# NCHRP 08-36, Task 117
# Sketch Tools for Regional Sustainability Scenario Planning

Requested by:

American Association of State Highway and Transportation Officials (AASHTO) Standing Committee on Planning

Prepared by:

Uri Avin
University of Maryland
National Center for Smart Growth
1112K Preinkert Field House
College Park, MD 20742

**With:**
Cambridge Systematics, Inc.
Paul Patnode

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- Robert Balmes, Michigan Department of Transportation, Chair;
- William Cesanek, CDM Smith;
- Robert Deaton, North Carolina Department of Transportation;
- Thomas Evans;
- Kristen Keener-Busby, Urban Lands Institute, Arizona;
- Amanda Pietz, Oregon Department of Transportation;
- Elizabeth Robbins, Washington State Department of Transportation;
- Nicolas Garcia, Liaison, Federal Transit Administration; and
- Fred Bowen, Liaison, Federal Highway Administration.

The project was managed by Lori L. Sundstrom, NCHRP Senior Program Officer.

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# Executive Summary

## Objectives

Sketch tools for scenario planning have been used across the country at various geographic scales – including the site, corridor, municipal, regional, and even statewide level – to evaluate alternative transportation and land use patterns across various dimensions of sustainability. Examples of these tools include CommunityViz, Envision Tomorrow and Envision Tomorrow Plus (ET+), INDEX and SPARC/INDEX, i-PLACE3S, and UrbanFootprint.

This report synthesizes the state of practice on scenario planning sketch tools to support regional sustainability, evaluates their relative strengths and weaknesses, provides guidance on their appropriate use, and suggests how they may be improved. This report is intended as a resource for staff at metropolitan planning organizations (MPO); state departments of transportation (DOT); and other organizations who are considering applying a sketch tool for scenario planning to support local, regional, or statewide transportation and land use planning.

## Background and Scope

Several recent Federal and state programs and initiatives in the transportation realm have spurred interest by planners in scenario-based approaches to regional planning and in tools to accomplish this. All of these initiatives have pushed planners' analytical envelopes well beyond the traditional transportation modeling framework. They have encouraged planners to grapple with the broader challenges of imagining and analyzing sustainability, of adding environmental, economic, and equity impacts to the transportation-related impacts traditionally analyzed. Because of the typical time and resource constraints to execute these efforts, the appeal of regional scenario sketch tools in a comprehensible, quick-response public setting is extremely strong.

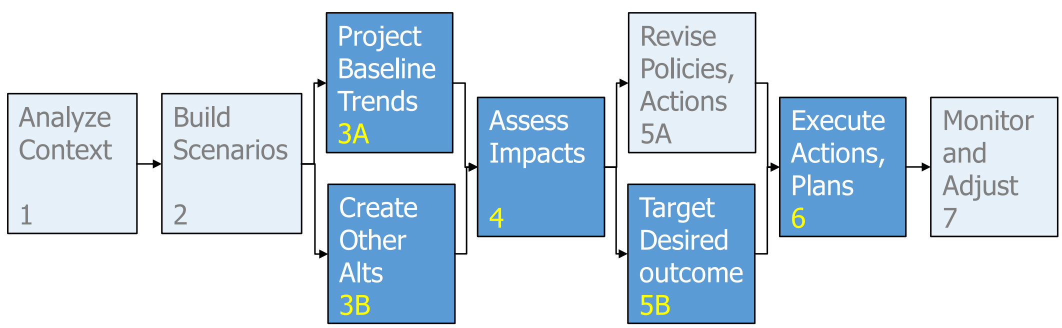
Nevertheless, the actual penetration of scenario planning and, therefore, of such tools into the practices of agencies is not high. In a 2013 survey by the Federal Highway Administration (FHWA), only 15 percent of MPOs were using a scenario approach. Obstacles include funding to hire experienced staff or consultants, time and resources given existing staff workloads, and staff's limited experience with scenario planning.

This report does not address all of the challenges of scenario planning, but rather focuses on the tools aspect. At least 10 reviews of tools have been developed over the past 15 years, but the field is evolving rapidly. This report goes beyond past reviews by placing the review within a broad discussion of current scenario thinking, emphasizing trends and the future evolution of topics, software, and hardware; and identifying areas of future research and development. The report also is the first to focus specifically on scenario sketch tools for regional sustainability, provides an independent assessment rather than one done by the tool developers, uses application case studies to support its findings, and develops a detailed analytical framework for the comparative assessment of the tools; and it suggests a framework for which approaches and tools should be used and when.

## CONTENTS AND ANALYSIS

Sketch tools must be understood in the context of regional scenario planning, whose purposes they must serve. Three scenario planning approaches – predictive (trend-based forecasts), normative (desired end-states), and exploratory (range of plausible alternatives) – are defined, along with their mindsets and process steps. Regional planning scenarios have traditionally been heavily slanted to the normative or end-state approaches and, as a result, so have their planning support systems or tools. Figure ES.1 illustrates the seven steps of scenario planning and shows which steps the tools highlighted in this report typically address.

**Figure ES.1 Scenario-Planning Steps Emphasized by Normative, Lightweight Sketch Tools**




This picture is in flux, however. Scenario approaches are broadening; and simple sketch tools are being complemented by more rigorous and theoretically informed tools and models, called "middleweight" tools in this report. Furthermore, simple sketch tools are being used in tandem with traditionally heavyweight tools (like integrated econometric models for land use forecasting). This variety and exploration is typical of a fast-evolving field, and it is consciously highlighted in this report. The range of options is a signal to avoid settling prematurely on a select set of tools or approaches as "the standard."

The report identifies six tools that met the definition of scenario sketch tools for regional planning and describes these tools. The most widely supported of these – CommunityViz, ET+, and UrbanFootprint – were selected for further in-depth analysis through seven case studies of their application and the creation of an analytical framework to assess the tools. The analysis is organized by three types of attributes: conceptual (what kind of a tool is it?); functional (how does it work?);

and implementation (what does it take to apply it?). The results are summarized in an evaluation matrix.

In looking at trends, and since the tools are moving targets, several important developments for each of the tools are noted, including new add-ons or modules that are being created by university-based researchers or private firms, which add considerable utility to the tools. Because of these add-ons and their evolving capacities, the tools also are being applied in new ways. These cross traditional boundaries between the public and private sector and researchers. The tool enhancements and new applications described suggest that these lightweight tools can morph into middleweight tools as their underpinnings and rules of thumb benefit from ongoing research.

The report provides guidance on which types of tools to use when and where from several perspectives. One organizes scenario approach by how predictable the future is in a particular region, and how much influence the particular agency has over it. Then, at the level of matching planning contexts to tools, guidance is provided on aligning tools with key influencing factors at play. In terms of the three levels of tools and models (lightweight, middleweight, and heavyweight), the tools are positioned according to ease of use and how much of the seven-step scenario process they address.

## Suggestions for Further Research and Development

The current generation of tools has matured to the point where they are all stable products, run faster than ever, and are more accessible than ever. These advances will help address some of the major adoption hurdles for scenario planning. The trend toward more supported, web-based open-source tools also will facilitate greater adoption of scenario planning and tool usage.

The nature of scenario planning is in flux. The interest in exploratory scenarios is not yet tool-supported, but its emphasis on addressing uncertainty is a healthy counterpoint to normative thinking. Facing uncertain driving forces raises questions about standard scenario indicators. While tempting, it may be premature to standardize scenario metrics across the board, although some components or aspects may warrant consolidation.

Our suggestions for productive areas of further research and development include:

- Address exploratory scenarios;
- Encourage work on middleweight models and tools for regional scenarios;
- Be more explicit about capturing stakeholder values in sketch tools and processes;
- Encourage the combination of various sketch tools with other models in regional planning processes;

- Emphasize people-based rather than place-based tool components and processes;
- Encourage academic research into the use and evolution of sketch tools;
- Make open-source and open-access tools more accessible;
- Continue and expand the development of web-based tools;
- Support user-driven enhancements of tools; and
- Explore restructuring and modularization of scenario sketch tools.

Scenario sketch tools for regional sustainability are now well-established in practice; their continued evolution promises to broaden and deepen their capabilities and penetration at all scales and levels of user capacity.

# 1.0 Introduction

## 1.1 Report Objectives

Scenario sketch planning tools have been used across the country at various geographic scales – including the site, corridor, municipal, regional, and even statewide level – to evaluate alternative transportation and land use patterns across various dimensions of sustainability. Examples of these tools include CommunityViz, Envision Tomorrow and Envision Tomorrow Plus (ET+), INDEX and SPARC/INDEX, i-PLACE3S, and UrbanFootprint.

This report is intended as a resource for staff at metropolitan planning organizations (MPO), other regional planning agencies, state departments of transportation (DOT), municipal agencies, and nonprofit organizations who are considering applying a scenario sketch planning tool to support local, regional, or statewide transportation and land use planning. It also may be useful to others – such as citizen groups – interested in the application of these tools, as well as to the developers of the tools, and to Federal or national agencies who may support tool research and development.

Beyond the traditional transportation/land use arena for sketch tools, they are increasingly being used for additional kinds of analysis, such as greenhouse gas (GHG) reduction, energy planning, health planning, economic and fiscal impact analysis, and project feasibility. Planners and analysts interested in these other areas also may, therefore, find this report useful.

The report provides an overview of existing tools, a detailed evaluation of selected tools, guidance on which tools to use when, and case studies of the application of selected tools. It also identifies trends in tool development and provides suggestions for further research and development for these types of tools. Background research for the report included a literature review, practitioner survey, case study research, and a detailed review of selected tools.

## 1.2 Background

Several recent Federal and state programs and initiatives in the transportation realm have spurred interest by planners in scenario-based approaches to regional planning and in tools to accomplish this.

In 2011, in acknowledgment of the growing ability of traditional models and maturing sketch tools to execute transportation and land use simulations for generating required MPO plans, the Federal Highway Administration (FHWA) published its Scenario Planning Guidebook. In 2012, a new transportation authorization act, Moving Ahead for Performance in the 21st Century (MAP-21), explicitly encouraged the application of scenario planning and performance-based planning and programming (PBPP) by MPOs. In 2015, the Transportation Research Board (TRB) published the six-volume series of the *National Cooperative Highway Research Program (NCHRP) Report 750: Strategic Issues Facing Transportation* (under the overall label of Foresight). This series includes sociodemographic drivers and resultant scenarios (Volume 6) and freight-related drivers and scenarios (Volume 1). In mid-2016, the FHWA will publish a new guidebook that relates their 2011 scenario planning framework to PBPP; and in 2017, will update their 2011 Scenario Guidebook.

Between 2010 and 2012, many of the grants awarded under the U.S. Department of Transportation (DOT), Department of Housing and Urban Development (HUD), and Environmental Protection Agency's (EPA) Partnership for Sustainable Communities also incentivized the application of scenario approaches and tool development. California's Senate Bill (SB) 375, with its mandate to meet the challenges of climate change, has further pushed the envelope on regional scenario tool development and use. Concurrently, about a dozen states were implementing state-level land use planning efforts in the 1990s and 2000s, as well as developing climate action plans that further spurred scenario work and tool development.

Moreover, the requirement for public engagement in all the above efforts added the need for intelligible public communication and participation around planning processes that are inherently complex. The longstanding requirement and culture of public engagement in the U.S. is a fundamental driver behind the development and adoption of regional scenario sketch tools. It also is a key reason why such tools have originated in the U.S. rather than in Europe, where top-down planning is more typical.

All of these initiatives and requirements have pushed planners' analytical envelopes well beyond the traditional transportation modeling framework. They have been encouraged to grapple with the broader challenges of imagining and analyzing sustainability, and of adding environmental, economic, and equity impacts to the transportation-related impacts traditionally analyzed. Because of the substantial time and resource constraints to execute these efforts, the appeal of regional scenario sketch tools that promise to meet these analytical challenges in a comprehensible, quick-response, public setting is extremely strong. And, indeed, in a 2013 FHWA survey of agencies' use of regional scenario approaches, their main reasons for using sketch tools were need to engage stakeholders and citizens (52 percent), desire to integrate land use and transportation plans (48 percent), and financial or economic development concerns (48 percent).

Nevertheless, the actual penetration of scenario planning and, therefore, of related tools, into the practices of agencies is not high. Only 15 percent of MPOs responding to the 2013 survey used a scenario approach. The major obstacles cited by between 40 and almost 60 percent of respondents (mainly MPOs and state DOTs) to adopting scenario planning (and by inference, tools), were funding to hire experienced staff or consultants; time and resources given existing staff workloads; and staff's limited experience with scenario planning, in that order.

These survey responses frame some of the challenges that this report addresses. Are the concerns articulated still valid? Is scenario planning (and, by inference, its associated tools) becoming more affordable, more understandable, and simpler to execute? This report does not focus on the challenges of scenario planning per se, but rather focuses on the tools aspect. The purpose of this research project is to synthesize the state of practice on scenario sketch planning tools to support regional sustainability; and in synthesizing the state of practice, to evaluate the relative strengths and weaknesses of these tools, provide guidance on their appropriate use, and suggest how they may be improved.

## 1.3 DEFINITIONS

The complex title of this project – Sketch Tools for Regional Sustainability Scenario Planning – combines multiple ideas and meanings and begs definition up front:

- ***Scenarios –*** The standard definition of scenarios differs from mere alternatives or options in by injecting the notion of a *story about the future* into them, and also proposes that the story or stories have some degree of *plausibility* to them. They are about *imagining and discovering* future conditions so as to develop a *readiness and agility* in addressing multiple futures. The purpose of these exercises is to identify the *most robust and resilient actions* in the face of these multiple outcomes. The definition of scenarios used by many planners, however, differs somewhat from the standard definition in the literature in that it derives rather from the tradition of *Visioning*, in which planners and communities are engaged in imagining and describing how they would like their future world to look and be. They do not necessarily ignore trends and forces, but these are often seen as impediments to the better future to be striven for. These differences in mindset also are key to understanding the right fit for various tools.
- ***Sketch Tools for Scenario Planning –*** For the purposes of this report, can be briefly defined as simplified, agile spatial tools that require limited data and can generate multiple scenarios of the built and natural environment and provide rapid feedback on their impacts on regional sustainability (see Section 3.1 for a fuller definition). While these tools also have been applied at the local scale, our focus here is on the region and, therefore, the issues of tool scalability, while important, are not central to our comparative analysis. ("Sketch," as used here, has nothing to do with hand-drawn graphics.)
- ***Sustainability –*** Our definition of sustainability hews to the conventional 3 Es of Environment, Economy, and Equity.
- ***Regional –*** Our definition of a region is an area that encompasses multiple jurisdictions (towns, cities, or counties), oftentimes a metropolitan area. The region, however, could include multiple metros and could cross state boundaries (i.e., megaregions).

## 1.4 ORGANIZATION OF THE REPORT

The remainder of this report is organized as follows:

- Section 2.0 provides an overview of research activities;
- Section 3.0 provides an overview of the tools researched and evaluated;
- Section 4.0 provides an evaluation of selected tools and identifies trends;
- Section 5.0 provides guidance on which tools to use when and on alternative options to the set of sketch tools that were evaluated in depth; and
- Section 6.0 discusses the future of tools and provides suggestions for further research and development for these types of tools.

The main report is written for an audience of nontechnical professional planners with an interest in this topic. Appendices provide more detailed and technical documentation of the research findings, including:

- Literature review (Appendix A);
- Survey findings (Appendix B);
- Case studies (Appendix C);
- Detailed evaluation of the tools (Appendix D); and
- Detailed description of the tools (Appendix E).

# 2.0 Overview of Research Activities

## 2.1 LITERATURE REVIEW

A literature review was conducted in fall of 2013 and spring of 2014. The review considered the state of practice and state of the art in the use of sketch tools to support regional scenario planning. The overall state of the practice gleaned from the reviews is synthesized in Appendix A. Given the extensive amount of literature potentially available, including individual studies, the review of documents was primarily a "meta-review" focusing on other published reviews of scenario planning tools and practices. Of particular interest in the reviews was the analytical framework used with the intent to inform the framework developed for this report. Reviews of 10 such studies are included in Appendix A. None of the reviews focused on the specific topic of this report, and none provided as detailed an assessment framework as does this report.

Based on the literature review the research team also characterized the state of practice in scenario planning, and developed critical definitions of the terms embedded in the title of this research – *scenarios*, *sketch tools*, and *regional sustainability*. The research team's criteria for identifying "sketch tools for regional sustainability" are provided in Section 3.1. More detailed discussion of the practice of scenario planning, as well as the meaning of "scenarios" and "regional sustainability," is provided in Appendix A.

Finally, the literature review included descriptions of six tools in recent or current use. The descriptions are based on their published documentation and other literature, supplemented by communication with tool developers. The descriptions focused on the tool's conceptual approach, scenario creation, software requirements, data requirements, evaluation and indicators, and available documentation; and are described in detail in Appendix E. The tools included:

1. CommunityViz;
2. Envision Tomorrow/ET+;
3. i-PLACE3S;
4. INDEX/SPARC INDEX;
5. UPlan; and
6. UrbanFootprint.

This information has been incorporated into the tool overview and evaluation in Sections 3.0 and 4.0.

## 2.2 SURVEY

A survey of tool users was conducted in April 2014. Its intent was to gather basic information on agencies' application of scenario sketch-planning tools. The survey was sent directly to agencies known to have recently applied the tool, as determined through contact with the tool developers and other sources. It also was distributed broadly to membership of the National Association of Regional Councils and the Association of Metropolitan Planning Organizations. Survey responses were received from the following 13 agencies:

- Allegheny County Department of Economic Development – Pittsburgh, Pennsylvania;
- Centralina Council of Governments – Charlotte, North Carolina;
- Chicago Metropolitan Agency for Planning – Chicago, Illinois;
- Chittenden County Regional Planning Commission – Burlington, Vermont;
- Envision Utah – Salt Lake City, Utah;
- Gulf Regional Planning Commission – Biloxi, Mississippi;
- Information Center for the Environment, University of California at Davis;
- Macatawa Area Coordinating Council – Holland, Michigan;
- Metropolitan Area Planning Council (MAPC) – Boston, Massachusetts;
- North Front Range MPO – Fort Collins, Colorado;
- Sacramento Area Council of Governments (SACOG) – Sacramento, California;
- San Diego Association of Governments (SANDAG) – San Diego, California; and
- Southern California Association of Governments (SCAG) – Los Angeles, California.

Follow-up telephone interviews also were conducted with selected responding agencies, and some agencies who did not respond, to determine suitability for case studies for the project. Detailed survey findings are presented in Appendix B.

## 2.3 CASE STUDIES

The survey results were used to select tool applications to be documented as case studies. The survey results were used to select the case studies documented in this research. Individual examples were considered good candidates for case studies if they met the following criteria:

- Willingness of lead agency to provide information for the case study;
- Tool was applied at a regional scale;
- Agency had a relatively complete and in-depth experience with the tool; and
- Agency had some degree of independent application and tool "ownership" (as opposed to complete dependence on consultant or tool developer).

In addition, the following collective criteria were established for the group of case studies selected:

- Diversity in size and sophistication of agency; and
- Diversity in geographic location of application and agency.

Seven case studies were ultimately completed documenting three tools, as follows:

- Three **CommunityViz** case studies – in the Boston, Charlotte, and Holland (Michigan) regions – were selected from a larger list of options. They represent complete applications of the tool that provide a depth of insight into the tool's capabilities.
- Two **Envision Tomorrow** case studies were selected – Envision Utah in the greater Salt Lake City region, and the City of Austin. Envision Utah was the only agency responding to the survey who had used this tool. The City of Austin was contacted as a follow-up to the survey and determined to be a suitable case study subject.
- **Two UrbanFootprint** case studies were selected. Three agencies were identified that have applied UrbanFootprint, all California MPOs (serving the Los Angeles, Sacramento, and San Diego regions). Of these, Sacramento and San Diego were selected as preferable case study candidates because both have applied the tool at a regional level. Both agencies also run other sophisticated models that interact with their sketch tools, making them particularly rich case studies.

Case studies were not conducted for the following tools that were included in the survey:

- **INDEX/SPARC INDEX –** Only two agencies responded regarding their use of INDEX or SPARC INDEX, and the project team was unable to obtain sufficient information from the local agencies involved with these model applications to develop case studies. Furthermore, the developers of INDEX have stopped developing it for regional sketch planning, and its conceptual architecture is now fully embedded in UrbanFootprint.
- **i-PLACE3S –** Only one agency (SACOG) responded regarding this tool, and said they were replacing its use with UrbanFootprint due to cost, complexity, and other factors. SACOG was the tool's major supporter, and this withdrawal suggests the tool will have a limited life.
- **UPlan –** No public agencies responded regarding this tool. Also, it is somewhat different than the others in that it is more suited to land use allocation by algorithm rather than for public input in creating scenarios.

The case studies were researched through a review of documents produced for the tool application project and conversations with public agency staff and consultants involved with the tool's application.

The seven case studies are compared in Table 2.1 based on their geographic context; agency type; primary work (performed by agency, consultant, or academic); prior experience with similar tools; funding sources; and duration of project. Most case studies highlight larger urban areas – which are more likely to have the funding and technical resources to apply these types of tools – although one smaller area is included. The lead agency is usually an MPO or other regional agency, such as a council of governments (COG), but often the project involves a consortium of stakeholders. Prior experience varied considerably. Funding for a number of projects came from HUD Sustainable Communities Initiative (SCI) grants, but others were funded with state and MPO funds. Duration of the project ranged from two to five years.

### Table 2.1 Comparative Features of the Case Studies

| Tool/Place | Context | Agency (Type) | Primary Work | Prior Work with Tools | Funding | Duration |
|---|---|---|---|---|---|---|
| ***CommunityViz*** | | | | | | |
| Charlotte region, NC | Large urban, suburban, rural | COG (Centralina Council of Governments) | Consultant | None | HUD SCI grant | 2 years |
| Boston region, MA | Large urban, suburban | RPA (Metropolitan Area Planning Council) | Consultant, Agency | Extensive | HUD SCI grant | 2 years |
| Holland region, MI | Small rural suburban | MPO (Macatawa Area Planning Council) | Consultant | None | MPO funds | 5 years |
| ***UrbanFootprint*** | | | | | | |
| Sacramento region, CA | Large urban, suburban, rural | MPO (Sacramento Area Council of Governments) | Consultant, Agency | Very extensive | State and MPO funds | 4 years |
| San Diego region, CA | Large urban, suburban, rural | MPO (San Diego Association of Governments) | Consultant Agency | Moderate | State and MPO funds | 2 years |
| ***Envision Tomorrow*** | | | | | | |
| Salt Lake, UT | Large urban, suburban, rural | Consortium (Salt Lake County lead) | Nonprofit, academic | Very extensive | HUD SCI grant | 4 years |
| Austin, TX | Large urban, suburban, rural | Consortium (Capital Area COG lead) | Consultant, academic | Limited | HUD SCI grant | 4 years |

Key: COG = Council of Governments; MPO = Metropolitan Planning Organization; RPA = Regional Planning Agency; HUD = Department of Housing and Urban Development; SCI = Sustainable Communities Initiative.

It is important to note that the three tools in the case studies are all moving targets. The UrbanFootprint case studies, in fact, document work undertaken by MPOs as part of the development of the tool itself. The case studies, thus, represent snapshots as of late 2014/early 2015. Each agency applying a tool was provided the opportunity to review its respective case study for accuracy.

The outline of each case study is as follows:

- A summary table of key project information;
- Project overview – a description of the larger planning/visioning process that the tool supported;
- Tool and process overview – how the tool was applied to support this project;
- Tool characteristics – platform, data requirements, indicators, etc.;
- Tool application – how the tool was applied, including data gathering, developing scenarios, indicators, and outputs;
- Evaluation – lessons learned as reported by the agencies involved; and
- Resources – for further information.

The detailed case studies are provided in Appendix C.

## 2.4 Evaluation of the Tools

Following the literature review, a framework was developed to evaluate the tools along three dimensions:

1. Conceptual (what kind of a tool is it?);
2. Functional (how does it work?); and
3. Implementation (what does it take to apply it?).

After the case studies were completed, the three tools documented in the case studies were then subjected to the evaluation framework. A detailed evaluation was first conducted, and then a summary evaluation to condense the information into a summary table. The evaluation was based on the case study information, literature review, review of tool documentation, and discussions with tool developers to ensure the project team had accurate information about the tools and their capabilities.

The tool summary evaluation is documented in Section 4.0, with the detailed evaluation matrix provided in Appendix D. This section also discusses trends in scenario planning and in tool and model development.

## 2.5 Guidance on Approaches and Tools

In the course of the research for this report, it became clear that other approaches to scenario planning and other sketch tools are emerging. While not meeting our definition of scenario sketch tools for reginal planning, they are evolving rapidly. Therefore, they are discussed in Section 5.0, which also provides guidance on which approaches and tools to use in which contexts.

## 2.6 Suggestions for Further Research and Development

In the course of the literature review and the evaluation, the research team identified limitations of the various tools, as well as some opportunities, both individually and collectively. The team also identified important trends in the use of tools generally. The different factors that influence the evolution of sketch tools are discussed and alternative trajectories for tools are imagined. The report concludes with suggestions in a number of areas for further research and development.

# 3.0 Overview of Scenario Sketch Planning Tools

## 3.1 Scenario Typologies and Processes

The term "scenarios" is now used indiscriminately to cover many different concepts and approaches. This report distinguishes between three types of scenarios (following Borjeson, 2006):

1. **Predictive Scenarios** (also often called Trendline, Expected, Probable, or Baseline) are typically the most plausible, trend-based platform against which alternatives are measured;
2. **Normative Scenarios** (also often called End-State, Preferred, or Prescriptive) are typically the desired end-state (e.g., Smart Growth land use pattern) and how to reach it; and
3. **Exploratory Scenarios** (also often called Contingent or Plausible) are typically the range of alternatives that reflect external forces and stakeholder goals and the most robust, resilient strategies in response.

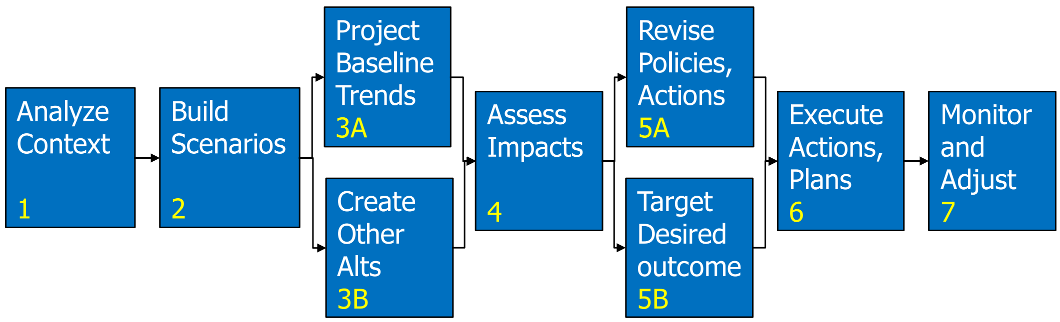
The Baseline and the Exploratory relate to alternative states of the world that could occur absent action to influence it; the Normative is the preferred state of the world and the reason for action. They all have a role in scenario planning. But they also imply different processes and tools, and it is very important to distinguish between these.

Urban planners are very familiar with the first two types, and this is how most planners and agencies think of scenarios. The tools explored in this report are based on and support these approaches. This is their strength, but also their weakness. They can quickly capture, compare, and analyze desired visions. They are not conceived and set up, however, to analyze and address uncertainty. Exploratory scenarios represent a different approach and mindset, and most planners are both unfamiliar with this approach and how it might be applied. Tools or models that can support this approach are less developed than for Predictive and Normative scenarios and not deployed yet in many scenario planning efforts. Because, however, they are of increasing interest to planners and because we see the emergence of tools and models that relate to this approach, this report also addresses them briefly. Appendix A discusses the range of scenarios more extensively.

This subsection sets the regional sketch tools addressed in the remainder of the report in the broader context of scenario typology, so that planners can understand other options and developments in this rapidly evolving field. Section 5.2 provides some guidance on when to use which types of tools.

The various steps in scenario processes have been described in many publications. The diagram in Figure 3.1 is developed for this report because it can be related to the steps that various tools address most centrally. There is some overlap between this report's process and that of the FHWA six-step process.[1]

**Figure 3.1 A Seven-Step Scenario Process**

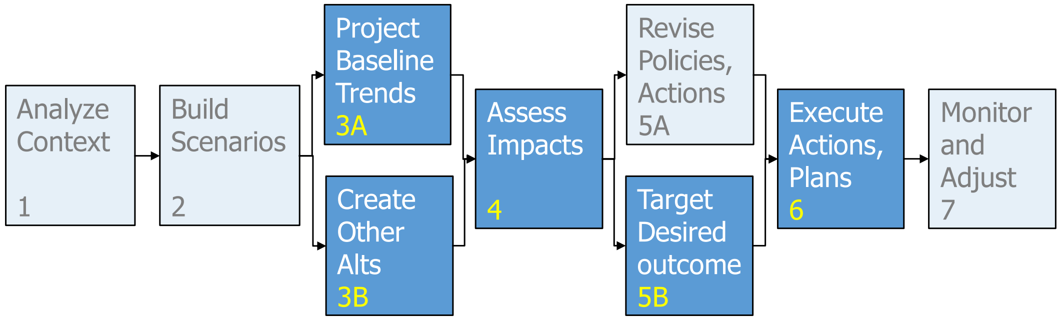



The seven steps in the diagram represent a complete working through of a scenario planning process (Stakeholder values and goals are built into the Build Scenarios step in this diagram.). Scenario tools and models, however, do not necessarily provide cradle-to-grave support for all of these steps. The kinds of agile, simplified tools we address in this report we call *lightweight tools* in that they tend to be vision-oriented, rather a-theoretical, noncalibrated, generalized, and limited in the degree of support they provide for different steps of the process.

Figure 3.2 represents the relationship of normative, lightweight tools to the overall process steps shown in Figure 3.1. The darker boxes show those steps that these tools execute directly. The actual creation of the scenarios in such processes tends to be part of the, often public, process of developing the baseline and alternatives, rather than the result of a detailed analysis of the context and the painstaking and careful construction of scenarios.

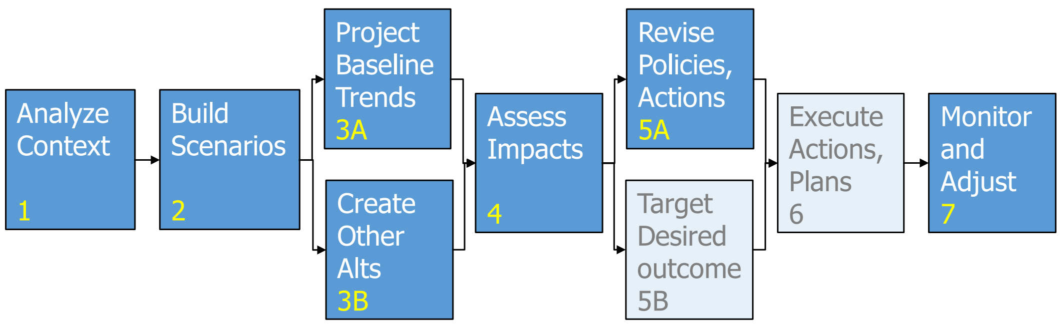
[1] Steps 3, 4, and 5 in this report's process correspond with Steps 4, 5, and 6 in the six-step FHWA process. The FHWA process expands on the front-end of our process and inserts the development of goals and aspirations before the development of alternatives; whereas, we include this work within our scenario building step itself. Our process also extends to implementation and monitoring.

**Figure 3.2 Scenario Steps Emphasized by Normative, Lightweight Sketch Tools**




The process steps emphasized in Exploratory scenario processes are shown in Figure 3.3. Note that it downplays targeting desired outcomes and executing actions and plans. A good demonstration of an exemplary exploratory process is found in the 2014 *NCHRP Report 750, Volume 1: Scenario Planning for Freight Infrastructure Investment*. The framework of the four scenarios created in this process is used to vet current strategies, plans, and investments. It should be noted that this effort, and most like it, are developed through creative thinking, structured analysis, and debate; and not via models or tools.

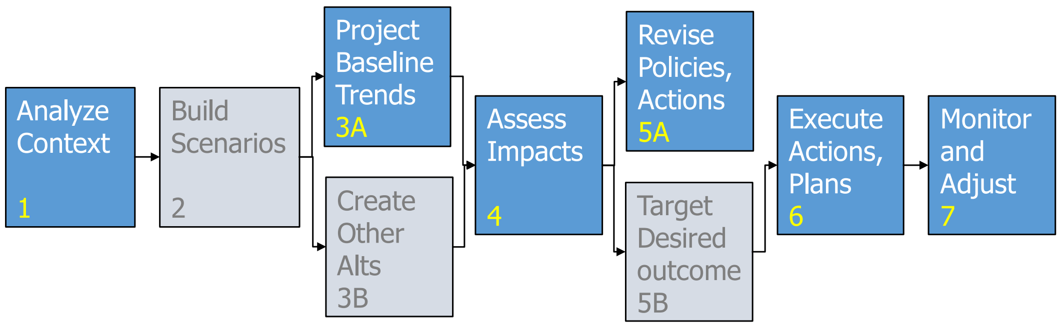
**Figure 3.3 Scenario Steps Emphasized by Exploratory Processes**




It is possible, however, to imagine an extension of exploratory scenario thinking in which the most robust actions selected constitute a desired outcome and become the basis for a plan. Indeed, there are some newer models and tools that have the promise to deliver such results, and these could be called *middleweight tools*. In terms of process steps, they would strive to address all the seven steps in the process. While they do not yet meet all our criteria for regional sketch tools, as described below, they are an important evolution in planning support systems. We describe these emerging tools in Section 5.1 of this report under Alternatives to Scenario Sketch Planning Tools.

Finally, Figure 3.4 shows the steps emphasized in the predictive process. Such approaches require much up-front data collection and analysis if they are part of a modeling approach. Many of these data inputs also are used to monitor changing conditions after plan adoption and implementation.

**Figure 3.4 Steps Emphasized by Predictive Processes**




## 3.2 Definitions

For the purposes of this report, "sketch tools for regional sustainability scenario planning" are defined as having the following 10 characteristics:

1. Are spatially explicit (i.e., more than numerical or policy frameworks);
2. Require limited data (i.e., can use readily available sources or provide default values);
3. Employ simplified algorithms to derive impacts and indicators (i.e., tend to use transparent logic);
4. Can generate spatially explicit land use patterns at a regional scale (i.e., "scenarios");
5. These patterns must include a range of built environment and natural environment features (i.e., tools only directed at environmental outcomes and impacts do not qualify);
6. Can generate at least two-dimensional maps with spatial attribute data;
7. Can generate a range of quantitative impacts and indicators from these patterns and compare these across scenarios;
8. These impacts and indicators can be related to equity, the economy and/or the environment, both natural and human (e.g., data outputs like land consumed or job and transit accessibility can be used to infer aspects of sustainability's 3 Es – Equity, Economy, and Environment);
9. Are relatively straightforward to use; and
10. Provide rapid or instantaneous feedback.

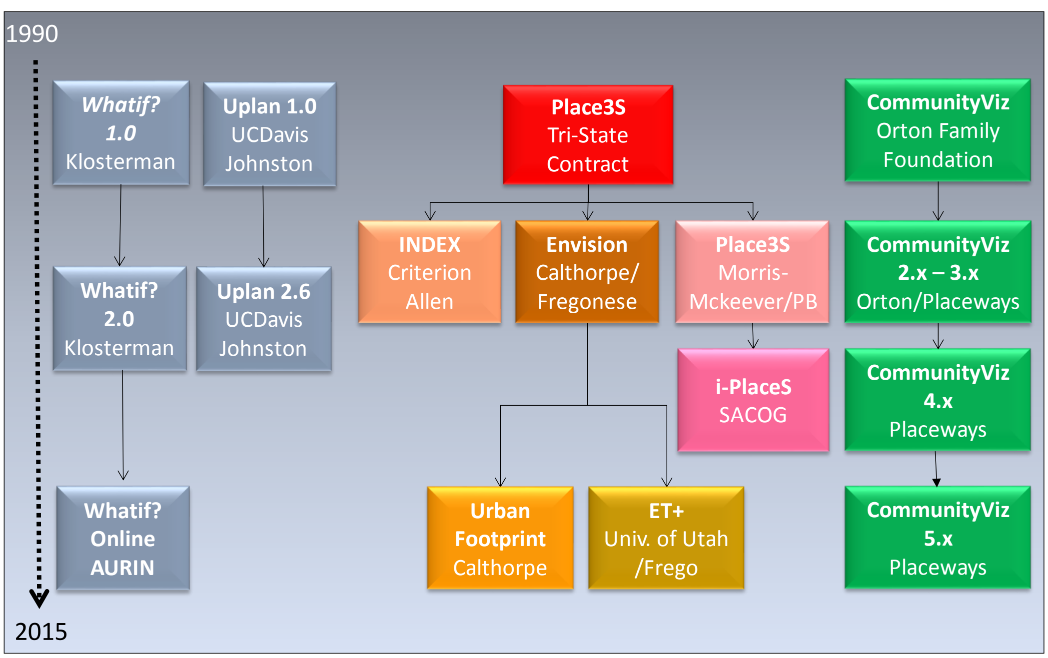
The tools treated in depth in this review are those that are commercially available and have support from their developers. These are tools from tool developers who have been in these trenches for over a decade, and have established a track record of reliability and support. All are U.S.-developed, although some have been applied overseas. They are developed by consultants or university-based researchers who have migrated the tools to a commercial setting. Some tools still undergoing development were included in the review.

