

Predicting/Modeling Improvements in Public Health and Ecosystems Goods and Services Associated with Major Urban Redevelopment and Infrastructure Projects at Sun Valley in Denver.

Environmental Protection Agency (EPA) Regional Sustainability and Environmental Sciences (RESES) Research Program

The RESES program, led by EPA's Office of Research and Development (ORD), matches Agency scientific and technical expertise with high-priority, short-term research needs in each of the Agency's ten Regions across the nation. The RESES program has helped Regions respond to state, local and Tribal interests in addressing priority science issues such as waste materials management. Approaches include development of methods, use of science-based tools and multi-stakeholder engagement. RESES has also provided resources for developing innovative regional approaches that can then be used on a national scale. It has supported citizen science projects to address community concerns such as air pollution.

By design, RESES emphasizes collaboration and partnerships to deliver targeted science that can inform Agency and local decision-making. Projects are funded through an internal (EPA-only) annual solicitation for proposals. This year's program encouraged proposals focused on three topic areas:

- Contaminated sites
- Beneficial reuse of waste materials
- Integration of ecosystem services with public health outcomes

In 2018, EPA Region 8 in conjunction with the Office of Research and Development submitted a proposal for a RESES project and was selected. The project is described below.

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Project Summary:

EPA Region 8 has low-income neighborhoods with little green space or recreational areas, often located near major highways with the resulting incidence of many diseases being disproportionately high. Every city and every EPA Region is looking for solutions to the problems in these neighborhoods. The Sun Valley neighborhood in Denver Colorado (Region 8) is one such neighborhood. Denver's Sun Valley neighborhood is the poorest neighborhood in the Denver region and Sun Valley is one of EPA's 51 Making a Visible Difference (MVD) Communities. The Sun Valley community is about to become the Sun Valley "Eco District". It is often assumed that green design, or planning for sustainability and associated environmental improvements will create additional or synergistic public health benefits for community residents. Much work has been performed on specific aspects of this relationship (i.e. between increased green space and mental health), but there have been few real-world studies that rigorously document a whole suite of EGS metrics prior to revitalization and then apply sophisticated models to predict how, where and why conditions will improve after revitalization based on detailed plans. In short, green design and

revitalization are most often pursued as an abstract public good, but the Region can't predict *how much* improvement can be expected based on a given revitalization plan, and which EGS are impacted/ expected to improve. This study will help fill that capability gap. It will also help validate modelling tools available for this and other regions to estimate the provision of ecosystem services and their potential linkages to health. (How good are the predictions? Should we use these tools for decision making, or do they need to be revised?)

Summary of Other Research and Findings:

Studies of the role of EGS on human health have primarily been observational research of intermediate processes and few address the full pathways from ecosystem to EGS to human health, limiting our ability to assess causality (de Jesus Crespo and Fulford, 2017). For example, de Jesus Crespo and Fulford (2017) found that the connection between EGS and asthma was inconsistent and in need of more research. Other studies have found consistent evidence linking green spaces to improvements to physical activity and mental health, but raise important issues about potential confounding socio-economic factors not effectively accounted for in most studies (Lee and Maheswaran, 2011). The Sun Valley project presents an unprecedented opportunity to study the same community, before and model what can occur after a restoration project, to assess the causal linkages between green space restoration and human health outcomes while controlling for potentially confounding socio-economic, environmental and infrastructure factors.

Objective:

The Sun Valley Choice Neighborhood Transformation Plan includes residents, community members, businesses, local, state federal government agencies and stakeholders that are invested and driven towards the revitalization of the Sun Valley Neighborhood. HUD has committed \$30 million to a phased redevelopment project that will involve: razing the 1955-era existing housing stock and replacing it with modern, energy and water-efficient low-income and mixed-income development; re-orient streets into a grid pattern to reduce traffic pollution; dramatically increasing available greenspace and natural viewscales for residents. Millions have also been invested in Sun Valley and nearby S. Platte River restoration to improve safety, reduce flooding and provide recreational access. These and additional improvements in green infrastructure are *expected* to provide a variety of new EGS that will improve health and well-being for the community. This study will help Region 8, Denver Housing Authority, and other EPA Regions and communities, document and better understand those expectations by quantifying and modeling the impact of local environmental restoration on human health. It will also help document which EGS improvements are likely to have the biggest demonstrable impact on public health, and where that relationship is less clear.

