Decision Support Tools *for* Climate Change Planning

WRITTEN BY
Caryn Ernst and Kathy Blaha

PRODUCED UNDER A GRANT FROM
The MacArthur Foundation

for the Trust for Public Land's *Climate Smart Cities* program

Table of Contents

I. Purpose of Report 3

II. Background: Green Infrastructure and its Relationship to Climate Mitigation, Adaptation and Resilience, and Climate Justice 4

III. Research Methodology 5

IV. Challenges in Planning Green Infrastructure for Climate Change 6

1. **Insufficient Staffing, Funding and Authority** 7
2. **Lack of Data on Costs and Benefits** 8

V. The Disconnect Between Regional Science/Data Development and Local Planning and Implementation 9

VI. Data Gaps and Availability 10

1. **Currently Available Data and Gaps** 10
2. **Potential Data Sources to Fill Gaps** 10
3. **International Data Sources** 12

VII. State of Existing On-line Decision Support Tools 13

1. **Web-based Decision Support Tools** 13
2. **Decision Support Tool Software** 14
3. **Custom Decision Support Tools for Cities or Regions** 14

VIII. Findings: Creating Tools that Support Effective Climate Change Planning 15

1. **Meet the needs of different types of users** 15
2. **Integrate Diverse Priorities** 16
3. **Visualize and compare a variety of scenarios** 18
4. **Support collaborative, as well as independent, action** 18

IX. Conclusion 19

Appendix A: Interviewee List 20

Appendix B: Decision Support Tool List 21

Appendix C: Representative Web-Based Decision Support Tools 23

Appendix D: Representative Decision Support Tool Software 27

Appendix E: Representative Custom Decision Support Tools 31

Appendix F: Cities using green infrastructure as a primary stormwater management strategy 36

Appendix G: Data Inventory Spreadsheet (separate) 36

I. Purpose of Report

The Trust for Public Land's *Climate Smart Cities* program is founded on the principle that to respond to climate change, cities must restore natural functions of the land by weaving green elements into the built environment. The Climate-Smart Cities program helps cities meet the climate challenge through conservation and design—from creating waterfront parks and restoring wetlands to creating green alleys and "water smart" playgrounds.

A flagship service of the Climate-Smart Cities program is the development of **spatial decision support tools** to translate goals from a city's strategic climate planning into priority sites for green infrastructure development through the use of Geographic Information Systems (GIS) technology. The Trust for Public Land believes that delivering effective spatial decision support to municipal governments and their partners will enable cities to turn Climate Action Plans and other climate strategies into action. Translating written strategies into place-based priorities will enable cities to efficiently develop needed policies and apply on-the-ground investment for mitigation, resilience, and climate justice objectives.

The purpose of this report is to research the tools and data currently available to cities for climate change decision support, and to understand the interests, needs and capacity of potential users within municipal government and among partner organizations. This inquiry is intended to help inform the development of more effective spatial decision support tools for climate change planning.

The term Decision Support Tool (DST) refers to a wide range of computer-based tools developed to support decision analysis and participatory processes. *Spatial* decision support tools use GIS and differ from static maps in that they allow users to interact with the data, combining and overlaying data in dynamic ways to answer different questions or display different scenarios. This combination of flexibility and user control enables users to effectively customize their analysis to their specific decisions and related criteria.

In order for The Trust for Public Land and other public and private actors to continue enhancing the effectiveness of decision support tools for cities, we must understand the current state of decision support for climate response, and the needs and interests of potential users. Important questions include:

- What spatial decision-support tools are cities currently using for climate planning, particularly for green infrastructure?
- Who is using them and for what purposes?
- What DST functionality best supports local climate planning and implementation?
- What are the current data gaps and availability specific to climate planning?

II. Background: Green Infrastructure and its Relationship to Climate Mitigation, Adaptation and Resilience, and Climate Justice

Climate *mitigation* involves reducing emissions of greenhouse gases in order to prevent the most extreme climate impacts from occurring – avoiding the unmanageable. Mitigation strategies are broadly divided into two categories: (1) reducing greenhouse gas emissions at their source and (2) offsetting the effects of greenhouse gas emissions through carbon sequestration.

Climate *adaptation* involves addressing the climate impacts that can't be avoided -- managing the unavoidable. Climate *resilience* takes adaptation a step further by creating environmental, economic and social systems that are resilient to, or can bounce back from, the impacts of climate change. In contrast to mitigation, adaptation and resilience strategies don't necessarily address the underlying causes of climate change.

Climate justice is about addressing the potential for climate change to exacerbate longstanding inequities in cities relating to quality of life, risk and opportunity. For example, climate change will increase urban air temperatures and heat risk in cities. This will have a greater impact on low income neighborhoods with low tree cover and therefore stronger heat islands, increased health risks across the population, and less prevalent air conditioning in people's homes.

For this study, green infrastructure (GI) is defined as any strategy that uses ecosystem services to address climate mitigation, adaptation and resilience, and climate justice. Green infrastructure encompasses a wide range of urban greening strategies. The Trust for Public Land's *Climate Smart Cities* program categorizes these strategies under the climate objectives of connecting, cooling, absorbing, and protecting:

1. **Connect**—Linking walk-bike corridors at the city scale to create carbon-free transportation options for all residents.
2. **Cool**—Planting shade trees, transforming grey infrastructure (asphalt and cement) to green infrastructure, and creating new parks to lessen the urban "heat island effect" that drives increased summer energy use and worsens heat waves.
3. **Absorb**—Creating "water smart" parks and green alleys that manage storm water naturally to reduce flooding, save energy used for water treatment, and recharge drinking water supplies.
4. **Protect**—Establishing waterfront parks, wetlands, and other green shorelines to buffer low-lying cities from sea level rise, coastal storm surges, and other flood risks.

Green infrastructure strategies have the benefit of reducing both *human and environmental* vulnerability to climate change impacts, particularly from flooding, stormwater, extreme heat and drought, and are therefore important to improving climate *resilience*. Connect, cool, absorb and protect are green infrastructure strategies that also have the potential to *mitigate* climate change by reducing energy use and related greenhouse gas (GHG) emissions and offsetting the effects of emissions through natural carbon sequestration. Addressing climate justice requires application of these green infrastructure strategies in communities where human needs and vulnerabilities are higher than the norm.

III. Research Methodology

In order to better understand the current state of decision support tools being used for climate change planning, The Trust for Public Land undertook this current conditions analysis to determine tool availability and function, the readiness of cities for tool use, their capacity and capabilities, the availability of data for planning and their experience in some cases of translating results to action. The effort included research, interviews, surveying and analysis of findings. This work was made possible through the generous support of the MacArthur Foundation.

Specifically, research for this report included:

1. Documenting 50 online spatial tools for climate planning,
2. Conducting 40 interviews and surveys with potential tool users and decision-makers, and
3. Compiling an inventory of over 75 different types and sources of national data for climate planning.

The interviews included 30 local government staff and 10 senior leaders from federal agencies, national and international nonprofits and academic institutions. We selected cities for our interviews from diverse geographies, of various sizes, from different climates and with differing levels of engagement on climate change issues. The interviews included senior staff from a variety of city departments, including Office of the Mayor, Sustainability, Planning, Environment, General Services, Information Technology and GIS. We also interviewed senior leaders from federal agencies and academic institutions engaged in developing decision-support tools and data for climate change planning, and from national and international nonprofits actively engaged in supporting local climate planning and decision-making. The full list of interviewees is included in Appendix A.

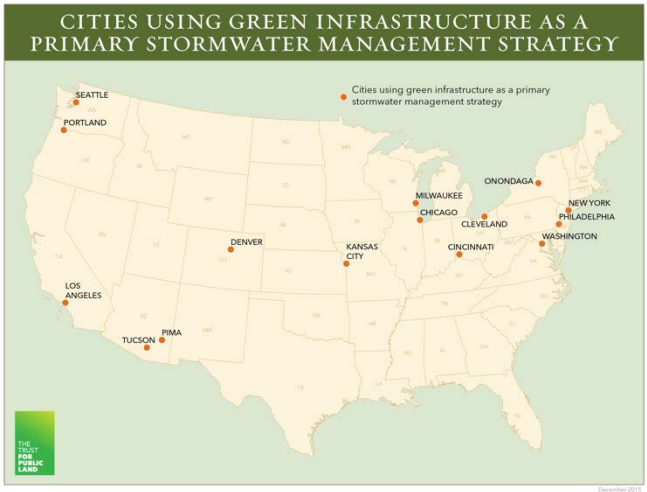
For our online research, we explored spatial decision support tools for climate planning, with a particular focus on tools to support green infrastructure for mitigation and resilience planning. The types of tools we researched ranged from simple online interactive maps that show one type of data, such as sea level rise and storm surge, to complex, custom decision-support tools created for individual jurisdictions or multi-jurisdictional regions that allow users to overlay multiple data layers and run custom scenarios. We also researched "off-the-shelf" software and modeling tools available for city agencies and their consultants to upload local data and run analyses, such as I-Tree, HAZUS and InVEST. For each tool, we documented its functions, the types of planning it could support, and the data used. Representative decision support tools are included in Appendices C, D, and E, with a description, list of key functions and web addresses. The full list of tools researched for this project can be found in Appendix B.

The data inventory was created by searching online for national datasets from federal, private, nonprofit and academic sources that support adaptation and resilience planning. The inventory is organized by data that supports Climate Smart Cities' planning objectives to connect, cool, absorb and protect through green infrastructure. For each dataset, we have documented the source, download link, and a brief description, including data resolution where possible. The full inventory of over 75 datasets see Appendix G.

IV. Challenges in Planning Green Infrastructure for Climate Change

Almost all of the cities we interviewed have experienced extreme weather in recent years and have had to plan for and respond to threats from flooding, wildfires, storm surges, drought and extreme heat. As a result, most of their sustainability and climate resilience planning has focused on vulnerability assessments, emergency management planning and coordination between agencies. Extreme weather has mobilized cities to begin addressing climate change, even those for whom the term "climate change" does not resonate.

Green infrastructure is one of many strategies cities are implementing to build resilience to extreme weather and lead climate mitigation. This can involve any and all city agencies, depending on the specific threats and opportunities. The actions taken by these agencies might include strategies as diverse as planning new transportation routes, relocating core infrastructure, improving emergency response systems, planting trees, creating composting services, improving energy efficiency, developing clean energy sources, creating new parks and greenways, or greening roofs and alleys.