Because of the ubiquity of computing power and ongoing developments in the geographic information systems (GIS) world, it is quite likely that the review missed some tools that qualify. These may be less visible in the marketplace or are home-grown by specific agencies or consultants for particular projects, or are mostly service-based or are without broader market ambitions. Some examples include Facet's PlanMaster/Cause-and-Effect platform, the Delaware DOT's LUTSAM (a one-off for them), or CorPlan by the Renaissance Planning Group. Such tools usually do not have the market presence or support that the more durable, commercially available tools do.

## 3.3 Evolution of Scenario Sketch Tools

Many of the tools share a common conceptual approach and origin. It is helpful to trace the genealogy of the primary sketch tools because their history informs their structure and design. Figure 3.5 captures a simplified version of the evolution of three main branches of the genre and notes their associated companies or main developers.

**Figure 3.5 25-Year Genealogy of the Primary U.S. Sketch Planning Tools**



The three branches differ in their approach to the design of their sketch tools. *Whatif?* and UPlan are early, rule-based, land use allocation systems developed primarily by academics, which coincided with the release of ESRI's object-oriented software that made such tools possible. Early applications were at the city and regional scale.

PLACE3S was the result of broad public/private collaboration by the Energy Departments of Washington, Oregon, and California to create a GIS tool to help communities understand the implications of their future development patterns, especially for energy. This effort spawned several other tools, all sharing the same Place Types/outreach structure. It was initially developed for neighborhood-scale applications. INDEX created a "Paint the Region" extension in 2002, which was oriented to regional applications, while Envision used a spreadsheet-type approach for all scales and applications. The two "offspring" of the Envision tool (UrbanFootprint and ET+) are in an evolving mode and are the latest versions of these tools. Both depend on users selecting and applying ("painting") prototypical development types (called Place Types) with specified characteristics, metrics, and attributes to maps in creating scenarios. Both tools are adding new modules on an ongoing basis (e.g., for fiscal, health, and agriculture impacts).

CommunityViz originated through The Orton Family Foundation to enhance the quality of life in rural places and regions by supporting better decision-making through decision-making tools for alternative scenarios. The software is an open framework that guides users through populating a geodatabase enhanced with spreadsheet-type capabilities. This is a different approach than the more defined and rigid setups for the other tools; and this makes CommunityViz more demanding in a way, but perhaps more flexible and useful for other GIS-driven applications, such as natural-resource management, risk-assessment, and school district "redistricting," to name a few. There have been five major releases of the tool; each adding new decision-making tools, such as a Land-Use Suitability "Wizard," a Build-out Wizard, Common Impacts Wizard, a simple Allocation Model, and more.

## 3.4 Tools in Use

The literature review identified six major scenario sketch tools currently available or under development. These are:

1. CommunityViz;
2. Envision Tomorrow or Envision Tomorrow Plus (ET+);
3. i-PLACE3S;
4. INDEX or SPARC/INDEX;
5. UPlan; and
6. UrbanFootprint.

Several other tools that do not fit our definition of scenario sketch tools are, nevertheless, worthy of mention. They are part of alternative approaches to scenario sketch tools discussed in Section 5.1.

While not a regional scenario sketch tool as we define it, UrbanCanvas is noteworthy. Part of the UrbanSim/Synthicity group's products, UrbanCanvas is a powerful visualization tool with some analytical capacities, which is evolving rapidly and is worth watching. It allows the 3D visualization of growth patterns from UrbanSim, the powerful simulation model developed by Paul Waddell over the past two decades. A new release of UrbanCanvas with an emphasis on building an open data "commons" for built environment data is slated for mid-2016, as is a release of national coverage with a simplified UrbanSim on the cloud.

While similarly not a scenario sketch tool, ESRI's City Engine deserves mention. A powerful visualization tool, City Engine has just been acquired by CitiLabs, the makers of CubeLand, a robust land allocation model similar to UrbanSim. This merging in the marketplace of heavy-duty land use models with high-quality visualization capabilities is an important phenomenon in a dynamic field.

W*hatif?*, an early pioneer in rule-based land use allocation tools, has been given new life as *Whatif?*/AURIN by a group of Australian academics/tool developers, who have created an on-line, enhanced version of the tool. Geodesignhub is another important tool, which meets our sketch tool criteria, but whose recent release did not allow of detailed examination in this report. Geodesign is a term closely associated with long-time systems thinker/practitioner Carl Steinitz of Harvard, whose approach animates this tool. This software supports a very evolved, mature workshop-oriented planning and design process, which, in particular, bridges the perilous gap between generating alternatives and moving towards a plan. It is discussed briefly in Section 5.1.

Table 3.1 provides a descriptive summary of the six scenario sketch tools listed above, including their development history, platform, approach to scenario creation, and indicators produced. Similarities among the tools are evident. The differences between them are teased out in Section 4.0 of this report. Appendix E provides a detailed description of the six tools.

## Table 3.1 Summary of Tools and Their Capabilities

| Tool | Developer | History | Platform | Scenario Creation Approach | Indicators |
|---|---|---|---|---|---|
| CommunityViz | Originally developed by Orton Family Foundation who envisioned a software tool that would make the planning process more accessible to ordinary citizens. Currently supported by Placeways, LLC. | First two major releases by the Orton Family Foundation in 2001 and 2003, respectively. Mostly applied in rural communities. Three subsequent releases by Placeways, LLC applied at local and regional scales in both rural and urban contexts. | Proprietary extensions to ArcGIS running on Windows OS. | Flexible: Scenarios can be created "from scratch" or with the "Land-Use Designer" and "Sketch Tools," using predefined or custom Place Types and "Painting" (applying the Place Type attributes) them onto geographic features such as parcels or more generalized features such as grid cells or traffic analysis zones (TAZ). Allocation modeling tools also can be used to generate "rule-based" scenarios at any scale. | The range of indicators produced can vary based on the detail of inputs used in the place type/ scenario creation process. They can be generated through the use of various "wizards," which produce anywhere from 12 simple demographic and environmental impacts requiring only basic building information as inputs; up to 101 more complex indicators requiring additional environmental, demographic, and fiscal inputs; and potentially an unlimited number of impacts if building the impacts "from scratch." |
| Envision Tomorrow or Envision Tomorrow Plus (ET+) | Fregonese and Associates | Originally developed by Fregonese Associates as a proprietary spreadsheet tool and further refined by Fregonese-Calthorpe and Associates; subsequently evolved into a collaboration with academics at the University of Utah and Austin into a more extensive, open-access tool. | Open-access Excel Spreadsheet models and an extension to ArcGIS running on Windows OS; or via an on-line tool still in development. | Place Types are created from two Excel Spreadsheets: Prototype Builder and Scenario Builder. Prototype Builder serves as a template for creating a library of building types with associated attributes that can be aggregated with other building types to create Place Types using the Scenario Builder template. Then Place Types are "painted" onto geographic features, such as parcels or more generalized features such as grid cells or TAZs. | When Place Types are "painted" on to a geographic feature, all associated Place Type attributes are copied to that feature and impacts on land use, environment, transportation, etc., are calculated accordingly. |

| Tool | Developer | History | Platform | Scenario Creation Approach | Indicators |
|---|---|---|---|---|---|
| i-PLACE3S | A public/private collaboration initiated originally by the Energy Departments of Washington, Oregon, and California as desktop software – PLACE3S – to create a GIS tool to help communities understand the implications of their future development patterns, especially for energy. Until 2014, tool was supported primarily by SACOG, but no longer. | Original software application developed in the public domain by Parsons Brinckerhoff, Fregonese Calthorpe Associates, and Space Imaging, in collaboration with ESRI, the California Energy Commission and with additional support by the U.S. Department of Energy, SACOG and several other regional planning agencies and state DOTs. In 2002, the CEC commissioned EcoInteractive to convert the desktop version of PLACE3S to an Internet version referred to as i-PLACE3S. | On-line platform; originally meant to be open-source, but not widely distributed or supported. | Place Types in PLACE3S are user-defined. They are created and managed from the "Place Type Manager," which lists all the Place Types within the project along with summary information for each Place Type. Scenarios are created out of Place Types assigned ("painted") to parcel polygons or other unit of geography. There are three ways to do this: 1) interactively by clicking on features, 2) querying a group of features and assigning a place type all at once, or 3) uploading a shapefile with place type overlays. | When a Place Type is assigned, the assumptions that are associated with the Place Type are transferred to the parcels and summarized across the entire scenario into indicators summarizing impacts on land use, environment, transportation, etc. |
| SPARC/INDEX | Originally an extension to ArcGIS desktop, INDEX "PlanBuilder" was introduced in 1994 by Criterion Planners to support urban and regional scenario planning, with an emphasis on measuring the sustainability of scenarios to find the most robust preferred alternative. | Evolved into "Paint the Region" in 2002 and SPARC/INDEX a decade or so later. | SPARC/INDEX On-line: SPARC stands = "Scenario Planning Analytical Resources Core," an open-source, cloud-based GIS data schema, warehouse, quality transformation, and tool interoperability service. SPARC is meant to address the issue of data interoperability across jurisdictions and allows multiple agencies to upload and efficiently use multiple data sets | Place types are created in INDEX On-line by populating a table with "paint" attributes, that is, attributes that describe a particular place type, then "painting" the various place types to a parcel or other more generalized geographic feature. | When Place Types are "painted" on to a geographic feature, all associated Place Type attributes are copied to that feature and impacts on land use, environment, transportation, etc., are calculated accordingly.<br>INDEX PlanBuilder came with a comprehensive set of 90 indicators that address land-use, urban design, transportation, and the environment. Custom versions of INDEX have indicators |

| Tool | Developer | History | Platform | Scenario Creation Approach | Indicators |
|---|---|---|---|---|---|
| | | | with a variety of sketch tools, including INDEX On-line. | | specially designed for local issues. |
| UPlan | Developed primarily by academics as a simple rule-based urban growth model intended for regional or county-level modeling. | Development coincided and ended with ESRI's support of extensibility of ArcGIS using Microsoft Visual Basic for Applications (VBA) object-oriented programming language from the mid 1990s through the mid-2000s. | An extension to ArcGIS running on Windows OS. UPlan was written in the Microsoft VBA programming language, which is no longer supported by ESRI. VBA is still available for use with newer systems via a separate installation, but it requires an additional licensing file that must be requested specifically from ESRI. | Rules-based allocation model with seven default Land Use Categories (place types). The user needs to match their General/Future/Desired Land Use plan categories to UPlan categories. If different land use categories are desired the user has to set up and use a variant model schema. This is accomplished through the Data Loader interface. To change the scenarios, the user needs to change the General Plan layer that the run is based on. The user does not "Sketch" directly into this tool, but is able to indirectly "sketch" by creating alternative General Land Use Plans, then loading them into the system. | UPlan is an allocation modeler and does not create indicators by default, but many indicators can be derived from the allocated land uses. For instance, a plugin is available that can be used to generate indicators on GHG emissions based on the households and employment generated from the allocated land uses. |
| UrbanFootprint | Calthorpe and Associates/Urban Analytics. | UrbanFootprint is an "offspring" of PLACE3S/ Envision Tomorrow/ INDEX tools and has been under development since 2010, much spurred by the passage of SB 375 in California. | UrbanFootprint is based on a fully open-source server/client software stack that does not include any proprietary components. This means that it is possible for users to implement a fully operational instance of UrbanFootprint without the need to purchase a single software license. | UrbanFootprint has a library of more than 35 Place Types and 50 Building Types used to represent existing land use plans and build new scenarios. Place Types are composed of a mix of Building Types and represent the full range of development patterns that make up existing land use and future scenarios. Once an existing plan is translated into UrbanFootprint, various scenarios can be created by editing or "painting" new place types over the original Place Types. | When Place Types are "painted" on to a geographic feature, all associated Place Type attributes are copied to that feature and impacts on land use, environment, transportation, etc., are calculated accordingly. |

# 4.0 Evaluation of the Tools

## 4.1 Evaluation Framework

In the course of conducting the literature review, we encountered many frameworks for the review of scenario tools, both sketch and beyond. These are captured throughout Appendix A. We culled these to ensure that our review categories did not miss important elements, and then added our own categories, as informed by the literature review and thinking about the specific focus of this project. Our resulting framework divides into three major tool attributes:

1. Conceptual (What kind of a tool is it?);
2. Functional (How does it work?); and
3. Implementation (What does it take to apply it?).

Most prior frameworks focus on the Functional categories, but we believe that the Conceptual dimension is essential to exploring and exposing the breadth of approaches we discuss in our literature review and to set the tools within a broader, more useful context. Many frameworks cover aspects of implementation under their functional discussions, but we wanted to separate out and highlight these pragmatic attributes given the guidebook nature of this project and the realities that agencies face in making choices (cost, time, resources, ongoing maintenance, etc.).

Within each of the three major tool attributes, we create seven conceptual categories, six functional categories, and six implementation categories. Each of these categories is further divided into subcategories that describe the specifics of the tools.

We first conducted a detailed evaluation of each tool, presented in Appendix D. The evaluation of each tool was based on information obtained from the case studies, technical documentation, and discussions with tool developers. Tool developers were given the opportunity to review the evaluations in late 2015 to ensure there were no factual errors in our descriptions of the tools.

## 4.2 Summary Evaluation

We synthesize the detailed evaluation findings presented in Appendix D in a summary matrix presented in Table 4.1. This matrix corresponds to the framework developed above, which draws on the literature review, case studies, our review of the tools themselves, and responses to our draft assessments by the tool developers.

## Table 4.1 Summary Assessment Matrix of Tools

**Legend:** Poor (red circle) | Fair (orange circle) | Good (white circle) | Very Good (light green circle) | Excellent (dark green circle)

| Category/Subcategory | | ET+ | CV | UF | Comments |
|---|---|---|---|---|---|
| **Conceptual Attributes** | | | | | |
| **Types of scenarios supported**<br>Predictive/Exploratory/Normative? | | Good | Very Good | Good | Only CV, through its Allocation and Suitability Tools, begins to accommodate Exploratory approaches. |
| **Approach to scenario creation**<br>Place Types (e.g., Predefined, User-defined?) | | Very Good | Very Good | Very Good | All have predefined Types that allow expansion and customization. Some have more Types “out-of-the-box” (UF) and other have more flexible customization (CV). |
| Method of Place Type/land use distribution (e.g., “Painting,” Rules, Models?) | | Good | Excellent | Very Good | Painting mode common to all though geographic flexibility varies currently. Only CV has a rule-based allocation option. |
| Sustainability Framework | Environmental | Good | Good | Very Good | |
| | Economic | Excellent | Fair | Good | Currently, ET+ has the most extensive capabilities here, including Return on Investment (ROI), Fiscal and employment resilience indicators and calculators. UF has a fiscal model.as does CV. |
| | Equity | Very Good | Good | Very Good | ET+ and UF have Public health indicators. |
| **Inclusion of nonspatial parameters, policies**<br>Converted to spatial effects; Maintained in parallel form in tool? | | Very Good | Good | Very Good | UF, because of its California origins, has particularly extensive energy and GHG indicators. |
| **Regional adjustments**<br>Designed for region or subarea or scalable with different attributes by scale? Does software allow combining values and averaging them? | | Very Good | Very Good | Good | UF’s modules have been California-specific, though it is now being used outside of CA as well. |
| **Educational Aspects**<br>Opportunities for feedback and double loop learning (e.g., real-time updates?) | | Very Good | Excellent | Good | For UF user must manually input new datasets currently. New GUI in 2016 will allow user to adjust key assumptions. |
| Entertainment/Engagement Quotient (e.g., Presentation Tools? Charrette tools?) | | Very Good | Very Good | Fair | Runtimes constrain instant comprehensive feedback; UF functionality for visualization still under development. |

**Table 4.1 Summary Assessment Matrix of Tools (continued)**

**Legend:** Poor (red) · Fair (yellow) · Good (white) · Very Good (light green) · Excellent (green)

| Category/Subcategory | ET+ | CV | UF | Comments |
|---|---|---|---|---|
| **Conceptual Attributes (continued)** | | | | |
| **Expert Aspects**<br>Transparency of assumptions, algorithms | Excellent | Excellent | Fair | UF is "translucent." There is some documentation, but it is not easy to look at actual relationships embedded in the tool. |
| Linkages to econometric, travel and other models | Very Good | Very Good | Excellent | Open-source tools (like UF and ET+) only a net benefit if agency staff are used to working with them. For less equipped staff, ArcGIS-based tools can be easier to use out of the box. UF automates input of census, land use, and transportation network data. |
| **Functional Attributes** | | | | |
| **Getting started – Data requirements, management, and organization**<br>Minimum amount of data required to create and run scenarios (e.g., existing land use and future land use) | Good | Very Good | Poor | UF requires parcel and TAZ-level land use and sociodemographic data; census data; transportation networks. The extent and specificity of initial data requirements means it is a more robust model, however. |
| Format (e.g., Native (Most data can stay in original format and tool can be adapted to match)); Specified (Most data can stay in original format but must have specific fields); Imported (Data must be imported into a new file/format) | Excellent | Excellent | Excellent | |
| Data Quality required (e.g., moderate) | Fair | Good | Poor | Only CV has built in checks on formula syntax. |
| Ability to organize and convert data and mapping inputs (e.g., Land use classifications; Infrastructure mapping/data) | Very Good | Excellent | Excellent | UF has a Translation Engine to interpret parcel and land use data and Place Type inputs from other formats and convert them into a base raster grid CV probably has the lowest requirements in terms of inputs; whereas, ET and UF have better organization and optimization routines. |
| Ability to link to/import other data sources | Excellent | Excellent | Fair | For UF, many California-specific datasets already loaded, but not set up to automate linking to comparable datasets outside of California. |
| Linkages to econometric, travel and other models | Fair | Fair | Poor | UF working toward out-of-the-box functionality. |
| Nonplace type approaches (e.g., allocation routines) | Poor | Excellent | Good | CV has an allocation model built-in; UF has a query tool that allows for rule-based painting. |

**Table 4.1 Summary Assessment Matrix of Tools (continued)**

**Legend:** Poor (red) · Fair (yellow) · Good (white) · Very Good (light green) · Excellent (dark green)

| Category/Subcategory | ET+ | CV | UF | Comments |
|---|---|---|---|---|
| **Functional Attributes (continued)** | | | | |
| **Creating Scenarios** (e.g., Via a Set range of Place Types; "Core" Place Types with basic attributes; "Core" with detailed attributes; Large range of Place Types; Large range of Place Types with basic attributes; Large range of Place Types with detailed attributes) | Good | Good | Very Good | UF has largest number of Place Types (over 35 currently); these are calibrated from CA and other western state environments. For ET+ Placetypes are created by defining the mix of prototype buildings. |
| Ability to add customize land use/place type | Excellent | Excellent | Excellent | |
| Soundness of allocation method | Poor | Very Good | Poor | Only CV has an allocation methodology. |
| **Creating a baseline**<br>Existing conditions (e.g., Can use LU/LC data "as is"; Must convert/match existing LU/LC to Place Types) | Fair | Good | Very Good | ET+ must convert existing LU/LC to Placetypes; UF has "existing plan translation" tools. |
| Assumptions: preloaded/template; customizable; from scratch | Very Good | Excellent | Very Good | For CV, assumptions for each core Placetype are already loaded, but can be easily be customized. Interface also allows easy creation of assumptions from scratch. |
| Trend scenario generation: Methodology (e.g., manual, assisted, defaults built in etc.) | Fair | Very Good | Good | |
| **Creating alternative scenarios**<br>Number of scenarios supported/Limitations on numbers and scales of scenarios compared simultaneously and number of features | Very Good | Very Good | Excellent | While ET and CV technically have no limits to number of features and scenarios, they both are frequently constrained by the performance limitations of ArcGIS running on desktop hardware. UF plans to support processing on multiple CPUs over "the cloud," which could make the number of features virtually irrelevant. |
| Are scenarios end-state only or can user create incremental snapshots? | Poor | Very Good | Fair | CV's TimeScope Wizard allows basic snapshots/slices and the new Allocation Tool allows multiple iterations where output of one becomes input to next. The other tools are end-state. UF scenarios present end-date results only. |
| Types of feedback: "real-time" indicators, alerts and/or warnings, error checking, others | Poor | Very Good | Fair | CV currently has the broadest options here. |

## Table 4.1 Summary Assessment Matrix of Tools (continued)

**Legend:** Poor, Fair, Good, Very Good, Excellent

| Category/Subcategory | ET+ | CV | UF | Comments |
|---|---|---|---|---|
| **Functional Attributes (continued)** | | | | |
| **Creating alternative scenarios (continued)** Changing assumptions: Easy to do/on the fly; Hard to do/separate process | Good | Excellent | Fair | For ET+, changes made in Excel templates, which then propagate through the scenario; for CV, easy to do/on the fly; for UF, real-time feedback functionality still under development, including ability to change assumptions. |
| **Evaluating scenarios and making decisions** Range of indicators produced: Default/natively; With additional inputs (to get more types indicators additional types of data would be required); Customized | Very Good | Excellent | Very Good | CV has particularly extensive formula capabilities with over 90 built-in functions that be used to create a wide variety of custom indicators. |
| Ability to add stakeholder "values" to indicators (e.g., Weighting; Rating; Prioritization routines) | Fair | Excellent | Poor | For CV, can add weighting as a multiplier assumption to an indicator or performance measure. |
| Ability to normalize indicators/create a performance "Dashboard" – method (e.g., better than/worse than today, normalized versus benchmarks, normalized for range (worst = 0; best = 100) | Fair | Excellent | Poor | For CV, this can be done and normalized by range. |
| Technical quality of indicator calculations: General overview (algorithms are simple rule-of-thumb with coarse "ballpark" figures or they are highly complex and precise, etc.) | Good | Good | Good | For UF, generally reports using high-quality/state-of-the-practice methods, but cannot be verified, as methods are not yet well documented or transparent. |
| **Presenting Scenarios and Indicators** Map outputs (e.g., one at a time/single; side-by-side) | Good | Very Good | Fair | For CV, map outputs can be displayed one at a time or two side-by side on monitor or using the report generation tool. For UF, outputs currently delivered by tool developer since end-user functionality still in development. |
| Indicator formats (e.g., Table, Charts, Export to other apps supported, Thematic maps) | Excellent | Very Good | Excellent | For UF, tables, charts, thematic maps output in open-source database tools can be queried into standard Excel and ESRI formats. ET's charting is Excel-based, and it has much flexibility in terms of graphic quality. CV defaults require some manual work for quality graphics but can be exported to Excel for presentation purposes. |

## Table 4.1 Summary Assessment Matrix of Tools (continued)

**Legend:** Poor (red) · Fair (orange) · Good (white) · Very Good (light green) · Excellent (dark green)

| Category/Subcategory | ET+ | CV | UF | Comments |
|---|---|---|---|---|
| **Functional Attributes (continued)** | | | | |
| **Presenting Scenarios and Indicators (continued)** | | | | |
| 3D Visualization: Regional scale (e.g., Thematic 3D maps, 3D maps with charts); Local scale (e.g., Parametric-generated building massing models; Parametric-generated building textured models | Good | Very Good | Fair | |
| Reporting tools (e.g., Summary of inputs, assumptions, algorithms, Summary of results, Static or dynamic, Story-boarding/saved views, Web-based, Printer-friendly) | Very Good | Excellent | Very Good | |
| Public comments captured | Poor | Poor | Poor | Noteworthy limitation of all three tools. |
| ***Implementation Attributes*** | | | | |
| **Access** | | | | |
| Platform (e.g., Free-standing desktop app, Desktop GIS extension, Desktop GIS extension and spreadsheet models, Self-hosted Web/Cloud-based, Vendor-hosted Web/Cloud-based) | Good | Good | Very Good | ET+ and CV are desktop GIS extensions. UF delivered as "Software as a Service" (SaaS) via "thin" web-based client, but in still in development. |
| Distribution (e.g., Shrink wrapped (license, installer) – Fixed seats/Floating Seats; Software as service; Open-access (free software, installer, closed code); Open-source (free software, components, open code) | Very Good | Very Good | Very Good | Both ET+ and UF are open-source, thought UF is still under development for end-user full functionality; CV comes shrink wrapped with installer/licenses for fixed or floating seats. CV is distributed as a one-step Windows installer. UF involves setting up multiple software server-stacks, which, although "free" – have a high overhead of expertise required. |

## Table 4.1 Summary Assessment Matrix of Tools (continued)

**Legend:** Poor (red) · Fair (orange) · Good (white) · Very Good (light green) · Excellent (dark green)

| Category/Subcategory | ET+ | CV | UF | Comments |
|---|---|---|---|---|
| ***Implementation* Attributes (continued)** | | | | |
| **Prerequisites**<br>Hardware | Very Good | Very Good | Very Good | One needs a lot of hardware and software to serve UF, but very little if using Software as a Service (SaaS) as a client; whereas, one needs no server software for ET+ and CV. |
| Software, including any open-source stack components | Very Good | Very Good | Good | Again, if an agency was trying it implement UF themselves, there is a very large software stack it is built-on. However SaaS would be virtually none for the client. |
| Staff Expertise required | Good | Good | Fair | ET+ and CV require skilled ArcGIS user to set up analyses. CV is scalable and supports simple to complex applications. UF requires data and GIS experience, along with IT support to set up servers. |
| **Costs**<br>Hardware | Good | Good | Good | For ET+ and CV minimal if already own desktop/laptop; for UF minimal if already own servers, otherwise possibly significant. |
| Software – Initial and Ongoing/updates | Excellent | Fair | Excellent | |
| Amount of support (e.g., consultants) needed | Very Good | Very Good | Fair | For ET+ and CV, consultant support helpful, but not required; For UF, consultant support currently required. |
| Training | Good | Very Good | Fair | For ET+ and CV, training by vendor or authorized consultants: available; for UF training by tool developer currently required. |
| **Performance/Robustness**<br>Speed | Good | Fair | Excellent | For UF, the server/client setup is that the server processing could be done in the cloud and be very fast. |
| Stability | Very Good | Very Good | Poor | |
| Methods and assumptions clearly documented | Very Good | Excellent | Fair | |
| Quality of graphic output | Good | Very Good | Excellent | CV has far more reporting tools than the others, various web reports, output to AGOL (ArcGIS On Line), Google Earth. |

## Table 4.1 Summary Assessment Matrix of Tools (continued)

**Legend:** Poor, Fair, Good, Very Good, Excellent

| Category/Subcategory | ET+ | CV | UF | Comments |
|---|---|---|---|---|
| ***Implementation* Attributes (continued)** | | | | |
| **Ease of Use**<br>Skill level to set up application and to create/evaluate scenarios | Very Good | Very Good | Fair | For ET+, users familiar with Google Maps should be capable of creating/evaluating new scenarios; for CV, takes moderate staff training (e.g., 12 hours) and time to become familiar with basics and then function with intermittent guidance; for UF, currently takes significant staff training and time to become familiar but future editions may become more user-friendly over time. |
| **Support**<br>Help files: Context accessible, Manual-based, Wiki-based, Updates | Good | Excellent | Poor | |
| Tutorials (e.g., Free/web-based, Vendor-supplied, Workshops available?) | Very Good | Excellent | Poor | |
| One-on-one support (e.g., Dedicated support staff/line, Vendor consulting-based, Email/web form-based, Wiki/discussion board-based, None) | Good | Very Good | Poor | |
| *Maintenance/updates (e.g., Manual, Automatic, Semi-automatic, Host application – done by vendor, Self-hosted – must update all stack components)* | Fair | Excellent | Very Good | |

A research design in which the report authors would have applied each of the tools to the same project might have been a more first-hand, less derivative assessment method, but it would have required additional training, resources, and time not available to the team. Our assessments are, thus, *comparative judgments* between the tools by category or attribute. In this, they differ from prior tool reviews, which tend to avoid such judgments.

No weighting is assigned the various categories and ratings, and so no definitive, cumulative assessment can be made here; the relative importance of any category or item and any cumulative assessments and decisions should ultimately be based on the user's interests and needs. The tools all have their own specific characteristics, and these vary by the needs and desires of the user. That said, however, it is apparent from our matrix that, at a conceptual level, the three tools compare well with each other, with differing strengths. Functionally, CommunityViz, the most mature of the tools, has the edge. From the perspective of tool implementation, CommunityViz seems to have the edge over ET+ currently. As noted, UrbanFootprint is still under development in some regards. Again, the tools are moving targets, and these judgments are subject to rapid obsolescence.

The matrix does not address the issue of scalability – whether the tools work well at various scales – since our focus is regional. SACOG, for example, uses UrbanFootprint at all scales, but addresses the complexities of regional predictions via the more substantial PECAS model, whose trend projections UrbanFootprint modifies based on policy goals and scenario testing. MARC in the Kansas region tends to use ET+ at the local and corridor level, but not at the regional scale. Similarly, MAPC in Boston uses CommunityViz at the local scale and provides data-loaded versions of the tool to its municipalities to apply, but relies on the Cube Land model for its regional projections.

All three tools produce outputs that can be used as the socioeconomic inputs into travel demand models, but all also incorporate default algorithms for travel behavior. These algorithms draw on research findings to allow for the comparative assessment of overall travel behavior indicators within a simpler framework than a network-based travel demand model.

Two weaknesses shared by all the tools include limited linkages to other, more in-depth, models (econometric, travel, etc.) and a limited ability to capture stakeholder discussion and comments during tool application.

The summary matrix, which provides a comparative snapshot of the three tools we have focused on, is a "bottom-line" product for this report. However, readers should exercise caution as they use it for several reasons:

- It is a snapshot in time – late 2014 to early 2016 – and all the tools are moving targets; this is especially true for UrbanFootprint, which was the least mature of the three and in beta-testing, and this penalizes some of the findings and judgments on that tool's performance, especially under functional and implementation attributes

- The graphic designations are this team's judgments based on the greater detail given in the matrix in Appendix D. In many cases, the "comments" column elaborates on these judgments, but typically only to explain significant differences in ratings. The reader must look at the detailed matrix for a fuller understanding of any category.
- Structural differences between the tools are not necessarily apparent in the matrix. For example, while ET+ and UrbanFootprint share the same conceptual roots, CommunityViz has a somewhat different origin and philosophy. This was described earlier in Section 3.3 under "Evolution of Scenario Sketch Tools."

## 4.3 Tool Trends

As noted, the above matrix captures a moment in time. In this regard, several important developments for each of these tools bear mention. New add-ons or modules are being created by university-based researchers, private firms, or user agencies, which add considerable utility and weight to the tools, particularly the open-source ones. For example:

- **UrbanFootprint** is being enhanced by a unique module, developed by staff at SACOG and the University of California (UC) at Davis that focuses on agriculture. It will allow users to specify their mix of crop types and agricultural industries and other inputs into agriculture, such as labor force, machinery, water and energy needs, and vary these in scenarios. Outcomes or indicators include costs and revenues and associated economic impacts. The U.S. Department of Agriculture is supporting this initiative, and the Farm Bureau also is a stakeholder. In addition, a significant conservation module currently is being created in collaboration with The Nature Conservancy and others. A collaboration between University of British Columbia researchers and Calthorpe Associates is expected to produce a substantial public health model. A recent fiscal impact model developed by Smart Growth America and RCLCo is now embedded in UrbanFootprint. It is possible, in fact, that the State of California may support UrbanFootprint as the statewide tool and use UC Davis to manage the evolution of the software.
- **ET+** is the target of several current enhancements. A module that addresses potential displacement and gentrification along transit corridors is being developed at the University of Texas (UT) at Austin, which is a partner in the overall development of ET+. Based on measures of development pattern intensity and other inputs, the displacement risk to renters is assessed at the parcel level, and ROI measures are applied for alternative projects. Access to job opportunities for remaining renters also is calculated as part of a strategic acquisition program by the City of Austin. A complementary effort by

researchers at the University of Michigan hopes to add a Social Vulnerability Index and a neighborhood-scale Equity component to ET+ that keys off the research on neighborhood effects. ET+ also is the target of a bicycle demand and supply analysis by UT researchers. ET+ also has a fairly recent fiscal impact module called Refit modeled after the Federal Reserve Board's Fiscal Impact Tool.

- **CommunityViz's** latest version of incorporates improvements to the Allocation Modeling Tools that enable more sophisticated allocation modeling with greater control over methods, competing land uses, and allocation iterations. The Triangle J COG in North Carolina, for example, uses focus groups and Delphi techniques to both weight factors driving land use allocation, and to vet the outcomes for reasonableness. CommunityViz also now has a basic fiscal impact model in place.
- An ongoing research effort to provide integrated economic impact metrics (dubbed "Alpaca") into several of the tools is being pursued by the former developers of CubeLand. Bid-rent functions developed for numerous jurisdictions are a key component of this evolving module.
- Local agencies are customizing tools. MARC adapted Criterion's Paint The Town (part of its INDEX suite) in 2004 for regional growth allocations to the parcel level; MAPC has adapted the ROI module from ET+, and built it into CommunityViz; several of the large California MPOs using UrbanFootprint (SANDAG, MTC, ABAG) have linked it to UrbanCanvas for visualization; Wasatch Front MPO staff have developed their own GIS scripts for a reduced set of ET+ metrics that they use routinely.

Because of these modifications, add-ons, and their evolving capacities, the tools also are being applied in new ways. These cross traditional boundaries between the public and private sectors and researchers. For example:

- ET+ is being used ("Code Next") to assess the current, complex, zoning code in Austin, Texas. ET+ applies desired or desirable Place Types in a form-based code framework to the City's vacant lands at the parcel level. These are compared to currently available zoning categories with their setback and other constraints. Their impacts on building feasibility are made evident using Sketchup and the tool's ROI module, and this supports recommendations for code changes.
- ET+ also is being used to derive a shortlist of core metrics for performance measures, which reinforces the recent focus of FHWA's guidance and criteria for project implementation by MPOs.
- An effort to link ET+ to HAZUS, an environmental hazard assessment tool, is being undertaken at UT Austin as well.
- Development offerings based on ROI and buildability analysis are now being conducted for developers, particularly for infill projects, where answers and pro forma methods are less obvious than for greenfield projects. Market

segmentation using psychographic analysis by ESRI, for example, is enriching the demographic component of market analysis for various applications.

- Exploration of new, open-source GIS platforms (as opposed to dependence on ESRI products) promises further expansions for affordable applications.
- The RAND Corporation is working with SACOG to apply sketch tools for megaregional analysis, formerly the domain of much more complex, data – hungry modeling suites.
- Coalitions of COGs are combining resources as in an MTC/SACOG/ San Joaquin effort to develop an Urban Resilience Project that builds on the knowledge being generated in California in the wake of climate change analysis in response to SB 375.

The tool enhancements and new applications described above suggest that these lightweight tools can morph into middleweight tools as their underpinnings and rules of thumb benefit from ongoing research. Some of their inherent limitations are discussed in the next section as are the mixing and matching of tools of various kinds in scenario planning.

But beyond tool enhancements and innovations in application, regional agencies also are finding ways to fund their ongoing use and maintenance of tools. DRCOG, for example, after investing five years in bringing UrbanSim into its repertoire, is now offering the model's analytical capabilities to local governments as a fee-for-service. MARC also receives fees for the technical services it offers its members for applying ET+. MARC and several other MPOs who offer Livable Communities Initiative or similar grants to their members are tying them to tool deployment under the agency's aegis. Such programs are an excellent way to diffuse tools and encourage their greater adoption and, thus, to improve planning practice.

