A Response to the Washington State Academy of Sciences' Review for the Puget Sound Partnership

Compiled by Kory Kramer | Master of Geographic Information Systems Candidate
University of Washington
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Background

In August 2012, the Washington State Academy of Sciences (WSAS) published a review of the Puget Sound Partnership's progress in developing the scientific basis for monitoring and assessing progress toward achieving a vibrant Puget Sound[1]. In September 2012, as part of the Professional Master of Geographic Information Systems (PMPGIS) program at the University of Washington, students began their second year with a quarter-long study of Coastal GIS. During the fifth week of the quarter, students read and discussed Sound Indicators: A Review for the Puget Sound Partnership, the WSAS recommendations to the Puget Sound Partnership (PSP).

The PMPGIS program teaches students to use GIS as a tool, combined with spatial and systems thinking, to create sustainable solutions to real-world social-ecological problems. The Coastal GIS course used geodesign concepts from Carl Steinitz' A Framework for Geodesign: Changing Geography by Design[2] to expose students to a number of case studies that demonstrated various design models. These case studies emphasized the necessary contributions of the geographic sciences, information technology, design professions, and the people of the place in arriving at sustainable solutions that are environmentally, socially and economically balanced. While the course used Chrisman[3] to cover technical aspects of GIS such as measurement, representation, operations and transformations, many of these concepts built upon information presented during the first year of the master's program. In other words, students were encouraged to explore the interdisciplinary interactions and cooperation that lead to successful solutions, while at the same time being trained to consider the technical requirements necessary to implement a computationally enabled decision support system.

With an eye to preparing students to face real-world challenges that will likely comprise their professional careers in GIS, the final project for the Coastal GIS course required students to adopt a recommendation made by the WSAS Committee in the Sound Indicators review and navigate the Committee's recommended six-step roadmap to deliver a response to the WSAS recommendations. Adding one final step to the Committee roadmap, the final project called for students to describe an appropriate change model that would move the target attribute from its current state to a preferred future state, as well as explain why or why not a public agency should consider the student's recommended solution.

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[1] Washington State Academy of Sciences. Committee on Puget Sound Indicators. 2012. Sound Indicators: A Review for the Puget Sound Partnership. Olympia, WA: Washington State Academy of Sciences. http://www.washacad.org/about/files/WSAS_Sound_Indicators_wv1.pdf
[2] Steinitz, Carl. A Framework for Geodesign: Changing Geography by Design. 2012. Esri Press.
[3] Chrisman, Nicholas. Exploring Geographic Information Systems. 2002. Second Edition. John Wiley & Sons, Inc.

In a personal communication to Robert Aguirre, the professor who guided students through the present project, the esteemed Guy H. Palmer DVM, PhD, wrote, "Robert-- As President of the Washington State Academy of Sciences, I am responding on behalf of both Professor Orians and the Academy. We are pleased and impressed that the Academy's report has been useful and promoted both further analysis and action in terms of improving monitoring and the health of the Sound. This validates the usefulness of the report in that, similar to reports of the National Academy of Sciences, it has served as a leading analysis.

As an Academy, we would fully support your using these recommendations to move forward."

With that encouragement, and with motivation from Professor Aguirre, we present our work to the Puget Sound Partnership in hopes that it will be of further use in responding to the WSAS recommendations, and lead to continuing improvements in the social and ecological health of the Puget Sound.

Methodology

This response to the WSAS Committee recommendations is compiled from students' final projects, completed in December 2012 to fulfill the requirements for GEOG 562, Coastal GIS. As such, projects were administered in the form of a "final exam." Congruent with real-world scenarios, while students were provided direction, there was a high degree of uncertainty in what the final product would entail. With wide latitude to meet the requirements of the project, students had the flexibility to be creative in their approach to responding to the Committee recommendations. This flexibility is reflected in the final products; they all follow the roadmap, yet there is a range of solutions, based on varying conceptual frameworks and differing interpretations of the underlying phenomena, relationships and interactions between real-world entities.

