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Abstract

In 2017, the U.S. Census Bureau announced Idaho to be the fastest growing state by population in the country. As these trends continue, this growth can have various impacts on socio-ecological systems such as increased development, pressure exerted on agricultural production, and increased effects of urban stream syndrome. Various scenarios, driven by stakeholders, can help effectively guide the designs of our green infrastructure networks. This project evokes stakeholder-defined key issues addressed within a National Science Foundation (NSF) funded project in Idaho's Magic Valley. Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) is an interdisciplinary research initiative seeking to address issues concerning drought, water demand, water quality, and food security by using a stakeholder-driven alternative futures framework (Steinitz 2012).

Researchers within the project seek to operationalize stakeholder-driven assumptions for various scenarios utilizing the planning and suitability of effective Best Management Practices (BMPs) for the Magic Valley in Idaho. The project will utilize an alternative futures methodology to interpret and represent rural and urban green infrastructure interventions at various locations within the watershed. This approach has the potential to operate at various scales and, through this project, we seek to construct the narrative at both the landscape and the site scale.

The results aim to provide policy makers, planners, developers, and landscape architects about siting various BMP types through a framework for planning and design. These outputs will also depict modeled landscape change via various scenario solutions. The stakeholder group will substantiate plausible solutions and scenarios for the Valley, which will guide the green infrastructure network. Once validated, we will focus on the siting of three different structural BMP networks to address water quality, water quantity, soil health, and inclusion of public green space.

Introduction and Background

The INFEWS (Innovations at the Nexus of Food, Energy, and Water Systems) Research Project uses an integrated approach to investigate effective means of stakeholder engagement for a National Science Foundation-funded (NSF) resource solutions project in the Magic Valley, Idaho, USA. With a growth rate of 2.2%, Idaho has become the fastest growing state in the U.S. Because of this growth, many anticipated uncertainties challenge researchers and stakeholders alike. The INFEWS project intends to integrate models from various researchers backed by stakeholder assumptions to address the following landscape scale issues: increase in population, increasing temperatures because of climate change, water quality and quantity issues, and demand for food production. This paper investigates the suitability of green infrastructure networks as a solution to water quality and resource allocation issues in the face of uncertainty through scenario-based planning.

Creating a synergistic interaction between a research project and a stakeholder group can have a significant impact for research and practical application. Creation of this synergy requires a systematic method for coupling stakeholder assumptions about the future and researcher models. Spatially explicit land use models generally operationalize a deterministic or probabilistic modeling framework (Arbab 2018); however, this project seeks to iteratively define and represent these land use changes dictated by a stakeholder group within the region.

These key issues evoked through stakeholder engagement require a framework to represent anticipatory trajectories of change driven by the stakeholder's understandings of the system. For this process, we used the GeoDesign Framework (Steinitz 2012), described in subsequent paragraphs. The following diagram illustrates the INFEWS process for incorporating researcher assumptions with stakeholder input (Figure 1).

