Priority 3:
Urbanization & The Salish Sea

Audrey E. Nelson, Oregon State University for Puget Sound Partnership

Introduction

Over 8.75 million people currently reside in the Salish Sea region bridging British Columbia and Northwestern Washington, with the majority of residents populating large cities such as Seattle and Vancouver, B.C. (Government of Canada, 2021). Current predictions estimate an increase of 1.8 million residents in Puget Sound alone by the year 2050, a growth of nearly 42% (Fesler, 2018). As major hubs for industry and transportation, urban regions are rapidly expanding to accommodate a growing population, encroaching on wildlife habitat, altering ecosystem function, and swiftly converting land use patterns. While traditional methods of grey infrastructure continue to dominate development, greener and more sustainable methods of construction provide social and ecological benefits that are often overlooked for convenience and immediate gains.

While urbanization has clear and well-documented ecological impacts, human health and wellbeing can also be negatively impacted through changes to the natural environment. Increased pollution, deteriorating ecosystem services, and declining resources can all be attributed to expanding development through increased greenhouse gas emissions, changes to food webs and ecological systems, and threats to biodiversity (Rosa and Dietz, 2012). Quality of life is greatly influenced by one's access to resources, ecosystem services, and sense of place, factors that will inevitably change as social and local ecological processes are impacted by increasing development.

In this unexhaustive review, I analyze several pieces of literature relating to the development and urbanization of the Salish Sea region and projected impacts on the local social-ecological system. While I used local literature when possible, I supplemented with non-local sources when necessary to provide the most comprehensive evaluation. The following analysis is sorted into three segments: socio-ecological repercussions of urbanization, sustainable infrastructure, and social considerations of shoreline protection, addressing the multifaceted challenges of a rapidly expanding urban center.

Socio-ecological Repercussions of Urbanization

Urbanization and development are commonly associated with habitat loss and declining biodiversity, both of which are projected to increase as climate change effects escalate and the Earth becomes more populous. Ecosystem services, natural processes which benefit humans (e.g., air and water filtration, soil health, and protection from weather events), are often overlooked when analyzing the effects of urbanization despite their close association with human holistic health (Yee et al., 2021). The ability to access clean, safe water, breathe healthy air, and grow fertile crops are all the result of ecosystem services provided by a diverse array of organisms.

In Yee et al.'s (2021) recent article, two different land-use change scenarios are simulated on the Pensacola Bay Watershed in Florida to analyze the effects of ecosystem services on human wellbeing under varying levels of urban sprawl. Under one scenario (titled A2), the population continues to steadily grow with heavy dependance on fossil fuels, little protection for natural resources, and region-specific economic development (Yee et al., 2021). These changes resulted in loss of forest and wetland ecosystems, with increased agricultural regions and human infrastructure (Yee et al., 2021). Under the alternative scenario (B1), a more sustainable approach is taken towards resource management and renewable energy sources, environmental protection is emphasized, and population growth is minimal (Yee et al., 2021). Under this scenario, ecosystem services remained steady, with the least developed regions experiencing increases in productivity (Yee et al., 2021).

Using a 40-year simulation, Yee et al. (2021) project that under scenario A2 the human wellbeing index (HWBI) would fall well below the U.S. average, and continue to drop over time, with highest declines occurring under the most urbanized regions. Alternatively, the least developed regions under the sustainable development and minimal population growth scenario (B1) had the least decline in wellbeing (Yee et al., 2021). Individual wellbeing indicators including leisure time, social cohesion, education and living standards were predicted to decline over time under both scenarios, but these rates dropped much swifter under scenario A2 (Yee et al., 2021). This is likely correlated with declines in food, fuel and fiber sources which would require increased energy expenditure from individuals (Yee et al., 2021). Additionally, greenspace has been linked with improved interpersonal and problem-solving skills as well as higher average test scores, explaining the declines in educational indicators under highly urbanized scenarios (Yee et al., 2021).

While safety and security scores did not fluctuate in either scenario (remaining under the U.S. average), health and cultural fulfillment scores dwindled through time under scenario A2 as traditional resources declined (Yee et al., 2021). Surprisingly, connection to nature increased under both scenarios, with the highest increases occurring in the most urbanized regions (Yee et al., 2021). The latter could be explained by a few factors, including the perceived association of increased crime with greenspaces in urban regions, or possibly newly found appreciation for a vanishing asset: nature (Yee et al., 2021).

