-social security retirement benefits. The island's unemployment rate is under 4 percent, but only about half of the population over the age of 16 has steady employment compared with two thirds of the 16 and older population in the state of Washington. This most likely results from the high number of retirees on Lopez Island [5].

...IN A GLOBAL CONTEXT

The 21st century will see massive sociological, economic, and environmental shifts on a global scale not seen since the height of the Industrial

Revolution over 200 years ago. Islands are particularly vulnerable to shocks and shifts, whether on a global, regional, or island scale. How islands choose to adapt to these new realities will determine their ability to thrive in a world of economic uncertainties, social transformations, and environmental change. It is in this context of global paradigm shifts that we situate our analysis for Lopez Island.

These shifts are already underway. Take, for example, climate change. Sea levels have risen over 8 inches since 1900 [10], as glaciers are melting at a faster rate than anytime in the last 350 years [11]. Unprecedented ocean acidification – a result of chemical reactions between atmospheric CO2 and seawater – threatens thousands of species on which coastal societies depend for their livelihood [12]. The last five summers have seen the largest polar ice melt since scientists first started collecting data over 30 years ago [13]. The 10 hottest years for the whole planet since 1880 have occurred in the last 14 years [14]. A growing body of scientific evidence links the dramatic, worldwide increase in extreme weather events to the warming atmosphere's ability to retain more moisture (see, for example, The Weather of the Future, by Heidi Cullen, a widely respected climatologist).

The world stands on the verge of global economic change. Brazil, India, and China have emerged as economic powerhouses that can outcompete the US and European Union on a number of metrics, from high-powered talent ([15]: Applied Materials CTO Mark Pinto relocates to China) to high-value investment ([16]: Intel opens its Systems Research Center in India) to high-technology infrastructure ([17]: Brazil to roll out smart meters by the millions). The 2008 financial crisis in the United States brought billions of dollars of losses to millions of people around the world, upending the way policymakers and economists previously understood the economy (See, for example, "Mind over Money" by NOVA). The European debt crisis and concurrent recessions and employment crises signaled to the world that the once stable Eurozone stood on much more unstable ground than previously imagined. A spike in food commodity prices is sending millions of people in both developed [18] and developing [19] countries into nutritional insecurity. Opaque OPEC oil production and reserves statistics [20], combined with skyrocketing costs in oil exploration, production, and refining costs [21] in the rest of the world have sent oil prices into peaks and troughs along a steadily increasing trend.

Communities are already mobilizing in the face of these global paradigm shifts. Over 500 eco-villages – communities created for environmental sustainability, self-sufficiency, and resilience to external shocks – exist throughout the world today [22]. Hundreds of college and university campuses have signed carbon neutrality pledges [23]. Cities around the world have set aggressive targets to become "green" (see, for example: [24] and [25] and [26]). A new field of island-scale sustainability is gaining momentum around the world (note, for example, Denmark's goal to be entirely reliant on renewable energy by 2050, or the new Cradle to Cradle Islands project in the North Sea). These microcosms of environmental sustainability may well prove to play not only a key role in global sustainable development, but also in long-term resilience in the face of dramatic change for communities in both developed and developing economies alike. For small islands around the world, this type of sustainable transformation can bring about a growth trajectory that achieves resilience, adaptability, and minimal environmental impact.

GUIDED BY PRIOR RESEARCH

Extensive prior work on island- and community-scale sustainable transformations, from academia as well as the public and private sectors, guided our analysis of Lopez Island. In particular, the authors benefited from local and regional analyses of Lopez Island and San Juan County. The Institute for Environmental Research and Education's "Pacific Northwest Energy Independent Communities: A 10-year

Plan" provided both data and insights into how key systems – particularly transportation and energy – on Lopez Island could be strengthened to improve their resilience and environmental sustainability. In 1998, San Juan County's Community Development and Planning Department adopted a comprehensive plan for the county's development through 2020, and it regularly updates this plan as new data or new strategic plans become available. From this plan, the authors gleaned valuable information about Lopez Island and San Juan County, including data and plans for sustainability, adaptability, and resilience already under way. Our report, in many instances, complements the ideas and development strategies found in San Juan County's comprehensive plan.

Several issue-specific San Juan County studies provided critical guidance to this report. First, the transportation section of this report gained a considerable amount of inspiration and data from the San Juan County Human Services Transportation Plan as it describes existing services and residents needs, especially senior, disabled, and low-income citizens. Second, the Agricultural Resources Committee of San Juan County published in 2011 a strategic plan for increasing the county's agricultural independence and resilience. The report, entitled "Growing our Future: An Agricultural Strategic Action Plan for San Juan County," advised the author's agriculture-related recommendations and, when applicable, background assessment of Lopez Island's agriculture sector. Third, San Juan County published in 2004 a water resources management plan that identifies water as a limiting resource for the county as a whole and islands like Lopez that do not have large, on-island, natural freshwater sources. This report places a similar importance on fresh water for Lopez Island, and draws ideas for how best to manage this scarce resource from the county's report, "San Juan County Water Resource Management Plan." Finally, the Northwest Power and Conservation Council's, "Sixth Northwest Conservation and Electric Power Plan" published in 2010 served as a foundation to the electricity and heating section of this report, as many of its action plans and data collection and analysis underpin our assessment of Lopez Island's electricity system and our recommendations for action.

While freshwater may be a limiting natural resource for Lopez Island requiring proactive management, energy may be the limiting man-made resource for the island requiring an equally proactive management strategy. Even if someday the ultimate sources of energy on the island derive from natural and renewable resources (e.g., the sun, tides, or wind), they require man-made processes to convert them to usable forms of energy (e.g., electricity, heating fuel, or transportation fuel). Throughout this project, the authors recognized the importance of energy on Lopez Island, including the security, cost, and emissions dimensions, among others. Three authors contributed significantly to our understanding of global energy imperatives that are relevant for Lopez Island. Daniel Yergin's two seminal works, The Prize and The Quest, offered a perspective on how the world arrived at the energy system we have today and where it may develop from here. Larry Lohman's article "Energy Security for Whom? For What?" published by Corner House in February 2012 gives another excellent overview of the energy transformations that the world will undergo in the coming century. Finally, James Williams' article in the November 2011 issue of Science informed our thoughts on the transition away from fossil fuels and the importance of energy system electrification in order to achieve significant reductions in greenhouse gas emissions over the long term.

The central focus of this report, however, are the island-scale transformations needed to improve Lopez Island's resilience, sustainability, and adaptability. This report treats its different subject areas – transportation, agriculture and water, waste, and electricity and heating – as overlapping and interconnected systems on the island. We therefore turned to a number of previous works on island- or

community-scale transformations, systems change, and case studies. These include: The Transition Handbook: From Oil Dependency to Local Resilience by Robert Hopkins, which presents ideas and strategies for creating resiliency and self-sufficiency in local communities that range from the impractical to the innovative; the Center for Ecosystem Literacy's "Seven Lessons for Leaders in Systems Change" that gives clear recommendations for those leading others through transformations of established systems; Steve Melia's "The Road to Sustainability: Transport and Car-Free Living in Freiburg, Germany," which describes the sustainable transformations that Freiburg, Germany, undertook over the last several years; and three reports from Lund University's International Institute for Industrial Environmental Economics (IIIEE) in Sweden, "Distributed Treasure: Island Economies," "Energy Supply Models for Transition to Renewable and Locally Produced Energy," and "Locally Sustainable Development: The Municipality of Tjorn," which each present different angles on small-scale community transformations designed by the IIIEE graduate program. The authors benefited greatly from this body of research in the field of localized systems transformations, and incorporated their lessons-learned, ideas, and key principles in this report.

SCOPE AND METHODOLOGY OF ANALYSIS

Lopez Island is connected physically, economically, socially, and environmentally to the world around it. Therefore, any island-scale analysis will necessarily need a boundary. We set our boundary to be the activities on Lopez Island or those directly resulting from activities on Lopez Island like ferry service to/from Lopez or electricity delivery to Lopez. This enables us to focus on what Lopezians can do between now and 2025 to bring about their own sustainable transformations for Lopez Island's resilience. Recognizing the important role that state, county, and, in the case of electricity and heating, utility policies play in bringing about island-scale transformations, we present broader recommendations outside the scope of Lopez-specific actions in Appendix 1.

This report is the outcome of a four-month research project conducted by 11 students at the Monterey Institute of International Studies in Monterey, CA. We structured the project in four phases: background research, pre-departure preparations, on-island research, and post-trip follow up and analysis. During the first phase, the authors conducted background research on Lopez Island, San Juan County, and previous studies and reports on island-scale sustainable transformations. Our pre-departure preparations also included numerous teleconference interviews with local experts on our key subject areas. In mid-March, 2012, nine of the authors traveled to Lopez Island for a week-long intensive research trip. During their stay, they conducted numerous site visits, interviews, and meetings, to gather as much information as possible in their limited time on the island. The authors cannot overstate the importance of this trip to their research and to their understanding of the unique characteristics of Lopez Island. Following the trip, the authors reconnected with key individuals with whom they wished to clarify or expand on information gathered on the island. This post-trip phase also included compiling all of the data and information that the authors had collected before and during the research trip.

Before arriving on the island, the authors created an online survey that they administered to Lopez residents immediately following their research trip to the island. This survey asked Lopezians questions that pertained to each of this paper's major sections – transportation, agriculture and water, waste, and electricity and heating. At the time of writing this report, 73 households had responded to our survey. Because of the high likelihood that a large majority of survey respondents were 'sustainably biased' (e.g., bicycled more than the average Lopezian, ate more locally-sourced produce

than the average Lopezian, composted more than the average Lopezian, etc.), the authors used the survey data primarily to give a qualitative perspective to a particular issue raised in the report, or to highlight trends when they became apparent in the survey data. Therefore, the authors relied on interviews with local experts as well as official reports from public and private entities to gather island-wide statistics or 'hard data.'

The authors of this report wished to create a transparent process throughout the course of this project. Therefore, they created a website, accessible to anyone, that introduces the project and the authors, and presents overview information about the project. The authors invited comments about the project on the website from all interested parties, and continue to monitor the website and respond to comments when possible. The URL to this website was distributed widely on the island through the local newspaper and email listservs, and the authors include it here and encourage readers of this report to visit it and post their comments. Readers may visit the project's website here: http://blogs.miis.edu/resilientcommunities/

REPORT ROADMAP

The authors divided their analysis of sustainable transformations for Lopez Island into four distinct categories: transportation; water and agriculture; waste; and electricity and heating. This report will reference synergies and overlaps among these areas as they arise, but each of the four topic areas will focus on its particular relevance to an issue that cuts across one or both of the other categories. For example, the transportation section might reference the transport of home heating fuel and propane, while the electricity and heating section would address how much of these fuels the island uses.

Each section follows a similar structure. First, we quantitatively and qualitatively describe current practices on the island. Next, we identify risks and problem areas associated with continuing on a business as usual trajectory. The third subsection discusses potential solutions that address these risks. The potential solutions fall into three categories, ordered as follows: 1) solutions for implementation; 2) solutions warranting further research; and 3) potential solutions that arose during our research but should not be considered for implementation at this time. We weigh the pros and cons of each solution based on the following three metrics: environmental sustainability, resilience, and acceptability on the island. We also address cost when possible. We then give each potential solution a score of 1, 2, 3, or ? for each of these metrics (3 signifying the highest score, and ? implying a need for further research). For those solutions that we suggest implementing, we include potential strategies for doing so. We present broader policy recommendations that fall outside the scope of Lopez-specific actions (e.g., for county and state policymakers) in Appendix 1. A brief conclusion marks the end of each of the paper's major sections. The paper also features vignettes, including quotes from Lopezians to accentuate an important idea, case studies to highlight a best practice, and expert insights to share local experts' perspectives on key issues.

The paper concludes by summarizing all of the Lopez-scale potential solutions – those for implementation, those requiring further research, and those not recommended for implementation – in a matrix, with each potential solution along the vertical axis and its score on each of the three metrics along the horizontal axis. We also note some ways we could have improved our analysis, and note what broader implications and applications this assessment might have on sustainable transformations for resilience elsewhere in the world.

Transportation

Early settlements on Lopez grew in clusters, each having its own school, post office, and store, reducing the need to travel across the island. This settlement pattern matched well with the earliest modes of transportation on Lopez such as boats, horse riding, and walking. In the 1920's widespread road construction began on Lopez, leading to broad adoption of the automobile [27]. The arrival of the automobile shaped modern-day Lopez and led to the consolidation of schools and businesses. Zoning laws such as the one stipulating one house per 5 acres also led to a low-density housing pattern that increased dependence on motorized vehicles.

Low population density and relative isolation as an island shape Lopez's transportation needs. Low population density has led to a dependence on cars, and as an island, Lopez depends on the Washington State Ferry as the primary means of moving traffic between Lopez and the mainland. Envisioning a more robust transportation system for Lopez given these constraints is challenging but several opportunities exist to make incremental improvements, such as increasing the share of hybrid vehicles, encouraging hitchhiking and ridesharing, and building a community transit service. However, to increase the overall sustainability and resilience of Lopez, the most effective path to achieving lasting change appears to be closing as many loops in resource flows (e.g., using waste products from one process as inputs for another) as practical and adapting the economy to rely less on the movement of goods and people on and off the island. This means re-localizing the economic structure of Lopez as much as is practical.

Below we describe the current state of transportation flows and services on Lopez, including land, air, and water transportation, and transportation fuel consumption. We gathered data from public resources as well as interviews with Lopez residents and businesses. The online survey of Lopez residents that we administered captures a snapshot of the transportation profile of a small sample of residents, lending depth to our description of the island's current practices. We then present and evaluate potential solutions, some of which we identified through direct feedback from Lopez residents.

Fuel Tanker
SOURCE: http://2.bp.blogspot.com/_4WUPg88IbTU/S90FjA-q6UI/AAAAAAAAABo/63CcKoJcmfc/s1600/

CURRENT PRACTICES

(transportation)

LAND TRANSPORTATION

We describe the current state of land-based transportation on Lopez in three categories: personal, public, and commercial. Personal transportation options include bicycling, walking, hitchhiking and carpooling. However, the dominant transportation mode remains personal motorized vehicle use. The island does not have a public transportation system, except for the school bus system. Under commercial transportation we describe the movement of goods, resources, and waste, on and off the island.

Personal Transportation

Lopez households depend on driving for many transportation needs. Lopez has over 3,200 housing units, of which around 1,400 are occupied most of the year and around 1,700 are seasonally occupied [3]. More than 2,800 motorized vehicles is available to these housing units [5]. While most households own at least one vehicle, between one and four percent of households do not own any. According to the U.S. Census Bureau, 2006-2010 American Community Survey data, 405 households had one vehicle and 932 households had two or more vehicles [5].

The annual mileage driven by respondents of our online survey covered a wide range, from only a few hundred miles last year to nearly 20,000 miles last year. On average, respondents drove 6,374 miles in their primary vehicle and 3,569 miles in their secondary vehicle for a total of almost 10,000 miles per household with two vehicles. Lopez residents regularly pay about a $0.50 premium on gasoline purchased on island compared to gasoline purchased on the mainland. However, the respondents also indicated that nearly half of their total miles driven occurred on the mainland. Correspondingly, respondents reported that just over half of their fuel purchases occurred on the mainland. If we assume an annual mileage of 10,000 per household, use the US average fuel efficiency of 22.6 miles per gallon [28], and an average price

paid per gallon of $4.25 (half of fuel purchased on mainland at $4.00, half on Lopez at $4.50), a household on Lopez spends nearly $1,900 per year on gasoline, or about $100 more per year than the identical mainland household that purchases all their fuel on the mainland. Through interviews and responses from our survey, we noted that some residents keep a vehicle in Anacortes to avoid taking a vehicle on the ferry, thereby saving on ticket cost and avoiding wait time.

Hitchhiking and carpooling currently serve as two alternatives to traveling longer distances on Lopez. Many Lopez residents view hitchhiking as a common island practice, and an opportunity to socialize with neighbors. Michael Jennings, a long-time Lopez resident, commented that "hitchhiking is part of the culture, not only accepted, but also a community tradition." Hitchhiking works well most of the year but a summertime surge of part time residents and tourists unfamiliar with the culture make it more difficult to find a ride during the summer [27]. While the frequency of hitchhiking is difficult to measure, a sense of the extent of carpooling may be derived from U.S. Census data. Lopez residents use about 700 vehicles for regular commutes and less than 80 involved carpooling. This rate of carpooling among commuters who use a car is statistically no different than the U.S. national rate [5]. To build upon the principles of hitchhiking and carpooling as transportation alternatives, San Juan County launched a ridesharing system (http://www.sjrideshare.org/) in 2006/7, but due to a lack of funding, this ridesharing program has not yet expanded to Lopez. Nevertheless, some residents feel that ridesharing programs are unnecessary because hitchhiking already serves that need. Regular hitchhiker, long-time Lopez resident, and 20-year transportation expert C.B. Hall remarked, "All you need is a thumb."

Many residents ride bicycles to replace short car trips or to exercise, making cycling a common mode of transportation on Lopez, as. Residents living within or near Lopez Village find cycling particularly convenient. Moreover, each summer many tourists come to Lopez specifically to cycle, and the annual Tour de Lopez attracts locals and tourists alike. However, for most of the island, cycling can be unsafe due to narrow shoulders or the lack of shoulders on the majority of roads including main arteries. A dearth of cycling-oriented signage to indicate road hazards, directions, and traffic rules further impedes safe cycling conditions. The summer season exacerbates this issue when the number of cyclists on the roads increases dramatically, occasionally leading to frustration among drivers when large packs of cyclists impede traffic or ignore traffic laws.

The compact size of Lopez village makes walking to complete one's errands easy. However, most residents live too far away from key areas like the ferry terminal, parks, Lopez Village, and Lopez School to make walking practical. Furthermore, the lack of shoulders on many roads reduces pedestrian safety. Despite the distances, some residents express interest in improving both island pedestrian and cyclist access with a trail network. The existing trail network totals to 1.3 miles of "road right-of-way" trails located along Fisherman Bay Road, Lopez Road, and Weeks Road, a very limited trail network indeed [29]. Road right-of-way trails are adjacent to public roads, about 4 to 5 feet wide, and ADA compliant where possible. The Lopez Community Trails Network (LCTN), a group of Lopez residents, works to improve island connectivity by "creating and maintaining a network of safe non-motorized trails to benefit all community members" [30]. Kirman Taylor of the LCTN explained that the LCTN owns no land, but they acquire public easements for building trails. This activity receives funding from private organizations like the San Juan Islands Preservation Trust, and public institutions like the San Juan County Land Bank. Taylor acknowledged that funding is not the only challenge to expanding Lopez's trail network. Many landowners express concern about granting general public access through or alongside

their properties, although they willingly grant access to individuals who ask [31].

Public Transportation

Low population density and correspondingly low potential ridership volume make it no surprise that Lopez does not have a public bus system. These characteristics also limit the feasibility of other services for community transit needs. The Lopez School District bus system is the only regular "bus service" but can transport only students under current regulations. For details on the school bus fleet and its operations, see Appendix 2. The Lopez Senior Center has one San Juan County-owned 8-person van to take seniors to the mainland for medical appointments and other errands. Volunteer drivers provide the van service to about 15 seniors on a regular basis, and the drivers typically need a one-week lead time [32]. Many residents are not aware that a taxi service exists on Lopez; it struggles to build a viable business. Ruby Walker, owner of the taxi service for the past two years, believes Lopez needs a taxi, though she struggles to connect demand to her service [33].

Given these limited services, many residents view public transportation on Lopez as an unmet need. Public meetings and resident surveys described in the San Juan County Coordinated Human Services Transportation Plan of 2010 [4] identified greatest demand by Lopez residents for the following types of service:

- *Shuttle service between the ferry terminal and Lopez village*
- *Year-round small bus service islandwide*
- *Subsidized taxi service for medical appointments and errands, serving low income seniors and mobility-constrained individuals*
- *More frequent off-island Senior Center van trips for these purposes*
- *Allow broader use of the Senior Center vans*

Such sentiments indicate a desire for public transit, and we discuss later in this paper some potential solutions to meet the demand for a public transportation network to serve the aging population as well as disabled and lower-income community members.

Commercial Transportation

This section describes the movement of goods, resources, and waste, on and off the island. We find it impossible to describe the flows for all businesses or public institutions, however we can present the flows for several key Lopez institutions, including the Lopez Village Market, the Transfer Station, the Sewer District, Lopez Sand and Gravel, and the US postal service. Food supply and waste management details are addressed in their respective sections later in this paper, however this section describes the transportation-related resource flows relevant to food supply and waste management.

The Lopez Village Market (LVM) is a primary supplier of food, fuel, and other necessities on Lopez. Owner Aaron Dye's philosophy is to "obtain whatever the customer demands. If the customer asks for it, I will try to stock it." LVM shipping expenses average around $1,000 per week for two to four shipments (usually one to two trucks of non-perishables and one to two trucks of perishables) from the mainland via the ferry. Non-produce items come from a distribution center in Seattle near Boeing field. Produce items, averaging about 170 cases per week, come from United Salad on the mainland. The quantity doubles during the summer. Despite being the only large supermarket on Lopez, LVM profit margin averages a modest 2 percent, sufficient to cover repairs and maintenance, and a summertime influx of tourists doubles sales volumes and helps LVM recoup much of those costs [34].

LVM also sells gasoline and diesel, averaging 450 to 500 gallons per day during much of the year but increasing to about 600 to 700 gallons per day during

the summer months. Annual liquid fuel sales total around 190,000 gallons. Diesel comprises about two percent of this sales volume. Despite being one of three gasoline stations on Lopez, this part of Mr. Dye's business operates at a loss. He maintains this sector of his business to meet a community need. Richardson Fuels, discussed later in this section, resupplies LVM's gasoline pumps [34].

Two entities manage solid waste on Lopez, the Lopez Transfer Station and San Juan Sanitation Company. San Juan County operates the Lopez Transfer Station and handles nearly all residential waste. Most residents deliver solid waste to the Transfer Station themselves, usually while running errands in Lopez Village. The Transfer Station aggregates solid waste in 40 cubic yard containers and ships it via the ferry to Orcas Island where other services further aggregate it into 120 cubic yard intermodal (rail) containers and ship it via the ferry to the mainland for final disposal. In 2011, the Transfer Station collected and shipped 432 short tons of garbage and 291 short tons of comingled recyclables from Lopez to Orcas. The shipments occur every few days, more often in the summer. San Juan County has a long-term contract with Waste Management to transport garbage to a landfill near Arlington, Oregon, 350 miles away. Comingled recyclables are destined for a Waste Management facility in Woodinville, near Seattle [35].

San Juan Sanitation Company is the only entity allowed to provide curbside collection on Lopez. They serve only about 30 mostly commercial customers. Based on Orcas Island, they regularly send trucks to Lopez via the ferry for collections and the trucks often return to Orcas less than full [35]. The shipment and processing of waste by both San Juan Sanitation and Lopez Transfer Station account for much of the cost in the existing solid waste management system. The Waste section of this paper covers further details on the waste management infrastructure.

Lopez Sand & Gravel, a subsidiary of Buffum Brothers Farms, provides materials for construction on Lopez Island and also accepts a significant amount of green waste. Lopez Sand & Gravel imports about 7,000 to 8,000 cubic yards per year, on two barge trips. Material and transportation costs per barge of gravel total about $78,000. Lopez Sand & Gravel purchases about 40,000 gallons of diesel per year

from Richardson Fuels to operate the business. Their site receives a few trucks per day of customers dumping green waste or purchasing wood chips and soil [36]. The Waste section of this paper further discusses Lopez Sand & Gravel operations.

The Lopez Island Sewer District and septic tank customers use an independent contractor to transport solid waste from septic tanks. The contractor operates a 5,800-gallon truck to deliver septic solid waste to the Sewer District for processing. Processing at the Sewer District facility significantly reduces the volume of solid waste. The Sewer District pumps the remaining untreatable waste back into the contractor's truck for final shipment to a mainland treatment plant. In the summer the truck travels to the mainland weekly and in the winter twice a month. Due to weight limitations on the ferry, the truck transports only about 3,500 gallons at a time [37].

As for mail and package deliveries, the U.S. Postal Service volume is usually less than a truckload per day [38]. UPS, Federal Express, and other commercial delivery services serve Lopez regularly but do not charge extra for the ferry crossing.

AIR TRANSPORTATION

Aviation has been an important part of travel to and among the San Juan Islands since the 1940's. The Port of Lopez owns and operates Lopez Airport and receives federal and state funding for capital improvements. Lopez Airport is classified as a community service airport, but retains no staff, no onsite fuel, and no amenities. In 2010 the airport had 18,250 enplanements, none of which were moni-

SOURCE: Port of Lopez (http://www.portoflopez.com/index.htm)

tored. Private hangars adjacent to the airport provide space for 28 aircraft [29]. Private plane owners form the majority of airport users. On occasion, some of these owners volunteer to fly residents in need of medical treatment to the mainland [39].

For Lopezians needing commercial service, Kenmore Air provides daily seaplane flights from the Islander Resort dock at Fisherman's Bay [40]. San Juan Airlines offers regular flights to Bellingham and Anacortes [41] while Island Air provides charter, scenic, or ambulance flights from the Lopez airport [42]. For emergency medical needs, Airlift Northwest provides helicopter service for Lopez [43].

WATER TRANSPORTATION

Marine transportation options for Lopezians include the Washington State Ferry (WSF), private watercraft, rentals, inter-island fast boat services, and water taxi services. Island Express and the San Juan Island water taxi offer services to the San Juan Islands [44]. Residents that need to travel to smaller islands that WSF does not serve use informal inter-island private boat services. These boats generally have a capacity of no more than 6 and typical fares range from $30 for a one-way trip to as much as $100 for a single passenger trip [45]. However, the vast majority of residents use the WSF to travel off island.

WSF ferry routes generally visit each of the serviced islands (Lopez, Shaw, Orcas, San Juan) in sequence on each sailing from Anacortes. The sailing schedule changes both seasonally and annually, depending on ship availability and in accordance with WSF's experiments to improve service. This creates difficulties in coordinating with regional land transit like airport shuttles and public buses. Currently, no formal transportation services exist at the Lopez ferry terminal. However, public buses and private shuttles do serve the Anacortes terminal [46], but their departure and arrival times lack coordination

with ferry departures and arrivals. Examples of this may be found by comparing the Spring 2012 WSF schedule and the Skagit Transit route schedule [46, 47]. On average, 5 out of 6 westbound journeys to Lopez require over an hour wait at the ferry terminal, while eastbound journeys from Lopez require passengers to wait about 25 minutes for the bus on morning trips, and longer in the afternoon. Travelers between Anacortes and the I-5 corridor have the added complication of transferring buses at March's Point [47]. Bellair Airporter Shuttle serves as another lack of timing coordination example: shuttle departures from Anacortes occur at least 50 minutes after ferry arrival while shuttle arrivals at Anacortes occur more than one hour before ferry departure until mid afternoon [48].

WSF maintains an island specific vehicle quota to ensure that drivers from each island along the ferry route have a chance to board the ferry. The quotas change seasonally. Despite the quota system, many residents experience unpredictable wait times from almost none during the winter to as much as twelve hours during the peak summer season. The Lopez ferry terminal lacks an online traffic camera, so residents must call the terminal to get an estimate of wait time. Businesses on the other hand, can use WSF's reservation system for commercial traffic to control their wait times [46]. WSF may make the reservation system available to non-commercial customers in the future.

Some Lopez residents note that the pricing structure of WSF encourages drive-on passengers and discourages walk-on passengers; in other words, the ferry is too cheap for vehicles and too expensive for passengers. Table 1 (on the next page) illustrates a portion of the Winter 2012 price structure. While a limited number of free 72-hour parking spots are available on a first-come, first-serve basis, typical parking rates at the Anacortes terminal are $10 for one day and $40 for seven days [46].

SOURCE: IBike USA/Canada (http://ibike.org/ibike/salish/essay/5-San%20Juan%20Island.htm)

Price	Passenger type
$12.05	Walk-on
$14.05	Walk-on with bicycle
$15.45	Motorcycle
$26.15	Driver with up to 14' vehicle
$29.00	Driver with up to 22' vehicle

***TABLE 1: Selected WSF winter 2012 westbound single-use full fares**. SOURCE: Washington State Ferries*

In 2011, the Anacortes-Lopez ferry segment recorded 150,348 vehicles, 106,924 vehicle passengers, and 37,194 foot passengers [49]. To gain a better characterization of riders at the Lopez ferry terminal, we looked at data from a 2008 Washington State Transportation Commission survey on the Anacortes/San Juans ferry route as a proxy. According to the survey, ridership varied significantly by season, increasing by 109 percent from winter to summer. About 90 percentage points of that increase resulted from growth in recreational ridership. Riders with recreation as the primary trip purpose comprised 34 percent of all riders in the winter but 63 percent of all riders in the summer. In the summer 63 percent of passengers had recreation as the primary trip purpose [50].

Based on the 2011 vehicle count above and the percentages by trip purpose, if we assume that non-recreational riders are all Lopezians and recreation riders are all tourists, then Lopezians took about 70,000 ferry trips with vehicles in 2011. If the number of households on Lopez is about 1,500, then each household averaged 3.9 ferry trips with vehicles per month in 2011. This estimate is probably a bit inflated since a certain percentage of non-recreation traffic is commercial traffic, like delivery of goods to Lopez. Many of the Lopezians that responded to our online survey indicated that they ride the ferry no more than two or three times per month while a few respondents said that they ride it several times per month.

TRANSPORTATION FUELS CONSUMPTION

All liquid fuels that Lopez residents consume must be transported from the mainland by means of one of two methods: either via barge service or via the Washington State Ferry. Combustible liquids (diesel, heating oil) may be transported on the ferry while flammable liquids (gasoline, propane) are not allowed on the ferry so they must travel on the barge service. Island Transporter, the only barge service in the area, regularly transports fuel tanker trucks with its charter landing craft service.

Lopez uses four categories of liquid fuels: gasoline, diesel, propane, and heating oil. Gasoline and diesel satisfy motorized transportation needs as well as some domestic usage like electric generators. Propane and heating oil primarily satisfy heating needs. One company, San Juan Propane, imports propane. In 2011, San Juan Propane imported 321,870 gallons of propane to Lopez [51]. Assuming a tanker truck size of about 6,000 gallons, this averages to about one shipment per week.

Richardson Fuels imports the remaining liquid fuel categories and serves several other islands not served by ferries in San Juan County. Lopez native Rex Ritchie owns and operates Richardson Fuel with a staff of one – himself. Low sales volume and high fixed costs burden Richardson Fuel with high operating costs – the underlying reason behind the $0.50 price premium for on-island gasoline and diesel retail purchases. Richardson Fuel maintains a fleet of three trucks, a 2,300-gallon local delivery truck, a 9,000-gallon gasoline tanker truck, and a 9,800-gallon diesel tanker truck. The trucks also double as fuel storage. Richardson Fuel supplies the three gas stations on Lopez, the Lopez Village Market, the un-staffed Weeks station near the Library, and Islandale Store at the southern end of Lopez [52].