Of the cities we interviewed, 83% said they are currently implementing some form of green infrastructure or ecosystem services for climate mitigation and resilience, and an additional 14% said that they plan to explore green infrastructure (GI) strategies in the future. However, **for most of the cities, green infrastructure is a very small portion of the resilience and mitigation work they are doing**. GI is being implemented by multiple departments and agencies, often as opportunities arise (streetscape improvements, park upgrades) and in many cities with minimal planning or coordination at the city scale.

The green infrastructure currently being implemented by most cities is almost entirely focused on meeting Clean Water Act requirements for stormwater management ("absorb"). Although there is a growing number of cities using GI as a primary stormwater management strategy, they struggle with how to do this effectively as the quantity of stormwater runoff can easily surpass the amount of land available to store the water while it infiltrates. Cities and water agencies are experimenting with a wide-range of creative strategies for stormwater storage and more efficient infiltration, particularly strategies that can enhance public spaces and uses while simultaneously meeting stormwater management goals. TPL is releasing a report in March, 2016, "City Parks, Clean Water: Making Great Places Using Green Infrastructure," which delves into the many challenges of urban GI, as well as the creative solutions

cities are successfully employing to meet these competing demands. (For a list of cities using green infrastructure as a primary stormwater management strategy, see Appendix F).

Some cities expand the green infrastructure definition to also include protecting shorelines and wetlands to mitigate flooding ("protect") and some include planting trees, green roofs and eliminating hardscapes for heat mitigation ("cool"). None of the cities we spoke with include trails and connectivity as part of their green infrastructure planning for climate resilience. Helping municipal agencies visualize and implement a multiple-benefit approach would represent a paradigm shift in how this work is being done in most cities.

City staff identified two primary barriers to greater planning and implementation of green infrastructure: (1) insufficient staff capacity, expertise and funding, and (2) insufficient data on the value, or costs and benefits of green infrastructure.

1. Insufficient Staffing, Funding and Authority

Green infrastructure is a comprehensive resilience strategy that necessarily crosses departmental boundaries. Most of the cities we interviewed had created an Office of Sustainability or Resiliency to lead the interagency planning and coordination necessary to address the wide-ranging and inter-connected challenges of climate resilience; however, we found that they often lack the budget or authority to implement comprehensive cross-departmental and cross-sector resilience efforts.

For example, five years after the creation of a Sustainability Office within the Mayor's Office, elected officials in the District of Columbia are proposing the additional step of creating a Commission on Climate Change and Resiliency to address the need for improved cross sector action on climate. "Because climate change cannot be addressed piecemeal, bringing all the related agencies and industries together ensures mitigation and adaptation are priorities as the District moves forward when planning and designing policies, programs, and projects."

Over 80% of the cities we interviewed are actively engaged in some form of sustainability or climate resilience planning on a department by department basis and have invested significant time in collecting data and conducting analyses that relate to sustainability, vulnerability and/or climate resilience. In most cities, however, this planning work is being done within individual departments and is not coordinated across silos.

City departments and agencies are taking advantage of tools available from the federal government and national nonprofits to help them analyze and plan for resilience; however, these tools are not necessarily designed to integrate with or relate to one another, and as stand-alone tools they do not necessarily meet the diverse climate resilience needs of cities. Most of the tools currently available are designed to meet the needs of specific departments or answer a specific set of questions – such as STAR for sustainability assessments, VAST for transportation vulnerability assessment, CREAT for water system vulnerability, ClearPath for Greenhouse Gas Inventories and CMIP for climate change modeling.

Implementation of most of these planning tools requires multiple years of data collection, planning, and substantial investments of time by city and nonprofit staff. As a result of limited staff capacity and expertise, over 50% of the cities we spoke with have contracts with consultants to analyze what types of tools they need to be using, gather data, conduct the technical analyses and/or facilitate the process.

The Office of Sustainability or Resilience within a city is the most likely driver of more comprehensive and coordinated climate change planning, but these departments are lightly staffed and don't have in-house GIS capability. Most of the sustainability and resilience officers we talked to are supporting the sustainability and resilience planning of each agency and trying to build connections between departments wherever possible. However, they rarely have the funds or mandate to develop comprehensive spatial analyses or invest in custom decision-support tools. Water and wastewater agencies with regulatory mandates for CSO controls and stormwater management are much more likely to have the funds and the impetus to conduct spatial planning for green infrastructure. However, their primary focus is meeting their EPA-mandated stormwater requirements, so they are unlikely to play an inter-agency coordination role and will be interested in inter-agency planning only to the degree that it can support CSO or stormwater mitigation.

2. Lack of Data on Costs and Benefits

Most cities have GHG reduction targets and mitigation goals. However, since green infrastructure reduces GHG emissions *indirectly, rather than directly,* some of the climate mitigation benefits, such as reduced energy for water treatment, are harder to measure and monetize. There is limited measurable data on the mitigation or resilience benefits of green infrastructure in its most traditional frame of water management, particularly since effectiveness is somewhat dependent on long-term management and maintenance, and the resilience benefits may not be fully realized until after an extreme weather event. The costs of green infrastructure are perceived as high and the lack of comprehensive data on many GI strategies makes it difficult to counter that perception. Without data on costs and benefits, it can be challenging for cities to make the case for investments in green infrastructure when it is competing with other mitigation and resilience strategies.

Of the cities that are comprehensively planning and implementing green infrastructure, they are almost all motivated by regulatory stormwater and combined sewer overflow (CSO) requirements or a recent and costly history of flooding or wildfires. For cities that have CSO requirements, they have a regulatory incentive to pursue green infrastructure as well as a financial incentive, as green infrastructure has been shown to be less expensive than grey infrastructure (tunnels and pipes).

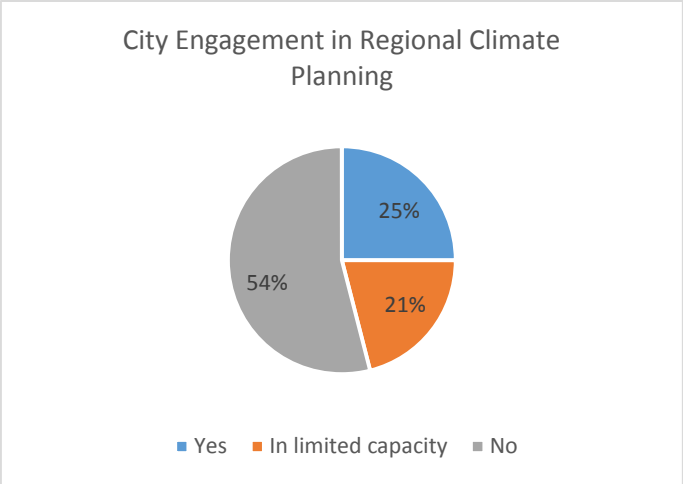
Flooding and wildfire events have likely stimulated investments in GI because cities are able to compare the costs of action directly to the recent costs of inaction. Los Alamos, NM, for example, made significant investments in improving the region's climate resilience and coordinated response capabilities after a record wildfire that was extremely costly to the town, the Los Alamos National Lab and surrounding communities. Because of their proactive investments, the impacts to the town and the Laboratory were greatly reduced when the next (and even larger) wildfire hit several years later.

One green infrastructure strategy for which there is readily available data on costs and benefits is tree planting. US Forest Service's I-Tree and EcoSmart Landscapes Tools have made it relatively easy to assess the costs and climate mitigation and resilience benefits of trees and to plan strategic tree planting programs at the parcel, city or regional level. Tree planting programs are proliferating in cities across the country and, along with green infrastructure for stormwater and CSO management, are the most common green infrastructure strategy reported by interviewees. The relatively low cost of tree planting, combined with the myriad climate mitigation benefits of trees, and the availability of tools to measure these costs and benefits, has contributed to the proliferation of tree planting programs both nationally and internationally.

V. The Disconnect Between Regional Science/Data Development and Local Planning and Implementation

Climate change, and the resulting changes to weather patterns, is being realized at an eco-regional level. Most climate change scientific research, predictive modeling and data development is being done at the regional or national level, such NOAA's Regional Integrated Sciences and Assessments (RISA) teams. However, most of the climate planning and implementation is being done by individual jurisdictions.

Only 25% of the cities we interviewed are currently engaged in regional climate resilience planning, another 21% are engaging in limited coordination with neighboring jurisdictions, while 54% are not engaged in any regional planning or coordination around climate change.



With climate science and data being developed at the regional or national level, but mitigation and adaptation being planned and implemented at the local level, there is a disconnect between climate planning and implementation and the availability of relevant tools and data.

Although climate mitigation and resilience strategies will likely continue to be implemented at the jurisdictional level, most of our interviewees agreed that there is a need for more inter-jurisdictional climate change planning and coordination. Some metropolitan councils of government are starting to engage with local jurisdictions on this, but many don't have the resources or expertise to lead, and even when they do, they may face political resistance from elected officials in jurisdictions that are not yet embracing climate change as a priority.

The Trust for Public Land and the Metropolitan Area Planning Council are engaged in one such regional effort working with the City of Boston and the Metro Mayors' Coalition covering 13 adjacent municipalities. There are a few other NGOs that support regional climate planning, such as the Institute for Sustainable Communities. However, most of these entities lack the technical capacity to develop the GIS tools to support regional planning that links down to local decision support. And many of the NGOs that are engaging with cities around climate planning, such as C40, ICLEI and 100 Resilient Cities, are working with individual cities, not at a regional level.

Climate change mitigation and adaptation strategies, particularly those that use ecosystem services, will be most effective in addressing regional climate change issues, like heat and flooding, if planned at the eco-regional level, even if they are implemented at the local level through smaller scale interventions. Many interviewees said that an on-line spatial decision support tool developed by an NGO would be the ideal forum for regional climate resilience planning, particularly if the NGO or its partners supported the outreach and engagement needed to facilitate inter-jurisdictional planning. This work would need to be done in collaboration with metropolitan or regional planning agencies, but not necessarily led by them.

VI. Data Gaps and Availability

Much of the data currently available for climate resilience planning is at the national scale. In a number of regions that have experienced devastating impacts from extreme weather, such as New York/New Jersey and the Gulf Coast, there has been a concerted effort to develop regional datasets, some of which are high resolution and can support local planning.