Approach:

Effective project assessment requires a suite of metrics linking EGS and community health, as well as current EGS and community health “baselines” from which to measure change. This baseline will be quantified before the transformation, using tools and databases currently available as well as new data collection. The Sun Valley Transformation Plan (created by Mithun and City Craft Ventures) and associated architectural and planning documents will be used to construct a scenario using baseline values and existing detailed revitalization plans to estimate future improvement in EGS and community health. The scenario will be constructed on the assumption of 100% implementation of the Sun Valley Transformation Plan. We will estimate the future EGS-health impacts of Sun Valley restoration based on the metrics, baseline values, available literature, and change scenarios.

Baselining EGS, Public Health, and Environmental Quality

- A number of ORD Tools like EnviroAtlas, H2O, i-Tree, etc. and tools like the South Platte River Urban Waters Partnership Natural Capital Resource Assessment and Prioritization Tool (hereafter, abbreviated “Natural Capital Tool”) will be used to assess and quantify the current conditions and a scenario of proposed changes to EGS as reflected in the Transformation Plan. The Natural Capital Tool (NCT) was created with significant stakeholder involvement and represents a complex and sophisticated ecosystem services valuation tool. In addition, high resolution land cover maps will document the distribution of green

space and identify and quantify current vegetation. The present building plot will be used to quantify current building height for estimating “viewscales” and sunlight penetration using EPA’s “H2O Tool” (Russell et al., 2013). Analysis of thermal infrared bands and other remote sensing techniques will be used to estimate current land surface temperature, as described in Mendez-Lazaro et al. (2017). Water quality improvements are unlikely to be measurable from a redevelopment at this scale. Existing and ongoing water quality data is available at <http://www.exploremetrodenverwaterquality.org/> and the Colorado Data Sharing Network <http://www.coloradowaterdata.org/>. The Natural Capital Tool already incorporates water quality and riparian habitat as part of the ESV <https://pg-cloud.com/NaturalCapital/>. Water quality is an EGS that we can account for,

- Current air pollution will be assessed in the Sun Valley community via AQM-65 sensors acquired from Aeroqual (CRADA with ORD) measuring PM 2.5; Ozone and Sulphur Dioxide. A sensor will be deployed on the roof of the new Colorado Department of Transportation building, which is located at the North end of the neighborhood. An additional sensor is already located at the Elementary School at Sun Valley via project with City and County of Denver that can be used as a co-reference.
- Public Health conditions, both mental and physical, will be assessed in this baseline analysis, and projected improvements represented in the scenario. Congestion, crime, lack of green space and recreational opportunities can cause mental health issues like depression and suicide. (See Figures 1-3 in the Appendix for current conditions in Sun Valley community.) Green space usage and physical activity levels will be estimated using a variety of tools, including neighborhood survey data from Sun Valley’s EcoDistrict certification process (<https://ecodistricts.org/get-started/the-ecodistricts-protocol/>), interpolated estimates from the 500 cities project (<https://www.cdc.gov/500cities/>), and modelling frameworks using existing national surveys (Mansfield et al. 2016). Existing health databases such as the Center for Medicare and Medicaid Services database can be used to track incidence of health issues through time, such as before and after the planned restoration activities.
- Because the housing in the community is being razed and rebuilt, it is also important to quantify co-variates in the indoor environment that might impact our estimates of EGS. (An overall assessment of health conditions in the Sun Valley neighborhood was published in 2014.) Much of the indoor assessments are being performed by the DHA and the University of Colorado at Denver who are redesigning the community. However, our team will assess the current indoor air contamination including PM measurement of PM2.5 and PM10 with TSI Dustrack II and mold contamination using the ORD Environmental Relative Moldiness Index (ERMI). As the present apartments in Sun Valley become vacant, the Regional investigator team will work with the Denver Housing Authority (DHA) to gain access. A MOU is in place with DHA. Three TSI Dustrack II monitors, already located in R8, will be used to monitor indoor air and also to collect a dust sample for mold analysis. A representative sample of apartments (up to 10%) in the Sun Valley community will be assessed and sampled. Existing plans for the new housing, including insulation ratings and build standards will be used as the basis for projecting air quality improvements in the scenario.