Richardson Fuel reports importing about 250,000 gallons of gasoline per year, averaging about one shipment per week and 100,000 gallons of die-

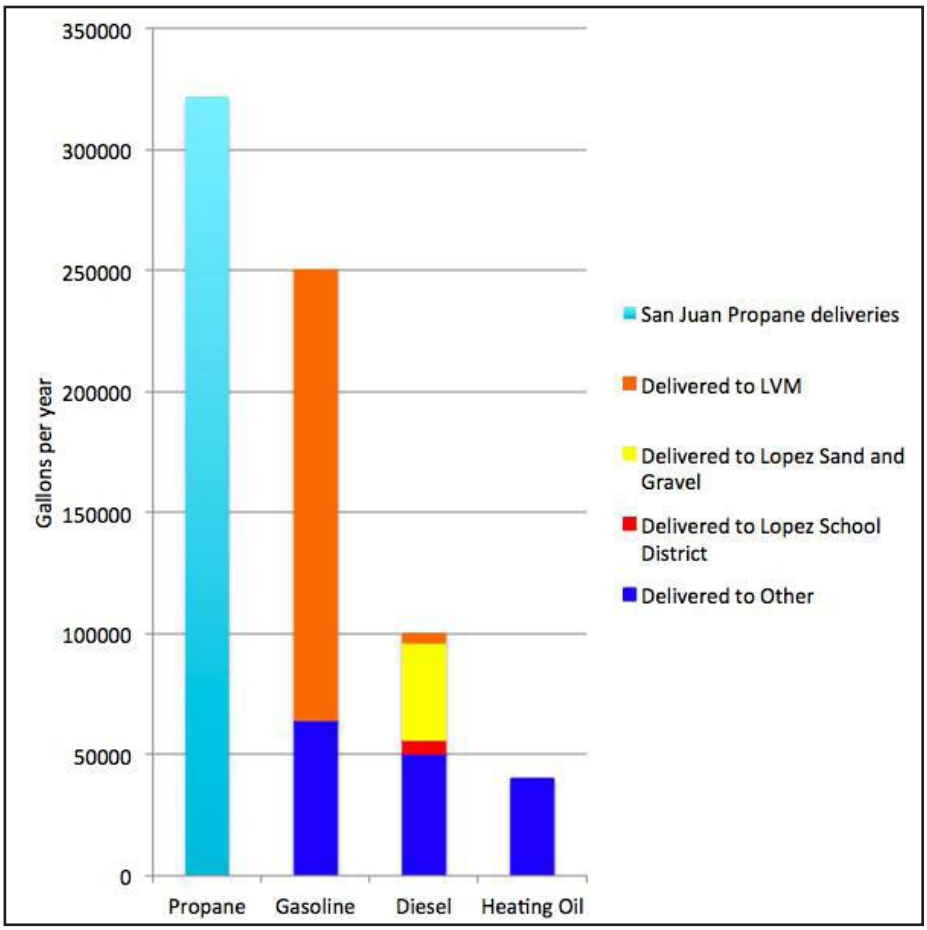


FIGURE 3: 2011 Estimates of Liquid Fuel Imports to Lopez

sel per year, averaging about two shipments per month. Heating oil imports occur in winter only and average about 40,000 gallons per year. In recent years, sales volume was flat or decreased slightly, likely due to the recession and increasing fuel efficiency [52]. Sales volume at the Lopez Village Market, however, indicates that diesel occupies a small fraction of car and truck purchases, around 2 percent [34]. The Lopez School District purchases less than 6,000 gallons of diesel [53], Lopez Sand and Gravel accounts for about 40,000 gallons [36], and the rest of diesel imports goes towards other non car or truck uses such as boating, excavation, and agriculture. Figure 3 below summarizes the estimates of liquid fuel that Lopez imported in 2011.

Though residents have the convenience of purchasing fuel at one of the three local gas stations, many Lopez residents opt to purchase fuel on the mainland instead due to cheaper prices. Residents are allowed to transport small quantities of combustible liquids such as diesel on the State Ferry. Moreover, many residents regularly purchase vehicle fuel on the mainland. Respondents to our online survey indicated that on average 54 percent of their gasoline purchases occurred on the mainland. Though we cannot extrapolate on this data due to survey bias, suppose that we assume that this purchasing pattern reflects the wider Lopez community. Given that purchases on Lopez amount to around 250,000 gallons per year according to Richardson Fuel sales, total fuel consumption would be around 500,000 gallons per year, if Lopez residents purchase about half of their fuel on the mainland.

Community Transportation Options: Insights from Lopez Resident Christopher Aiken, San Juan County Mobility Manager

It's been six months since I became San Juan County's first Mobility Manager. Since moving to the island, my family and I have been welcomed to Lopez with wide-open arms and have truly begun to feel like a part of the community fabric. In my time here, I have been working with various agencies and groups to understand our transportation issues and expand our community transportation options.

As I have come to know Lopez, my work has made me particularly aware of the unique transportation issues and struggles of our seniors, disabled, veteran and low-income residents. Nearly half of the population of San Juan County falls into one of these categories. I remember seeing a wheelchair-bound elderly woman travelling on one of the narrow shoulders of a main road, and as I watched, I remember thinking: she's doing this because she has to–there is literally no other way to get there, there should be room for her in our transportation system, and there should be better and safer travel options for our residents. I worry that seniors, the disabled, veteran, low-income and non-driving residents are not getting an adequate transportation system currently, and that their needs are not well represented in our local plans for the future.

Roughly six months into my role as mobility manager, I am happy to say we are making some headway. San Juan County recently received a grant from the Washington State Department of Transportation that will bring a coordinated focus to our unique transportation issues here in the islands. For Lopez, the grant will support the addition of a wheelchair accessible van and the implementation of a voucher program for our most transportation-vulnerable residents. This program will allow for vouchers to be used on a variety of transportation services, including taxis, bicycles, paying voluntary drivers, fixing broken vehicles, as well as for buying gas. We'll be conducting personalized transportation assistance to match our residents' unique needs with appropriate local providers.

With that said, there is still more to do. San Juan County stands at a transportation crossroads: we have a high proportion of aging citizens, a vast income disparity gap between low and high income earners, and a large number of us do not or will not have access to personal vehicles. We cannot use the same auto-centric logic of the past to solve our multi-modal problems of the future, but we can work together to chart a course towards a more resilient one. I look forward to seeing the ideas that this project spurns, as I'm sure they will help inform the ongoing evolution of community transportation solutions here on Lopez.

POTENTIAL PROBLEM AREAS AND RISKS FACTORS

(transportation)

After analyzing Lopez Island's unique characteristics and reviewing its current practices, we highlight below several key risk areas that could pose problems for transportation on the island between 2012 and 2025. These fall into five categories: fuel price and supply, bottlenecks, population and demographics, climate change and the environment, and disaster response.

FUEL PRICE

A heavy reliance on gasoline- and diesel-powered modes of transportation presents two risks to Lopez Island between now and 2025. First, experts predict that the price of gasoline and diesel will rise significantly over the next 13 years. The US Energy Information Agency predicts that gasoline and diesel prices could rise by between 2 and 3 percent each year between now and 2025, but any number of supply-side shocks, like intensifying conflict in the Middle East, pipeline disruptions between Canada, the US, and Mexico, or European boycotts on oil from Iran, among others, could lead to even higher prices by 2025. These year-over-year increases – from 2-3 percent per year to perhaps 5 or 6 percent per year – would result in a 30-90 percent increase in gasoline and diesel prices at the pump by 2025, on Lopez Island and on the mainland in 2025 compared with 2012 prices. If Lopezians continue to rely on gasoline- and diesel-powered modes of transportation as heavily as they do now, rising fuel prices will further increase the cost of living on Lopez Island, which, as noted in this report's introduction, is already high relative to the rest of Washington. This can have a particularly deleterious effect on low-income households; according to the Bureau of Transportation Statistics, US households in the lowest 20 percent income bracket can spend up to 42 percent of their annual income on transportation costs [54]. Along with increasing the cost of personal transportation, rising fuel prices would increase the cost of food, waste processing, shipping, and ferry services. Lastly, it is important to note that vehicular travel comprises a large portion of Lopez Island's carbon footprint, which may pose a real financial risk to Lopezians if the county, state, or federal governments enact legislation that puts a price on carbon.

FUEL SUPPLY

The second fuel-related risk that Lopez Island could face if current practices are continued stems from possible disruptions to supply. First, any delay or disruption to the fuel barge service could create an immediate shortage of fuel on Lopez Island, particularly if current consumption rates continue or increase. Second, a heavy reliance on gasoline and diesel requires a reliance on fuel storage, yet fuel storage on the island is limited, and could be vulnerable to leaks or explosion from age-related degradation. And third, a single individual manages almost all gasoline and diesel import and distribution on Lopez Island [52]. Heavy reliance on gasoline and diesel makes this single-point management structure particularly risky.

BOTTLENECKS

The next major risk area that we identified – transportation bottlenecks – stems from the island's current reliance on two primary modes of transportation: personal vehicles and the ferry. Dependence on a personal vehicle creates a bottleneck at the household level. As long as the primary vehicle functions properly or has access to the fuel it needs, this bottleneck does not pose a problem. But because a majority of households on Lopez Island rely on a personal vehicle as their primary mode of transportation, any interruption (e.g., car

breakdown, fuel supply disruption) becomes particularly disruptive. Reliance on a single ferry service presents a second bottleneck that could pose a risk to Lopez Island through 2025. In the event that ferry service is disrupted, the current heavy reliance on the Washington State Ferry service would mean significant inconvenience, cost, or even inaccessibility to vital supplies (in the case of food or medical supplies) for Lopezians.

POPULATION AND DEMOGRAPHICS

Significant demographic changes, namely population increase in San Juan County and a large and growing population of older Lopezians, also present risks to the Lopez Island transportation sector. A rapidly aging population could lack viable transportation options by 2025, particularly if a mechanism is not in place to expand the senior van usage or if some form of organized elderly transportation options do not exist. The aging population will need more frequent visits to medical facilities off the island, depending even more on the transportation bottlenecks listed above. In addition, San Juan County's population will likely increase by 30 percent by 2025 [4]. This increase in population, if accompanied by the same rates of car ownership that Lopezians have today, could strain the already crowded ferry service from island to island and island to mainland. It could also pose risks for bicyclists on Lopez as even more cars will share the road with bicycles. If cars purchased during this population growth operate at similar efficiency rates as they do today, then even more residents would be at risk to gasoline or diesel price shocks – particularly if the income disparity on Lopez Island worsens or remains the same – and carbon emissions from vehicle use would continue to rise.

CLIMATE CHANGE AND THE ENVIRONMENT

Climate change and environmental shifts similarly exacerbate Lopez Island's exposure to the above risks, from fuel price shocks and supply disruptions, to transportation bottlenecks, to adaptation to demographic changes, to disaster response. But a changing climate poses direct risks to Lopez Island's transportation sector, as highlighted by a 2012 report from the state of Washington, entitled "Impacts of Climate Variability and Climate Change on Transportation Systems and Infrastructure in the Pacific Northwest." This report identifies specific transportation-related threats brought about by a changing climate. First, more severe weather events and predicted increased precipitation will strain weather drainage systems, the majority of which were built in the middle of the 20th century, and could expedite the erosion and degradation of roads, particularly those along the coast. Second, coastal roads and parking areas are at risk for erosion not only from rising sea levels, but also increased precipitation and more severe storms. Third, small or individual boat ports or docks are similarly at risk. The ferry terminal on Lopez Island, while more robust than smaller boat ports, is at a similar risk to service disruption from extreme weather events.

DISASTER RESPONSE

Disasters, whether natural or man-made, can be seen as black swan events for which Lopez Island cannot plan in advance. Nonetheless, the other risks listed above would make disaster response – whether it entails bringing assistance onto the island or evacuating residents off of the island – even more difficult.

Potential Solutions and Recommendations

(transportation)

This section describes several solutions that could improve the transportation system on Lopez Island. To formulate our ideas, we considered input from residents, best practices from similar communities, and existing research. We evaluate each solution on how well it could address current transportation needs of Lopezians and the issues described in the preceding section, within the context of environmental sustainability, resilience, acceptability to Lopezians, and cost, when available or approximate. For solutions that meet these criteria, we propose courses of action to start the implementation process. For solutions that show promise but require further research, we identify next steps.

Recommend "Go" for Implementation:

1) Conduct a transportation infrastructure climate change vulnerability assessment
2) Implement "Lopez Rocks & Rolls" – an informal rideshare program
3) Improve bicycling infrastructure
4) Increase the share of hybrid vehicles on the island

Recommend Further Research:

5) Build a community transit service by expanding the senior ride services
6) Start a fuel import and distribution internship
7) Implement vehicle-share programs

Recommend "Hold" at this Time:

(4) Increase the share of electric vehicles on the island
8) Expand usage of school bus system for public transportation
9) Implement a commercial freight coordination system
10) Diversify community-scale marine transport

CONDUCT A TRANSPORTATION INFRASTRUCTURE CLIMATE CHANGE VULNERABILITY ASSESSMENT

Climate change is a global reality with local consequences, to which Lopez Island is not immune. To address the risks identified in the aforementioned 2012 Washington State report, Lopez Island could undertake a climate change vulnerability assessment of its transportation infrastructure, including ports, storm drains, parking areas, coastal roads, and flood prone areas. Many frameworks already exist for climate change vulnerability assessments, and a cadre of volunteers could complete one for Lopez Island in two to four weekends. Lopezians would then submit the results to the appropriate authority, like the Washington State Department of Transportation or San Juan County's Public Works Department.

PROS

- Clearly identifies threats to the island's resilience and recommends action to address these threats
- Frameworks for climate change vulnerability assessments already exist and could be easily tailored to Lopez Island
- Provides an opportunity to identify other transportation infrastructure problems that were overlooked or unnoticed
- Vulnerability assessment requires relatively little time and labor, and is essentially free (with the exception of transportation cost for volunteers and any supplies needed for the assessment)
- Project management requires a dedicated individual or team of individuals to see it through completion, and Lopez Island's high population of retirees may provide the right demographic of wisdom, willpower, dedication, and time

CONS

- Ultimate solutions (i.e., fixing or improving infrastructure) are both costly and time consuming
- Ultimate solutions may temporarily disrupt access or usability of certain components of the transportation-related infrastructure
- Successful implementation may require persistence in pushing action through bureaucracies in multiple county, state, or federal departments

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Recommendation: **Go**

Although there are no direct environmental benefits to undertaking the vulnerability assessment, neither are there any damages, and the future benefits of adapting to climate change are key to Lopez's long-term resilience. This important consideration, along with the other pros and cons identified above, lead the authors to recommend that Lopez Island complete a transportation infrastructure climate change vulnerability assessment.

Implementation:

The implementation of this project would require three phases: Prepare, Assess, and Submit. During the preparation phase, the community assembles a team of dedicated individuals to lead the project and see it through to its completion. The team should include Lopez Island residents who are familiar with the island and who, collectively, have an understanding of the island's geography, weather patterns, ports and marinas, coastal roads and parking areas, and stormwater runoff systems. The

next step in the preparation phase entails selecting a climate change vulnerability assessment framework that meets Lopez Island's needs and characteristics. Examples of possible frameworks to use on Lopez Island include:

- Pages 83-86 of the University of Washington's Center for Science in the Earth System: <http://cses.washington.edu/db/pdf/snoveretalgb574ch8.pdf>,
- The Coastal-Marine Ecosystem-Based Management Tools Network: <http://ebmtoolsdatabase.org/resource/climate-change-vulnerability-assessment-and-adaptation-tools>; and
- The US Department of Transportation Federal Highway Administration: <http://www.fhwa.dot.gov/hep/climate/conceptual_model62410.htm>, among others.

Once the project team selects a framework, they determine which sites on Lopez Island to assess and assemble a team of volunteers to visit the sites. The preparation phase could take one to two months.

In the assessment phase, the team of volunteers travels to the selected sites on Lopez and observes, records, photographs, videos, documents, and measures anything that may be useful to the vulnerability assessment. The project team would then compile all of this information for use in the final assessment report. This phase could take between two and four weekends, depending on the depth of analysis and number of volunteers and sites identified as vulnerable to climate change.

The final phase entails completing the climate change vulnerability assessment report and submitting it to the appropriate county, state, or federal agency. This phase should also include the selection of an individual or team of individuals who will continue to seek the requested changes, improvements, or repairs from the appropriate government agency. This phase would then be ongoing until the vulnerabilities are addressed and minimized.

2 IMPLEMENT "LOPEZ ROCKS & ROLLS" (AN INFORMAL RIDESHARE PROGRAM)

Building on the "hitchhiking is a community tradition" idea, we propose that Lopez Island create a casual rideshare program that we call "Lopez Rocks & Rolls." It promotes resilience and sustainability on Lopez, is acceptable to the community, and addresses some of the risks identified above. The program differs from hitchhiking in that it specifies designated pick-up sites with signage and includes advertising campaigns to increase program awareness. It is less formal and more spontaneous than pre-arranging a rideshare/carshare program in an online venue like lopezrocks.org.

Why bother creating a rideshare program when a strong hitchhiking culture seems to work? Adding a degree of predictability and creating community awareness of the program will increase the comfort level or 'acceptability' of hitchhiking even further, and, more importantly, it will give the system a feel of legitimacy and consistency that would encourage tourists and part time residents to participate.

Lopez Rocks and Rolls would be well suited for Lopezians making routine trips to and from common destinations like the ferry terminal, the village, or the high school, and for individuals like Liza Michaelson, co-founder of sjRIDESHARE, who enjoy meeting fellow residents through shared transportation. We propose basing the system on the principles of sjRIDESHARE, but adapting it to match the uniqueness of Lopez and requiring minimal funding. Pick-up site selection would be prioritized by transportation hot-spots like LVM, the ferry terminal, and the high school, and by areas that require no additional engineering (i.e., safe pull out areas that already exist). This avoids road widening and water diversion costs, which can be as much as $10,000 per site [55]. Signage need not be the conventional metal post and panel, but instead could be something as simple, yet visible, as a brightly painted rock with a unique logo. Preserving traffic safety for both riders and drivers remains the top priority so techniques such as sight distance analysis must be employed during pick-up site selection and design [56].

PROS

- Lowers greenhouse gas emissions by reducing miles driven per person
- Reduces number of vehicles on road
- Reduces per capita cost of personal transportation (maintenance, fuel, parking, insurance, etc.)
- Promotes the island's social connections
- Creates awareness of ridesharing as safe, cheap, and convenient transportation alternative

CONS

- Requires shift in behavior of Lopezians, for example, to let go of independence of personal vehicle
- Creates potential hazard at pick up sites due to increased pedestrian traffic and vehicles pulling in and out of road
- May require funding to develop some pick up sites
- May require bureaucratic clearance to install signage and create pick-up sites

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Average Cost of Single Occupancy Vehicle Commuting in the U.S.:

Daily. $16.65

Weekly. . .$83.25

Monthly. . $333

Yearly. . . .$3,996

Potential Savings Per Day Versus Driving Alone

MODE	DAILY ($)
Carpool-2	$6.11
Carpool-3	$8.14
Carpool-4	$9.16

To illustrate the potential savings that can be realized with broader participation in Lopez Rocks & Rolls, we present data on carpooling as a proxy for ridesharing benefits.

According to the Volpe Center automobile commuting cost calculation, the annual cost to commute alone in a personal vehicle totals nearly $4,000, assuming average fuel cost of $3.00/gallon (fuel prices at the time of writing of this paper are significantly higher than this). Replacing all those one-person commutes with a 2-person carpool could result in as much as $1,466 in savings. Ridesharing is not the same as carpooling, however, and riders would be the primary financial beneficiary – unless drivers accepted cash in exchange for giving a ride, a concept, Liza Michaelson notes, that Islanders are hesitant to accept.

[SOURCE: Volpe Center, US DOT, 2010, Federal Highway Administrations, D.C. (Ridesharing Options Analysis and Practitioners' Toolkit)]

Recommendation: **GO**

Despite the challenges mentioned above, we recommend implementing a "Lopez Rocks and Rolls" informal rideshare program because of the substantial environmental and social benefits at minimal cost.

Implementation:

We outline here three phases that Lopez Island could use to build the "Lopez Rocks and Rolls" informal rideshare program:

PHASE I: Installation of "Lopez Rocks & Rolls" signposts in designated safe and accessible locations that do not require additional road engineering for car-pull outs

> Assemble volunteers for site assessment
  - Identify sites (can start with site assessment reports from sjRIDESHARE)
  - Evaluate traffic safety and perform sight distance analysis at each site

> Assemble volunteers to develop signage (potential volunteers could be artists or high school students). Signage need not be the conventional post and panel – it could be a large, brightly painted rock with a characteristic logo – but it should be standardized.

> Install signage at designated pick-up sites

PHASE II: Program promotion / advertisement

> Assemble volunteers to advertise the program
  - Advertise by word of mouth
  - Create a website, perhaps developed as a high-school project, to provide basic information like what the program entails, how it works, and maps of pick-up sites
  - Advertise through local newspapers like Islands Weekly and local websites like lopezrocks.org

PHASE III: Other promotional activities / programs

> Promote an informal "hitch-a-ride" or "pick-up-a-hitch-hiker" day once a month

> Mobilize youth, e.g. high school students, through creative incentives to reduce solo driving by high school students (Proposals here require piloting to assess their efficacy in achieving goal)
  - Reward students for lowering transportation carbon footprint (bonus: students learn how to make carbon footprint calculations)
  - Reserve some prime parking spaces at the high school for students who carpool, via Lopez Rocks & Rolls or otherwise

sjRIDESHARE PROGRAM

Envisioned by Liza Michaelson—a San Juan County resident—through her international travel experience, sjRIDESHARE program was established in 2006 to provide sustainable local transportation solutions to the inhabitants of the County and to "put public back in public transportation." The program roughly replicates a similar project –"GO Geronimo" of Marin County, California that offered "safe roadside stops, where riders and car drivers can safely connect," along a 20-mile stretch of the Sir Francis Drake boulevard.

The distinct feature of the sjRIDESHARE program rests on its simple yet visually authentic sign as shown in the figure above. The San Juan County Council as well as the town council for the Town of Friday Harbor both voted unanimously to approve the program and to pay to create and install the signs. There is one at every exit, totalling 5 signs in the town. Ms. Michaelson and her team avoided the engineering overheads born out of road widening for safe car pullouts by intelligently siting the pickup locations. The signs are installed in sites that meet the strict safety criteria, which do not require additional engineering.

The sjRIDESHARE program has successfully installed 22 pickup location signs in San Juan County, nine are pending, and over 15 are under consideration. Ms. Michaelson notes that the biggest challenge for the success of the program is convincing people to use it, as "people are addicted to their cars." She foresees more islanders making use of the program in the future as the fuel prices continue to rise. Indeed, "I use the Rideshare as my primary mode of transportation to and from town daily," says Ms. Michaelson.

Local artist Anne Sheridan helped create the program, designed the logo and built the website, www.sjrideshare.org.

3 IMPROVE BICYCLING INFRASTRUCTURE

Cycling, especially when it can replace motorized vehicle trips, promotes resilience by reducing fuel consumption and motorized vehicle dependence, benefits the environment by reducing vehicle emissions, enhances health, and is well accepted in the community. However, safety concerns such as narrow/no shoulders on most roads and insufficient signage constrain wider use of cycling to replace vehicle trips. We suggest three actions to address these issues. First, Lopez Island could widen the shoulders of the main roads such as Port Stanley, Center Road, Fisherman Bay Road, and Mud Bay Road, all of which receive substantial bicycle traffic, especially during the summer months. Second, Lopez Island could create more pathways that connect key locations such as Lopez School and Lopez Village. Third, Lopez Island could deploy more signage to indicate road hazards, give directions, and promote traffic safety and road sharing between cyclists and drivers.

PROS

- Lowers Lopezians dependence on personal vehicles
- Prioritizes cyclist and vehicle driver safety
- Enhances Lopez Island's attractiveness to bicycle enthusiasts
- Improved signage is relatively easy to implement
- Increase connectivity on Lopez Island
- Promotes physical activity, increased quality of life (health benefits), and psychological well-being
- Emissions-free transportation

CONS

- Widening road shoulders is expensive
- Possible resistance from property owners along roads targeted for widening
- Trail expansions require construction and maintenance Safety education requires personnel and classroom
- materials, all with a potentially high cost for a school system that already has a tight budget
- Signage may require bureaucratic permission

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

To quantify potential benefits of increased cycling in the community, we present a cost-benefit analysis conducted by Dr. Thomas Gotschi in 2011 for Portland, Oregon. His analysis compared and calculated the cost of bicycle infrastructure investment from 1990 to 2040 with health care cost savings, value of statistical lives (reduction in mortality resulting from bicycling), and fuel cost savings [57]. He calculated that the "benefit-cost ratios for health care and fuel savings are between 3.8 and 1.2 to 1, and an order of magnitude larger when value of statistical lives is used." In other words, every $1 invested on bicycle infrastructure will provide a return (benefit) of between $1.2 and $3.8 in combined health care and fuel cost savings, and much more if factoring in reduced mortality resulting from bicycling [57]. To arrive at this conclusion, he used the conceptual framework as shown in the figure on the next page.

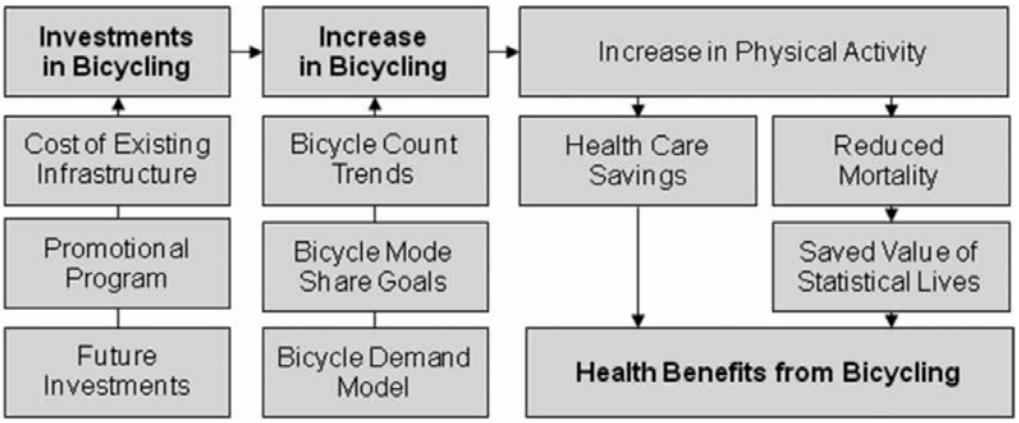


Figure 4: Conceptual framework of the cost-benefit analysis (not including benefits of fuel savings)

Source: [57]

Recommendation: **GO**

We think the clear benefits of increased cycling that improved infrastructure will justify the extra effort it may take to secure funding, negotiate with property owners, and navigate county bureaucracy. We therefore recommend the community make improvements to cycling infrastructure on Lopez.

Implementation:

San Juan County Public Works completed a 1.7-mile shoulder widening and drainage improvement project along Fisherman Bay Road about two years ago. The project required the acquisition of permanent easement for road right-of-way from 24 property owners and road construction agreements from 19 other owners along the road [58]. The project met considerable resistance from local residents at the time [1].

We recognize that obtaining funding as well as potential resistance from property owners may become obstacles to road shoulder widening and bicycle route/trail development projects. Should the community pursue these projects, they could assemble a team of dedicated volunteers (likely bicycle enthusiasts) to explore county, state, and federal funding options, conduct site assessments, and work with property owners and the county to acquire public easements. The team could be subdivided into engineering assessment and financial assessment groups. The former will study, assess and prioritize sites based on safety criteria, the latter will submit grant proposals, allocate funds, and navigate legal requirements. These projects likely require sustained long-term commitment to see them through completion.

Deploying more signage to indicate road hazards, give directions, and promote traffic safety and road sharing between cyclists and drivers, however, could be realized with modest funding and effort. The biggest challenge may be navigating county bureaucracy to legally install signage. We suggest the following steps:

1) Conduct a needs assessment:

- Assemble volunteers to identify sites and type of desired signage, with highest priority to safety
- Develop a "Bicycle Master Plan," a guide for cycling on Lopez
- Prioritize high traffic zones and intersections
- Improve and maintain signs at existing sites
- Obtain permission from county for signage installation

2) Calculate costs and obtain funding:

According to the North Central Texas Council of Governments (NCTCOG), the estimated cost of a sign including installation ranges from $150-$200 [59]. Similarly, the District of Columbia Department of Transportation "estimates that it takes ¼ of a Full Time Equivalent (FTE) to plan its signed bicycle route network" [60]. Depending on county requirements, signage could be constructed from wood or even waste material, instead of ordering conventional posts and panels.

3) **Install signage:**
Assemble workers and volunteers to construct, install, and maintain signage (potential volunteers could be artists or high school students).

4 INCREASE THE SHARE OF HYBRID OR ELECTRIC VEHICLES ON THE ISLAND

A cursory search of the Internet reveals an extensive list of pros and cons regarding both fully electric vehicles and hybrid vehicles compared to gasoline vehicles. Here we present increasing the share of hybrid or all-electric vehicles on Lopez Island as a possible solution to some of the key risks identified above.

To estimate the total lifetime cost of ownership of hybrid, all-electric, and conventional vehicles, we display below the results from University of Minnesota instructor Douglas Tiffany's free online calculator [61]. The following table details a comparison of electric, hybrid and conventional vehicle models available in 2012. The analysis assumed a $5,000 down payment on a 60 month loan with 5 percent interest, 10,000 miles driven per year, a 15 year vehicle lifetime, and a 6 percent personal discount rate (Vehicle data from [61], [62], [63], [64]).

Table 2: Cost Comparison of Conventional, Hybrid, and Electric Vehicles

	Toyota Matrix L (conventional)	Toyota Prius Two (hybrid)	Nissan Leaf SV (electric)	Chevrolet Volt (plug-in hybrid)
MSRP	$20,445	$24,760	$36,050	$39,995
Efficiency	28.5 mi/gal	49.5 mi/gal	3.4 mi/kWh*	2.0 mi/kWh + 30 mi/gal
Tax credits	none	none	$7,500	$7,500
Maintenance	$60.84 / 3000 miles	$2,000 battery service in year 8	$8,000 battery service in year 8	$8,000 battery service in year 8
Lifetime ownership & operating cost (avg $6.00/gal & $0.08/kWh)	$42,150	$38,672	$34,848	$47,538
Lifetime ownership & operating cost (avg $4.50/gal & $0.12/kWh)	$37,038	$35,729	$35,991	$46,761

SOURCE: [61], [62], [63], [64]

ALL - ELECTRIC

PROS

- Eliminates household dependence on liquid fuel for transportation
- Removes household susceptibility to oil price or supply shocks
- Lowers operating cost per mile than gasoline cars
- Reduces local pollution – including harmful particulates – from tailpipe emissions
- Reduces Lopez Island's carbon footprint since electricity generation is primarily from hydroelectric dams
- Maintains household transportation independence for short trips in between recharges

CONS

- Creates more dependence on OPALCO's imports of electricity from the mainland (OPALCO is the utility company that provides electricity to Lopez)
- Current rate of renewables adoption may not be able to keep up with the extra load of expanded electric vehicle charging
- Likely to have a higher upfront cost than gasoline vehicles
- Limited range on a single charge
- Long recharging time, which can decrease household transportation flexibility and independence
- Battery lifetime is typically shorter than vehicle lifetime
- Requires specialized technicians and replacement parts
- Existing models do not have large hauling capacity

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

HYBRID

PROS

- Reduces household dependence on liquid fuel
- Reduces household susceptibility to oil price or supply shocks
- Lower operating cost per mile than gasoline cars
- Reduces local pollution – including harmful particulates – from tailpipe emissions
- Reduces Lopez Island's carbon footprint since electricity generation is primarily from hydroelectric dams
- Maintains household transportation independence

CONS

- Likely to have a higher upfront cost than gasoline vehicles
- Requires specialized technician skills and replacement parts
- Hauling capacity in existing models occurs only when the engine is running on gasoline alone, and not a combination of battery and gasoline or battery only, thereby nullifying some of the hybrid benefits while hauling or towing

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Electric Recommendation: **HOLD**
Hybrid Recommendation: **GO**

We recommend increasing the share of hybrid vehicles on Lopez Island. While hybrids have a higher upfront cost, they have a lower lifetime operating cost, particularly as gasoline prices continue to

rise. Hybrids also do not have the range limitations of all-electric vehicles, and they can dramatically increase the time between refueling as compared to a conventional vehicle. At the household level, hybrids preserve mobility independence, reduce oil dependence and its inherent risks, and avoid replacing oil dependence with electricity dependence for household transportation.

This report also recommends that when companies or organizations on Lopez Island decide to buy a new light- or medium-duty vehicle (e.g., cars, vans, pickup trucks, SUVs, etc.), they purchase a hybrid. Most vehicle manufacturers make hybrid models of their light- and medium-duty vehicles that offer the same or similar performance with greatly improved fuel efficiency. As noted in the pro/con analysis of this recommendation, the fuel efficiency gains during hauling or towing may not be significant, but fuel efficiency gains during all other times would likely be substantial and lead to a relatively short payback period for the comparatively high upfront cost.