The project guided students, or student teams, through the six-step roadmap, broken down into 15 sub-steps. The outline is provided here as part of the methodology. In the appendices, each sub-step is labeled so that it can be referenced back to the project framework provided in this section. With that explained, here is the framework from which students worked to create a response to the WSAS recommendations:

The WSAS Committee strongly recommended that the Puget Sound Partnership use the following overall roadmap to refine its choice of indicators. The WSAS (2012, 90) stated: "[W]e stress the importance of developing and using a conceptual model of the Puget Sound system to identify the key attributes for which indicators need to be developed. We have suggested a stepwise procedure that, if adopted, would help the PSP select, describe, and provide the rationale for the indicators that it needs to develop and refine."

Step 1. Develop a conceptual framework that summarizes the major structural elements and processes of the ecosystem to identify the key attributes (characteristics) that should be tracked.
Step 2. For each attribute, identify potential indicator(s), explicitly describing the rationale for determining that the indicator accurately represents the attribute by using a conceptual model or an empirical association with predictive power.
Step 3. Develop an appropriate measure (metric) that demonstrates the response of the indicator to changes in the ecosystem.

Step 4. Evaluate each potential indicator and its associated measure (metric) for quality, using criteria such as reliability.
Step 5. If more than one high-quality indicator has been identified for an attribute, winnow the set of potential indicators using other factors appropriate to the application, such as cost or response time.
Step 6. Reassess the resulting set of indicators to ensure that they capture all of the important attributes identified in Step 1 above.

To build your computational geodesign solution, you will be required to follow the spirit of the WSAS roadmap, which has been further broken down into 15 sub-steps to help you think carefully about and document your stepwise work. Simply read the instructions in each sub-step, do the appropriate work, and answer the questions below in as much space as you need.

STEP 1: FROM CONCEPTUAL FRAMEWORKS TO KEY ATTRIBUTES

Sub-Step 1A: Cite the primary conceptual framework(s) you are using to identify the major structural elements and processes of the state of the Puget Sound social-ecological system and identify its key attributes. Explain why you selected this conceptual framework instead of other options.

Sub-Step 1B: Cite the other conceptual frameworks you reviewed. Mention at least one thing you feel is important to consider even though these others you reviewed are not your primary conceptual framework.

Sub-Step 1C: If not explained in sub-step 1A, specify exactly what key attribute(s) you chose to focus on for your indicator.

STEP 2: FROM KEY ATTRIBUTES TO INDICATORS

Sub-Step 2A: Given the key attribute(s) you selected in step 1, specify exactly what indicator(s) you selected to represent this key attribute.

Sub-Step 2B: Cite a valid source or rationale determining that the indicator(s) you are selecting accurately represents the key attribute(s) you selected in step 1. Explain why some other indicator might not better represent this key attribute(s).

STEP 3: FROM INDICATORS TO RELEVANT MEASURES

Sub-Step 3A: Given the indicators you selected in step 2, specify exactly what relevant measures or metrics you selected. Based on the indicator, key attribute and conceptual framework you selected, explain how your measurements represent a driver, pressure, state, impact, or response of something in the Puget Sound social-ecological system.

Step 3B: As in step 2, cite a valid source or rationale determining that the relevant measure you are selecting accurately represents the indicator you selected. Explain what other relevant measures you considered, and why you did not select those instead.

Sub-Step 3C: MAP SKETCH. In the space below, insert a legible scan or digital photo of a hand-drawn map representation showing the past or existing state of something in the Puget Sound region according to the relevant measures or metrics you selected; then describe in words what this hand-drawn map representation shows. Explain or imagine a spatial pattern of interest. Be sure to consider issues of geographic scale and spatial resolution carefully.

Step 3D: GRAPH SKETCH. In the space below, insert a legible scan or digital photo of a hand-drawn graph representation showing the past or existing state of something in the Puget Sound region according to the relevant measures or metrics you selected. Describe in words what this hand-drawn map representation shows. Explain or imagine a temporal pattern of interest. Be sure to consider issues of time scale and temporal resolution carefully.