1. Currently Available Data and Gaps

The types of data available at the national level include (See Appendix G for full Data Inventory):

- Sea level rise, storm surge, coastal flooding and shoreline change
- Streamflow and river flooding
- Changes in vegetation and crop health
- Critical infrastructure, such as highways, bridges, tunnels, rail networks, utilities, hospitals, schools, police stations, and emergency operation centers
- Climate change, precipitation, temperature and extreme weather
- CO2 emissions from facilities and carbon sources and sinks
- Wind power, solar power and biofuels availability data

With climate science, data and tool development happening at the regional or national level, there is still a gap in the availability of consistent, high resolution, locally relevant data available to jurisdictions for climate resilience planning.

Local jurisdictions need the following types of data to support resilience planning:

- Down-scaled climate models
- Data on existing green infrastructure assets, both natural and built
- Downscaled models that show the cumulative impact of sea level rise and storm surge
- High resolution data on ambient air temperature to identify hot spots within cities
- Economic data and models that predict the local economic impact of severe weather events
- More detailed data on local infrastructure, including cultural and historic buildings and sites
- Demographic and public health data at the neighborhood level
- Capital and maintenance costs of various resilience strategies, particularly green infrastructure
- Predictive models that can estimate the potential benefits of various resilience strategies designed to mitigate GHG emissions, cool urban areas, prevent flooding and absorb stormwater, particularly green infrastructure
- Connectivity planning information, including the ability to project carbon savings from increased mode shift associated with improved access

2. Potential Data Sources to Fill Gaps

Although datasets, such as climate and health, are often not available at the city scale, there are modeling tools that enable the down-scaling of national or regional data to be used in climate modeling at the city or neighborhood scale. For example, TPL has created models that downscale regional data to use as proxy datasets at the local level with a high degree of confidence in many planning scenarios.

Data being generated through crowd-sourcing applications can also be used to help inform modeling efforts where local data currently doesn't exist. For example, trail and walk/bike route usage data is not collected at a local level and not connected to specific trails; however, Strava is an application that crowd-sources users' walking and biking activity. By overlaying Strava usage data in a geospatial format over existing trail networks, TPL can identify usage on individual trails. In order to estimate reductions in CO2 emissions and increases in personal health from new and improved trails and walk/bike routes, TPL extrapolates increases in walking and biking if trails were created or improved.

Another potential source of high resolution local data is private sector companies, who collect and "own" some of the data that could support local resilience planning. In some cases the data is considered proprietary and is not shared. In other cases it can be purchased, but the cost can be prohibitive. For example, insurance companies keep data on frequently flooded properties that could help cities identify areas where green infrastructure could alleviate flooding; however, they either don't make the data available or sell the data at a prohibitively high cost. Private sector companies often have "cost" data that could be used to create cost impact models and support cost-benefit scenario analyses of potential resilience strategies. For example, some companies have data on the actual replacement cost of civil infrastructure, such as bridges that can get damaged or washed out during a flooding event, as well as data on non-tangible costs to the city like diverting traffic and providing emergency services.

There is currently no comprehensive, accessible, national data base for trails and connectivity. Rails to Trails has compiled a national GIS database that is the most comprehensive multi-use trails database in the country; however, the raw data is not accessible, because Rails to Trails doesn't receive funding to serve as a GIS data clearinghouse. Rails to Trails is developing a GIS portal that planners will be able to access on Railstotrails.org for planning purposes in 2016, but this portal won't allow users to download raw data. Despite the lack of a comprehensive and accessible national trails database, there is extensive connectivity planning for active transit ongoing in virtually every city in America. The primary challenge to integrate "connect" strategies into green infrastructure planning is to integrate this wealth of local connectivity data and planning with data focused on other more traditional climate objectives. This integration has been a major focus of The Trust for Public Land's Climate-Smart Cities DST.

Some cities are exploring innovative strategies to collect needed data for Climate Resilience. For example, New York City is exploring whether they can add temperature gauges to old telephone booths as they are converted to free wifi stations. These temperature gauges would allow the city to track data on ambient air temperature, which can help monitor and target urban heat mitigation efforts.

Academic institutions have played a large role in developing these types of locally relevant datasets, as well as applied models, often working in partnership with cities and national nonprofits. For example, TPL uses academic research findings as metrics or equations that can be fed directly into GIS analyses showing the potential mitigation benefits of specific strategies for a particular location. When these types of metrics are incorporated into decision support tools it enables local leaders to make more informed decisions about the potential impact of various scenarios.

These best practices need to be shared across jurisdictions so local governments benefit from lessons learned and don't have to reinvent the wheel. Given the urgent need for more data, particularly for determining costs and benefits, academic and research institutions will continue to play an important and perhaps increasing role in filling these critical data gaps.

3. International Data Sources

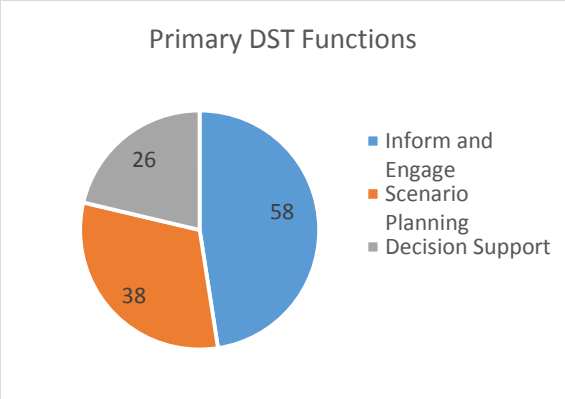
There are a number of international efforts to collect climate change and resilience data. Most of these data are not spatial and are not designed to support spatial planning, but the databases are important for benchmarking cities and countries and to support cities' efforts to measure their progress towards specific goals.

- ICLEI's ClearPath GHG Protocols are designed for local-scale accounting of emissions that contribute to climate change. Their US Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions is designed to enable accounting of emissions from businesses, residents and transportation and is widely used by US Cities.
- The City Biodiversity Index, developed by Singapore and currently supported by ICLEI and the international Convention on Biodiversity, is the only biodiversity index designed specifically for monitoring and evaluating biodiversity in cities.
- World Council on City Data is implementing ISO 37120 Sustainable Development of Communities: Indicators for City Services and Quality of Life, the new international standard. The WCCD Open City Data Portal allows users to explore, track, monitor and compare member cities on up to 100 service performance and quality of life indicators. The indicators collected by WCCD are similar to the indicators collected by the US-based STAR program, which modified the ISO 37120 indicators to include more US specific indicators and eliminated indicators not applicable to most US Cities.

The World Council on City Data enables benchmarking between cities around the world on a wide range of sustainability measures. This is a comparison of environmental data from Boston, Los Angeles and Rotterdam.

VII. State of Existing On-line Decision Support Tools

To assess the range, content and functionality of existing spatial decision support tools for green infrastructure, we researched over 50 tools for climate change planning. Of those, 58% were designed primarily to inform and engage, 38% enabled scenario planning, while just 26% supported decision analysis – comparing, analyzing and ranking decision alternatives. (These functions were not mutually exclusive.)



Decision support tools are primarily being created by federal government agencies and their regional partners, such as NOAA's RISA, academic and research institutions, such as Harvard's Climate Interactive (?) and Oak Ridge National Laboratories, and national nonprofits, such as The Trust for Public Land, The Nature Conservancy and RAND. Private consulting firms, such as AECOM, have created some tools, but private sector work in this area is focused more on supporting project identification, i.e. decision support tools for locating solar arrays.

The decision support tools we researched generally fell into three categories:

(1) Web-based decision support tools (Appendix C)
(2) Decision-support software (Appendix D)
(3) Custom decision support tools designed specifically for and in cooperation with individual cities or multiple jurisdictions within a region (Appendix E).

We limited our research to spatial decision support tools that supported some form of green infrastructure. Almost all of them are free and readily available to city staff, nonprofits and the general public. Only about 30% of them required a log-in.

1. Web-based Decision Support Tools

We found a large number of simple interactive maps designed to visualize climate change impacts on one or two variables, such as storm surge, sea level rise, heat, habitat, forestry or agriculture. Almost half of them focused on flooding and resilience. Many of the tools allow users to display impacts based on two or three different climate change assumptions, such as three feet vs five feet of sea level rise or heat predictions with or without mitigation. Very few of the tools allow users to overlay diverse variables, such as habitat and sea level rise or forestry and agriculture. The few that do overlay multiple variables, don't model how those variables interact with each other, for example the compounding effect of sea level rise and storm surge.

Almost 70% of the tools we researched were available for free online, with no login required. However, only 35% of our interviewees said that they have explored online decision support tools. Those who had explored the sites said that the resolution of the data used was too low and the models weren't sufficiently downscaled to support local planning and decision-making. As a result, they weren't taking

advantage of some of the sites' features, like data download, which they might otherwise have used. They primarily used the sites for visuals that could support outreach and engagement.

2. Decision Support Tool Software

There are a number of free, decision support software tools for green infrastructure and ecosystem services planning that are available for download. These are mostly designed for technical users, but the results can support local decision-making and potentially be incorporated into more accessible and comprehensive spatial planning tools. These software tools are designed to integrate local data with regional and national data, and to conduct comprehensive analyses of a limited number of issues or strategies. For example, HAZUS is designed to assess the vulnerability of critical infrastructure, EcoSmart Landscapes is designed to do cost/benefit analysis for tree planting and urban greening, and InVEST is a suite of free, open-source software models used to map and value ecosystem services and is an effective tool for measuring and balancing environmental and economic objectives.

3. Custom Decision Support Tools for Cities or Regions

There are a number of nonprofit, academic and research institutions creating custom decision support tools for individual cities and multiple cities in a region. These tools have the advantage of building on the best available data at the local, state and federal level and of integrating the types of modeling and functionality that best supports the decisions that need to be made in that jurisdiction or across that region. A range of scenarios, costs and benefits can be modeled that are locally relevant. This is the approach of The Trust for Public Land's Climate-Smart Cities DST, which it has constructed for a diverse range of cities, including New York City, New Orleans, and Chattanooga, to conduct multiple-benefit green infrastructure planning linked to priority populations. Milwaukee has a tool that incorporates not only stormwater management, but also water quality improvements, jobs, air quality improvements and energy savings.