Increasing urbanization is closely linked with declining biodiversity and associated loss of ecosystem services as habitats are converted to farmland and housing developments and man-made structures replace natural systems that filter, store, and regulate water, air, soil, and weather (Yee et al., 2021). While ecosystem services are not solely responsible for human wellbeing, they provide the basic tools for a human life (air, water, food) and provide us with a plethora of benefits ranging from arable land and natural resources (including fuels, medicinal compounds, and materials for fabric) to mental health benefits (greenspace) and climate control. As the population continues to grow, these services will be needed more than ever as food and water demands increase, pollution escalates, and climate events intensify.

Despite the geographic limitations of this study, the results are relevant across all regions with regards to human dependance on healthy functioning ecosystems. Local analysis using similar methods of simulation could prove extremely beneficial to local Salish Sea planning and development efforts, helping to determine the best steps forward for future infrastructure expansion to minimize risks to ecosystem health, biodiversity, and human wellbeing. Furthermore, understanding and preparing for potential risks could greatly increase the resiliency of Salish Sea communities to forthcoming urbanization.

Sustainable Infrastructure

While still largely underrepresented, green infrastructure has been gaining traction in the Pacific Northwest. The first mandate of its kind in the nation, green stormwater infrastructure is required by law in Western Washington under stormwater regulations as of 2013 (Jayakaran et al., 2020). Unlike its less-sustainable counterpart, grey infrastructure, green infrastructure (GI) utilizes natural ecological processes to solve urban challenges instead of trying to control nature using man-made structures (Jayakaran et al., 2020). GI provides a plethora of ecosystem services to local communities and ecosystems, including water and air filtration, flood mitigation, aesthetic value, habitat conservation, regional climate regulation, carbon sequestration, pollination, and increased greenspace connectivity (Jayakaran et al., 2020).

Barriers to the widespread adoption of GI include lack of tangible benefits, apprehension regarding longevity and affordability, lack of coordination among institutions, maintenance requirements, and scale mismatches (Alves et al., 2020; Jayakaran et al., 2020). Additionally, the implementation of GI requires specialized knowledge of local community needs and ecology, unlike traditional grey infrastructure designs (Jayakaran et al., 2020). Extensive adoption of GI may prove to be a challenge in the Salish Sea region, but hybrid strategies combining grey, green and blue (the latter relating to hydrological function) infrastructure methods can also provide a multitude of social, ecological, and financial benefits (Alves et al., 2020). In recent years there has also been an increasing interest in the use of natural infrastructure composed entirely of organic elements such as seagrasses, salt marshes, and barrier islands to aid in protection from natural disasters (Sutton-Grier et al., 2015).

While green infrastructure generally provides positive social and ecological benefits, it can also fuel inequalities through green gentrification and environmental injustice. Greening projects, or the implementation of green infrastructure, is a tactic often used in the development of new housing projects which displace or exclude lower-income groups by incorporating contemporary techniques to spruce up previously industrial or commercial regions and send housing prices sky high (Haase et al., 2020). This inequality is detailed in a 2011 article by Brander and Koetse (2011) in which they determine that urban greenspaces are associated with higher real estate prices in nearby neighborhoods, and alternatively lower-income regions generally have much lesser levels of vegetation and parks.

Social Considerations of Shoreline Protection

Roughly 27% of Puget Sound's 2,500 miles of shoreline is armored, with nearly 50% of residential properties fortified by some form of shoreline protection (Von Reis Crooks, 2015). While the downsides of traditional shoreline armoring have been well-documented in recent years, including beach narrowing, loss of habitat and loss of wetland function, these impacts aren't always evident to the public due to their slow or hidden changes (Dethier, 2016). On the other hand, armoring provides immediate benefits such as increased property values, flood prevention, and bluff erosion protection for landowners (Von Reis Crooks, 2015). Though shoreline armoring implementation appears to be slowing and is even being removed in some cases, a large portion of armoring being implemented is being done so illegally (without acquiring proper permits and authorization), or not following permit guidelines (Dethier, 2016). Understanding landowner incentives and values is key to maximizing sustainable development options and restoring the Salish Sea.

Soft shore armoring techniques are a sustainable alternative to traditional grey shoreline infrastructure (Dethier, 2016). Methods of soft shore armoring include utilizing oyster reefs, riparian buffers, and natural substrates such as logs to neutralize wave energy and allow natural beach migration while maintaining habitat connectivity (Dethier, 2016). Soft shore armoring not only provides longer resiliency and greater ecosystem benefits than traditional methods, but it can also provide homeowner benefits such as increased beach access and aesthetics (and correlated real estate prices), but these advantages are often overlooked due to misconceptions about longevity, cost comparisons and ecological impacts (Dethier, 2016; Scyphers, 2014).

