



**NATURE'S VALUE: TOWARD ECOSYSTEM SERVICES
VALUATION
AS A MAINSTREAM CONCEPT**

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Senior Project Write-Up

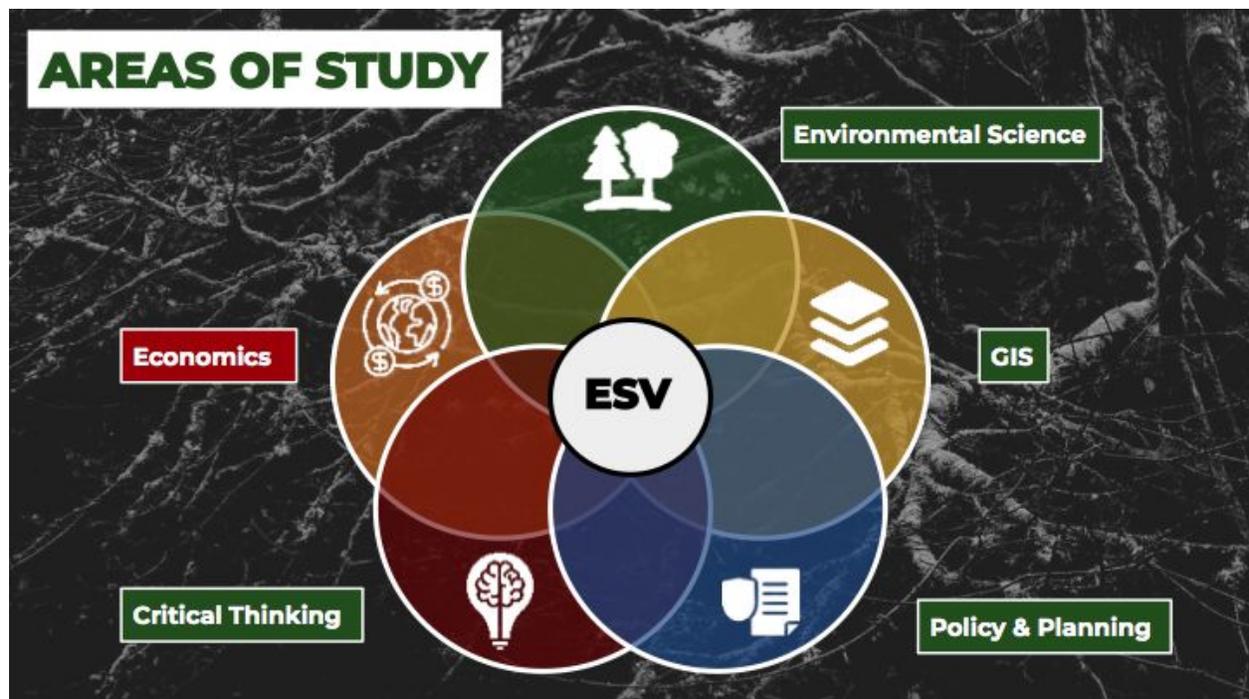


ABSTRACT

In our world, we standardize worth with money. We determine a market price for everything we care about--objects, services, experiences, information, time--and can compare worth between seemingly incomparable concepts. Anything that doesn't have a market value is very difficult to count or weigh; and nature is one such concept. Ecosystem Services Valuation (ESV) is a way of attaching a market value to ecosystems in order to give them weight in policy decisions, to justify investments in environmental stewardship, and to reduce costs long-term. By assessing the monetary values of the goods and services ecosystems provide to humans, we can attempt to determine nature's contribution to the economy and begin to give nature stake in larger issues. ESV has great potential for both businesses and government organizations that are trying to reduce their environmental footprints while increasing their economic well being. While the concept of ESV dates back to the late 1950s and early '60s and is used worldwide, ESV is not a ubiquitous practice. By creating a booklet with design inspired by popular educational video series, I seek to introduce the general public to the concept of ESV in the hope that they will be inspired to want to learn more, to engage in conversation about it, and to normalize the practice of accounting for the environment. In the booklet I establish credibility by explaining the history of ESV. Then, I outline ESV methodology and discuss applications of ESV through several case studies. The booklet concludes with actions the general public, businesses and government organizations alike can take in order to account for nature's contributions to the economy and promote environmental sustainability.

INTRODUCTION

This is the story of my senior project, in which I researched Ecosystem Services Valuation (ESV) and developed a booklet intended to educate the general public about ESV. I became interested in ESV during my internship with the Port of Seattle Aviation-Environmental Department when my supervisor asked me to look into the subject and brief him on what it is and how it works. I came across Tacoma, WA-based non-profit, Earth Economics, which is a leader in ESV doing cutting edge work. Earth Economics' reports helped me to understand ESV in process and practice, and convinced me that ESV is a powerful tool for creating change in a world where profit is nearly always the bottom line. ESV gives the environment stake in the economy and provides justification for investing in our planet. At the time of my internship I had only scratched the surface of the topic, yet I was already excited, hooked, and inspired to learn more and tell people about ESV. At this time I realized that I wanted to pursue ESV as the subject of my senior project. ESV is the culmination of all the subjects I've focused on at UW, including environmental science/sustainability, GIS, policy, planning, and critical thinking. This project also gave me the opportunity to learn more about economics--an essential element of ESV that I had little prior knowledge of.