# 5.0 Guidance on Approaches and Tools

## 5.1 Alternatives to Scenario Sketch Planning Tools

In Section 3.1, we identified three approaches to scenarios, noting that the three tools we will evaluate in detail tend toward scenario approaches that are normative in structure. That is, they solicit desired end-states and assess their impacts iteratively. This kind of work can and has been done in low-tech mode as well without the use of software-based tools of the kind we focus on in this report. An example is the North Central Texas COG's Vision North Texas 2050, which was developed between 2005 and 2010 by a large group of stakeholders, and received a 2011 American Planning Association Excellence Award for Innovation in Sustaining Places. The plan's creators used Lego™ blocks at group tables in multiple charrettes to generate initial scenarios that were somewhat predefined by the project leaders. This growth allocation brainstorming was entered into spreadsheets for simple analysis. Other similar large-scale efforts (e.g., Reality Check by the Urban Land Institute in the Washington, D.C. region in 2005 and Reality Check Plus by the National Center for Smart Growth for the State of Maryland in 2007) also have consciously chosen to avoid canned software approaches to plan development.

Since the selection and use of scenario sketch tools is such a significant step in an agency's work program and mode of scenario development and assessment, understanding the costs and benefits of much more limited, low-tech approaches should be balanced against the case studies and assessments in this report. It is important to note, however, that the actual costs of tool software is a minor expense in the decision to move forward with tools. The important costs relate to hiring and/or training staff in their use and in developing and maintaining the data they need.

Integrated travel demand, land use, and economic forecasting models such as PECAS and UrbanSim provide another alternative to sketch planning tools for some steps in the scenario process. Rather than simply analyzing user-input growth scenarios, these tools forecast the evolution of land use patterns based on user-input drivers such as transportation networks and land use policies, trends and prices that inform land use models. Alone among our sketch tools, CommunityViz allows this kind of approach, albeit in a simplified, rule-based way. In the same family is Cube Land, which predicts land-use changes given modifications to the transportation system and incorporates "MUSSA" (Modelo de Uso de Suelo de Santiago), a microeconomic approach to simulate demand and supply of real estate. These *heavyweight* tools are extremely data-intensive and require considerable technical expertise to populate, calibrate, and apply. Therefore they are only in use in between 10 and 20 of the largest or most sophisticated metropolitan areas in the U.S.

The divide between heavyweight tools and this report's focus – lightweight sketch tools – may be narrowing somewhat, however. Models like UrbanSim are now web-based, have strong visualization capabilities via UrbanCanvas, and are more accessible and rapid, but they are still a ways away from the immediacy that sketch tools offer. (Both of these products are about to be updated with an anticipated 2016 release of national coverage with a simplified UrbanSim on the cloud, and potentially an earlier release of UrbanCanvas with an emphasis on building an open data "commons" for built environment data. These tools are available from UrbanSim, Inc. at [www.urbansim.com](http://www.urbansim.com)).

This picture is changing however. DRCOG has been working on UrbanSim software, in its newer Python repackaging, and on hardware modifications and now allows the MPO to run new scenarios in five minutes that previously took nine hours. They can thus target desired allocations (e.g., 50 percent of future households and 75 percent of future jobs) to specific parcels (e.g., urban centers or transit-oriented developments) or impose different regulatory constraints, timing sequences etc., and run simulations on the fly.

We also noted in Section 4.3 that lightweight tools are being used in conjunction with heavyweight tools in scenario planning. Scenario sketch tools, for example, are being used together with more robust models for land use allocation so as to provide a more defensible and objective baseline. MAPC, for example, uses Cube Land for allocations to the TAZ level and then uses CommunityViz for smaller area work; the Wasatch Front MPO uses UrbanSim for its first cut allocation of land use and then uses ET+ for scenario work; SACOG has used PECAS, their econometric model, to produce a "reality-based" trend scenario off which they pivot, at a finer grain, with applications of UrbanFootprint (and previously with i-PlaceS) to produce Smart Growth type environments. San Francisco Bay Area's MPO, the Metropolitan Transportation Commission, needed more confidence in the vision-produced scenarios from the regional planning agency, the Association of Bay Area Governments, which had used i-PlaceS to produce their Environmental Impact Report (EIR). MTC used UrbanSim to "reverse-engineer" results to try approximate the envisioned scenarios by modifying the model inputs. The resultant compromises passed muster for the required EIR.

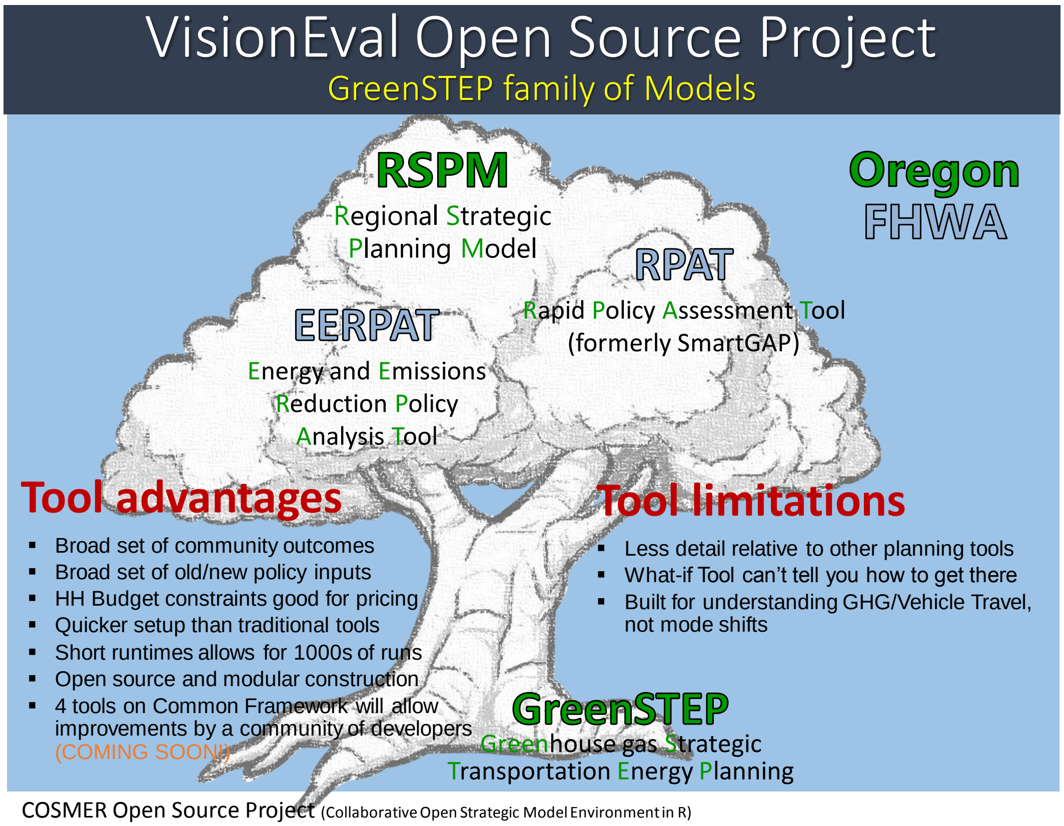
As noted up front in Section 3.2, however, the emergence of *middleweight* tools, which are more robust theoretically and also more responsive to exploratory scenario planning, in which scenarios are constructed from a range of inputs with empirically derived relationships, is an important development in the field. Three examples of such models and tools merit further coverage: these are the Regional Strategic Planning Model (RSPM) by Oregon DOT (ODOT), *Impacts 2050 from NCHRP Report 750, Volume 6: The Effects of Socio-Demographics on Future Travel*

*Demand*, developed by RAND, RSG, and others; and Geodesign Hub by Ballal and Steinitz.

### *Regional Strategic Planning Model*

RSPM is part of a family of tools developed by ODOT, shown in Figure 5.1, many of which have been peer-reviewed and embraced by the FHWA.

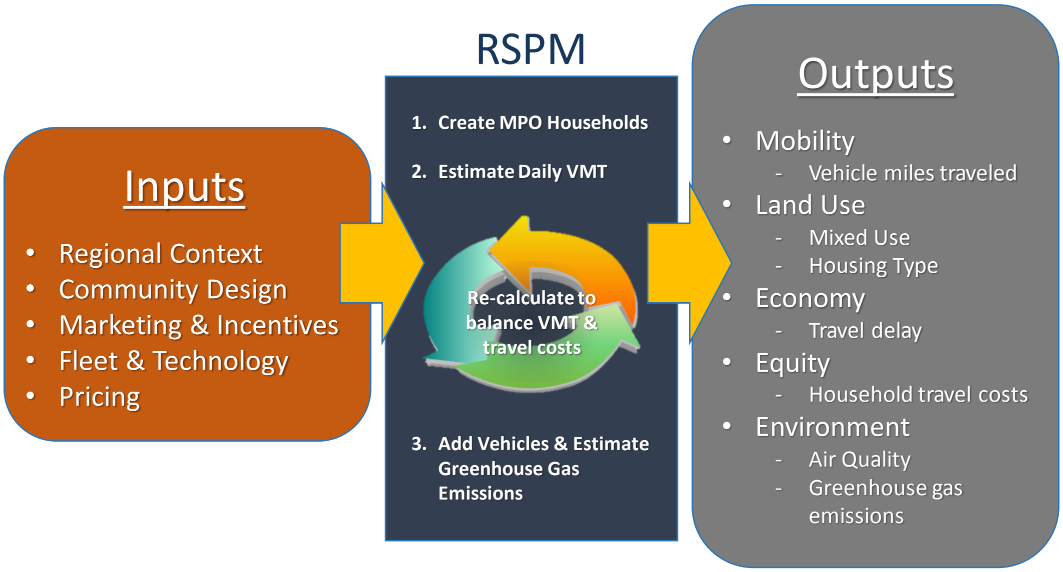
**Figure 5.1 ODOT Family of Models, Including RSPM**




Source: Tara Weidner, Oregon Department of Transportation.

RSPM is designed to respond to GHG reduction strategies and to complement other tools, have quick runtimes, be simple and visually interactive, emphasizing breadth over depth. RSPM comes very close to matching our criteria for a regional scenario sketch tool except that it does not create scenarios – they are external to the tool and some of their assumptions are inputs into the tool. The structure of the model is shown in Figure 5.2.

### Figure 5.2 Structure of the RSPM Model




Source: Tara Weidner, Oregon Department of Transportation.

Depending on the inputs entered, different scenarios are created for the distribution of synthetic households, which is based on balancing household travel costs and vehicle-miles of travel (VMT). Spatial resolution is at a "district" scale. The inputs are further defined in Figure 5.3, which provides a sense of which variables are massaged in the model.

### Figure 5.3 RSPM Inputs

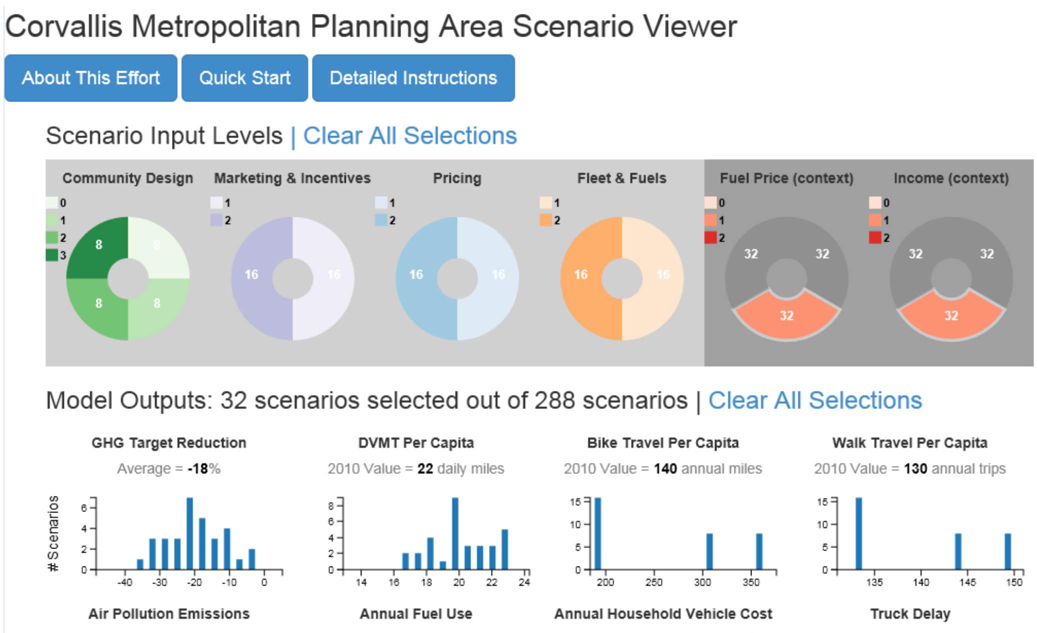
| Regional Context | Local Actions | | Collaborative Actions | |
|---|---|---|---|---|
| | Community Design | Marketing & Incentives | Vehicles & Fuels | Pricing |
| • Demographics<br>• Income Growth<br>• Fuel Price | • Future Housing (Single- & Multi-Family)<br>• Parking Fees<br>• Transit Service<br>• Biking | • TDM (home & work-based)<br>• Car Sharing<br>• Education on Driving Efficiency<br>• Intelligent Transportation Systems | • Vehicle Fuel Economy (mpg)<br>• Fuels<br>• Commercial Fleets | • Pay-As-You-Drive Insurance<br>• Gas Taxes<br>• Road User Fee |

Source: Tara Weidner, Oregon Department of Transportation.

Model outputs and its graphic interface are displayed in the next figure. Selections made in the "circle" variables produce instant results in Figure 5.4 as applied in the Corvallis MPO in Oregon. Thousands of alternative scenario combinations were pre-run overnight and incorporated into a web-based interactive viewer for exploring with an intention to identify the outcomes of chosen policy actions or the reverse – what policies meet desired minimum outcomes.

The family of tools in Figure 5.1, including RSPM, has been renamed VisionEval, which is much more than a rebranding. It is a refactoring of the code (and the definition of a model system) underlying GreenSTEP, RSPM, EERPAT, and RPAT to make these models very modular, extensible, open source, and open access.[2] This open-source tool (scripted in R) and its family are actively seeking other users who can add modules to it and join its user consortium. The Atlanta Regional Commission (ARC) is considering adopting this tool in work towards its 2020 Regional Plan.

### Figure 5.4 RSPM Applied to the Corvallis MPO




Source: http://www.oregon.gov/ODOT/TD/TP/Pages/scenarioviewer.html.

## *Impacts 2050*

*Impacts 2050* is another "middleweight" tool. It is a systems dynamics model developed for the *NCHRP Report 750, Volume 6: The Effects of Socio-Demographics on Future Travel Demand* by a team, including RAND, RSG, and the Renaissance Planning Group. Its focus is the influence of socio-demographic change on travel behavior. It is geographically aggregate (e.g., models a metropolitan area as one entity) and divides people into categories by age, household structure, "acculturation," race/ethnicity, workforce status, household income, and residence area type. It models demand for residential space and the transitions of populations between groups over time. It also models car ownership, trip rates, mode choice, trip distance, and employment and demand for commercial space. *Impacts 2050* models aggregate transportation systems (road and transit supply). The model has been tested for Atlanta, Boston, Detroit, Houston, and Puget Sound.

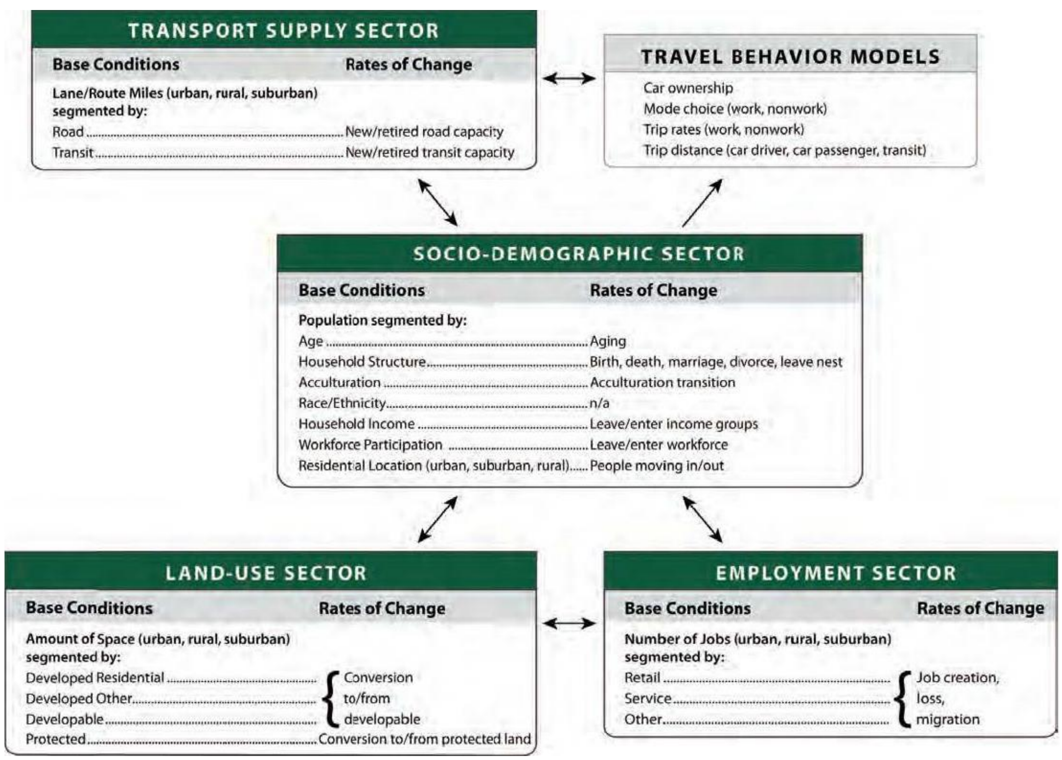
[2] Project web site: https://gregorbj.github.io/VisionEval/.

It has recently been applied by the Delaware Valley Regional Planning Commission (DVRPC) and the Mid-Ohio Regional Planning Commission (MORPC), who are very interested in diffusing the tool to others.

The model comes with four preset scenarios – Momentum, Technology Triumphs, Global Chaos, and Gentle Footprint – which can be modified by the user. These scenarios are exploratory in nature and are derived from an in-depth consideration of driving forces and their likelihood and impact. Each scenario has characteristics associated for demographics, employment, land use, transportation supply, and travel behavior.

The structure and interactions of the model are represented in Figure 5.5.

**Figure 5.5 Impacts 2050 Model Structure**




Source: *NCHRP Report 750, Volume 6: The Effects of Socio-Demographics on Future Travel Demand*.

Some important differences between RSPM and Impacts 2050 are worth noting:

- Impacts 2050 is geared more toward evaluating the effects of external influences on transportation (e.g., age demographics, immigration, employment, etc.) than toward policies that can influence transportation. While RSPM also addresses external influences (age demographics, household income), it does not do so as comprehensively. However, RSPM is much more oriented toward assessing the effects of many different policies that influence transportation (e.g., pricing, transportation system management, pay-as-you-drive insurance, travel demand management).

- This difference stems from the different study goals behind these models. *Impacts 2050* came out of the NCHRP research to study the effects of socio-demographics on future travel demand (externally oriented). RSPM originated from GreenSTEP whose purpose was to help determine how to reduce GHG emissions to meet state goals (policy-oriented).
- Impacts 2050 models more attributes of the population (race, ethnicity, acculturation) and models transitions in the population over time. It does so at a more aggregate level (putting people into groups). RSPM simulates individual households, but limits demographic characteristics to age and income.
- Impacts 2050 treats the metropolitan area as one geographic unit with three land use categories (urban, suburban, and rural). RSPM divides up the metropolitan area into districts with each district having a population density and a proportion that is urban, metropolitan, or urban-mixed use.
- Impacts 2050 models residential and commercial land markets in the aggregate. In RSPM, the supply of housing units by type in each district is specified as a scenario input. The model then assigns households to housing types and districts. Employment and commercial space are not modeled.

These two models can complement each other. DVRPC, for example, is using both Impacts 2050 and the Regional Planning Analysis Tool (RPAT), a land use-focused tool that was a product of the Strategic Highway Research Program (SHRP) 2, Project C16.

Both RSPM and Impacts 2050 represent approaches to creating scenarios that are more "objective" and empirically based than scenario creation in the sketch tool realm. They allow of scenarios that go beyond the predictive mode but they are more strategic in nature (more narrowly focused and specialized) than the sketch tools assessed in this report, which are broader in scope. In the impacts department, they are also more focused and limited than the range of indicators typically derived in the regional sketch tools.

### *Geodesignhub*

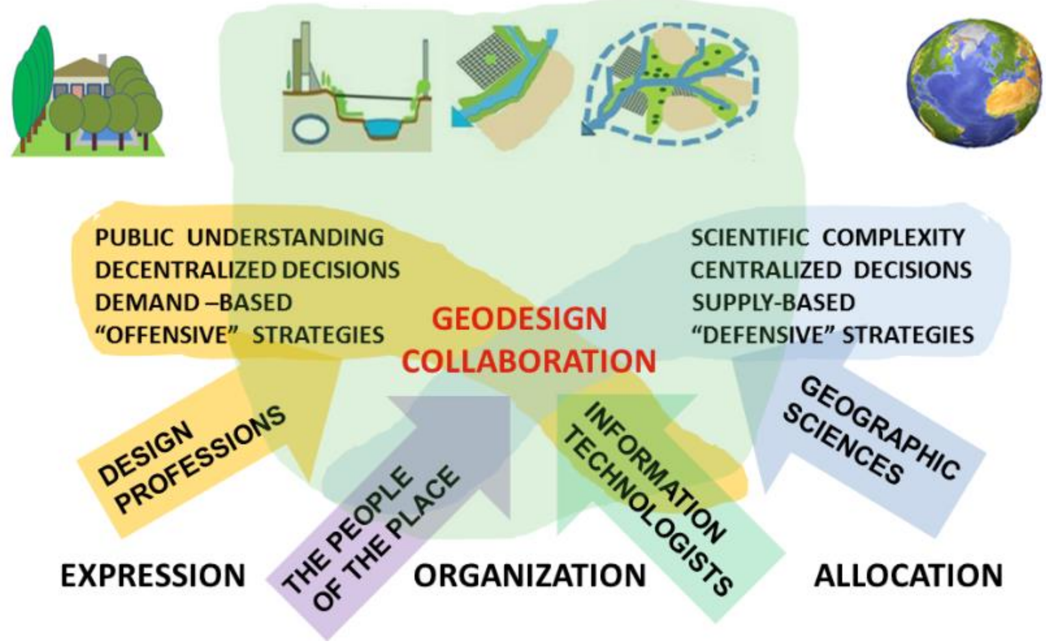
This tool has a very different provenance than the three dissected in this report or, for that matter, than the other tools referenced in this report. It derives from the seminal work of Carl Steinitz who, over the past 50 years, has influenced generations of planners as a teacher in the landscape architecture program at the Harvard School of Design. The philosophy behind the tool stands in the tradition of the regional science and planning school exemplified in the pioneering work of Patrick Geddes, further developed through the influential ideas of Kevin Lynch and undergirding the work of Ian McHarg. There is a straight line connecting McHarg's iconic book, *Design with Nature* (1969) with the creation of geographic information systems, the overlay approach to regional design that is baked into the DNA of ESRI's products.

Geodesign, as Steinitz's framework has come to be known, has gestated over the past 50 years and, thus, represents a mature, systems approach to collaborative design. It has typically been applied in two- to three-day workshop or charrette settings as an off-line methodology for years, and has only just found expression in a comprehensive software product called Geodesign Hub, developed by Hrishikesh Ballal, one of Steinitz's former Ph.D. students.

This description of the approach and tool is in the form of summary bullets that capture its differences from the tools analyzed to date, note its key characteristics, and present core diagrams that illustrate the framework. More information on the tool can be gleaned from https://www.geodesignhub.com/, a comprehensive support manual at http://www.geodesignsupport.com/, from Youtube videos like https://www.youtube.com/watch?v=rwZjeUCSqc0 and, most completely, from Steinitz's 2012 book *A Framework for Geodesign: Changing Geography By Design.*

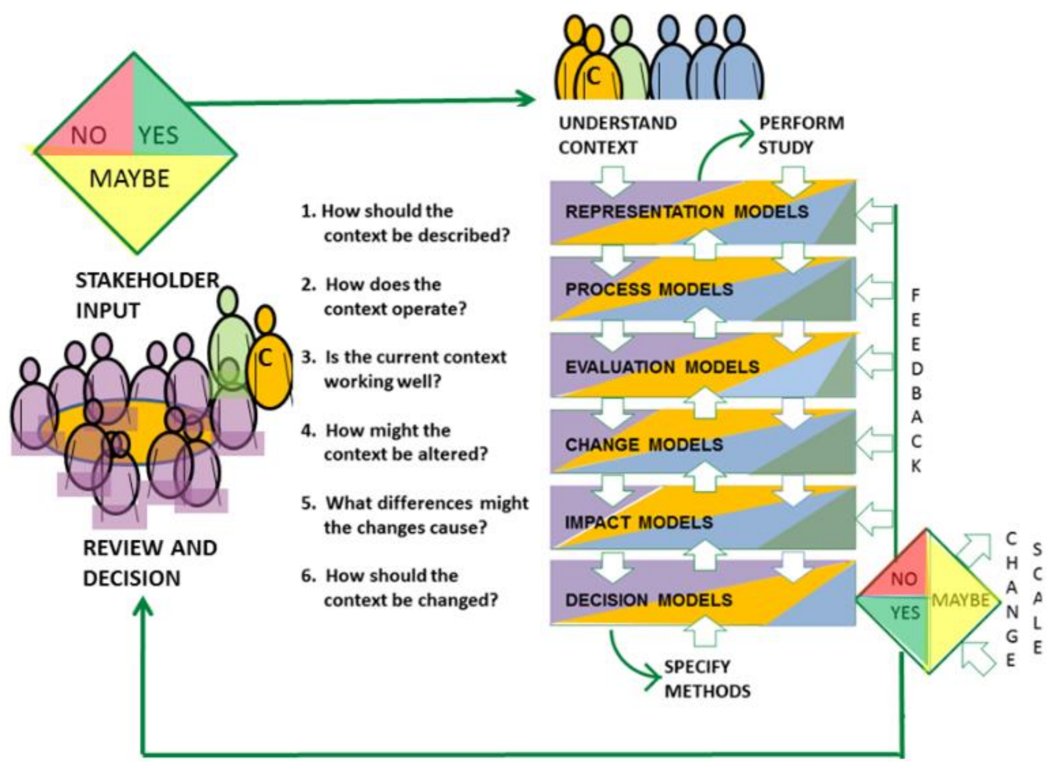
- Geodesignhub was conceived to address the gap in tools and models that we have noted earlier and described as middleweight tools for middle-scale contexts, rather than neighborhood or multiregion contexts (see Figure 5.6 and the graphic representations of scale above the diagram).
- The framework is organized around a collaborative process that requires users to address six questions relating to six models and requiring a sequence of three iterative processes (What? Where? When?) in a workshop setting (see the core conceptual diagram of Figure 5.7). Figure 5.8 shows the normal workflow sequence through the third iteration on Figure 5.7 when applying Geodesignhub.
- In terms of the typology of scenario approaches used in this report, Geodesignhub sits somewhere between the end-state and exploratory approaches (see Figure 5.9, whose nomenclature above and below the three columns in the graphic echoes concepts used in this report). These ways of designing when generating the spatial and temporal consequences of scenarios are described in Steinitz (2012).
- The tool is an empty shell to be populated by the user; compared to other sketch tools, it requires minimal data and no GIS expertise; the tool itself is very flexible; the design process that it supports is very structured.
- It is a cloud-based, open-source, open-platform software written in Python and Node/JavaScript and is explicitly designed to link to other tools or models, rather than containing complex substantive algorithms itself; its design is tied to the collaborative design process it supports. The software is dynamic, in that any single change and its impacts can update all systems states.
- Geodesign Hub is best used is at the very beginning and strategic stages of resolving a large and complex problem.

**Figure 5.6 Where Collaboration in Geodesign is the Most Significant**



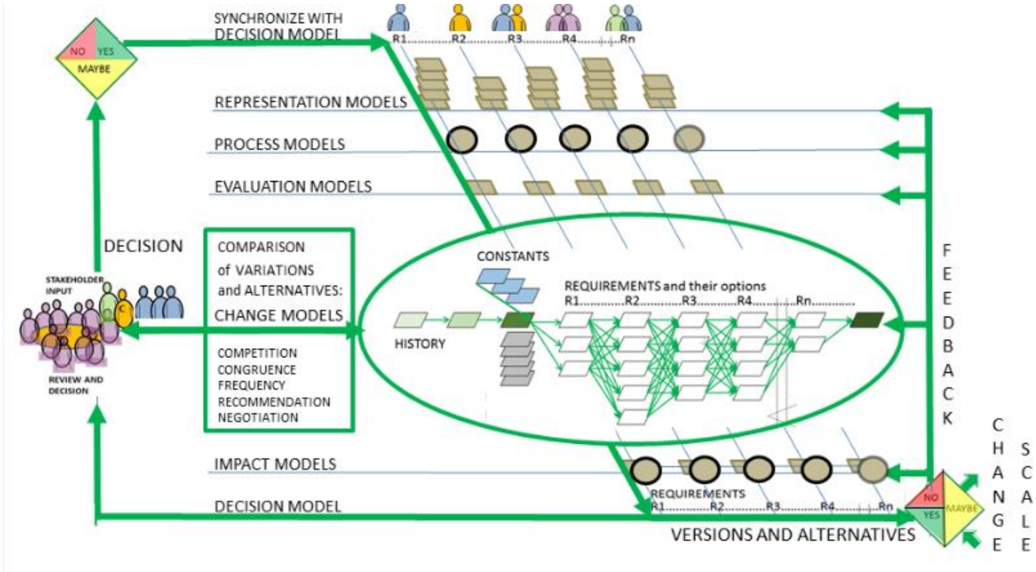

Source: Carl Steinitz.

**Figure 5.7 The Stakeholders, the Geodesign team, and the Framework for Geodesign**



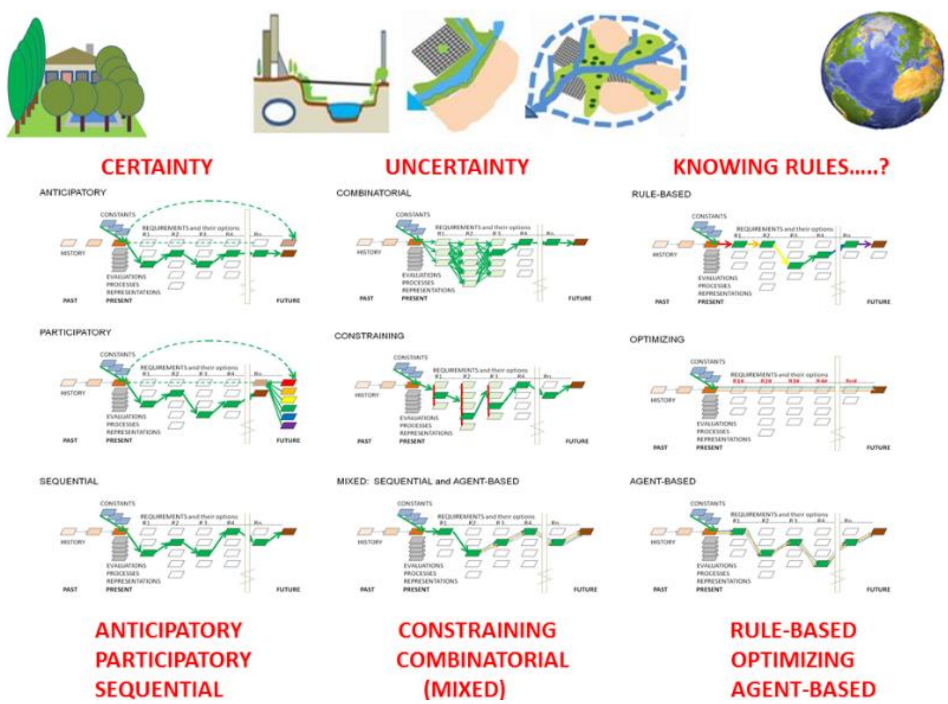

Source: Carl Steinitz.

## Figure 5.8 The Dynamics of Geodesign Support Technology




Source: Carl Steinitz.

## Figure 5.9 Change Model Strategies: Ways of Designing




Source: Carl Steinitz.

- Geodesignhub, in contrast to the three tools analyzed in this report, is explicitly designed to incorporate sketching, GIS, drawn diagrams, and diverse algorithmic approaches as inputs to describe systems' changes. These methods also can be combined when making a future state.
- Rather than using Place Types to create future visions, the tool accepts multiple iterative design diagrams from multiple teams that can be synthesized in different ways.
- This process is not expert-driven; it generates scenarios based on diverse stakeholder knowledge and perspectives; the tool is particularly strong in surfacing a plan that maximizes consensus.

## 5.2 Fitting the Tool to the Planning Approach

Given the range of scenario types and tools or models available and under development, more guidance on which to use when and where is desirable. Fitting tools to tasks and contexts has been the subject of limited practice, research and publication. There are several ways to think of this challenge.

One, which organizes scenario approach by how predictable the future is in a particular region and how much influence the particular agency has over it, is represented by Figure 5.10. To elaborate on the logic of some of the cell placements in the matrix, where the future is both unpredictable and policy influence is low (top left cell in the matrix above), it is critical to explore plausible futures well so as to develop a broad repertoire of responses. Conversely, when both the regional future is reasonably predictable and the agency has strong influence on outcomes (bottom right cell), it is reasonable to engage in baseline or end-state scenarios.

At the level of matching planning contexts to tools, Figure 5.11 suggests the key factors at play and where various tools currently align.

A more complete and complex guide is found in Chakraborty and McMillan (2015) in which the same tripartite scenario typology that is used in this report is related to the structure of the organization, stakeholder engagement and so forth. This guidance, however, remains general on the tools front.

In terms of the three levels of tools and models (lightweight, middleweight, and heavyweight) defined in this report, one way to position their appropriate use is in terms of their ease of use and how much of the seven-step scenario process (Figure 3.1) they address. Figure 5.12 does this.