Implementation:
Increasing the share of hybrid vehicles on Lopez Island serves as an excellent example of an action that Lopezians can take between now and 2025 to be more resilient, more environmentally sustainable, and maintain their unique culture and traditions. When an individual, a household, a business, or an organization decides to purchase a vehicle, we recommend they use lifetime cost calculation tools such as the one used to produce Table 2 above to inform their decision about what kind of vehicle to purchase. Lifetime cost calculations as well as a broader assessment of fuel supply and price risks provide more accurate estimates of future costs and benefits than simple payback period calculations (payback period = upfront cost / annual savings).

5 BUILD A COMMUNITY TRANSIT SERVICE BY EXPANDING THE SENIOR RIDE SERVICES

A common theme we found through research of San Juan County [4] and interviews with Lopez residents is a strong demand for public transportation services. Lopez's lack of public transportation options affects all residents and particularly the young, the elderly, those with low incomes, and the disabled. The county Human Services Transportation Plan published in 2010 concluded that there was strong demand for a regularly scheduled shuttle service for the entire island, and residents thought the senior van service should be made available to the general public [4]. Here we propose developing a community transit service integrating these elements. The service would leverage existing vehicle inventory such as the Senior Center van, be scheduled year-round, and have a fixed route with several pick-up spots around Lopez, including Lopez Village, the ferry terminal, and the school. To accommodate the spread-out structure of the Lopez community, this service should also offer the flexibility to deviate from the fixed route on-demand. The table below details the pros and cons of such a service.

PROS

- Accessible to all residents
- Reduces the number of drivers on the road, and miles driven per person
- Reduces air pollution like particulates and greenhouse gases
- Increases island connectivity
- Provides a valuable, low-cost alternative to individual
- vehicle travel, reducing the impact of rising fuel costs
- Increases the mobility of youth, seniors, the disabled, and those with low incomes
- Lowers the number of non-emergency calls to 911 *

*Dialing 911 is often the preferred choice for non-emergency care simply because no other alternative exists [4].

CONS

- Requires logistical and financial support for service creation and expansion
- Requires hiring, training, and certifying drivers and mobility coordinator
- Conventional fuel van fleet vulnerable to rising fuel costs and possible supply disruptions

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY UNKNOWN

Recommendation: **RESEARCH**

While estimating cost for this option presents difficulties, we recognize that this solution could present funding issues. Public financing of this service could be obtained from a variety of special state grants, rural transportation grants, or other federal funding sources. San Juan County has a proven track record of obtaining funding from public sources for transportation initiatives including a Washington Department of Transportation grant to replace Senior Center vans on each of the three major islands of the county with wheelchair accessible vehicles [65]. Funding for ongoing operations could be supplemented with a fare structure that charged a higher fare for non-residents of Lopez and a reduced fare for Lopez residents. The higher fare that tourists and other non-residents would pay could cover free rides for certain classes of riders such as seniors and the disabled.

Areas of Further Research:

Recognizing the strong positive impacts of a community van service and a clear local demand for this transportation option, we propose further research on this potential solution's overall viability that Lopezians can address before moving forward with this important initiative.

To determine the cultural acceptability – and overall viability – of this potential solution, Lopezians should first determine demand, profit and cost estimates, as well as possible pricing schedules for expanding the senior ride program to create a community transit service. Additionally, we offer the questions on the following page as a guide to Lopezians to make their viability assessment of this program.

Generally, Lopez residents have fewer transportation choices than either San Juan and Orcas islands, both of which have summer shuttle buses and limited taxi services. Creation of the community van service would provide an affordable and reliable transportation option for residents that enable them to be mobile in times of emergency and in their daily lives.

Schedule information:

- What are peak travel times on Lopez?
- What are the key destinations during peak time?
- How frequently should shuttle/vans travel the island?
- Should the schedule coordinate with the ferry service or off-island modes of transportation?
- Should the service run on a standardized or flexible schedule?

Mobility Coordinator:

- Should Lopez Island hire a mobility coordinator to oversee this transportation service? If so:
- Where will the mobility coordinator be located?
- How will the mobility coordinator be reached? By phone and/or email?
- Will the mobility coordinator be a volunteer or paid staff?
- Who will provide training/ pay/ reimbursement to the mobility coordinator?

Van Numbers and Operation:

- How many vans are available? Can the Lopez school vans and the senior vans be utilized?
- How many vans should be in service?
- What should the pay structure be for van drivers?
- Would a volunteer van service work efficiently?
- How should van drivers be trained and certified? Who will provide the training? Would vans be a more affordable option than taxi vouchers?

Logistics:

- How should pick-up points be identified?
- Who should pay for the service? Everyone? Everyone but seniors?
- How much should be charged? What will be the method of collection?
- Where will the vans be based? Who will handle the maintenance and upkeep?
- Who will receive the profits?

6 START A FUEL IMPORT AND DISTRIBUTION INTERNSHIP

As the Transportation section's Potential Risk Factors and Problem Areas noted, a single individual (Rex Ritchie, the owner/operator of Richardson Fuels) manages and makes possible nearly all fuel import and distribution on Lopez Island. This single-point management structure could pose a risk to the long-term resilience of Lopez Island's fuel supply if anything should happen to disrupt Mr. Ritchie's operations. This recommendation entails Richardson Fuel taking on a summer intern from the local high school to document its business practices and contacts, creating an "operations manual" that could be used in the event something were to happen to Mr. Ritchie or his current operations.

PROS

- Establishes resilience to the import and distribution of fuel to Lopez Island
- Provides a high school student with a valuable learning opportunity
- Could reveal areas of improvement or best practices to share with respect to Richardson Fuel's operations

CONS

- Requires the owner/operator of Richardson Fuel to take on the responsibility of managing an intern
- Would likely require Richardson Fuel to reveal potentially proprietary information in order to create the operations manual

Recommendation: **RESEARCH**

We recognize the importance of this solution, or another like it, to address the single point fuel supply management risk on Lopez Island, even if it does not have a direct environmental sustainability impact per se, and therefore propose it as a solution that warrants further research.

Areas of Further Research:

Significant "acceptability" questions exist that Lopezians and Mr. Ritchie would need to answer before implementing this solution. In particular, how amenable would Mr. Ritchie be to taking on a summer intern? In addition, how open would he be to creating an operations manual of his current business practices and contacts that could be used to continue his business in the event he was no longer able to do so?

IMPLEMENT VEHICLE-SHARE PROGRAMS

At least two instances of organized vehicle sharing programs (i.e., a single vehicle owned and used by multiple individuals, or owned by a single organization and used by multiple individuals) have existed in the past on Lopez Island. Both involved shared ownership of a single car, with an organized way to schedule access and arrange fuel payments. However, both of these car share programs are no longer operational – one community auctioned the shared vehicle to raise money for another project and the other program's shared vehicle became the primary vehicle for a Lopez resident at college. This proposal entails reinstating organized vehicle sharing programs in communities around Lopez Island.

PROS

- Provides a low-cost transportation option to community residents
- All future users share higher upfront cost of vehicle
- Reduces individual household dependence on a single vehicle
- Promotes community cohesion and ownership of a shared asset
- Provides an affordable way to increase ridership of hybrid vehicles if the vehicles purchased for these programs are hybrids

CONS

- Difficult to ensure long-term availability of car (as evidenced by two previous car sharing programs on Lopez Island)
- Requires honesty and integrity of all users to prevent "free riders"
- Potential unfairness in adding new people to the program who did not share in the initial cost of the vehicle
- Requires coordination of liability, vehicle maintenance, fuel purchases, and vehicle access

ENVIRONMENTAL SUSTAINABILITY	UNKNOWN	RESILIENCE & ADAPTABILITY		CULTURAL ACCEPTABILITY	UNKNOWN

Recommendation: **RESEARCH**

At first glance, a vehicle share program seems like a great option for communities around Lopez Island to give another transportation option to their residents. For example, a shared pickup truck or SUV could provide moving and hauling capabilities to households who cannot afford to buy this type of vehicle. In addition, programs like this have already existed on Lopez Island and are successful elsewhere around the world (e.g., Zipcar). In addition, it provides an affordable way to give community residents access to a hybrid vehicle, thereby reducing the negative environmental impacts of relying on conventional vehicles and reducing household exposure to oil price and supply risks

Areas of Further Research:

Before communities on Lopez Island implement this recommendation, they should first consider several challenges. How do communities raise money for the purchase of a shared vehicle, and what type of vehicle should they purchase? How do new community members, or those who did not share in the initial cost of the vehicle, join the car share program? How should communities coordinate vehicle access, vehicle maintenance, liability and insurance, and fuel costs? The use of an online platform for coordinating vehicle access seems like a logical approach, but that might discriminate against seniors or other non-Internet users. If communities decide to purchase a hybrid vehicle and they can implement a program that answers these basic but fundamental questions, then we recommend Lopezians implement this recommendation.

8 EXPAND USAGE OF SCHOOL BUS SYSTEM FOR PUBLIC TRANSPORTATION

The next potential solution would expand the school bus system to become a public transportation system. The school has three vans that are rarely used outside of school hours, primarily because of lack of funding and county regulations that permit only students as passengers on school buses and vans. However, some residents have called for maximizing the utility of school vans by including them as part of a community transit system, serving the transportation needs of not just students and the elderly, but the general population. The added cost of labor and operation of these vans may be offset by the benefits of maximizing use of these assets and providing a valuable service to the community by replacing single car trips.

PROS

- Maximizes the utility of the vehicles
- Provides viable transportation option for the Lopez Island, especially for elderly and needy individuals along with students (for extra curricular activities)
- Strengthens social cohesion among different generations
- Creates job opportunities
- Potentially provides additional financial assistance that the school needs for extra curricular activities (from fares for van service)

CONS

- Difficult to leverage funding since the government funds the school van service
- Coordination challenge to serve students and the general public
- Navigating different government agencies that all regulate some aspect of the consolidated program School risks losing state funds
- Washington State law only allows students, bus driver, and bus monitors on school vans and buses
- Must address Driver's Union issues due to schedule changes
- The school van might not meet the standards set by the American Disabilities Act

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Recommendation: **HOLD**

While it may make practical sense to maximize use of school vans, the coordination and bureaucracy challenges are daunting. Based on the above pros and cons, we do not recommend trying to integrate school vans into a community transit system at this time.

9 IMPLEMENT A COMMERCIAL FREIGHT COORDINATION SYSTEM

As this report notes earlier, Lopez Island relies on a relatively small number of companies to transport the majority of its commercial freight (e.g., construction materials, store inventories, etc.). Transportation from the mainland to Lopez Island adds a considerable cost to some items, especially if the shipping trucks, containers, and crates return to the mainland empty. This round trip for one-way deliveries imposes a negative impact on the environment, and exposes Lopezians to potential oil price shocks. One way to minimize this cost, risk exposure, and environmental harm would be to create a coordination system for commercial freight. This system would limit the number of empty trucks and containers returning to the island after making their deliveries by allowing goods on Lopez Island needing to be shipped to the mainland to travel back in the same trucks, crates, and containers that previously brought deliveries to Lopez.

PROS

- Improves efficiency of goods transportation for both mainland and on-island distributors and receivers
- Once a system is in place, it decreases cost of transporting goods to and from Lopez Island since round trips for one-way deliveries are now round trips for two-way deliveries
- Decreases the emissions per unit shipped
- Limits exposure to oil price shocks since the fuel cost of transport would be shared by two separate shipping/receiving entities

CONS

- Not resilient to service disruptions since two sets of shippers and receivers would be affected instead of just one
- Requires considerable coordination of deliveries to the island and shipments to the mainland
- Could decrease the shipping and inventory flexibility for both on-island and off-island shippers and receivers
- Would likely require a salaried individual to coordinate deliveries and shipments, along with other startup and overhead costs for which no single entity or group of companies would likely be willing to support financially

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Recommendation: **HOLD**

Based on a careful consideration of the pros and cons of this potential solution, weighed against its environmental sustainability, long-term resilience, and acceptability on the island, the authors do not recommend implementing the commercial freight coordination system.

10 DIVERSIFYING COMMUNITY-SCALE MARINE TRANSPORT

For many Lopez residents, the WSF serves as the only practical means of getting on and off island. To decrease the risk of disruption from interruptions in ferry service, several residents we spoke to suggested developing alternatives to the ferry system, to increase both resilience and environmental sustainability.

	PROS	CONS
Solar-powered boats	> Quiet > No Emissions > Fuel is Free	> Expensive > Immature technology > Slow > Small-scale > For calm waters
Community-owned sail-boats	> Quiet > No Emissions > Fuel is Free > Shared Costs	> Wind unpredictable > Difficult or impossible to stick to a precise ferry-like schedule > Crew-intensive > Requires complex ownership and access system
Independent passenger-only ferry service	> Reduce Dependence on WSF	> High upfront and overhead costs > Requires new port access > Duplication of WSF service > Wasteful competition, a situation that occurs when multiple operators lead to a decrease in average ridership and a rise in cost per passenger [66]

ENVIRONMENTAL SUSTAINABILITY | RESILIENCE & ADAPTABILITY | CULTURAL ACCEPTABILITY

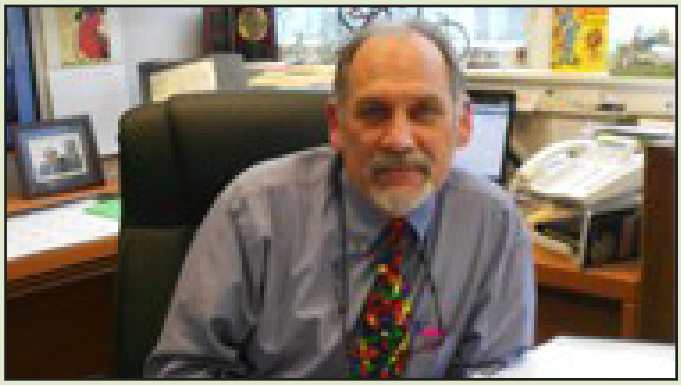
Solar-powered Boats Recommendation: **HOLD**
Community-owned Sailboats Recommendation: **HOLD**
Independent Passenger-only Ferry Service Recommendation: **HOLD**

PERSPECTIVES FROM RESIDENTS OF LOPEZ

We visited Lopez for one week in March 2012 and gained insight into the Lopezian perspective on a variety of issues. Here are a sample of opinions from Lopezians on transportation-related issues that informed our research.

Ferry Tales

Ferry terminal manager Shelley Clark remarked that the lack of connectivity to regional transit and long and unpredictable wait times for vehicles to embark on the ferry are the two biggest complaints about the WSF by Lopezians. Regarding transit connectivity, Lopez resident Randall Waugh commented on our blog, "What about a bus from the ferry terminal to/from the Amtrak train station in Mt. Vernon, especially if the ferry/bus/train schedule were sensibly organized?" Shelley Clark also noted that many Lopezians oppose an expanded reservation system for all riders. Such a system benefits mainly tourists, while Lopezians feel like the state would be forcing Lopez to use a system inappropriate to the island's needs.



Oil Pressure

We gained some valuable perspective on transportation when we interviewed owner and operator of Richardson Fuels, Rex Ritchie. Born and raised on Lopez, Mr. Ritchie has been delivering fuel for most of his working life, and doing it alone. Lopez is lucky to have experienced very few disruptions in its fuel supply given that only one person delivers most of Lopez's liquid fuel needs. When he retires, someone else will have to take over, and that someone will probably hire a staff which would surely increase the cost of providing service. Mr. Ritchie noted that rising fuel prices present a substantial risk to consumers on Lopez. He explained that a large proportion of the high price of oil comes from widespread trading in oil futures.

Biker Beware

On bicycling, we heard a common refrain from students of the Lopez School District that cycling is not very safe due to narrow or lack of shoulders on most roads and there is frequent frustration among drivers when the summer season brings a large influx of cycling tourists to the island. School superintendent Bill Evans is an avid cyclist himself yet sympathizes with driver complaints. He suggests that a potential solution may be as simple as better signage to direct bicycle tourists, and encourage road sharing and respect for traffic laws. At the same time, he and many of his students feel it is important to widen road shoulders and build bicycle lanes to improve safety.

Concluding Remarks

(transportation)

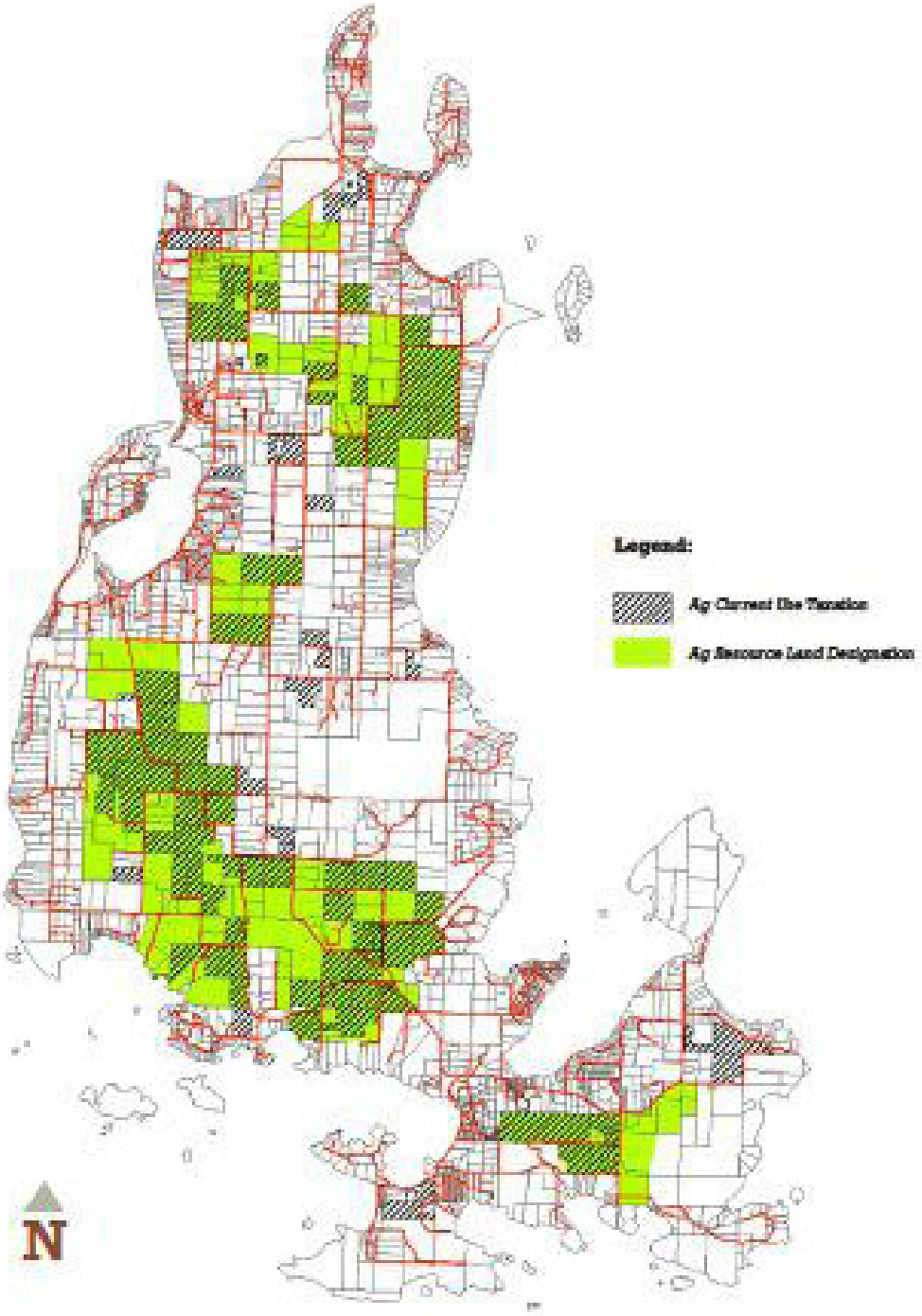
Despite the challenges inherent to transforming the transportation system on Lopez, the island's resilience and environmental sustainability depend on it. Rising oil prices, relatively high income inequality, an aging population, transportation bottlenecks and single-point import/distribution management, among other threats and risk factors noted earlier, emphasize the need for change.

This section covered a number of specific, incremental solutions to improve the transportation system on Lopez Island. Solutions identified for expedited implementation include completing a climate change vulnerability assessment, increasing the share of hybrid vehicles on the island, creating an informal ride share system, and improving bicycling-related infrastructure. Others we identified as requiring further research before implementation; in particular, creating a community transit service on Lopez Island would have large potential benefits and would meet a documented demand, but significant information gaps stand between this potential solution and its implementation.

Moving beyond these incremental solutions to further increase environmental sustainability and island-wide resilience in the transportation sector, while respecting island culture and tradition, requires an overall decrease in the reliance on transportation in the first place. In order to make this possible, substantial changes would need to happen in transportation both on and off the island. To reduce reliance on transportation on Lopez Island, structural changes like more clustered communities would need to occur. Reducing reliance on off-island transportation would require changes in key sectors of the economy – in particular, food, agriculture, and waste. In this regard, closing resource loops, increasing local production of food and other goods, and reducing exported solid waste in general would localize economic activity and decrease Lopez Island's exposure to transportation-related risks. The next two sections of the paper, which focus on agriculture, water, and waste, addresses some of these key transformations.

Agriculture and Water

Lopez Island



Historically, Lopez Island has been a net exporter of food, especially under the management of the native population before the arrival of Europeans. In the 19th and early 20th cennturies potato farming and orchards prevailed on the island until distribution problems made those industries economically unviable. Today, pasture-raised meat, haying, and grain farming are the most popular agricultural activities. Lopezians cultivate fruits, berries, and a variety of vegetables, but they currently import the majority of their food. Lopez therefore relies heavily on a well-functioning external supply chain [67].

Several areas define the current agriculture system challenges on Lopez:

1) Current land use patterns: Consistent with the trends in San Juan County as a whole, the size of agricultural parcels has declined in recent years. Additionally, the 2007 USDA Census of Agriculture measures a net loss of income for farming operations in San Juan County. Thus, the farming community must determine the most appropriate use of and production patterns on existing agricultural lands.

2) Consumption Trends: Seasonality affects consumption and production patterns on the island. Producers seek to find a balance between local production and distribution patterns while consumers seek to find the appropriate balance of off- and on- island purchases in accordance with growing season and the population flux during peak tourist season. Consumption on Lopez is thus characterized by a strong support for local goods accompanied by the purchase of off-island goods to meet consumer needs and preferences.

3) Economic Challenges: The farming sector faces challenges around the price of land and farm inputs as well as identifying efficient distribution systems. The agricultural sector must identify an economically viable model to ensure the legacy of farming continues on Lopez.

4) Regulatory Challenges: Regulatory challenges naturally arise in a system that seeks to address county-wide issues for islands comprised of differing land area and demographics. Lopez must work within current regulations and identify key areas to advocate for adjustments to the current system.

This section first details the current practices characterizing the island's agriculture and food system today. Next, it explores potential climate-induced threats to the food system. Finally, it presents potential solutions in terms of economic efficiency, environmental sustainability, contribution to resilience and adaptability, and cultural norms – and arrives at a set of recommendations for achieving a more resilient food system on Lopez by 2025.

CURRENT PRACTICES

(agriculture and water)

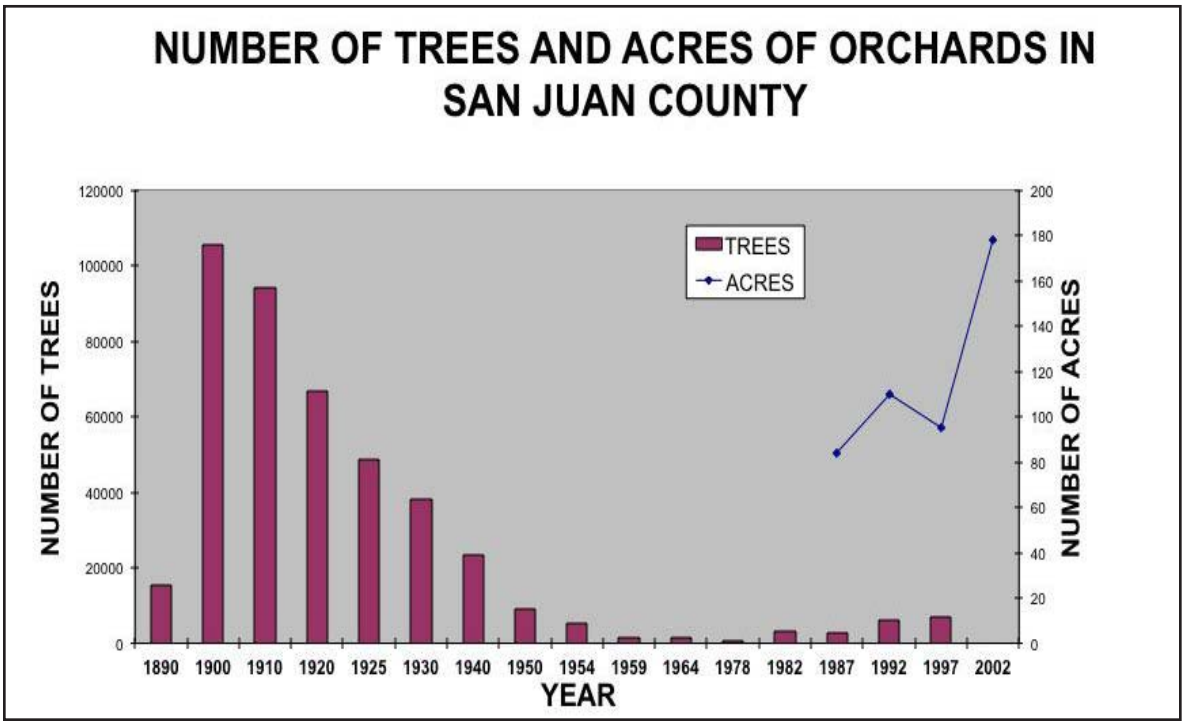
CURRENT LAND USE PATTERNS

The agricultural production of food crops for human consumption on Lopez Island has declined over the last century. As the chart below shows, orchards were prevalent in the early to mid 20th century. The island also cultivated potatoes in abundance. Currently there are 160 parcels of actively farmed land on Lopez. The 2007 USDA Census of Agriculture for San Juan County found the average farm size in the county to be 74 acres. However, aside from livestock and hay, most active farm operations such as market gardens occur on relatively smaller parcels of less than 20 acres [67]. Currently there is an almost even breakdown between leased and owner operated farms with just over 100 leased parcels of farmland, and 99 parcels of owner operated farms on the island. In addition to small parcels for commercial production, many large tracts of farmland on Lopez are leased, mainly for livestock grazing and haying [67].

The current farming mix ranges from small-scale growers of diversified produce to large scale cattle ranching and haying. The production processes range from conventional to beyond organic, as in the case of Henning's biodynamic S&S Homestead Farm. Currently, 26 farms produce a mix of livestock, fruit, and vegetables on Lopez [68]. A number of the farms use organic practices and some even exceed organic standards, but cannot afford, or choose to not pay, the certification inspection fees required for official certification.

It is noteworthy that Lopez Island farmers today dedicate a large proportion of their agricultural land to the production of hay as an animal feed and bedding crop. Reasons for this are numerous. Residents of the island explain that haying is a viable option for aging farmers and landowners for whom farming is not the main income generating activity. Many of these landowners favor haying

FIGURE 5. SOURCE: United States Department of Agriculture, National Agricultural Statistics Service



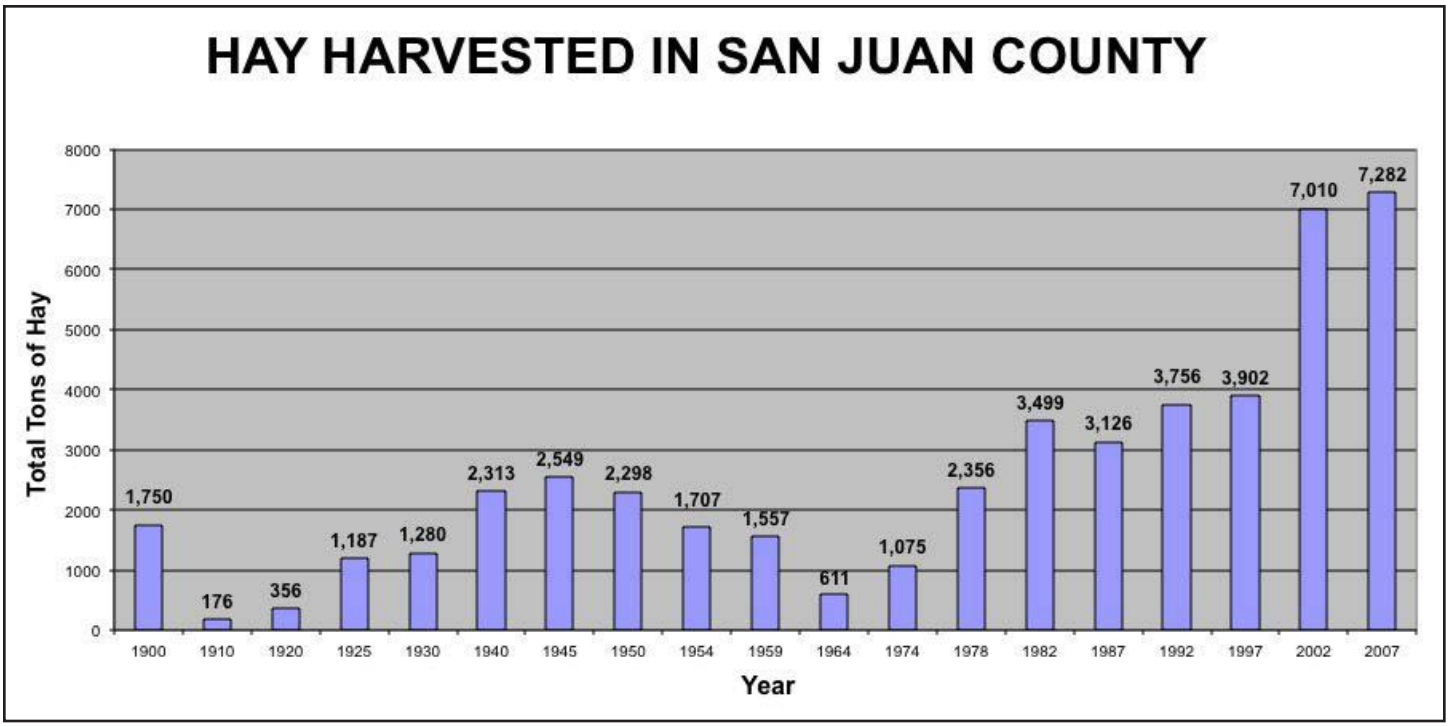


FIGURE 6. SOURCE: United States Department of Agriculture, National Agricultural Statistics Service

for animal feed on large tracts of conserved land due to the low cost of initial entry, the low labor intensity requirement, and the low maintenance costs. These reasons make haying the favored form of cultivation for those landowners who must show agricultural activity on their land in order to qualify for certain tax benefits. However, because haying practices that occur season after season with little to no soil amendments, many fields have become nutrient poor, resulting in lower quality livestock feed [1].

Haying permits landowners to qualify for the Open Spaces Taxation Act (RCW 84.34) for agricultural land. This tax benefit supports the ongoing use of land that may not be put to its fully calculated production potential. This is ideal for landowners who are not full time farmers, but rather farm their land in addition to other income generating activities or choose to lease it for other farmers to use.

Conservation of large tracts of land and support for keeping land in agricultural production is a common practice on Lopez today. Lopez Island and San Juan County have prioritized the need to preserve open space in the face of changing land use patterns. The San Juan Preservation Trust and the San Juan County Land Bank provide support in placing land under several categories of conservation: general land easements and land preserves in addition to agricultural land easements and agricultural land preserves. Regulations such as the Open Spaces Taxation Act (RCW 84.34) ensure that land remains available for open space conservation and/or agricultural production depending on the particular agreement. In this process, large landholders agree to maintain these tracts of land in perpetuity and as a result adhere to limits on infrastructure and certain types of land development.