While exploring ESV I found there to be a lack of literature on the topic for the layperson. Nearly all the information on ESV I found was intended for experts in the environmental or economic sectors and came in inaccessible formats such as scientific reports, business journals, or extensive toolkits chock full of technical terms and jargon. Important environmental topics such as cap & trade, the greenhouse effect, ocean acidification, and carbon taxes are easily accessible--there are countless articles, infographics, and videos for the layperson that explain and use these terms. ESV is something that should be mainstream, not niche, as I'd found it to be. I decided to create an informational booklet to bring the general public up to speed and to attempt to help make ESV an everyday topic. The research question driving this project is: *What is Ecosystem Service Valuation (ESV) and how can more people be informed about it so that it will one day become a more ubiquitous practice?*

PROJECT EVOLUTION

My intended senior project product has taken several forms as my interests have changed and as I have realized some of my limitations. I am limited by factors including time, funding, and my own skills and knowledge. This is not to say that any of these factors would have been impossible to overcome; however, with my motivation and additional commitments these were factors that caused me to change my project plans over the course of the year. I initially intended to research possibilities for ESV in small towns and suburban areas, to complete a small-scale ESV in Burien, WA, and to create an ESV manual for small cities. This project idea stemmed from my finding more ESV case studies in larger, wealthier urban areas, and from my desire to do something practical for my project. After winter quarter it became apparent that my skill set is not suitable for carrying out a valuation on my own, and that I would not have time to try convince experts to help me out. At the start of spring quarter, I had already reviewed a significant amount of literature on ESV and projects were supposed to be wrapping up, so I kept ESV as my topic but changed course and decided to present my year's worth of literature review in a booklet form. The booklet was meant to boil down my findings and to present ESV to the general public.

METHODOLOGY

General Methodology Steps

In order to present information on ESV accessibly to the public, I (1) completed a literature review of ESV history, methods, and applications, (2) researched best practices for booklet design and creating effective educational tools, and (3) synthesized my findings to begin to create an educational booklet on ESV. The booklet is simply a vessel--the true purpose of the project is to make ESV more well-known because I believe it has the realistic potential to have a dramatically positive effect on the environment. To distribute my booklet I plan to share it in print and as a PDF with my colleagues at the Port of Seattle and at San Juan County, and with the Environmental Science Center in Burien. I completed these steps chronologically, with some overlap.

Part 1: Research ESV [Autumn and Winter]

Research is the heart of my project. The purpose of the research phase of this project was to establish the credibility of ESV as a practice used around the world by scientists, economists, policy makers, planners and the like. In the research phase I learned about ESV in theory in several areas. I defined ESV in terms of *Natural Capital* and *Ecosystem Goods and Services*. Then, I learned about ESV's purpose as a way of translating nature's value into the universal policy language of money. Next, I studied several cases to learn about the various methods for actually completing an ESV. I researched ESV methods in order to better understand essential steps of the process and areas that can be simplified for the general public. To do so, I explored the websites of organizations that advocate for ESV and read case studies' methods sections. I also researched ESV case studies to provide readers with applications for their understanding of cut and dry ESV processes. These cases can also provide inspiration to anyone who would want to do an ESV by showing them how they could potentially use it in their unique context. I have my own ideas, but my answers to these questions must be evidence-based. Case studies, again, are a good way to figure out how to apply ESV because they show what has previously worked and not worked. Aside from researching ESV itself, I investigated actionable steps for individuals, government and businesses to apply ESV according to their environmental agendas, current projects and values to get a better idea of how ESV might fit into their operational strategies.

Part 2: Research Educational Tools & Booklet Design [Spring]

I had initially planned on completing a small-scale ESV and creating an ESV guide, based on my Autumn and Winter research at this point. However, with my project's change of course, phase 2 was about understanding how people learn best. During my literature review I had become overwhelmed by the breadth and depth and intricacy. How in the world could I boil such a complicated subject down to a booklet people were only ever going to skim? I watched educational videos intended for younger audiences (and curious adults) to learn the ways of the masters. Rather than paying attention to the videos' content, I sought to understand the elements of what makes a good educational tool. The patterns I saw became guidelines for creating content for a booklet. During this phase I also spent time considering booklet layouts and infographic design, knowing that even with excellent content and enthusiasm, my work would be futile if my booklet was poorly designed. I turned to magazines, scientific reports, and graphic design templates for inspiration in order to develop booklet design guidelines.