**Figure 5.10 Predictability versus Policy Influence**

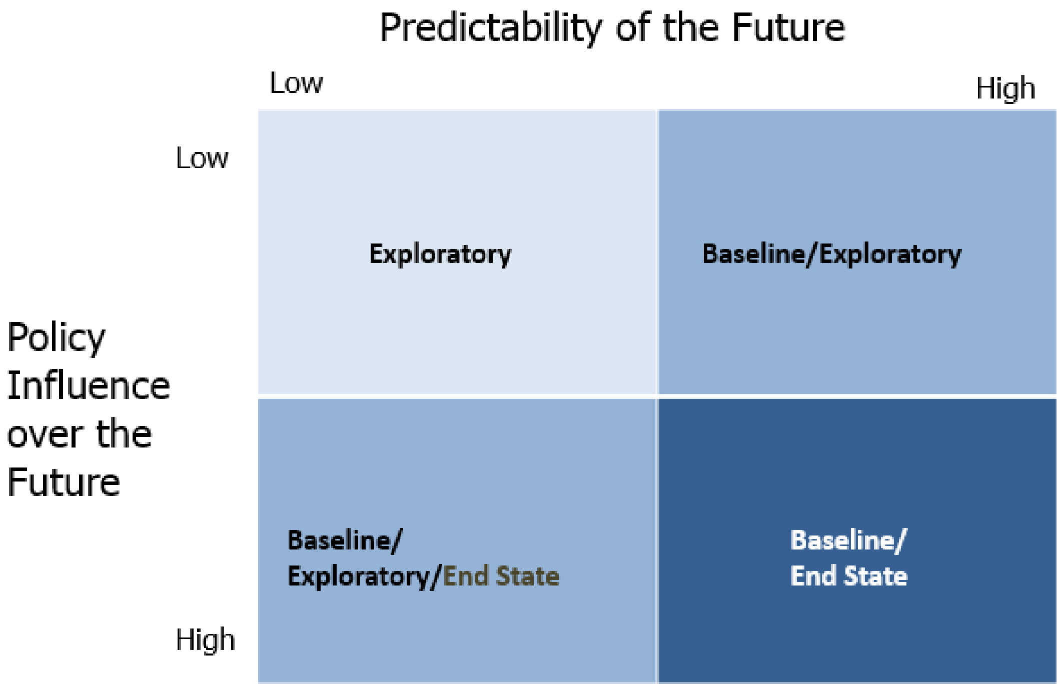



**Figure 5.11 Alignment of Tools with Driving Factors**

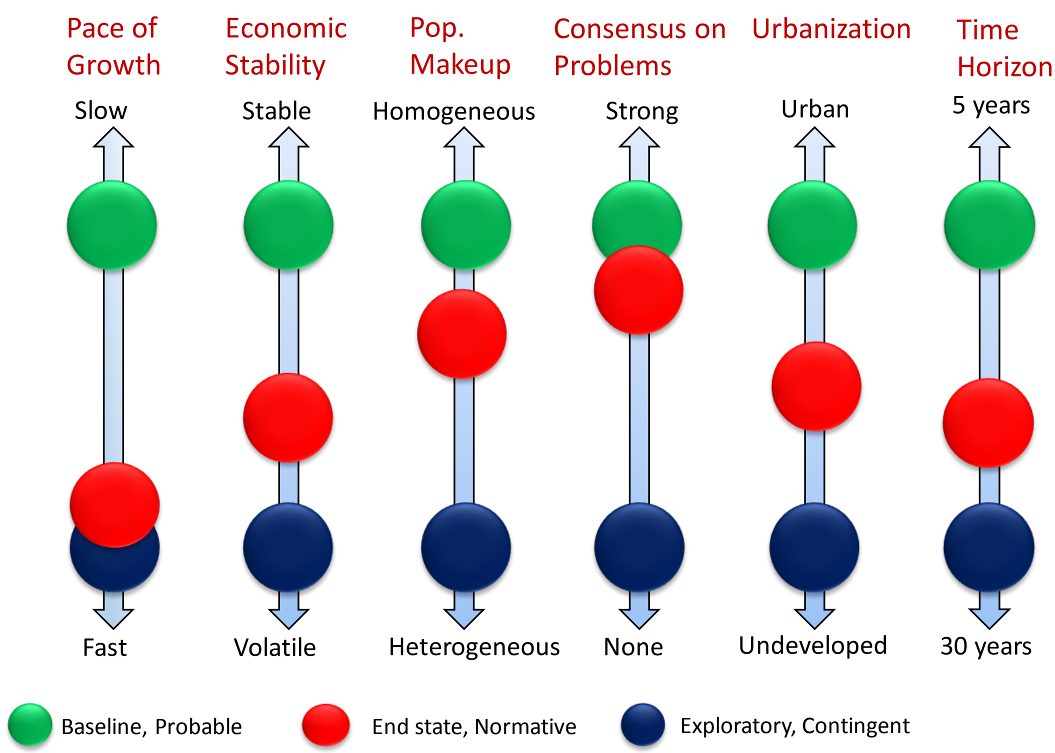
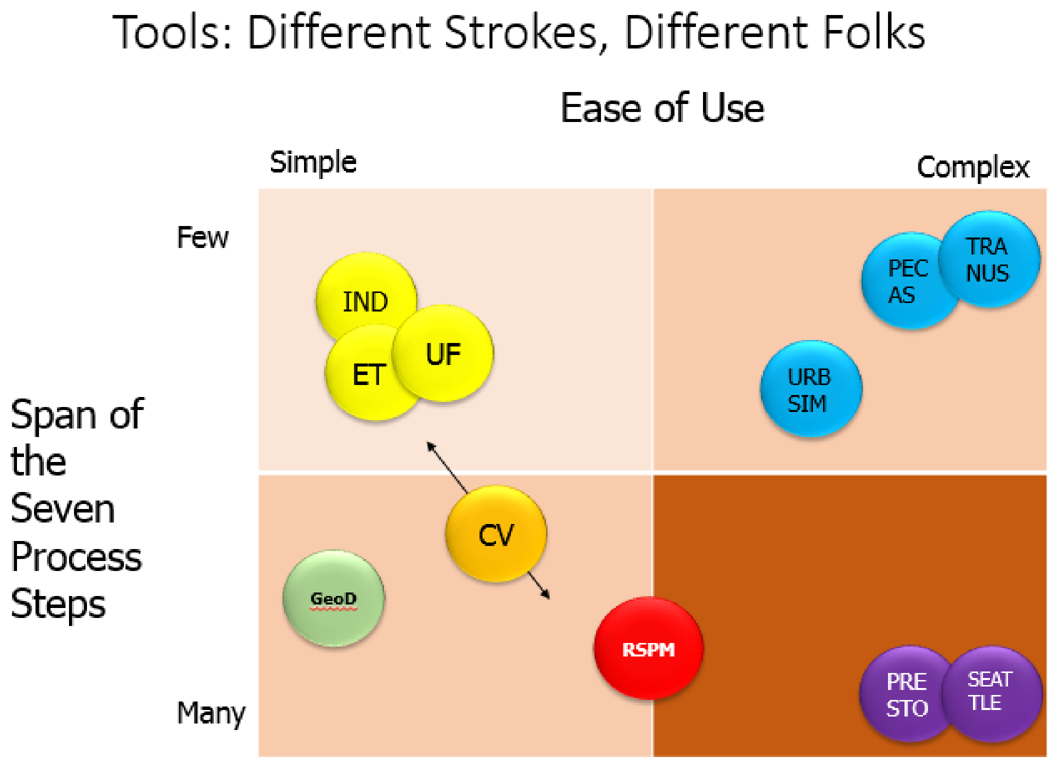


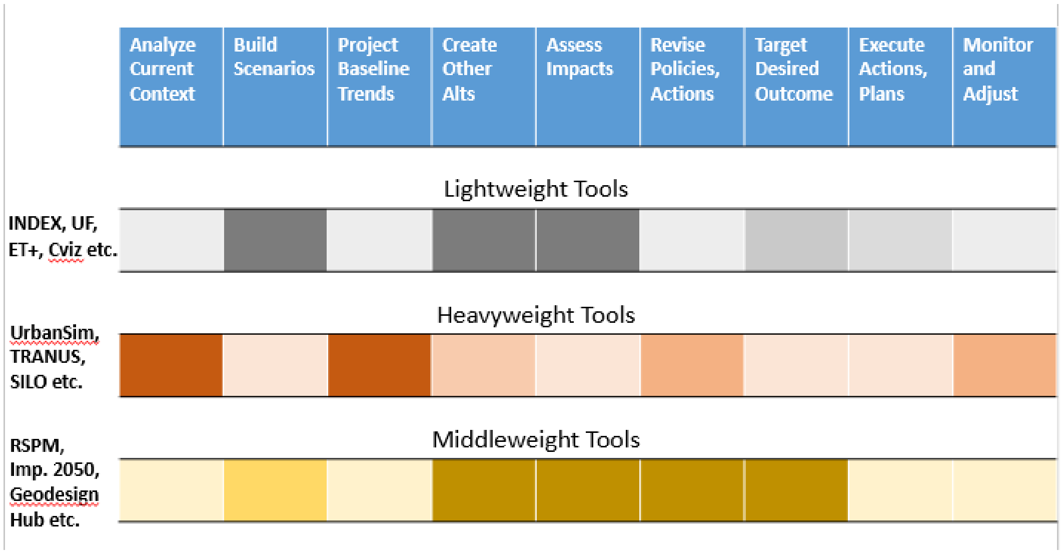
**Figure 5.12 Tools Evaluated by Ease of Use and Span of Scenario Planning Process Covered**




Three well-known tools that have been referenced in this report, ET+, UrbanFootprint, and INDEX, are shown in the top left cell, the domain of simple tools that do not cover all the steps in the scenario process. CommunityViz, by virtue of its allocation capacity and other features, can move around this diagram depending on the application and expenditure of resources, as the diagonal line suggests. Geodesignhub has some unique characteristics that place it in the lower right cell. The two circles in the bottom right cell refer to the PRESTO project by the National Center for Smart Growth at the University of Maryland (http://smartgrowth.umd.edu/PReSTo.html#overview) and the University of Washington's modeling suite around the Snohomish Basin scenarios project (http://urbaneco.washington.edu/wp/research/snohomish-basin-2060-scenarios/).

Another take on the question of how tools address the different steps in the scenario process is presented in Figure 5.13, which relates tool types against the scenario steps showing in darker tones, where the various tool types have their greatest strengths and applicability.

### Figure 5.13 Comparative Strengths of Tool Types by Scenario Steps




The obvious point to be made here is that there is no magic bullet on the horizon and it would likely be counterproductive to try to design the right comprehensive tool for all seasons. The inherent conflicts in tool and model design between transparency, simplicity, complexity, public engagement, lay versus expert users and so on mean that we need a menu of tools equal to our diverse circumstances.

Figures 5.12 and 5.13 do not address the question of scale in relation to approaches and tools. Figure 5.14 does this in a simplified way, suggesting tool types and processes at different scales, but an important caveat applies: as we have stressed, tools are moving targets and as they evolve, they can and are crossing scale boundaries. Nevertheless, at this time, the scenario sketch tools we have evaluated are probably most credible as stand-alone applications, in terms of public understanding and input as well as outcomes, at the more local scale.

The selection of any of these tools has, of course, significant implications for the expenditure of time (and, therefore, resources). As a rough guide, Figure 5.15 suggests these implications.

**Figure 5.14 Tools and Processes in Relation to Project Scale**

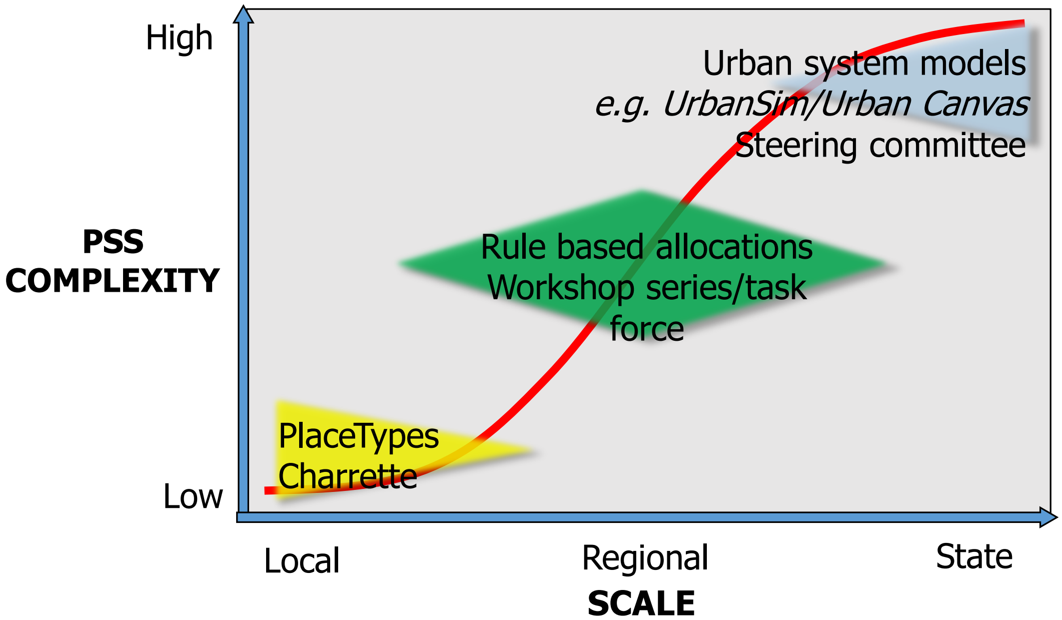
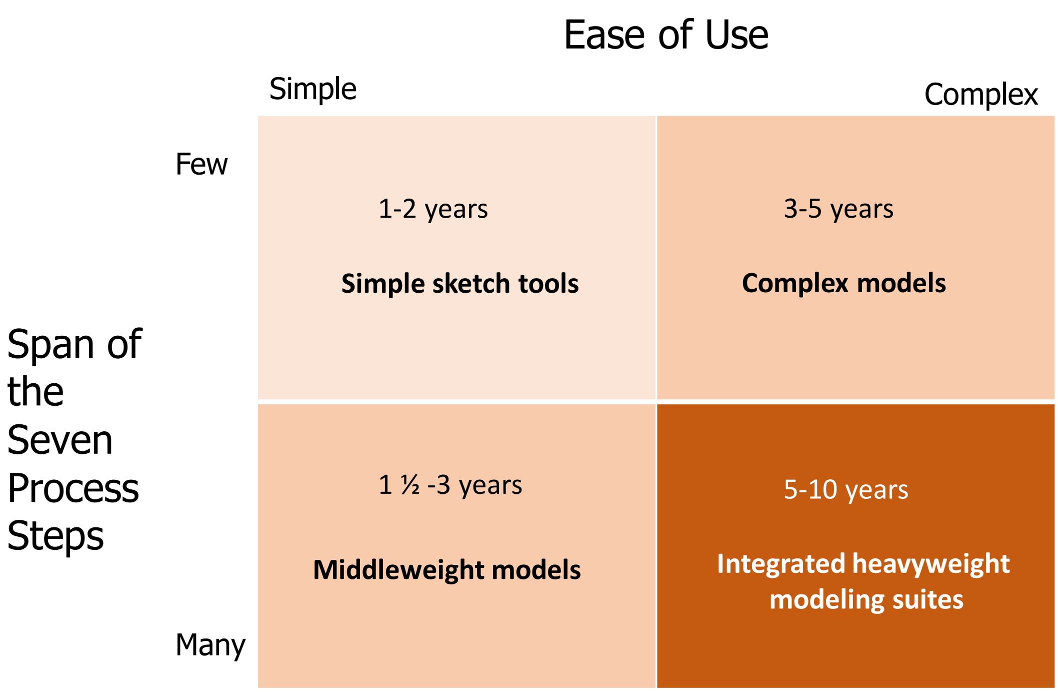



**Figure 5.15 Characterization of Each Cell in the Ease of Use-Span of Steps Matrix**



# 6.0 Suggestions for Further Research and Development

## 6.1 The Future of Scenario Sketch Tools

Scenario sketch planning tools are now into their third generation. This is a dynamic and changing field and some early pioneers have left the arena, others have spawned follow on versions and others have stayed active, updating and upgrading their capabilities as computing resources and data resources have exploded. Around a half-dozen scenario sketch tools have usually been in play and supported by their developers at any one time. The current crop of the three leading tools – the focus of this report – is smaller; the tools overlap with each other's capabilities, and their developers continue to add modules and to compete strongly in the U.S. and now the international market.

Overall, the current generation of tools has matured to the point where they are all stable products (earlier versions were prone to hardware and software glitches), run faster than ever and are more accessible than ever. These advances will help address some of the major adoption hurdles for scenario planning, including funding to hire experienced staff or consultants, time and resources given existing staff workloads, and staff's limited experience with scenario planning. The trend toward more supported, web-based open-source tools will also facilitate greater adoption of scenario planning and tool usage.

The nature of scenario planning is in flux. The interest in exploratory scenarios is not yet tool-supported (and may, by definition, be less susceptible to planning support system tools than end-state scenario work) but its emphasis on addressing uncertainty is a healthy counterpoint to normative thinking. Facing uncertain driving forces raises questions about standard scenario indicators. The reliance, for example, on VMT as a key staple indicator in regional scenario outputs is quite upended by the impending arrival of automated vehicles and zero emission vehicles.

Some tool users are moving toward establishing or strengthening user groups, others are pushing to standardize scenario metrics as a means of encouraging more scenario and tool usage. Some are seeking to organize different offshoots of their tools into a Federally supported, consolidated tool.

Tools too are in flux, as we have noted many times throughout this report. Some lightweight tools are developing more complex modules and applications; the advent of user-friendly middleweight tools adds more and welcome choice to a current menu of scenario sketch tools that share many common roots and are, therefore, somewhat inbred. These fluid currents and dynamics suggest a field that is itself ripe for the application of exploratory scenario thinking, which is addressed next.

## 6.2 Future Scenarios for Regional Sketch Tools

In standard Exploratory scenario mode (see the steps in this process in Figure A.4 in Appendix A) the following is a selected list of Givens and Indeterminates that apply to the near future (the next five years, say):

- **Givens:**
  - More and faster computing capacity;
  - More interest in scenarios from planners;
  - More interest from Federal and state agencies in GHG reduction; and
  - The growth of Federal interest in and multistate coalitions around megaregions for water, energy, climate change and GHG challenges.
- **Indeterminates:**
  - Extent of Federal intervention;
  - Extent of MPO empowerment;
  - Number and role of tool developers and vendors;
  - Scope of technological breakthroughs requiring rethinking of basics;
  - Importance of regional planning; and
  - Acceptance of mitigation against climate change.

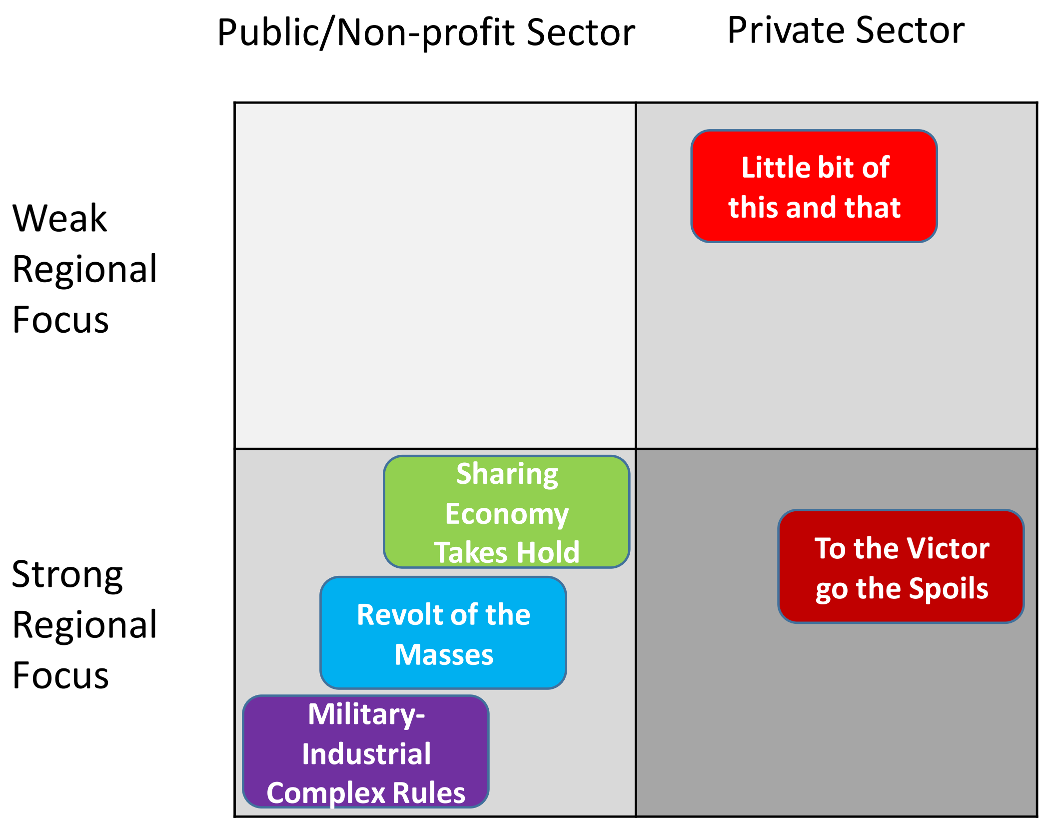
If one further explores the Indeterminates and arrays them by the standard STEEP categories (Social, Technological, Economic, Environmental and Political) a more extensive set of drivers can be yielded. These are organized into five different scenarios in the following table. The flags or signals to watch for in monitoring movement toward one or another scenario are implicit in the assumptions in the cells.

From the perspective of sketch tools, the driving forces identified in Table 6.1 can be further consolidated and clustered around two key axes – Regionalism and Public/Private-Sector roles. This configuration produces a 2x2 matrix as in Figure 6.1. The five scenarios from Table 6.1 are arrayed in this matrix.

**Table 6.1 Future Scenarios for the Short-Term Evolution of Sketch Tools: Primary Drivers**

| | Scenarios | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| | Little Bit of This, Little Bit of That | To the Victor Go the Spoils | Revolt of the Masses | Military-Industrial Complex Rules | Sharing Economy Takes Hold |
| **Social** | Little significant or sudden change | Entrepreneurs and venture capitalists see the benefits of harnessing big data and models to planning and policy challenges | User groups multiply and coalesce to pressure agencies, institutions, and vendors to support user agendas for model and tool improvements and standards | U.S. maintains leadership in science and math innovations | The collaborative economy is embraced by millennials and drives innovation<br>Job mobility blurs public- and private-sector boundaries |
| **Technological** | Continued, but steady, progress | Various crises or opportunities (economic, environmental, etc.) inject huge demand and profitability into the regional toolmaking technology market | Open access to computing resources and web levels the playing field for public-sector innovators | Major technological breakthroughs in computing, transportation, health require Federal, state, and regional coordination | Open access to computing resources and web levels the playing field for public-sector innovators |
| **Economic** | Little significant change | Consolidation in marketplace of tool developers, vendors and absorption by larger, well capitalized companies | Local and regional agencies continue to lack funds to address emergent shocks and Federal and state mandates to address them | Sudden economic shocks or changes (shortage or boom) make regional and state collaboration a priority | Shareconomy and collaborative consumption penetrate everyday commerce in all sectors with great success |
| **Environmental** | Trends continue, but no shocks or thresholds passed | Environmental activism embraced by many public- and private-sector players; various shocks add to this movement | Climate change, water scarcity, and similar shocks or challenges become widely acknowledged priorities | Climate change, water scarcity, and similar shocks or challenges become widely acknowledged priorities | Environmental activism embraced by many public- and private-sector players |
| **Political** | No changes sufficient to support changed roles and powers at state or regional levels | Federal policies support private-sector innovation and growth | Federal government requires local, state, and regional responses to emergent shocks and support and empower public-sector entities (including universities, nonprofits) to address these | Shocks in above driving trends cause Federal government and states to intervene and to emphasize regional collaboration | Federal easing of rules and regulations to facilitate shared economy |

**Figure 6.1 How the Sketch Tool Scenarios Relate to Key Parameter**




## 6.3 Suggestions for Further Research and Development

Our suggestions for productive areas of further research and development, in the light of this report's explorations and findings, are presented below.

1. **Address and support exploratory scenario practice.**

   In defining scenario approaches in Section 3.1, we noted that Exploratory scenarios represent a very different approach and mindset than Normative scenarios, the approach that the most popular sketch tools are typically set up to generate and analyze. While Exploratory scenario thinking has a well-developed and rigorous methodology associated with it (see, for example, Figure A.4 – Typical Contingent Scenario Planning Approach – in Appendix A), honed by decades of application in the military and business worlds, this methodology has only recently been adopted (but not necessarily *adapted*) for urban planning. It is important to provide planners with support systems for this kind of scenario work that explicitly addresses uncertainty in an increasingly uncertain world.

It may be that the analysis-of-driving-forces aspect of creating exploratory scenarios and their creative synthesis into scenarios may essentially be an iterative process of debate and research that is fundamentally resistant to being "modeled"; that attempting to somehow model it is the wrong idea. Nevertheless, it is quite possible that parts of the exploratory process (consensus seeking tools, idea clustering tools, including factor analysis apps) can be facilitated by decision support tools and software. Indeed, there are several such tools now available to do this.

Some of the current commercially available tools may also be capable of morphing into frameworks that facilitate exploratory scenarios. We have noted earlier that the allocation module of CommunityViz, for example, requires scenario developers to debate the relative importance and role of the forces driving development rather than what they would like to see where.

The other relevant aspect of this area of research and development is that many exploratory scenarios have now been developed for planning purposes that can be assembled and organized so as to constitute a "library" of options that planners can select from and modify without reinventing the wheel. We noted the freight scenarios developed for the *NCHRP Report 750, Volume 1, Scenario Planning for Freight Transportation Infrastructure Investment* (2013), and those with a socio-demographic emphasis developed for *Impacts 2050* in NCHRP Report 750, Volume 6. There are others and a valuable task would be their collection, review and organization.

2. **Encourage work on middleweight models and tools for regional scenarios.**

   This suggestion is related to the first one. There is merit in encouraging the growth of middleweight tools. They have the potential to allow for more exploratory scenario work and for more robust scenario creation. The two examples cited in this report are testimony to this potential but there are other examples (e.g., see the Town of Sahuarita's exploratory scenario work to evaluate their comprehensive plan, funded by the Lincoln Land Institute, at https://www.lincolninst.edu/pubs/download.asp?doc_id=2955&pub_id=3608, and Lincoln's 2015 work with the Southwest Colorado COG).

   Sponsored research on such planning efforts through NCHRP and FHWA or by NARC or AMPO are ways to do this. Adoption and peer-testing by FHWA or other agencies of such models and tools by advanced agencies is another. The small number of current middleweight tool users are the nucleus of a user group.

3. **Be more explicit about capturing stakeholder values in sketch tools and processes.**

   The selection of scenarios to develop and analyze in the private sector or in the military reflect the missions and interests of their authors, which tend to be clear and explicitly articulated. In the public sector, in regional planning contexts, these interests and values are not necessarily explicit or unified. They warrant clear articulation and scenario tools structures should facilitate this.

There can be inherent tensions and tradeoffs within the concept of sustainability. Balancing equity, environmental and economic goals within a given context will always entail tradeoffs in the development, analysis and implementation of scenario-based efforts. Where tools have gaps (e.g., too few or too many indicators in a certain area) or lean toward certain outcomes (e.g., historic development trends very heavily influence predictive tool outcomes), these should be so noted by tool developers, reviewers and user groups. Sometimes these can be self-evident in the scenario names or narratives (e.g., emphasizing environmental, land development or fairness concerns) but often they are only implicit.

4. **Encourage the combination of various sketch tools with other models in regional planning processes.**

   This point relates to the previous one. Some tools or models do some things better than others as Figure 5.9 makes clear. Using a variety of tools and models in combination can provide a more robust approach. Where tools can be linked or coupled, this will facilitate such approaches. Some examples from practice discussed in Section 5.1 highlight this point. A reason to watch the relationship between heavyweight and lightweight approaches is their potential to work synergistically to produce results that are more market informed and theoretically grounded than sketch tools alone. Heavyweight tools (or sketch tools applied regionally) also provide the bigger picture context that more localized application of a sketch tool may ignore.

   While outside the realm of sketch tools, some places have combined various models that allow them considerable flexibility to simulate various trends and policies in ways that may not be accessible to the public but are readily accessible to staff for scenario work. Portland, Oregon, long a leader in planning applications, developed Metroscope, a set of decision support tools. These include an economic model that predicts regionwide employment and households, a travel model that also converts travel time by mode to comparable costs by mode, and two real estate models that predict the locations of households and employment respectively plus related attributes like land consumed and prices. This approach, by agencies that have the staff and resources to support such efforts, represents an alternative to the use of sketch tools. University-based planning think tanks also tend to be the locus of such suites of tools that, in combination, produce substantial scenario capacity. In the U.S., the University of Washington's Urban Ecology Lab's work on the Puget Sound Future Scenarios[3] and the National Center for Smart Growth's PRESTO project[4] are noteworthy. While they likely produce more robust results, such loosely coupled planning support system tools are essentially tied to their agency and are not generally available or applicable.

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[3] http://urbaneco.washington.edu/wp/wp-content/uploads/2012/09/scenarios_report.pdf.

[4] http://smartgrowth.umd.edu/assets/documents/presto/prestoadvisorygrouppacket.pdf.

5. **Emphasize nonplace-based tool components and processes (i.e., people-based options).**

   The three tools evaluated and this family of tools are geared toward interpreting policies that have spatially explicit outcomes. Thus, for example, the direct application of Place Types or Building Types will translate into travel behavior, health and economic impacts. Policy variables, however, that are not spatially explicit, like parking or pricing policies or vouchers directed at individuals to incentivize behavioral changes, are not well captured or not captured at all in the sketch tools assessed. There is a longstanding debate in the social policy world about the relative merits of such people-based versus place-based investments. The current structure of the tools should be examined to open them up to such people-based inputs, which are more explicitly accommodated in middle weight tools.

6. **Encourage academic research into the use and evolution of sketch tools.**

   Despite the use of scenario sketch planning tools by many regional planning agencies and jurisdictions and the widespread interest of Federal agencies and practitioners in them, such tools have drawn very little attention from academic researchers. Perhaps because scenario sketch tools, unlike large, complex models, have typically not been produced by academics, they have not been subject to the scrutiny that their actual utilization and visibility warrant.

   The range of research questions that should be addressed is wide. In our literature synthesis we suggested a sampling of questions raised by the literature in each of the three aspects of the topic of this report.

   Under "scenarios" we raised the following questions:

   - What does the expansion of the context, scenarios and tools imply for current tools and future tools?
   - How should we parse out the influence of end-state thinking on current and future tools? and
   - How can we bridge the divide between various modes of scenario creation and how does contingent thinking relate to the design of planning support systems?

   Under "sketch tools" we noted the following issues:

   - Parsing out tool developer's outcome bias in the design of tools;
   - Keeping an eye on the interface of sketch tools with more robust models; and
   - Going beyond mere description of tools to identify the more enduring principles of tool design and application.

Under "regional sustainability" we raised the following issues:

- Limitations on handling Economy and Equity in the current structure of tools and indicators;
- Difficult theoretical and design issues for tools raised by the consideration of Regional Sustainability; and
- Addressing the challenges posed for tool design by the Education versus Empowerment paradigms.

While this report sheds some light on several of these issues it does not drill down and explore them in the way that academic research would. For example, subjecting the same area project to different scenario tools would illuminate their differences in important ways. Or, applying a sketch tool approach like rule-based land use allocation and comparing results with an econometric land use model would also be illuminating.

**7. Make open-source and open-access tools more accessible through support.**

"Open-source" and "open-access" are two terms that are used a lot, sometimes (incorrectly) interchangeably, by software developers. "Open-source" means that the software code is freely available in an unlocked and uncompiled state, so that it can accessed and modified by anyone with the know-how. "Open-access" might mean that the software is free to access and use – but it does not mean the code itself is nonproprietary and unlocked. "Open-access" might also simply refer to a model, not necessarily the software that it runs on. An Excel spreadsheet model is a good example of a potentially open-access tool. Assuming the tool developer does not hide and lock the spreadsheet formulas, she can give it to anyone else as a file and, if the recipient has Excel, they can open it and examine or change any of the of formulas and assumptions. Therefore the model is open and accessible, but the source code it runs on (Excel) is proprietary.

Just because a developer might call a tool "open-source" or "open-access" does not mean that the tool is actually accessible. Ideally, an open-source tool will have its own landing page or wiki where, in addition to being able to download the code, a potential user can access documentation on the history of the tool development, documentation on the code itself, a roadmap for future code development, and support resources. Support resources may or may not contain on-line help files, but most often provide support and collaboration through a user/developer forum that is (ideally) actively supported by a large and diverse group of users. If code for a tool is available but not well-documented and/or not well supported, it may indeed be "open-source" but it might not be all that useful. A good example of this was PLACE3S: not only was the code difficult to find, but the code itself was not well documented and there was not an active user group to turn to for support.

Of the three tools reviewed, UrbanFootprint is the "most" open-source where all the underlying code is freely available. That is good in terms of initial cost and if one wants to change some fundamental aspect of how the program works. On the other hand, it could end up costing more in terms of the time and expertise needed to set it up. Unfortunately, as of this writing, support options are very limited and the user group is small and mostly confined to California. UF would benefit greatly by better documentation and a larger and more geographically diverse set of users – making it more accessible. If, on the other hand, one is more interested in the formulas and assumptions that go into a particular model rather than the code that runs the model, ET+ and CommunityViz are probably the more open and accessible tools. CommunityViz is the only tool with a price tag, but it is also the tool with the most robust support in terms of documentation, help files, and dedicated support staff. Oddly, CommunityViz does not have an official user forum, which would facilitate peer-to-peer support and collaboration; and ET+ forums are sparsely populated by a collection of about 15 advanced users, as of this writing. The tool developers do not support such user groups, which can be an expensive proposition and a stretch for the tool developers who tend to be small business operations. This is an area where public sector or nonprofit funding would be very helpful. This dearth of user communities is probably a reflection of the fact that with all three of these tools, a consultant is typically hired to set up the models – which begs the question: just how "open" are these models if a consultant is required. Better documentation support would help mitigate that need.

8. **Continue and expand the development of web-based tools.**

The power and "connectedness" of the World Wide Web presents some unique opportunities that are being realized, in different degrees, by each the tools. Cloud computing can transcend the performance and compatibility limitations of desktop computers that have limited processing power, memory, and storage that quickly become obsolete. In addition, software and drivers require constant maintenance and updates in order keep things running efficiently and to keep current with bug fixes and new features as they become available. With cloud computing, the specifications of the client hardware and software matter very little, so long as the client has an up-to-date web browser and a fast and stable Internet connection. Cloud computing also offers one centralized "place" where multiple planners and stakeholders can access the same data, from anywhere.

At the regional scale, where there can easily be hundreds of thousands or even millions of features (parcels, for instance) the performance of a desktop tool can degrade to the point where it becomes unusable, particularly for any kind of public meeting or charrette. This has meant that many of the case studies reviewed in this report had to generalize their land use data into larger and coarser geographies. The creation of "place types" is, in fact, necessitated in order not to lose detailed information about the mix of land use and building types in any given geography and much time is consumed creating, matching, and massaging place types to existing places. Of the three tools evaluated, UrbanFootprint has clearly been the on the forefront of addressing these issues and is the only tool conceived and being executed in "the cloud." CommunityViz, as an extension to ArcGIS desktop software, is probably the furthest away from cloud implementation, although it does generate a variety of reports and presentations "web-ready" in HTML format and now to ArcGIS Online. But the actual processing of an analysis is run on the local machine, with all its inherent hardware and software limitations. ET+ is in the process of "porting over" to a web version. All of the tools will need to be multithreaded (run on more than one physical processor at a time) in order to fully realize the processing power and resultant speed of cloud computing. It is an engineering challenge, but one well worth pursuing because of the potential to increase the speed and accuracy of the models.

9. **Support user-driven enhancements of tools.**

In earlier suggestions we have commented on the limited nature of tool user groups and support. These tend to be ad hoc communities of users who get together virtually to share experience and lessons and help one another. A small sketch planning users group called SPAN (formerly the Open Planning Tools Group – OPTG), was established in 2010 with support from the Lincoln Land Institute. Convened by PlaceMatters Inc., it maintains a web site, holds regular conference calls and organizes an annual conference. Tool developers, some academics and leading tool users make up the group. This group and its networks are committed to sharing ideas and information, to improving the tools and the practice of scenario planning, and to making tools more accessible to users (see http://placematters.org/blog/category/optg/).

Currently, around 15 percent of MPOs use a scenario approach and thus, presumably, related tools. Chief among the hurdles cited in surveys (one by FHWA in 2013 and NARC in 2015) are staff and resource limitations. These same surveys cite public engagement and outreach efforts as the chief benefit of tool usage. There would seem, therefore, to be a clear role for those who believe in the utility of tools and who wish to increase their penetration and usage by regional agencies and others. Federal agencies like FHWA and others who support regional planning, therefore, can leverage their funding programs to include incentives or requirements for agencies that enhance the resources of regional agencies' and others to improve, streamline and make more interoperable the tools as they evolve. A good example of this trajectory is the family of tools developed by Oregon DOT over time. Some of these received support from FHWA, after peer review and testing, or were part of the Federal SHRP 2 program. ODOT is seeking further support and a framework for further consolidating and diffusing their open-source tools.

**10. Explore restructuring and modularization of scenario sketch tools.**

Going beyond the above recommendation, several MPOs with deep experience in sketch tool usage have suggested that the current set of three or four normative or end-state tools are ripe for opening up and modularization. These tools are designed as stand-alone software projects and as "all-in-one" software, handling database functions, basic scenario technology (capturing assumptions, making calculations, capturing user input, displaying results in charts and maps), with specific applications to derive sought-after indicators, algorithm choice and implementation to estimate those indicators, and providing a user interface. These "power users" argue that it is this "all-in-one" design that keeps users tied to a particular tool. Instead, they propose a modular design that would allow tool developers to work on one part without breaking all the others or having to wait on all the others to be upgraded to use an improvement. Such an initiative, they maintain, can increase both standardization and innovation. It would standardize that which might be common across the country, standardize how new functionality can be added and create the potential to mix and match "best in class" apps/algorithms.

In order to undertake such an ambitious program, a comparative assessment of the current tools and their potential to be mined for such a makeover is needed. This report and assessment provides the basis for such an initiative.

# Appendix A

*Literature Review*

# A. Literature Review

## A.1 INTRODUCTION

The complex title of this project – Scenario Sketch Planning Tools for Regional Sustainability – combines multiple ideas and meanings and begs definition up front. It also suggests a good template and sequence for the literature review. We start by providing an overview of Scenario Planning, contrasting the state of practice with the state of the art (Section A.2). We then define and discuss, in turn, what we understand by Scenarios, Sketch Planning Tools, Regional and Sustainability (Section A.3), and raise some key questions for each. This discussion incorporates references to the literature and constitutes the synthesis portion of the literature review. This literature review was conducted in late 2013.

Beyond this synthesis, in Section A.4 (Review of Reviews) we present and discuss 10 reviews of scenario tools that have been written since 2000. These prior efforts, which range from academic syntheses to practitioner guidebooks, serve as examples of composite reviews like this one and are potential models for this project's final products.