Alternatively, traditional grey shoreline armoring, which is often adopted over natural infrastructure for perceived lower costs and durability, commonly requires costly repairs and maintenance after natural events or day-to-day wear (Powell et al., 2019). Additionally, grey armoring approaches often fragment habitats and spawning grounds, provide niches for invasive species, and degrade ecosystem services such as sediment cycling and water filtration by altering water flow (Powell et al., 2019). In some situations, hybrid methods that merge grey and green infrastructure have been shown to be beneficial for coastal communities, such in the case of sandy dunes, mangroves, or marshes (Powell et al., 2019). Such hybrid structures can include living shorelines which combine natural biota such as oyster reefs and native vegetation with artificial materials such as concrete to improve energy absorption (Powell et al., 2019).

In a 2014 survey in Mobile Bay, Alabama (Syphers, 2014), the majority of shorefront homeowners reported being concerned about ecological impacts and noted a partiality to natural aesthetics (versus grey infrastructure) but perceived unaltered or minimally protected shorelines to require additional maintenance (Syphers, 2014). Alternatively, methods of traditional shoreline armoring such as vertical walls and riprap were identified as the most functional yet environmentally harmful options (Syphers, 2014). Overall, efficacy, price, and resilience were identified as the chief decision-making factors, with water access, permit approval and aesthetics ranking further down the list (Syphers, 2014). In the same study, social norms and peer influence appeared to be a large driver in shoreline alteration decisions, with many homeowners choosing to install armoring only after observing installation on neighboring real estate (Syphers, 2014).

A variety of factors influence homeowner decisions to install shoreline protection including attitudinal factors (e.g., beliefs, values, norms, culture), resources (e.g., finances, time, knowledge), age and value of property, regulations, and social influences such as social customs, homeowner associations, neighbor actions, and community norms (Syphers, 2014; Von Reis Crooks, 2015). Trimbach (2021) demonstrates that sense of place (which is positively associated with length of residency and property ownership) in Puget Sound can also play a major role in shoreline modification decisions. Furthermore, a strong connection to place suggests a level of local environmental concern, thus serving as a potential predictor of environmental behaviors (Trimbach, 2021).

Dethier et al. (2016) argue that while influences vary drastically among individuals and groups, informing homeowners of the diverse ecosystem services and goods impacted by shoreline armoring could provide personal incentive to increase compliance with policy. Dethier et al. (2016) further suggest increasing guidance and education about alternative armoring techniques for contractors, as well as providing policy incentives for more ecologically friendly alternatives to traditional grey armoring. Additionally, facilitating a sense of place or connection to the shoreline through imagery and words in shoreline restoration programs or campaigns could positively influence outcomes (Trimbach, 2021).

Conclusion

Rapid urbanization and development will undoubtedly continue to impact the environment around us as natural systems are encroached upon by urban sprawl. Ecosystem services such as carbon sequestration and air filtration will diminish as marshes are dried up and forests are chopped down. Food and fuel sources will decline, impacting human wellbeing through personal quality of life and for those financially dependent on the natural resource industry, the ability to make a living. Understanding the population growth patterns and drivers for the Salish Sea region is vital to be prepared for increasing urbanization in the future. While local research on the impacts of development on human wellbeing is lacking, there is available literature on the subject in general, providing a baseline for our understanding. Future research on the specific impacts and projected changes to Salish Sea communities would further prepare local governments for sustainable planning and development practices.

While the State of Washington already requires green stormwater infrastructure, other forms of development, such as shoreline protection, have no such regulations in place (Jayakaran et al., 2020). Furthermore, in some cases, its implementation may be fueling social-ecological inequities by treating sustainability as a high-priced commodity reserved for those who can afford it. Future development research and practices should consider community health and inclusion to ensure all have access to its benefits.

Despite the benefits of natural and hybrid shoreline infrastructure, widespread implementation still proves challenging due to public misconceptions, lack of contractor education, and regulatory barriers (Powell et al., 2019). Decreasing uncertainty and streamlining the use of natural infrastructure requires increased public and contractor knowledge on the costs and benefits of all methods, and improved resilience planning at the community level (Powell et al., 2019). Additionally, long-term monitoring of pre- and post-installation shoreline protection would prove beneficial to strengthen our understanding of the differing resilience and ecosystem impacts of green, grey and hybrid infrastructure in different locations and habitats (Powell et al., 2019).