Part 3: Synthesis & Implementation [Spring]

In the final stage of my senior project I synthesized the findings from my research and literature review, developed a booklet outline, and created text and some graphics. I intended to complete the booklet and distribute by the project due date; however, I did not reach my goal and am still working on the booklet. My progress has been slow as I have been learning to use Adobe Indesign and Illustrator.

LITERATURE REVIEW

What is ESV?

Amid the array of organizations across the world that perform ESVs for different purposes via a variety of methods, there seems to be an agreement on the two foundational terms, *natural capital* and *ecosystem services*. This is important because it means that between all the different sources I have encountered, I can more or less trust that they are all talking about the same thing when they refer to Ecosystem Service Valuation. ESV is the valuation of *natural capital*, which is "any natural resource (including plants, animals, minerals, and ecosystems) that provides functions that produce ecosystem goods and services" (Earth Economics, 2019). *Ecosystem services* are "defined as services

provided by the natural environment that benefit people" (DEFRA, 2007). Typically, natural capital is not included in assessments of the market value of land, meaning that people don't consider the economic value of impacts they cause on the environment. ESV allows us to quantify the value of the natural environment, so that we can count it when making decisions that will affect it.

This project and the definition of ESV builds off of a rich body of existing research that started in the 1950s/60s. The valuation of ecosystem services is "well established and there have been literally thousands of peer-reviewed publications in which economic valuation of various ecosystem services have been performed" (Sutton & Anderson, 2016). Still, when I have conversations with people about my project, many of them have never heard of the concept of ESV. Standing on the shoulders of past research gives my project credibility when for many people ESV is a new concept they might be skeptical of the usefulness of. Some might say that environmental issues are outside the scope of economics. The concept of the *triple bottom line*--economy, society, and environment--makes these factors seem separate. However, "when ecosystem protection projects and policies are proposed, it is appropriate to ask whether they achieve the stated goals in a cost-effective and efficient manner," and in order to do so, we must be able to place an economic value on ecosystems (Heal, et al., 2005). The value of ecosystem services should *always* be counted when dealing with environmental policy.

ESV Purpose

ESV is an aid for informing decisions that impact the environment. Monetary value is the type of value we know how to work with in our society, however, money aside, "as long as we are forced to make choices, we are going through the process of valuation" (Costanza, 1997). If we make decisions based off of what we value, and money is the way of standardizing value across seemingly incomparable things, ESV is the best way to translate the worth of the natural environment and to draw attention to environmental issues by demonstrating economic impact.

Some ecosystem services are more difficult to assess the value of than others. For example, in assigning the value of a single tree in terms of timber, one need only discover the tree's volume and the current market price of timber per that volume. On the other hand, there is no market value for other factors such as the educational or spiritual value of places. For forests as opposed to objects (i.e the individual tree), "culturally derived

norms, beliefs, and values help drive preferences for forested landscapes and forest-based benefits such as diversity and identity, justice, education, freedom, and spirituality” (Sills, et al., 2017), and we must rely on other methods, such as people’s willingness to pay to have access to a place, or the cost of how far people are willing to travel.

Using carefully researched and justified methods for valuation, ESV can determine the monetary worth of both tangibly and subjectively valuable ecosystem goods and services. “Because ecosystem services are not fully ‘captured’ in commercial markets or adequately quantified in terms comparable with economic services and manufactured capital, they are often given too little weight in policy decisions” (Costanza, 1997). Without assigning monetary value to nature, we rely on ethical subjectivity and good will toward people and the planet when making policy decisions that affect the environment. Arguably, it is more rare to find a policy decision made based off of goodwill than it is to find one based off of profit or economic discernment. ESV provides a route to environmentally sound decision making within the current system of economic discretion as the bottom line.

Uses of ESV in Context

By studying cases of ESV in urban areas I have gained insight into the potential methods and outcomes of ESV. In 2018, Tacoma-based ESV non-profit, Earth Economics completed an ESV of Seattle’s Discovery Park that revealed that the park produces over \$1 million in ecosystem services per year with regards to air, water, biology, and climate stability. The study points out that “by naturally filtering water as it makes its way through the park and into Puget Sound, Discovery Park provides between \$203,000 and \$469,000 worth of water filtration and stormwater runoff reduction services each year” (Van Deren, 2018). These numbers help confirm that Seattle is making the most of this space by keeping it as a public park. The site initially considered using for my project, Seahurst Park in Burien, WA, has ecosystem services are comparable to those of Discovery Park (trails, beachfront, forest, cliffs, creeks, ravines, in an urban area). While Discovery Park is 534 acres and Seahurst park is 178 acres, both are the largest parks in their cities.