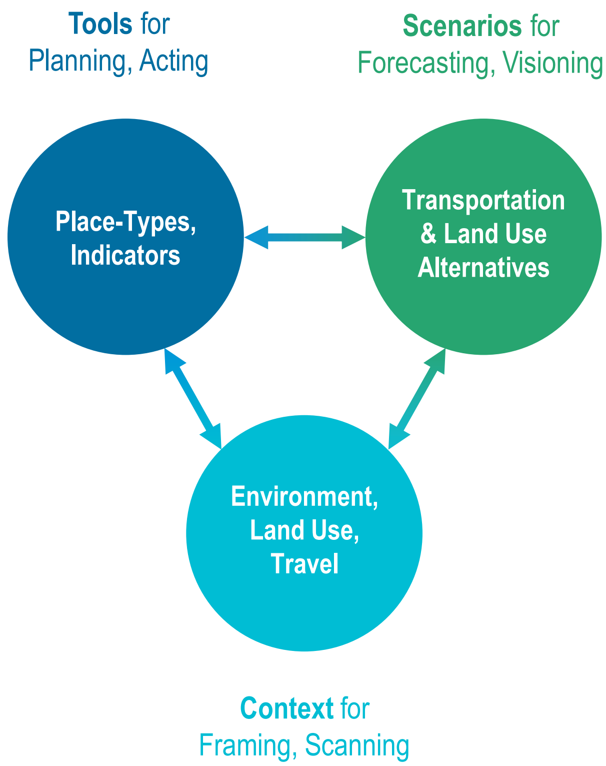
We do not review the vast universe of books, monographs, or articles that address Scenarios, Sketch Planning Tools, and Regional Sustainability. For the purposes of this literature review, we use our Review of Reviews as a sufficient secondary source of such primary sources. Our Overview cites numerous references to this literature based on our own reading, judgment, and experience. While not comprehensive, it serves as a sufficient introduction to this immense literature.

## A.2 OVERVIEW OF SCENARIO PLANNING

### State of the Practice

The current state of the practice in scenario planning using sketch tools is captured in Figure A.1. The *context* for the effort typically includes environmental spatial data, land use spatial data, and some form of travel data and networks, sometimes even a travel model of some kind. The *scenarios* derived typically involve land use and transportation assumptions for forecasting or visioning. The sketch *tools* typically incorporate some version of "place types" and produce performance indicators that permit plans and actions to be developed.

**Figure A.1 Sketch Tools in Scenario Planning: State of the Practice**




The now-iconic regional scenario projects from the 1990s, like LUTRAQ (Blizzard, 1996) or Envision Utah (Grow, 2006) followed this pattern. In fact most of the regional scenarios conducted since, including the "Blueprint" series that have followed the lead of the Sacramento Area Council of Governments (SACOG), share these same sequences and approaches. It is no accident that they all also shared the same or similar sketch tool software frameworks since many share a common origin.[5] This raises an important chicken-and-egg question: are the framing, creation, and selection of the scenarios driven by the capabilities of the tools rather than the intrinsic features of the context and the problems at hand? How much is the typical formulation of scenarios as variants of a sprawl versus compact development pattern (be it in corridors, centers or satellites) driven by the tools and their assumptions or limitations? This literature review will delve into this question somewhat and it will be addressed more directly in the final report for the project.

[5] The States of California, Oregon, and Washington's Departments of Energy solicited the development of a sketch planning tool in the early 1990s for the effort that spawned PLACE3S, INDEX, and Envision Tomorrow.

## Expansion of the Practice

The expansion of the *context* for this report to incorporate the concept of regional sustainability immediately broadens the framing and scanning of the drivers behind scenarios. It adds the Equity and Economy features to the Environmental ones usually captured.[6] These features stretch the limits of standard practice indicators, which are forced to derive measures of equity or economy from their land use and transportation inputs and outputs.

Table A.1 illustrates this practice by relating the typical indicators used in the Federal Highway Administration Scenario Planning Guidebook (FHWA, 2011) to either land use or travel behavior calculations.

### Table A.1 Standard Scenario Indicators and their Derivation

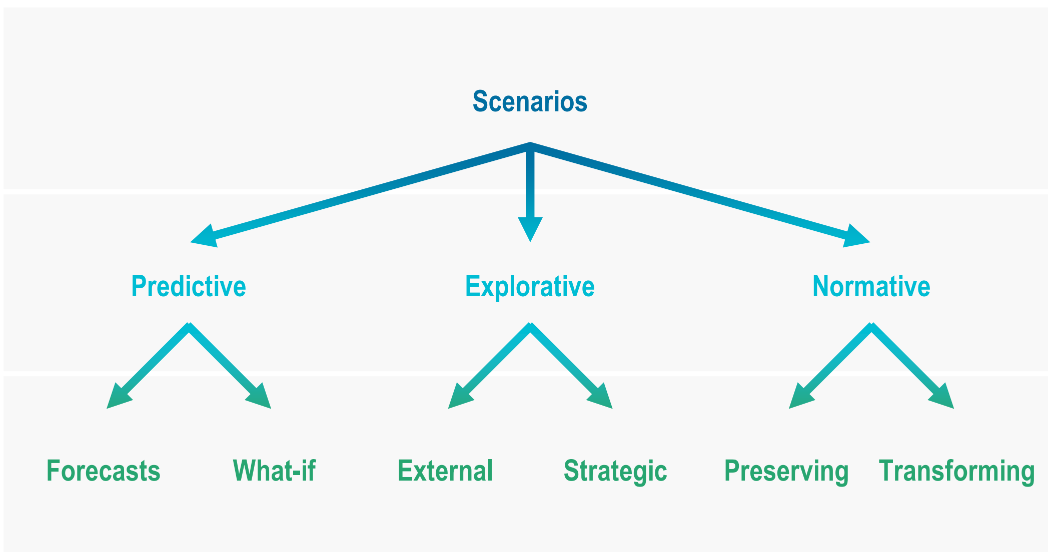
| From Travel Outputs | From Land Use Outputs | Typical Scenario Indicators |
|---|---|---|
| | | Environmental/land-use indicators |
| | ✓ | Acres of nonurbanized land |
| | ✓ | Percentage of farms and forests |
| | | Community livability indicators |
| | ✓ | Percentage of population living in clustered communities |
| | ✓ | Percentage of population with access to transit |
| ✓ | | Annual gallons of gas consumed |
| | | Jobs/housing indicators |
| | ✓ | Number and/or percentage of jobs located near affordable housing |
| ✓ | | Change in average commuting times |
| | | Transportation system indicators |
| ✓ | | Number of highway congested hours |
| ✓ | | Vehicle miles traveled by mode |
| | | Percentage of work or all trips by mode |
| | | Climate change indicators |
| ✓ | | Greenhouse gas emissions by sector and county |
| ✓ | | Greenhouse gas emissions due to vehicle miles traveled |
| | ✓ | Acres of land deforested for development |

[6] We follow the accepted Brundtland Commission's tripartite definition of sustainability as including the 3 Es (Economy, Equity, and Environment) here and throughout this report.

The definition of scenarios, as we have noted, also should go beyond the alternative transportation/land use patterns typically explored in current practice, which tend to be end-state or normative in approach. As Holway et al. (2012) notes, "the second type, exploratory scenario planning, is used to anticipate the impact that different future conditions may have on values, policies, or goals that have been established or are being considered" (p. 10).

Other kinds of scenarios discussed in the wider literature on scenarios[7] include one by Borjeson et al. (2006) that set up a tripartite typology and divide each into two subcategories, as shown in Figure A.2.

## Figure A.2 Tripartite Typology of Scenarios




Source: Borjeson et al. (2006).

Predictive scenarios answer the question "What *will* happen?" Exploratory scenarios answer "What *can* happen?" Normative scenarios answer: "How can a specific target be reached?" For this literature review and for urban planning purposes, we will use the terms exploratory, anticipatory and contingent scenarios interchangeably.

How are exploratory scenarios best created and can they be fitted within the conceptual frameworks of current and evolving sketch tools? Should this expanded vocabulary of scenarios be directed at education and consciousness-raising or at technical analysis? Are they for use by the broader public or by experts, and should they be structured and used for assessment and ongoing monitoring or as targets for end-state outcomes?

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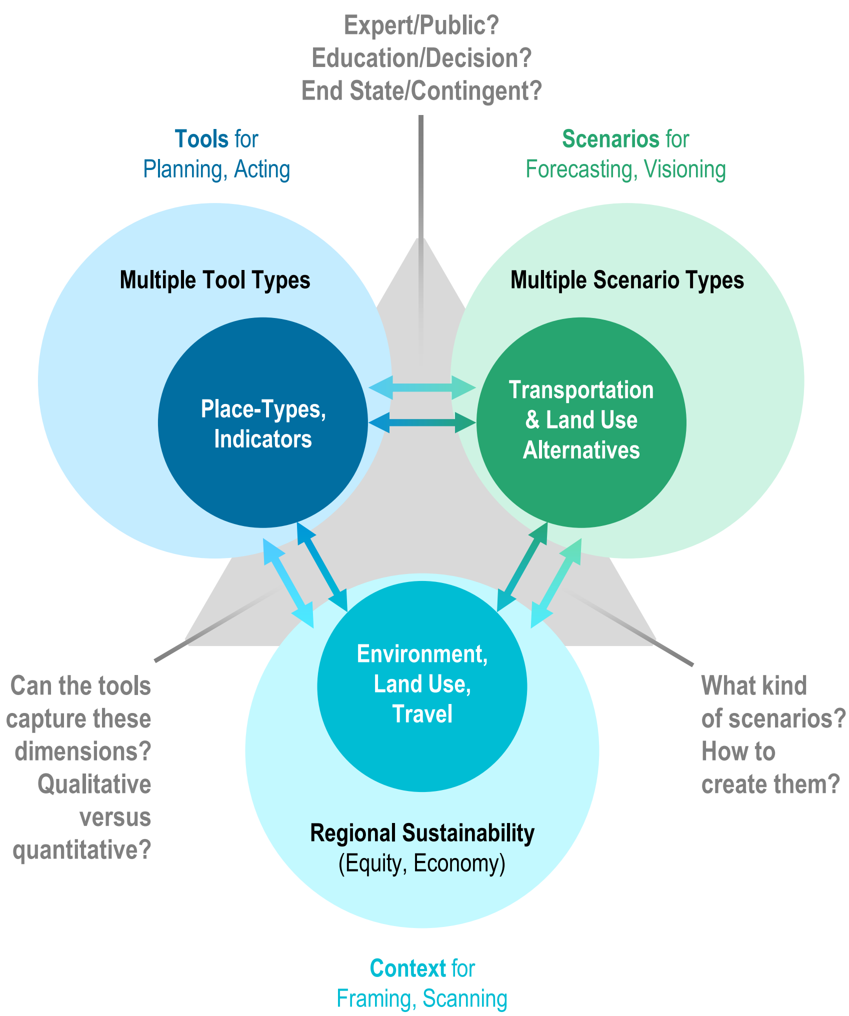
7 An excellent overview of scenario types and techniques is by Bishop, Hines, and Coolins (2007) in which they focus in depth on techniques of scenario building. Mahmoud et al. (2009) provide another schema of four types and Salewski (2012) presents the French group DATAR's typology in a useful table (page 49).

## State of the Art

The expanded dimensions discussed above for context, scenarios and tools suggest that the diagram in Figure A.3 should be set within the expanded understanding that our literature review reveals. Figure A.3 captures this expanded framework. It shows an expanded context, a wider range of scenario types and many more tool types. It also reiterates the kinds of questions raised by the new relationships between the three components of our literature review – scenarios, sketch tools, and regional sustainability. While these three components obviously interact and interrelate, there is benefit in treating them separately in our review.

**Figure A.3 Sketch Tools in Scenario Planning: State of the Art**



# A.3 Definitions and Key Questions

## Scenarios

### *Standard Definition*

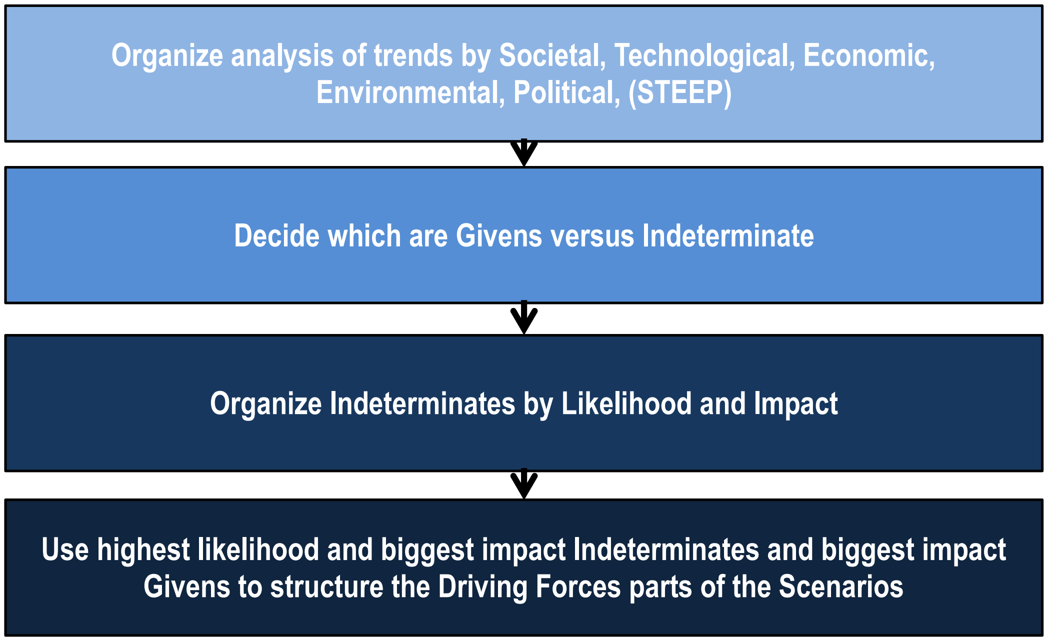
The word "scenario" has come to mean all things to all people, as popular concepts and buzzwords do with time. However, the literature clearly differentiates scenarios from mere alternatives or options by injecting the notion of a *story about the future* into them. The literature on scenarios also proposes that these story or stories have some degree of *plausibility* to them. That is to say, they need some grounding in a sense of *what may happen,* almost irrespective of what one would like to have happen, and what forces are at work driving change. They also should be sharply differentiated from one another and avoid "straw man" stories and predetermined favorites. They are about *imagining and discovering* future conditions so as to develop a *readiness and agility* in addressing multiple futures. The purpose of these exercises is to be able to identify the *most robust and resilient actions* in the face of these multiple outcomes.

This approach produces *contingent* scenarios, which depend on an ongoing monitoring the environment for signals of trends which portend a shift to which the corporation or institution or government must respond, if it is to survive and succeed.

The literature on scenarios is part of a tradition that originates in military war games in the 1950s and 1960s and is usually connected to the work done at Shell Oil by Pierre Wack (1985) and his colleagues in the 1970s running through the firm Global Business Network (GBN), which housed at various times individuals like Peter Schwartz (1991), Kees van der Heijden (1996), and John Oglivy (1997), and whose names are synonymous with key publications on scenarios. They and their colleagues have, over the past 20 years, developed a strong and evolved body of methodologies on how to develop contingent scenarios and apply them (e.g., Ringland, 2006). Figure A.4 illustrates the steps in the typical contingent approach.

The contexts, in which these approaches have incubated, typically have been for corporations or institutions or governments seeking to define strategies for the longer term, so as to develop robust shorter-term actions.

**Figure A.4 Typical Contingent Scenario Planning Approach**




### *Planners' Definition*

While urban planners now use the term "scenarios" all the time, it is important to note that their appropriation of the term derives from a very different tradition than that described above. Indeed, until recently, the two traditions have proceeded along quite different tracks despite their semantic conflation.

Planners' scenarios derive from the tradition of *Visioning*, in which planners and communities are engaged in imagining and describing how they would like their future world to look and be. The early (Ames, 1992, 1995, 2001) and later (Walzer and Hamm, 2012) approaches to visioning emphasize developing and soliciting a motivating and inspiring vision of the future to which current actions and plans should be directed. They do not necessarily ignore trends and forces but these are often seen as impediments to a better future to be striven for.

This planning tradition has deep roots in the work and words of a long line of visionary planners (Burnham's exhortation to "make no little plans" stands as their motto). There is a long list of planners, often architects, who can both describe and visualize the preferred future, based on an analysis of current ills extrapolated.[8]

The approaches and techniques developed by visioning planners have little to do with those of the scenario planners described earlier. They tend to specify a base case scenario, usually a variant of current "sprawl" land use patterns, against

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8 Two of the best known early examples include Duany and Plater-Zyberg (1991) and Calthorpe (1993).

which alternative urban forms ("centers and corridors," "satellite cities," etc.) are posited for evaluation followed by the selection of a "preferred alternative." They can be described as *end-state scenarios* (normative or prescriptive scenarios are other terms used in the literature[9]) because of their strong focus on achieving a defined long-term outcome.

Crucially, many of the sketch tools developed and now applied to regional transportation and land use planning were developed by these same visioning planners and reflect the outreach/engagement/motivation aspects of this tradition.[10]

### *The Divide*

Only in the last few years has this fundamental divide between contingent and end-state scenarios been clearly recognized[11] and attempts made to come to terms with the different world views they represent.[12] While other types of scenarios and processes are discussed and covered in the literature (Van Notten, 2003 and Bishop, Hines, and Collines 2007) the divide represented by the two approaches we have identified are, we believe, central to this discussion and review. The divide continues to cloud thinking about scenarios[13] and tools and is thus worthy of attention.

The different foci of end-state versus contingent worldviews help explain the emphasis in end-state approaches on *aspirations* and how they may be crystallized into desired Place Types. Contingent approaches tend to start from a very different place and, in fact, tend to avoid such thinking and tools, preferring an

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[9] An excellent summary and overview of the typologies and techniques of scenario planning is Bishop (2007). Bishop's article also has a very useful basic bibliography on scenario planning under its "Further reading" heading at the end of the article. Another good comprehensive review is Van Notten et al. (2003).

[10] Most of the large regional Smart Growth plans done in the last decade have been executed by the firm of Calthorpe/Fregonese using the Envision Tomorrow tool and many plans have been executed using INDEX (which EPA's Smart Growth office adapted in simplified form as Smart Growth INDEX and required of jurisdictions when using EPA funds for certain kinds of planning). CommunityViz has also been used extensively but less at the regional scale than the other two tools.

[11] Some of the standard texts on planning techniques, such as Berke et al. (2006), have clearly not resolved the differences in conceptual approach between visioning and scenario planning.

[12] Quay (2010), Chakraborty et al. (2011).

[13] Holway et al. (2012), for example, talks approvingly of the growing interest in tools that support anticipatory governance but both examples they cite (Reality Check by the Urban Land Institute in Maryland and Vision North Texas) are both really in the end-state visioning mode.

offline conversation/brainstorming/debate mode of interaction to develop their scenarios. It is a mode of scenario creation much less susceptible to a software environment, especially a cradle-to-grave sketch tool, which is the typical planning support systems (PSS) environment for creating, evaluating, and visualizing end-state scenarios.[14]

In fairness to urban planning contexts, however, we must acknowledge the basically different mission of a planning entity compared to that of a business or institution, the original clients for the contingent approach. Businesses have a very singular and unified mission, and their anticipation of events is crucial to their survival and prosperity. Public sector planners, on the other hand, are obliged to create plans with some stability, which cannot morph with each changing signal the way contingent scenarios imply. Moreover, planning that reflects the "public will" and a democratic process must inevitably come to grips with peoples' values, a component of contingent scenarios that is not central at best,[15] or missing, at worst.

### *Questions to Resolve*

This brief survey of scenarios and their creation thus raises several profound questions for further examination in the next sections and in the remainder of this project:

- What does the expansion of the context, scenarios and tools imply for current tools and future tools?
- How should we parse out the influence of end-state thinking on current and future tools?
- How can we bridge the divide between various modes of scenario creation and how does contingent thinking relate to the design of planning support systems?

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[14] A very interesting software model that tries to capture the stakeholder-driven element of scenarios is by Sarloos et al. (2005) who have developed a multiagent model for generating alternative land-use plans in which the agents are land use experts who initiate the development of plan proposals and communicate with each other over time to draw up the proposals incrementally.

[15] The corporation shares a unitary mission after all, unlike the diverse stakeholders who are contribute to and are reflected in public-sector planning.

## Sketch Tools

### *Definition*

For the purposes of this report we define scenario sketch planning tools for regional sustainability as having the following 10 characteristics:

1. Are spatially explicit (i.e., more than numerical or policy frameworks);
2. Require limited data (i.e., can use readily available sources or provide default values);
3. Employ simplified algorithms to derive impacts and indicators (i.e., tend to use transparent logic);
4. Can generate spatially explicit land use patterns at a regional scale (i.e., "scenarios");
5. These patterns must include a range of built environment and natural environment features (i.e., tools only directed at environmental outcomes and impacts do not qualify);
6. Can generate at least two-dimensional maps with spatial attribute data;
7. Can generate a range of quantitative impacts and indicators from these patterns and compare these across scenarios;
8. These impacts and indicators can be related to equity, the economy and/or the environment, both natural and human (e.g., data outputs like land consumed or job and transit accessibility can be used to infer aspects of sustainability's 3 Es – Equity, Economy and Environment);
9. Are relatively straightforward to use; and
10. Provide rapid or instantaneous feedback.

This definition consciously does not use the word "models" to describe the tools, even though the literature around them oftentimes loosely calls them models. Models imply a theory and the ability to simulate a set of relationships and typically the ability to calibrate and validate them against existing conditions. Sketch tools, in our definition, are absolved from meeting this high bar (but we discuss this blurry line later).

Note that this definition excludes tools like Mosaic, which is nonspatial (http://www.oregon.gov/ODOT/TD/TP/LCP/MosaicTool_Handout.pdf) and is primarily intended for economic and benefit/cost analysis of transportation system investments, rather than more comprehensive development and analysis of transportation and land use scenarios. We similarly exclude the current version of MetroQuest, which is now really a "wrapper" and user interface tool that displays maps and indicators generated by other tools and/or methods. Note too that this definition does not require certain attributes like public engagement or 3-D display capabilities although many tools do this. It also says nothing about whether such tools must be available to the broader public, are web or PC-based or are open source. Locking in such characteristics would, we believe, overly constrain a rapidly evolving field.

While we have not specified that the tools must be commercially available, standalone or require support from their developers, the 6 tools we choose to treat in depth in this review are those that are commercially available and have support from their developers. These are tools from tool developers who have been in these trenches for over a decade and have established a track record of reliability and support. All are U.S.-developed although some have been applied overseas. They are developed by consultants or university-based researchers who have migrated the tools to a commercial setting (the trajectory behind *Whatif?*, UrbanSim and MetroQuest, for example). It is possible that in an open-source world of tools to come, this commercially supported context may become less important but we are not yet there.

We also do not require the tools to be tested and active since several important tools are in the throes of beta-testing but warrant inclusion in our review.

There are, in fact, only a limited number of tools that meet the above definition. A list of primary tools that qualify as of late 2014 includes:

1. AURIN Whatif? (U.S./Australia);
2. **CommunityViz**;
3. Envision Tomorrow and **Envision Tomorrow Plus (ET+);**
4. **i-PLACE3S** (its predecessor, PLACE3S, is no longer available and runs on old hardware);
5. LUCIS;
6. **SPARC/INDEX**;
7. **UPlan**; and
8. **UrbanFootprint**.

Those shown in bold typeface are described in some depth Appendix E.

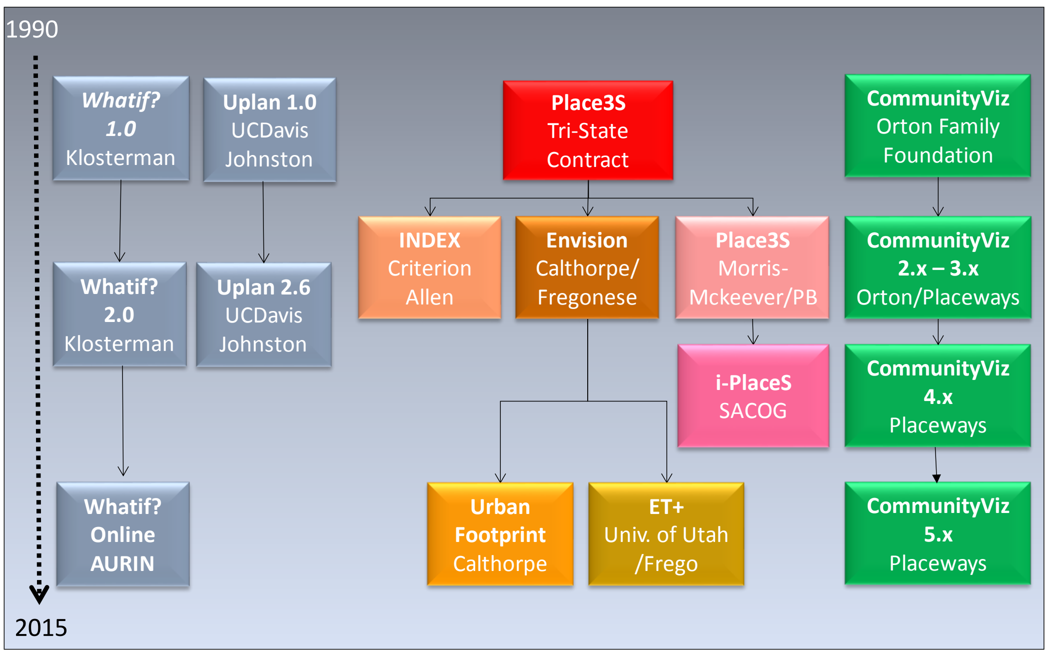
Because of the ubiquity of computing power and ongoing developments in the geographic information systems (GIS) world, it is quite likely we have missed some tools that qualify. These may be less visible in the marketplace or are home-grown by specific agencies or consultants for particular projects or are mostly service-based or are without broader market ambitions. Some examples of which we are aware include Facet's PlanMaster/Cause-and-Effect platform or the Delaware Department of Transportation's LUTSAM (a one-off for them) or CorPlan by Renaissance Planning. Such tools usually do not have the market presence or support that the more durable, commercially available tools do. A very recent entry into the tools world is Geodesignhub, based on the longstanding work by Carl Steinitz of Harvard and his approach to collaborative, workshop based processes, described in his book *A Framework for Geodesign* (2012). While it meets most of our criteria for this report, because of its recent release it is not fully treated but is discussed in this report.

This U.S. focus is justified by the advanced nature of sketch tools in the U.S. compared to overseas. This relative evolution is largely explained by the strong emphasis on communication, education, and outreach in the U.S. compared to a more top-down and less participatory planning culture elsewhere.

### *Evolution of Scenario Sketch Tools*

It is helpful to trace the genealogy of the primary sketch tools because their history informs their structure and design. Figure A.5 captures a simplified version of the evolution of three main branches of the genre and notes their associated companies or main developers.

**Figure A.5 A 25-Year Genealogy of the Primary U.S. Sketch Planning Tools**




The three branches differ in their approach to the design of their sketch tools. *Whatif?* and UPlan are early, rule-based, land use allocation systems developed primarily by academics, which coincided with the release of ESRI's object-oriented software that made such tools possible. Early applications were at the city and regional scale. PLACE3S was the result of unusually broad public/private collaboration by the Energy Departments of Washington, Oregon, and California to create a GIS tool to help communities understand the implications of their future development patterns, especially for energy. This effort spawned several other tools, all sharing the same Place Types/outreach structure.[16] It was initially developed for neighborhood-scale applications. INDEX created a "Paint the Region" extension in 2002, which was oriented to regional applications while Envision used a spreadsheet-type approach for all scales and applications. The two "offspring" of the Envision tool (Urban Footprint and ET+) currently are in beta-test mode and are the latest evolution of these tools. CommunityViz originated to enhance the quality of life in rural places and regions and guides users through populating a spreadsheet type framework. The latest version of CommunityViz incorporates several modifications and even more significant modifications will be incorporated in a late 2014 release. All of these tools are described in more detail in a later section of this review.

As we read previous reviews of this kind, we are struck by how rapidly they obsolesce as interconnectivity, tools, and the field evolves. This underlines the importance and value of going beyond just a time-bound review. We should attempt, in this effort, to define principles of tool design and application that can be of more enduring value than three or four years. It also reinforces the importance of capturing *emerging* tools and trends that seem relevant.

### *Some Trends to Ponder*

One such noteworthy trend is the blurring of lines between the "lightweight" sketch tools we have been describing to date and the "heavyweight" models. Lightweight tools, for example, have been the recent beneficiary of research efforts to improve the rules of thumb that drive their quantification of impacts. Quantifying the effects of the 5 Ds (Design, Density, Diverse Uses, Destination accessibility, Distance to Transit) on travel behavior has now been significantly improved in the emergent tools as has the travel impacts of Mixed Use projects. At the other end of the spectrum, UrbanSim, a heavy-duty econometric model, has developed very strong visualization and sketching capabilities (UrbanCanvas).[17] The company that develops this software, Synthicity, is planning to move into the sketch planning domain in the coming years.

While outside the realm of sketch tools, some places have combined various models that allow them considerable flexibility to simulate various trends and policies in ways that may not be accessible to the public but are readily accessible

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[16] Initially, Mike McKeever, Elliot Allen, and John Fregonese collaborated on preliminary design concepts for the tool. Early during the course of the tool's development, Allen split off to form Criterion, Inc., to create a proprietary version of the tool called INDEX, and Fregonese left Portland's Metro Regional Center and formed Fregonese/Calthorpe Associates to successfully market regional growth management services, using the PLACE3S framework, in part. Morris left to join Parsons Brinckerhoff and continue the use of PLACE3S there, and McKeever went to SACOG and continued to support its evolution to the web-based version, i-PLACE3S, until 2013.

[17] http://www.UrbanSim.org/Main/WebHome is the best way to review the range of tools and products in this suite.

to staff for scenario work. Portland, Oregon, long a leader in planning applications, developed Metroscope, a set of decision support tools (Portland Metro, no date). These include an economic model that predicts regionwide employment and households, a travel model that also converts travel time by mode to comparable costs by mode, and two real estate models that predict the locations of households and employment respectively plus related attributes like land consumed and prices. This approach, by agencies that have the staff and resources to support such efforts, represents an alternative to the use of sketch tools. While it likely produces more robust results, such loosely coupled PSS are essentially tied to their agency and are not generally available or applicable.

A final reason to watch the relationship between heavyweight and lightweight approaches is their potential to work synergistically to produce results that are more market informed and theoretically grounded than sketch tools alone. SACOG, for example, has used PECAS, their econometric model, to produce a "reality-based" Trend scenario, of which they pivot, at a finer grain, with applications of i-PlaceS to produce Smart Growth type environments. When San Francisco's transportation agency, the Metropolitan Transportation Commission, needed more confidence in the plausibility of the vision-produced scenarios from the regional planning agency, the Association of Bay Area Governments, using i-PlaceS to produce their Environmental Impact Report (EIR), they used UrbanSim to "reverse engineer" results to try to approximate the visioned scenarios by modifying the model inputs. The resultant compromises passed muster for the required EIR.

### *Questions to Resolve*

This brief survey of tools raises several questions for further examination in the next sections and in the remainder of this project:

- Parsing out tool developer's outcome bias in the design of tools;
- Keeping an eye on the interface of sketch tools with more robust models; and
- Going beyond mere description of tools to identify the more enduring principles of tool design and application.

## Regional Sustainability

### *Definition*

As noted earlier, our definition of sustainability hews to the conventional 3 Es.[18] Our definition of a region is an area that encompasses multiple jurisdictions (towns, cities, or counties), oftentimes a metropolitan area. The region, however, could include multiple metros and could cross state boundaries (i.e., megaregions). The geographies included in the Department of Housing and Urban Development's (HUD) Sustainable Communities Initiative (SCI) grants[19] furnish good examples of expanded regions. These grantees also have been attempting to collect data and, in some cases, apply scenario-oriented tools for these regions and this latest experiment in federally funded scenario-based planning also furnishes additional case-study candidates, insights, and opportunities for this study.

Regional sustainability is the hardest topic to cover in the literature review, not because there is a lack of material – there is a surfeit – but because the subject is so broad and its coverage within the scenario sketch tool world is rather focused. It is limited by what sketch tools that meet our definition currently can address and by the perspectives their users have on the topic.

There are some specialized tools[20] that deal with aspects of regional sustainability, especially environmental aspects, in ways that are quite robust and useful for planning, but if they are not integrated into scenario sketch tools, we do not address them in this memo. The range of sustainability outputs from the primary tools is described in the subsequent sections of this memo under the various tools themselves. A summary composite of *environmental* outputs, however, would include:

- Greenhouse gas (GHG) emissions;
- Pollutant emissions;
- Land consumption;

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[18] We would specify that environment includes both human and natural (human encompassing metrics like accessibility – which may have implications for the economy – but is about more than just that). Our preference would really be for a typology of social-economic-environmental with equity cross-cutting, although it inconveniently introduces a word that does not start with "e."

[19] Approximately $170 million were given out in FY 2010 and 2011 in Sustainable Communities Regional Planning Grants, directed to multijurisdictional, regional entity, and nonprofit partnerships to develop a Regional Plan for Sustainable Development (Ho, 2013).

[20] NatureServe Vista is a robust, conservation-based tool and relies on CommunityViz to do the "sketching" part. CITYgreen is another example, but is not regional in scale. GreenSTEP, which is designed for transportation GHG analysis, is not spatial in nature.

- Build energy consumption; and
- Water consumption.

On the *economic* front, the primary sketch tools have a more limited palette. Culling their indicators yields the following listing:

- Total jobs;
- Infrastructure costs (streets, parks, sewage, public services, etc.);
- Tax revenues; and
- Return on investments.

The *equity* front provides even slimmer pickings. In general, equity indicators tend to be couched in either public health or environmental justice terms. They include:

- Transportation safety (pedestrian/automobile collisions);
- Amenities;
- Respiratory impacts; and
- Walkability.

The limitations evident in the last two categories result from the spatial land use/ transportation roots of scenario sketch tools, which have tended to govern planners' expectations on these fronts. The expansion into regional sustainability through SCI work, however, has exposed the need for planners and their tools to encompass more than the traditional, end-state paradigms. Supplementing such scenario work,[21] for example, with Opportunity Mapping helps to flesh out the sustainability picture for *current* conditions, but many indicators (e.g., crime, education, income) remain hard to project both for technical reasons as well as political ones (imagine the panic among elected officials over projecting future areas of crime or changes in ethnic makeup, even if we could plausibly do so).

The deeper reality, however, is that planners, too, are unclear about how to tackle sustainability in the regional context, which makes the design of sketch tools that much more difficult. In a June, 2013 analysis of half of all SCI grant applications, Chapple and Mattiuzzi (2013) sought to tease out how applicants viewed sustainability and how they would tackle the planning and analysis associated with it. About a quarter referenced the 3 Es formulation, and almost a fifth mentioned environment/climate change, location efficiency, and livability respectively. Economic development (the Economy) approaches were place and

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[21] Opportunity Mapping (OM) is an attempt to visualize the spatial distribution of the neighborhood resources that promote social mobility. The premise of OM as a tool for spatial equity planning is that neighborhoods are unequal in their access to resources such as quality education, public services, job accessibility, and powerful social networks, among many others. The goal of OM, then, is to quantify access to such resources, and display how their spatial variation impacts different demographic groups differently. An overview of Opportunity Mapping techniques and examples can be found at http://kirwaninstitute.osu.edu/opportunity-communities/mapping/.

people-focused rather than business-focused and only benefits, not costs, received attention. Most applicants, however, failed to make the case for economic development (p. 13). Equity was addressed mostly by setting goals rather than developing equity-related strategies for implementation (p. 8).

In their recommendations, Chapple and Mattiuzzi suggest that applicants and plans be required to clarify the costs *and the benefits* of sustainability – the latter feature being rather absent in sketch tools. They note applicants are likely to require technical assistance integrating equity strategies into their sustainability plans. One specific area where clarity is needed, they suggest, is in the definition of displacement, both direct and indirect. This poses a particular theory and design challenge for sketch tools because of the subtlety and complexity of the impact. They also note that economic development in sustainability planning requires a better understanding of the equity effects of different types of strategies, raising another challenge for sketch tools (p. 16).[22] Their final recommendation also has implications for sketch tools: that HUD should carefully consider whether they want education and buy-in or whether empowerment is important. These different goals would produce different designs for the public's access to and power over the tools and results and their interfaces.

### *Questions to Resolve*

This brief discussion of regional sustainability raises several questions for further examination in the next sections and in the remainder of this project:

- Limitations on handling Economy and Equity in the current structure of tools and indicators;
- Difficult theoretical and design issues for tools raised by the consideration of Regional Sustainability; and
- Addressing the challenges posed for tool design by the Education versus Empowerment paradigms.