Measures to conserve Lopez's major land resources are important to the community considering that

the majority of land on Lopez Island is either agricultural or designated for agricultural use [67]. The National Resources Conservation Service has identified 34 soil types suitable for farming in San Juan County [69]. The soil survey determined that most of the soils in San Juan County support a "vigorous plant community" of agricultural grasses and forbs species (an herbaceous flowering plant other than grasses) [70].

CURRENT CONSUMPTION TRENDS

Current food consumption trends on Lopez vary depending on the season, as increased summertime population and local growing seasons affect both supply and demand. The increased island population during the summer season causes sales at LVM to roughly double compared to the winter season.

Overall, there appears to be a strong local interest in consuming local products, as demonstrated by an active Locavores group, two Community Supported Agriculture (CSA) programs, farm stands, and a number of local outlets that highlight locally grown and produced products. Some of our survey respondents reported looking at labels "always" or "often" to see where a product was made or grown. Blossom Grocery offers Lopez Island's largest selection of local and organic products. Lopez Village Market, the largest retail market on the island, has a Lopez-local section. Stores on Lopez usually label locally-sourced produce, meat, and shellfish when it is available for sale. However, most vendors (e.g., LVM) focus mainly on meeting the demands of their customers, without much distinction between whether the products are locally sourced or not.

In spite of the interest in buying local products, very few – if any – Lopezians consume solely Lopez-made products. The few who do, or who successfully did for a short period of time, describe the necessity of dramatic changes in lifestyle and eating habits. Henning Sehmsdorf, owner of S&S Homestead Farm, described a year that she and her family spent eating a strictly local diet, which included a large portion of potatoes and lard [71]. Sehmsdorf's goal of eating only food produced on his farm and only feeding his animals food produced on his farm requires a level of time and commitment that most would find daunting: pickling, canning, and drying large amounts of summer produce for winter consumption; a lack of diversity in meal options during the winter months; and careful storing and feeding regimens for livestock, to name a few – all of which took the time and effort of nearly a full-time job [1]. Almost all Lopezians buy some of their food off-island, for greater product diversity, a lower price point, and/or the convenience of already being in a big box store off-island.

In interviews, Lopezians often remarked that the greatest hindrance to eating locally is the lack of adequate and consistent supply. Aaron Dye of LVM stated that most local farms on Lopez simply cannot provide enough for his volume of sales. Brian Kvistad of Blossom Grocery estimates that there are only about 5-6 "truly vibrant" farms on the island in terms of the ability to produce sufficient goods for a steady market supply during the growing season [72].

In addition, most contemporary consumers are accustomed to a diverse – and, in the case of many processed foods, subsidized – food basket. Lopez Island's climate, size, and current agriculture practices make it impossible for the island to provide a similar level of diversity, or heavily processed and subsidized food products. At the same time, a number of crops and livestock are currently underdeveloped on Lopez. When asked what local products they would like to see that are not currently available from local sources, survey respondents listed dairy products, various grains, affordable meat, organic meat, and fish. Notably, these are mostly products that Lopez Island harvested successfully in the past, but currently produces in much smaller volumes.

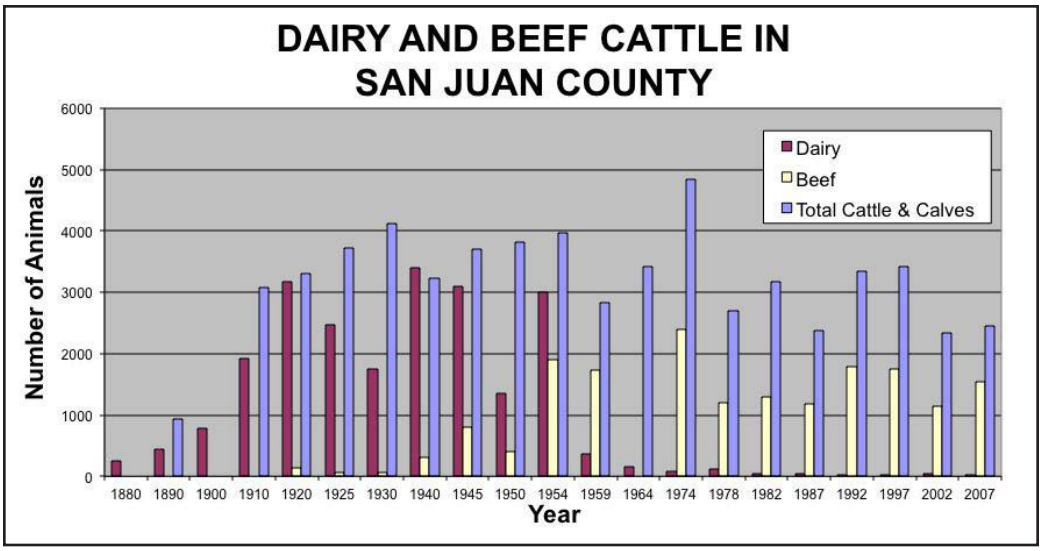


FIGURE 7. SOURCE: United States Department of Agriculture, National Agricultural Statistics Service

The exception is beef. While dairy farming has sharply declined since the 1950s due to changes in regulations that make small-scale dairies more costly or even cost-prohibitive, in the same period, the beef industry on Lopez has risen dramatically (see Figure 7 below). Sweetgrass Farm and Jones Family Farm are two successful operations that raise Wagyu and grass fed cattle respectively, mostly for off-island markets in Seattle. Lopez farmers also produce lamb and pasture raised pork for off-island markets.

CURRENT ECONOMIC CHALLENGES

Land Acquisition:

The high price of land on Lopez creates a cost-prohibitive environment for those seeking to purchase land for agriculture. The value per acre of farmland in San Juan County has increased from $1,759/acre in 1964 to $8,691/acre in 2007, adjusted for inflation [73]. Wealthy residents, many of whom are only part time residents, own a majority of the large tracts of land on Lopez. Many of these landowners have placed their properties under conservation easements to ensure they remain as open spaces in perpetuity. Conservation measures meant to protect land from development limit the number and location of structures that can be built on a property. Young farmers often lack the capital to purchase or lease the available parcels for farming purposes. Due to these barriers to entry, the farming demographic is composed of mostly aging farmers with very few young farmers entering the industry.

Nick Jones of Jones Family Farm explained that securing land entails the demonstration of commitment and credibility by young farmers. He notes that it is a “big conceptual leap” for landowners to transition to the constant presence of animals, cultivated plants, and fenced land on their open space. He noted that even when land is acquired, returning intensively hayed or fallow lands to productivity requires a long process [74].

Infrastructure:

In addition to the cost of land, farming on Lopez requires basic infrastructural inputs such as deer fencing, secure water source(s), land preparation, farming equipment, tool sheds, housing and more. These inputs can be too expensive for beginning farmers and make hiring interns or seasonal help uneconomic. Farmers with access to land through leases or other agreements must work with the landowners to determine who will pay for and in-

Jones Family Farm

In operation for 10 years on Lopez Island, the Jones Family Farm (JFF) is an excellent example of how a young farmer can build a financially viable farm. Nick Jones attributes their success to the volume and diversity of their products and to the importance of gaining the trust of landowners and mentor farmers.

JFF operates mainly on 3 fronts: a natural, grass-based pastured livestock farm producing USDA inspected beef, goat, and pork, as well as home-based produce; a shellfish farm producing 3 types of clams and 3 varieties of oysters and mussels; and a commercial fishing operation harvesting healthy wild stocks of seasonal salmon in Puget Sound. JFF also does agricultural land consulting and restoration. They do not use commercial pesticides and use organic fertilizer produced on the farm (check if correct).

In an interview with Nick, he described how JFF struggled until it reached a large enough volume and diversity of products. He also described how "liberating" it was to expand their market beyond San Juan County. JFF nurtured connections in the local area and now their products are available in the San Juan County islands and Seattle. Sales in San Juan County sustain them through the summer while sales in Seattle sustain them through the winter. They also distribute for other Lopez growers.

Networking with landowners and other farmers was essential for JFF's successful growth. Their farm now includes 300 acres of entirely leased land that was attained parcel by parcel as they gained the trust of various landowners. Nick also acknowledges the invaluable advice and mentorship of more experienced farmers on the island and the importance of tapping into that valuable source of knowledge instead of attempting to reinvent the wheel. He emphasized that it is "more incumbent on incoming farmers to demonstrate a certain level of respect and humility to their elders."

Like many farmers on Lopez, he considers regulation to be the biggest impediment to the innovation and growth of the local food system: "When we started farming, the economics were stacked against small farming and it was a very challenging, difficult thing to wind our way through to a point where we were stable and solvent. Now, what I see is that the economics have improved…but the level of regulation, scrutiny and oversight has increased to the point where it's impossible from that angle. I look back at where we've been and someone starting in our position, essentially with no capital, and interested in the things we're interested in …they wouldn't be able to do it now."

Nick believes that "there is a very good living to be made in farming" and that as fuel prices increase, small farmer will be at a greater comparative advantage. He especially sees great potential on Lopez Island for shellfish growing and describes it as a low input, environmentally sustainable industry that "could potentially employ a lot of people."

For more information about Jones Family Farm, visit www.jffarms.com

stall the basic farming infrastructure. Sandy Bishop and Rhea Miller from the Lopez Community Land Trust explained that limits on the number and location of new structures on land under conservation measures proves challenging for farmers and apprentices who need to live on or near their farm. Conservation regulations also make it difficult to install or acquire farming infrastructure. Farmers who have land often share equipment costs through informal equipment sharing agreements. Although costs are minimized, sharing becomes challenging when farmers need to use equipment at the same time.

Inputs:

"On Lopez you either have too little water or too much," said Sweet Grass Farms' Scott Meyers. Yet Lopez Island experiences an annual rainfall of only 26.44 inches while according to the National Oceanic and Atmospheric Administration, Seattle-Tacoma receives over 37 inches per year, and the island has limited groundwater storage, extensive runoff, and seawater intrusion in many wells. All of the interviewed farmers acknowledged an unspoken understanding that the aquifers on the island are limited and therefore limit well water usage. Instead, they usually draw from ponds permitted for commercial use in order to irrigate crops.

Interviewed farmers expressed great concern about proposed regulations that would no longer permit the use of ponds for agriculture and proposed regulations that would prohibit contact between livestock and surface water. Such restraints on water would impede new farms from developing and force existing farms to alter practices that are currently mindful of the entire island's fresh water supply.

For an area of less than 30 square miles, Lopez Island shows a surprising diversity of soil characteristics, ranging from sandy and dry to clay and wetlands. Some areas on the island experience extreme run-off with the soil acting as a sieve and other areas are best described as sponges. Much of the island is a seasonal wetland. All of this has proved challenging for water retention, soil drainage, soil fertility, productive growing, and properly balancing regulations such as wetland protection with farming needs. Many of the interviewed farmers improve their soil fertility by applying compost and compost teas from organic animal and crop waste. Many others purchase other types of soil enhancing inputs like petroleum-based fertilizers.

Distribution and Storage:

Distribution of foods on Lopez range from informal bartering with neighbors to imports/exports to and from locations hundreds of miles away. Distribution systems between Lopez and the rest of San Juan County, Seattle and the Pacific Northwest are fairly reliant on fossil fuels. As the price of fuel rises, it will become more important to strengthen distribution systems between nearby points.

As detailed earlier, LVM receives the majority of its stock from a small number of suppliers on the mainland. Due to economies of scale, Blossom sometimes finds that the most cost-effective distribution route is one that is not ecologically efficient. For many organic products, placing an order from a source in Seattle is only possible by routing the

product through the supplier Organically Grown Company in Eugene, Oregon. Distribution systems between the islands of San Juan County are also challenging, since travel between Lopez and the mainland is sometimes easier than travel between the islands. Individuals are responsible for the storage of produce for consumption during the off-season. While some residents have recognized the potential for canning and freezing at a larger scale, no such commercial operation yet exists on the island.

While LVM and Blossom describe the challenges of needing to stock from off-island producers simultaneously, some on-island producers find it necessary to sell to off-island consumers. Nick Jones describes how it "has been really liberating to expand beyond San Juan County" and how sales to Seattle restaurants carry their farm's diverse products through the slow winter sales on Lopez.

REGULATORY CHALLENGES

Any farmer or businessperson who has dealt with the bureaucracy of the modern world will complain about the headache of regulations. Unfortunately, this is no different for the farmers on Lopez Island. Throughout interviews, it became clear that regulations are the root cause of what makes establishing new farmers, increasing distribution, and dealing with compliance so difficult. Many farmers described the need for regulatory reform because current regulations impede innovation, which is vital to building a healthy food system. One farmer went so far as to say, "We're talking about food safety regulation that actually degrades the quality of the food system. Environmental regulation that actually degrades the quality of the environment. Worker safety and protection laws that actually endanger people" [74].

Examples of current countywide regulations meant to preserve the county's environment and cultural character exist, but they actually have the opposite effect of reducing Lopez's rural character. Perhaps more applicable on other islands in the county to protect against large-scale farming and industry, these regulations can deal serious blows to small the farms of Lopez Island. For example, a number of hand painted U-pick berry signs on Lopez were taken down by the county because they violated county regulations on billboards while some farm stands were shut down due to lack of compliance with public space requirements [75]. In the case of farm stands, county ordinances do not include rules specifically addressing these roadside stands; the county instead often invokes public space rules that prevent the construction or siting of roadside stands. Existing regulations may need to be adapted or new regulations may be needed to support emerging practices.

Housing also poses a major regulatory challenge. Some landowners on Lopez do not actively farm but would welcome having a farmer use the land productively. The biggest roadblock to that, however, is accommodating the farmer with additional housing on the land he or she farms. This is due to the regulations that dictate land use and establishes those land use districts, or "zoning laws."

Most farming on the island takes place in districts zoned either as "agricultural resource" or "rural farm forest" zones. In relation to these zones, the San Juan County code stipulates that "Subject to the provisions of this section, a detached [accessory dwelling unit] is permitted (County Code 18.40.240)." Provisions for "farm stays," "farm worker accommodations," "duplexes," and "cottage enterprises" are also included in section 18.30.040.

However, the allowance for these additional forms of housing is "provisional" which means there are many restricting limitations. From interviews we found that there are still many roadblocks for farmers looking for accommodations on land they are farming or leasing but do not own [68].

At the time of our visit to Lopez Island, a long delayed countywide audit of the Current Use Farm and Agriculture Programs was beginning in Lopez and creating frustration among farmers and landowners. At a council meeting relating to the Agriculture Current Use Taxation Program, Agricultural Resources Committee Coordinator Peggy Bill stated that under the current program, “Our tradition of leasing land, sometimes without payment, to a farmer for production of hay and/or seasonal grazing will no longer be allowed.” The San Juan Journal describes this tradition as “win-win for farmers and landowners especially when it comes to seasonal farming because land is used for free and the landowner is able to maintain their property for future agricultural uses. However, County Assessor Charles Zalmanek maintained, “The law says that land has to be farmed by commercial purposes, the law is not for bartering. It was never an option” [76].

Water Story on Lopez : Is there enough?

Water resource issues in San Juan County have traditionally been very controversial and have been used to advocate no additional growth. As noted earlier, a number of environmental factors challenge water resources on Lopez Island: low annual rainfall (26.44 inches), limited groundwater storage, extensive runoff (14 percent of precipitation), and seawater intrusion [80].

With such a vital resource in limited quantity, one would expect detailed monitoring of water usage rates and aquifer recharge rates on Lopez Island. However, the most recent water consumption rates we obtained were from the Lopez Village Water Supply Report and Recommendations report conducted nearly ten years ago. In the survey we conducted for this report, we asked Lopezians how many gallons of water/month were used for domestic usage. More than half, 44 of the 81 surveyed households, responded "no idea," "don't know," "unmetered usage" or simply with a question mark. Of the 37 households that did provide a usage rate, many indicated uncertainty about the exact figure and responses showed a dramatic range from 35 gal/month to 6,000 gal/month.

Water policies that result in the widespread use of exempt, mostly unmetered wells cause the uncertainty about water usage on Lopez Island. Fisherman Bay Water Association acts as the main purveyor of water on Lopez Island, but their service area is limited to the Village center. Washington State's Department of Ecology has been hesitant to grant new water rights and rather than engage in the often lengthy and laborious process of applying for a water right, most Lopezian landowners have taken advantage of Washington State's exempt well provision. The law allows a person to drill a well and withdraw up to 5,000 gallons per day of groundwater without applying for a water right and receiving a permit from Ecology. The provision was added so that the withdrawal of small quantities of water would not need to go through the formal permitting process of larger uses of water, but on Lopez it has become the most common source of household water usage, resulting in great uncertainty about the island's actual water consumption. Meters have been added to newer wells, but these meters are not monitored by any government agency or community group.

This is a cause for concern since water system managers in San Juan County have found that the single most effective tool for conservation in water system management is the installation and reading of meters. The initial saving is in leak detection and repairs, second is customer awareness, and finally, for the larger systems, a rate structure based on use encourages additional efficiency [80]. Uncertainty about the island's total water consumption can lead to drawing more groundwater than can be recharged. Imagine multiple straws being added to a drink that is refilled infrequently. Everyone is told to sip slowly, but no one is actually keeping track of how quickly he/she is sipping.

Fortunately, a strong culture of water conservation is practiced on Lopez. Farmers have an unspoken understanding that the aquifers on the island are limited and usually draw from permitted ponds for commercial use. Many households use low-flush or composting toilets. Estimated total island consumption in 2000 was 40,990 Cft/day and projected to be 64,477 Cft/day in 2020 [81]. Assuming island population of 2,500, that is 16.4 Cft/day/person or 123 gal/day/person. By comparison, the average water consumption in Washington State is 300 gal/day/person. In addition, long before Washington State's Department of Ecology officially allowed the capture of rooftop rainwater in 2009, Lopezians were already harvesting rainwater for non-potable usage and the installation of rainwater catchment systems is becoming increasingly popular.

However, there are a number of challenges to continuing these existing conservation practices. For example, one explanation for the low average of water usage in the 2003 Lopez Village Water Supply Report might be because 37 percent of the households included in the study were only occupied part of the year. As more part-time vacation homes become full-time homes for retirees on Lopez, water usage will increase. In addition, the farming practice of drawing from ponds and other surface water, even for small diversions, currently requires applying for a water right and a permit. Many farmers expressed concern that these rights and permits are becoming harder to obtain. Since small diversions of water are allowed under exempt wells, more farmers may begin drawing more water from aquifers. Lastly, harvesting rainwater in Lopez's low precipitation climate has its limitations.

There are currently two desalination/reverse osmosis plants on Lopez Island: one at Lopez Legacy Lodge and one at Sperry Peninsula. Such plants seem like an easy solution to water shortages for an island surrounded by seawater. Unfortunately, desalination plants are costly and typically result in significant environmental impact on delicate marine ecosystems. Ron Mayo's 2009 report, "The Current Status of Desalination Systems in San Juan County, Washington" argued that the existing desalination plants were small enough that they currently did not have a significant environmental impact, but the widespread use of desalination plants is also cost prohibitive, with capital costs about $25/gallon per day.

Due to the limited time and scope of this report and due to conflicting, or absence of, data concerning the resilience of the aquifer on Lopez, this report's main recommendation is that accurate and current baseline data on water consumption on Lopez Island be collected. This report also supports policies that encourage, rather than hinder, existing water conservation practices. Finally, this report strongly recommends collecting and distributing the 400-500 thousand gallons of treated water currently discarded by the Fisherman Bay sewage district each month. This recommendation is discussed in detail in the Waste section. Protecting the island's water supply and ensuring that the island's water budget is integrated in building policies are pivotal as the island demographics, population size, and economic change.

Fisherman Bay sewage treatment facility.

POTENTIAL PROBLEM AREAS AND RISKS FACTORS

(agriculture and water)

Given the current practices and regulations described above, this section extrapolates as best as possible what future scenarios might threaten the agricultural productivity on Lopez Island within the next 30 years. Some of these threats are within the direct control of the island community while others are influenced by larger geopolitical influences and a climatic changes that collective action of the Lopez community cannot directly impact. These potential risks can, however, be mitigated through planning for resilience.

ECONOMIC VIABILITY

If it remains increasingly difficult to come up with an economically viable business plan for farming, farmers will be unable to expand local food production. Prohibitive start-up costs and regulatory restrictions threaten the long-term sustainability of farming. Lopez already faces a lack of young farmers entering the business. Potentially interested young farmers will have little means or incentive to undertake the business risks necessary for continuing the farming legacy of today's aging farming population [67]. Moreover, although some large landowners are willing to lease their land, this opportunity cannot be maximized without the identification of a viable economic model that supports initial infrastructural needs on farmland.

SOIL FERTILITY

The intensively haying of many large parcels also threatens the long-term sustainability of agriculture on the island. This practice has depleted soil fertility. Although the soils can be reconstituted, they will require time and care if a healthy amount of organic matter is to be reestablished in an organic,

ecologically responsible manner.

CLIMATE CHANGE

Climate change predictions may affect growing patterns and practices on Lopez. Predicted changes from the National Oceanic and Atmospheric Administration and the International Panel on Climate Change (IPCC), for example, include a net decline in annual precipitation and a net increase in temperatures. The predictions report drier summers with 1.5 inches less rain in the Pacific Northwest during the summer months, 20-60 years from now. The IPCC report projects precipitation changes based on a global climate model. This model predicts that winters will be wetter and summers drier in the Seattle region. More specifically, between December and February, the region is expected to experience 10 additional inches of precipitation. Between June and August, however, the region will experience anywhere from 10 to 20 inches less rain [77]. The net change will therefore be between 0 and negative 10 inches of precipitation. While an increase in temperature may seem good for agriculture, the climate is complex. Hence, the combined change in precipitation and temperature can possibly lead to more evaporation and cloud cover. These predicted shifts will undoubtedly affect growth rates and cultivation schedules on Lopez Island.

Moreover, as a net importer of food, the island will be subject to yield and price fluctuations in off-island food producing regions. Such changes could include shifting precipitation patterns, disease, changing crop yields, and more, all of which may affect both on and off island food prices depending on the magnitude and type of change.

COMMODITY SHOCKS

Lopez may experience a changing market due to higher costs associated with food purchases both on and off island. Global and local food systems depend on fuel for production through distribution and consumption. For this reason, the cost of food imports and exports for Lopez may increase in response to rising fuel costs and the subsequent effect on supply chains. As the transportation sector explains in detail, gasoline and diesel prices are predicted to increase at least 2 to 3 percent annually between now and 2025 [78]. The resultant rising food prices could pose challenges to both farmers and island consumers. If fuel costs increase, it will become more expensive for Lopezian farmers to use farm equipment for food harvesting and production. This added cost could potentially necessitate an increase in prices of local farmers' goods. Moreover, farmers will face higher costs for shipping food off the island to their current markets. This also means that food imports will be more expensive. Rising fuel prices will also increase the cost of trips to purchase food commodities and necessities from off island stores.

POTENTIAL SOLUTIONS AND RECOMMENDATIONS

(agriculture and water)

This section presents potential areas of exploration for increasing the resilience of the agriculture system on Lopez. They are organized by those targeting land use and infrastructure, labor challenges, community buy-in to make lasting change, and sharing costs / resources.

Recommend "Go" for Implementation:

1) Form a local agriculture advisory committee
5) Promote local farmers through educational campaigns
6) Host seasonal community events to promote local agriculture
8) Create a value-add communal industrial kitchen
9) Build a co-op greenhouse

Recommend Further Research:

2) Reform zoning laws
3) Form agriculture partnerships with research institution
4) Implement a farmer sponsorship program
7) Support a GMO-Free Lopez Island
10) Construct communal roadside stands for local farmers

1 FORM A LOCAL AGRICULTURE ADVISORY COMMITTEE

The formation of an advisory committee of farmers is mandated under Washington State Statute RCW 84.34.145: "The county legislative authority shall appoint a five member committee representing the active farming community within the county to serve in an advisory capacity to the assessor in implementing assessment guidelines as established by the department of revenue for the assessment of open space, farms and agricultural lands, and timber lands classified under chapter 84.34 RCW." The advisory committee does not give advice regarding the valuation or assessment of specific parcels of land. However, it may supply the assessor with advice on typical crops, land quality, and net cash rental assessments to assist the assessor in determining appropriate values [79]. At the time of writing this report, such an advisory board does not exist.

PROS

- Compliance with state law
- Auditing and regulation can be better informed of and guided by the specific complexities of farming on Lopez Island
- Promote greater transparency and consistency in application of laws

CONS

- Potential for more bureaucracy
- More meetings for involved community members

ENVIRONMENTAL SUSTAINABILITY NOT APPLICABLE

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Recommendation: **GO**

We recommend the appointment of such a committee. Under current law, an advisory committee is required. However, at this time, the legislative authority has yet to convene one. Because lack of an advisory committee does not invalidate the listing of a property on its value assessment or the taxes associated with the property, the impetus must come from the local community to lobby that such a committee is necessary and valuable.

2 REFORM ZONING LAWS

This potential solution would allow additional housing and additional permanent structures on protected parcels. Reformed zoning laws would facilitate accommodations for farmers and their equipment. This recommendation received unanimous consent from all farmers interviewed for this paper. Since reforming these laws requires a challenging political process, it is directly in line with San Juan County's Comprehensive Plan and in accordance with the intent of county's code. The San Juan County Comprehensive Plan states that "[Land use districts] are clearly defined so as to conserve agricultural, forest, mineral resource and environmentally

sensitive lands. These areas provide for commerce and community activities without losing their small scale and attractive island ambiance." This plan is referenced in Chapter 18 of the San Juan Code, which states that its purpose is "To implement the San Juan County Comprehensive Plan goals and policies through land use and other regulations" while maintaining "aesthetic advantages of orderly development." These goals can still be accomplished while making additional provisions for extra farm housing that can be recessed from view, maintaining a rural look and function.

PROS

- Clearer legal guidelines for land use planning
- Ability to house workers on farm land
- Incentive to utilize open land for farming

CONS

- Additional bureaucract process

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Recommendation: RESEARCH

We recommend that Lopez explore community zoning preferences further before acting on this solution. Moreover, we recommend a focus on increasing community wide buy-in for farm friendly zoning laws prior to influencing the policy cycle. Once this is established, to Reforming Zoning Laws has to start through a policy cycle. The first step of this policy cycle is to draw attention to the problem, thereby setting the Political agenda so that zoning laws are brought up in county meetings. Considering the attention this issue receives from members closely associated with farming and farm planning, getting it on the agenda should not be too difficult unless previous attempts to do so have been stifled in the past.

3 FORM AGRICULTURE PARTNERSHIPS WITH RESEARCH INSTITUTIONS

Lopez can partner with a research institution such as the nearby University of Washington (UW) to address agricultural needs and generate valuable information for the agricultural sector as it adapts to climate change. Currently UW's College of the Environment runs a laboratory for marine biology exploration on Friday Harbor. This college has a Climate Change Impacts research group exploring climate change impacts on the Pacific Northwest through research and engagement with regional stakeholders. There is a potential for Lopez to offer the island's' agricultural sector as a research area for the Climate Change Impacts Group. The research group may find it possible to use the existing Friday Harbor laboratory as its local base, visiting Lopez to engage with local farmers.

PROS

- Funded research to identify Lopez-specific agricultural challenges linked to climate change
- Potential identification of strategies for farmers to adapt to projected climate induced changes on Lopez (resiliency)
- Access to technical agriculture experts

CONS

- Lopezian farmers relying on university funded support (subject to budget cuts)
- Funded research or technical help subject to changes in university budget
- Closest research station located at Friday Harbor

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY UNKNOWN

***Recommendation*: RESEARCH**

We suggest that Lopezians explore the feasibility of this partnership further. Due to the prior existence of a research facility and relationship with the surrounding area, the College of the Environment may be willing to discuss the idea with Lopez. The potential for research-based support regarding agriculture-related climate change challenges could benefit Lopez. This will require an individual from the island to make inquiries with the University and to explore options for designing a mutually beneficial partnership. At this point it is recommended that Lopezians explore this option further, following the implementation of other recommended solutions in this section.

POTENTIAL SOLUTIONS FOR LABOR CHALLENGES (4)

4 IMPLEMENT A FARMER SPONSORSHIP PROGRAM

This program would be designed to connect donors with young farmers looking to start a career on Lopez. This is a way to engage part-time or full-time residents who own agricultural land on Lopez with beginner, landless farmers. This connection could occur either through direct sponsorship or reduced lease rates for young farmers to use their land for farming purposes.

PROS

- Engaging part-time residents with land in the community and agricultural system on Lopez
- Support system for young farmers is in line with the community centric mindset in Lopez
- Increased economic access to land and resources may increase local food production and support local economy
- Balance out the aging population of farmers

CONS

- Farmers may be constrained by the farming "vision" of their sponsors (those with the funds)
- Possible over-expansion of the farming sector if large amount of funds made accessible

ENVIRONMENTAL SUSTAINABILITY	UNKNOWN	RESILIENCE & ADAPTABILITY		CULTURAL ACCEPTABILITY	

Recommendation: RESEARCH

We recommend that Lopezian's begin planning this program. The Farmer Sponsorship program is economically sustainable because it invigorates the local economy. The program supports a resilient farming system by enabling young and new farmers to enter into the farming sector currently characterized by an aging population. This ensures continued development of the farming sector. Furthermore, it upholds the strong sense of community Lopezians have. However, the impact on environmental sustainability would require further stipulations around the type of farming that is supported by this sponsorship program. For example, an increase in more conventional, intensive agriculture would result in less environmental sustainability while an increase in more sustainable, organic agriculture practices would likely increase environmental sustainability.

Eventual Implementation:

If Lopezians can construct a farm sponsorship program that promotes environmental sustainability, then they could design it based on these main initial steps. First, current and potential farmers must work together to form a small group dedicated to overseeing the organization and communication of the sponsorship program. This group would ideally be made up of new and current farmers as well as several non-farmer community representatives such as Localvore members This group should gather local data at the county level to determine which residents to target as sponsors. A strategic plan should be composed to determine a targeted approach for engaging with potential sponsors and farmers from the moment of initial financial support through the process of facilitating communication between sponsors and farmers receiving their support. This group must utilize existing outlets such as Lopez Rocks and informal community events to foster the support of community members in making this a viable program.

POTENTIAL SOLUTIONS FOR COMMUNITY BUY-IN: MAKING LASTING CHANGE (5-7)

There are varying opinions about the role and degree to which food security and independence should be set as a target for the future. Despite a lack of island wide consensus, there is a strong interest in increasing local food production and consumption for economic, environmental, and health reasons. There is still potential to increase food production on Lopez Island for both local and off-island markets. Our policy recommendations therefore aim at achieving three objectives: increasing food production, increasing the local market, and increasing the distribution networks. This will help small farmers achieve the necessary economies of scale that will make their investments and commitments worthwhile and encouraging. In this section, methods for increasing the local market are examined with a focus on purchasing behavior.

5 PROMOTE LOCAL FARMERS THROUGH EDUCATIONAL CAMPAIGNS

Educational campaigns such as those supported by the Locavore movement accomplish much in the way of directing consumer attention to the benefits of buying local, like those to their personal and environmental health and to the local economy. Big areas of focus range from encouraging consumers to eat seasonally to reconsidering the number of trips they make to big-box stores off-island for non-staple goods.

PROS

- Promotes local purchasing
- Keeps money in the local economy
- Builds community spirit

CONS

- Time and money spent on campaign requires a cadre of dedication
- Likely will not influence tourist behavior in the summer

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Recommendation: **GO**

We recommend that Lopez begin planning an educational campaign. A shift to more local begins by understanding existing attitudes and behaviors behind consumption trends. This assessment would seek to determine what constitutes a "necessity" or "staple food item" for consumers that can not be purchased on-island.

Educational Campaigns will have to be implemented by a group of people probably working on a voluntary basis. Because they are not huge campaigns, funding will be small, and implementation would probably work best small, easily digestible, hour-long, one-day, weekend workshops or meetings. We recommend beginning with a community wide survey to determine key areas of focus and knowledge gaps. High school students can be utilized to conduct consumer assessments and measure levels of awareness around certain topics. Students can potentially earn credit and real world research experience through the drafting of surveys and interviews. In this way, the educational campaigns can work with the school and community members alike. Over time, community leaders can be identified and trained to teach more workshops.