While not in Washington and not in an urban area, the case of the 2013 Rim Fire in California is *the* most compelling ESV story I know, and it is actually one of the things that got me interested in ESV in the first place. When California first applied for federal disaster aid to help with the damages left by one of the state’s largest wildfires, their application

was denied because the value of the damages was not thought to be severe enough. The fire had destroyed 3 commercial buildings and 98 residences (“Rim Fire” 2018, 1) despite having burned 402 square miles near Yosemite National Park, where much of the Bay Area and Central Valley’s water comes from. An ESV, also completed by Earth Economics, revealed that the true costs of the fire were between \$388 million to \$1.271 billion. After reapplying with the numbers accounting for ecosystem damages, California received the necessary federal aid! This case sets precedent for future disaster aid calculations to not only consider damage to human structures, but also the damage to ecosystems that affects people as well.

After a comprehensive ESV of the metropolitan park system of Tacoma, WA, the next step was to figure out what to do with the numbers in order to have a positive impact via policy. The report on the ESV makes an argument for investing in the quality of ecosystems over replacing their functions with infrastructure. According to the report, “investments [in natural systems] typically reduce tax spending on solutions designed to address a single problem, such as odd risk reduction, and instead invest in a suite of ecosystem services for maximum economic returns” (Christin, et al. 2011). This report exemplifies the importance of discussing next steps and not just leaving case studies at the “what.”

ESV Methods

In researching ESV methodologies, I found that all of Earth Economics’ ESV reports provide detailed methodologies for their cases, whereas other reports typically state that an ESV occurred while focusing more on the policy implications of the findings. I find Earth Economics reports to be the best, most clear texts on data collection, data analysis and valuation best practices for ESV. These reports’ methods sections typically outline their main process as: 1) “Identification and Quantification of Land Cover Classifications,” 2) “Identification and Valuation of Ecosystem Services,” 3) “Annual Value of Ecosystem Services,” and 4) “Net Present Value Calculations” (Van Deren, et al., 2017). This list is the general sequence I am going through for this project. The value of ecosystems transcends time, meaning that, “to understand the overall value of services in an ecosystem therefore requires some way of eliciting from all stakeholders (present and future) how and how much they value the services” (Roberts, et al., 2015). I do not have the time or capacity to complete the sort of research needed to extrapolate future ecosystem values; however, I

now know I will be adding a section on market and non-market valuation into my final report. The Green Cities Research Alliance's valuation of Seattle's forests is a good model for my own ESV because it was completed by hand more than with remote sensing technologies. The Alliance took a more analog approach where, "for each plot in Seattle, a field crew completed a series of measurements to capture both general plot and vegetation-specific data" (Ciecko, 2012). As a student working independently, I am limited in the data collection and analysis technologies I can use. For my ESV I will be studying a single site, therefore collecting data by hand, on the ground (a.k.a. Field work) is acceptable. Another section of this project report provides a more detailed description of my complete project methodology.

Based on my findings, the following would be the simplified ESV process outlined by Earth Economics in their ESV reports if, for example, one were to be doing an ESV based upon air quality as affected by vegetation.

Step 1: Identification and Quantification of Land Cover Classifications

Options for factors to consider in ESV range from air quality, habitat, soil, and water to recreation and tourism. In this example I am most interested in assessing air quality contributions from vegetation in a forested urban public park. I will delineate several 25'x25' study areas and take inventory of the plants, shrubs and trees. A 25-foot square is large enough to encompass several large trees, and small enough for me to take inventory of the plants and within a few hours. By sampling multiple plots I can estimate an average vegetated square at this park.

Step 2: Identification and Valuation of Ecosystem Services

After taking inventory of the plants, shrubs and trees in my study areas I will identify the annual contributions of each type to air quality. Air quality factors include, ozone (O₃), nitrogen dioxide (NO₂), and sulfur dioxide (SO₂) absorption; intercepting particulate matter such as dust, ash, and smoke; and releasing oxygen through photosynthesis. These are all examples of ecosystem services. Using the Earth Economics ESV toolkit (created by a team of expert scientists, economists, GIS specialists, computer programmers, and local knowledge) I will assign monetary values to the ecosystem services, which I can attach to the each aspect of the vegetation inventory.

Step 3: Annual Value of Ecosystem Services

To estimate the annual value of ecosystem services toward air quality via vegetation in my study areas I will use the following equation. I developed this equation based off of my understanding of the relationships between natural capital, ecosystem goods/services, and annual \$ value.