In summary, further investment into researching the future population trends and development patterns in the Salish Sea and their potential impacts on local communities should be addressed. While development impacts on human wellbeing are documented, they cannot encompass the different cultures, values, and concerns of all Salish Sea communities. Similarly, while there is no lack of literature on shoreline armoring in the Salish Sea, available research is almost exclusively based in natural science, highlighting the need for more social science exploration on the subject. Further research should include consider the influence of infrastructure education on shoreline protection decisions. Individual and community-level decisions will play a major role in the subsequent health of the Salish Sea, and ensuring access to proper resources is crucial to future sustainability.

Works Cited:

Alves, A., Vojinovic, Z., Kapelan, Z., Sanchez, A., and Gersonius, B. (2020). Exploring trade-offs among the multiple benefits of green-blue-grey infrastructure for urban flood mitigation. *Science of The Total Environment.* 703(10). DOI: 10.1016/j.scitotenv.2019.134980

Brander, L.M. and Koetse, M.J. (2011). The value of urban open space: meta-analyses of contingent valuation and hedonic pricing results. *Journal of Environmental Management.* 92(10), 2763-2773. https://doi.org/10.1016/j.jenvman.2011.06.019

Dethier, M.N., Toft, J.D. and Shipman, H. (2016). Shoreline armoring in an inland sea: science-based recommendations for policy implementation. *Conservation Letters.* 10(5), 626-633. https://doi.org/10.1111/conl.12323.

Fesler, S. (2018). Nearly six million residents in central Puget Sound by 2050, PSRC says. The Urbanist. Nearly Six Million Residents in Central Puget Sound By 2050, PSRC Says | The Urbanist.

Government of Canada (GOC). (2021). Importance of the Salish Sea ecosystem. Importance Salish Sea - Canada.ca.

Haase, D., Kabisch, S., Haase, A., Andersson, E., Banzhaf, E., Baro, F., Brenck, M., Fischer, L.K., Frantzeskaki, Kabisch, N., Krellenberg, K., Kremer, P., Kronenberg, J., Larondelle, N., Mathey, J., Pauleit, S., Ring, I., Rink, D., Schwarz, N., and Wolff, M. (2017). Greening cities- to be socially inclusive? About the alleged paradox of society and ecology in cities. *Habitat International.* 64, 41-48. http://dx.doi.org/10.1016/j.habitatint.2017.04.005.

Jayakaran, A.D., Moffett, K.B., Padowski, J.C., Townsend, P.A. and Gaolach, B. (2020). Green infrastructure in western Washington and Oregon: Perspectives from a regional summit. *Urban Forestry & Urban Greening.* 50, 1-7. https://doi.org/10.1016/j.ufug.2020.126654

Powell, E.J., Tyrell, M.C., Milliken, A., Tirpak, J.M. and Staudinger, M.D. (2018). A review of coastal management approaches to support the integration of ecological and human community planning for climate change. *Journal of Coastal Conservation.* 23(1), 1-18. https://doi.org/10.1007/s11852-018-0632-y

Rosa, E. A., and Dietz, T. (2012) Human drivers of national greenhouse-gas emissions. *Nature Climate Change.* 2, 581-586. https://doi.org/10.1038/nclimate1506.

Scyphers, S.B., Picou, J.S. and Powers, S.P. (2014). Participatory conservation of coastal habitats: the importance of understanding homeowner decision making to mitigate cascading shoreline degradation. *Conservation Letters.* 8(1), 41-49. https://doi.org/10.1111/conl.12114.

Sutton-Grier, A. E., Wowk, K., and Bamford, H. (2015). Future of our coasts: the potential for natural and hybrid infrastructure to enhance the resilience of our coastal communities, economies and ecosystems. *Environmental Science & Policy.* 51, 137-148. https://doi.org/10.1016/j.envsci.2015.04.006.

Trimbach, D. J. (2021). Sensing liminal landscapes in Puget Sound. *Geojournal.* https://doi.org/10.1007/s10708-020-10350-w

Von Reis Crooks, S. (2015). *Landowner experience with soft shore projects in Puget Sound* (Masters Dissertation). University of Washington, Seattle.

Yee, S.H., Paulukonis, E., Simmons, C., Russell, M., Fulford, R., Harwell, L. and Smith, L.M. (2021). Projecting effects of land use change on human well-being through changes in ecosystem services. *Ecological Modelling.* 440, 1-20, https://doi.org/10.1016/j.ecolmodel.2020.109358