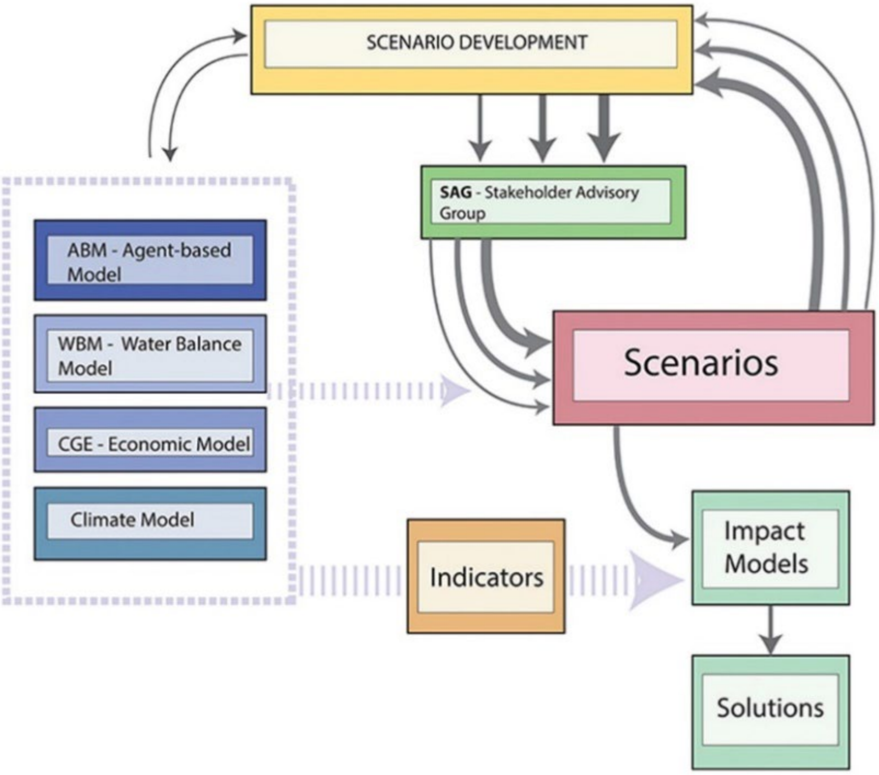

Figure 1. INFEWS Project Process Diagram

Carl Steinitz' GeoDesign Framework, also referred to as Alternative Futures, is centered on the question, "How do we get from the present state of this geographical study area to the best possible future?" (Steinitz 2012). This process occurs across scales, temporal and geographical, to produce "constructed physical change" in site-scale projects and to "influence the way society values and changes its geography" in landscape-scale projects (Steinitz 2012). GeoDesign relies on an interconnected, representative matrix of experts including regional stakeholders that Steinitz describes as “the people of the place,” geographic scientists, design professionals, and information technologists (Steinitz 2012).

The framework includes six inquiries: “How should the study area be described? How does the study area operate? Is the current study area working well? How might the study area be altered? What differences might the changes cause? How should the study area be changed?” (Steinitz 2012). Multiple iterations through these questions are employed to calibrate the models and refine stakeholder and researcher assumptions. Results of this iterative process demonstrate plausible futures for a given landscape or site. These futures are referred to as scenarios.

As mentioned earlier, this paper will focus on water quality issues as effects of interactions between growth and climate. Because of an increase in impervious surfaces and systems exerted from agricultural production, agricultural and urban stormwater runoff poses a threat to groundwater quality and stream networks (Walsh et al. 2005). Within the methods section, we propose a framework for landscape scale network planning solutions for green infrastructure to address water quality issues for a rapid increase of agricultural and urban growth.

Goals and Objectives

The goal of this project is to provide a spatially explicit suitability model for aligning stakeholder and researcher assumptions about Magic Valley 2050. This project will focus on a high population growth model coupled with an RCP 8.5 climate model (Riahi et al. 2011). This paper reflects on one of six scenarios produced within the INFEWS project. This particular scenario was selected because it reflects peak negative externalities regarding: a) a temperature increase of 3.5 degrees Fahrenheit (*Figure 2*), b) a decrease of two inches of average annual rainfall, c) a 2.2% population increase for the region (*Figure 3)*, d) increased water quality impacts due to nitrogen, phosphorus, and potassium. Through a spatially explicit analysis, this paper intends to answer the following question as the main objective: “What are suitable locations for siting agricultural and urban Best Practices (BMPs) for a site within Magic Valley, Idaho, U.S.?”

Best Management Practices, within the context of this project, are a network of site-scale interventions implemented to reduce urban and agricultural runoff, to mitigate runoff through phytoremediation, and to reduce soil loss from erosion (Shoemaker 2012). Their functions can be conceptualized as collection, conveyance, and recharge of urban and agricultural runoff. BMPs are categorized by function of facility type: point, line, and area BMPs. ‘Point BMPs’ are “practices that collect and capture drainage and may utilize detention and/or infiltration to manage flow and reduce pollutants (Shoemaker 2012).” ‘Line BMP’ facilities simulate natural stream channels to move, filter, and possibly recharge urban or agricultural runoff to suitable recharge locations. Lastly, ‘Area BMPs’ improve runoff recharge through bioretention and infiltration techniques (Shoemaker 2012). Examples of these facility types include porous paving and greenroofs.