plant A in square: P_A

Rate at which one plant produces air quality service 1: R_{A1}

Annual \$ value of service 1: V_1

$$[P_A][R_{A1}][V_1] + [P_A][R_{A2}][V_2] + [P_A][R_{A3}][V_3] \dots$$

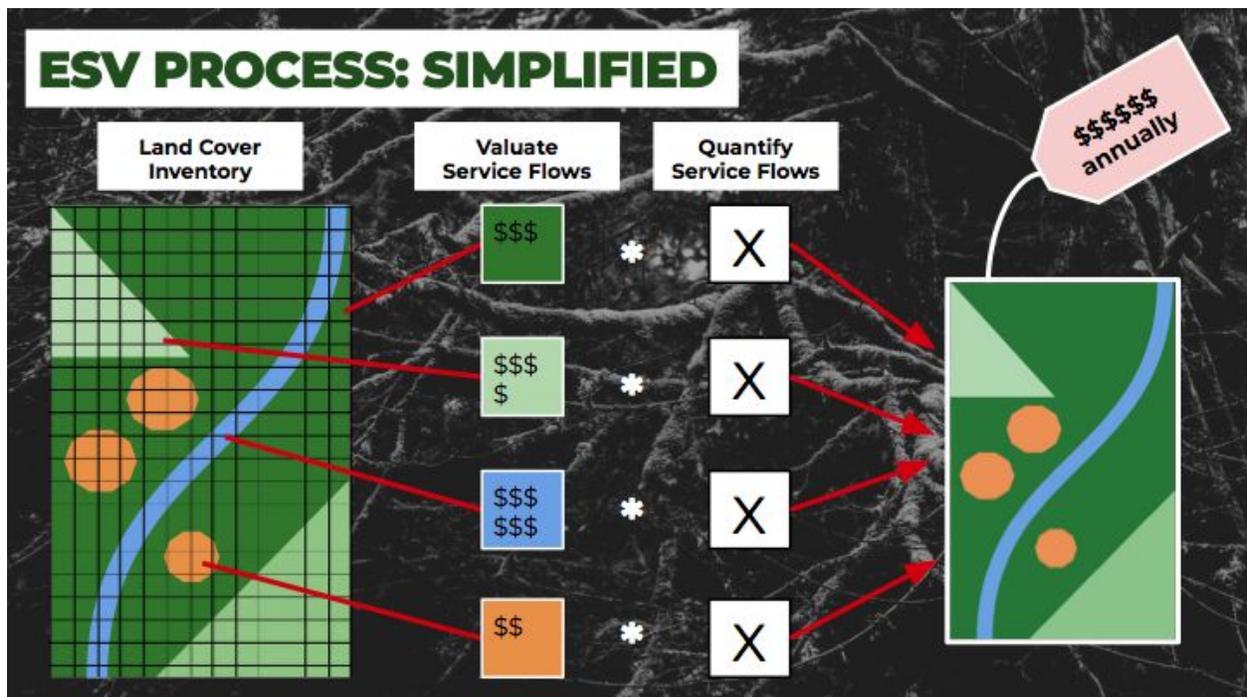
+

$$[P_B][R_{B1}][V_1] + [P_B][R_{B2}][V_2] + [P_B][R_{B3}][V_3] \dots$$

+

$$[P_C][R_{C1}][V_1] + [P_C][R_{C2}][V_2] + [P_C][R_{C3}][V_3] \dots$$

= Estimated Annual Value of Ecosystem Services



Step 4: Net Present Value Calculations

Net present value incorporates the fact that ecosystems do not stay exactly the same over time. As shrubs and trees grow, their capacities for producing ecosystem services increases. In the same way, some vegetation waxes and wanes seasonally. Using the rates of shrub and tree growth I will be able to calculate what the cumulative value the study areas will produce over a period of time. I will calculate this for 1, 5, 10, 25 and 50-year spans. Larger spans are not as meaningful calculate because I cannot know the future of the park, and the valuation is an estimate that grows less and less accurate the more I extrapolate.

COMMUNICATING MY FINDINGS

Good Educational Tools

When considering how to explain ESV to the public I thought back to how I have learned about complex topics in the past. I wanted to create something that is fun, simple, and effective at teaching a memorable lesson. I recalled how, when I was in early elementary school, I learned about everything from weather to thermodynamics to anatomy from Bill Nye on his show, *Bill Nye the Science Guy*. I thought of the stick figures and metaphors that Annie Leonard uses in her *The Story of Stuff* videos to discuss concepts such as planned obsolescence, consumerism, and climate change. I first watched her videos in 5th grade and my family still recites some of her one liners to this day! I remembered learning AP U.S. History from Hank Green on his *Crash Course* YouTube series, full of mnemonics, bright colors and absurdity. My research led me to discern common patterns between these sources and I developed a set of key tenants of good educational tools. These are strategies used to effectively teach about complicated topics in simpler terms that the everyday person can understand.

- Enthusiasm
- Simplicity
- Visuals
- Defining Terms
- Examples
- Call to Action
- Short & Fast Paced

Bill Nye The Science Guy

Bill Nye may be the most enthusiastic scientist I have ever encountered in media. His awe-filled voice tone, facial expressions and language are infectious and capture the audience. While his videos are cluttered with color, knick knacks and fun facts, his models are simple--limited to single concepts with 2-3 new terms, often labeled. He caters to several learning styles with visuals, movement, sound and text. Nye is pictured in the image below in an episode about plate tectonics, doing a demonstration with a seismometer. Not only are Nye's episodes short at about 20 minutes, he keeps them fast-paced by spending no more than 2-3 minutes on each model, demonstration, explanation, mini game show or field trip.