6 HOST SEASONAL COMMUNITY EVENTS TO PROMOTE LOCAL AGRICULTURE

These events can also function as educational campaigns with the added benefit of entertainment and recreation. Events such as cook-offs and perhaps the occasional indulgent pie eating competition could be organized around locally grown and cooked foods. This brings the community in direct contact with the farmers they are supporting. If organized throughout the year, the seasonality of certain foods is easy to spotlight, encouraging additional purchases of those products.

PROS	CONS
> Promotes sense of community and sharing > Use of local products	> Can be challenging to organize

ENVIRONMENTAL SUSTAINABILITY | RESILIENCE & ADAPTABILITY | CULTURAL ACCEPTABILITY

Recommendation: **GO**

We recommend that Lopez increase the number of seasonal community events currently held. These events support local consumption and community building while providing an alternative outlet for educating the community about the local food system. Seasonal Community Events are easy to organize in public spaces such as the Community Center where facilities already in place can be used for cook-offs, presentations, and auctions. A rotating schedule for planning and hosting can be enacted to ensure that the responsibility of planning the events is shared throughout the community. These events can also be hosted in in peoples' homes. As the events grow in popularity, perhaps they can be expanded to include more educational information.

7 SUPPORT A GMO-FREE LOPEZ ISLAND

This is the initiative to keep genetically modified organisms off the island and to limit their presence in the food chain and distribution network on the island. As many non-organically produced foods purchased off-island have a large chance of being genetically modified, this campaign will help Lopezians understand the importance of supporting small-scale local agriculture thereby increasing the market share of local agricultural products.

PROS	CONS
> Potential funding from organizations and institutions > Allows Lopez-grown produce to remain GMO free and therefore reach a niche market off-island > Potential for higher profit	> Challenges when importing food to island > Would require buy-in from food importers, and likely the creation of an oversight committee

ENVIRONMENTAL SUSTAINABILITY: UNKNOWN | RESILIENCE & ADAPTABILITY: UNKNOWN | CULTURAL ACCEPTABILITY

Recommendation: **RESEARCH**

Areas for Further Research:

Further research is necessary for promoting a GMO Free Lopez. Scientific data on the environmental impacts of GMOs is not definitive at this point. Thus, it is unclear what the environmental impact of an increase in non-GMO products would be on Lopez. Similarly, it is unclear whether a non-GMO focus would increase local resilience more than other practices focused around supporting the local food system. The promotion of a GMO-free Lopez is already being implemented through a public policy campaign that is collecting signatures for a ballot measure. However, increased community buy-in is necessary if Lopezians do feel strongly about this passing as a countywide policy.

POTENTIAL SOLUTIONS FOR SHARING COSTS / RESOURCES (8-10)

In order to help increase the local market, distribution networks, and achieve economies of scale, this paper recommends a series of cost and resource sharing options for farmers.

8 CREATE A VALUE-ADD COMMUNAL INDUSTRIAL KITCHEN

This potential solution deals with perishable agricultural items and creates a place where food for community events can be prepared, among other activities. Processing them into sauces and canned soups is a way to keep or sell healthy but misshapen produce, retain shelf life of surplus produce, and add value to the product. Examples of value-added preservation techniques include turning berries into jam or sorbets and making fried or baked chips out of wintergreens. Canning fruits and vegetables and pickling certain items are other viable solutions.

PROS

- Less food wasted
- Earn money during off-season
- Shared cost of kitchen equipment and facilities
- Knowledge and recipe sharing would likely lead to innovations

CONS

- Building or renovating a structure requires significant resources (e.g., time, money, management)
- A single kitchen decreases the resilience of having multiple kitchens in the event something happens to the communal one
- Equipment costs can run high
- Finding a group to maintain equipment and manage kitchen use

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Recommendation: **GO**

We recommend the continued planning of a communal industrial kitchen which is already underway and working through the permitting and funding stages under the lead of Randal Waugh. In order to ensure the success of this project, we recommend a light community outreach process in order to get all community members on board and perhaps to help with fundraising for the land and structure. Upon completion of the structure, Lopezians should establish a rotating management and maintenance system to ensure that community members both use and take responsibility for upkeep of the facility

9 BUILD A CO-OP GREENHOUSE

A co-op greenhouse addresses the seasonal cultivation challenges that Lopez geographically faces for year-round agricultural production. A greenhouse allows farmers to start seedlings in the late winter and early spring without the risk of frost killing the crop. This also increases the number of harvests that can be attained in any given year, thereby increasing market share and helping to attain economies of scale.

PROS

- Shared cost
- Rentable space
- Knowledge sharing would likely lead to innovations

CONS

- Responsibility for maintenance and management must be arranged
- Structure, seeds, and tools could carry a significant total cost
- A single greenhouse decreases the resilience of having multiple greenhouses in the event something happens to the communal one

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Recommendation: **GO**

We recommend the construction of a community greenhouse on Lopez. Lopezians must first locate a prime location for the greenhouse, taking into account weather, accessibility, sunlight exposure, and more. Funding for the greenhouse project must come from community pooled funds or an identified donor. Those farmers hoping to use the greenhouse should be involved in construction and preparation of the greenhouse. A set of common practices for preparation, planting, cultivation methods (i.e., organic or inorganic, type of inputs, irrigation methods, etc.), harvesting, and care should be decided on by all users. The division of space and maintenance responsibilities should be documented and overseen by a greenhouse manager to ensure proper maintenance and a set of common practices are upheld in the greenhouse.

10 CONSTRUCT COMMUNAL ROADSIDE STANDS FOR LOCAL FARMERS

These are the most direct way of eliminating the middleman or third party distributor and getting fresh agricultural products directly to consumers. A central location like the Lopez Village Center would be ideal as consumers already on their trip to town would not be inconvenienced by visiting multiple farms to gather their desired agricultural items. Meeting public space regulations are obviously a challenge, but through collective action, modifications to the County Code and exceptions to it can be made to allow a permanent farm stand structure. Farmers can rotate duties manning the stand and acting as a sales representative for all items available. Common crops such as greens and veggies can be pooled together and revenues shared while specialty items such as grass fed meats can be directly deposited in an accountable manner to that respective farmer's cash box. Compared to buying food off island, this option is more environmentally sustainable in terms of fuel costs saved for shipping or travel to obtain the goods.

PROS

- Centrally located = more business
- Shared cost of space
- Low labor costs if done on a trust basis

CONS

- Cost of land and structure
- Accountability for working at and maintaining the farm stand
- Communal roadside stand decreases the resilience of having many individual stands in the event something happens to the communal ones (more farmers would be affected per stand)

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY UNKNOWN

Recommendation: **RESEARCH**

We recommend exploring the communal roadside stands further due to uncertainties around public space regulations and zoning regulations. It is unsure whether there would be total community buy in due to the need to the need to address public space regulations.

S&S Homestead Farm

S&S Homestead Farm is an amazing example of the sustainable productivity potential of land on Lopez Island. Based on estimations of output-to-land rations, if all farms were all well managed as this one, Lopez Island would not only be self-sufficient but they would have a perfectly healthy and diversified diet of grains, fruits, vegetables, and high quality organic meat. Its owners, Henning Sehmsdorf and Elizabeth Simpson, use an intensely integrated form of biodynamic farming to achieve maximum yields with zero artificial inputs. In fact, all inputs come from the farm itself. To explain biodynamic farming, one could get into the philosophies and technicalities behind living in a closed looped integrated system, but to sum it up simply, Henning's idea is to essentially "feed" the soil organic compost so that the soil itself is a living thing, full of micro-organisms that excrete essential nutrients plants need to grow. This is similar to organic agriculture, of course, in that it uses natural cycles instead of chemically manufactured inputs. Their biodynamic farm takes the concept of natural cycles to the limit, however. Whereas officially certified organic crops can still use inputs and fertilizers classified organic, their farm is considered a closed-loop system that utilizes a no-till, integrated pest management system that requires almost comically little labor for weeding. They produce everything from meat, vegetables, dairy, and hay. Anything that remains in surplus is sold or pickled for year-long personal consumption and the grasses are used to feed the livestock. They do not buy hay, but rely only on what he farm can produce. Henning's philosophy is that in order to remain in balance and sustainable, only the number of animals that the land can support on its own should be farmed in any one place. If the land can only support x number of animals, then Henning will only maintain x animals. This is an example of a balanced system, and balance means resilience.

For their own subsistence, Henning and Elizabeth grow a variety of fruits, vegetables, and grains. Chickens provide eggs and dairy cows provide milk and cream, which is subsequently churned to make butter. They grind rye and wheat into flour to make bread. Barley and oats are fed to the animals.

Besides being intimately in tune with its natural surroundings, S&S Homestead Farm also has some very technical aspects to it which help reduce energy and water use. Henning planned in advance when he originally bought the land and started to build on it by facing all large roof surfaces directly to the south so as to take advantage of the continually developing solar technology at the time. Once the price for panels dropped and their efficiency increased to levels that would make it worthwhile, he made the investment and had them installed. Years later, the panels are "paying for themselves".

More information can be found at:
http://www.sshomestead.org/.<http://www.sshomestead.org/

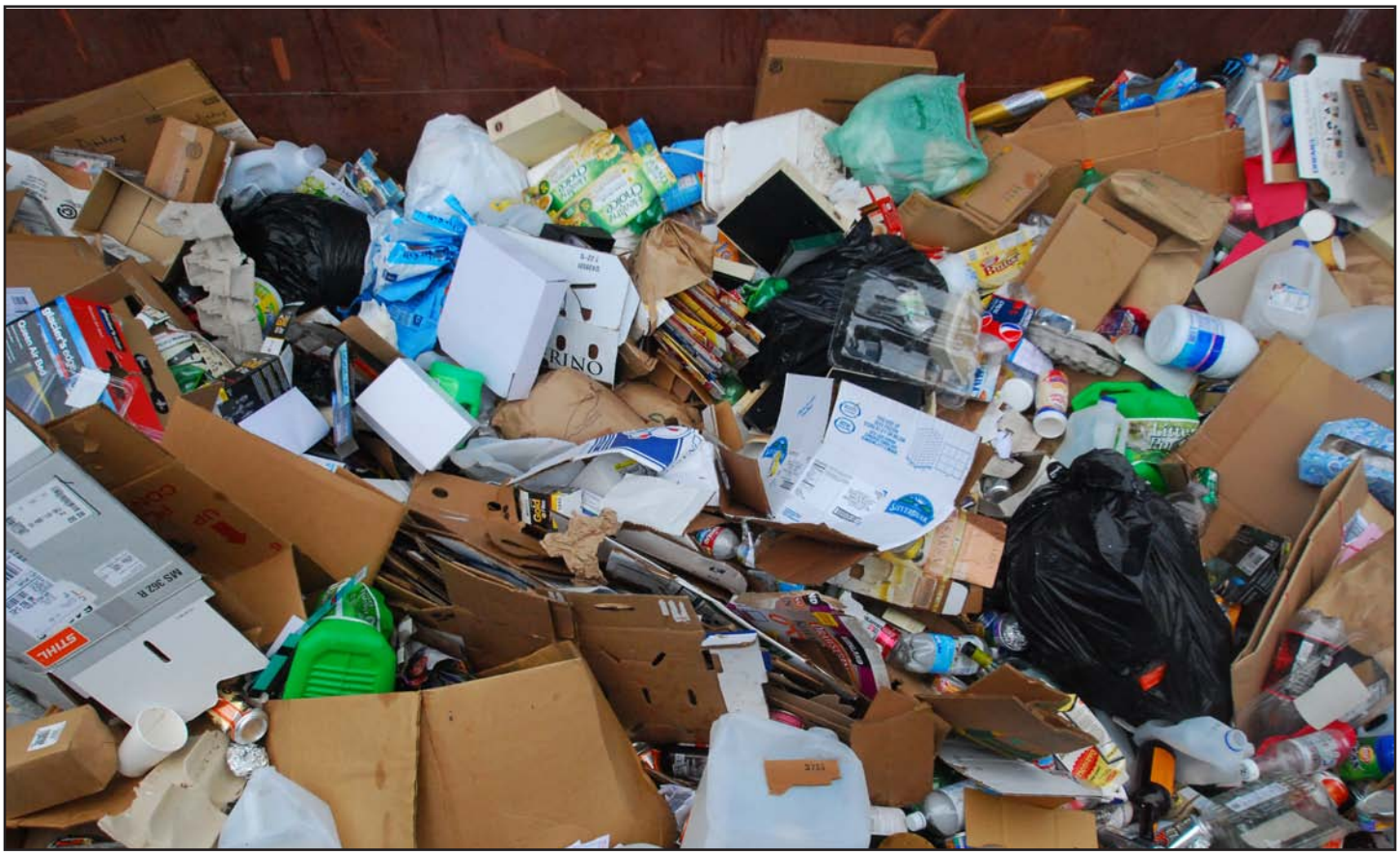
CONCLUDING REMARKS

(agriculture and water)

Overall, Lopez today stands as a forward thinking place in terms of agricultural production and its food system. Many of the farmers and community members with whom we spoke have spent many years thinking critically about the challenges that Lopez faces and the opportunities for overcoming these challenges. Our interviews with local farmers revealed a wealth of knowledge and innovative ideas for transforming the local food system, increasing the resiliency of the value of the agricultural sector, and above all of fostering a sense of community in all aspects of the food system. The farming community is well-equipped to make some necessary changes but must do so in a way that is economically, environmentally, and socially acceptable.

The most pressing issues for Lopez to address include re-thinking the kind and quality of agriculture that is promoted on the island. This includes land use patterns, fostering consumption trends that support local resilience, identifying an economically viable model to ensure the legacy of farming continues, and addressing regulatory challenges currently hindering the advancement of the agricultural system and limiting the resiliency of the local food system. As an island, Lopez has many options for fostering community buy in and pushing forward meaningful change but this must be done in an informed and well-planned manner. It is hoped that this section highlights key issues for consideration in forming a resilient and environmentally sound food system on Lopez.

Waste



Over the course of our visit on Lopez, it became apparent that the types of "waste products" we observed on our trip are better classified as "potentially recoverable resources" – the majority of which Lopezians pay to have removed. In addition to traditional "solid waste," we identified agricultural by-products, yard clippings, and sewage as potential sources of closing resource loops.

As with all other material products on island, the rising costs of fossil fuels will make cost of transporting waste materials off-island more expensive. This report will identify various opportunities for closing resource loops, thus eliminating or significantly reducing this cost along with its associated environmental burdens.

CURRENT PRACTICES

(waste)

Below, all "waste" products have been organized into one of five categories: garbage; recyclables; green waste; sewage waste; and hazardous waste. Lopezians currently pay to have the majority of these waste products removed from the island, with the notable exception of green waste.

SOLID WASTE: GARBAGE

Over the last decade, Lopez island solid waste and recyclable production has more or less leveled out despite mild population growth, suggesting that local initiatives promoting waste reduction have been fairly successful.

San Juan County offers limited curbside pick-up services managed by the San Juan Sanitation Company. Most residents do not have curbside service and take their solid waste and recyclables directly to the Lopez Transfer Station while on their way into town. Regardless of whether the waste is picked up or dropped off, residents pay a fee to cover all collection services, including disposal of their garbage and recyclables.

The Transfer Station currently collects garbage and co-mingled recyclables year round. Waste Management, a private company working on a contract basis with Lopez Island, then picks up the waste and transports it to Orcas Island. Containers at Lopez Transfer Station are 40 cubic yards. Waste Management ships by ferry about one garbage and one co-mingled container to Orcas every few days, more often during the summer season. Once there, the garbage is consolidated into 120 cubic yard intermodal containers (truck / rail) and then ferried to Anacortes. Next the garbage is trucked from Anacortes to a location near Seattle, where it is transferred to rail lines. Finally it reaches its ultimate destination by rail to a landfill near Arlington, Oregon – approximately 350 miles from Lopez.

Before the privatization of the collection system in 2002, the Lopez Transfer Station compacted and bundled waste at its facilities. Lopezians still use the transfer station for collection, the station no longer compacts or bundles waste there. An on-island activist group called "Take Back the Dump" is pushing to restore local management and create a locally owned Solid Waste Disposal District for Lopez Island. Despite popular support, the program has recently come up against a limit: the need for an on-island county management presence. As of the writing of this paper, the group collected and submitted over 1200 signatures to have a $100,000 tax proposal on the next ballot in order to pay for on-island management. For more information regarding this campaign, readers may visit http://takebackthedump.blogspot.com.

Even if Lopezians vote to restore a local collection system, it would not remove the need to ship the final waste bundles to a landfill off-island. Prospects of siting a landfill on Lopez are limited, due to the complications of agreeing upon a location, and because San Juan County currently has a long-term contract with Waste Management. The long-term contract obligates Lopez to continue using the services of Waste Management for solid waste disposal, and thus removes the decision of landfill siting from Lopezian control.

The Lopez Transfer Station also collects gently used items in a large open shed, providing a free-cycle "take it or leave it" center for residents. This program is widely celebrated by the community, and successfully diverts thousands of otherwise usable items from the landfill each year.

"Take it or Leave it" shed, an informal freesycle space located at the Lopez Transfer Staion.

SOLID WASTE: RECYCLABLES

Through a San Juan County contract, Lopezians also pay Waste Management to collect and ship their recyclables alongside their garbage (financed through drop-off fees). As with garbage, the Lopez island transfer station is still used for collection, but no longer compacts, bundles, or sorts the recyclables. The station used to have a right to sell the recyclables for a profit, but under the new system individuals must pay to drop recyclables, and the collection company owns the sales profits. According to the Lopez Transfer Station Log for the year 2011, 291 tons of co-mingled recyclables were collected and shipped off Lopez Island. Scrap metals, the only sorted recyclable materials, are sent to the Skagit River Recycling company in Burlington, WA, while the co-mingled recyclables are destined for a Waste Management Company facility in Woodinville, north of Seattle. As with most recycling regimens, the quantity of material ultimately recycled depends almost entirely on the market for recyclables. Therefore, it is impossible to say how much of Lopezian recyclables are truly sent to factories to be melted down for reuse, and how much are sent instead to the landfill.

GREEN WASTE: YARD CLIPPINGS AND FOOD SCRAPS

Neither the San Juan County Sanitation Company nor Waste Management Company collect food waste or yard clippings in a separated waste stream from solid waste. Of households that responded to our survey, a strong majority reported that they handle their yard clippings on their personal property, either spreading, composting, wood-chipping or burning it on-site. The majority also handles food scraps at home, either composting outdoors, maintaining a worm bin, or using it as animal feed. While it is important to factor in the likely "green" bias of our survey respondents, most farms that we observed or spoke with have self-contained compost systems, utilizing food scraps, agricultural by-products, manure or all of the above for compost production, which is then applied back to the land to improve soil fertility.

The Lopez Sand and Gravel company collects approximately 5,000 cubic yards of yard clippings per burn. Buffum grinds roughly one-third into mulch to sell, and burns the remaining two-thirds. The quantity mulched reflects the island demand for Buffum Co. mulch [36]. Buffum combines the ashes

from the burn pile into a compost mix, which is composed of 1/3 ash, 1/3 soil and 1/3 sand, and sells about 2,000 cubic yards of this mix annually for $30/cubic yard.

SEPTIC WASTE

The Fisherman Bay Sewer District collects the sewage waste from 150 households within or near Lopez Village as well as the Lopez School. Through a series of aerobic and anaerobic ponds, the district filters and treats approximately 400,000-500,000 gallons of water each month, which are then discharged directly into the ocean. While this water is not treated to a level appropriate for potable consumption, it does meet the standards for most agricultural irrigation (except root crops).

Outside of the Fisherman Bay Sewer District, Lopezians use 1,000-gallon septic tanks that require periodic draining. For a fee, an independent contractor pumps the septic contents into 3,500-gallon truck and stops at the Fisherman Bay treatment plant to siphon off the lightest fluids. The remaining septic waste is then taken to Anacortes by ferry, where it is incinerated. The trucking company makes an average of two ferry trips per month during the winter, and four ferry trips per month during the summer. This sums to between 100,000 and 120,000 gallons of septic waste ferried off the island per year.

HAZARDOUS WASTE: CHEMICALS AND E-WASTE

Empty toxic containers (from oil, antifreeze, pesticides, paints, etc.) and electronic waste (e-waste) are not accepted in the garbage for curbside pick up, nor via drop-off at the Transfer Station. There is, however, a state-registered e-cycle facility on Orcas Island. The Lopez Transfer Station holds special events for the collection of e-waste and hazardous materials throughout the year, and then ships this waste to the Orcas island facility.

POTENTIAL PROBLEM AREAS AND RISKS FACTORS

(waste)

If all current waste management practices were to continue without changing, Lopezians day-to-day lives would probably not be drastically affected. But herein lies the danger: the impacts of the waste stream are largely invisible in contemporary society – even for conscious citizens like Lopezians. That said, they certainly would feel the economic impact from continuing to pay to have these potentially recoverable resources removed from the island – and in the process would be paying for the continued burning of fossil fuels. The potential impacts from continued fossil fuel use are described in detail in the transportation section of this paper.

But a risk factor completely unique to waste also exists: methane production. As a soup of organic materials, chemical sludge and slowly decomposing products, landfills let off a lot of gas. The most common "landfill gas" is methane, which is 25 times more effective at atmospheric warming than CO2 (per molecule), and thus is a commanding contributor to climate change.

Most importantly, if Lopezians continue current waste disposal practices they will lose the opportunity for re-using these increasingly valuable resources. As the impacts of climate change begin to affect rainfall patterns on Lopez, greywater (such as the treated water from the Fisherman Bay Sewage District) may prove to be an essential resource for agricultural irrigation. This need may be compounded as rising average temperatures increase the need to irrigate crops. Landfill gases, such as methane, could become a valuable input for on-island energy production in the face of potentially decreased hydropower from the mainland.

POTENTIAL SOLUTIONS AND RECOMMENDATIONS

(waste)

Numerous waste cycles on Lopez Island offer easy opportunities to close resource loops. The potential solutions will focus on 6 projects to do just this:

Recommend "Go" for Implementation:

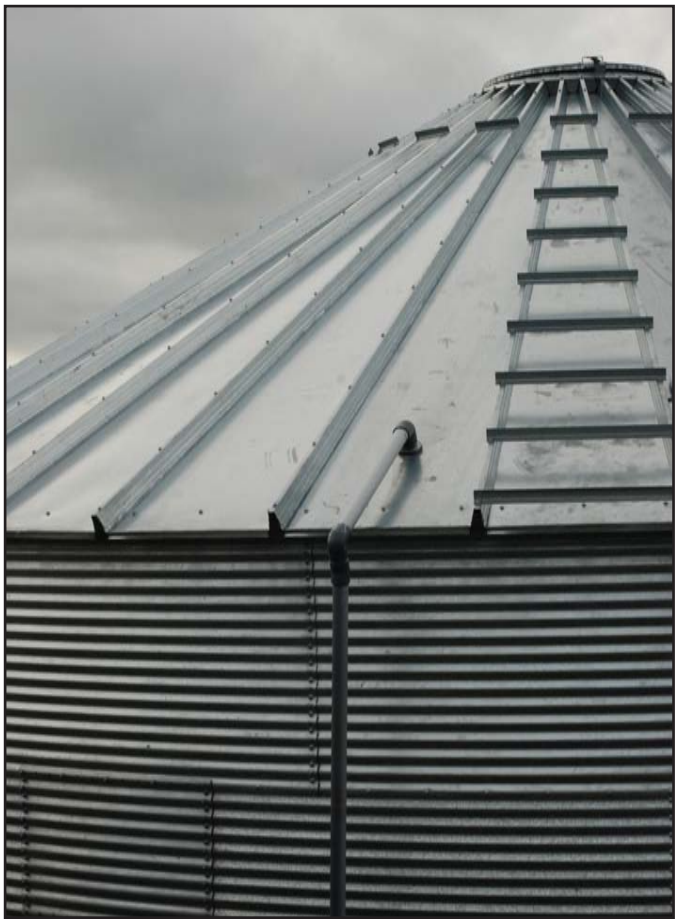
1) Localize the waste collection system
2) Collect and distribute treated sewage water

Recommend Further Research:

3) Centralize the collection of organic matter and production of compost

Recommend "Hold" at this Time:

(1) Localize the waste disposal site
4) Capitalize on landfill biogases
5) Utilize sewage solids to generate compost
6) Harvest energy from sewage and yard clipping incineration



LOCALIZE THE WASTE COLLECTION SYSTEM AND DISPOSAL SITE:
CREATE A SOLID WASTE DISPOSAL DISTRICT ON LOPEZ TO RE-LOCALIZE THE COLLECTION SYSTEM AND SITE A LOCAL LANDFILL

Re-localizing the waste collection system offers the opportunity to utilize existing infrastructures and reduce transportation costs. A source-separated garbage and recycling system (rather than co-mingled) could put the baler at the Lopez Transfer station back into use compacting plastics and aluminum, thereby reducing the overall volume for shipment. Sorted recyclables could be sold directly to the recycler, with the income directly supporting the local collection system. In addition, the creation of a local landfill would reduce the quantity of waste that must be shipped off of the island. Curbside pickup need not be part of the local solid waste disposal district, as the island demographics and geography would require a collection system that inefficiently uses energy and labor.

PROS

- Reduce transportation costs by compacting garbage and recyclables on-island, therefore reducing the number of shipments required for the same quantity of garbage.
- Reduce transportation costs by diverting waste to on-island locations.
- Reduced cost of sorting by sorting on-island
- The income remains on-island, thereby supporting the local economy

CONS

- Lopez does not currently own the rights to retain its solid waste, due to a long term contract between San Juan County and Waste Management Company, and therefore cannot re-route waste into a local landfill.
- A social dispute may arise from attempting to locate an acceptable on-island site.

FINANCIAL COSTS / CONSIDERATIONS

- Ongoing costs of administration, probably in the form of a tax. Proposal as of Feb 2012: $100,000 tax ($0.08 / $1000 of valuation).
- Capital costs of obtaining additional infrastructure
- Capital costs of land acquisition (for citing the landfill).

Local Collection Systems Recommendation: **GO**

Local Landfill Recommendation: **HOLD**

Due to positive environmental impacts of on-island compacting, the local support of creating a local solid waste collection system, and the potential job generation, we recommend that Lopezians pass the proposal to implement a $100,000 tax for the creation of a Lopez Solid Waste Disposal District. However, because of the long-term contract with Waste Management Company and the social challenges of citing an on-island landfill, we do not recommend that Lopezians pursue the creation of an on-island landfill at this time.

Implementation:
"Take Back the Dump," a local activist group, has already done much of the work toward implementing this option. As of the writing of this paper, they have gathered 1,200 signatures to levy a $100,000 tax implementation proposal on the next ballot, specifically for the creation of a Lopez Solid Waste Disposal District. The $100,000 reflects approximately $0.08 / $1000 of valuation. If this passes, the next steps are to hire the necessary labor to manage the re-activated sorting and baling system at the existing transfer station.

It is recommended that curbside pickup remain an option provided by private services to those who desire it rather than as part of the local solid waste disposal district. The island demographics and geography simply are not suited for an energy and labor efficient system. Furthermore, it would require additional infrastructure and labor, which would cost additional capital.

2 COLLECT AND DISTRIBUTE TREATED SEWAGE WATER FROM THE FISHERMAN BAY SEWAGE DISTRICT FOR USE IN SELECT CROP IRRIGATION

The discharged water from the Fisherman Bay sewage district offers a particularly easy loop to close, because the infrastructure is almost completely in place already. The treatment facility currently collects and treats 400-500 thousand gallons of water each month; the next step is to divert the discharge into a storage tank and distributing it to farms via truck. While not potable, this water is suitable for agricultural irrigation (except root crops) and landscape needs.

PROS

- A "free" source of water; the treatment facility is already in full operation discharging treated water into the ocean
- Could benefit crops that require more irrigation than provided by the Lopez rainshed.
- Could promote the expansion of agriculture on Lopez

CONS

- If poorly maintained, there is a slim chance that the treated water could contaminate the groundwater.
- Potential for pharmaceutical chemical contamination in the ecosystem

FINANCIAL COSTS / CONSIDERATIONS

- Capital costs of storage system (ranging dramatically depending upon storage and distribution system) and trucks
- Operational Costs: periodic infrastructure maintenance and ongoing distribution costs.

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

***Recommendation*: GO**

Because the water is already treated to a level suitable for most irrigation, and the limits of the Lopez rain-shed prohibit certain crop irrigation requirements, collecting the discharge from the treatment facility offers a natural source of needed agricultural inputs. With climate change promising to affect rain patterns – possibly reducing overall rainfall, or simply altering the timing of distribution – this solution provides a the opportunity for building island resilience. For these reasons, we highly recommend that this option be taken into strong consideration.

Implementation:

The needs to implement this option are straightforward: purchase and assemble storage capacity, determine the distribution model, and purchase the infrastructure necessary for the desired distribution model. But the first step must be communicating with existing and potential farmers about the desire and potential demand for this water.

The precise storage capacity needs largely depend upon the frequency of distribution. The system currently treats approximately 16-34 thousand gallons per day (winter and summer). This would require two 20,000 gallon storage tanks or one 50,000 gallon if the water were distributed daily, or more if the water were distributed less frequently. The price per 20,000-gallon tank varies depending on material, from $12,500 for fiberglass, to $18,750 for plastic, to around $20,000 for a new stainless steel tank. Thus the costs of tanks required for storing daily treated water discharge ranges anywhere from $25,000 (for two 20,000-gallon fiberglass tanks) to $280,000 (for fourteen 20,000-gallon stainless steel tanks).

There are essentially three types of distribution systems for water: roadways (truck), independent surface transport (aqueducts), or subsurface transport (pipes). Because of labor costs and limited flexibility of constructing a subsurface piping system to far reaching islands, this distribution method is not recommended. Trucking water from the treatment plant to farming facilities would require the purchase of one or two 4500 gallon trucks, depending on how many load deliveries are possible and desired each day. This, of course, would require additional operating expenses for the maintenance of the truck, fuel and labor.

Constructing an aqueduct system from the treatment facility may present a viable alternative to trucking that would simultaneously serve storage and distribution needs, and allow for greater flexibility than submerged piping. A single aqueduct exiting from the facility and branching north and south along Center Street may serve to reach a large number of farms. Water from the treatment facility could be continually discharged directly into the aqueduct and siphoned off into on-farm storage ponds as needed by the farmers. Excess water could either be contained in storage tanks or allowed to discharge into the ocean.

Tests for pharmaceutical chemicals, heavy metals, etc. should also be considered in order to address concerns about water quality and contamination, as well as investigation into the metabolic impact and breakdown of these contaminants in the ecosystem.

3 CENTRALIZE THE COLLECTION OF ORGANIC MATTER AND PRODUCTION OF COMPOST

Options explored for this potential solution include large-scale collection for commercial production and sale, or organizing a compost market for individuals to sell their homemade compost. Given its current use, the existing Transfer Station offers an ideal location for a centralized collection point, potentially as part of the services provided by a new Solid Waste Disposal District on Lopez (but equally effective without this new district). A local compost producer could then pick up the collected organic matter and take it to private facilities for compost production. Alternatively, the transfer station could offer a monthly compost exchange, allowing individual producers to sell compost to the public.

PROS

- Increases awareness about soil fertility needs
- Potentially increases supply of local soil amendments, thereby making locals less reliant upon purchasing off-island soil additives.
- Reduces shipping costs and CO2 emissions

CONS

- Many Lopezians already utilize their organic matter on their own properties
- Informal island culture may not require a central exchange market due to existing neighbor-to-neighbor bartering

FINANCIAL COSTS / CONSIDERATIONS

- Capital costs of a collection tank at the transfer station
- Capital costs of a compost production facility (varies greatly by size and system type)
- Operational Costs: maintenance and labor

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY UNKNOWN

***Recommendation*: RESEARCH**

Finding a way to produce soil amendments on-island is certainly a crucial step toward becoming resilient to climate change. Generating compost from organic waste products is one of the most basic closed-loop systems, which has been sustainably practiced globally for millennia. Many respondents to our survey already utilize organic matter on their own property, be it a personal home or a farm. As such, it is difficult to assess whether or not there are individuals with enough excess organic matter for large-scale compost production, or a desire to contribute what they are currently producing to a centralized system. Furthermore, with the informal barter culture that thrives on Lopez, chances are high that neighbor-to-neighbor exchange already occurs. Therefore, we recommend the collection of additional data on household organic waste as a first step toward determining the viability of this solution.