Sub-Step 3E: MAP 1. In the space below, provide a map representation based on your design in sub-step 3C that reflects your computational solution for representing the past or existing state of the Puget Sound region given the relevant measures or metrics you selected. *Briefly* describe in words how you implemented your solution in terms of measurements, representations, operations and transformations. Be sure to mention the data and ArcGIS tools or processing steps used. Finally, explain what you see as a spatial pattern of interest.

Sub-Step 3F: GRAPH 1. In the space below, provide a graph representation based on your design in sub-step 3D that reflects your computational solution for representing the past or existing state of the Puget Sound region given the relevant measures or metrics you selected. Explain what you see as a temporal pattern of interest.

STEP 4|5|6: EVALUATING AND REASSESSING RELEVANT MEASURES OF INDICATORS

Look at the results of your computational design, testing, or implementation work in step 3 and provide an honest evaluation of how well the maps and graphs you designed and ultimately created actually represent the relevant measures, indicator, and key attributes intended by your conceptual framework. Explain why a public agency, for example, should or should not consider acting upon this information with some policy intervention.

STEP 7: FROM RELEVANT MEASURES TO GEODESIGN SOLUTIONS

Sub-step 7A: MAP 2. Consider the map representation of the existing situation MAP 1 that you produced in sub-step 3E (or the map sketch in sub-step 3C if you were unable to create a map using ArcGIS). Imagine a map representation of a preferred situation, which we will call MAP 2, and provide it in the space below. Describe the spatial nature of the change between MAP 1 and MAP 2 that you are attempting to represent. If you cannot imagine what MAP 2 might look like, why not?

Sub-step 7B: GRAPH 2. Consider MAP 1, MAP 2, and the graph representation of the existing situation GRAPH 1 that you produced in sub-step 3F (or the graph sketch in sub-step 3D, if you were unable to create a graph). Imagine GRAPH 1 extended into the future to represent a preferred situation, where your relevant measures reach a specified target within a specific time period. Call it GRAPH 2. Provide it in the space below. Describe the process that must occur for GRAPH 1 to look like GRAPH 2. If you cannot imagine what MAP 2 might look like, why not?

Sub-step 7C: If an organization such as a public agency with the authority to implement policy interventions were to try to change the existing situation (MAP 1, GRAPH 1) to a preferred situation (MAP 2, GRAPH 2), what change model would you advocate from the nine case studies presented in Steinitz (2012). Pose an argument for selecting one change model over the others (call that your Option "A"), but explain what one other change model you would also suggest trying as a secondary option (call that your Option "B").

Summary

A cursory overview of the final projects is provided in Table 1 below. This table provides a helpful “at-a-glance” summary of the projects in a way that allows the reader to compare and contrast students’ selections of, for example, an indicator even if working with the same key attribute as another student or group. Table 1 also makes it easy for the reader to quickly assess which project authors feel confident that their recommendation should be considered by PSP and where the author feels the work provides a solid conceptual foundation, yet needs to be refined before implementation.

In comparing the projects, it is apparent that there were varying interpretations of what constituted a conceptual framework of the Puget Sound social-ecological system. In other instances, there is not the level of clarity around key attributes and indicators that would be hoped for if strictly adhering to the WSAS roadmap. Nonetheless, this response to the WSAS Committee’s recommendations to PSP should be seen as a demonstration of what substantive progress can be made in a very short period of time. Students were given approximately two weeks to complete this project. This time included selecting which recommendation to address, conducting necessary background investigations to better understand the phenomena of interest and relevant interactions to take into consideration, collecting existing data to build a solution, and finally, creating a computationally enabled solution to the chosen recommendation. Of course, different projects gave greater weight to different aspects of the above workflow, but the end result is an array of projects that were born directly from an advisory document and provide a proposal for implementing a solution.