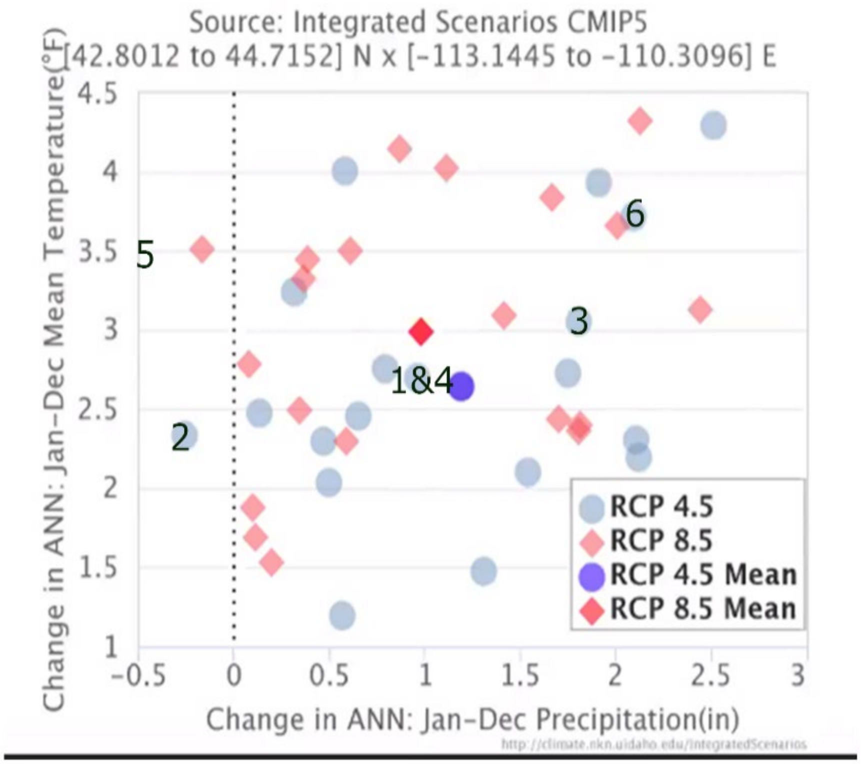

Figure 2. Graph illustrating scenarios with corresponding temperature increase and precipitation decrease