Modelling and Scenarios for EGS + Public Health improvements

Changes in these services can be best assessed in the scenario construction from a comparison to baseline conditions in Sun Valley (measured before improvements), proposed improvements in the Transformation Plan, as well as comparisons to other neighborhoods in the Denver area with similar potential access to these ecosystem services.

A. Develop links between target EGS and human health (HH) outcomes

- 1) HWBI-ES links in HWBI (see Kyle B. below)
- 2) Planned HIA to provide HH-ES links
- 3) Weight of published evidence approach for some links (e.g., activity/viewscales and depression)

B. Establish model baseline for assessment of improvements related to ES restoration.

- 1) Analysis of Medicare data (Sun Valley and reference site) – allows for an empirical comparison of health outcomes based on a BACI design.
- 2) H2O tool analyzes changes in landcover impacts on access to greenspace/viewsapes. For example, see Tampa Fish Hawk neighborhood report at end of this document – direct scenario analysis based on projected changes in Sun Valley for greenspace, trees, and reductions in impervious cover.
- 3) i-Tree model for examination of shading services from restoration – Shade analysis to support H2O assessment.
- 4) ENVISION analysis of ES-HWB links with a focus on HH – A suite of sub-models linked to provide scenario analysis of ES production linked to HWBI metrics.
- 5) Use Natural Capital tool as a baseline for ecosystem services values and a restored area in the maps as what the new values will be after restoration.

Environmental Quality and Public Health Issues Being Addressed:

Major changes are proposed in the Sun Valley Transformation Plan to improve and increase EGS in the community. Specifically, there will be a dramatic increase in available greenspace, a redesigned street grid to improve near road emissions, and a contaminated site from an old energy plant will be remediated and turned into a park.

Additional research or programs addressing this community priority (e.g., RARE, brownfields, Superfund) and describe the integration of this project.

- EPA funded a restoration design for Weir Gulch and the South Platte River which included a fishing jetty and all of the construction has been completed. EPA also completed a green infrastructure study of Sun Valley evaluating four different storm-water options with varying levels of green infrastructure and doing a capital cost and 20-year maintenance cost evaluation. In addition, the Army Corps of Engineers is conducting an ecosystem restoration study of this stretch of the South Platte River and Weir Gulch further up in the watershed.
- PI Kyle Buck- EPA-NHERL-GED: SHC Task 2.64.5: (Refining and Modifying Human Well-being Measures. Testing and refinement of well-being and resilience at the community level) is also working at Sun Valley using census and other datasets collected by project partners as a case study for both remote scaling validation and improvements in well-being linked to neighborhood transformation.
- Other communities in Denver have done Health Impact Assessments as part of their re-development projects. An HIA, coordinated with University of Colorado Denver, and Colorado Health Foundation, is planned as part of the Neighborhood Transformation