***Areas for Further Research*:**

Because soil fertility is of high concern on Lopez, we recommend that initial steps are taken to assess the viability of a centralized compost production system. Primarily, additional data on household organic waste (both food scraps and yard waste)

is greatly needed. Without a metric for quantifying the potential volume, it is difficult to assess the economics. In addition, a survey regarding local desire to participate and local demands would be helpful in assessing whether or not a market exists.

Current informal agreements should also be documented. Informal exchanges already exist on the island, so finding a way to further promote it should be considered in lieu of creating a centralized collection system.

4 CAPITALIZE ON LANDFILL BIOGASES: CONSTRUCT A BIOGAS COLLECTING LANDFILL AND ELECTRICITY GENERATING PLANTATION.

The construction of a local landfill-gas collection system and associated electricity generator offers an opportunity to reduce or even eliminate the need to ship waste off island, utilizing it instead to generate local electricity. One model captures landfill-gas and converts it into liquefied natural gas, which can then be combusted to create electricity. Another model is the SMARTFERM dry fermentation system, which stores organic waste, captures the off-gases to generate electricity, and produces in compost.

PROS

- The SMARTFERM system is particularly well suited for decentralized production of electricity and heat
- The SMARTFERM system could also produce compost, and thus serve to carry out potential solution 3.
- Small scale does not require much space.
- The system may function on local inputs alone, offering an independent on-island source of electricity
- Greenhouse gas emission reductions via methane capture.
- Reduced shipping costs. The precise measure depends upon details of the system. If the remaining landfill waste remains on-island after landfill-gas collection, then transportation costs would be reduced entirely to on-island collection and transport to an on-island landfill.

CONS

- Lopez may not produce enough organic waste to make the SMARTFERM dry fermentation system viable. SMARTFERM is suited for the treatment of substrates in amounts from approximately 3,000 to 3,600 metric tons per year.
- The high-methane generating sources of inputs (organic waste) may have other, more desirable on-island uses (such as for animal feed).
- Lopez does not currently own the rights to retain its solid waste, due to a long term contract between San Juan County and Waste Management Company

FINANCIAL COSTS / CONSIDERATIONS

- Capital costs of constructing plantation. For 4,500 tonnes per year, 100-150 kWe could be produced from a 3,000 sq ft plantation. (Costs vary by precise size, location and site conditions)
- Operational costs of collection and general maintenance costs. Operational costs could be reduced if the first solution in this section is also implemented.
- Distributional costs for electricity

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Recommendation: **HOLD**

Both landfill-gas and dry fermentation systems are highly environmentally sustainable, because they simultaneously divert waste and captures methane, the latter of which has a emissions factor 25 times higher than CO2 in terms of atmospheric warming effects. Furthermore, both systems offer a highly resilient source of energy production, for they can be operated off-grid, completely independent of off-island inputs. However, neither can be implemented while Lopezian garbage remains contracted to Waste Management Company, and thus destined for the landfill in Oregon. Also, unknown construction costs are potentially prohibitive. Thus we do not recommend that Lopez Island pursue this option at this time.

5 HARVEST WASTE HEAT FROM SEWAGE AND YARD CLIPPING INCINERATION: CONSTRUCT A HEAT RECOVERY OR DRY FERMENTATION SYSTEM TO GENERATE ELECTRICITY

Given that the septic sludge for Lopez is currently burned off-island, and the collected yard waste is burned on-island, this option provides a way to capture a secondary waste product generated from current disposal practices: waste heat. A steam generator could turn waste heat into electricity, and the resulting ashes may be used as a compost additive.

PROS

- The system may function on local inputs alone, offering an independent on-island source of electricity
- Reduced shipping costs.
- By capturing the waste-heat produced by current burn practices, this option generates useful energy out of an existing CO2 source. While CO2 emissions remain a concern, this option at least generates additional utility from existing emissions sources.
- Internalizing the incineration offers the opportunity to install CO2 scrubbers or another emission reduction technology on the outgas housing.

CONS

- Lopez likely does not produce enough septic sludge and yard waste to generate an adequate quantity of electricity from waste heat to provide meaningful power.
- At least one company, MR Buffum Sand and Gravel Co., already capitalizes on yard waste for other revenue-generating activities. Depending upon how this was implemented it could negatively impact that business.

FINANCIAL COSTS / CONSIDERATIONS

- Capital costs of constructing plantation.
- Operational costs of collection and general maintenance costs. Operational costs could be reduced if Lopez Island decided to localize its waste collection.
- Distributional costs for electricity

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY UNKNOWN

Recommendation: **HOLD**

Because neither yard waste nor septic sludge are bound to the Waste Management contract, this waste-to-power option is more politically viable than a dry fermentation biogas collection system. But, like the dry fermentation system, it also has potentially prohibitive capital costs for initial construction. We recommend that Lopez Island evaluate construction costs, and that it considers this solution for construction if the economics become favorable.

6 UTILIZE SEWAGE SOLIDS TO GENERATE COMPOST: COLLECT SEPTIC SLUDGE AND CONSTRUCT A PROCESSING FACILITY FOR COMPOST PRODUCTION.

A private contractor currently pumps septic sludge out of individual septic tanks, the lightest water is siphoned off at the Fisherman Bay Sewage District treatment facility, and the remaining solids are shipped off island for incineration. These solids could instead be kept on-island and turned into compost for select crops.

PROS

> Increases awareness about soil fertility needs
> Potentially increases supply of local soil amendments, thereby making locals less reliant upon purchasing off-island soil additives.
> Reduces shipping costs and CO_2 emissions

CONS

> Organic certification does not allow the use of compost generated using human septic sludge.
> Potential public discomfort

FINANCIAL COSTS / CONSIDERATIONS

> Capital costs of facility.
> Operational Costs: maintenance and distribution.

ENVIRONMENTAL SUSTAINABILITY UNKNOWN

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Recommendation: **HOLD**

Because of the prevalence for organic farming techniques on Lopez island, which does not allow the use of human compost, compounded with general public discomfort, this option is not recommended. However, it should be considered in the future – in the very least for use on non-edible landscaping. Additionally, whether or not this process would result in a net reduction of CO_2 emissions is unknown, because compost also emits CO_2 and methane.

Heating greenhouses with compost waste-heat

Scott Meyers of Sweet Grass Farms raises Wagyu, "Kobe" style beef. Scott holds a deep understanding of the challenges and opportunities facing the agriculture sector on Lopez. He embodies the type of forward thinking necessary to ensure the long-term viability of farming on Lopez. Scott envisions a waste heated greenhouse that will increase resource efficiency through a more closed loop farming system. Currently, he composts manure, resulting in large piles of mixed manure and hay that are broken down for soil fertility. Scott envisions capturing the waste heat from the compost in order to heat a simple greenhouse. This simple, yet elegant process will allow farmers to grow a greater variety of vegetables through the cold winter season and to start seeds earlier in the season.

This solution for utilizing otherwise environmentally harmful methane promises environmental efficiency, economic efficiency due to the free heat source, and supports increased food production by permitting growing in the off season. Moreover the holistic approach to farm management minimizes the products considered to be waste on a farm. The simplicity of the greenhouse model means that the project is easily scalable and replicable in any farming system with or in proximity to cattle. Scott emphasized his commitment to sharing this knowledge and technology openly, meaning it has the potential to transform systems at home on Lopez as well as those far removed from the island.

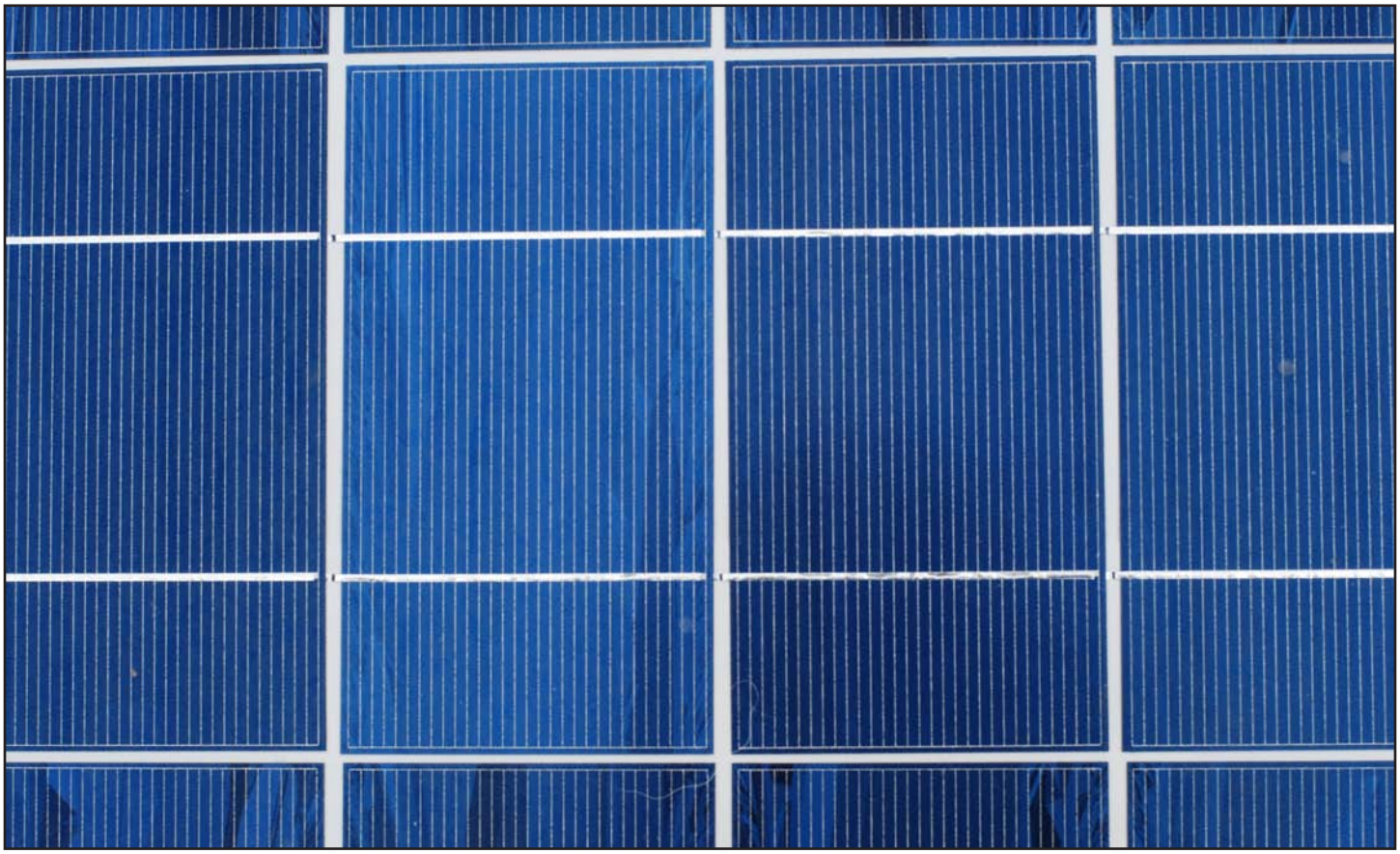
CONCLUDING REMARKS

(waste)

Lopez Island has many opportunities to improve waste streams and close resource loops in the near term, and for a relatively low expense. The positive environmental impacts and economic benefits of localizing trash collection management and compacting trash and recyclables on-island are undeniable and with few side effects. The distribution of treated sewage water from the Fisherman Bay sewage district may promote additional irrigation farming that would otherwise be impossible due to Lopez Island's low rainfall.

While several other potential solutions may not be feasible for realization before 2025, they should certainly remain under consideration for future implementation. In particular, once the contract with Waste Management expires, Lopezians should consider putting their waste to further on-island use before its ultimate disposal.

Electricity & Heating



Delivering electricity and other energy sources to islands is expensive, often carbon-intensive, and increases dependence on external resources. As an Island, Lopez relies heavily on the mainland for the majority of its electricity and heating needs. To become a more resilient and self-sustaining community, Lopez needs to take advantage of several significant electricity and heating opportunities present on the island: 1) Lopez has the potential to significantly improve energy efficiencies in the commercial and household sectors and 2) Lopez should develop renewable energy sources to help meet electricity and heating demands. In the early 20th century, Lopez sustainably managed local resources to produce the majority of its energy needs. By relying less on the mainland in the future, Lopez can develop as a sustainable and resilient community.

The Electricity and Heating section begins with an outline of current practices in the electricity and heating sectors on the island, then describes what challenges and risks may impact the island in the future. From existing reports and data collected through interviews with OPALCO, Sage Energy Solutions, and other stakeholders, the next section explores possible solutions, weighing their pros and cons, and costs when possible. Readers will find information on broader policy options for OPALCO, San Juan County, and the State of Washington, as well as a primer on Lopez's local energy resources, in Appendix 3.

CURRENT PRACTICES

(electricity and heating)

STATE OF THE ELECTRICITY SECTOR

San Juan County has an average of 2.1 people per household. Lopez Island uses over 60 percent of its non-transportation energy to heat homes and other buildings. Heating water, the island's next largest non-transportation energy usage, accounts for around 10 percent of the island's total energy demand [82]. Peak electricity demand occurs in the mornings from 7-9am, differing from mainland peaks, typically in the afternoon and evening from 4pm to 9pm [83]. In 2011, Lopez consumed 203 GWh of electricity; 72 percent for residential use and 28 percent commercial [84].

Because nearly half of homes in San Juan County (47 percent in 2009) rely on electric heat as a primary heating source and an additional 30 percent to supply a portion of heating needs, peak loads on Lopez are highest in winter months. The highest demand ever recorded for Lopez Island was 11 MW on 11 December 2008. Lopez Island experienced its lowest energy demand, 1.8 MW, on 20 June 2010. On average, the Lopez electricity load is 2.69 MW [83]. In 2011, Lopez Island's peak demand occurred on January 14th (7:00 a.m.) and its lowest demand on 7/1/2011, 1.87 MW (2:00 am). Similarly, and for comparison, San Juan County had a record peak of 72 MW on 12/20/2008 and in the same year, experienced its lowest demand recorded, 11 MW, on 6/20/2008 – the summer solstice [82].

Electricity Supply

Lopez relies on OPALCO, a non-profit member-owned utility, for the production of electricity and for its interconnection to the grid on the mainland. OPALCO contracts with the Bonneville Power Administration (BPA) and relies on BPA's power mix. In 2010, OPALCO signed a 20-year contract with BPA. The new contract includes a two-tiered rate structure that guarantees OPALCO a certain amount of low price electricity at Tier I pricing ($29.22/MWh or $0.02922/kWh) mainly from hydropower, until a demand ceiling is reached. At that point, power will be purchased by BPA and sold to OPALCO at market rates to meet the additional demand (Tier II). In addition to being greatly more expensive than the Tier I pricing, Tier II power will be subject to available sources, meaning that the clean fuel fix that OPALCO has benefited from will no longer be guaranteed or likely. At the current electricity demand growth rate of 1 percent per year, it is estimated that OPALCO will enter into Tier II pricing by 2014 [83]. Even without entering into the Tier II pricing structure, electricity costs are rising. In 2012, BPA increased wholesale electricity costs by 8 percent, requiring OPALCO to raise tariffs by 3 percent (effective March 2012) to balance the 2012 budget [83].

Nearly 75 percent of OPALCO's costs are in the operation and maintenance of the distribution system, representing about $12 million in annual fixed costs. OPALCO regains only about 37 percent of these fixed costs through the basic service charge ($26.25/mo for residential and $36.00/mo for commercial). The remainder is recouped through the demand charge paid by commercial customers and the energy charge ($0.781 cents/kwh) for all customers [85]. This current structure serves to promote energy savings and to make electrical service more affordable for low income and low consumption families. However this also means that homes that are vacant during the winter months (about 41 percent on Lopez) that are contributing to wintertime peaks (freeze control is typically set at 50 degrees) are likely paying less for their service than it costs to provide it. Year-round residents are effectively subsidizing the electricity costs of seasonally occupied homes.

Renewables in Supply

High precipitation and large elevation changes makes the Pacific Northwest a highly productive hydroelectric power generator, producing 80 percent of the region's electricity. Hydroelectric generators at the dams on the Columbia River supply 75 percent of OPALCO's electricity. (Figure 8) [84].

Washington State is currently considering whether hydropower should be classified as 'renewable'. The state's renewable energy law – Initiative 937, approved by voters in 2006 – does not include hydropower as a renewable energy source [86]. Although hydropower has no air quality impacts, construction and operation of hydropower dams can significantly affect natural river systems as well as fish and wildlife populations. In addition to disrupting the flow of rivers, water at the bottom of the lake created by a dam is often inhospitable to fish because it is much colder and oxygen-poor compared to typical ecosystem conditions. When cold, oxygen-poor water is released, it can kill fish downstream used to warmer, oxygenated water. Finally, to store energy, dams withhold water and release it at once when power is needed- this causes the downstream river to suddenly swell, disrupting plant and wildlife and potentially drinking water supplies [87].

If a large amount of vegetation is growing along the riverbed when a dam is built, it can decay in the lake that is created, causing the buildup and release of methane, a potent greenhouse gas. This is a significant issue in the construction of dams in tropical areas. Because the dams on the Columbia were built many years ago and biomass in the area is relatively low compared to the tropics, resulting methane emissions would have been limited at the time of construction and negligible today [87]. The electricity generated from hydropower is therefore virtually carbon-free [86].

Other renewables in the OPALCO supply include 2 percent wind, 0.22 percent biomass and 0.13 percent generated from waste. OPALCO estimates that

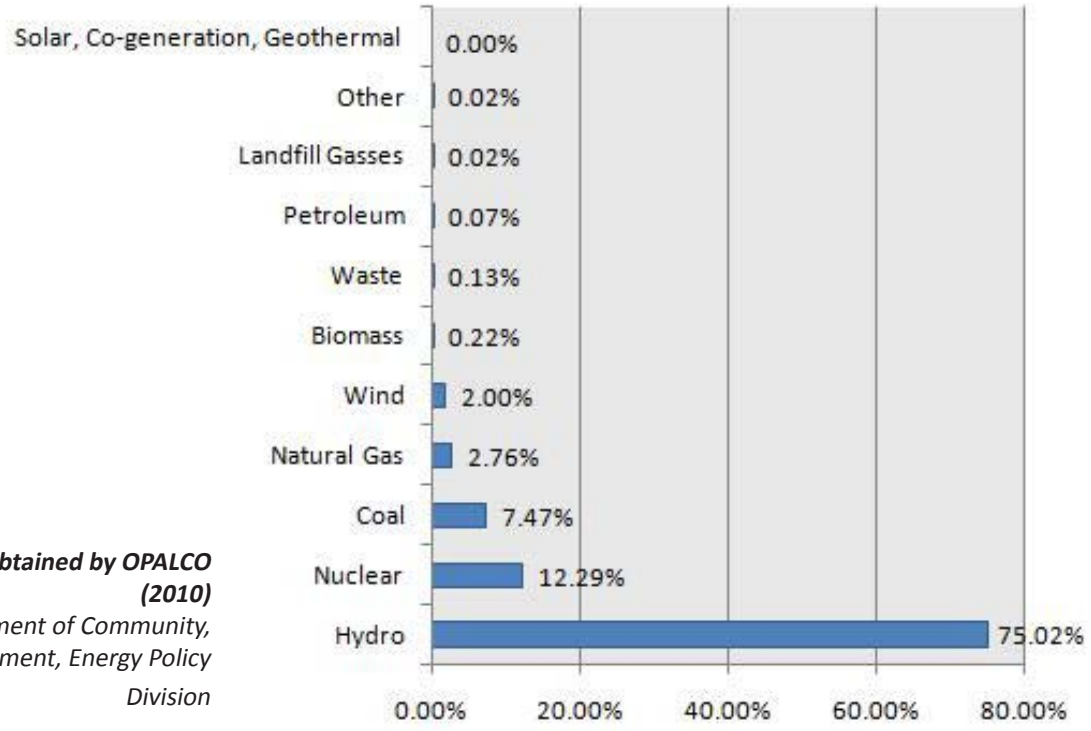


FIGURE 8: BPA Fuel Mix obtained by OPALCO (2010)

SOURCE: Washington Department of Community, Trade and Economic Development, Energy Policy Division

the electricity supplied to its members is 90 percent Greenhouse Gas (GHG) free on average. This does not mean however, that energy conservation is not an important issue in the region. Every kWh of low GHG electricity saved, means it can be used elsewhere in the Western Area Power Administration (WAPA) system and replace a kWh of fossil fuel generated electricity. This means that more people can benefit from clean power and that less natural gas or coal plants will have to be used or constructed to meet electricity needs.

Incentive Programs for Renewables

Currently there are many attractive incentives to developing the renewable energy supply in Washington State. The Washington State Renewable Energy Production Incentives program began in 2006 and provides up to $5,000 per year per household for the production of energy on the grid by solar thermal electric, photovoltaics, wind, and anaerobic digestion. The State will provide between $0.12/kWh and $1.08/kWh to the individual producer through June 2020, depending on the project, technology and the origin of the equipment. In 2009, legislation passed to allow community solar projects of up to 75 kW to benefit from the incentive. Under the law, each participant in the project can apply to receive up to the maximum of $5,000/year. However the available program funding is extremely limited – 0.5 percent of utility revenue or $100,000 is allocated to the incentives, which results in $5,000 for OPALCO and other small utilities. Therefore the economic feasibility of community renewable energy projects on Lopez is extremely limited with current funding levels [88].

MORE Program

In addition to statewide incentives programs, OPALCO's MORE program offers support for the installation of photovoltaics at the household level. More than 60 OPALCO customers currently sell locally generated renewable energy back to the grid. To promote member investment in renewable energy, MORE offers incentives for annual kilowatt-hours, which are fixed for ten years.

MORE also allows OPALCO customers to pay a premium for renewable energy in a number of different ways. Residents can pay $4 per street block, choose a higher monthly donation amount, or donate to the MORE Program's general fund (MORE brochure). MORE also offers a "Superhero" level that applies a four-cent premium per kilowatt-hour to all energy use.

Currently, 450 of OPALCO's 13,000 customers participate in the MORE program in some capacity. This low participation rate is static, and typical when compared to national voluntary renewable energy programs. The Free Rider problem impacts its success – most people are not interested in participating in voluntary programs that provide little individual benefit and only contribute to the collective good without guarantees that most others will contribute as well.

Energy Efficiency Programs

Energy efficiency programs in partnership with BPA and its public utility customers have saved over 1,100 aMW across its service area (aMW = average MW, equivalent to 8760 MWh) since the passage of the 1980 Northwest Power Act [83]. OPALCO continues to promote efficiency through rebate programs (appliance, windows and insulation) as the easiest and most economical way to address growing energy needs.

According to a 2009 NRECA survey, the vast majority of members believe OPALCO is actively addressing energy efficiency and conservation (85 percent) as well as renewable energy (79 percent). Nearly all (91 percent) rate the benefit of offering energy efficiency programs as "4" or "5" on a 5-point scale of benefits (NRECA survey 2009). The survey found that 28 percent of respondents are willing to pay 10 to 15 percent more per month to support OPALCO's renewable energy generation and energy efficiency programs.

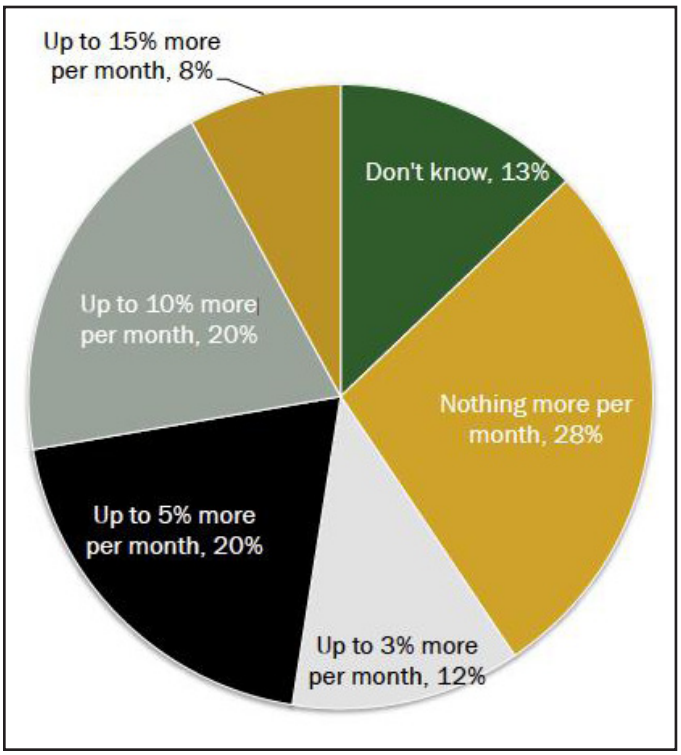


Figure 9: Amount Willing to Pay to Support OPALCO's Renewable Generation/Conservation Programs
SOURCE: NRECA Survey

OPALCO also offers members home energy assessments through their Snapshot Program. Customers can receive a "comprehensive energy estimate" for their home that would otherwise cost $150 for only $25. Local energy efficiency and home performance contractors conduct snapshot assessments and offer additional services, including free light-bulb replacement with CFLs and installing low-flow showerheads. Thus far, 250 out of 13,000 homes have participated in the assessment.

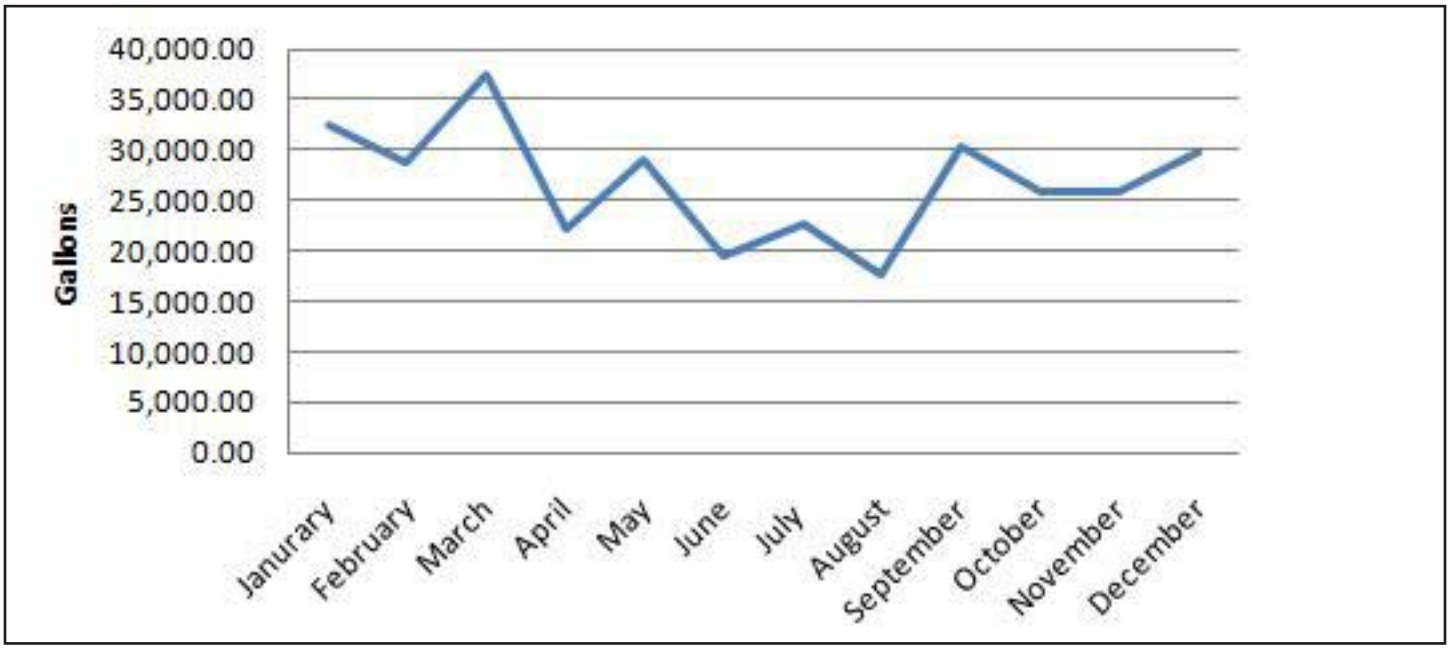
STATE OF NON-ELECTRICITY SOURCE HEATING

Propane

A total of 321,872.6 gallons of Propane were sold on Lopez Island in 2011 (see Figure 10).

About 18 percent of San Juan County residents use propane as a primary heat source, and 29 percent use it to provide part of their heating needs (Figure 11). The cost of propane on the Island is significant, as each gallon must be transported by barge from

Figure 10: 2011 Propane Sales on Lopez
SOURCE: San Juan Propane



the mainland (See Transportation Section). When the new Lopez Village Market was constructed, propane heaters were installed. The Lopez Village Market spends between $600 and $1,000 every week in propane costs; propane expenses can be as much as a quarter of the store's energy expenses [89]. Owner Aaron Dye estimates that since switching to propane heaters, the Lopez Village Market spends twice as much on heating as when the market relied on electricity [90].

Biomass

The other major heating source in San Juan County, is biomass: 29 percent of households use wood as a primary heating source and 48 percent use it to provide some of their heating needs.

Biomass Supply

Biomass accounts for 29 percent of primary space heating sources in San Juan County. Lopez Island has significant biomass resources. According to Tim Clark of the Agricultural Resource Committee, Lopez has about 6,500 acres of forests, covering approximately 22 percent of total land area. This equates to about 3 acres of forested land on Lopez per person. In comparison, about 7,000 acres are pastureland. To heat the average home on Lopez (< 2000 square feet) requires about 2 cords of wood per year.

In the 1920's, loggers, homebuilders, and other industries clearcut 90 percent of Lopez Island's forest, with 80 percent of stumps uprooted, removing valuable nutrients from the soil. The original composition of the forest on Lopez would have included maples, oaks, and cedars; today, the forest on Lopez is primarily Douglas Firs [91]. Zack Blomberg, agroforestry expert, believes that the forests on the Island are currently in poor health. The Department of Natural Resources defines forest productivity in Grades 1 to 5, in descending order, with grades 1 and 2 being the most productive (indices of 118-135 feet and 136+ feet, respectively). Forests in San Juan Country are graded 3 to 5, or are considered "poor" or "very poor", whereas forests in mainland Washington are rated "good" (2) and "superior" (1) [87]. Additional grades are not suitable for Douglas Fir, but can support other species, notably red alder (see Figure 12). Mr. Blomberg believes that with careful management (controlled burns, replanting, and the removal of diseased specimens) the forests could return to a healthy resource.

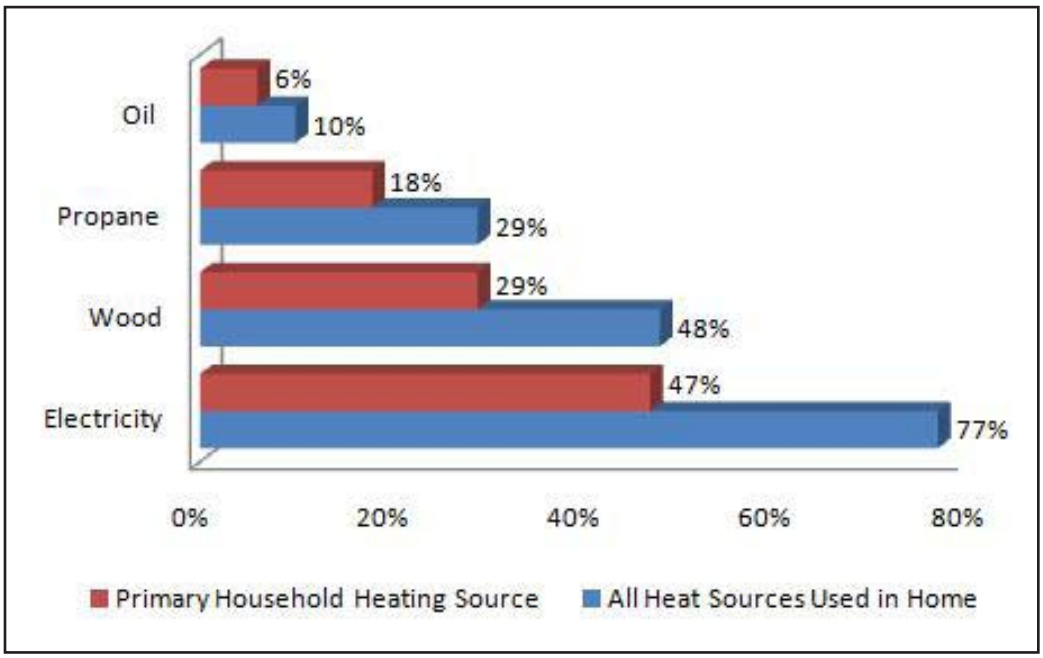


Figure 11:
Heat Sources in San Juan County
SOURCE: OPALCO Survey 2009

While there are countywide management plans for Agriculture, Marine Resources and Waste, there is no county-wide management plan for Forests. A new taxation assessment scheme (similar to the tax scheme for agricultural land) will put pressure on land tracts larger than 20 acres with forest designation to "be more productive" in terms of commercial harvest. This could lead to the clear-cutting of forests every 20-30 years so landowners can continue to benefit from the tax break.