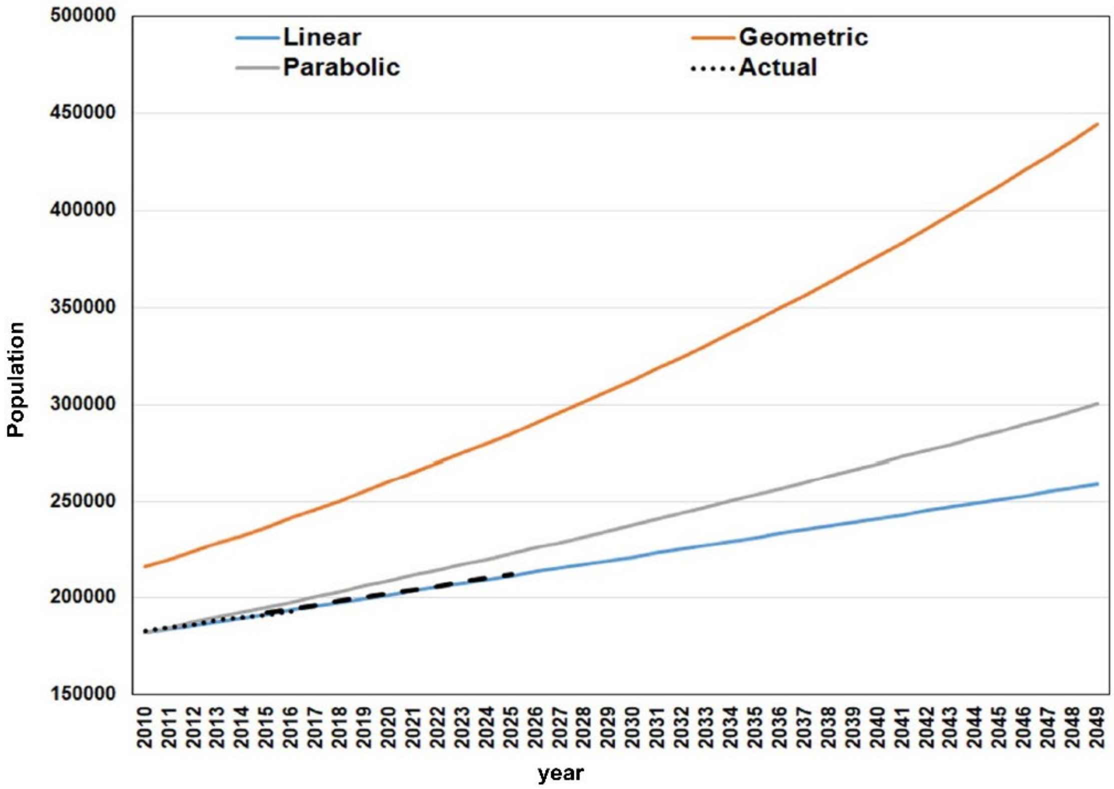

Figure 3. Magic Valley Population Projection

Methods

This section will explain the methods conducted for this study. This study utilizes spatial analysis methods to provide guidance for initial understanding of suitable locations for BMPs within this region. The methods used within this paper couples climate models with spatially explicit density models for an urban area within Magic Valley known as Twin Falls, Idaho. This site was selected based on the population growth projected to be the highest for the region (U.S. Census Bureau 2016). The current population for Twin Falls is approximately 49,200. Projection data suggests that by 2050 the population will approach 77,296 residents at a 57% increase for the city. Increases in population, development, and climate change are expected to expand impacts of urban stream syndrome (Hale 2016).