## A.4 REVIEW OF REVIEWS

This "review of reviews" surveys tool review publications between 2000 and 2013. The earlier reviews are summarized more briefly since they are now out of date. More recent reviews are covered more fully. We are interested in this survey in also culling the assessment frameworks applied to the tools under review so as to inform our own framework for comparing tools, the next task in this project. Our focus is on useful frameworks for evaluation for the next task (a comparative framework for tool evaluation) rather than on tools themselves. We use italics to

[22] One of the very few scenario modeling studies to attack the definitional and quantification aspects of equity is the outstanding work of PROPOLIS (Lautso et al., 2004), a major study by the European Commission of modeling analyses and case studies of six European metro areas.

note aspects of the reviews that are of particular relevance to this current effort. We also note, in passing, some candidate case studies that are described in these reviews for later tasks in this current effort.

While there are some interesting technical reports on transportation, land use, and GHG scenarios that are frequently referenced in the scenario literature, if they do not pertain to tools, we do not cover them here. Examples would be the Ewing et al. survey article (2010) and FHWA's report, New Trends in Transportation and Land Use Scenario Planning (2010).

### *U.S. EPA (2000): Projecting Land-Use Change: A Summary of Models for Assessing the Effects of Community Growth and Change on Land-Use Patterns*

This review by the U.S. Environmental Protection Agency (EPA) was a selective summary of 22 leading land use change models then in use or under development. This document is conceived as a guide, similar in purpose to the current effort, and it covers a very broad range of tools through models. The models include sketch tools and heavyweight models and many in between. The list includes three sketch tools that we include in our list of primary tools: INDEX, UPlan, and *Whatif?* At least seven of the models are of the more complex, econometric kind like DELTA, TRANUS, MEPLAN, and UrbanSim, the four that have survived the intervening 13 years. About 14 of the models appear to be no longer actively used or supported. Little detailed information is given on the level of technical support provided behind the models, suggesting the *importance of such information*, given the attrition rate of the models presented.

A useful table up front (pp. 3-5) tells users which sections to read depending on whether they have an extensive or limited background in land use planning and modeling. *This is a transferable idea for our project.* Chapters are short (the text minus appendices is only 36 pages). The meat of the comparative discussion and tables is in several appendices. The table of contents reflects a careful attempt to set up the appendices by educating users about the right questions to ask and a stepwise process for selecting the right model. A key exhibit in the guide presents the criteria used to evaluate the models discussed, shown in Figure A.6.

## Figure A.6 Example Criteria Rating Table

| Criteria | Weight[1] (W) | Rating Score: (RS) 10 = High Match, 1 = Low Match | | | | | |
|---|---|---|---|---|---|---|---|
| | | Alternatives | | | | | |
| | | Model #1 | | Model #2 | | Model #3 | |
| | | RS | RS x W | RS | RS x W | RS | RS x W |
| Relevancy | | | | | | | |
| Resources | | | | | | | |
| Model Support | | | | | | | |
| Technical Expertise | | | | | | | |
| Data Requirements | | | | | | | |
| Accuracy | | | | | | | |
| Resolution | | | | | | | |
| Temporal Capabilities | | | | | | | |
| Versatility | | | | | | | |
| Linkage Potential | | | | | | | |
| Public Accessibility | | | | | | | |
| Transferability | | | | | | | |
| Third-Party Use | | | | | | | |
| **Total Score** | | | | | | | |

[1] Weights may be numeric (e.g., 1=low weight, 5=high weight) or qualitative (e.g., low, medium, high). A numeric weight enables users to multiply the weight and the rating score to determine a numeric value for each model. For example, if relevancy was given a weight of "5" and Model 1 scored a 2 for a rating, Model 2 scored 5 and Model 3 scored 10, their respective numeric totals would be 10, 25, and 50. Clearly, Model 3 is best for relevancy. After all criteria are applied, the total scores for each model are tallied.

Source: U.S. EPA (2000), adapted from Chang and Kelly, 1995.

Information about the models is presented in four ways:

- Key selection criteria;
- General fact sheets;
- Comparative matrices; and
- Technical fact sheets.

Model features researched included the following:

- Model name;
- Contact information for the model developer;
- Description;
- Resource requirements;

- Theoretical framework;
- Data inputs;
- Model outputs;
- Strengths;
- Limitations;
- Required expertise;
- Geographic- and temporal-scale;
- Transferability to multiple locations;
- Capability of linking with other models; and
- Gaps that need to be addressed.

The contractor, SAIC, conducted independent research on these factors using journal publications, Internet web sites, user's guides, and demonstration models. Researchers used information collected from these sources to complete a summary worksheet for each model. These worksheets formed the basis for the narrative fact sheets (both general and technical) and comparative matrices found in this guide. Upon completion, SAIC provided the worksheets and fact sheets to the model developers, or appropriate designated colleagues, for verification of technical accuracy and supplemental information. All information on models presented in this guide was subject to this review process and was approved by the model developers.

Tables presenting data on the 22 models include:

- Technical expertise needed to use model;
- Purchase cost;
- Existence of model support;
- Ease of transferral to other locations; and
- How many locations has the model been applied to?

An example of the first bullet above, Technical Expertise Needed, is shown in Table A.2, which displays the models and tools covered.

### Table A.2 Technical Expertise Needed to Use Model[a]

| None | Some[b] | Extensive[c] |
|---|---|---|
| CURBA | CUF-1 | DELTA |
| Markov | CUF-2 | DRAM/EMPAL |
| METROSIM | GSM | INDEX® |
| SAM-IM | MEPLAN | IRPUD |
| Smart Places | SLEUTH | LTM |
| UGrow | Smart Growth INDEX® | LUCAS |
| | TRANUS | |
| | UPLAN | |
| | UrbanSim | |
| | What if? | |

Source: EPA (2000).

[a] Once the model has been installed/developed.

[b] Requires land use planning experience.

[c] Requires land use modeling experience.

The headings under which general information on the models is presented are a thorough and replicable list for our purposes as well. These descriptions comprise the bulk (108 pages) of the guidebook. The Strengths and Limitations discussion of each tool is a particularly relevant set of bullets. The actual longevity of the models and tools, however, would seem to be as much a function of the intent, capitalization, and organization of their developers as the technical attributes. *This is an important hindsight question and we will attempt to address it in subsequent tasks to some degree.*

The comparative matrices in the appendices are among the most useful attributes of this guide and include:

- Skills/Technical Expertise Comparative Matrix;
- Hardware Comparative Matrix;
- Software Comparative;
- Cost Comparative Matrix;
- Urban Land Use Categories Addressed Comparative Matrix;
- Nonurban Land Use Categories Addressed Comparative Matrix;
- Impacts of Community Decisions on Land-Use Patterns;
- Comparative Matrix;
- Impacts of Land-Use Patterns on Community Characteristics;
- Comparative Matrix;
- Model Utility and Integration Comparative Matrix;

- Basic Operational Characteristics Comparative Matrix; and
- Spatial And Temporal Capabilities Comparative Matrix.

**Bottom line relevance:** because it mixes so many different kinds of tools, precedes the growth of scenario planning, and is relatively out of date, this review's most useful aspects are its organization, presentation of information, and structuring of comparative data.

### *Brail and Klosterman (2001): Planning Support Systems: Integrating Geographic Information Systems, Models, and Visualization Tools*

This substantial book is a compendium of chapters by the leading thinkers and practitioners of planning support systems. Its 15 chapters are organized into three sections: An Overview of PSS; Simulation and Scenario Construction; Visualization. Like the previous guide, it covers a wide range of models and tools, with detailed chapters on eight of the 22 addressed in the EPA guide. The sketch tools included are INDEX, *Whatif?* and CommunityViz, each written by their respective developers.

From our perspective in this report, the two overview chapters on sketch plans by Britton Harris, the acknowledged godfather of PSS, and Lew Hopkins, one of its leading theorists, are of particular relevance.

Harris (2001) makes the important distinction between *instruments* and *procedures* for sketch planning and the importance of thinking about both separately and in relation to each other. He also emphasizes the limitations inherent in traditional models of transportation and land use in dealing with policy (e.g., equity) considerations and the challenges of relating cause and effect in sketch model chains. He suggests where in the sketch planning process computational support is essential, desirable, or counterproductive. Overall, Harris finds sketch planning a useful and necessary activity, but one that is unlikely to yield the final, optimal, plan. That needs a subsequent, more intensive effort.

Hopkins undertakes an ambitious task – to propose the structure necessary in a PSS for urban development. The design principles he lays out are germane to our broader goal in this effort and will be revisited in later tasks as a reference point in reviewing the tools and processes in hand today. He urges that scenario thinking must start well beyond the parameters of GIS and builds his PSS from concepts like Actors, Activities, Flows, Investments, Facilities, Regulations, Rights, Issues, Forces, Opportunities, and Constraints. He also usefully concludes by describing and organizing multiple types of tools by major tasks. These tasks are Sketch Planning, Model Building, Scenario Building, Evaluation, Lineage/Process, and Plan-Based Action.

The second and longest section of the compilation is a description of various PSS tools by their developers and, as such, is now outdated. The title of Paul Waddell's chapter on UrbanSim, interestingly, is "Between Politics and Planning: UrbanSim as a Decision-Support System for Metropolitan Planning," and it is one of the few to explicitly locate such models in the political milieu. It also presciently announces intentions to become web based and open-source. The third section on Visualization is similarly outdated.

**Bottom line relevance:** the four overview chapters, especially by Harris and Hopkins, provide the most relevant and useful concepts for our present effort.

### *Brail (2008): Planning Support Systems for Cities and Regions*

After the Hopkins/Zapata book, *Engaging the Future* (2007), which focuses strongly on scenario building approaches and approaches rather than tools, this was Lincoln's next sally into the world of scenarios and tools, a thrust they have continued to lead. As the table of contents below suggests, it is, in a sense, an update of Brail's ESRI book, discussed above, with many of the leading lights in the field contributing chapters. The appearance of Timmermans and Geertman is noteworthy, both being leading thinkers on scenarios, models and tools in Europe and key figures in the very evolved work in these areas in the Netherlands.

Foreword, Armando Carbonell

Introduction, Richard K. Brail

**Section 1: A Broader Perspective**

1. Planning Support Systems: Progress, Predictions, and Speculations on the Shape of Things to Come, Michael Batty.
2. Disseminating Spatial Decision Support Systems in Urban Planning, Harry Timmermans.

**Section 2: The Regional Scale**

1. A Decade of Cellular Urban Modeling with SLEUTH: Unresolved Issues and Problems, Keith C. Clarke.
2. Simulating Regional Futures: The Land-Use Evolution and Impact Assessment Model (LEAM), Brian Deal and Varkki Pallathucheril.
3. A New Tool for a New Planning: The What if?™ Planning Support System, Richard E. Klosterman.

**Section 3: Moving from Region to City**

1. UrbanSim: An Evolving Planning Support System for Evolving Communities, Paul Waddell, Xuan Liu, and Liming Wang.
2. Clicking Toward Better Outcomes: Experience with INDEX, 1994 to 2006, Eliot Allen.
3. Communities in Control: Developing Local Models Using CommunityViz®, George Janes and Michael Kwartler.
4. Development Control Planning Support Systems, Anthony G.O. Yeh.

**Section 4: Planning Support Systems in Practice**

1. Planning Support Systems: A Planner's Perspective, Stan Geertman.
2. Planning Support Systems: What Are Practicing Planners Looking For?, Terry Moore.

Some of the familiar model and tool names reappear in the chapter titles and the three sketch tools discussed are *Whatif?*, INDEX, and CommunityViz. Only *Whatif?* is covered under the regional scale heading, reflecting its origins in large-scale GIS applications. The other two are addressed in the next scale down. Klosterman, long a leading thinker in the field, starts his chapter on *Whatif?* by laying out four principles "that provide the foundation for any attempt to develop computer-based tools and techniques." These are titled:

- All Models Are Wrong – Some Models Are Useful;
- Prediction Is Hard, Especially About the Future;
- Keep It Simple, Stupid (KISS); and
- Use It Because It Is BAD (Best Available Data).

He defines these and goes on to apply them to *Whatif?* This is an interesting framework and may be useful in our own effort.

Being five years old largely consigns the substantive model and tool descriptions to obsolescence. However, in some chapters, the developers of mature tools apply a critical perspective to their work and products over time. The INDEX chapter by Eliot Allen is a particularly useful self-appraisal of what worked and what did not and why, and *serves as a useful model for this current effort*. The last two chapters are of particular interest since they deal with practice.

Geertman argues that in the PSS debate the practicing planner's perspective should become much more central. His perspective fits with the practitioner-driven concern that tool development should not just be about improving instrumental characteristics, but also about organizational adoption and carefully tailoring applications to the needs of varying planning actors. In an earlier article (Geertman, 2006) he complements these arguments by providing an overview of the contingent factors that influence the potential role of information, knowledge, and instruments in planning practice. Nevertheless, Geertman's present view on the value and penetration of PSS in general (as opposed to sketch tool applications), in the very latest compendium on PSS (Geertman, Toppen and Stillwell 2013), is rather pessimistic: "At present, there is a lack of evidence that PSS are indispensable in contributing to the proper guidance of urban sustainable development practices although there are some promising signs and results from important case studies…. Moreover, at the moment, there is a lack of sufficient insights into appropriate methodologies/approaches to achieve planning support for practitioners with the help of generated knowledge and PSS." (p. 3).

Why this dislocation between research and practice should be so durable is explored by Terry Moore in the last chapter, "What Are Practicing Planners

Looking For?" Moore notes the many contradictory demands placed by planners on PSS: complex enough to reflect the dynamics of urban development dynamics but simple enough to be transparent and understandable; fine grained enough for subarea work but fast enough for near-instant feedback; sufficiently accurate to instill confidence but able to work with available, limited datasets if need be, and so on. He argues persuasively that the pressures of time, resources, and politics will, in the end, always push planners in the direction of understandable, fast, and able to work with limited datasets.

This militates, at least in the U.S. context and for now, against the widespread adoption of the heavier weight type models that receive most of the coverage in the academic literature. The recent survey by FHWA (2013)[23] on planners' attitude towards scenario sketch tools validates Moore's perception.

These survey results reinforce the importance of an objective appraisal of the current and emergent crop of scenario sketch tools. Will they bring us closer to the technical and political thresholds that will mainstream the use of such tools in planning practice? A specific example Moore gives, germane to our current focus on sketch tools, has to do with the important aspect of tools' ability to place values (relative weights) on their predicted (simulated) outcomes: "For example, INDEX allows users to pull sliders to adjust relative weights, but does not have any rigorous system for developing mutually exclusive, non-overlapping evaluation criteria that get weighted in a consistent way" (p. 255).

An abbreviated version of Moore's list of eight criteria that would facilitate the adoption of PSS by planners is worthy of citation *and of revisiting for this current effort*:

- Make learning and operation simpler by tying the PSS to standard software (spreadsheet and GIS);
- Make the PSS flexible – that is, customizable to local circumstances and useful at different levels of sophistication;
- Develop standard, accepted benchmarks, and conduct peer review;
- Along the lines of standardization, develop more thorough promotional literature that addresses in a consistent and common way the kinds of issues raised;

[23] Agencies' main reasons for using sketch tools were: need to engage stakeholders and citizens (52 percent), desire to integrate land use and transportation plans (48 percent) and financial or economic development concerns (48 percent). The top purpose – public outreach – has much political resonance and it prizes speed, transparency and limited data inputs. Their major obstacles cited by between 40 and almost 60 percent of respondents in the survey to adopting scenario planning (and by inference, tools), were: funding to hire experienced staff or consultants; time and resources given existing staff workloads; and staff's limited experience with scenario planning, in that order.

- Focus on reliability. Accuracy may not be possible given the inherent uncertainty, but reliability should be;
- Reduce data needs by simplification and standardization;
- Produce output that local governments want; and
- Get Federal support through regulatory requirements or subsidies (page 243).

We should note, parenthetically, that progress has been made on several of these points since 2008. The final part of our literature review, which describes the current state of sketch tools and emergent tools, highlights some of these advances.

**Bottom line relevance:** an insightful set of reflections on mostly mature tools by their developers and leaders in the field but focused on Planning Support Systems as a whole rather than on scenario sketch tools, which limits it utility; practitioner reflections and definitional/evaluative frameworks are of most value to this current effort.

### *DKS Associates et al. (2007): Assessment of Local Models and Tools for Analyzing Smart-Growth Strategies*

This review was conducted in the same timeframe as the Lincoln book reviewed above but is different in important respects. Funded by FHWA and Caltrans grants, this effort is much more narrowly focused than the prior reviews. Its primary purpose was to help agencies, mainly metropolitan planning organizations (MPO) and Congestion Management Agencies, understand their options for enhancing the ability of their travel models to respond to land use variables, here defined as the "4D elasticities" (Density, Diversity, Design and Destinations). It focus is on evaluating different ways in which agencies can achieve this through a planning tool and/or postprocessing applications. In the course of this examination, the report provides useful evaluative criteria for our study and drills down into several scenario sketch tools. The report does not address the use of tools to *generate* scenarios; it is only interested in the impacts and assessment of land use features on travel behavior and models. From our perspective, its major utility is in its evaluation of i-PLACE3S and INDEX. The report incorporates eight case studies of cities that have attempted to enhance their travel models to reflect land use sensitivities. *These are useful to the current effort because they identify candidate case studies* in places with longstanding efforts in the transportation/land use tools arena.

In Fresno, the City had used both *Whatif?* and INDEX to develop future land use allocations and scenarios and then the latter to identify impacts of the scenarios on travel and other outcomes. Unfortunately, the report provides no comparative information on the specifics or performance of this interesting-sounding effort.

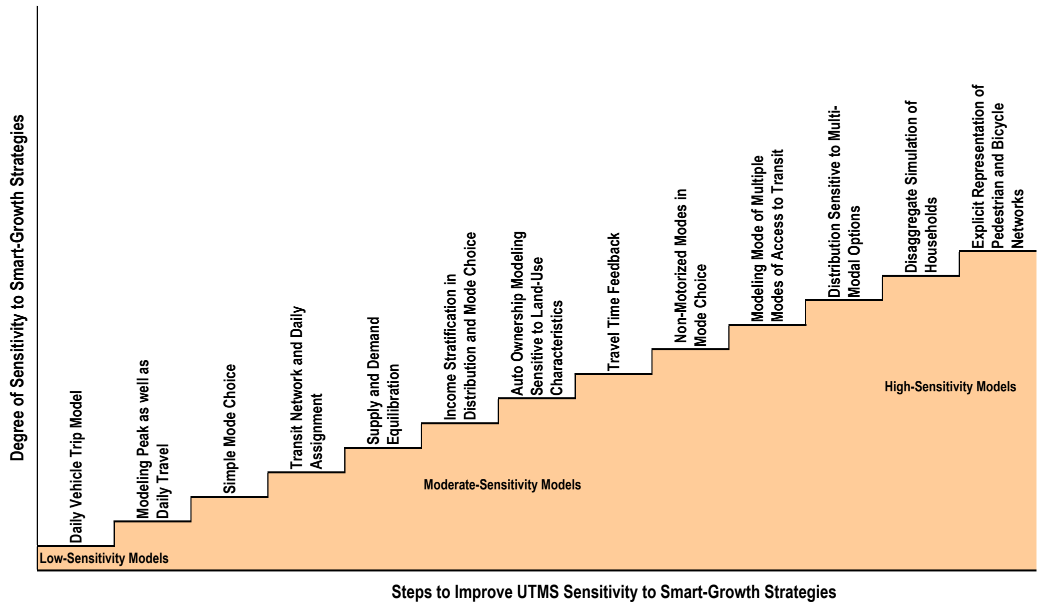
In San Luis Obispo, both the City and the County/MPO had initiated visioning work using UPlan and i-PLACE3S respectively. The report notes that in both cases there were some key data discrepancies in method and data that needed to be worked out. Some of the data for UPlan required for the types of scenarios analyzed did not exist at the county level. No further information is given on these efforts.

A separate chapter is devoted to testing the ability of INDEX and the 4D elasticities to reflect travel impacts under various development densities, land use mixes, and transit route availability. The test demonstrated several findings on using the INDEX tool (as it existed in 2007) to show 4D effects on vehicle-miles of travel (VMT) and vehicle-trips (VT). These are summarized below:

- Study area size and the proportion of the changed land use of that area has large effects on the extent of impacts measured. In general, the 4D elasticities are not to be applied to areas less than 2 miles in diameter or 2,000 acres in area.
- Variables used in the travel model that affect tripmaking (like income and number of workers per household) are taken into account in INDEX.
- Using INDEX may be appropriate for general policy development and planning but not for local traffic impact work, because it does not produce peak-hour trips but only daily trips, does not account for bus lines in the study area, does not account for mode-shift effects of carpooling, HOV lanes, biking facilities or parking costs.
- The travel studies behind INDEX's algorithms were outdated and new research (e.g., recent travel surveys) was needed to update them. Since 2007, Fehr and Peers, the firm most closely identified with developing the 4D elasticities, has significantly upgraded the research basis and capabilities of the 4D (now expanded to 7Ds) impact assessment aspects of the tool. The 4D process should not be used in conducting corridor planning of streets or highways (e.g., for specifying the number of lanes or other project-level details).
- The challenge of the combinatorial effects of the Ds is a vexing one and needs further research since the spurious effects of variable correlation in applying post processing is unknown.

The study usefully classifies travel models into having low, moderate, or high sensitivity to smart growth strategies, notes that the 4Ds capture only some of these, and identifies a number of ways to improve travel model sensitivity to these strategies. These are captured in a stepped diagram that has since found its way into the transportation model/land use literature (Figure A.7).

## Figure A.7 Steps to Improve Urban Travel Model Sensitivities to Smart Growth Strategies




Source: DKS Associates et al. (2007).

The study recommends enhancing travel models to capture smart growth effects but if resources preclude this, then to use a postprocessor, including models like i-PLACE3S or INDEX. The limitations of these tools, however, are noted and the importance of collecting locally validated data for use in any 4Ds postprocessing is stressed. Where jurisdictions already have high-sensitivity travel models in place, however, applying such tools can result in double-counting the effects of smart-growth strategies and are to be avoided.

**Bottom line relevance:** While limited in its scope vis-à-vis our study, this report is, nevertheless, a good example of testing the sensitivity of impacts of scenario sketch tools to reflect impacts on travel behavior, revealing important limitations and areas for improvement.

*Note:* In a follow up study by Caltrans and SACOG (2012), the issues raised in the DKS report were addressed through the creation of a new spreadsheet postprocessor tool developed with the help of Fehr and Peers. This work is not reviewed here since it represents an alternative to sketch tool use for a very specific aspect of impact assessment and does not meet our criteria for a scenario sketch tool.

### *Condon et al. (2009): Urban Planning Tools for Climate Change Mitigation*

Sponsored by Lincoln and the University of British Columbia's Design Center for Sustainability, this booklet is focused on the relationship between urban form and climate change (GHG emissions). The report includes four case studies using INDEX, i-PLACE3S, and Envision Tomorrow to assess their relative abilities to analyze and inform this relationship, from the neighborhood and up to the metropolitan scale.

The ideal characteristics (i.e., performance or functionality criteria) needed in such an urban form/GHG tool (or integrated suites of tools), of particular interest to us in this study, are given as follows (captions only):

- Comprehensive;
- Three-dimensional;
- Multiscalar;
- Policy-relevant;
- Iterative;
- Additive;
- Accessible; and
- Affordable.

The tools themselves are usefully categorized according to four characteristics:

- Scope (e.g., single versus multisector emission sources);
- Methodology (e.g., spatial, top-down, simulation, observation based);
- Scale (e.g., building, parcel, neighborhood, region); and
- Support for policy-making (e.g., at the info gathering, interpretation, policy formulation, implementation and monitoring phases).

An important table summarizes the 12 tools deemed to address urban form/ climate change according to the above four categories and is reproduced in Figure A.8.

## Figure A.8 Comparison of Tool Features

TABLE 1
**Comparisons of Tool Features**

| Tool | Scope | Methodology | Scale | Policy Support |
|---|---|---|---|---|
| **Athena Impact Estimator for Buildings** | single-sector; building energy on a lifecycle basis | nonspatial; spreadsheet-based | individual buildings | information gathering |
| **Community Energy and Emissions Inventory (CEEI)** | multi-sector; buildings, transportation, community waste, and land use change | nonspatial; observation-based; end-state assessment of current conditions | municipal; regional | information gathering |
| **CommunityViz** | multi-sector; various user-selected sustainability indicators | spatial; observation-based | neighborhood; regional | information gathering; interpretation; collaboration |
| **The Development Pattern Approach (DPA)** | multi-sector; buildings, transportation, renewable energy, and other sustainability indicators | spatial; observation-based; end-state evaluations | parcel; neighborhood; district; municipal; regional | information gathering; interpretation; collaboration; implementation |
| **Energy Demand Characterization (formerly the Canadian Urban Archetypes Project)** | multi-sector; transportation and building energy | nonspatial; observation-based and survey-based case studies | neighborhood (approximately 300 residential units) | information gathering; interpretation |
| **Envision Tomorrow** | multi-sector; various sustainability indicators including building and transportation energy and emissions | spatial; observation-based; end-state evaluations | parcel; neighborhood; district; municipal; regional | information gathering; interpretation; collaboration; implementation |
| **INDEX and Cool Spots** | multi-sector; various sustainability indicators including building and transportation energy and emissions | spatial; observation-based; end-state assessment | parcel; neighborhood; municipal; regional | information gathering; interpretation; collaboration |
| **I-PLACE$^3$S** | multi-sector; population, transportation, and employment patterns | spatial; observation-based; end-state assessment | parcel; neighborhood; municipal; regional | information gathering; interpretation; collaboration |
| **MetroQuest** | multi-sector; various sustainability indicators including building and transportation energy | spatial; end-state assessment | municipal; regional | information gathering; interpretation; collaboration |
| **Neighborhood Explorations: This View of Density** | single-sector; transportation | non-spatial; observation-based; end-state assessment spreadsheet | neighborhood | information gathering |
| **Tool for Evaluating Neighbourhood Sustainability** | single-sector; transportation | nonspatial; observation-based; end-state evaluation spreadsheet | neighborhood | information gathering; interpretation; potential for collaborative use |
| **UPlan** | multi-sector; urban growth model; emissions | spatial; process-based simulation | municipal; regional | information gathering |

Source: Condon et al. (2009).

Six of the tools on this list of 12 are ones we have mentioned to date (CommunityViz, Envision Tomorrow, INDEX, i-PLACE3S, MetroQuest, and UPlan). Development Pattern Approach (DPA) is listed as being under development by the University of British Columbia and its thumbnail description (p. 18) sounds like it may be a scenario sketch tool. Further investigation suggests this tool has not been further developed, but it warrants follow up in subsequent tasks. The other five do not meet our criteria for scenario sketch tools (e.g., they are purely spreadsheet-based).

The four case studies deploy INDEX, i-PLACE3S, Envision Tomorrow, and DPA and appear to have been written by the tool developers. In passing, the tool descriptions provide useful information on the number of times the tools have been applied and its market penetration. The case studies make up the meat of the report but they are not organized in a consistent fashion, making comparability difficult along dimensions of the characteristics and categories set up at the beginning of the report. Some of the authors provide self-appraisals of tool shortcomings and needed improvements, others do not. There also is a range of "spin" in the way the case studies and tools are presented.

It is no surprise, therefore, that the brief Conclusions and Recommendations in the report are thin and avoid specifics on the tools described in the case studies except to note that "…no one tool can yet address all of the desiderata identified by officials and experts in our research and conferences to date, the potential to build on the strengths of existing tools is promising." The report further states that "Perhaps the most critical gap we have identified is the inability of tools to move up and down the scales to support effective planning and regulatory decisions, and to set or adjust policy" (p. 45).

### *Portland Metro: Sketch Planning Tools Comparison*

An instructive application of the eight ideal characteristics proposed by Condon et al. is found in an in-house comparative assessment by Portland Metro of eight sketch tools (Table A.3). This work is noteworthy because Portland Metro and the Oregon DOT have a much evolved planning and modeling culture. The work of the Oregon Modeling Steering Committee, for example, is viewed by FHWA as an important national resource for innovative work. They have been responsible for some of the leading edge work in the U.S. on the land use/transportation/ sustainability front for decades, a result of the State's early and ongoing commitment to regional planning. It is also noteworthy that while Portland Metro has developed their own suite of in-house models (called Metroscope and mentioned in the Overview) they still see a need to deploy a scenario sketch tool in their planning work moving forward.

Metro adds some detail to the eight criteria from Condon, notably fiscal analysis (defined as Return on Investment (ROI) – calculations, not traditional fiscal impact analysis). This assessment predates current updates to Envision Tomorrow (now ET+) and Rapid Fire (now Urban Footprint) or upgrades to CommunityViz. The simplicity and clarity of the matrix allowed Metro to make decisions about their preferences and needs.

## Table A.3 Sketch Planning Tools Comparison

| | Oregon DOT | Metro | Fregonese and Associates | Criterion Planners | MetroQuest | Sacramento COG | Calthorpe & Associates | Placeways (Orton Family Foundation) |
|---|---|---|---|---|---|---|---|---|
| **Functionality** | **GreenStep** | **Metro Context Tool** | **Envision Tomorrow** | **INDEX** | **MetroQuest** | **i-PLACE3S** | **Rapid Fire** | **Community Viz** |
| | | | http://www.frego.com/ | http://www.crit.com/ | http://www.metroquest.com/ | http://www.sacog.org/services/i-PLACE3S/ | http://www.calthorpe.com/ | http://www.communityviz.com/ |
| **1 Scenario Building** | **Yes** | **No** | **Yes** | **Yes** | **Yes** | **Yes** | **Yes** | **Yes** |
| ***Iterative*** | | | ScenarioBuilder | Paint the Region | | | | |
| | | | "Allows planners to "paint" the landscape with different development types" | "Allows users to create future land-use and transportation scenarios by "painting" population and employment growth" | | | | |
| **2 Transportation Analysis** | **Yes** | **No** | **Yes** | **Yes** | **Yes** | **Yes** | **Yes** | **Yes** |
| ***Additive*** | | | ScenarioBuilder | PlanBuilder 2.0 | | | | |
| | | | | "Charrette-style interactivity, a comprehensive set of indicators, integrated multimodal travel networks" | | | | |
| **3 Environmental Analysis** | **Yes** | **No** | **Yes** | **Yes** | **Yes** | **Yes** | **Yes** | **Yes** |
| ***Comprehensive/ Policy Relevant*** | | | ScenarioBuilder; Simplistic treatment of environmental impacts | Models stormwater impacts as well as water and energy efficiency | | | | |

| | | Oregon DOT | Metro | Fregonese and Associates | Criterion Planners | MetroQuest | Sacramento COG | Calthorpe & Associates | Placeways (Orton Family Foundation) |
|---|---|---|---|---|---|---|---|---|---|
| | **Functionality** | **GreenStep** | **Metro Context Tool** | **Envision Tomorrow** | **INDEX** | **MetroQuest** | **i-PLACE3S** | **Rapid Fire** | **Community Viz** |
| 4 | **Fiscal Analysis** | **Yes** | **No** | **Yes – ROI Model** | **Yes** | **Yes** | **Yes** | **?** | **Yes** |
| | ***Comprehensive/ Policy Relevant*** | | | Uses a site specific ROI model to examine market feasibility of specific building designs in the context of local zoning codes | Illustrates fiscal impact on local government tax revenues for given scenarios | | ROI function | | |
| 5 | **Spatial Analysis** | **No** | **Yes** | **Yes** | **Yes** | **Yes** | **Yes** | **No** | **Yes** |
| | ***Comprehensive/ Policy Relevant*** | | | | | | | | |
| 6 | **3D and Visualization[a]** | **No** | **2D Heat Mapping** | **Yes with extensions** | **Yes with extensions** | **Yes** | **Web-based interface** | **No** | **Yes** |
| | ***Three-Dimensional*** | | | Firm has strong visualization expertise | Can output scenarios into | Good graphic output/reports | | | Web-based interface |
| | | | | Output to GoogleEarth or ArcGIS 3D extension | GoogleEarth or ArcGIS 3D extension | | | | |
| 7 | **Platform Compatibility** | **No** | **Yes** | **Yes** | **Yes** | **Yes** | **Yes** | **Not very "open" hard to customize** | **Yes** |
| | ***Accessible*** | Runs in "R" | | ArcGIS 9x and Excel 2007 | ArcGIS 9x and Excel 2007 | Web enabled version | | | |
| 8 | **Multiscalar** | **Statewide and County levels** | **Regional scale only** | **Parcel to regional scale** | **Parcel to regional scale** | **Regional scale only** | **Neighborhood to regional scale** | **Statewide and regional scale** | **Parcel to regional scale** |
| | ***Multiscalar*** | | | | | | | | |

| | Oregon DOT | Metro | Fregonese and Associates | Criterion Planners | MetroQuest | Sacramento COG | Calthorpe & Associates | Placeways (Orton Family Foundation) |
|---|---|---|---|---|---|---|---|---|
| **Functionality** | **GreenStep** | **Metro Context Tool** | **Envision Tomorrow** | **INDEX** | **MetroQuest** | **i-PLACE3S** | **Rapid Fire** | **Community Viz** |
| **9 Cost** | **Free/Open** | **Free/Available** | **Free/Open** | **$2,000** | **Expensive** | **Yes** | **Expensive** | **Expensive** |
| ***Affordable*** | | | Software is open and available for free. | Software is licensed for two seats at $2,000 | | | | |
| | | | Firm is local and available for customization and consulting | Firm is local and available for customization and consulting | | | | |

Source: Portland Metro.

[a] Both tools provide building blocks for visualization. Most of the effort will be accomplished using separate tools and resources.

**Bottom line relevance:** a useful assessment that should be matched against the updated versions of the tools studied in this effort and assessment criteria worth revisiting for the comparative framework in this study.

### *Using 3-D Modeling and Planning Decision Support Systems*

This report was written to give recommendations to the Prince George's County (Maryland) planning agency about choosing and building in-house capacity with 3-D modeling and planning decision support systems (PDSS). It involved a survey of available tools at the time, a national survey of planning departments and MPOs about the tools, and in-depth interviews with 10 agencies about their experiences with the tools. In addition, the report included a needs assessment specifically for the County, tool recommendations, and recommendations for building in-house capacity to use those tools.

Tools reviewed include CommunityViz**,** INDEX, i-PLACE3S, and MetroQuest. Numerous other tools were identified, but not reviewed in-depth.

The locations of applications are helpful in suggesting candidate case studies for our current effort:

- Chicago Metropolitan Agency for Planning (CMAP) – MetroQuest, INDEX and ROI Model/Model Builder (an early version of ET+) were used at the regional scale;
- Metropolitan Area Planning Council (MAPC) – CommunityViz was used at the regional scale (Boston) for scenario development. Numerous other tools were used for 3-D simulations, including the 3-D component of CommunityViz, Scenario 3D;
- The M-NCPPC/Montgomery County Planning Department used CommunityViz as an analytical tool at the front end of some long-rage planning processes at the County scale;
- Puget Sound Regional Council (PSRC) used INDEX to analyze regional growth scenarios;
- San Diego Association of Governments (SANDAG) used i-PLACE3S and CommunityViz to support General Plan updates for member jurisdictions;
- The remaining five jurisdictions interviewed were oriented towards 3-D modeling and simulation rather than scenario sketch planning.

This report reviewed a wide range of tools, including 3-D modeling software, 3-D viewers, parametric 3-D/3-D GIS modeling, and PDSS as part of a broader needs assessment for the County. The key finding was that the biggest challenges of successful tool deployment *were institutional in nature*, rather than in the specifics of the tools. Key findings *related to scenario sketch planning tools in general* (as of 2010) were:

- Agencies struggled with the speed and stability of the desktop tools when working at a large/regional scale (INDEX and CommunityViz) making them unsuitable for live workshop use. Both tools were, however, useful for in-house analysis;
- All tools had issues with transitioning from the regional and local scales. In general CommunityViz and INDEX worked better at the local neighborhood scales;
- The tools are very specialized and required a major commitment in training. In fact, the cost of training or hiring staff that can use the tools far exceeds the cost of the tools themselves;
- PDSS in particular required staff with advanced skills is both planning and GIS, which can be difficult to find and retain;
- Available "sketch planning" tools (at the time) did not substitute for more rigorous modeling tools, such as UrbanSim;
- Agencies would like these tools to be publicly accessible via the web, but tend to shy away from using web-based tools live due to sometimes unreliable Internet connection and meeting locations;
- Numerous agencies had difficulty collecting the data in the format required by the PDSS; and
- Numerous agencies cited the cost and inconvenience/complexities of licensing as an impediment to implementation.