Custom decision support tools tend to be more expensive and time consuming to build, and since they are designed to support the city's ability to conduct independent scenario analyses and data upgrades, they are most often being developed by nonprofits, academic and research institutions with foundation support. The custom decision support tools being developed by private sector companies are more often designed for use by specific city departments and are more focused on project identification for those agencies. There are a few notable exceptions, such as the California Urban Footprint tool developed by AECOM for the Southern California Association of Governments. Urban Footprint, enables both regional and local scenario development that incorporate fiscal, environmental, transportation, and public health impacts of plans and policies.

VIII. Findings: Creating Tools that Support Effective Climate Change Planning

The primary advantage of a web-based decision support tool is its ability to promote coordination and collaboration across city departments, organizations, sectors, jurisdictions, regions and countries. More than anything, effectively mitigating and adapting to the global impacts of climate change will require sharing information and collaborating on solutions at every level. Web-based decision support tools, therefore, should be designed to:

1. Meet the needs of different types of users
2. Integrate diverse priorities
3. Visualize and compare a variety of scenarios
4. Support collaborative, as well as independent, action

1. Meet the needs of different types of users

As part of our research, we explored the functionality of existing tools and asked our interviewees what tool functionality would best support their work. We identified three primary types of users of web-based decision support tools – decision-makers, public and technical staff – and assessed the type of functionality that would best meet their needs.

Public (general, specific community, interested stakeholders)

Half of the tools we researched were designed to enable general audiences to visualize climate change data and threats. Spatial tools can convey risks in a way that nontechnical users can relate, and by enabling interaction with the data, can share more complex data and build a deeper understanding of potential change and threats. Tools for the public must be able to make a compelling case that will build understanding and interest in an audience that may not be otherwise be engaged. The type of web-based tool functionality the public needs includes:

- Interactive map viewer that allows non-technical users to easily explore and overlay multiple datasets, query, zoom, pan and print maps online,
- Canned scenarios that allow users to quickly and easily compare potential scenarios that show the impact of various policy decisions or investments, and
- Visuals that tell a story and make the case.

One issue we explored with city staff was whether community interaction tools should be built into a web-based decision support tool. Although they all emphasized how critical community engagement is in building an understanding of the threats and support for resilience strategies, they were not in agreement as to whether an on-line platform for engagement and discussion would be effective. Proponents felt that it could offer unique ways to engage an increasingly tech-savvy public in climate change issues and to gauge reactions to potential strategies. Opponents felt that online engagement might be too unwieldy and time-consuming, and without proper monitoring, could be a negative distraction. All agreed that low-income and vulnerable populations would undoubtedly be left out of online dialogue, which would lead to further disenfranchisement of those most at risk.

Decision-makers (elected officials, agency leaders)

Creating effective decision support tools for decision-makers is challenging, which is likely why 65% of our interviewees were not using online tools. The data and analysis must be technically and scientifically sound, but accessible to non-technical users; and the results must be accessible at a high level and support "making the case", while also allowing for detailed, site-specific comparative analysis. While decision-makers need all the same easy and accessible functionality required by a public audience, they also need:

- High resolution data and downscaled analyses that can support investment decisions,
- Project profiling features that allow uploading or tracing proposed project boundaries and receiving a property specific "profile report", and
- Executive storytelling, which supports the creation of information-rich presentation tools and visuals to enable executives to "make the case."

Technical Staff (scientific, academic and agency)

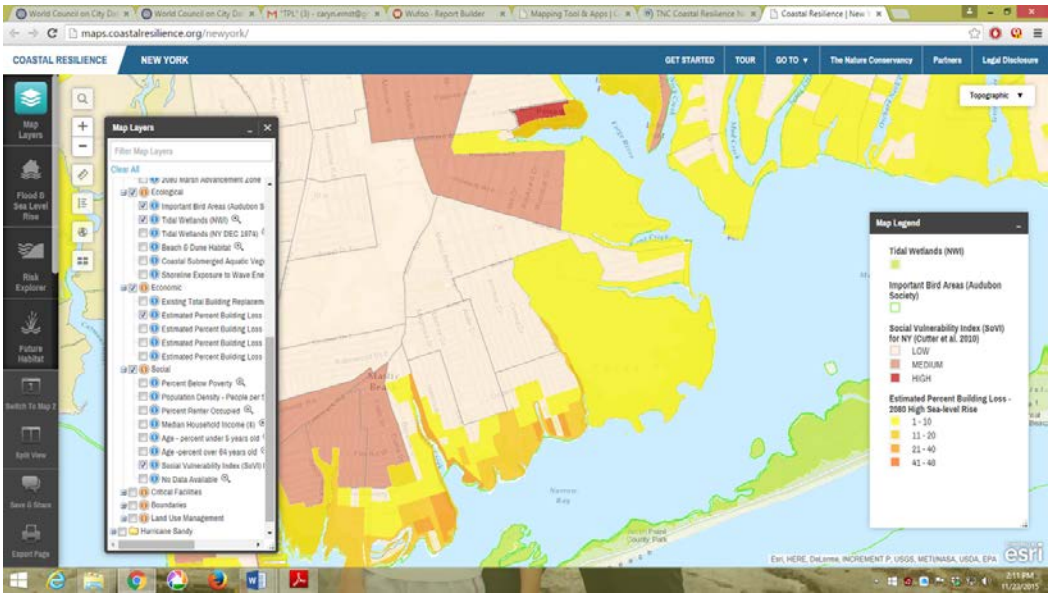
Technical staff often have access to data and in-house analytical tools. Web-based tools can serve as a platform for sharing high resolution data with other partners and key audiences, enabling their data to be integrated into applied solutions, and as a source of related data and analyses that can enhance their own work. The tool functionality needed by technical staff includes:

- Integrative – allows for easy compatibility with other in-house tools and datasets, including the ability to download the results of analyses and overlay them with data and planning results from other city departments.
- Data upload and download - allows advanced GIS and other technical users to upload high resolution data and incorporate into online maps and analyses, and download regional and national data for use with in-house GIS systems.

2. Integrate Diverse Priorities

Climate change planning, mitigation and adaptation strategies are by nature comprehensive and wide-ranging. Local and departmental climate planning is critical to on-the-ground implementation; however, that work needs to be integrated and coordinated across departmental and jurisdictional boundaries in order to be effective, to identify and take advantage of co-benefits and to magnify potential impacts.

Web-based decision support tools offer a potential platform for coordination and collaboration by enabling different types of spatial data and analyses to be uploaded and integrated into scenarios. In turn, enabling the data and analyses from a web-based tool to be downloaded to in-house GIS systems allows agencies to align their internal planning with other resilience objectives. The Nature Conservancy's Coastal Resilience Mapping Portal does this effectively by enabling the integration of analyses conducted with different software tools, such as HAZUS for hazard mitigation and SOVI for social vulnerability, and allowing them to be overlaid with other data and analyses, such as the Habitat Priority Planner. TNC's mapping portal includes these complementary analyses in select regions where they are most engaged, such as NY/NJ and Gulf Coast.



TNC Coastal Resilience Mapping Portal image of Long Island, New York with selected data overlays.

The Trust for Public Land's Climate-Smart Cities DST is built on a "Connect, Cool, Absorb, Protect" data framework that enables users to easily integrate these planning considerations by combining data and modeling to see where these opportunities "stack" on the landscape. Each DST also includes additional data and modeling on social and demographic variables, and cross-reference data such as tax parcels, vacancy status for properties, and soils information.

This type of integration can enable staff and decision-makers to see where they have multiple vulnerabilities, mitigation opportunities, and priority populations – and then to plan strategies accordingly. It also allows them to see where they have co-benefits, such as stormwater and habitat protection, enabling them to take advantage of resources available for one strategy (combined sewer overflows) to address a related but separate problem (river restoration).

TPL's Climate Smart Cities: Healthy Connected Chattanooga showing results of priority parcel query

3. Visualize and compare a variety of scenarios

Many interviewees emphasized that the politics and process of climate adaptation planning were as important, or more important, than the technical analysis. They face skepticism about climate change and about what a city can do in the face of it and have difficulty conveying a sense of urgency or immediacy. The data is speculative and includes wildly diverse scenarios, (i.e. potential 1' to 5' sea level rise), that extend into the distant future, and no one knows the cost of inaction.

Politicians and agency directors are having to make decisions with little comparative data on the costs or benefits and end up following the money (i.e. grey infrastructure), being reactive to political pressure, or taking the cheapest path with the least resistance. Low-income and vulnerable populations are often neglected in the process.

Scenario planning can help cities analyze alternative approaches and select those with the greatest combined benefits at the least cost; thus enabling thoughtful, proactive approaches to climate action. However, it is expensive and difficult for cities to do on their own in a comprehensive way. A web-based tool that enables cities to visualize and compare various scenarios and share them with constituents can help decision-makers weigh costs and benefits and justify investments. Even with limited data on costs, being able to Identify potential co-benefits through scenario planning can help guide more strategic investments and build public support.

4. Support collaborative, as well as independent, action

The flexibility and accessibility of a web-based decision support tool would enable individual jurisdictions to do local climate resilience planning with an eye toward regional (or ecosystem-wide) integration and coordination. A regional web-based decision support tool would take advantage of science and data being developed at the regional level, as well as new local data. It could reinforce commonalities among jurisdictions, bring in regional agencies, like water and sewer, while supporting more informed local decision-making. The tool functionality that supports integration and collaboration among city departments -- data upload and download, the ability to run different queries and overlap varied priorities to identify co-benefits -- is the same functionality that would enable regional planning with local implementation.

IX. Conclusion

This study has highlighted a number of opportunities, as well as a few important barriers to local climate mitigation and resilience planning, particularly for green infrastructure:

1. While data availability and quality is improving rapidly, there is still a need for high resolution, locally relevant data. In particular, there is a need for downscaled climate models, as well as data and analysis around the costs and benefits of various resilience strategies, particularly for green infrastructure.
2. Web-based custom decision support tools can support interdepartmental and interjurisdictional planning and can be a critical tool for comprehensive climate planning, particularly when employed in concert with tools for targeted vulnerability analyses.
3. Although data and tools are important to climate planning, the *process* of coordinating between departments within cities and between jurisdictions, and building support for climate action, are just as important.