Nye, Bill. "Earthquakes." *Bill Nye*, 2019. <https://www.billnye.com/the-science-guy/earthquakes>

The Story of Stuff

Planned obsolescence is another word for "designed for the dump." She goes on to clarify the concept, listing multiple examples of throw-away products, and taking time to explain just one in further detail so as not to overload the audience. In the below image, Leonard is explaining the term, "planned obsolescence" by providing an easy-to-remember

definition, injecting it in the context of the life cycle of our trash, and using simple symbols to represent concepts such as pollution, capitalism, and globalization. Rather than getting bogged down on explaining the intricacies of a government highly influenced by a first-world capitalistic economy, she simply includes a picture of little government leader at the White House holding hands with a big, fat money man. I first saw this video with my family when I was in the 5th grade, and to this day, we still refer to objects planned to be quickly obsolete as being “designed for the dump.” To extend its reach, The Story of Stuff Project created a Spanish version of *The Story of Stuff*, called *La Historia de las Cosas*, which is not only dubbed over in Spanish, but includes graphics in Spanish as well. Creating versions of educational tools in multiple languages broadens the accessibility of the information. When I have further developed my booklet, creating a version in Spanish could be a next step.

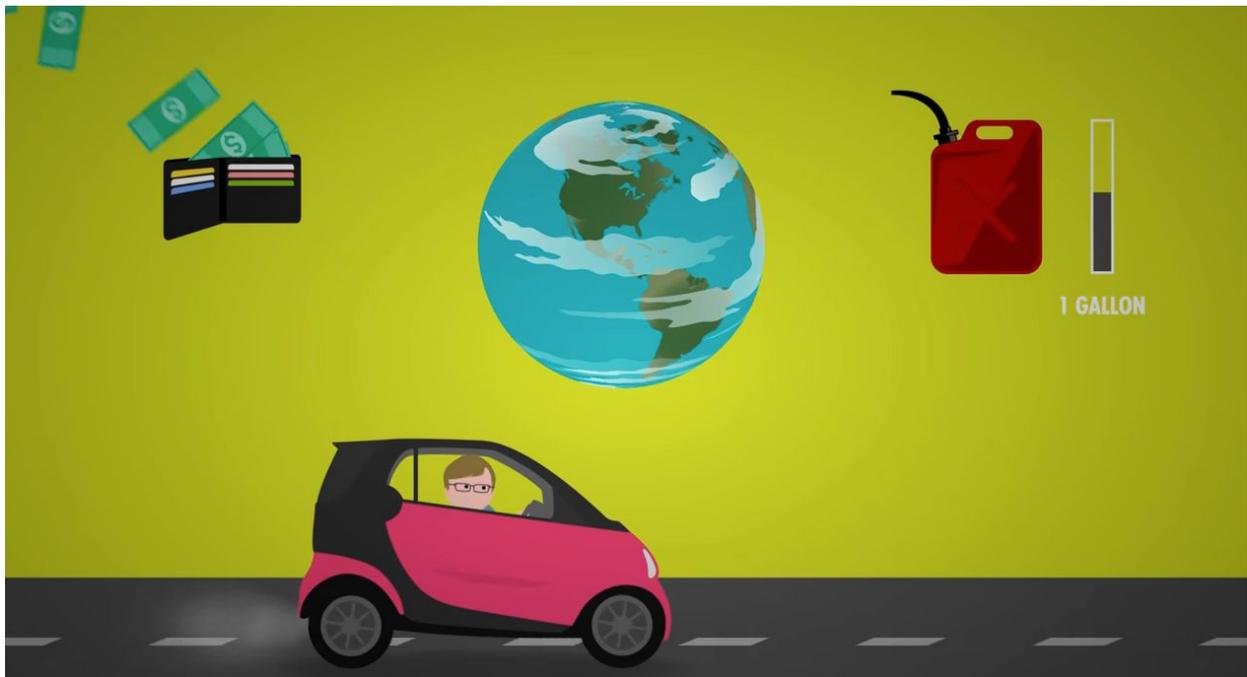


“The Story of Stuff by Louis Fox 2007.” *Films for the Earth*, filmsfortheearth.org/en/films/the-story-of-stuff.

Crash Course

While discussing consumer behavior in the *Crash Course* Environmental Economics video, we see the video creator, Hank Green, in a pink smart car with symbols for money savings, the environment, and fossil fuels above. *Crash Course* uses color brilliantly to make the concepts in their videos memorable. In this video, the Smart Car represents the idea of the “rebound effect,” which refers to the idea that energy efficient products might cause people

to change their behavior and make counter productive choices. For example, a Smart Car driver may save gas and money with their energy efficient vehicle, but then drive more or use the saved money to go on a vacation that requires a flight. The bright pink smart car sticks in the audience's memory as a symbol of the rebound effect.