The actual assessment of the tools reviewed displays a comprehensive list of criteria of much interest and relevance to the current effort (see Figure A.9). The 10 column headings add to the list of criteria or performance measure we have seen in previous studies, in part because of the broader scope or this review, which emphasized visualization. The column headings are self-explanatory – Shadow Impact Analysis is literally about shadows cast – and are defined in the text (pp. 82-84). The use of Consumer Reports type symbols is nice shorthand.

**Bottom line relevance:** very much on point for this study in terms of tools assessed, study methodology and assessment framework.

## Figure A.9 Tools Evaluated by Planning Activities

**Key**
- ● Excellent Support
- **O** Good Support
- ○ Some Support

| | 1. Community Outreach | 2. Visioning & Planning | 3. Developing Plans | 4. Developing Regulations | 5. Urban Design | 6. Development Review | 7. Visual Impact Analysis | 8. Shadow Impact Analysis | 9. Quantitative Impact Analysis | 10. Build-out Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| **Real-time 3D Viewers** | | | | | | | | | | |
| ArcGIS Explorer | ● | ● | – | – | ○ | – | – | – | – | – |
| Bing/Pictometry | **O** | **O** | – | – | ○ | – | – | – | – | – |
| Google Earth | **O** | ● | – | – | ○ | – | – | – | – | – |
| Simurban World Simulator | ○ | **O** | **O** | **O** | ● | **O** | ● | **O** | – | – |
| TerraExplorer (Skyline) | ● | **O** | ○ | ○ | **O** | **O** | ● | **O** | – | – |
| **3D Modeling Tools** | | | | | | | | | | |
| 3DS Max | ○ | ○ | – | **O** | ● | ● | ● | ● | – | – |
| ArchiCAD | ○ | ○ | **O** | ○ | ● | ● | **O** | **O** | **O** | – |
| AutoCAD | ○ | ○ | **O** | ○ | ● | ● | **O** | **O** | – | – |
| Google SketchUp | **O** | ● | ○ | ● | ● | ● | **O** | **O** | – | ○ |
| Microstation | ○ | ○ | **O** | ○ | ● | ● | **O** | **O** | **O** | – |
| Vector-works | ○ | ○ | **O** | ○ | ● | ● | **O** | **O** | **O** | |
| **3D GIS Tools** | | | | | | | | | | |
| ArcGIS 3D Analyst | ○ | **O** | **O** | ○ | **O** | ○ | **O** | – | ○ | – |
| AutoCAD Map 3D | ○ | ○ | **O** | ○ | ● | ● | **O** | **O** | ○ | – |
| CommunityViz® - Scenario 3D | ○ | **O** | **O** | ○ | **O** | ○ | ○ | – | **O** | ○ |
| **Planning Decision Support Tools** | | | | | | | | | | |
| ArcGIS (Desktop) | **O** | **O** | ● | **O** | ○ | ○ | – | – | ● | **O** |
| ArcGIS Spatial Analyst | ○ | **O** | ● | **O** | ○ | | **O** | – | ● | **O** |
| CommunityViz® - Scenario 360 | **O** | ● | ● | **O** | ○ | ○ | ○ | – | ● | ● |
| INDEX | **O** | ● | ● | **O** | ○ | ○ | – | – | ● | – |
| IPlace3s | ○ | ● | ● | **O** | ○ | ○ | – | – | ● | – |
| MetroQuest | ● | ● | **O** | – | – | – | – | – | ○ | – |

Source: Environmental Simulation Center (2010).

## *Holway et al. (2012): Opening Access to Scenario Planning Tools*

This report, the latest in Lincoln's interest in supporting this subject, is both a recap of scenario planning as understood by the authors in 2012 and a booklet that focuses on sketch tools and their potential specifically. It examines the current state of scenario planning, the promise of scenario planning tools to help prepare for the future, the challenges to expanding their use, and their potential to open access to the planning process. It makes specific recommendations to advance the use of scenarios and scenario planning tools, including development of an on-line platform to facilitate collaboration, capacity building, and open source activities among scenario tool developers, urban planners, and other tool users.

The authors review existing research and experience with scenario planning and document the results of a series of workshops and conversations convened by the Lincoln Institute of Land Policy and the Sonoran Institute in 2010 and 2011. Participants included professional and citizen planners who practice scenario planning, academics researching scenario planning, and experts who develop tools to support scenario planning. As a result of this initiative, a new web site, http://www.ScenarioPlanningTools.org, is now the on-line host for this initiative.

This push towards collaboration between tool developers for open source tools is a significant development in the evolution of tool making. Indeed, this is the prime target of the publication, although it does spend some time on current tools. It selects only four "leading scenario planning tools" for discussion – CommunityViz, Envision Tomorrow, INDEX and i-PLACE3S, a familiar palette by now.[24] These are each described, as of 2012, in narrative terms and a table (reproduced as Figure A.10) usefully summarizes some of their salient features, but only thumbnail examples of projects and little elaboration of the tools is provided. Limited space is given to theories of how scenarios may or should be constructed.

The report also devotes one and one-half pages to four emerging tools: Urban Vision, Decision Commons, Rapid Fire, and Urban Footprint. In the space of only two years this landscape has changed significantly. The first two tools (and their support staff) have been absorbed into the UrbanSim/Synthicity group headed up by Paul Waddell at Berkeley. As noted in the overview, this group also has set its sights on middleweight/lightweight tool creation. Rapidfire is really a nonspatial spreadsheet-based tool and does not meet our criteria for a scenario sketch tool. Urban Footprint currently is in beta-testing and is described in the next section of this review.

[24] Interestingly, *Whatif?* is lumped in with UrbanSim and SLEUTH (a cellular automata model) as belonging to the specialized brand of tools that "attempt to forecast future patterns of urban growth," which seems like an inaccurate judgment.

## Figure A.10 Salient Features of Scenario Tools Compared

TABLE 1
**Summary of Scenario Planning Tools**

| Tool | CommunityViz | Envision Tomorrow | INDEX | I-PLACE³S |
|---|---|---|---|---|
| **Developer** | Orton Family Foundation, Middlebury, VT; Placeways, Boulder, CO | Fregonese Associates, Portland, OR (Envision Tomorrow+ to be developed with University of Utah) | Criterion Planners, Portland, OR | Sacramento (CA) Area Council of Governments |
| **Year Developed** | 2001; 2004–2005 | 2004 | 1994 | 2002 |
| **Summary of Approach** | Spatial, GIS-based | Spatial, GIS- and Excel-based | Spatial, GIS-based | Spatial, web-based |
| **Scale** | Building to regional | Building to regional | Place type to regional | Place type to regional |
| **Open Source Status** | Proprietary with open access models | Open source, housed at University of Utah | Proprietary, in transition to open source | Open source |
| **2D Map Visualizations** | Yes | Yes | Yes | Yes |
| **3D Visualizations** | Yes | No | No | No |
| **Cost** | $500 (Self service support) and $850 per user (one year support and upgrades) | There is no cost associated with downloading Envision Tomorrow+. | A standard version of Index PlanBuilder costs $1900. | Contact SACOG |
| **Requirements** | Version 4.12, is compatible with ArcGIS 9.2 and up, including 10.<br><br>Windows XP, Windows Vista, or Windows 7 (with MS .Net Framework 2.0 and DirectX 9.0) is required.<br><br>A Windows operating system and at least the basic version of ArcGIS Desktop are required. | Requires Windows XP or Vista, MS Office 2000 Pro or greater, and Esri's ArcGIS desktop software 9.3 or greater.<br><br>The tool supports all ArcGIS license types (ArcView, ArcEditor, and ArcInfo). | Desktop tool requires Windows, MS Office 2000 Pro with Access, and ArcGIS 9.3.<br><br>Web tool operates on Windows or Linux servers using a PostgreSQL/PostGIS database and a Python-centric application featuring Django, Mapnik, GEO/OGR, ExtUS, OpenLayers, and GeoExt. | Requires an Internet browser, centralized server, a JAVA virtual engine, and access to an Esri ArcGIS application and license, which EcoInteractive maintains.<br><br>I-PLACE³S works with both the integrated 4-step travel model that requires a current Citilabs license, as well as any external travel model. |

Source: Holway et al. (2012).

The discussion of the standard normative or end-state scenario planning approach covers ground similar to previous reports. However this report now presents the notion of exploratory or anticipatory scenarios (what we have also called contingent scenarios), as a very different kind of endeavor, one which merits serious attention.[25]

But this thread in the report sits uneasily as a parallel narrative within the text and is not really integrated into the body of the discussion, which essentially treats end-state scenarios as the norm and assumes (rather blithely) that "these new methods of foresight and anticipation will not require the development of new modeling platforms in community and regional planning because existing scenario planning tools can be used as a base for added functionality, and modules

[25] Ray Quay, one of the report authors, whose PhD addresses ways of approaching anticipatory governance, is the force behind this thrust in the report.

can be developed to implement new scenario analysis methods." No further exploration of this issue is attempted and it is noteworthy that the assumption is made that it is or should be the object of sketch tools rather than other approaches. The one example given to represent the anticipatory approach – *Vision North Texas* – is not a persuasive one, *but warrants exploration as a case study for this effort*.

Some interesting points about the future of scenario planning tools are made under a section with that heading (page 26). Four broad trends in information technology with implications for scenario planning tools are noted:

- Crowdsourcing;
- On-line Internet access from mobile browsers and other devices;
- The emergence of web-based GIS; and
- The shift of government services and information to on-line systems.

*The current effort must update and take these trends into account.*

The bulk of the report, however, is devoted to a presentation of challenges to using scenario planning tools and to opportunities to expand their use. The challenges cover territory addressed in other reports and are consistent with the FHWA survey referenced earlier but extend them in important ways. The challenges, partially drawn from an informal survey of users and practitioners, are described under the following headings:

- Skepticism and Lack of Awareness;
- Complexity and High Cost;
- Difficulties in Obtaining and Using Data;
- Lack of Interoperability across Tools; and
- Need for Foresight and Anticipation.

The last two challenges, as noted, are new and mirror advances in the explosion in software and social media opportunities and the awareness of some of the limitations of the standard scenario paradigm. These challenges provoke a response in a chapter called "Opportunities to Expand the Use of Scenario Planning Tools," whose prescriptions, listed below, are fodder for additional criteria in a comparative framework of scenario sketch tools:

- Encouraging Acceptance of Scenario Planning and Tools;
- Reducing Complexity and Cost;
- Opening Access to Data;
- Enhancing Interoperability across Tools;
- Advancing Foresight and Anticipation; and
- Creating an Open Environment for Collaborative Action.

The treatment of the last four items in the report contains numerous performance measures for what is desired that can be translated into tool criteria moving forward *and should be revisited for the next task in this effort*. They also contain numerous proposals for general practice that are reinforced in the report's recommendations. The Open Tools group, which convenes around the open tools web site for monthly calls, is moving on the implementation of some of the "low hanging fruit." The tool developers of the primary tools all participate in these calls and so the discussion of open tools, access to tool modules for all, interoperability, all major changes to the current reality of tools competing in the marketplace, is squarely on the table.[26]

Several recent advances in some tools (e.g., SPARC/INDEX) are a response to these new pressures and goals. The report's vision is captured by the statement that "in the long-term, portable modules that are compatible with a wide range of scenario planning tools will lead to a comprehensive scenario development toolset with interchangeable parts" (p. 42).

**Bottom line relevance:** a very relevant document that incorporates the latest thinking by practitioners; must be revisited when creating the comparative framework for tool evaluation.

### *Moudon and Stewart (2013): Tools for Estimating VMT Reductions from Built Environment Changes*

While the title of this recent report does not seem directly related to our study, this research led by a seasoned academic in Washington State (along with Oregon, a national leader in planning innovation) is worthy of attention for several reasons:

- It provides a good primer and checklist for factors affecting travel behavior and choice;
- It thus furnishes a reference point for critically reviewing the land use/ transportation assumptions built into scenario sketch tools; and
- It provides an up-to-date table of professionally oriented tools from various sources[27] to estimate the impact of land use scenarios on travel demand.

[26] For example, the report states that "Envision Tomorrow could be used to create scenarios and then CommunityViz may be preferred for the visualization process" (page 35).

[27] In a report for the Washington State Department of Commerce, Fehr and Peers and AECOM (2009) evaluated eight tools for VMT reduction and then developed a decision tree to identify the most appropriate tool for the job based on various considerations. *This resource will be reviewed in the next task.*

Featured in the table referenced above under GIS- and/or model-based tools are CommunityViz, Envision Tomorrow, GreenSTEP[28], INDEX/SPARC, i-PLACE3S, UPlan, and Urban footprint, confirming the logic of our focus in this study. In assessing the advances made in relating Built Environment (BE) features to travel behavior (VMT reduction, trips switched to nonmotorized trips and nonmotorized trips induced) the authors conclude with a summary of considerations (criteria) for planners to use in identifying or creating such tools:

- Is the tool developed on using data from a population that is generalizable to the planning area population?
- Is the tool outcome the same as the planning outcome of interest? (e.g., is the travel behavior of interest nonmotorized travel along a facility, at the household-level, or to a work or retail destination?)
- Are the input variables readily available and current; do resources exist to collect data if necessary?
- Do the input variables reflect the BE characteristics that are intended to be modified?
- Does the tool operate at the same scale as the planning area?
- Do subjective input variables add or detract from a tool utility?
- Is the tool subject to ecological fallacy? (i.e., does the tool apply aggregate BE-travel relationships to individuals or vice versa?)
- Is the tool subject to the modified areal units problem? (i.e., will the results change arbitrarily when the planning area boundaries are changed?)
- Does the tool adequately quantify all outcomes of interest? Should it account for other planning goals?
- Does the tool rely on reasonable assumptions?
- Does the tool communicate the range/accuracy of the estimate?
- Is the tool readily usable? Are extensive training and resources necessary to use it? If it requires output from transportation demand model, is one available?

This list is a useful adjunct to the many we have been accumulating in this literature review.

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[28] GreenSTEP is primarily a tool to calculate greenhouse gas emissions. It requires a large amount of data, is nonspatial in nature, outputs primarily include GHG and transportation indicators, and it does not provide rapid feedback. It does not produce maps and does not qualify as a scenario sketch tool for our purposes.

### *Regional and Intergovernmental Planning Division of American Planning Association, Winter 2013 newsletter*

While rather less formal and "digested" than the reports covered in this review to date, this very ambitious American Planning Association Chapter newsletter is nevertheless worthy of review. This is because it contains, in one place, the latest write-up of tools-in-progress by their developers as well as comments on scenarios and sketch tools by others active in the field. The table of contents illustrates this point:

**Opening Access To Scenario Planning Tools**............................ Jim Holway, FAICP
**CommunityViz**.......................................................................... Doug Walker
**Better Data and Tool Interoperability on the Scenario Planning Horizon**.......................................................................... Thom York, Eliot Allen, LEED
**Using Interactive DIY Tools for Planning and Decision-Making**.......................................................................................... Ken Snyder
**Alluvial Fans Meet Geodesign**.................................................. Shannon McElvaney
**Kona Community Development Plan**................................ Michael Kwartler, FAIA
**Best Practices in Scenario Planning: Using Envision Tomorrow Plus Model**............................................................ C.J. Gabbe, AICP, John Fregonese
**Maryland Department of Planning's Growth Simulation**........................................................................ Richard Hall, AICP
**Beyond the Tools: Four Critical Elements for Good Public Engagement**................................................................ Daniel Clark, Stephen Brigham
**Afterword**.................................................................................. Uri Avin, FAICP
**Editor's Corner**........................................................................... Ron Thomas

Progress toward the ambitions of the 2012 Open Access report is noteworthy. The individual articles on tools are worth revisiting in the subsequent tasks.

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# Appendix B

*Survey Results*

# B. Survey Results

A web-based survey was conducted in the spring of 2014 to provide an overview of agencies' experience using common sketch tools for regional scenario analysis. The survey serves two functions: 1) to help the project team screen tool users for candidates for in-depth case studies; and 2) to provide basic information about tool usage and experience across a wider range of users than can be contacted for the case studies.

The survey was programmed using a web-based survey platform for which a link was distributed by email. Before distribution to a broad audience, the survey was pilot-tested, first internally and then with four agencies (regional planning agencies in Boston, Los Angeles, Sacramento, and San Diego) to confirm its functionality and obtain feedback on the questions. A two-prong distribution approach was applied:

- Staff at agencies known to have used the tools listed in Question 1 of the survey were sent an email directly asking them to complete the survey. An individual reminder was sent to those who had not completed the survey after three weeks. The project team also made phone calls to a few nonresponding agencies to confirm whether they had used the tool recently and if so to gather information directly.
- An announcement regarding the survey and a link was distributed through the National Association of Regional Councils (NARC). The Association of Metropolitan Planning Organizations (AMPO) was also contacted and expressed their willingness to assist, but was unable to distribute the link (through their newsletter) in the timeframe of the survey due to other communication priorities.

Follow-up telephone interviews were also conducted with selected responding agencies, and some agencies who did not respond, to determine suitability for case studies for the project.

## Respondents

Responses were received from 13 agencies or organizations (out of 20 contacted):

- Allegheny County Department of Economic Development -Pittsburgh, PA
- Centralina Council of Governments – Charlotte, NC
- Chicago Metropolitan Agency for Planning – Chicago, IL
- Chittenden County Regional Planning Commission – Burlington, VT
- Envision Utah – Salt Lake City, UT
- Gulf Regional Planning Commission – Biloxi, MS

- Information Center for the Environment, University of California, Davis
- Macatawa Area Coordinating Council – Holland, MI
- Metropolitan Area Planning Council (MAPC) – Boston, MA
- North Front Range MPO – Fort Collins, CO
- Sacramento Area Council of Governments (SACOG) – Sacramento, CA
- San Diego Association of Governments (SANDAG) – San Diego, CA
- Southern California Association of Governments (SCAG) – Los Angeles, CA

Nearly all of the responses came from agencies individually contacted, rather than from the distributed request. Table B.1 shows the number of agencies using each tool. Some agencies had used multiple tools. The majority had used CommunityViz. Since UrbanFootprint was initially developed for application in California, three agencies from California responded. One agency each had used the other tools. One agency (SACOG) responded for two tools – i-PLACE3S and UrbanFootprint. The response for UPlan was from university research staff that have supported application of the tool, rather than a public agency.

### Table B.1 Tool(s) Used by Respondent

| Response | CV | ET+ | i-PLACE3S | INDEX | UPlan | UF |
|---|---|---|---|---|---|---|
| Allegheny County Department of Economic Development | ✓ | | | | | |
| Centralina Council of Governments | ✓ | | | | | |
| Chicago Metropolitan Agency for Planning | ✓ | | | | | |
| Chittenden County Regional Planning Commission | ✓ | | | | | |
| Envision Utah | | ✓ | | | | |
| Gulf Regional Planning Commission | | | | ✓ | | |
| University of California, Davis | | | | | ✓ | |
| Macatawa Area Coordinating Council | ✓ | | | | | |
| Metropolitan Area Planning Council | ✓ | | | | | |
| North Front Range MPO | ✓ | | | | | |
| Sacramento Area Council of Governments | | | ✓ | | | ✓ |
| San Diego Association of Governments | | | | | | ✓ |
| Southern California Association of Governments | | | | | | ✓ |
| **Total Respondents** | **7** | **1** | **1** | **1** | **1** | **3** |

## Basic Information on Tool Application

The first set of questions were about the tool(s) used, how recently, in what context, and for what purposes. Table B.2 indicates the last time the respondent had used the tool. Most respondents were currently using the tool or had used it recently, within the past two years. Note that in this table (and subsequent tables), there are 14 respondents because one agency evaluated two tools.[29]

### Table B.2 Last Time Tool was Used

| Response | CV | ET+ | i-PLACE3S | INDEX | UPlan | UF | All |
|---|---|---|---|---|---|---|---|
| We are currently using it | 4 | 1 | | 1 | 1 | 3 | **10** |
| Within the past two years | 1 | | 1 | | | | **2** |
| Two to five years ago | 1 | | | | | | **1** |
| More than five years ago | 1 | | | | | | **1** |

Table B.3 shows the scales at which the tools have been applied. Not surprisingly, since the survey was targeted at regional planning applications, most respondents had used it at this scale. However, most respondents also reported using the tool at one or more other scales of planning.

### Table B.3 Scale of Application

| Response | CV | ET+ | i-PLACE3S | INDEX | UPlan | UF | All |
|---|---|---|---|---|---|---|---|
| Regional (metro or rural planning area) | 3 | 1 | 1 | 1 | 1 | 2 | **9** |
| Subregional (multimunicipality) | 3 | 1 | 1 | | 1 | 1 | **7** |
| City/municipal | 3 | 1 | 1 | | | | **5** |
| Transportation corridor | 1 | 1 | 1 | | | | **3** |
| Site/project | 1 | 1 | 1 | 1 | | | **4** |

Table B.4 shows the settings where respondents reported using the tool. Nearly all respondents used the tool to generate information for use with decision-makers, in public meetings, or in published documents. Some had used it exclusively or in part for internal purposes. A smaller number used the tool "on the fly" in meetings.

[29] In addition, two staff persons from this agency responded to the survey regarding using i-PLACE3S. For the questions in this section, the response is included if at least one of these two respondents indicated it.

## Table B.4 Settings Where Tool Used

| Response | CV | ET+ | i-PLACE3S | INDEX | UPlan | UF | All |
|---|---|---|---|---|---|---|---|
| Internal – staff use only | 5 | 1 | 1 | | 1 | 2 | **10** |
| To generate information for use with decision-makers, in public meetings, or in published documents | 6 | 1 | 1 | 1 | 1 | 2 | **12** |
| "On the fly" – real time interaction in meetings with decision-makers | 2 | 1 | 1 | 1 | | | **5** |
| "On the fly" – real time interaction in meetings with the general public | 1 | | 1 | 1 | | | **3** |

Table B.5 shows the indicators of primary interest to survey respondents. The top indicators were land use-related, followed by transportation, the environment, housing, and economic indicators.

## Table B.5 Indicators of Primary Interest

| Tool | Number of Respondents |
|---|---|
| Transportation | 9 |
| Land use | 11 |
| Housing | 7 |
| Environment | 8 |
| Economic/fiscal/return on investment | 5 |
| Equity | 2 |

Table B.6 shows whether agencies modified or customized the tool. In 10 cases, agencies reported having the tool developer or another consultant customize the tool. In one public agency case (MAPC), agency staff did the customization, and in two cases, the tool was used off the shelf.

## Table B.6 Did you Modify or Customize the Tool?

| Tool | Number of Respondents |
|---|---|
| Yes, by in-house staff | 2[a] |
| Yes, by tool developer or consultant | 10 |
| No, we used it off-the-shelf | 2 |

[a] One of these responses was from UC-Davis, not a public agency.

As shown in Table B.7, most agencies had linked use of the tool with transportation planning in some way. In some cases, the tool was interfaced with a travel demand model, either to create inputs or to process outputs. In other cases, indicators from the tool were used directly in a transportation planning process.

**Table B.7 How Was the Tool Linked to Transportation Planning?**

| Response | CV | ET+ | i-PLACE3S | INDEX | UPlan | UF | All |
|---|---|---|---|---|---|---|---|
| Transportation model outputs used as tool inputs | 2 | | 1 | 1 | | 2 | **6** |
| Tool output used to create transportation model inputs | 6 | 1 | 1 | 1 | | 1 | **10** |
| Information directly from tool used to inform transportation planning | 1 | 1 | 1 | | | 2 | **5** |
| Not linked to transportation planning | | 1 | | | | | **1** |

## Tool Utility and Value

The next set of questions asked for feedback on the tool's utility/value, strengths, and limitations. Table B.8 shows ratings for "ease of use," Table B.9 shows ratings for the tool's value/utility in *creating* alternative scenarios, and Table B.10 shows ratings for the tool's value/utility in *evaluating* alternative scenarios. Responses are shown individually for each tool since this part of the survey is important in evaluating each tool's capabilities. However, the results should be interpreted with caution; due to the small number of responses, results may reflect a particular user's experience and other users of the tool may have a very different experience.[30]

**Table B.8 How Would You Rate Ease of Use?**

| Response | Community Viz | Envision Tomorrow/ ET+ | i-PLACE3S | INDEX or SPARC/ INDEX | UPlan | Urban Footprint |
|---|---|---|---|---|---|---|
| Excellent | | 1 | | | | |
| Very Good | 4 | | 1 | 1 | 1 | 2 |
| Good | 2 | | 1 | | 1 | |
| Fair | 1 | | | | | 1 |
| Poor | | | | | | |

[30]Two different people from the same agency responded regarding i-PLACE3S. Both responses are shown in these tables.

### Table B.9 How Would You Value/Utility for Creating Scenarios?

| Response | Community Viz | Envision Tomorrow/ ET+ | i-PLACE3S | INDEX or SPARC/ INDEX | UPlan | Urban Footprint |
|---|---|---|---|---|---|---|
| Excellent | 1 | 1 | 1 | | 1 | |
| Very Good | 5 | | 1 | 1 | | 2 |
| Good | | | | | 1 | 1 |
| Fair | 1 | | | | | |
| Poor | | | | | | |

### Table B.10 How Would You Value/Utility for Evaluating Scenarios?

| Response | Community Viz | Envision Tomorrow/ ET+ | i-PLACE3S | INDEX or SPARC/ INDEX | UPlan | Urban Footprint |
|---|---|---|---|---|---|---|
| Excellent | 2 | 1 | | | | 1 |
| Very Good | 3 | | 1 | 1 | | 1 |
| Good | 1 | | 1 | | 1 | |
| Fair | 1 | | | | 1 | 1 |
| Poor | | | | | | |

Table B.11 indicates whether responses planned to continue to use the same tool in the future. For CommunityViz, most respondents answered "yes."

### Table B.11 Do You Plan to Continue Using This Tool in the Future?

| Response | Community Viz | Envision Tomorrow/ ET+ | i-PLACE3S | INDEX or SPARC/ INDEX | UPlan | Urban Footprint |
|---|---|---|---|---|---|---|
| Yes | 5 | 1 | | 1 | | 3 |
| No | 1 | | 1 | | | |
| Not Sure | 1 | | | | | |

If not, why not?

- CommunityViz. Our agency's approach to scenario planning has evolved toward nonquantitative visioning.
- i-PLACE3S. For the reasons described under weakness/limitation; too expensive.

One respondent provided additional comments. "We scoped a customized tool for purposes of inventorying municipal development prospects (i.e., not the product of a planning exercise, but actual local development proposals and perspectives "from the trenches"). The selected consultant built two layers of custom query on top of CommunityViz. The result was inefficient and prone to "freezing up." We concluded that a better tool could have been built within ArcGIS from scratch."

Table B.12, a key product of the survey, shows the primary strengths and limitations of each tool, as indicated by respondents in a free-response option.

### Table B.12 Primary Strengths and Limitations

| Tool | Strengths | Limitations |
|---|---|---|
| CommunityViz | Ability to develop custom calculations using a variety of built-in functions.<br>Developing alternative land use scenarios and testing them in the build out wizard to help planning commissioners understand the potential development of other density standards.<br>On-the-fly interactivity.<br>The visualization of the input and output data.<br>User friendly, easily integrates ArcGIS shape files and travel demand software.<br>Ease of use, cost of software, interaction with ArcGIS. We have used the tool for regional scenario planning for a 14-county region. The tool has been excellent for quantitative modeling.<br>The ability to develop your own modeling criteria. | Not particularly flexible.<br>The amount of data and complexity of data is somewhat challenging. The learning curve is steep.<br>As with other planning scenario software, it is heavily data driven and must be regularly updated. Staff time must be included in the budget for this task.<br>Scalability of modeling at regional level, down to county, municipal level. This may be a perceived limitation at this point, as we are just getting to this point in our process.<br>The need to have someone very skillful with GIS do the work. |
| Envision Tomorrow/ET+ | Everything you know about a building you can know about a scenario, so it is very powerful for understanding land use patterns and impacts, providing dozens of indicators.<br>It was originally developed for regions. It now also works well in small areas, particularly in understanding which buildings are market feasible and how finance gaps could be closed. | The tool does a great job identifying property tax and sales tax figures for scenarios, but it does not identify some cost side measures that would be useful, including some infrastructure costs (e.g., sewer, lanes miles). |
| i-PLACE3S | Fast, detailed. | Cost, proprietary pieces of the tool and high buy in limited number of users and potential for innovation. |
| INDEX or SPARC/INDEX | Transparency. Getting planners and decision-makers together and supplying information dynamically. Very helpful tool to receive feedback. | Must use weekly to maintain knowledge. |

| Tool | Strengths | Limitations |
|---|---|---|
| UPlan | Simple input data, user defined growth drivers. It is a predictive growth model as opposed to a majority of the tools in this survey that are design tools (requiring the use to assign land uses to locations). This predictive growth component uses algorithms are relatively easy to explain to a nontechnical audience. It uses a raster spatial structure that allows more dissociation between land use change and individual parcels. | Lack of a formal calibration process (though calibrations can and have been done), Written in VBA, which is being deprecated and dependent on ESRI licensing (ArcGIS and Spatial Analyst). Uses a raster framework, which requires careful handling for infill processes in constrained areas. |
| UrbanFootprint | An easy to use comprehensive web based tool that facilitates collaboration among regional and local planners.<br>Web based/Scenario painting/Results in the UI on the fly/Import/export of data/Ability to process large amounts of data/Open source framework/ | Slow performance/Input assumptions need additional R&D/refinement to include a range of specific local/regional policies/Complex UI/ Fairly significant learning curve/ ETL capabilities need automation/ |

Table B.13 shows whether agencies were considering the use of another scenario sketch/planning tool for regional sustainability. Most were not.[31]

## Table B.13 Are You Considering the Use of Another Tool?

| Tool | Number of Respondents |
|---|---|
| Yes | 2 |
| No | 11 |
| Not sure | 1 |

Table B.14 shows whether the agency uses other modeling tools in conjunction with the sketch tool(s). The majority had used it with a travel demand model, and some with a land use or other tool. Additional free response answers are provided below.

## Table B.14 Do You Use Other Modeling Tools?

| Tool | Number of Respondents |
|---|---|
| A travel demand model | 7 |
| A land use allocation or integrated transportation/land use model | 3 |
| Other | 3 |

[31] The two "yes" respondents were SACOG (the respondent for i-PLACE3S said they were considering UrbanFootprint, which is already included in this survey) and UC-Davis. The "not sure" respondent was SANDAG.

Other tools – comments:

- IMPACS, PECAS (will be).
- We work with others to integrate travel demand models into our work.
- We use outputs from CommunityViz to input into the regional travel demand model. Also use a 5-D transportation model for areas outside the travel demand model areas.

These tools are used together in the following ways:

- In addition to generating an array of performance indicators for Regional Transportation Plan/Sustainable Communities Strategy development, the tool is used to generate build environment variables as input to a travel demand model.
- DEFM, UDM, PECAS and ABM currently being used.
- Outputs of the travel demand model are used as basic transportation inputs for sketch planning.
- Outputs from i-PLACES feed into impacts to calculate infrastructure costs. PECAS under development – coordination between models to be determined but PECAS will inform scenario development in the sketch planning tool.
- To estimate travel for long range planning (about 20 years); to determine travel patterns and impacts for large, regionally significant developments; and to plan for future air quality impacts as a result of the transportation system.
- ET+ numbers feed the transportation model. Combined we can illustrate more complete scenarios and visions.
- Land use allocation and travel demand are loosely coupled through exchange of data and feedback, but not formal integration.
- Export from UPlan to Travel Demand Models for assessment of transportation related effects.
- CommunityViz is used to calculate future socioeconomic data. Portions of the travel demand model network are used as inputs to the land use model. The land use model results are part of the input to the travel demand model.
- Current trend forecasts for the year 2040 were developed using CommunityViz and are used directly in the travel demand model to identify deficiencies in the transportation network.

# Appendix C

*Case Studies*

# C. Case Studies

## C.1 INTRODUCTION

This appendix includes seven case studies describing applications of scenario sketch planning tools. Each case study is based on a review of documents produced for the project and conversations with public agency staff and consultants involved with the tool's application. The seven case studies describe the application of three tools:

- **CommunityViz,** in Charlotte, North Carolina; Boston, Massachusetts; and Holland, Michigan;
- **UrbanFootprint,** in Sacramento and San Diego, California; and
- **Envision Tomorrow,** in Salt Lake City, Utah; and Austin, Texas.

Selection of the candidates was based on:

- Willingness to be a case study;
- Scale of application (i.e., favoring regional scale);
- Completeness and depth of their experience;
- Degree of independent application and tool "ownership" by agency (as opposed to complete dependence on consultant or tool developer);
- Diversity in size and sophistication of agency; and
- Diversity in geographic location of application and agency.

The list of case studies does not include case studies for the following tools that were included in the survey:

- **INDEX/SPARC INDEX –** In the project team's original proposal for case studies, two case studies on the application of also were included – Biloxi, Missouri and Fort Myers, Florida. The project team was unable to obtain sufficient information from the local agencies involved with these model applications. Furthermore, we note that the developers of INDEX have stopped developing it for regional sketch planning and its conceptual architecture is now fully embedded in UrbanFootprint.
- **i-PLACE3S –** Only one agency (Sacramento Area Council of Governments) responded regarding this tool, and said they were replacing its use with UrbanFootprint due to cost, complexity, and other factors. SACOG was the tool's major supporter and this withdrawal suggests the tool will have a limited life.

- **UPlan –** No public agencies responded regarding this tool. Also, it is somewhat different than the others in that it is more suited to land use allocation by algorithm rather than for public input in creating scenarios.

Diversity in geography and agency sizes is achieved to the limited extent possible given our survey responses. UrbanFootprint has, to date, only been applied by large agencies in California. Envision Tomorrow also has seen only limited application to date. Examples for CommunityViz and INDEX allow the inclusion of smaller planning agencies in the case studies.

It is important to note that the three tools in the case studies are all moving targets. The UrbanFootprint case studies, in fact, were undertaken by MPOs as part of the development of the tool itself. The case studies, thus, represent snapshots as of late 2014.

The outline of each case study is as follows:

- A summary table of key project information;
- Project overview – a description of the larger planning/visioning process that the tool supported;
- Tool and process overview – how the tool was applied to support this project;
- Tool characteristics – platform, data requirements, indicators, etc.;
- Tool application – how the tool was applied, including data gathering, developing scenarios, indicators, and outputs;
- Evaluation – lessons learned as reported by the agencies involved; and
- Resources – for further information.

The seven case studies cover a fairly diverse set of circumstances, as Table C.1 shows.

## Table C.1 Comparative Features of the Case Studies

| Tool/Place | Context | Agency | Primary work | Prior work with tools | Funding | Duration |
|---|---|---|---|---|---|---|
| Charlotte region, NC | Large urban, suburban, rural | COG | Consultant | None | HUD SCI grant | 2 years |
| Boston region, MA | Large urban, suburban | RPA | Consultant, Agency | Extensive | HUD SCI grant | 2 years |
| Holland region, MI | Small rural suburban | MPO | Consultant | None | MPO funds | 5 years |
| Sacramento region, CA | Large urban, suburban, rural | MPO | Consultant, Agency | Very Extensive | State and MPO funds | 4 years |
| San Diego region, CA | Large urban, suburban, rural | MPO | Consultant. Agency | Moderate | State and MPO funds | 2 years |
| Salt Lake, UT | Large urban, suburban, rural | Consortium (county lead) | Nonprofit, academic | Very Extensive | HUD SCI grant | 4 years |
| Austin, TX | Large urban, suburban, rural | Consortium (COG lead) | Consultant, academic | Limited | HUD SCI grant | 4 years |

Key: COG = Council of Governments; MPO = Metropolitan Planning Organization; RPA = Regional Planning Agency.

In addition to the features noted above, the case studies vary by how the scenarios were generated (e.g., by place types or allocation rules); number of indicators used (from 6 to 18); and scale of application (e.g., region-wide or by subarea or demonstration project), furnishing a sense of how scalable these regional sketch tools are. They also vary in their linkages to tool developers, consultants and research entities like universities.