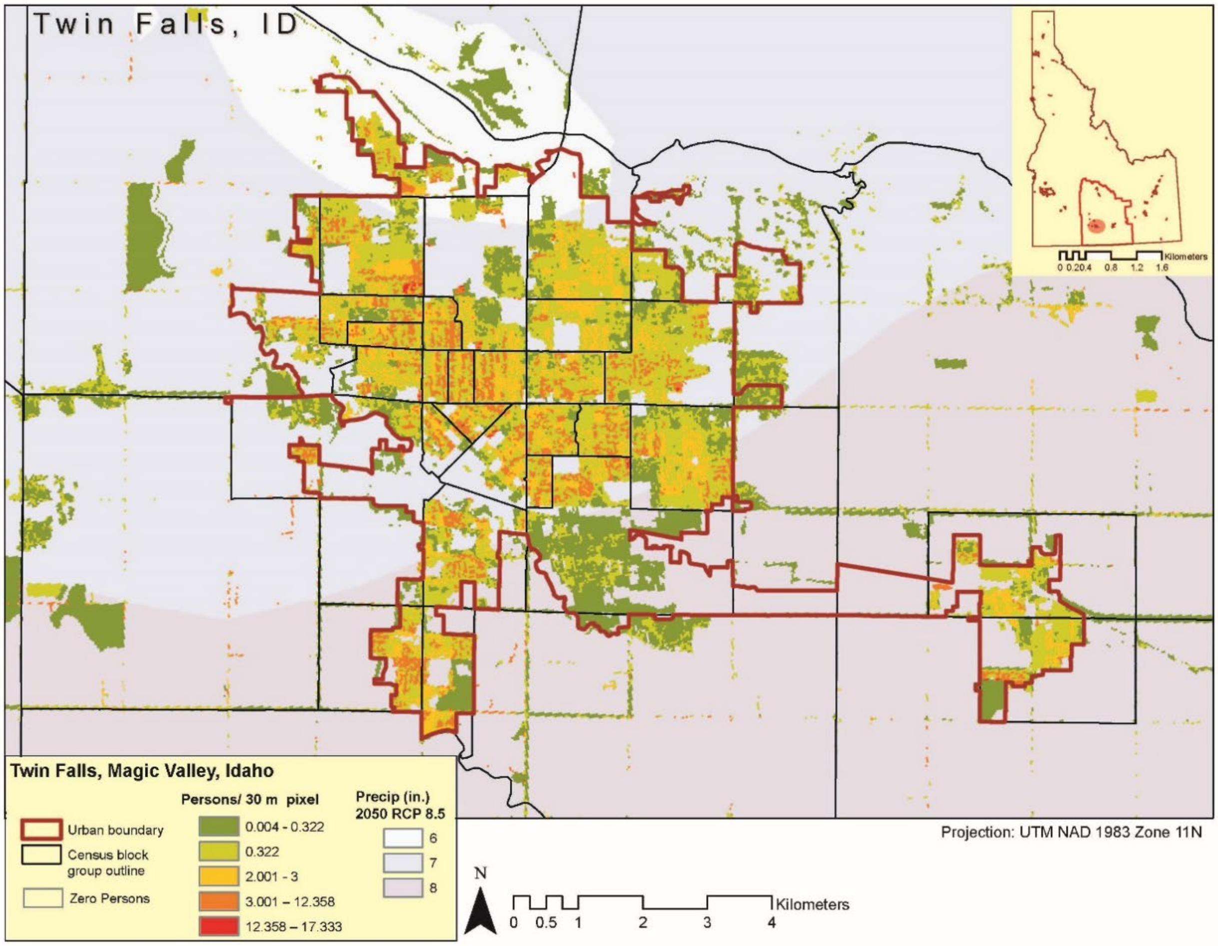

Figure 4. Dasymetric Mapping for Twin Falls, Idaho 2050

The methodology is composed of two parts: Daysymetric Mapping & Suitability Mapping. Potential locations of projected population density for the year 2050 and land cover distinctions of low, medium, and high development classes are quantified through a process called Dasymetric Mapping (Figure 4) (Sleeter et al. 2007). These models as maps are combined with suitability criteria for agricultural and urban BMPs. The agricultural BMP suitability criteria was constructed from the Agricultural Conservation Planning Framework (ACPF) developed for site-specific solutions to water quality issues (Tomer et al.

2017). The following criteria were used to site suitable locations for agricultural BMPs: a) 300 m buffer from streams, b) less than 10% percent slopes, c) Cropland Data Layer (USDA), and d) Hydrogroup Soils. Hydrogroup soils A and B are porous, in turn, increasing recharge. For detention facilities, hydrogroup soils C and D are used for suitability criteria.

Urban BMP suitability criteria was determined by applying a United States Environmental Protection Agency (USEPA) tool called SUSTAIN (Lee 2012). These models as maps were combined using ESRI ArcGIS tools (ESRI 2018) to create a range of spatially explicit locations for urban and agricultural BMPs for Twin Falls, Idaho.