This study highlighted that there is a large disparity in climate planning and readiness between cities. While some cities like New York, Boston and Santa Clara are very advanced in their climate planning, others are struggling to do basic coordination between departments, and still others are not yet looking at climate change as a priority. The cities that are most advanced in their climate planning and action are most often focused on protecting communities from sea level rise and storm surges, and absorbing and managing stormwater. Few cities are focused on connectivity as a greenhouse gas reduction strategy and, although they recognize urban heat as an issue, don't have the data to support targeted mitigation efforts. In many cities green infrastructure strategies are still in demonstration mode and remain a small percentage of public infrastructure investments.

The cities that are furthest along with their climate planning have a robust resilience or sustainability office within the city's leadership structure and/or the support of consulting contracts or partnerships with research institutions or national nonprofits, such the Trust for Public Land, RAND, Climate Interactive, or Institute for Sustainable Communities. These national and regional organizations are playing an important role in the transfer and successful replication of technology and innovation between jurisdictions, and are helping to scale up local capacity to mitigate and adapt to climate change.

Academic and research institutions, federal agencies and private sector firms are playing an important role in the development of high resolution, locally relevant data, and need to continue this work, with a focus on downscaled climate models and cost benefit data. Federal agencies, research institutions and national nonprofits have developed a wide-range of tools to support education and outreach, scenario analysis and local decision-making. This work needs to continue with a focus on creating decision-support tools that can be customized locally with a wide range of vulnerability analyses, high resolution, locally relevant climate data, and that support the ability to plan across city departments and across jurisdictions.

Although, the data and tools are critical to guiding effective climate mitigation and adaptation, our interviews taught us that this work is about much more than a tool; it's a process of identifying risk then assessing solutions, assisting with implementation, and finally, measuring and monitoring. It is also about integrating green infrastructure work into broader climate change planning, and facilitating and supporting partnerships between city departments, outside agencies and jurisdictions.

Appendix A

Interviewee List

Name	Last	Title	Organization	City, State
Cody	Hooven	Sustainability Manager	Economic Development Department	San Diego, CA
Catherine	Werner	Sustainability Director	Office of the Mayor, City of St. Louis	St. Louis, MO
Keith	Lucas	Planning Director	City of Buffalo	Buffalo, NY
John	Zeanah	Administrator	Memphis and Shelby County Office of Sustainability	Memphis, TN
Erick	Shambarger	Director of Sustainability	City of MIlwaukee	Milwaukee, WI
Brendan	Shane	Regional Director for North America	C40	
Steve	Adams	Director of Strategic Initiatives	Institute for Sustainable Communities	
Sarah	Wu	Deputy Director	Office of Sustainability, City of Philadelphia	Philadelphia, PA
Kevin	Bush		HUD, National Disaster Recovery	
Marc	Coudert	Environmental Program Coordinator	Office of Sustainability	Austin, TX
Jerry	Tinianow	Sustainability Director		Denver, CO
Jenita	McGowan	Chief of Sustainability		Cleveland, OH
T.O.	Bowman	Sustainability Manager	City of Oklahoma City	Oklahoma City, OK
Kevin	Martin	Tech Services Manager	Bureau of Planning and Sustainability	Portland, OR
David	Lessinger	Director for Planning and Strategy		New Orleans
Sam	Adams	Director of US Climate Initiative	World Resources Institute	
Ted	Weber	Strategic Conservation Science Manager	Conservation Fund	
Nate	Owens	Planner	City of Aurora	Aurora, CO
Katherine	Mortimer	Supervising Planner	City of Santa Fe, NM	Santa Fe, NM
Richard	Gelb	Performance Mgt Lead	King County Natural Resources and Parks	
Michelle	Gricius	GIS Manager	City of Albuquerque	Albuquerque, NM
David	Norwood	Sustainability Coordinator	City of Dearborn	Dearborn, MI
John	Bolduc	Environmental Planner	City of Cambridge	Cambridge, MA
Bradley	Roback	Coordinator, Economic Development	City of Chicago Plannin Department	Chicago, IL
Amanda	Campbell	Environmental Planner II	Metro DC COG	Washington, DC
Anne	Hunt	Environmental Policy Director	City of St. Paul	St. Paul, MN
Brian	Stone	Professor	Georgia Tech	Atlanta, GA
Demetra	McBride	Director, Office of Sustainability	County of Santa Clara	San Jose, CA
Eliza	Wallace	GIS Analyst	Metro Area Planning Council (MAPC)	Boston, MA
Erin	Gill	Director, Office of Sustainability	City of Knoxville	Knoxville, TN
Leah	Bamberger	Sustainability Director	City of Providence	Providence, RI
Tracy	Morgenstern	Climate Protection Program Manager	Seattle Office of Sustainability	Seattle, WA
Lauren	Marshall	Director, Technology & Science Delivery Team	USFS, National Urban Forest Team	Washington, DC
Lori	Carey-Kothera	Operations Manager for Science and Geospatial Solutions Division	NOAA Office of Coastal Management	Charleston, SC
Sarah	Murdock	Senior Policy Advisor, US Climate Change Adaptation Policy	The Nature Conservancy	Boston, MA
Laura	Graham	Ass't City Manager, Sustainability Program	City of Des Moines	Des Moines, IA
Daniel	Zarrilli	Director, Mayor's Office of Recovery and	City of New York	New York, NY
Bart	Crawford	Executive Director	Impact Loop	

Appendix B

Decision Support Tool List

Application Name, Host/Contributor	Website
ADAPT, ICLEI	http://icleiusa.org/tools/adapt/
AgroClimate, USDA and Southeast Climate Consortium	http://agroclimate.org/tools.php
Beach-fx, US Army Corp of Engineers	http://hera.pmcl.com/beachfx/software.aspx
Biofuels Atlas, National Renewable Energy Laboratory	https://maps.nrel.gov/biofuels-atlas/
California Urban Footprint, Southern California Association of Governments	https://www.youtube.com/watch?v=cvL8uTgmXGQ. TBD
CanVis, NOAA Digital Coast	http://coast.noaa.gov/digitalcoast/tools/canvis
Carbon Storage in Forests, EPA	http://cfpub.epa.gov/roe/indicator.cfm?i=86#3
Climate Change Explorer Tool, White House	http://toolkit.climate.gov/
Climate Wizard, The Nature Conservancy	http://climatewizard.org/
ClimateSmart - NYC, TPL	http://206.169.56.66/NYC_ClimateSmartCities/
Coastal Change Analysis Program, NOAA	http://coast.noaa.gov/ccapatlas/
Coastal Change Hazards Portal, US Geological Survey	http://marine.usgs.gov/coastalchangehazardsportal/
Coastal County Snapshots, NOAA, Digital Coast	http://www.coast.noaa.gov/snapshots/
Coastal Flood Exposure Mapper, NOAA	http://www.coast.noaa.gov/floodexposure/#/select
Coastal Resilience Mapping Portal, TNC	http://maps.coastalresilience.org/network/
COLE, USFS	http://www.fs.usda.gov/ccrc/tools/cole-carbon-online-estimator
CropScape, National Agricultural Statistics Services	http://nassgeodata.gmu.edu/CropScape/
EcoSmart Landscapes, USFS and UC Davis	http://www.ecosmartlandscapes.org/
EPA Facility Level Information on GHG Tool (FLIGHT), EPA	http://ghgdata.epa.gov/
Economic and Human Impact of Natural Hazards, HVRI, University of South Carolina	http://webra.cas.sc.edu/hvri/koshland/index.html
Forests to Faucents, USFS	http://www.arcgis.com/home/webmap/viewer.html
Habitat Priority Planner, NOAA Coastal Services Center	http://coast.noaa.gov/digitalcoast/tools/hpp
HAZUS, FEMA	http://www.fema.gov/hazus
Healthy Connected Chattanooga, TPL	http://tplgis.org/Healthy_Connected_Chattanooga/
I-Heat Evaluation and Assessment Tool, BioMedware, Inc. and Univ. of Michigan	http://www.biomedware.com/I-Heat/IHeatViewer.html
Integrated Hazards Assessment Tool (IHAT), University of South Carolina	http://webra.cas.sc.edu/hvri/ihat/index.html#
Interactive precipitation map, Natural Resources Conservation Service	http://www.wcc.nrcs.usda.gov/webmap/index.html
InVEST, Natural Capital Project	http://www.naturalcapitalproject.org/invest/

i-Tree Canopy, US Forest Service	http://www.itreetools.org/canopy/
Jamaica Bay Decision Support Tool, Science and Resilience Institute of Jamaica Bay, RAND	TBD
Louisville Urban Tree Canopy Assessment, City of Louisville	https://www.cartotronics.com/UTC_Viewer_Louisville/
Milwaukee Green Infrastructure DST, Metropolitan Sewerage District, Climate Interactive	http://maps.milwaukee.gov/SilverlightViewer_1_7/Viewer.html
Minneapolis Resilience Map, City of Minneapolis	http://cityoflakes.maps.arcgis.com/apps/MapTour/index.html
MOTF Hurricane Sandy Impact Analysis, FEMA	http://www.arcgis.com/home/webmap/viewer.html
Digital Coast Sea Level Rise Viewer, NOAA	http://coast.noaa.gov/slr/
OPAL, Natural Capitol Project	http://www.naturalcapitalproject.org/tools/#opal
Resilient Communities, ESRI	http://www.esri.com/industries/government/resilient-communities
RIOS, Natural Capital Project	http://www.naturalcapitalproject.org/tools/#opal
Scenarios Network for Alaska and Arctic Planning, International Arctic Research Center	https://www.snap.uaf.edu/sites/all/modules/snap_map_tool/maps.html
Sea Change Boston, Sasaki	http://seachange.sasaki.com/map
Silicon Valley 2.0, Santa Clara County	
SLAMM - Sea Level Affecting Marshes Model, US Fish and Wildlife Services	http://www.slammview.org/
Surging Seas: Sea level rise analysis by Climate Central, Climate Central	http://sealevel.climatecentral.org/
Urban Adaptation Support Tool, European Commission, EU, Covenant of Mayors	http://climate-adapt.eea.europa.eu/tools/map-viewer
Urban Climate Adaptation Tool -CAT, Oak Ridge National Laboratory	TBD
VegScape - Vegetation Condition Explorer, USDA's National Agricultural Statistics Survey	http://nassgeodata.gmu.edu/VegScape/
Water Supply Stress Index Ecosystem Services Model, USFS	http://www.forestthreats.org/research/tools/WaSSI

Appendix C
Representative Web-Based Decision Support Tools

Coastal Resilience Mapping Portal

Host: The Nature Conservancy
Website: http://maps.coastalresilience.org/network/
Login: No
Supports: Informing and Engaging, Scenario Planning, Decision Analysis
Data: National, Regional and Local

Description:
The Coastal Resilience Mapping Portal appears to be the most robust national online decision support tool for climate resilience planning. In select coastal regions, such as New York/New Jersey, the Gulf Coast and the Puget Sound, the site has been built out with extensive data and analyses from regional partners. In these geographies, it offers a robust, accessible tool for climate change planning. It allows cities and regions to customize climate resilience planning.