Currently, construction debris and wood scraps are dumped at Lopez Sand and Gravel, forming what is referred to on the Island as 'the Pile'. Owner M.R. Buffum estimates that 500 dump truck loads of 10 cubic yards is dumped at Lopez Sand and Gravel every year and that two-thirds of the pile is eventually burned. This means that about 3,000 cubic meters of wood are burned every year. As explained in the Agricultural section of this report, Lopez Sand and Gravel salvages a portion of this resource by mulching. Because 'The Pile" includes roots that may contain rocks and other wood debris, only a portion of the wood may be processed this way. What Lopez Sand and Gravel cannot salvage economically, they burn yearly in an open wood fire large enough to emit about 1.8 million pounds of CO2. Mr. Buffum feels that there is a possibility that burning the resource may no longer be allowed in several years, and at that time he will have to consider an alternative.

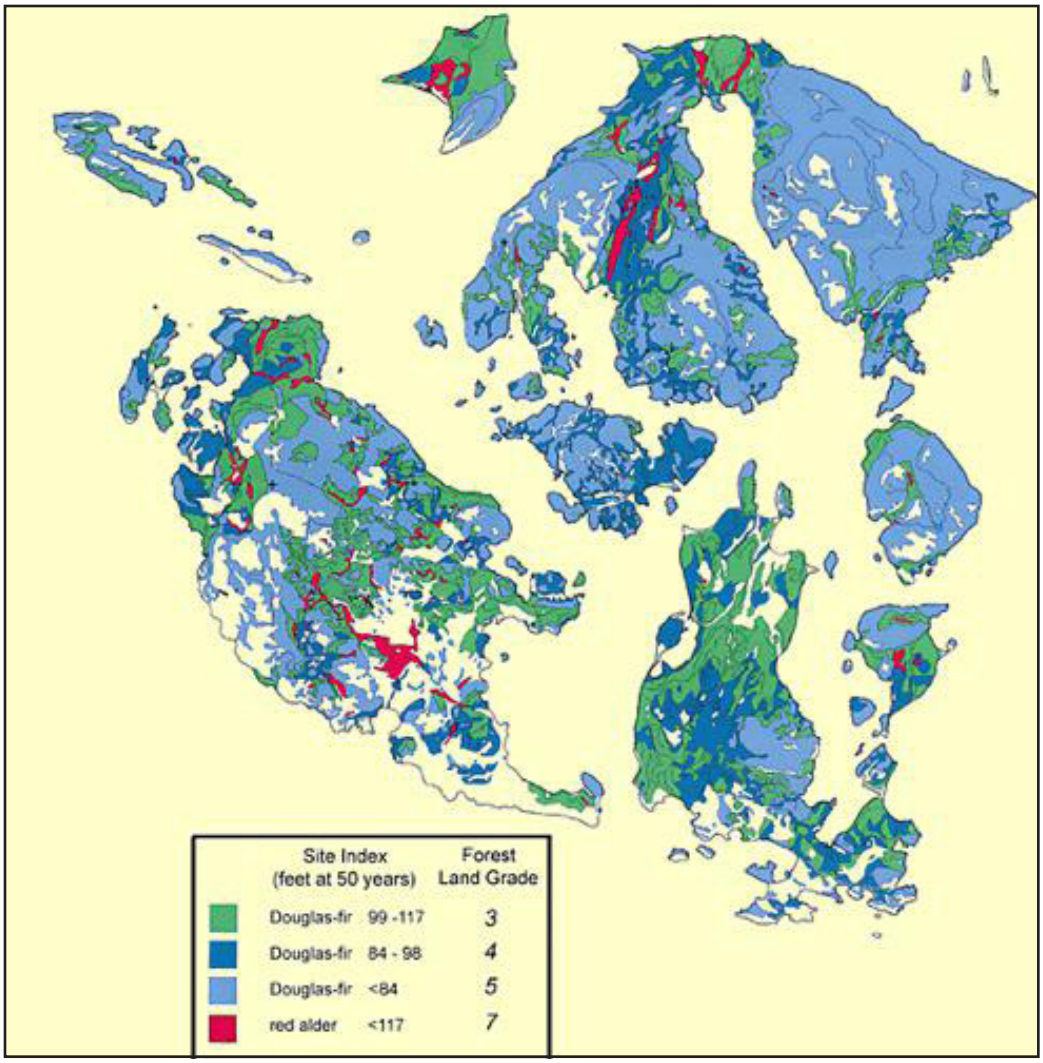


Figure 12:
Forest Land Grade Map
SOURCE: http://www.rockisland.com/~tom/Productivity%20maps.html

Rick Strachan

"I moved to Lopez Island because of two hurricanes at the other end of the country. Rita and Katrina were extremely damaging events for my South Louisiana family. I was deeply shocked by the failure of the government to respond effectively on any level at all. I was living in Portland, Oregon, a city bisected by a river, and I knew that if a comparable event occurred in that city, it would be almost impossible to survive. I had to get to a more viable location, so I moved north to Lopez Island to get to a place where I could put my long-held dreams of living a more resilient and aware life into practice. I came here specifically to build a house that could generate all its' own energy, to grow a lot of my own food and live in a community that could have a better chance to thrive in uncertain times that are certain to be full of challenges and tough choices. The challenges I have faced so far seem, predictably in retrospect, to have come from completely unanticipated directions.

Most everybody knows about my wind turbine. It's kind of hard to hide it. At the Conditional Use Permit hearing in 2009, there were over 100 people in attendance; 19 people testified in favor of it, and the hope and good energy expressed that day will stay with me forever. One guy said to me afterwards, "I feel like I've just been to church!" It took a long time to get to that hearing: 550 days of difficult slogging through the hurdles of the County government just to get a hearing. But in the end, I got my permit. Living up to the evident high hopes and good wishes of the Lopezians was almost as stressful for me as dealing with the County.

During the 550 days that it took to get to that CUP hearing, a period of time that was over 41 percent of the length of time between Pearl Harbor in 1941 and the surrender of Japan in 1945, I had plenty of time to reflect on both the State policy regarding renewable energy as expressed in RCW 80.60.005 which says:

The legislature finds it is in the public interest to:

- Encourage private investment in renewable energy resources;
  Stimulate the economic growth of this state; and
- Enhance the continued diversification of the energy resources used in this state. [1998 c 318 § 1.]

and the San Juan County Comprehensive Plan, which says:

2.2.C Energy
Goal: To conserve energy and promote energy efficiency. Policies (2.2.C.1-2)

1) Promote education on site planning methods that make maximum use of energy-saving features of the natural environment.
2) Provide opportunities within land use designations for the development and use of alternative energy resources which are compatible with the natural environment.

and think about the disconnect between those brave words and the inability of the governments to respond or act on their very own words. I'd seen that before.

The citizens of Lopez Island are way ahead of their government in thinking and planning for a future that is safe, sustainable, caring and thoughtful. My CUP documents cost over a thousand dollars a page to prepare, and they are freely available to anyone who wants to use them as a template for threading the many needle eyes of County regulations.

Actualizing my dreams here has been, and is, very difficult, but is becoming more rewarding. It has required much more tenacity and persistence than I was expecting. It helps to be much better prepared than the opposition; fortune favors the bold.

For me, the enduring lesson of the Louisiana hurricanes was that a strong local community that is well-prepared and proactive in facing the future will be much more important than any government in responding to shocking events and caring for itself in times of trouble. It's a lot more fun and hopeful to live in a community like that; this is my home now."

POTENTIAL PROBLEM AREAS AND RISKS FACTORS

(electricity and heating)

This section addresses potential economic, environmental and operational threats to Lopez's current heat and electricity consumption patterns. The effects of climate change, increased demand for electricity, and uncertainty about future energy costs and contracts create an unsteady future for Lopez if the current electricity and heating practices continue into the year 2025.

EFFECTS OF CLIMATE CHANGE

Electricity rates on Lopez have historically been low, but as hydropower becomes less reliable because of the intensification and variability of weather due to climate change, this paradigm may shift [92]. With 75 percent of OPALCO's electricity supply being serviced by hydroelectric generators, there is a significant risk of higher and more volatile energy prices. There may also be a small risk of service disruptions if reserve generation capacity is unable to make up for hydropower shortfalls in periods of low rainfall.

Severe weather patterns caused by climate change will increase infrastructure damage worldwide. Because 82 percent of OPALCO's 1,146 miles of power lines are underground, OPALCO is largely protected from this risk [84]. The severe rains and extreme weather of 2011 tested OPALCO's distribution system, which, according to an OPALCO board member, "fared well during the stormy weather" [83]. Phil Irwin, President and CEO of Federated Rural Electric Insurance Exchange, reported that while the number of insurance claims are decreasing year after year, the severity of claims is at an all time high [93]. Expenses related to infrastructure repair and insurance costs will only increase as the effects of climate change become more pronounced.

INCREASED DEMAND FOR ELECTRICITY

Electricity rates have remained low in the Pacific Northwest, due to the bounty of hydropower. As greenhouse gas standards and renewable portfolio standards become stricter in surrounding states, the demand for low carbon electricity sources will increase. This increase in demand may drive up the price of hydropower for utilities like OPALCO when the current contract expires.

FLEXIBILITY OF HYDROPOWER

The Northwest's hydroelectric generators are technically a tremendously flexible resource however, in order to protect downstream environments and human safety this flexibility is limited by regulation. Salmon ecosystem protection in Columbia and Snake rivers and the increasing amount of flexibility that is needed to make up for the intermittent power production from renewables, such as wind [92] make up the significant limitations on what is otherwise an easily dispatchable resource. If protection of salmon populations is increased, the flexibility of the system may be further compromised, leading utilities to look elsewhere for dispatchable generation capacity, often with natural gas turbines.

Currently, BPA has 6,500 MW of wind generating capacity. This is expected to rise to about 10,000 MW by 2020, which will make load balancing with hydropower difficult. Because of excess rainfall in 2011, BPA was required to order wind power curtailments so that it could prevent its reservoirs from swelling to unsafe levels [94].

CONTRACTS AND FUTURE ENERGY RATES

If the current electricity demand growth rate continues at 1 percent, OPALCO will reach Tier 2 pricing by 2014 [83]. This means that marginal energy

above the Tier 1 limit will be purchased at spot market prices. Last minute purchasing of energy could result in purchases of electricity several times more expensive than current rates.

In addition, OPALCO's contract with BPA is due to expire in 2028. After this time it is uncertain whether OPALCO will renew the contract or obtain other sources of energy.

NON-ELECTRICITY HEATING SOURCES

Propane, wood and heating oil are three alternative heat sources. Wood is most common, with 29 percent of Lopezians using it as a primary heating source, and 48 percent for some of their heating needs. Propane follows suit with 18 percent and 29 percent, and heating oil is used 6 percent and 10 percent respectively.

Homes reliant on propane for heating may see prices rise dramatically. Increased petroleum prices would increase the operating costs of transporting the fuel to the island as well as the cost of its production. Furthermore, if forests are not managed properly, the quality and value of this traditional heating source may decline. Impacts of climate change on Lopez Island's forests are not certain but may be significant.

Community Solar

Communities across the country are considering "Community Solar Gardens"- centralized PV installations that allow individuals otherwise unable to install their own system to benefit from a clean, local renewable resource. Community Solar gardens are ideal for small and medium scale arrays installed on large rooftops or otherwise unusable land.

In 2006, the Bonneville Environmental Foundation and Washington State University's Northwest Solar Center helped build one of first Community Solar Projects in the United States in Ellensburg, Washington. The Ellensburg Community Renewable Park installation has grown from 26 kW to 141 kW. Members of the Community Renewable Park receive a proportional share of the production based on their initial investment in the project. The value of the energy produced is credited on their electric bills every three months for a period of 20 years. Each contributor also receives state solar production incentive 0f $0.30 per kWh per year until 2020.

Seattle, in partnership with City Light and Seattle Parks and Recreation, is installing Community Solar on three new picnic shelters in Jefferson Park. Each solar unit is being sold for $600. Participants will receive a billing credit at a rate of $0.07 for each kWh generated by their solar unit(s) (about 50 kWh per solar unit, per year). Participants are also eligible to receive the Washington State Renewable Energy Production Incentive annually through June of 2020, offering up to an additional $1.08 per kWh, and a credit of $54.00 per unit, per year. It is estimated that participants will likely recoup most of their enrollment fee by June 2020.

University Park Community Solar (UPCS) in Maryland, took on 35 investors from $2,000 to $15,000 to fund a $130,000 PV installation and set up a power purchasing agreement (PPA) where a local church buys the generation from the system for 20 years at a rate slightly lower than the utility rate. The utility pays the group for any excess generation fed back to the grid.

SOURCE: Seattle.gov/light/solar/community.asp Beacon Mountain Shelter By Stephanie Bower, Architectural Rendering

POTENTIAL SOLUTIONS AND RECOMMENDATIONS

(electricity and heating)

While the potential solutions and recommendations in this section adhere to the Lopez-scale scope of our report, because many of the substantial transformations needed to improve the island's resilience and environmental sustainability will come about as a result of county, state, and utility policies. As such, we present in Appendix 1 to explore these broader policy recommendations.

This section outlines recommendations at the local level that could improve the resilience of the electricity and heating supply on Lopez, with an attention to those that are also environmentally sustainable and fit with the culture and traditions on the island. First, we highlight existing local opportunities on the island that promote energy efficiency and renewable energy generation. By taking advantage of local programs that currently have low participation rates, Lopezians can do their part to slow the growth of electricity demand and keep OPALCO's fuel mix as clean and inexpensive as possible.

Recommend "Go" for Implementation:

1) Create an energy interest group
2) Participate in OPALCO's MORE program
3) Conduct a solar resource site assessment
4) Take advantage of energy efficiency snapshots from OPALCO
5) Use available financing for energy efficiency improvements
6) Conserve energy and shift usage away from peak hours

CREATE AN ENERGY INTEREST GROUP

Energy is an important topic around which to rally a community, school, or island. Lopezians should consider organizing groups at any of these levels to educate about the possibilities of energy efficiency and promote improvements. Have members of the group sign up for "OPOWER" on Facebook, which automatically accesses a person's electricity data and compares it to similar sized households nearby. At the end of 2012, household real-time energy consumption data from OPALCO will be available online. Take advantage of this information by creating public art projects (see "Tidy Street"), sharing with neighbors, or creating friendly competitions for energy reduction in the home, in the neighborhood, or even inter-island competition (refer to vignette "Common Ground" to see how tracking energy use can decrease consumption). Renewable energy system owners, professionals, and other interested parties could also form an on-island or countywide organization to facilitate and improve RE interest and development.

PROS

- Contributes to community building
- An activity every age-level can participate in
- Saves money, low cost
- Helps keep others on track to reach their EE goals

CONS

- Requires time/ organization- an energy "champion"

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Recommendation: **GO**

Implementation:
Identify a local organization to champion the "Energy Superstar" program. Establish a month to focus on energy efficiency, possibly April because of Earth Day. Create a school project to monitor home energy use and report back, like the Tidy Street example in the United Kingdom (Tidystreet.org). Increase civic awareness so the reward and recognition for participating in the program has higher social value. OPALCO's options for energy efficiency and renewables are excellent, but require more community buy-in.

2 PARTICIPATE IN OPALCO'S MORE PROGRAM

OPALCO members on Lopez can contribute towards the development of local renewable energy sources in San Juan County by participating in the MORE program. Members for whom a solar PV or other renewable energy system of their own is not an option can pay into a fund that supports small scale renewable energy projects in the OPALCO area. Participation rates remain low, but the potential is attractive. By increasing participation rates substantially, Lopezians can dramatically increase the amount of funding available to support local renewable energy. At significantly higher levels of participation, the MORE fund could evolve into a more dynamic resource and could support more than just single-member small-scale projects. Table (X) shows the fundraising potential of the MORE program in its current incarnation.

As an OPALCO program, a MORE funder on Lopez is just as likely to be funding renewable energy generation on any other OPALCO serviced island in the archipelago than for the funding to support projects on Lopez. However, there is virtually no difference in the impact of a kilowatt-hour generated anywhere on the OPALCO grid on the electricity delivered to Lopez residents.

Table 3: MORE Program Potential for San Juan County. *SOURCE: OPALCO*

Participation	1 Block	2 Blocks	4 Blocks	8 Blocks	10 Blocks	Full
Monthly Contribution ($/mo)	$4.00	$8.00	$16.00	$32.00	$40.00	-
MORE E. Contribution ($/kWh)	-	-	-	-	-	$0.04
Avg. Res. Utility Bill w/ MORE	$103	$107	$115	$131	$139	$138
Diff. from Avg. Bill w/o MORE	$4	$8	$16	$32	$40	$39
MORE fund revenue ($/mo.):						
at 5% Participation	$2,504	$5,008	$10,017	$20,034	$25,042	$24,259
at 10% Participation	$5,008	$10,017	$20,034	$40,067	$50,084	$48,517
at 25% Participation	$12,521	$25,042	$50,084	$100,168	$125,210	$121,293
at 100% Participation	$50,084	$100,168	$200,336	$400,672	$500,840	$485,171

PROS

- Facilitates local assistance for local generation
- Increases share of member energy payments returning to OPALCO membership
- Members without access to sites with good resource can help those who do
- At high participation rates small individual contributions can make big changes

CONS

- With weaker resource, funds invested in local generation can have less impact on overall energy economy than the same investment elsewhere

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Recommendation: **GO**

Implementation:
Based on the above review of the MORE program's pros and cons, we suggest this recommendation be implemented immediately. Island residents should pressure for "opt-out" as the default option for MORE program participation (see OPALCO recommendation section in Appendix 1 for details).

Lopezians should also organize public-facing events to increase program participation. The island can also identify local businesses that want to support MORE – possibly by offering store discounts for MORE members, or other exclusive options.

3 CONDUCT A SOLAR RESOURCE SITE ASSESSMENT

For any family on Lopez that owns their home or has access to install a rooftop or small-scale photovoltaic system, determining the feasibility and weighing the costs and benefits of installing a PV system with site and use specific information is an important first step. Many homes and businesses on Lopez have good access to the solar resource. Many solar system installers offer free or low cost site assessments to help potential consumer-producers make informed choices about solar energy. Contacting a professional is probably the easiest way to learn and explore the renewable energy options available. Other resources are also available to aid in the exploration and development of home-scale RE projects. One excellent tool is the HOMER energy modeling software program developed by the National Renewable Energy Lab, now distributed by HOMER Energy at www.homerenergy.com.

PROS

> Solar assessment low cost, easy
> A positive solar assessment means a household can benefit from many types of solar technologies- solar thermal, solar powered heat pumps, PV.

CONS

> EE measures should be considered first
PV-only off-grid systems will not meet most families electricity demand

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Recommendation: **GO**

Implementation:
Based on the above pros and cons, this recommendation should be implemented. To generate civic participation, offer a public-facing energy drive – possibly offering prizes, raffles, or periodic events – to discuss long-term energy generation concerns.

4 TAKE ADVANTAGE OF EE SNAPSHOTS FROM OPALCO

Providing meaningful information to consumers will help them make informed choices about their energy sources and uses. For many homeowners, there are substantial economic opportunities in EE improvements and conservation. An energy audit, conducted by an expert, can provide a resident with the information they need to efficiently exploit those opportunities. A home energy assessment is the first step to determining how much energy a home consumes and where savings may lie in the household. The professional assessment offered by OPALCO is only $25 and offers free light bulb replacement and low-flow showerhead installation. Replacing two standard light bulbs with efficient CFLs pays back the $25 assessment fee in one year in electricity savings. The snapshot identifies other problem areas in the home where energy- and dollars- may be escaping from the home. Start an energy efficiency club by sending around a sign-up sheet. Start a neighborhood energy-efficiency transformation competition. This is an excellent opportunity to ensure that homes are performing as they should. Currently only 250 out of 13,000 homes in the county have participated on the island [84].

PROS

- Identifies key areas in the home where energy is being lost/wasted
- Cost can be instantly recuperated with simple, free upgrades that come with the audit
- Larger problem areas will be identified and prioritized by the auditors for homeowners further action

CONS

- Necessary to schedule an appointment, have privacy invaded
- Some updates suggested to make significant improvements may be unacceptable/too costly (i.e., reframing the house to improve the R value).

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Recommendation: **GO**

Implementation:
Same as implementation for conducting a solar resource site assessment.

5 USE AVAILABLE FINANCING FOR ENERGY EFRICIENCY IMPROVEMENTS

After participating in the OPALCO energy snapshot program, residents will have a prioritized list of recommendations for improving the efficiency of their home and reducing their electricity bills.

Islander's Bank offers a "Small Home Improvement" loan program that can be applied to energy efficiency or renewable energy projects. The small loans offered ($2,000-10,000) have a 5-year interest rate of 4.5 percent or a 10 year interest rate of 5 percent, with a $100 documentation fee. It is likely that for many homes, some efficiency improvements will realize a net economic profit to the energy consumer over the long run. Loan

financing helps those who cannot afford the upfront costs of these improvements. By paying back the loan as the savings are realized, lower-income families have easier access to the EE improvements possible savings and increased comfort.

AVAILABLE FINANCING EXAMPLES:

Loan Amount $5,000	Loan Amount $10,000
5 year fixed rate of 4.5% APR	10 year fixed rate of 5% APR
60 monthly principal & interest pmt $93.22	120 monthly principal & interest pmt $106.07
$100 Documentation Fee	$100 Documentation Fee
Rates include a 1% discount for an auto payment from an Islanders Bank Checking account	Rates include a 1% discount for an auto payment from an Islanders Bank Checking account
Rates Current as of April 2, 2011	Rates Current as of April 2, 2011
Loan programs, rates and fees are subject to change without notice	Loan program, rates and fees are subject to change without notice
Financing subject to meeting qualification standards	Financing subject to meeting qualification standards

* APR = Annual Percentage Rate

Table 4:
Available Financing Examples.
SOURCE: Islander's Bank

PROS

- Local, low-interest rate loan
- As improvements are made, savings are instantly generated that can immediately be returned to pay interest on the loan
- Savings continue year after year

CONS

- Effort of documentation

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Recommendation: **GO**

Implementation:
Implementing energy efficiency improvements is a multi-phase process. Phase I: receive an OPALCO snapshot. Phase II: (optional) get a solar site assessment if it is possible that a home may have good solar potential. Phase III: contact Islander's bank representative, establish regular rates and loan packages for qualified families and businesses.

6 CONSERVE ENERGY AND SHIFT LOADS AWAY FROM PEAK HOURS

Automatic Meter Reading data will become available to residents by the end of 2012. This data will help residents track their energy use and compare their usage to similar households. Understanding how a household uses energy is the first step in better managing home energy costs. Energy cost, and electricity in particular, is often remote from a consumer's mind when they are consuming it. Conserving energy is essentially free, and conscious consumers can significantly reduce their energy use, bills, and impact.

Furthermore, the greatest potential driver of electricity rate increases in the short-run is demand growth. By shifting electricity loads away from the winter morning peak hours, individual families can help keep electricity rates from increasing unnecessarily.

PROS

> Low Cost
> Simple measures are easy and become habits

CONS

> Conservation often requires sacrifices in lifestyle that beyond a certain threshold are unacceptable to most

ENVIRONMENTAL SUSTAINABILITY

RESILIENCE & ADAPTABILITY

CULTURAL ACCEPTABILITY

Recommendation: **GO**

Implementation:
We recommend immediate implementation of this program. Encouraging citizens to monitor their energy use and shift off peak times can be done through education campaigns, competitions, and by discussing introducing variable electricity rates in the future, preparing Lopezians to consider time of use in their energy choices.

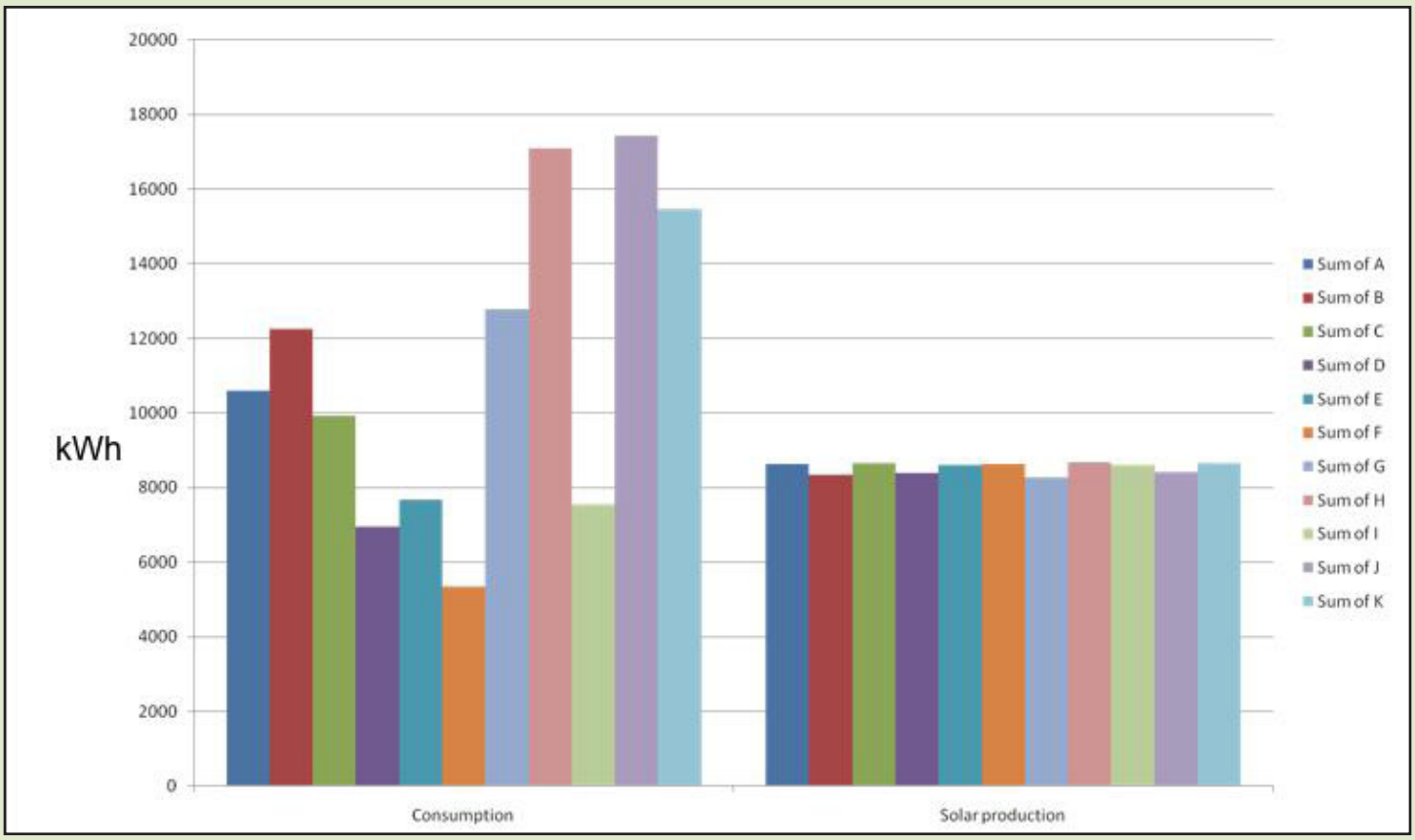
Common Ground Co-operative Housing

Common Ground is a net zero energy project that was completed in 2009 by the Lopez Community Land Trust. The mixed income development includes 11 homes, 2 rental units, and an office/resource center. The average home in Common Ground uses less than 400 kWh/month while average Lopez homes use about 1000 kWh/month. Four of the homes at Common Ground have been net zero energy since the beginning of occupancy.

Since 2009, residents have been monitoring electricity production from the solar array and usage per household. Analysis of this data shows that households with the same occupancy, living in the same energy efficient structures, have greatly varying electricity consumption. One household of four used 66 percent less energy than a similar household.

The difference in consumption is explained by occupancy behavior, an aspect of energy conservation that is often overlooked. Electricity consumption can be reduced by simple measures such as dressing more warmly in the home, turning off the lights when leaving a room, or unplugging electronics when not in use.

Figure 13: Common Ground Consumption and Solar Production 7/2009-9/2011
SOURCE: Common Ground
Note: Each bar represents an individual residence.



CONCLUDING REMARKS

(electricity and heating)

Lopez relies on the services of OPALCO for the production of electricity and its interconnection to the grid on the mainland. Electricity from OPLACO is also the primary heating source on the island. Local electricity generation remains low on Lopez though there are excellent programs in place to promote local production. Rising electricity prices, increased energy demand, especially for clean energy produced by hydropower, and other risks will present major challenges to the sustainability of the current system by the year 2025 if no improvements are made.

This section covered solutions to improve the resilience of the electricity and heating sector, favoring actions that Lopezians can take on themselves. The most important action Lopezians can take to improve the resilience and environmental sustainability of their electricity and heating supply is to increase local awareness surrounding energy use and encourage friends and neighbors to join existing energy efficiency programs and change behaviors to reduce energy needs. Changing behavior alone, as discussed in the report, can drastically reduce electricity and heating usage.

Conclusion

MATRIX OF POTENTIAL SOLUTIONS

(conclusion)

Lopez Island is far more than a summertime tourist destination in Puget Sound. Its diverse community of over 2,000 residents, vibrant multi-sector economy, rich natural resources, geographic location, and climate present unique opportunities and challenges to the island's long-term resilience and environmental sustainability. The preceding sections rooted their analysis in these factors, taking stock of the island's current practices and highlighting some of the risk factors to which the island is currently exposed.

The potential solutions in this report that address these risk factors are action-oriented. They are leverage points at the intersection of environmental sustainability (E.S.), resilience and adaptability (R&A), and cultural acceptability (C.A.) – a combination that we believe is vital to the success of a potential solution. The matrix of recommendations below summarizes all of the report's potential solutions, as well as our recommendation for action: Go, Research, or Hold. The matrix ranks the solutions not by topic area but by score on the three metrics and by recommended course of action.