"Environmental Econ: Crash Course Economics #22." *The Crash Course*, Jan. 2016. <https://thecrashcourse.com/search?query=environment>

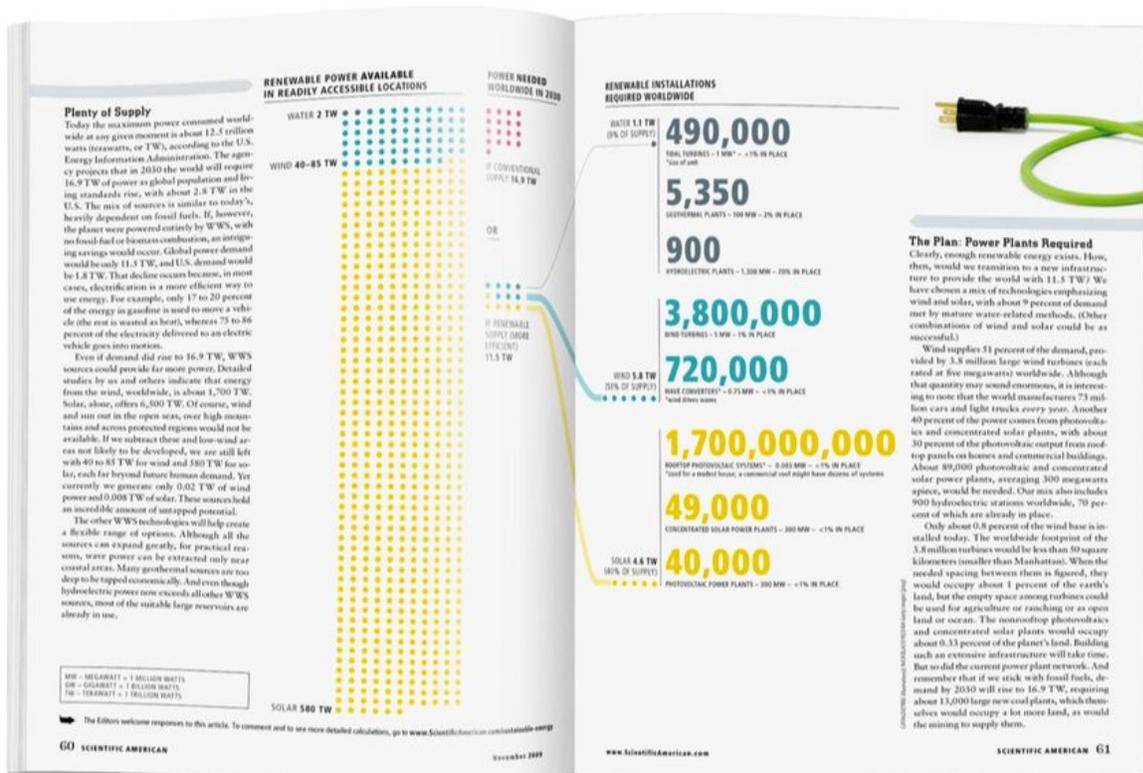
Booklet Design

I chose to create a booklet for several reasons. First, a booklet is easily distributable as a PDF or as a print copy. If access to information is my objective, it only makes sense to seek out the most easily distributable medium possible. Additionally, a booklet, like a magazine, conveys information regardless of the reader's commitment. Whether someone flips through, skims, reads selectively, or dedicates themselves cover to cover, they will learn something. All they have to do is pick it up! Third, I chose a booklet because I could develop the skill set I need to create a product within the project timeline (as opposed to creating a video, which would require video and animation skills that I do not have time to learn). I reviewed magazines, professional reports, and design templates to develop a set of Layout Guidelines for my booklet.

- Color Scheme
- Clean & Simple

- Columns & blocks, not walls of text
- Graphics convey immediate meaning
- Appropriate aesthetic

When it comes to text layout, columns and blocks suit the eye better than full-page walls of text. My booklet contains side-by-side columns and small text boxes in order to prevent Graphics should convey meaning immediately so that someone skimming through the booklet can understand them at a glance. With further observation and reading, the audience should gain more information. The booklet aesthetic must be neither overly earthy nor overly shiny. If the booklet gives off an earthy, grassroots, flowery, “I love mother earth” feeling people won’t take ESV seriously as an economic practice. At the same time, an overly shiny and cold design can make ESV feel corporate and unreachable to the layperson.



Scientific American's graphics convey meaning at a glance



The symmetry of National Geographic's case studies tells readers to know what information to expect in each study, allowing for quick comparisons between cases.