Table 1 can be used as a sort of table of contents to the appendices. Projects in the table are presented in the order that the appendices are attached, so that a reader can quickly reference a project of interest. Each project provides details and explanations to justify the student’s decisions at every step. Some students/teams provided more direct responses as to whether they would recommend their solution to a public agency, while other answers were less direct. For this reason, it was difficult to summarize such a large amount of nuanced information into a single cell of a table. Refer to individual projects for full explanations.

Finally, it is interesting to note that the majority of the student projects addressed attributes and indicators that the WSAS Committee classified as “missing,” while two projects addressed indicators that the committee recommends be refined, and one project that addressed the social indicators. If nothing else, we hope that our work might provide a jumpstart or other value to PSP in pursuing the development and improvement of Puget Sound social and ecological indicators as recommended by WSAS.

We commend the progress that PSP has made to date on a very complex task. We hope that our input is helpful in the furtherance of your work and stand by to respond to questions or feedback regarding these projects.

Appendix	WSAS Recommendation	Conceptual Framework	Attribute(s)	Indicator(s)	Recommend to Public Agency?
1	Add as potential indicator (pg. 6)	Heinz Center 2008	Puget Sound estuarine habitats	Diagnostic spp. From Dethier (1990,1992)	Not Stated
2	Add as potential indicator (pg. 6)	Levin 2011	Extents of Marine Habitats	Extent Index	Yes
3	Add as potential indicator (pg. 6)	DPSIR; O'Neill 2008	Habitat area, extent, and pattern/structure	Composite linear extent of eelgrass, kelp, saltmarsh, intertidal wetlands, and oyster/clam beds	Yes
4	Add as potential indicator (pg. 6)	Not Stated	Acreage of intertidal flats adjacent to secondary estuarine drainage channels	Secondary drainage channels	Needs Refinement
5	Add as potential indicator (pg. 6)	O'Neill 2008	Water quality in freshwater lakes and specifically trophic lake status	Primary productivity in freshwater lakes	Yes
6	Add as potential indicator (pg. 6)	Not Stated	Freshwater quality	Ammonia, nitrate+nitrite, total phosphorous, fecal coliform bacteria, average annual flow	Needs Refinement
7	Focus on attributes of human well-being that are unambiguously due to the state and functioning of the PS ecosystem (pg. 70)	Levin 2011	Ecological Indicators; Market Activities; Accessibility and Recreation	Change in landuse/landcover inside and outside UGA; Median Family Income; Index of proximity to public lands	Needs Refinement
8	Refine and Use in the Initial Dashboard (pg. 88)	DPSIR	Physical / Chemical Parameters surrounding Marine Water Quality	Dissolved oxygen	No
9	Add as potential indicator (pg. 6)	EPA SAB	Energy Flow	Primary Productivity	Yes
10					
11	Add as potential indicator, differs from marine primary productivity (pg. 78)	Not Stated	Forest productivity	High areal density of carbon biomass	Needs Refinement
12	Refine and use in the Dashboard (pg. 5)	SAB, Heinz Center, Levin 2011	Water Quantity	% of Streamflows below critical levels	Not stated

Table 1. At-a-glance summary of project results

Appendices

1. Extent of the range of marine habitat types in Puget Sound (1) *Palmer, Stcherbinine*
2. Extent of the range of marine habitat types in Puget Sound (2) *Foster, Teut*
3. Extent of the range of marine habitat types in Puget Sound (3) *Eckhardt, McAuslan*
4. Extent of the range of marine habitat types in Puget Sound (4) *Novak*
5. Freshwater quality in lakes as well as streams, and primary organic productivity in freshwater habitats *Perkins*
6. Freshwater quality in lakes as well as streams, and primary organic productivity in freshwater habitats *Walker*
7. Four broad attributes of human well-being *Gardner, Price*
8. Marine Water Quality *Dong*
9. Primary productivity (marine) *Kramer*
10. Primary productivity (marine) *Timbers*
11. Primary productivity (terrestrial) *Johnstonbaugh*
12. Water Quantity *Schmitz*