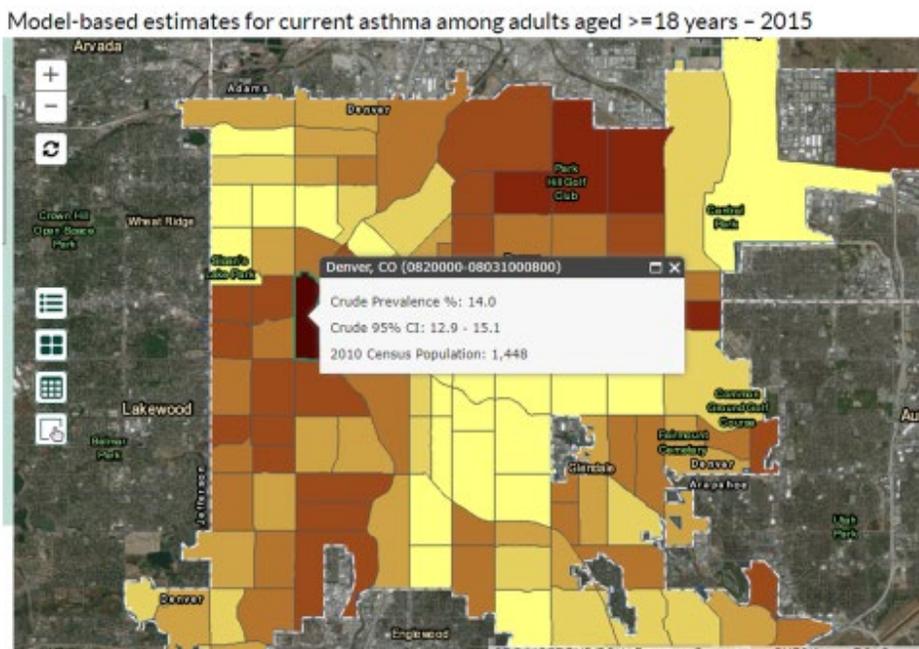
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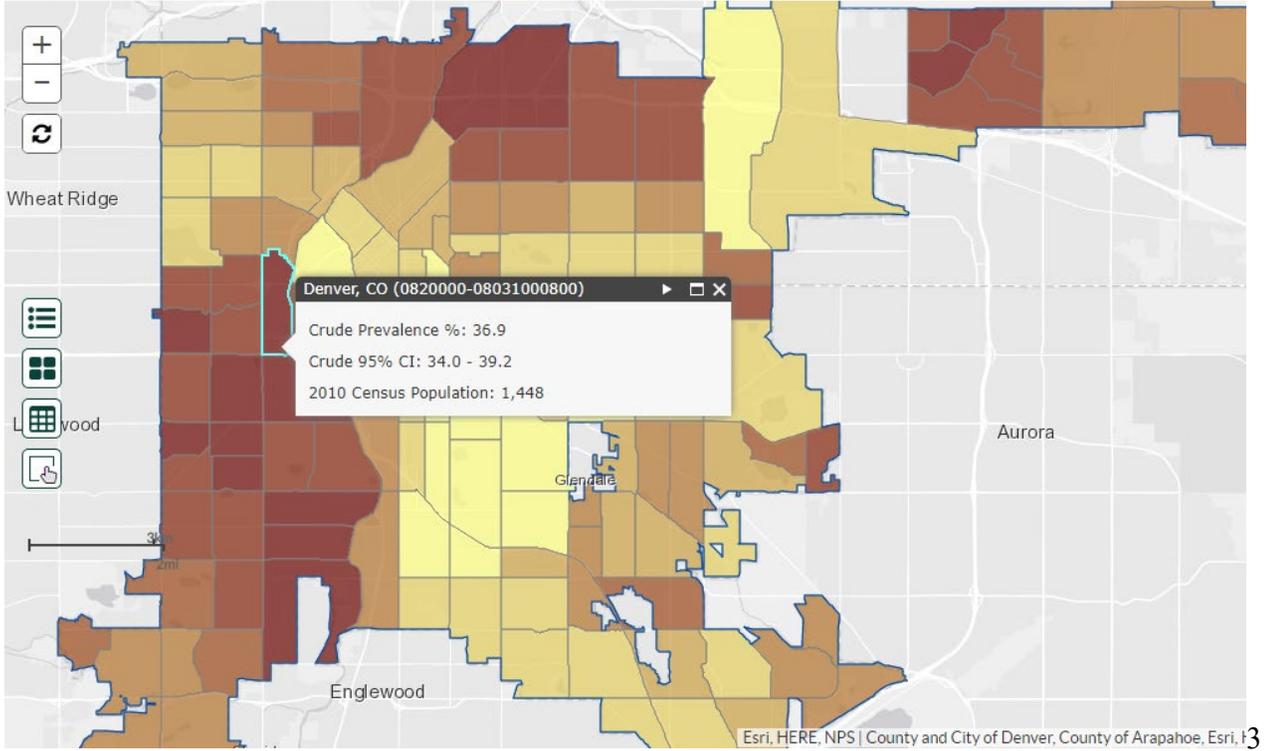
Appendix