Functionality: The Climate Resilience Mapping Portal demonstrates the capabilities of a unified, national spatial decision support tool.

- Includes local, regional and/or national data on sea level rise, flooding, storm surge and stormwater, habitat and wildlife resources, forestry, buildings and community assets and economic data;
- Data can be viewed and overlapped in a variety of ways;
- Custom models, analyses and unique data can be uploaded and integrated into the site, such as results from decision support software tools like InVEST and HAZUS, described below.
- Ability to run a variety of scenarios;
- Ability to download data and results
- Access to background information and related research
- Community interaction tools

Limitations:

- The tool appears to be most effective where regional partners are engaged in uploading and building out the site for their region.
- The local decision-makers and staff who would be most interested in using the site don't have the technical training to engage with it effectively.
- Some of the data required for resilience planning is highly sensitive, as it highlights key infrastructure vulnerabilities; therefore, cities don't want to upload it onto a public site.
- The high resolution parcel level data that cities need to identify site-specific strategies isn't available on the site and cities might be reluctant to upload that data into a public portal.
- The portal may be more suited for national and regional nonprofits and planning organizations than individual cities.

Coastal Flood Exposure Mapper

Host: NOAA
Website: http://www.coast.noaa.gov/floodexposure
Login: No
Supports: Informing and Engaging
Data: National

Description: This tool supports users undertaking a community-based approach to assessing coastal hazard risks and vulnerabilities by providing maps that show people, places, and natural resources exposed to coastal flooding.

Functionality:

- Allows users to select a location and explore maps that show people, places, and natural resources exposed to coastal flood hazards
- Creates a collection of maps to download or share online to communicate flood exposure
- Provides guidance for using the maps to engage community members and stakeholders in conversations about potential coastal flood impacts
- Offers access to map services and tips on using them in an online mapping platform

Limitations: This tool allows for relatively easy access to maps that show different types of flooding hazards overlaid with spatial data showing vulnerable populations, infrastructure and open space; however, it doesn't allow users to look at all of them at one time. Also, the data is national, so not at the resolution most communities need for decision making. This tool is better for education and engagement, but real planning would require higher resolution data and greater analysis.

Coastal Change Hazards Portal

Host: US Geological Survey
Website: http://marine.usgs.gov/coastalchangehazardsportal/
Login: No
Supports: Informing and Engaging
Data: Regional, National

Description: The Coastal Change Hazards Portal allows anyone to interactively "see" past, present and future hazards. It provides interactive, mobile access to coastal change science and data for the nation's coasts. This information can support emergency preparedness, ecosystem restoration, and where and how to develop coastal areas.

Functionality:

- Portal enables exploration of coastal hazard risks at varied scales, from a local area of interest to a national perspective.
- A range of information is provided through the portal, such as historical data, existing publications, satellite imagery, maps, and more.
- The portal will enable users to view USGS science in conjunction with their own personalized data to answer specific questions.

Limitations: This tool focuses on coastal hazards and shoreline change. It offers easy access to a variety of low-resolution data and analyses for shoreline change and hazards. The tool doesn't allow for flexible analysis, queries or multiple overlays.

The Climate Wizard

Host: The Nature Conservancy
Website: http://climatewizard.org/
Login: No
Supports: Scenario planning
Data: National

Description: The Climate Wizard provides access to leading climate change information and the ability to visualize impacts that may occur anywhere on Earth.

Functionality:

- Pre-calculated map products allow the user to toggle between various climate conditions relating to different greenhouse gas emission scenarios for two future time periods.
- Examine the statistical variations of 16 different general circulation models used to generate these future climate projections using any combination of general circulation model and emission scenarios.
- View and analyze historical data and future climate projections for rainfall, temperature, and moisture conditions
- Perform unique custom climate analyses, with the ability to draw or upload analysis boundaries
- Receive analysis results, downloadable maps, tables, and graphs via Web link

Urban Adaptation Support Tool

Host: European Commission – Climate Adapt
Website: http://climate-adapt.eea.europa.eu/tools/map-viewer
Login: No
Supports: Scenario planning
Data: European Local, Regional, and National

Description: The aim of the Adaptation Support Tool provided is to assist users involved in development of climate change adaptation policies by practitioners in cities and towns.

Functionality:

- The Search and Discover function allows for integrated searches through the contents (like datasets, documents, tools, guidance) of the Climate-ADAPT quality controlled database.
- The Case Study Search Tool provides geographical access to case studies.
- The section on 'Uncertainty guidance' provides guidance on handling uncertainty in the process of planning adaptation strategies.
- The Climate-ADAPT Map Viewer provides observations and projections of climate change impacts, vulnerability and risks from the following projects and organisations: ClimWatAdapt, ESPON Climate, JRC-IES and ENSEMBLES.

Limitations: This tool is designed for European cities, but ICLEI is championing it as a model for US Cities.

Digital Coast Sea Level Rise Viewer

Host: NOAA
Website: http://coast.noaa.gov/slr/
Login: No
Supports: Scenario planning
Data: National

Description: The purpose of this sea level rise viewer is to provide coastal managers and scientists with a preliminary look at sea level rise and coastal flooding impacts. The viewer is a screening-level tool that uses nationally consistent data sets and analyses. Data and maps provided can be used at several scales to help gauge trends and prioritize actions for different scenarios.

Functionality:

- Use the tabs at the top of the legend to explore visualizations of sea level rise.
- The slider bar in each tab can be used to examine the impacts of sea level rise scenarios.
- The overview text directly below the legend describes individual impacts. Additional documents and links provide further detail.

Limitations: The sea level rise viewer is fairly limited in use and only allows you to look at one layer at a time, along with sea level rise data, including confidence, vulnerability, flood frequency and marsh. It has a slider that allows you to look at the impact of increasing sea levels.

Surging Seas

Host: Climate Central
Website: http://sealevel.climatecentral.org/
Login: No
Supports: Informing and Engaging, Scenario Planning
Data: Local, Regional, National

Description: Search or navigate our interactive map tool to see maps of areas below different amounts of sea level rise and flooding, down to neighborhood scale, matched with area timelines of risk. The tool also provides statistics of population, homes and land affected by city, county and state, plus links to factsheets, data downloads, action plans, embeddable widgets, and more.

Functionality:

- An interactive searchable data toolkit that shows populations, infrastructure, and assets exposed to coastal flooding aggravated by sea level rise.
- The Risk Finder incorporates the latest, high-resolution, high-accuracy lidar elevation data supplied by NOAA and assesses exposure of over 100 infrastructure and other elements in order to allow users to explore vulnerability from state down to zip codelevels.
- It provides the ability to compare risk across areas, as well as the ability to analyze the likelihood of coastal flood and sea level threats occurring in the future by decade.

Limitations: Good for making the case from a large scale, but doesn't go to a high enough resolution for most communities to make informed decisions. More macro level, making the case for one community over another, but not high enough resolution for local investment or adaptation decisions.

Appendix D
Representative Decision Support Tool Software

EcoSmart Landscapes

Host: USDA Forest Service and UC Davis
Website: http://www.ecosmartlandscapes.org/
Login: Yes
Supports: Decision Analysis, Scenario Planning
Data: Local Data and National Data based on 20 years research on tree growth dynamics and urban forestry by scientists at the USFS, UC Davis and Pacific Southwest Research Station.

Description: (USFS and UC Davis) is a decision support tool designed to help members of the public, cities and other organizations estimate the carbon and energy impacts of trees. EcoSmart Landscapes Public is intended for residential property owners, while EcoSmart Landscapes Enterprise is for planning and management of carbon offset projects by organizations such as utilities, campuses, and municipalities.

Functionality:

- This suite of tools provides quantitative data on carbon dioxide sequestration and building heating/cooling energy savings afforded by individual trees.
- Results can be used to estimate the greenhouse gas benefits of existing trees, to forecast future benefits, and to facilitate planning and management of carbon offset projects.
- Allows uploading or tracing proposed project boundaries and receiving a "profile report" specific to that property that calculates the water conservation, stormwater reduction, energy savings, fire risk reduction and carbon sequestration benefits of a specific project or landscape.
- Carbon calculations are based on methodology approved by the Climate Action Reserve's Urban Forest Project Protocol.

i-Tree

Host: USDA Forest Service
Website: http://www.ecosmartlandscapes.org/
Login: Yes
Supports: Decision Analysis, Scenario Planning
Data: Local Data and National Data based on 20 years research on tree growth dynamics and urban forestry by scientists at the USFS, UC Davis and Pacific Southwest Research Station

Description: I-Tree is a software suite from the USDA Forest Service that provides urban and community forestry analysis and benefits assessment tools. The i-Tree tools help communities of all sizes to strengthen their urban forest management and advocacy efforts by quantifying the environmental services that trees provide and the structure of the urban forest.

Functionality:

- i-Tree Eco is designed to use field data from complete inventories or randomly located plots throughout a community along with local hourly air pollution and meteorological data to quantify urban forest structure, environmental effects, and values.

- i-Tree Streets focuses on the benefits provided by a municipality's street trees. It makes use of a sample or complete inventory to quantify and put a dollar value on the street trees' annual environmental and aesthetic benefits.
- i-Tree Hydro (beta) is an application designed to simulate the effects of changes in tree and impervious cover characteristics within a watershed on stream flow and water quality.
- i-Tree Vue allows you to make use of the NLCD satellite-based imagery to assess your community's land cover, including tree canopy, and some of the ecosystem services provided by your current urban forest.
- i-Tree Design provides a platform for assessments of trees at the parcel level.
- i-Tree Canopy produces a statistically valid estimate of land cover types (e.g., tree cover) using aerial images available in Google Maps and estimates values for air pollution reduction and capturing atmospheric carbon.