POTENTIAL SOLUTION	ENVIRONMENTAL SUSTAINABILITY	RESILIENCE & ADAPTABILITY	CULTURAL ACCEPTABILITY	RECOMMEN-DATION
Host seasonal community events to promote local agriculture	●●●	●●●	●●●	GO
Localize the waste collection system	●●●	●●●	●●●	GO
Collect and distribute treated sewage water for use in select crop irrigation	●●●	●●●	●●●	GO
Create an energy interest group	●●●	●●●	●●●	GO
Create a value-add communal industrial kitchen	●●●	●●○	●●●	GO
Conduct a transportation infrastructure climate change vulnerability assessment	●●●	●●●	●●○	GO
Implement "Lopez Rocks & Rolls" – an informal rideshare program	●●●	●●●	●●○	GO
Improve bicycling infrastructure	●●●	●●●	●●○	GO
Promote local farmers through educational campaigns	●●○	●●●	●●●	GO
Participate in OPALCO's MORE program	●●●	●●●	●●○	GO
Conduct a solar resource site assessment	●●●	●●●	●●○	GO

POTENTIAL SOLUTION	ENVIRONMENTAL SUSTAINABILITY	RESILIENCE & ADAPTABILITY	CULTURAL ACCEPTABILITY	RECOMMEN-DATION
Take advantage of energy efficiency snapshots from OPALCO	●●●	●●●	●●○	GO
Use available financing for energy efficiency improvements	●●●	●●●	●●○	GO
Conserve energy and shift loads away from peak hours	●●●	●●●	●○○	GO
Build a co-op greenhouse	●●●	●●●	●○○	GO
Increase the share of hybrid vehicles on the island	●●○	●●○	●●○	GO
Form a local agriculture advisory committee	NOT APPLICABLE	●●○	●●●	GO
Reform zoning laws	●●○	●●●	●○○	RESEARCH
Implement a farmer sponsorship program	UNKNOWN	●●●	●●●	RESEARCH
Centralize the collection of organic matter and compost	●●●	●●●	UNKNOWN	RESEARCH
Form agriculture partnerships with research institutions	●●●	●●○	UNKNOWN	RESEARCH
Construct communal roadside standsh for local farmers	●●●	●●○	UNKNOWN	RESEARCH
Build a community transit service by expanding the senior ride services	●●○	●●○	UNKNOWN	RESEARCH
Start a fuel import and distribution internship	NOT APPLICABLE	●●●	UNKNOWN	RESEARCH
Implement vehicle-share programs	UNKNOWN	●●●	UNKNOWN	RESEARCH
Support a GMO-free Lopez Island	UNKNOWN	UNKNOWN	●●○	RESEARCH
Capitalize on landfill bio-gases	●●●	●●●	●●○	HOLD
Site a local landfill	●●●	●●●	●○○	HOLD
Increase the share of electric vehicles on the island	●●●	●○○	●●○	HOLD
Harvest waste heat from sewage yard clipping incineration	●●●	●●●	UNKNOWN	HOLD
Expand usage of school bus system for public transportation	●●●	●●○	○○○	HOLD
Utilize sewage solids to generate compost	UNKNOWN	●●●	●○○	HOLD
Implement a commercial freight coordination system	●●●	○○○	○○○	HOLD
Diversify community-scale marine transport	●●○	●○○	○○○	HOLD

ROOM FOR IMPROVEMENT

As with many complex projects, we found ourselves constrained not only by time but by geography and expertise. While the authors gathered as much information as they could while on the island during their research trip, one week was not nearly enough time to collect all of the data, observations, and other information that we would need to provide an even deeper analysis. Additionally, we found our geographic distance from Lopez Island challenging as we conducted background research and post-trip analysis. Our lack of technical expertise in many of the subjects that we analyzed on Lopez Island also impeded our ability to provide a more technical analysis. As environmental policy graduate students, we have an excellent higher-level understanding of how the systems analyzed in this report interact, but not a deep knowledge of any particular system. Our collective knowledge was horizontal across subjects, with only limited verticality within individual topics. The ideal setup for a report like this would entail a team of subject area experts, led by a generalist, located in situ for a long enough period of time to collect the measurements, data, observations, interviews, and other information that an in-depth technical assessment of possible sustainable transformations for resilience requires. This ideal setup beckons the creation of a research- and action-based consultancy – an idea that some of us may actively pursue in the near future.

In addition to time, geography, and expertise constraints that future projects like this could improve upon, we believe that more accurate cost estimates would greatly assist the assessment of which potential solutions we recommend for action. Many islands, including Lopez Island, would place the most importance on the cost component of a potential solution. While we tried to provide some cost estimates throughout our potential solutions sections, we lacked the data and subject-area expertise to compile accurate cost estimates for many of the potential solutions. It is important to note, however, that with a sufficiently distant time horizon – likely at least 20 years in the future – cost concerns can take on secondary importance if the future costs of inaction are sufficiently high, even when discounted against the time value of money, to warrant a relatively large upfront investment. A cost accounting of this nature would greatly benefit any analysis of potential solutions, and future studies like ours should consider applying this accounting approach whenever possible.

Lastly, while our report focused on the actions that Lopezians can take between now and 2025 to improve the island's environmental sustainability and island-scale resilience and adaptability, it provided only a limited discussion in the appendix on broader policy recommendations. County-, state-, or even national-level policies have a significant impact on the implementability of many – if not all – of the island-scale sustainable transformations for resilience that we propose. Neglecting to analyze the full push and pull power of these policies on our potential solutions presents a limitation to the depth of our report.

IMPLICATIONS AND APPLICATIONS

Despite the limitations highlighted above and the Lopez-specific focus of our report, we strongly believe that this research has broader implications and applications. Islands with similar population, geographic, or climatic characteristics may find a direct relevance of many of this report's potential solutions and risk areas. In addition, many of the potential solutions and risk areas that this report identified for Lopez Island would apply to landlocked towns and even cities – especially those without a robust public transportation system in place, those that rely heavily on outside sources for food and water, and those that have a high potential for energy efficiency and conservation improvements.

Perhaps the most significant and innovative legacy of this report lies not in its research or findings, but in its use of environmental sustainability, resil-

ience and adaptability, and cultural acceptability as a framework for analyzing potential sustainable transformations for resilience. Community and city planners, business strategists, local and regional policymakers, and individual households can apply this framework to locate the leverage points of lasting change. Islands in particular could benefit from this approach. Often, traditional practices are more environmentally sustainable and more resilient and/or adaptable to change than modern techniques. For example, Lopez Island historically grew a variety of produce, which reduced its reliance on external sources of food and exposure to fuel price increase, and promoted soil fertility by avoiding monocropping. As economic pressures pushed farmers toward haying while prices for a variety of produce available year round dropped significantly, Lopez shifted towards a reliance on imports for the majority of its agricultural products. Looking out to 2025, however, brings to light the environmental unsustainability and lack of resilience and adaptability inherent to this modern practice. In this instance, increasing local production of a variety of agricultural goods is a leverage point at the intersection of our three metrics. It is a sustainable transformation for resilience that several of our potential solutions would help to make a reality.

We welcome the reader's ideas, reactions, comments, critiques, and questions. Please contact our lead author, James Knuckles, by email: jamesknuckles@gmail.com

A P P E N D I C E S

APPENDIX 1: Broader recommendations outside the scope of Lopez-specific actions

TRANSPORTATION

Washington State Ferry improvements

In the preceding text, we sought to identify and evaluate actions that Lopezians can take to improve their transportation system, guided by the principles of environmental sustainability, resilience, and acceptability. The WSF forms a vital part of that system. As the primary means for moving people and goods on and off the island, it is both a transportation bottleneck and a risk area for off island transportation flows should there be a service disruption. Reducing off island transportation needs as much as is practical alleviates these impacts and is something Lopezians can control. Still, off island transportation is a necessity so improving the ferry system remains important to Lopezians. But, because the WSF is a state-operated regional transit system serving a diverse set of communities, Lopezians have limited ability to influence ferry system changes. Nevertheless, for completeness, here we identify and evaluate several options to improve this important connection to the mainland.

OPTION	PROS	CONS
Expand commercial vehicle reservation system to all drivers.	> Guaranteed boarding time. > Convenience of reserving on Internet. > Less need to plan trips working around peak traffic times.	> Extra cost to rider. > Ferry terminals need upgrade to segregate traffic. > Must plan and reserve trips in advance. > Some Lopez riders do not use the Internet or use it infrequently.
Change routes to dedicated point to point and reduce sailings per day	> No need for car quota. > Ferries much more likely to be on time.	> Fewer sailings per day per route.
Status quo of sequential multi-point routes	> Maintain current number of sailings per day.	> Need car quota. > Ferries less likely to be on time as delay at uproute port affects arrival at downroute port.
Increase passenger only service, decrease vehicle service	> Shorter trip times and fewer delays > Lower fuel consumption and lower emissions > Lower impact from vehicles at terminals and on roads	> Reduction in vehicle service > Requires fare restructuring > Requires high level of coordination with other transit agencies and regional transportation services

Some Lopezians argue that a ferry reservation system would unfairly benefit those who plan trips in advance, use the Internet often, and have reliable and convenient Internet access. From this perspective, tourists probably stand to benefit the most from a ferry reservation system. We argue that a stronger case against a reservation system (other than the existing one for commercial traffic) is that it would require significant lane restructuring in already crowded vehicle waiting areas at ferry terminals, as well as extra processing time for departures.

As for route changes, we think a compromise between the current route system and a dedicated point-to-point route system warrants investigation. In order to limit the reduction in sailings necessary to accommodate point-to-point routes with a fixed size ferry fleet, we suggest reallocation of large ferries to serve direct island to Anacortes routes and smaller ferries to serve inter-island travel. Direct island to Anacortes routes eliminate the need for vehicle quotas and reduces schedule slips.

We also suggest exploring passenger-only ferry expansion, especially on inter-island routes. While this might require the acquisition of new pedestrian- and cyclist-oriented vessels, or reconfiguring current smaller vessels to expand accessibility for these riders, converting as many routes to passenger-only as practical has several benefits: shorter trip times, lower fuel consumption and lower emissions from smaller vessels, higher boat speeds, reduced demand for terminal expansion and vehicle holding areas, as well as reduced traffic on state roads [95]. Even if the movement of commercial goods comprises a large portion of inter-island boat traffic, these businesses should still be able to adapt their delivery schedules to less frequent but regular ferry service.

To reduce ferry wait times and increase passenger-only ridership, we recommend route changes that would also reduce wait times for the ferry. To motivate demand for passenger-only service, two characteristics would need to be in place: an appropriate fare structure to incentivize passenger-only travel and connectivity of the ferry system to land transit corridors. Currently, neither of these is in place. To accomplish the necessary change, Lopezians should first lobby WSF to restructure fares and in parallel work, with connecting transit services to schedule arrival and departure times coordinated with the ferry schedule. This will facilitate reduced demand for vehicle service and higher demand for passenger only service. As demand for passenger-only service increases, WSF can implement the route changes to facilitate reduced vehicle wait time, namely point to point routes between Anacortes and each island with no vehicle quotas. The challenge would be coordinating the changing WSF schedule with land transit connections during the transition period.

ELECTRICITY AND HEATING: OPALCO RECOMMENDATIONS

1. Change MORE to automatic participation with the choice to opt-out

Participation in the MORE program is currently 'opt-in' with a default of non-participation. OPALCO should consider making the default participation in the program, with an 'opt-out' option. This simple action would significantly increase enrollment in MORE without making the program absolutely mandatory. As discussed in Recommendations for Lopezians, increased involvement in the MORE program would advance the growth of renewable electricity generation on the island.

We recommend shifting the default for participation in the MORE to enrolled for new customers, with an opt-out option. Psychologically, people are often more comfortable with whatever is represented as the default normative option, and in this way MORE can create higher enrollment without additional marketing or education costs.

PROS

> Improves MORE participation rates
> Simple change

CONS

> Some members may take issue with the approach

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2. TOU Rate Structure

OPALCO also has a strong incentive to prevent increased peak demand growth both because of the terms of the contract with BPA and the costs associated with their transmission infrastructure. A time-of-use (TOU) rate structure, where electricity used during peak hours is more costly than electricity used in off-peak hours can incent customers to move some of their peak hours use to off-peak hours or to simply conserve electricity during the peak. To be effective, TOU rates cannot be simply voluntary as only those customers who would benefit from the rate without the desired behavior change would volunteer.

In general electricity tariff changes can be politically prickly issues. However they are a powerful tool for shaping the energy future of San Juan County.

Despite the likelihood of negative reactions to this potential solution, we recommend implementing time of use rate plans as soon as feasible, creating a built-in incentive for all OPALCO customers to conserve and prefer off-peak times.

PROS

> Electricity conservation and use during off-peak hours is incentivized

CONS

> Requires wide participation to be effective
> Can shift load without reducing overall consumption

3. Electricity Tariff Restructuring

Most obstacles to major changes in the residential and commercial energy sectors are economic. The utility customer feels the price signals from the energy economy in their monthly energy bill. Electricity tariffs can be designed and set so that consumer behavior is altered in such a way as to solve a problem. A steep tiered rate structure can send a strong price signal to customers with unnecessarily high electricity consumption and incent them to invest in EE improvements, adopt conservation practices, or offset their consumption with RE generation without hurting those who can ill afford a price hike. Extra revenue from the higher tiers could be set aside for financing EE improvements or RE production incentives like the MORE program.

At first glance, this appears to be a win-win solution that charges the 'energy hogs' while rewarding conservation. While its implementation would require OPALCO to change its policies, it could instigate long-term shifts in consumption with multiplied benefits to reduced energy use and increased energy cooperative earnings. However, OPALCO would first need to answer significant questions of this potential solution's overall impact to their customers' resilience to electricity supply disruptions, and its effects on their electricity rates before implementing this policy change.

PROS

- Encourages greater energy savings and local distributed renewable generation
- Does not need to increase cost burden on low income families
- Simple to implement

CONS

- Requires wide participation to be effective
- Can shift load without reducing overall consumption

4. Separate customer class for seasonally occupied homes

OPALCO's operation and maintenance costs account for a majority of the energy charge paid by the ratepayers. This imbalance between the utilities ratio of fixed costs to energy costs and the ratio of a ratepayer's line charge versus energy charge serves to promote energy conservation and helps low income families afford basic electricity service. However, OPALCO members who occupy their homes only seasonally underpay for their service, but still contribute to wintertime peak demand due to freeze protection measures in unoccupied homes. This imbalance could be addressed by establishing a second residential customer class for seasonally occupied residences.

This recommendation would be very beneficial for OPALCO customers and overall energy efficiency, but may be politically impractical. Community focus groups should be held to identify the plausibility of this suggestion, and OPALCO should determine the effect of this policy change on the resilience of its electricity supply.

PROS	CONS
> More rational distribution of cost burden for OPALCO members	> Potentially difficulties in implementation and account classification

5. Explore Ptential for electricity bill integrated financing for EE and RE

Utility Financing is just like PACE, except that the utility is the entity that pays for the upfront costs and the principal and interest is paid back through an additional fee on that customer's utility bill. A low interest rate can be justified to OPALCO members as compensation for the public good of the resulting energy savings or local generation, which increases the accessibility of this financing for low-income families.

Areas for Further Research:
Electricity bill financing can be very attractive, but there are some points of caution. Credit risk cannot be ignored and it is not usually the function of coop utilities to take on that risk. Furthermore, because of credit risk, it may put OPALCO in a position that would require it to extend access to this brand of financing to some members and not others. However, the potential of this model is worth consideration. To determine the feasibility of this model for the OPALCO area, further research is required. Namely, the value to the coop membership of the energy savings is important to know, as is the extent to which the interest rate charged to low income members could be reduced to reflect that value, and which EE and RE investments will likely realize a positive net present value.

PROS	CONS
> Increases the ease of financing EE and RE projects	> Against current regulations

ELECTRICITY SECTOR COUNTY AND STATE POLICY RECOMMENDATIONS

The following policy recommendations focus on changes at the county and state level that could benefit Lopez substantially. The scale of the electricity grid and the way that it is operated and regulated creates significant limitations for unilateral local action. Lopezians' lowest level capable policy institutions are the county and OPALCO. Furthermore, many policy options can only be achieved at the state level or above. Policies that must be implemented at the county and state level are not easily or quickly affected by efforts of a small island community, but they are of utmost importance to the electricity sector, and even a community like Lopez can help drive and shape these policies. Most actions available at the island level are not potential policies of the polity, but rather up to individuals to choose for themselves and to encourage for others. In this section, we present some possibilities

for county and state level policies that could help improve the sustainability and resilience of Lopez Island's electricity supply and use.

1. San Juan County: Streamline and expedite permitting process for renewable energy projects and energy efficiency renovations

Not all obstacles to energy sector transformations are economic. There are also significant political and regulatory barriers that often stifle investment and interest. Most obviously, the permitting process for RE projects can be troublesome. For rooftop PV, permitting in Washington is straightforward, however for wind generators and other RE projects, there can be significant uncertainties and the process can be byzantine and costly. Finding ways to streamline the permitting process for RE projects so that developers can accurately predict the feasibility of a project, time required to get a permit, and the cost of the permit, will help minimize the risk of projects.

Another way that regulations can be shaped to incentivize RE is by protecting producers' access to the resource. A solar PV array or a wind turbine is a significant upfront investment with a useful lifespan that could extend to thirty years or more. For the system operator to realize the returns to their investment, they must have access to the sunlight or wind at their installation site for a long time. Establishing rights to RE resources can help reduce the risk to RE system investors. It is also possible to have a public fund to indemnify investments in RE systems against the loss of access to the resource.

Other less obvious barriers may also be found in the regulatory environment and positive steps can come from a collaborative program between regulators, ratepayers, and utilities that would identify regulatory issues and opportunities and propose changes to codes and practices.

2. San Juan County: Consider Municipal Financing

Property Assessed Clean Energy (PACE) financing is way for municipal and county governments to extend access to low cost credit to property owners who may not qualify for or cannot afford private loans. With PACE financing, the municipal or county government provides for the upfront costs of an EE or RE project and the homeowner pays the public back through a special assessment on their property taxes. In this way the public takes on part of the risk burden from the owner as a way of compensating the owner for the public good of the project. A 2010 Federal Housing Finance Authority (FHFA) policy has put PACE financing on hold for almost all municipalities and counties in the US. However, if the policy should change, PACE financing would be an attractive option for San Juan County.

3. San Juan County: Create a Countywide forest management plan

San Juan County forests are an important renewable resource that needs to be protected and managed. While countywide management plans exist for Agriculture, Marine Resources and Wastes, a plan for Forests does not exist. Developing a Forest Management plan at the county level would help ensure the protection and health of this valuable local resource.

4. San Juan County: Change building codes to require energy efficiency measures/ renewable energy features when appropriate

Stringent building codes are one way to increase the energy efficiency performance of the building stock. Mandating performance standards for new buildings and major renovations is a blunt instrument, and if the mandated measures are not economical or their value cannot be captured by the developer or owner then stringent codes may increase the incentive to extend the life of the existing building stock. However, direct regulation can be more effective for energy performance gains

because they are not stymied by market failures like the agent-principal problem that often plagues market-based solutions.

5. Washington State: Improve framework and incentives for community RE projects

There are many properties on Lopez that do not have access to good solar resources, yet many residents living on shady plots would be interested in investing in solar if only they had access to a productive site. Likewise wind resources are geographically disparate and the most economically viable wind turbines for Lopez are too large and too tall for a single home's needs. Community RE projects would allow utility customers to "buy in" to a project and to receive credit on their utility bill for the share of the projects production that they hold. This "Virtual Net Metering" would allow those who do not have the geographic advantage of full sunlight to have similar access to RE incentives and benefits as those who do. Public facilities and spaces can be the host sites for community RE projects as well.

Currently, incentives for community solar are extremely limited. In Washington, for residents to establish a community solar project, they would need to form a limited liability corporation, which may be unreasonably costly for smaller projects. However, the incentives that are available in the OPALCO area could only financially support a single project up to 5kW in capacity (where a single family home would normally have approximately 3kW or more to offset their electricity demand). To be an attractive option on Lopez, community RE would need significant policy changes at the state level. For a more detailed analysis of the community solar options available on Lopez Island see the "Community solar on Lopez Island Feasibility study" by Clancy et al (2011).

APPENDIX 2: Lopez School District bus fleet and operations

In this appendix, we describe the Lopez Island School District bus fleet and operations. These assets may be of interest to Lopezians should they decide to integrate school bus vehicles into a broader community transit system. The School District maintains a fleet of 6 buses and 3 vans for school transportation purposes. Table 6 summarizes the bus fleet capacity and age, and table 7 summarizes the mileage covered by the school bus system for the 2010/11 school year. Typically, one bus covers each quadrant of the island for daily student pick up and drop off before and after school. The four buses cover 170 miles per day or about 42 miles per bus. An average of 23 students ride on each bus and most are elementary or junior high students. High school students tend to drive themselves to school once they obtain driver's licenses. In 2010/11, each high school class had roughly 20-25 students. The School District uses its three vans for various activities during the school day; however, no funding exists to operate the vans after school even though there is considerable demand from students who miss the afternoon school bus run due to extra-curricular activities. The school buses are used for large group extracurricular activities like team competitions and class field trips [53].

For the same school year, the school bus fleet consumed 5,214 gallons of diesel at an expense of $19,162, or an average price of $3.68 per gallon. The School District purchases fuel at a discounted rate from a San Juan County facility on Lopez, located off-site from the school. All the buses run on ultra-low sulfur diesel, but none have biodiesel capability. The fleet average fuel efficiency is 7.45 miles per gallon [53]. Because the buses must be refueled off-site, the School District is considering purchasing buses with larger fuel tanks when it is time to buy a new bus. This will reduce the frequency of refuelling trips.

The school buses have a 13-year depreciation period, after which County or State funds are allocated to fund replacement buses if necessary [53].

Year	Capacity
2011	66
2008	54
2007	72
2007	30
2004	54
1995	unknown

Table 6: Lopez Island School District bus fleet capacity and vintage

SOURCE: [53]

Miles	Purpose
29,977	Transport students to/from school
999	Field trips
6,378	Extra-curricular activities (often to mainland)
1,510	Maintenance, refueling, training
38,864	**Total**

Table 7: Lopez Island School District bus fleet mileage in 2010/11 school year

SOURCE: [53]

APPENDIX 3: A primer on Lopez Island's energy resources

Local Generation

Local primary energy resources on Lopez are physically limited to solar, wind, tidal, wave, and biomass. How much each of these can and should be harnessed to provide electricity and heating to residents and businesses on Lopez is a function of the resource itself, the economic costs, the political feasibility, and the appropriateness of the technology to the energy demand it must service.

Solar PV

So long as Lopez is linked to the mainland electric grid, solar energy will likely be a significant part of the future energy mix for Lopez Island, whether that includes substantial on-island solar electricity production or not is another matter. According to the National Renewable Energy Laboratory's modeling of photovoltaic potential, full sun sites on Lopez would average between 3.5 and 3.9 kWh per square meter of collector area per day [88]. In comparison, Monterey, CA averages between 5 and 5.5 kWh/m2-day. PV productivity is directly a function of solar insolation, which is intermittent and uncertain. Furthermore, over Lopez, the seasonal variation is very pronounced. Output is greatest at midday with clear skies in the summer and almost negligible for long stretches in the winter.

The nature of the resource presents the greatest limitations for solar PV. The productivity of PV systems is highest in the season when demand for electricity is lowest. On the other hand, summertime solar productivity can help service summer demand in bad hydro years, and allow for excess capacity to be exported to other WECC states in good hydro years. In this respect, solar is a good compliment for the electricity provided by BPA, and with the incentives in place, grid connected and net-metered systems can be beneficial and economical even with the limitations of the solar resource on Lopez.

Solar Water Heating

Solar water heating (SWH) uses solar radiation to heat water directly without converting the solar energy into electricity. When the direct normal insolation is strong, SWH systems can provide a significant amount of a home's hot water load and upsized systems can also be used to provide space

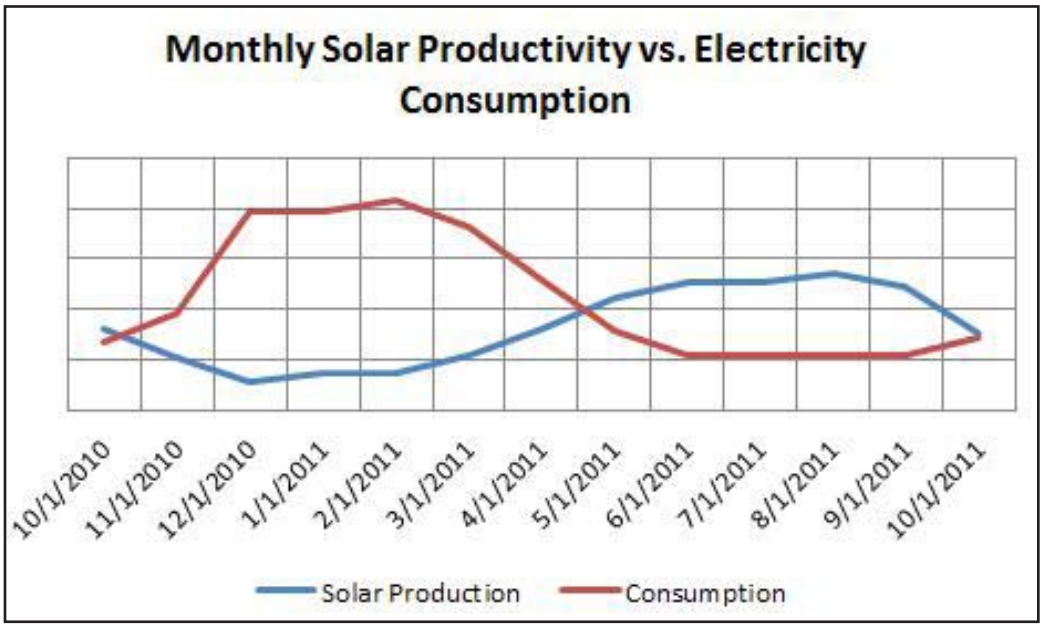

Figure 14.
SOURCE: Data from readings taken at the Common Ground LCLT housing project

heating. On Lopez, the viability of SWH has some major limitations. First, the disparity between winter and summer productivity is so great that a system that is not oversized for summer hot water loads would produce very little in the winter. Second, unlike with a net-metered grid-connected PV system, production from a SWH system is not transferable to other consumers and is therefore not "bankable." Heat produced with the SWH system above the demand of the household is of no value. To optimize the economic value of a SWH system, it must be sized to a capacity that would provide for the summertime hot water loads and would be paired with a secondary electric heater or heat pump to make up the difference between solar water heating and demand, particularly in the winter. However, on Lopez a home equipped with a SWH system would still be heating most of its water with the secondary energy source. The question of whether it is better to install a SWH system at a residence or to simply use the available site for a PV system with an electric water heater is one that each resident should consider when exploring RE solutions for water heating.

Wind

The wind resource on Lopez is best characterized as highly variable and seasonal with a winter peak; weak at low altitudes and significantly better at higher altitudes. Peak production for wind turbines and peak demand for electricity roughly coincide in the winter. The advantage of this is that wind energy can supplement hydroelectric power during the months with the highest demand for electricity. However, without substantial grid energy storage capacity, the intermittency of the wind resource from week to week, from day to day, and from minute to minute is still an issue. In complementing hydroelectric power, wind's winter peak is possibly a disadvantage. In 2011, a conflict arose between BPA and Washington's wind farm operators as that year's heavy spring runoff led to a glut of hydropower as the reservoirs approached full capacity. BPA ordered wind developers to curtail production in order to prevent over-generation. While instances such as these have been few, with increased market penetration in the Pacific Northwest, balancing hydro with wind will be more of a challenge.

Figure 15. Monthly Wind Speed Averages at 30 and 50 meters
SOURCE: Meyer, Terrance P:E & Rose Woofenden. "Lopez Community Land Trust Final Wind Energy Report". 2007

On Lopez, siting for wind turbines has both advantages and disadvantages. The extent of the tree cover on the Island limits the potential sites for wind generators on Lopez. The blade sweep of a turbine must be above the height of the nearby trees in order to limit the productivity reductions caused by turbulence (for household scale turbines, a rule of thumb is "30 feet above anything within 500 feet"). Alternatively, Lopez has a substantial amount of open space cultivated lands. Wind turbines and cultivated lands mix well since the footprint of turbines is minimal and they do not monopolize the solar insolation so land used for cultivation can host wind turbines without significantly impacting agricultural productivity. Politically, siting and permitting a wind turbine is much more difficult than for solar. This is primarily a factor of the economies of scale for wind and the aesthetics and mechanism of wind turbines themselves.

Wave and Tidal Energy

The development of wave and tidal energy has been accelerating worldwide. Various pilot projects have been operating for a number of years, highlighting the technical potential of the technologies. Commercial scale plants are now coming online. Wave energy is intermittent in the same way as solar or wind, but tidal energy is different. Tidal energy fluctuates predictably and reliably according to the gravitational influence of the moon and the sun. The wave energy potential around Lopez and the other San Juan Islands is not well studied and further research is needed to properly analyze the local potential. Unlike the other renewable energy sources, with tidal energy, the San Juan Islands have a significant geographic advantage as that they are flanked by the chokepoints of the northern channel of the Puget Sound.

Currently both forms of ocean energy are very expensive, more so than even PV on a cost per MWh basis. However, the technologies are young and costs are expected to continue to decline over time – by what factor is still very uncertain, but if ocean energy systems become commercially competitive, the channels around the San Juans may be among the most ideal sites in the US. Unfortunately, ocean energy projects would face political hurdles as well because of concerns over environmental impact, competing use, and – in the case of wave generators – aesthetics as well.

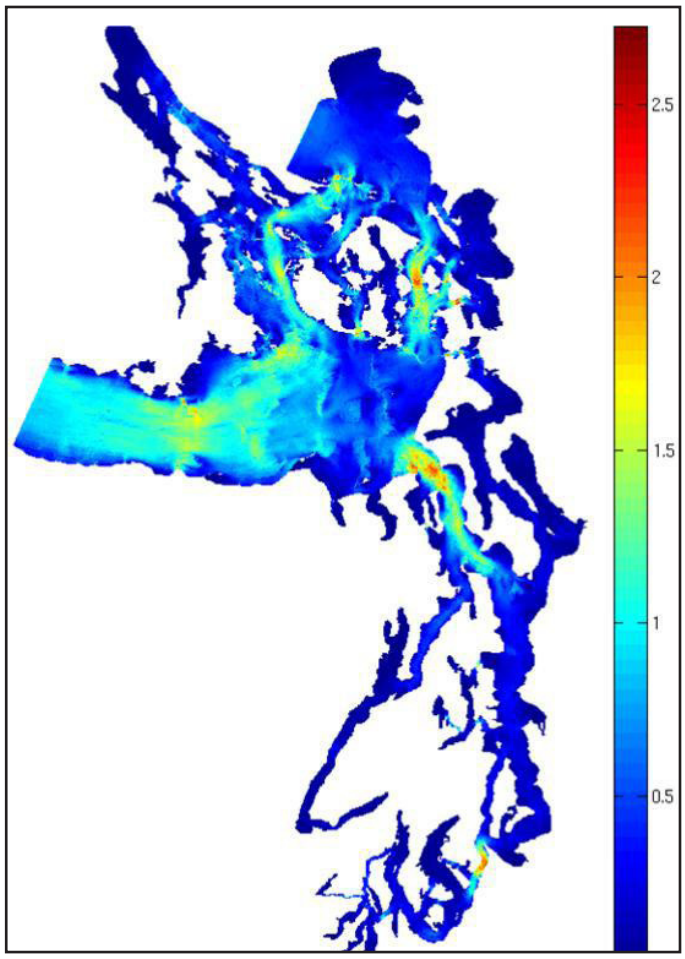

Figure 16: Maximum Tidal Current Speed Map
SOURCE: University of Washington, http://www.washington.edu/research/energy/researcher/mitsuhiro-kawase

The image on the previous page shows the maximum tidal current speed in Puget Sound, the San Juan Islands and the eastern Strait of Juan de Fuca from the NNMREC three-dimensional model of tidal currents in the Washington inshore waters.

Biomass

Many Lopez residents already provide much of their home heating with locally sourced biomass. Firewood from local forests is inexpensive, potentially sustainable, and reasonably abundant. Using a wood-burning furnace to heat a home also helps to reduce peak demand for electricity. Shifting some percentage of home heating loads from electricity to sustainably sourced local firewood would help smooth out electricity demand, which benefits OPALCO and its members. The drawbacks of using local biomass are the limitation of the resource, the point-of-use pollution, and the labor involved. Using local biomass to generate electricity would be inefficient relative to direct-use home heating, and it is very unlikely that the local forests are productive enough to sustainably provide enough energy to make up a substantial share of the island's potential electricity generation. Most of the forest on Lopez would benefit from having some of the dense douglas firs thinned out. In this respect, the current ideal short-term yield from the forests is substantially higher than the long-term sustainable yield. Harvesting of wood from the forest could be ramped up in the near term, decline over time, and level off at a sustainable and well managed level in the future.

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