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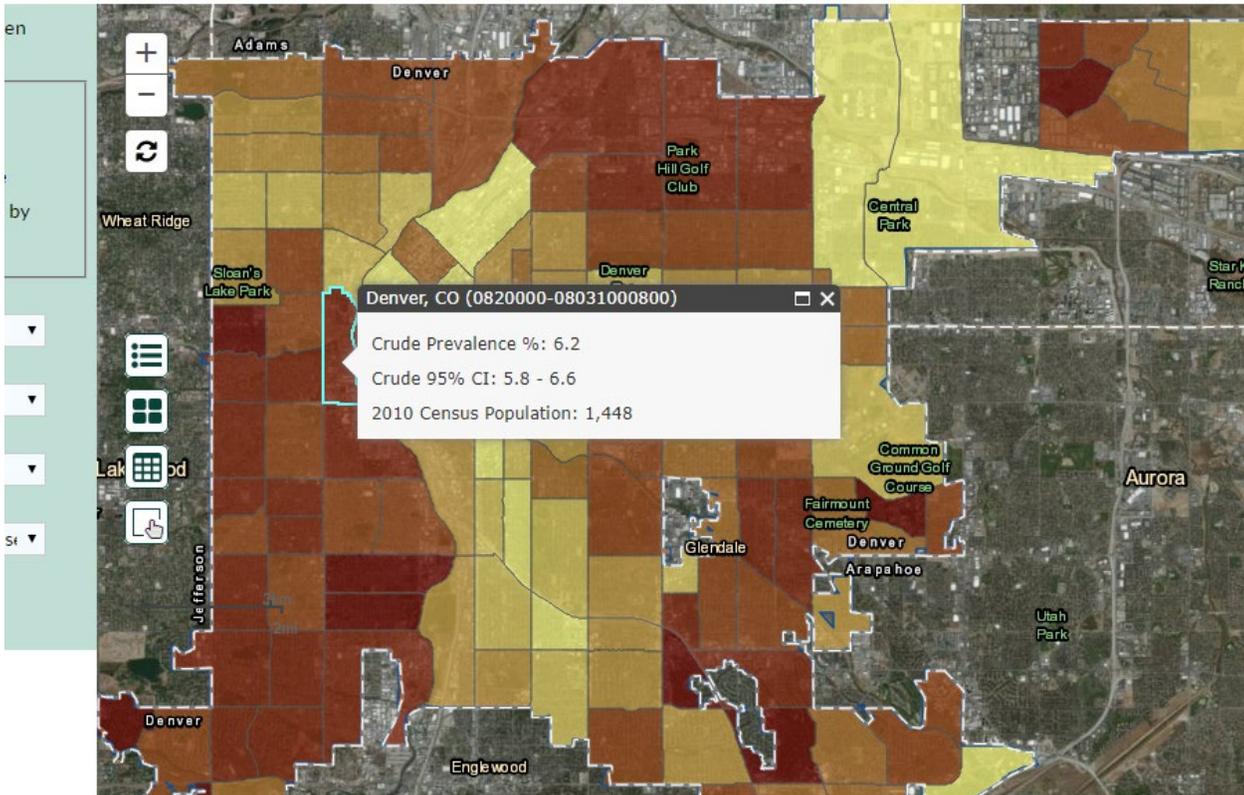