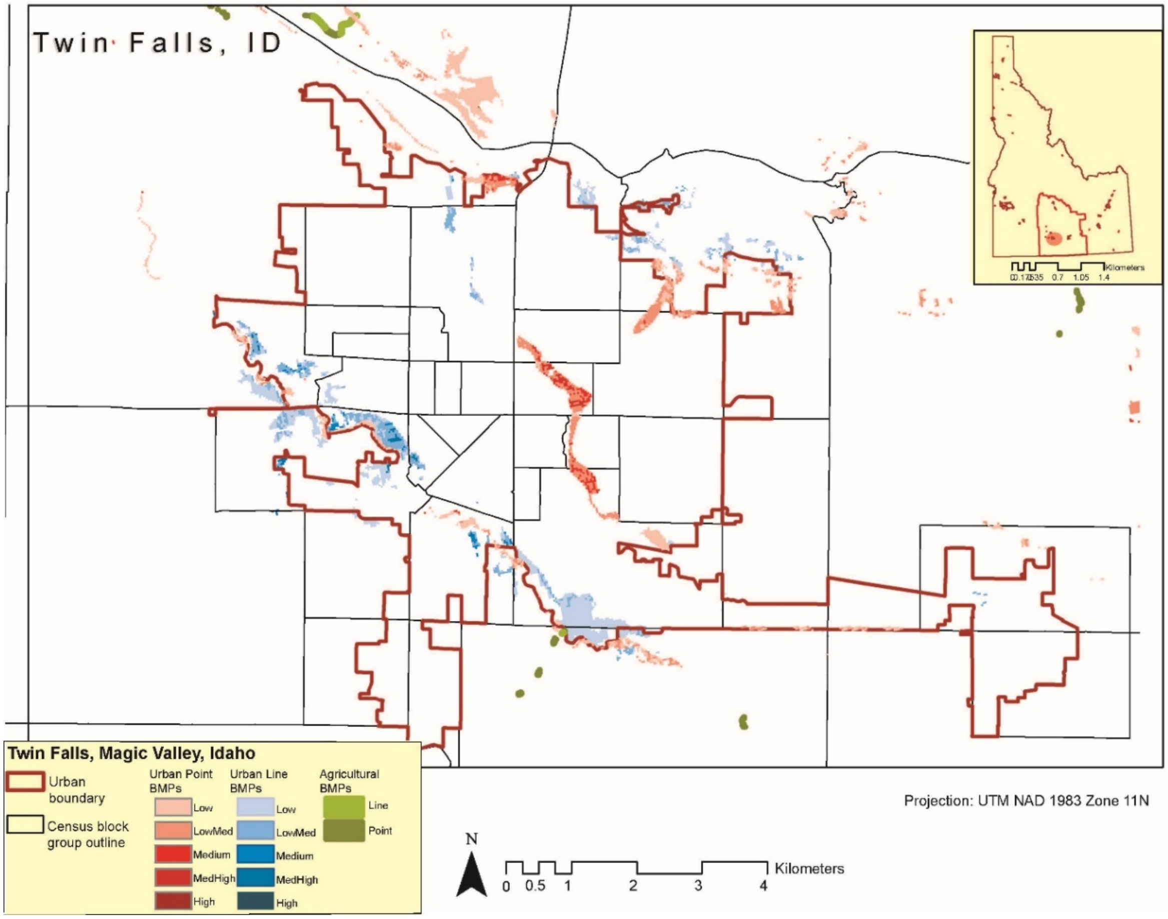

Figure 5. BMP Network for Twin Falls, Idaho 2050

Results

The following section reports and interprets the results of the project. The results provide a range of spatially explicit areas through siting techniques discussed in the methods section. These results intend to provide a framework for policy makers, planners, developers, and landscape architects about information regarding siting suitable locations for BMPs. Agriculture and urban BMPs were prioritized from 'Low to High.' Areas listed as 'High' are organized for initial implementation because of a projected larger amount of development.

The BMP network (*Figure 5*), from the landscape scale, illustrates the hydrogroup A and B band bisecting Twin Falls. This is an indication that the criteria of hydrogroup soils are an intrinsic component of both SUSTAIN and ACPF solution frameworks. Utilizing this criterion for siting this BMP network, demonstrates how this stormwater system would require conveyance facilities and an increase in conveyance filtration along upstream slopes prior to recharge. These results also illustrate that at the landscape scale, stormwater management networks for agricultural and urban runoff require additional process at a smaller scale.

Conclusion

This project provides a framework for optimizing areas of higher concern due to a larger amount of impervious surfaces per population projection and Dasymetric mapping. The results answer the initial question, "What are suitable locations for siting agricultural and urban Best Management Practices (BMPs) for a site within Magic Valley, Idaho, U.S.?" Evidence of the inquiry takes the form of siting and suitability framework and results take the form of measurement and mapping for an agriculture and urban BMP network.

Based on this project's research findings, recommendations for scenario driven alternative futures green infrastructure projects include:

> 1) Incorporate site-scale criterion and design constraints for siting urban BMPs. Showing site specific agriculture conservation practices, urban BMP designs, and implementation strategies can offer stakeholders and policy makers specific design guidance.
>
> 2) Include additional criterion integration of various models used within the project. Agent-based models to project stream and soil contaminant levels can prioritize areas of high concern.
>
> 3) Integrate economic land use models for phased development.
>
> 4) Calibrate models of dasymetric mapping with a statistical regression analysis. Once coupled, these models may over or under predict spatial distribution of designated areas for BMP implementation. Iterative runs and evaluation metrics must be included into the coupled model.

This project and similar versions can work as preliminary iterations of models to validate understandings of researchers and stakeholders. Promotion of benefits for green infrastructure projects also requires future research and require further exploration through spatial analysis. For example, suitability of habitat corridors for various species and provision of park space are two major opportunities of utilizing green infrastructure; however, stakeholders do not regard these benefits as being 'key drivers.' However, coupling these major benefits with a holistic model may provide a more robust representation of solutions for key uncertainties of the future. While there is still a need development of stakeholder and researcher driven validations, this project provides a framework for coupling various population projection components with green infrastructure suitability criteria.

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