NEXT STEPS

At the end stages of the CEP senior project my intended final product, a booklet on ESV for the general public, is incomplete. I currently have developed text based on my literature review and have created several graphics for the booklet; however, as someone learning Adobe Indesign and Illustrator, my progress has been very slow. I may be switching to Canva to speed up the process and because I will no longer have access to Adobe software after I leave UW. My next steps are to create several more graphics to accompany the text, to develop a cohesive booklet layout reflective of my research-based design guidelines, and to distribute the booklet. See below to get an understanding of what the booklet will contain! I plan on distributing my booklet by sharing it in print and as a PDF with my now-past colleagues at the Port of Seattle and with my future colleagues at San Juan County, and with the Environmental Science Center in Brien which I connected with this

past winter. I am excited about the idea of my work contributing even in the slightest way to the proliferation of ESV!

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SENIOR PROJECT TAKEAWAYS

The following points are lessons I have learned throughout the senior project process.

Project management

1. Time management: break tasks up and set deadlines along the way.
2. Working with external organizations or individuals can slow projects down. People have different timelines, motivations, commitment levels, and communication styles.
3. Simplicity and realisticness are essential. Overly complex and far reaching projects are discouraging and overwhelming.

Ecosystem Services Valuation

1. ESV is complicated! Creating a reliable and realistic estimate of natural systems' value over time involves collaboration between many areas of expertise.
2. There are so many sources I can draw information from. Research and literature review are not just about reading academic journals! I learned about educational tools by watching videos intended for kids and I learned about print layouts by browsing magazines on subjects unrelated to my topic.
3. People typically won't do things unless it will bring them economic benefit, which is why ESV is so important and has potential to be effective. ESV shows that environmentally responsible decisions are actually also fiscally responsible decisions, especially over longer periods of time.

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Taking inventory of wetland vegetation in Auburn, WA in summer 2018 for the Port of Seattle Aviation-Environmental Wetland Mitigation Monitoring program.

REFERENCES

- Behance. "2015 National Geographic Annual Report." *Behance*,
www.behance.net/gallery/31074959/2015-National-Geographic-Annual-Report.
- Christin, Z., Batker, D., Harrison-Cox, J., 2011. Economic Impact of Metro Parks Tacoma Ecosystem Services: Economic Impact Study Phase II Economics, Tacoma WA. (2011)
- Ciecko, Lisa, et al. "Seattle's Forest Ecosystem Values." *Green Cities Research Alliance* (2012).
- Costanza, Robert. "The Value of the World's Ecosystem Services and Natural Capital." *Nature* Vol 385 (1997): 259.
- DEFRA. "An Introductory Guide to Valuing Ecosystem Services." Department for Environment, Food and Rural Affairs (2007)
- "Ecosystems and Human Well Being." The Millenium Ecosystem Assessment, 2005.
<https://www.millenniumassessment.org/documents/document.48.aspx.pdf>
- "Environmental Econ: Crash Course Economics #22." *The Crash Course*, Jan. 2016.
<https://thecrashcourse.com/search?query=environment>
- Heal, Geoffrey M. et al. *Valuing Ecosystem Services*. National Academies Press (2005)
<https://www.nap.edu/read/11139/chapter/1>
- Marre, Jean-Baptiste, et. al. "The Use of Ecosystem Services Valuation in Australian Coastal Zone Management." *Marine Policy. Volume 56, June 2015, Pages 117-124* <https://www.sciencedirect.com/science/article/pii/S0308597X15000469?via%3Dihub>
- Nye, Bill. "Earthquakes." *Bill Nye*, 2019. <https://www.billnye.com/the-science-guy/earthquakes>
- "Rim Fire." Headwaters Economics, 2018. Accessed March 1, 2019. <https://headwaterseconomics.org/wp-content/uploads/full-wildfire-costs-rim-casestudy.pdf>
- Roberts, et al. "The Nature of Wellbeing." *New Zealand Department of Conservation*. (2015)
- Rotman, Michael. "Lake Erie." *Cleveland Historical*, clevelandhistorical.org/items/show/58.
- Sills, Erin O. "Trees at Work: Economic Accounting for Forest Ecosystem Services in the U.S. South." *Forest Service Southern Research Station General Technical Report SRS-226* (2017): 1-3.
- "Sustainable Energy Solutions – Lucy Reading." *Lucy Reading*, www.lucyreading.co.uk/project/sustainable-energy-solutions/.
- Sutton, Paul C. "Holistic valuation of urban ecosystem services in New York City's Central Park." *El Sevier* (2018)

"The Science Guy." *Bill Nye*, 2 May 2018, www.billnye.com/the-science-guy.

"The Story of Stuff by Louis Fox 2007." *Films for the Earth*, filmsfortheearth.org/en/films/the-story-of-stuff.

Van Deren, et al. "Nature's Value in the Skykomish Watershed." *Earth Economics*. (2017)

Van Deren, et al. "The Natural Value of Discovery Park, the Public Benefits of Seattle's Largest Park." *Earth Economics*. (2018)

Vásquez, J.A., Zuñiga, S., Tala, F. et al. *J Appl Phycol* (2014) 26: 1081.

<https://doi.org/10.1007/s10811-013-0173-6>