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Model-based estimates for no leisure-time physical activity among adults aged ≥ 18 years - 2015

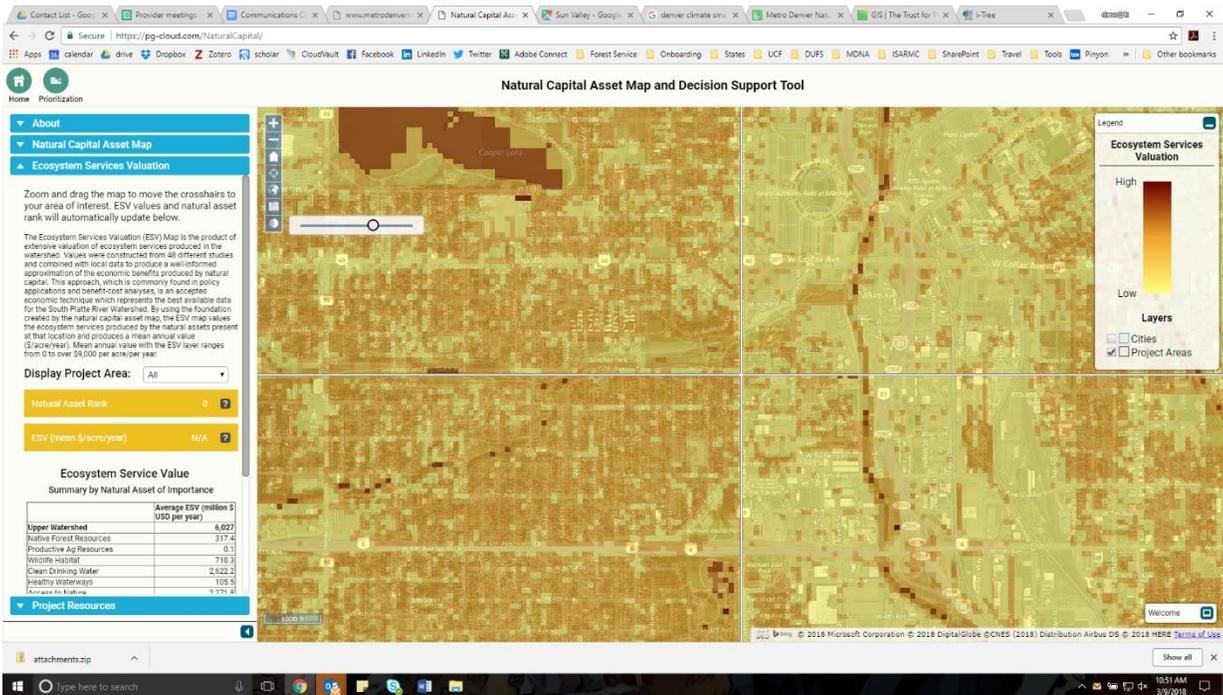
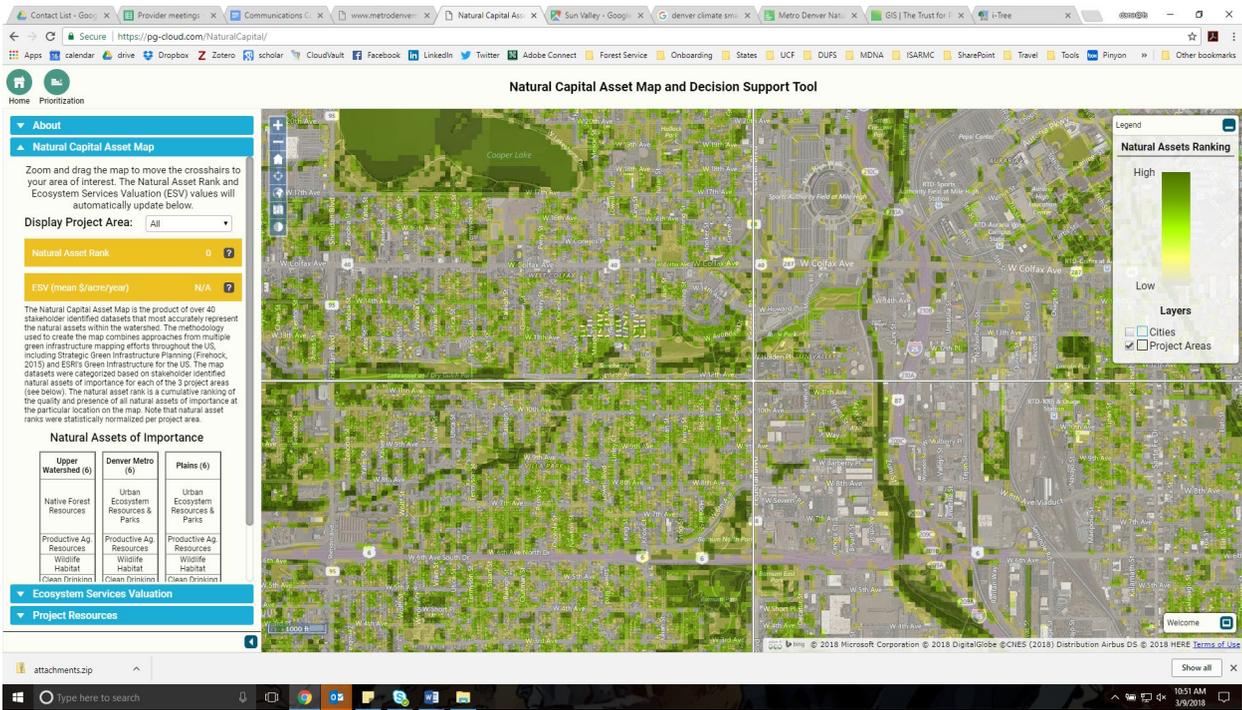


