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Mariam Guizani
Oregon State University, guizanim@oregonstate.edu

Meghna Babbar-Sebens
Oregon State University, meghna@oregonstate.edu

Eugene Zhang
Oregon State University, zhange@eecs.oregonstate.edu

Adriana Debora Piemonti
debora.piemonti@gmail.com

Snehasis Mukhopadhyay
Indiana University Purdue University Indianapolis, smukhopa@iupui.edu

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Visual Analytics for Identifying Patterns in High-dimensional Decision and Objective Spaces of User-Preferred Conservation Plans

Mariam Guizani[1], Meghna Babbar-Sebens[2], Eugene Zhang[3], Adriana Debora Piemonti[4], and Snehasis Mukhopadhyay[5]
[1] Oregon State University (guizanim@oregonstate.edu)
[2] Oregon State University (meghna@oregonstate.edu)
[3] Oregon State University (zhange@engr.orst.edu)
[4] Intera Inc (dpiemonti@intera.com)
[5] Indiana University Purdue University Indianapolis (smukhopa@iupui.edu)

Abstract: Design of conservation practices and their locations in the watershed landscape can be posed as a computational multi-criteria decision making problem. While multi-objective optimization algorithms are aimed to solve for such types of problems by simultaneously optimizing conflicting cost-benefit goals, formulation of multi-criteria conservation planning problems is not an easy task. The co-existing stakeholders and watershed inhabitants necessitate involvement of multiple subjective criteria and "soft" preferences, many of which are not easy to quantify within a computational optimization algorithm. Hence, methods involving interactive multi-objective optimization have been proposed in the recent past in order to include the stakeholders within the search loop via graphical user interfaces, and guide the optimization algorithm in simultaneously optimizing for numerical cost-benefit functions as well as the user-provided subjective "soft" fitness of design alternatives. At the end of such search processes, sets of user-preferred design alternatives obtained from different users can then be compared for identifying and visualizing agreement and disagreements among stakeholder-generated designs. Visualization must articulate patterns in users' preferences for particular spatial decisions (e.g., a specific conservation practice at a specific watershed location, etc.), as well as the extent to which decisions meet particular cost-benefit goals at local as well as system-wide watershed scale. In this research, we developed a novel visual analytics methodology for evaluating typologies in high-dimensional decision spaces and objective spaces of user-preferred conservation plans. The novel visual analytic technique is based on a multivariable network map visualization approach that encapsulates both the decision and objective space in a network graph without losing the relative geographical information between the neighboring sub-basins. The method was compared with existing visual analytics techniques for watersheds, and then used to evaluate user-preferred watershed plans of filter strips and cover crop conservation practices found by multiple participants who interacted with an Interactive Genetic Algorithm-based decision support system called WRESTORE.

***Keywords**:* Visual analytics; watershed; optimization; stakeholders.