InVEST

Host: Natural Capital Project
Website: http://www.naturalcapitalproject.org/invest/
Login: Yes
Supports: Scenario Planning and Decision Analysis
Data: Local, Regional, National, with custom models driving the ecosystem service and cost benefit analyses.

Description: InVest is a suite of free, open-source software models used to map and value ecosystem services. This suite of tools is designed for governments, non-profits, international lending institutions, and corporations to evaluate the tradeoffs between various natural resource management strategies. The multi-service, modular design of InVEST provides an effective tool for measuring and balancing environmental and economic objectives. InVEST returns results in either biophysical terms (e.g., tons of carbon sequestered) or economic terms (e.g., net present value of that sequestered carbon). InVEST enables decision makers to assess quantified tradeoffs associated with alternative management choices and to identify areas where investment in natural capital can enhance human development and conservation.

Functionality:

- The toolset currently includes eighteen distinct ecosystem service models designed for terrestrial, freshwater, marine, and coastal ecosystems, as well as a number of "helper tools" to assist with locating and processing input data and with understanding and visualizing outputs.
- InVEST models are spatially-explicit, using maps as information sources and producing maps as outputs. The spatial resolution of analyses is also flexible, allowing users to address questions at the local, regional or global scales.
- RIOS, which is part of the InVEST toolkit, supports the design of cost-effective investments in watershed services. It combines biophysical, social, and economic data to help users identify the best locations for protection and restoration activities to maximize the ecological return on investment, within the bounds of what is socially and politically feasible.

Limitations: Designed for use by technical staff with consulting support. In select regions, TNC has incorporated the results of InVEST analyses into their Climate Resilience Mapping Portal.

HAZUS
Host: FEMA
Website: http://www.fema.gov/hazus
Login: Yes
Supports: Decision Analysis, Scenario Planning
Data: National

Description: HAZUS is a nationally applicable standardized methodology that contains models for estimating potential losses from earthquakes, floods and hurricanes. HAZUS uses Geographic Information Systems (GIS) technology to estimate physical, economic and social impacts of disasters. It graphically illustrates the limits of identified high-risk locations due to earthquake, hurricane and floods. Users can then visualize the spatial relationships between populations and other more permanently fixed geographic assets or resources for the specific hazard being modeled. Hazus is used for mitigation and recovery, as well as preparedness and response. Government planners, GIS specialists and emergency managers use Hazus to determine losses and the most beneficial mitigation approaches to take to minimize them. Hazus can be used in the assessment step in the mitigation planning process, which is the foundation for a community's long-term strategy to reduce disaster losses and break the cycle of disaster damage, reconstruction and repeated damage.

Limitations: Relies on national data. Would be good as one component of a broader resilience analysis. TNC incorporates the results of HAZUS in its Coastal Resilience Portal.

Water Supply Stress Index Ecosystem Services Model
Host: USFS
Website: http://www.forestthreats.org/research/tools/WaSSI
Login: Yes
Supports: Scenario Planning, Decision Support
Data: National

Description: WaSSI is an integrated, process-based model that can be used to project the effects of forest land cover change, climate change, and water withdrawals on river flows, water supply stress, and ecosystem productivity (i.e. carbon dynamics). WaSSI operates on a monthly time step at the HUC-4 (8-digit HUC) watershed scale (see more on HUCs) and across Mexico at the 0.5 degree scale. For the conterminous U.S., the model can also be run at the HUC12 scale for water and carbon balances from 1960 to 2012. As water yield and carbon sequestration are tightly coupled, WaSSI can be used to evaluate trade-offs among management strategies for these ecosystem services.

Functionality:

- The web application for WaSSI allows users to define a custom simulation scenario, view/download model inputs and outputs in tabular and graphical form for a location of interest, and view/export model outputs spatially for a variety of time scales using an interactive map viewer. Users may select their location in the map viewer, select a specific HUC, or input a zip code to view model inputs and outputs.

- WaSSI users can select and adjust temperature, precipitation, land cover, and water use factors to simulate an unlimited number of global change scenarios for user-determined timeframes through 2100.
- Simulation results are available as downloadable maps, graphs, and data files that users can apply to their unique information and project needs.

Limitations: Focused on water supply. Could be an important input to a more comprehensive resilience model where water supply is an issue.

CanVis

Host: NOAA
Website: http://coast.noaa.gov/digitalcoast/tools/canvis
Login: No
Supports: Informing and Engaging
Data:

Description: The CanVis tool offers coastal managers the opportunity to visualize future changes related to sea level rise, storm surges, and flooding. The free visualization software, developed through a collaboration between the U.S. Department of Agriculture and NOAA, is easy to use and is compatible with most computers. City planners, business owners, and land managers can use CanVis to visualize possible future changes to ecosystems and the built environment, and to evaluate the visual impact of options for protecting homes, businesses, and recreational spaces. City planners have used these features to show possible impacts of rising sea level or storm surge on waterfront communities.

Functionality:

- By importing photographs from a place in their community, users are able to view the potential impacts of rising sea levels in that specific area.
- In order to paint a vivid picture of the potential change, users can add elements such as docks, houses, and marshlands from CanVis's extensive object library.

Limitations: This tool does not integrate directly with other planning tools, but users could explore ways to incorporate these visuals as enhancements to a planning process, particularly during public engagement.

Appendix E

Representative Custom Decision Support Tools

Milwaukee: The Green Infrastructure Scenarios Tool (GIST)
Host: Milwaukee Metropolitan Sewerage District/Climate Interactive
Website: N/A Login:
Supports: Cities determining green infrastructure plans and projects
Data: See March 2015 Climate Interactive Report, *GIST – The Green infrastructure Model for the Kinnickinnic Watershed.*

Case Study: https://www.climateinteractive.org/wp-content/uploads/2014/01/GIST-Documentation-V12-Compressed.pdf

Description: The GIST focuses on the Kinnickinnic River watershed, a 26 square mile section of greater Milwaukee that has experienced flooding, basement backups and combined sewer overflows. This watershed is one of the most densely populated and highly paved parts of the city. The Kinnickinnic River Watershed – 26 square miles, densely populated, high percentage impervious surface.

The simulation itself is a system dynamics simulation that tracks the stocks of green and grey infrastructure based on a user's decisions about allocation of investment. The user can also set different rainfall regimes and modify the assumptions about the effectiveness of different types of green infrastructure at capturing and retaining water.

Functionality: The model is an ordinary differential equation system, solved by Euler integration that, tracks the stocks of green and grey infrastructure based on a user's decisions about allocation of investment. The user can also set different rainfall regimes and modify the assumptions about the effectiveness of different types of green infrastructure at capturing and retaining water. A range of benefits beyond stormwater management are tracked and reported, including water quality improvements, jobs, air quality improvements and energy savings.

The decision support tool performs the following:

- runs very quickly, simulating 10 to 20 years in less than 60 seconds;
- aims to provide a full picture, with economic, social, environmental and performance outputs;
- allows for creation of different investment scenarios – for 8 different classes of green infrastructure, as well as additional investment in grey infrastructure;
- supports exploration of different possible future rainfall patterns, to see how different investments might play out under different future climate conditions; and
- allows users to vary key assumptions, such as costs or performance of different types of green infrastructure.

Limitations: Tool does not executive storytelling or project profiling. They are working on simpler graphics interface.

Silicon Valley 2.0: A Regional Effort to Minimize the Impacts of Climate Change
Host: Santa Clara County, CA
Website: Request account for beta testing. Background:
https://www.sccgov.org/sites/osp/SV2/Documents/SV%202.0%20One-Sheet.pdf
Supports: Santa Clara County
Data:

Description: The Silicon Valley 2.0 Project was developed by the County of Santa Clara Office of Sustainability in order to respond to a gap in regional climate adaptation planning, and the need for an implementation playbook rather than, simply, a plan. In addition, authors of the project focused on the question of what tool would best serve decision-makers and those who influence and consult them where significant commitments and long-term strategies are needed.

Within these guidelines, Silicon Valley 2.0 assumed a risk management approach to:

- identify the region's future climate vulnerabilities
- catalogue regional built and natural infrastructures (assets)
- map climate impacts and sensitivities
- develop a comprehensive gaps analysis that would leverage existing or parallel efforts, and expose those strategies and measures that would respond to voids in climate preparedness
- create a decision-support tool that would map assets within impact zones, measure their sensitivity, and calculate the value of the risk of loss of those assets

Urban Climate Adaptation Tool (CAT)
Host: Oak Ridge National Laboratory
Website: N/A – under development
Supports: City of Knoxville, Stormwater permitting challenges

Data: "Using a common spatial grid, we meshed downscaled and bias-corrected climate data for both historical (1960-2005) and future (2010-2050) periods with land use/land cover information, topography demographics, sewer pipe layouts, social media accounts of local flooding events, among other sources, to effectively characterize the complex Knoxville urban landscape and its water infrastructure. This integration helps to identify areas vulnerable to flooding and discriminate system exposure, sensitivity, and stress, among other risk factors.

In order to integrate approximations of both adaptive capacity and the adaptive process into the tool, a set of indicators were developed and used to quantify each spatial grid. We defined urban resilience as a measure of eight components (Ross, 2013) – climate, social, community, capital, economic, institutional, infrastructure, and ecological – using multiple indicators from different sources including land cover/land use, imperviousness, slope, demographics, projected extreme precipitation, projected extreme temperature, and floodplain areas.

These indicators are then aggregated to create a score for each grid cell. The scores are in turn used to rank the spatial cells and the overlapping urban areas. The ranking was subsequently used to develop resilience profiles for each spatial cell. The developed indicators and resilience profiles are jointly used to develop risk-based approaches for stormwater and floodplain management respectively."

Description: Urban-CAT will be developed as a scenario planning tool that is locally relevant to existing urban decision-making processes. While cities may already have sophisticated tools to evaluate current site-specific scenarios, they lack: (i) tools that scale site-specific conditions to neighborhood and citywide scales; and (ii) credible climate data projections and population growth data to project future changes to urban landscape.