3 Model-based estimates for coronary heart disease among adults aged ≥ 18 years - 2015



4

Images From the Natural Capital Tool Demonstrating Low Natural Asset and Ecosystem Services Values in the Sun Valley Area:



Fish Hawk Example:

From: Russell, M., A. Teague, F. Alvarez, D. Dantin, M. Osland, J. Harvey, J. Nestlerode, J. Rogers, L. Jackson, D. Pilant, F. Genthner, M. Lewis, A. Spivak, M. Harwell, and A. Neale. 2013. Neighborhood scale quantification of ecosystem goods and services. U.S. Environmental Protection Agency, Office of Research and Development, Gulf Ecology Division, Gulf Breeze, Florida. EPA/600/R-13/295. November 2013

Table 1. Summary of neighborhood scale metrics used to estimate ecosystem goods and services and valuation method used to estimate global, regional, and locally derived benefits.

Metric	Ecosystem Service (FEGS)	Benefit	Valuation Method
Tree canopy coverage	Atmospheric pollution removal (Clean air)	Increased respiratory health	Avoided medical costs
Tree canopy coverage (South side of residential property)	Shading (Shade)	Decreased energy use	Avoided energy costs
Rate of carbon sequestration	Atmospheric regulation (Stabilized climate)	More predictable climatic patterns	Avoided social costs
Rate of denitrification	Nutrient removal (Clean water)	Water of sufficient quality is available to meet designated uses	Replacement costs
Walking distance to open green spaces, trails, and parks	(Accessible green spaces)	Increased opportunity to recreate	Hedonic pricing
Number of viewable mature trees	(Viewable, aesthetically pleasing trees)	Increased mental health and well-being	Hedonic pricing
Number of viewable water features	(Viewable water)	Increased mental health and well-being	