Functionality: The capabilities of the tool will include an advanced visualization platform to support decision making, access to future climate scenarios and environmental modeling results tailored for urban planning, connectivity to multitude of data sources that promote assessment and comparison of local project scenarios under different climate conditions, and better insights into local effect of climate change through scenarios management capability for testing and comparing planning alternatives.

Limitations: No demographic considerations yet; no cost-benefit analysis.

Climate-Smart Cities™ Decision Support Tool (TPL)

Host: Trust for Public Land
The tool is currently available in two cities and is under development in several others.

Healthy Connected Chattanooga
The project is a collaborative effort of The Trust for Public Land, the City of Chattanooga Departments of Public Works, Transportation, and Economic and Community Development, and The Benwood Foundation.
Website: http://tplgis.org/Healthy_Connected_Chattanooga/ (password protected)
Supports: Chattanooga
Data: http://tplgis.org/Healthy_Connected_Chattanooga/Downloads/Overlay_Metadata.pdf

Green Infrastructure for Coastal Resilience in Staten Island and Jamaica Bay:
Website: http://tplgis.org/NYC_ClimateSmartCities/ (password protected)
Supports: New York City
Data: http://tplgis.org/NYC_ClimateSmartCities/Downloads/Overlay_Metadata.pdf

Description: The DST focuses on helping TPL's partners prioritize green infrastructure investment oriented around four climate change objectives:

- Connect: "Hyper-connect" walk-bike corridors and public transit at the city and regional scales to maximize potential mode shift toward carbon-free and resilient transportation options.
- Cool: Utilize specially designed urban greenspaces, high albedo surfaces, and strategically-sited shade trees to lessen the energy use and human health impacts resulting from the urban heat island effect.
- Absorb: Deploy wetlands, "water smart" parks and playgrounds, green alleys, and other permeable surfaces to recharge local aquifers, curb stormwater runoff pollution, address inundation threats in the urban core, and reduce energy used for water management.
- Protect: Create integrated networks of strategically-sited waterfront parks and living shorelines, such as wetlands, to protect cities from sea level rise and storm surge, river-borne flooding, and other related inundation threats at the urban edge.

While each of TPL's objectives for Climate-Smart Cities is robust in isolation, they are focused on helping municipal governments work strategically to develop green infrastructure networks that "stack" these four benefits at the project, neighborhood, and city levels while prioritizing investment to vulnerable populations.

Functionality: The tool integrates diverse data and modeling to prioritize areas based on "Connect, Cool, Absorb, Protect" and vulnerable communities in each partner city. Users can create customized queries to identify opportunities for multiple benefit green infrastructure at the parcel level. This parcel-level analysis includes "one click" maps and parcel reports and the ability to identify all parcels within a city meeting user-generated criteria. Users can also take advantage of the tool's responsive design to access it on a range of devices from desktop computers to smart phones.

TPL Urban Heat Risk Explorer
Host: Trust for Public Land
Website: http://tplgis.org/UrbanHeatRiskApp/
Data: Utilizes data from the NASA MODIS satellite as well as local or national data on impervious cover, tree canopy, and cooling centers.

Description: This map highlights Urban Heat Island Hotspots, with elevated daytime land surface temperatures averaging at least 1.25 degrees Fahrenheit above the mean daily temperature during July and August of 2013; impervious surfaces; nighttime heat island hotspots with elevated nighttime land surface temperatures averaging at least 1.25 degrees Fahrenheit above the mean daily temperature during July and August of 2013; tree canopy; city cooling centers.

California Urban Footprint
Host: Southern California Association of Governments
Website: A portal is not available publicly, but there are some webinars online and a technical summary.
Webinar: https://www.youtube.com/watch?v=cvL8uTgmXGQ
Summary: http://www.scag.ca.gov/Documents/UrbanFootprintTechnicalSummary.pdf
http://www.scag.ca.gov/committees/committeedoclibrary/mtf092612_urbanfootprint.pdf

Data: Fully loaded with all major California MPO base data

Model Includes:

- Automated base data loading
- 35+ Place type library
- 90+ Building type library
- Scenario translation engine
- Thin-Client GUI
- Web-based scenario painter
- 8d sketch travel engine
- Full co-benefits analysis
- Modular, expandable

Description: The Urban Footprint model is a land use planning, modeling, and data organization framework designed to facilitate more informed planning by practitioners, public agencies, and other stakeholders. Built on fully open-source software platforms and tools, Urban Footprint requires no proprietary software of any kind. Its development is led by Calthorpe Associates, based in Berkeley, California.

Urban Footprint comprises a suite of tools and analytical engines that vastly decrease the time and resources required to get up and running with scenario development, while significantly increasing the technical capacity of state, regional, and local users to analyze the fiscal, environmental, transportation, and public health impacts of plans and policies. Moreover, it provides a common data framework within which planning efforts at various scales can be integrated and synced.

Functionality: Scenario-based planning with Urban Footprint involves four stages: data organization, the translation of existing plans, scenario development, and scenario analysis.

Appendix F
Cities using green infrastructure as a primary stormwater management strategy[1]

DC Water—The DC Water Clean Rivers Project is DC Water's ongoing 20-year, $2.6 billion program that was designed to reduce combined sewer overflows into Washington D.C.'s waterways (the Anacostia and Potomac Rivers and Rock Creek). The project, which began in 2005, aims to capture and clean stormwater during heavy rainfalls before it reaches the rivers.

Kansas City, Missouri—Under its Overflow Control Plan, the city will implement green infrastructure projects to control wet weather flows. Green solutions include: catch basin retrofits in road and street rights-of-way, curb extension swales, street trees, permeable pavement, green roofs, and stormwater planters.

Philadelphia—Green City, Clean Waters is a partnership between Philadelphia and EPA that involves a $2 billion investment in green infrastructure to better manage Philadelphia's stormwater. The 25-year agreement could be a national model for other cities interested in implementing green infrastructure.

Denver—In 2010, EPA selected Denver to become a partner for its Sustainable Communities Project. In 2011, the city and other Denver groups were also selected as EPA green infrastructure partners. By using green infrastructure, the city and its partners hope to improve the water quality of Cherry Creek and the South Platte River, while at the same time decreasing flood risks for waterfront property.

Milwaukee, Wisconsin—The Green Milwaukee program will help the city manage stormwater while providing added benefits of energy conservation, recycling, and urban renewal. The city has constructed two major bioretention facilities that remove contaminants from stormwater before the flows are discharged into the Menomonee River and has funded projects aimed at reducing the flow of stormwater into the sewer system. This work has been featured in several case studies, including by the Water Environment Research Foundation and the Natural Resources Defense Council (NRDC).

Cincinnati, Ohio—The Metropolitan Sewer District (MSD) of Greater Cincinnati's Project Groundworkis a two-phase initiative involving the rebuilding and improving of the city's sewer system. Green infrastructure projects such as retention basins and pervious pavement are being used to controlcombined sewer overflows. Phase 1 involves completion of 45 construction projects in and around the city by 2018; Phase 2 (after 2018) comprises 256 construction projects across Hamilton County. The entire plan is estimated to cost $3.5 billion.

Northeast Ohio Regional Sewerage District—Under Project Clean Lake, the District will invest $42 million in green infrastructure to address stormwater and combined sewer overflow issues. The District aims to convert thousands of acres of parking lots, roadways, and abandoned buildings to green spaces and ponds. One project that is nearing completion consists of an $11-million complex that uses bioretention ponds, sand beds, and a 1,800-gallon cistern to capture stormwater before it enters the combined sewer system.

Portland, Oregon— Portland's Grey to Green initiative will manage stormwater runoff and improve water quality (as well as air quality and community livability) by using green infrastructure. Since its start in 2008, the 5-year, $55-million program has added 6.5 acres of eco-roofs and 546 green street facilities throughout the city.

New York City— In September 2010, New York City introduced its NYC Green Infrastructure Plan, which uses green infrastructure practices to improve water quality. One approach is the use of right-of-way bioswales (small patches of plants, trees, and rocks that help prevent flooding by absorbing rainwater), which have been installed at

[1] http://blog.nacwa.org/green-infrastructure-have-we-reached-a-tipping-point/

Dean Street and Fourth Avenue. The city plans to invest more than $190 million in the program over the next 20 years.

Los Angeles, California—In September 2011, Los Angeles passed the Low Impact Development Ordinance, which requires that all development projects greater than 500 square feet be designed to capture, reuse, or infiltrate stormwater runoff. Los Angeles's Green Alleys Initiative program will add permeable pavement, bioswales, and drought-tolerant vegetation to urban alleys. These projects will improve water quality, reduce flooding, and reduce water demand while creating recreational opportunities and more.

Chicago, Illinois—Chicago has several green infrastructure programs. Since 2005, its Green Roof Program has provided residential and commercial grants for green roof construction; the city now has more than 1 million square feet of green roofs. The city began its Green Alley Program in 2006 and has since installed permeable pavements in over 100 alleys. The city's Urban Forest Agenda provides maintenance and planting of street trees, with a goal of 20% tree canopy coverage citywide by 2020. Both NRDC and the Sierra Club have summarized the project as well.

Onandoga, New York—The "Save the Rain" program, launched in 2009, is a comprehensive stormwater management plan using green infrastructure to reduce pollution to Onandoga Lake and other waterways. The program's "Project 50" campaign began with 50 green infrastructure projects to manage stormwater in 2011 alone. The program also includes a grant incentive program that provides financial incentives for the installation of green infrastructure on private property.

Pima/Tucson, Arizona—Plan Tucson, to be voted on in November 2013, will replace Tucson's 2001 General Plan to further green infrastructure efforts. One of Plan Tucson's primary goals is to reduce the amount of impervious surface and control urban runoff to improve water quality. The Urban Landscape Framework, finalized in 2008, is a recent initiative that addresses this issue. Both Tucson and Pima are working together to implement green infrastructure strategies in their respective counties.

Seattle, Washington—Seattle's Green Stormwater Infrastructure (GSI) initiative includes several programs and projects to protect the city's waterways including: RainWise program – designed to educate the public on various Green Stormwater solutions for their private property; Restore Our Waters program – implementing projects such as rain gardens, green roofs, and habitat restoration; and several tree-planting programs to reduce run-off.