# C.2 CommunityViz: Charlotte

| **Lead Organization** |
| --- |
| Centralina Council of Governments |
| **Type of Organization** |
| Regional Planning Organization |
| **Organization Jurisdiction** |
| Nine-county region, including and surrounding Charlotte, North Carolina |
| **Geographic Scope of Project** |
| Fourteen counties (7,100 square miles) in North and South Carolina, including four MPOs and two RPOs |
| **Project Timeframe** |
| 2012-2014 |
| **Lead Organization's Prior Scenario Planning Experience** |
| Little to none in the CCOG; some of the member jurisdictions had CommunityViz experience |

## Project Overview

*CONNECT Our Future* is a three-year program (2012-2014) aimed at bringing together communities, counties, states, businesses, educators, nonprofit organizations, four metropolitan planning organizations[32] (MPO), two regional planning organizations[33] (RPO), and the general public across 14 counties in North and South Carolina to develop a shared, long-term vision for the future of the region. The program is led by the Centralina Council of Governments (CCOG) in partnership with the Catawba Regional Council of Governments (CRCOG). The CCOG serves nine counties in the Greater Charlotte area with a staff of 40 overall, eight of whom are dedicated to planning. *CONNECT Our Future* builds on the CONNECT Vision completed in 2008, and continues the region's focus on well-managed growth, a safe and healthy environment, a strong and diverse economy, high-quality education opportunities, enhanced social equity, and increased collaboration among jurisdictions. Work groups under *CONNECT Our Future* include public engagement, blueprinting (infrastructure), economic development, housing, energy, air quality and climate change, food access and logistics, and public health. The program is supported by a $4.9 million Department of Housing

[32] Charlotte Regional Transportation Planning Organization (CRTPO), Gaston Cleveland Lincoln (GCLMPO), Cabarrus Rowan (CRMPO), and the Rock Hill/Fort Mill Transportation Study (RFATS).

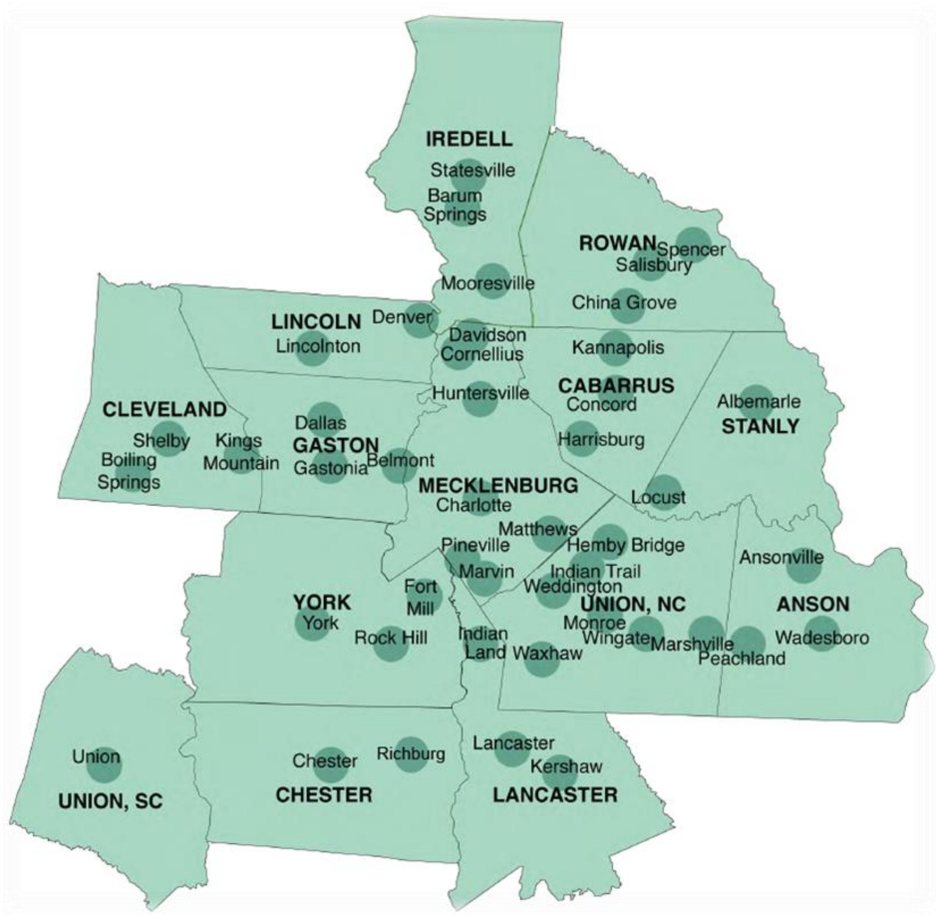
[33] Rocky River RPO in North Carolina and the Catawba Regional Council of Governments (CRCOG).

and Urban Development (HUD) Sustainable Communities Grant and $3.0 million in local public and private resources.

As part of the *CONNECT Our Future* project, a scenario planning process was undertaken to educate citizens and reach consensus on the growth priorities for the region. The scenarios themselves, generated by a number of methods using CommunityViz, were primarily a means to reach consensus on the growth priorities that were ultimately used to create a final "preferred" scenario, which was vetted by all the participating municipalities. At the time of this case study, CCOG was adding socioeconomic data forecasting for the transportation models that the MPOs in the region run, and plans to support their municipal partners in using CommunityViz at the municipal level.

Figure C.1 shows the *CONNECT Our Future* planning area that includes the 14 counties surrounding Charlotte, North Carolina.

**Figure C.1 *CONNECT Our Future* Planning Area**




Source: Centralina Council of Governments.

## Tool and Process Overview

CCOG had little experience with scenario planning tools prior to this project and was open to various possibilities. After CCOG was awarded the HUD grant, it hosted a HUD-sponsored workshop for attendees from across the nation where one of the topics of interest was scenario planning and, in particular, what have other agencies done in that regard and what software they used. When CCOG asked "what scenario planning software should we be looking at?" CommunityViz and Envision Tomorrow were mentioned as leading contenders. A consultant working with CommunityViz was ultimately selected based on the capabilities and track record of both the consultant and the software, and hired to design and lead the scenario planning effort (the contract value was approximately $467,000.) Other factors that influenced their choice of CommunityViz included that there already were quite a few communities in the region using CommunityViz, and also that CommunityViz is an add-on to ArcGIS,[34] which is the GIS used by most of the communities in the region.

The scenario planning process was branded as "Blueprinting." The process used CommunityViz to create indicators that reflected the goals people want to achieve, generate several alternative patterns for growth and development, analyze the patterns using the indicators, and develop consensus around the patterns that produced the best results on indicators. Four alternative scenarios were developed with CommunityViz, and MetroQuest was used to help present the outcomes in a more user-friendly format.

To reach consensus on 10 priorities, CCOG hosted numerous public outreach activities:

- "Phase One" was public engagement that lasted for a couple of months and consisted of open houses and small group meetings in all 14 counties to find out what people valued in communities and did not want to lose once growth occurred.
- "Phase Two, Part One" was an Urban Land Institute "reality check" meeting. Over 400 people participated, looking at how much growth is coming and where it should go. This was a decidedly low-tech effort using Lego pieces to represent development. The exercise helped frame discussions about thoughts on growth and guiding principles and produced distinct development patterns that were used in subsequent workshops, as described under the section on Developing Scenarios.
- "Phase Two, Part Two" consisted of 57 Community Growth Workshops held in the 14 counties to support the scenario planning process and reach

[34] Envision Tomorrow and INDEX, at the time, also were ArcGIS based.

consensus on the growth priorities for each county. The top 10 priorities rose to the top almost immediately and were quite clear:

1. More Transportation Choices;
2. Support Our Communities;
3. Parks and Open Space;
4. Support Local Farms;
5. Cost of Providing Services;
6. Improved Water Quality;
7. Improved Air Quality;
8. Work Closer to Home;
9. More Housing Choices; and
10. Cost of My Commute.

At each workshop, growth scenarios were developed using "chip" games whereby participants allocated chips representing 10 specific community types representing the projected growth of each county. Participants could trade in chips representing lower-density community types for higher-density community types, or vice versa, keeping control totals the same. This produced maps for each table that were then used after the workshops to create a composite map for each county. The composite maps were created by overlaying an acetate sheet over the workshop maps and marking areas of consensus, then digitizing the marked areas into GIS format. The composite maps for each county were tiled together and became one of the final four scenarios for evaluation.

- "Phase Three" was the last phase of public engagement. The top 10 priorities and 4 scenarios were presented to the public and preferences tabulated using clicker voting.

As outlined above, the scenario planning effort was interwoven with the public outreach activities. More detail about creating the scenarios is described below in the "Tool Application" section.

## Tool Characteristics

The open framework that CommunityViz provides for scenario development was appealing to CCOG for a number of reasons. First, the framework is transparent: all formulas and assumptions were fully exposed for review and comment by member jurisdictions and the public. When questions arose at a workshop about the validity of a counterintuitive indicator result, the team was able to go into the model and easily show and explain the results. CommunityViz's open framework also has the advantage of flexibility and scalability. This was critical in working over such a large region with communities of significantly different sizes and scales, with base data organized in a number of different ways.

The scale of the region and the size of the model (number of records) proved to be a significant problem with regards to the amount of time it would take to run the model. Updating one record in a layer would trigger a recalculation of all records in a layer, whether those other records made any difference in the result or not. This meant that every time an edit was made to the layer, all 140,000 grid cells would recalculate. This became time-consuming and impractical in the Centralina model. To address this issue, the consultant contracted with Placeways (the developer of CommunityViz) to implement "incremental updates" into the software, whereby individual features could be updated without triggering the update of the entire layer and only update data affected by the individual edit. The contract value was approximately $18,000.

Another issue was the lack of "proximity" functions in the software, partially within the Suitability Wizard. For instance, one location would be considered "more suitable" than another location if there were more households within a certain distance. A "ProximityCount" function would count the number of households within a distance of a given site, and a higher score would be given for more households. As part of the "upgrade" contract, Placeways also agreed to add proximity functions as well as other improvements to the Suitability Wizard. Eventually, the incremental updates, proximity functions, and improvements to the Suitability Wizard were rolled into the latest release of the software. The consultant and CCOG obtained a prerelease of the software to use for this project.

## Tool Application

The consultant was the project leader for the entire scenario planning initiative, including development of the project scope, brainstorming a model architecture, and leadership roles in meeting strategy/facilitation. His work was supplemented by a model development team (CCOG and CRCOG staff) that did nearly all of the data collection and coding to fulfill the model architecture for such a large-scale effort. CommunityViz was used to create all alternative scenarios, as well as all the steps that lead up to scenario planning, including data gathering, carrying capacity, and build out potential analyses, land suitability analysis, and growth allocation modeling. The combined efforts of consultant, client model development team, and member jurisdictions to develop the scenario planning tools and test the four alternative growth scenarios lasted approximately 22 months. Staff commitments varied over the course of the project, but generally, four full-time equivalent employees (consultant and client team members combined) worked on the project from month-to-month. Input from participating agencies, stakeholder groups, and local governments generally equated to two full-time equivalent employees (combined across the region) from month-to-month.

### *Data Gathering and Establishing a Baseline*

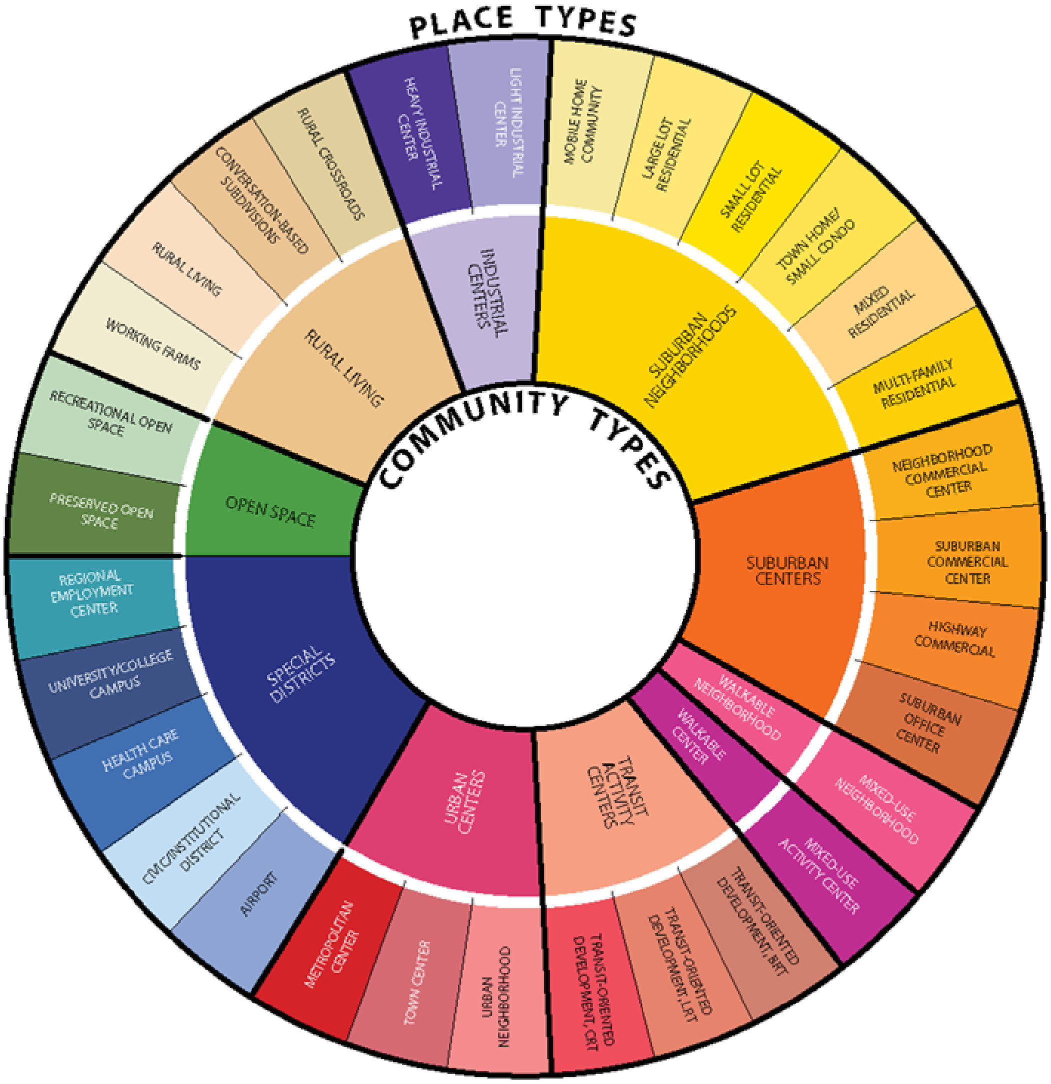
Given the scale of the region, it was impractical to perform a parcel-based analysis in CommunityViz because the analysis would take too long. Generalizing parcels to a uniform grid also would create too many records to evaluate in a reasonable amount of time. Instead, an uneven grid was created where large swaths of land with common use (such as farmland) were represented by larger cells than smaller-grained land use (as in urban areas). In general, urban areas were assigned 10-acre cells, areas one-half mile to major transportation routes were assigned 40-acre cells, and remaining open space and farmland were assigned larger cells still. To assign the predominant land use from parcels to the cells, CommunityViz's "OverlapMost" function was used. In the end, there were 149,000 grid cells representing the 7,100 square mile region, which was a number that CommunityViz could handle in a reasonable amount of time when analyzing the performance of 10 indicators in four scenarios. It still, however, took hours – making CommunityViz impractical for "live" application in a public meeting.

Although CommunityViz does have a built in tool for build-out analysis, it was deemed insufficient for an area of this size with so many different jurisdictions, each with their own zoning code. The "Build-Out Wizard" in CommunityViz requires entering building form, size, and setback requirements for all zoning districts into what essentially is a look up table, which is then referenced when evaluating each parcel for build-out capacity. In this case, because there were so many zoning classes and CCOG did not want to lose any detail, it made more sense to enter the data into a spreadsheet-based lookup table that was vetted by each community and then imported into CommunityViz and used to calculate carrying capacity and build-out potential.

A similar process was used to establish generic place types to describe the existing land uses and for creating alternative future scenarios. Each community had different existing and future land use classifications and definitions. In order to "normalize" these classifications, 31 "place types" were developed for the region and vetted through each of the member jurisdictions. Although CommunityViz does allow place types to be created via the "Land Use Designer" wizard, CCOG wanted to create a master look-up table where the original land use for each jurisdiction was directly linked to each place type. For public workshops involving "chip" exercises, the 31 place types were generalized into 10 "community types" because more than that number became difficult to manage and visualize.

Figure C.2 illustrates how the 31 place types nest into more generalized Community Types.

**Figure C.2 Community Types and Corresponding Place Types**




Source: Placeways, LLC.

## *Developing Scenarios*

The “final four” scenarios used for the MetroQuest application and Phase Three of public engagement were developed with CommunityViz using the Allocation Wizard. They were:

1. **“Maintain Suburban Focus.”** This scenario assumes that current zoning and land use practices continue and community plans are not followed. The “supply” side of the model considered development potential based on zoning.

2. **"Follow Community Plans."** As the name implies, this scenario showed how the region might develop if adopted community plans were followed. The model's supply was generated from development potential based on existing community plans.
3. **"Focus on Regional Transportation."** This regional scenario emerged from the composite Community Growth Workshops. Supply was generated considering development potential based on the place types assigned during the workshops.
4. **"Grow Cities, Towns, Centers, and Transit."** Place types were assigned by planners in response to Scenario 3 and best practices to maximize performance on the 10 growth priorities, based on planners' experience and judgment. Those place types were used subsequently to generate development potential, which was used for the supply side of the allocation model.

In all scenarios, the "demand" component of the allocation model was constant, based on the regional control totals for each jurisdiction for population, households, and employees by category used in the Metrolina Travel Demand Model (used by Charlotte Regional Transportation Planning Organization). The "suitability" input to the allocation model was based on a land suitability analysis that was generated using CommunityViz's built in Land Suitability Wizard. Suitability was based on a dozen factors, including proximity to major roads and interchanges, Growth Activity Centers, transit corridors and stations, sewer and water service areas, and others. The "supply" (development potential) generated for each scenario was allocated via the place types and broken down into six categories: single-family units, multifamily units, retail employees, office employees, industrial employees, and institutional employees. The Allocation Wizard in CommunityViz can only be run for one supply/demand source at a time, meaning that the model had to be run for each demand control total (14 counties) for six categories, for a total of 84 runs.

The CommunityViz Allocation Wizard can be run in either strict order or probability-based modes. In probability mode, the model can be set to apply either a linear or an exponential probability. The consultant chose to use the probability-based, exponential mode since, based on his experience with other jurisdictions, it tends to provide more realistic results than strict order allocation, which assumes 100 percent efficiency and 100 percent adherence to the order of land suitability scores.

### *Indicators*

CommunityViz includes a "wizard" that helps users create up to 100 generic indicators (with assumptions based on national standards) depending on how many base data sets are available. Typically, however, more experienced users – like the consultant in this case – choose to set up their own indicators that are more tailored to their needs, local conditions, and data quality/availability. CommunityViz has a "Formula Editor" for this purpose that provides templates, auto-complete, context-sensitive help, and formula validation. For this project, the consultant developed 10 custom indicators to measure performance against the 10 growth priorities established earlier in the process, as shown in Table C.2.

### Table C.2 Top 10 Growth Priorities and Indicator Definitions

| Growth Priority | Indicator Definition |
|---|---|
| Parks and Open Space | The percentage of people moving to the CONNECT Region that may live near an existing park of some kind. Result good (+)/Result bad (-) |
| More Transportation Choices | The amount of mixed-use, walkable development (as a percent of total land area) that could support multiple travel modes. Result good (+)/Result bad (-) |
| Support Local Farms | The absolute change for the amount of farmland saved from future development in the alternative scenario. Result good (+)/Result bad (-) |
| Work Closer to Home | An index for the number of people living near potential job opportunities (uses a 10-mile radius). Result good (+)/Result bad (-) |
| Support Our Communities | The land consumed (as a percent of total development footprint) for new growth inside communities as infill and redevelopment as greenfields versus outward expansion. Result good (+)/Result bad (-) |
| Cost of Providing Services | The generalized ad valorem tax value per acre change associated with preferred development types, patterns, and intensities. Result good (+)/Result bad (-) |
| Improved Air Quality | The amount of $CO_2$ or $NO_x$ that could be generated by automobiles. Result good (-)/Result bad (+) |
| Improved Water Quality | Land assumed to be impervious surface (as a percent of total development footprint) under the preferred development pattern. Result good (-)/Result bad (+) |
| Cost of My Commute | The percentage of household income spent on transportation (dual-income household). Result good (-)/Result bad (+) |
| More Housing Choices | An index for the variety of housing choices in the scenario. A positive score (0-10) is an improvement over the starting scenario. (0 = Low/10 = High) |

Proxies were used for a number of indicators in cases where there were strong correlations to data that were easier/simpler to derive than the "full" calculation. For instance, the amount of impervious surfaces was used as a proxy for water quality. More "accurate" formulas could have been developed in CommunityViz to calculate actual nitrogen and phosphorous runoff, but the complexity of the model, the additional data required for numerous watersheds, and the additional computation time were considered too high a price to pay when there already is a strong correlation between impervious surfaces and water quality. A similar choice was made for "Transportation Choice." A more complex model could have been developed, but for the purposes of scenario planning, the amount of mixed-use walkable development was used as a proxy.

### *Output and Graphics*

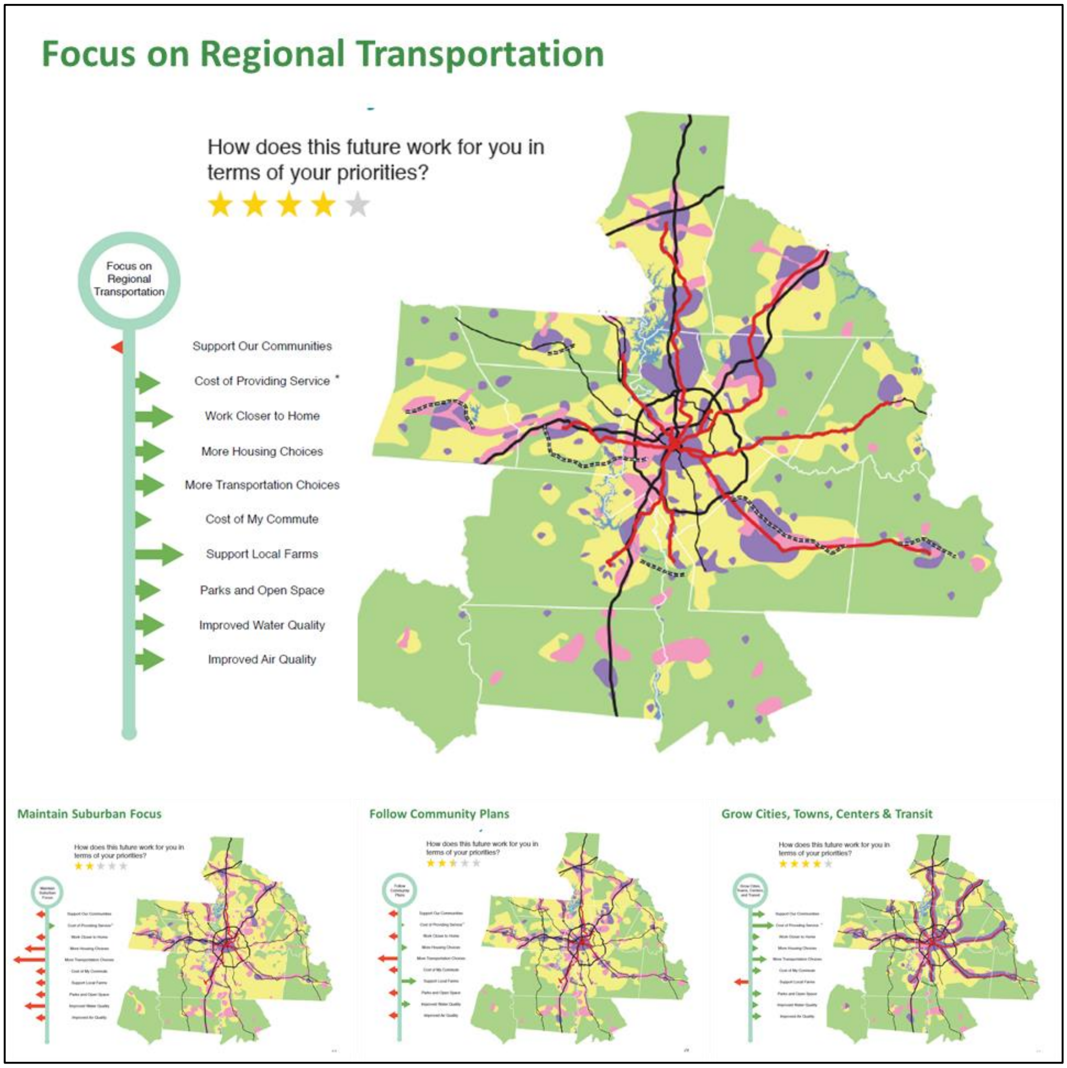
CommunityViz output – maps, indicators, and charts – can be a bit unwieldy, especially for such a large area and so many indicators. This was acceptable for internal use, but it was clear that something else was needed for the public outreach effort – both on-line and for workshops. CommunityViz does have several "reporting" functions, which create reports with varying degrees of interactivity meant for public education. They include:

1. **The Report Wizard.** This wizard creates HTML reports for:
   a. Summary of the analysis;
   b. Detailed scenario comparison report; and
   c. List of files needed to run the analysis.
2. **The WebShots Wizard.** This wizard creates snapshots of an analysis that can be displayed on a web site as a slide show or in a partly interactive format.
3. **Analysis Publisher.** This function creates freely sharable, read-only versions of Scenario 360 analyses that anyone can view using the free CommunityViz Analysis Viewer together with ESRI's free ArcReader software.

These CommunityViz reporting tools lacked the polish and clarity desired by CCOG. MetroQuest, a software-as-service tool specifically designed for public engagement, did have the desired level of clear graphics, ease of use, and stability. MetroQuest packages client-provided content (maps, indicators, pictures, graphics, and narratives) into an on-line, interactive "game" where a planning project gets introduced, the public gets to make certain choices, the results of those choices are displayed as maps and charts, and feedback is collected and tabulated for further analysis. There is no model running behind the interface: all possible combinations of choices and scenarios are precalculated. This does limit the number of choices available, but in the case of Centralina, there were only four scenarios to choose from. Preloading the maps and indicator results makes the application fast and stable – two critical features for public outreach. CommunityViz and MetroQuest are quite complementary to each other: CommunityViz generates scenario analysis and content, and MetroQuest provides an accessible "public face" to the analysis that also collects feedback about the scenarios. Using the feedback gathered through MetroQuest on-line and at numerous public meetings, CCOG created a final "Preferred" County-Level Consortium Scenario, which was vetted by all the participating municipalities.

Figure C.3 shows the four scenarios generated for the CONNECT Our Future project. The map and graph at the top was the scenario that emerged from the composite Community Growth Workshops. The three at the bottom were developed by staff using the various methods described. All of the scenarios and indicators were analyzed in CommunityViz, although the results were visualized using MetroQuest. The arrows showing relative performance of the indicators, as well as the rating scale, are elements from the MetroQuest interface.

**Figure C.3 Scenarios Generated from the CONNECT Our Future Workshops**




Source: Centralina Council of Governments.

## Evaluation

The scenario planning horizon year was timed to correspond to the next round of MPO Long-Range Transportation Plan development, a key implementation step, so that the scenario planning outputs could inform the development of that plan. There are four MPOs in the CCOG region. Both the Mecklenburg-Union MPO and the Gaston MPO wanted to use the process for this purpose. The process also was expected to inform the Regional Freight Plan, the Mobility Management Plan, and other transit planning.

CCOG is quite satisfied with CommunityViz and intends to continue to use the software to support a number of initiatives. One proposal is for the CCOG to work with the multiple MPOs in the region to adjust the model so that it "better fits" what the MPOs need. For instance, the MPOs are interested in more travel-related indicators and "beefing up" the ones that already are there. The MPOs also might want to revert to finer grain inputs (parcels) for the model rather than the generalized grid used for the regional process. CCOG also plans to run allocations for 10-year increments from 2020-2050 for the MPOs use. (The model was only used to allocate households and jobs for the plan's horizon year of 2050.) Another proposal is for CCOG to be responsible for keeping the data collected for the regional planning process up to date so that the MPOs can use that data for the transportation planning process. Finally, the model is intended to be turned back over to the COGs, MPOs, and municipalities for their use. CCOG has set up training sessions for their staff so they can learn to use the model without the assistance of the consultant and assist member jurisdictions with CommunityViz.

### Table C.3 Agency's Perception of Strengths and Weaknesses of the Tool

| Strengths | Weaknesses |
|---|---|
| ArcGIS-based | Graphic output quality |
| Used by a number of member agencies | Processing time[a] |
| Open framework provides transparency, flexibility and scalability | Lack of proximity functions[b] |
| Built-in allocation wizard | Build-out wizard difficult to use over multiple jurisdictions |
| Fully customizable indicators | Major commitment of resources |

[a] Partially addressed in newer version.

[b] Addressed in newer version.

## Resources

| Lead Agency | |
|---|---|
| Centralina Council of Governments | http://www.centralina.org/ |
| **Consultants** | |
| Seven Hills Town Planning Group, Inc. | http://www.seven-hills-group.com/ |
| Stantec Consulting Services, Inc. | http://www.stantec.com/ |
| University of North Carolina Charlotte, Design and Society Research Center | |
| Kimley-Horn and Associates, Inc. | |
| Urban 3 | |
| **Links for More Information** | |
| CONNECT Our Future Home Page | http://www.connectourfuture.org/ |

# C.3 CommunityViz: Boston

| |
|---|
| **Lead Organization** |
| Metropolitan Area Planning Council |
| **Type of Organization** |
| Regional Planning Organization |
| **Organization Jurisdiction** |
| Covers 101 jurisdictions, including Boston and the communities inside Route 128 (approximately 1,422 square miles) |
| **Geographic Scope of Project** |
| 164-municipality region used by the Boston MPO for transportation modeling |
| **Project Timeframe** |
| From "Process Design" in May 2002 to plan release and adoption by MAPC in May 2008; scenario planning component was January 2005 to December 2006 |
| **Lead Organization's Prior Scenario Planning Experience** |
| None for MAPC, and little to none for member jurisdictions |

## Project Overview

MAPC (Metropolitan Area Planning Council) is a regional planning agency for the Boston metropolitan area, which includes 101 communities covering 1,422 square miles. MAPC is a strong advocate for "smart growth" planning in the region, and has about 80 staff performing planning, research, and outreach on a wide variety of related topics, including transportation, housing, energy, environment, and others. MAPC is not the MPO; that function is filled by the Boston MPO, which is staffed by the State through the Central Transportation Planning Staff (CTPS).

MAPC has been using CommunityViz for about 10 years, at different scales of application. The first application, and the focus of this case study, was at a regional scale creating alternative future land use scenarios as part of the "Metro Future" project. More recently, CommunityViz has been applied at the corridor level to support land use scenario planning in conjunction with proposed transit investments, and at the site level using visualization capabilities to support development planning and analysis. As of this writing, it is being used in various ways to support the HUD Sustainable Communities Challenge Grant project that MAPC is administering. MAPC describes MetroFuture as follows:

"MetroFuture is MAPC's 30-year plan for [the Boston Metro region], and serves as a guide for the work in all areas of the agency. The MetroFuture plan supports a vision of smart growth and regional collaboration through the promotion of:

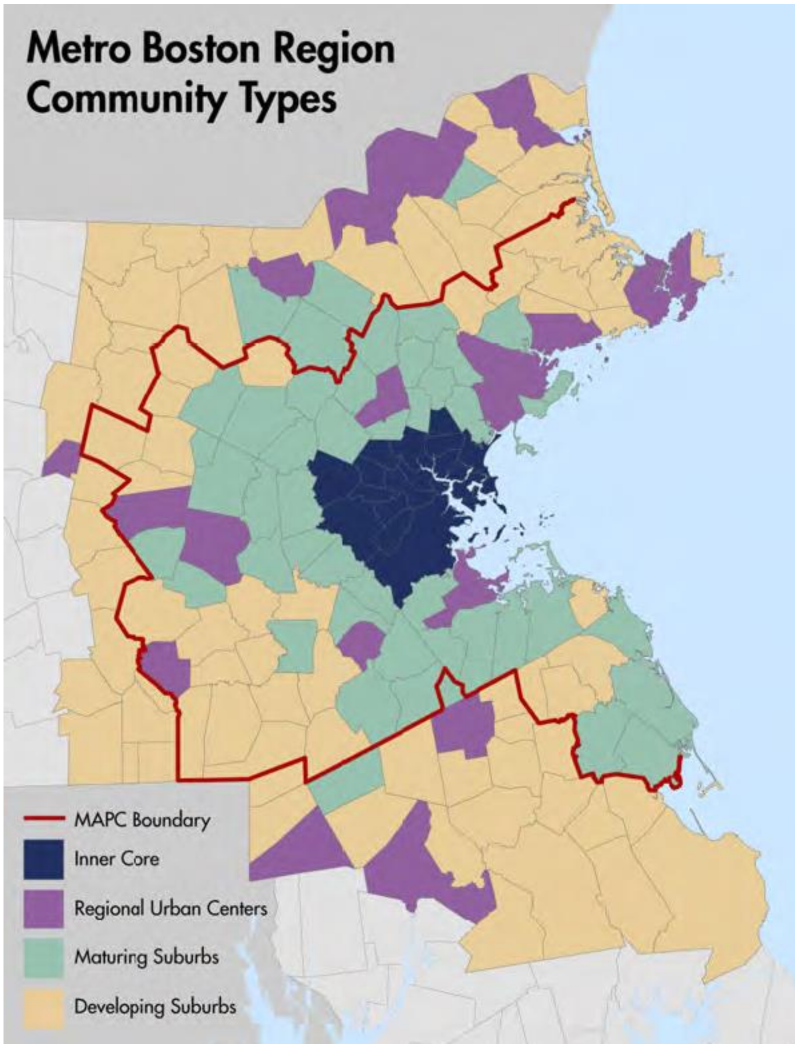
- Efficient transportation systems;
- Conservation of land and natural resources;
- Improvement of the health and education of residents; and
- An increase in equitable economic development opportunities for prosperity."[35]

In 2003, MAPC began the process to update the original MetroPlan dating from 1990. MAPC defined a process that included technical planning, civic engagement, and implementation in equal measures. The process was guided by a Steering Committee comprising representatives from government, nonprofits, institutions, business, and advocacy organizations. The plan was adopted by MAPC in 2008.

The scenario planning process was mostly in support of the civic engagement process, but also supported technical planning for the project. The goal was to create a preferred regional growth scenario for the year 2030 that could be used to develop a set of socioeconomic projections for the region. Because the forces that shape the region extend beyond MAPC's official statutory boundaries, the analysis was expanded to cover the 164-municipality region used by the Boston MPO for transportation modeling. Figure C.4 shows the MetroFuture planning area, with the four basic community types highlighted with colors, and MAPC's official statutory boundaries shown in red.

[35] http://www.mapc.org/metrofuture.

**Figure C.4 MetroFuture Planning Area**




Source: Metropolitan Area Planning Council.

The bulk of the scenario planning work was done over a two-year period from 2005-2006 using CommunityViz 2.2. CommunityViz is at version 4.4 at the time of this writing and there have been numerous improvements and upgrades to the software. Nevertheless, other than improvements in stability and speed, the core features of CommunityViz remain much the same, and this application relied mostly on those core features to generate scenarios.

## Tool and Process Overview

In June of 2004, MAPC issued a request for proposals (RFP) for "Building Capacity for Regional Decision-making in Support of the Boston Area's MetroFuture Project." The two main components of the RFP were: 1) the development and initial application of decision support tools that met extensive criteria specified by MAPC, and 2) training in the use and ongoing application of such decision support tools, including technical support. A consultant team was awarded the RFP and CommunityViz was chosen as the tool, for a contract amount of approximately $80,000. CommunityViz fit most of the criteria specified for baseline and alternative scenario generation and evaluation. Given the large number of municipalities involved, and the varying levels of data detail and completeness, the software's flexibility also was seen as a plus. There also was a desire to make the process as transparent as possible, so CommunityViz's open and accessible framework was an ideal match. MAPC also wanted to use the software interactively at public workshops, which the software is designed to do, although the success of that was limited (as described later).

The MetroFuture plan was developed over five phases, three of which used CommunityViz to create and analyze alternative scenarios for the region:

- Phase 1 consisted of the **Initial Visioning Activities** from which 52 Visioning Themes emerged based on feedback from 30 Visioning Workshops and 1 Citizens Seminar, as well as telephone polls and surveys administered on-line, in person, and through the local papers.
- Phase 2 analyzed **Current Growth Trends** to create a scenario to project what the regional would look like if current trends for demographics, employment, labor supply, land use, open space resources, housing supply, water demand, municipal finance, transportation, and energy consumption continued until 2030.
- Phase 3 developed three **Alternative Future Scenarios**, based on public input from the previous phases plus large-scale meetings where participants used CommunityViz to experiment with assumptions about the distribution of future growth to better understand the impacts and the type of development that will occur. (The scenarios are described in more detail later in this document.)
- Phase 4 established a **Preferred Scenario**, based on two working sessions of over 400 people who used CommunityViz to adjust assumptions to see how the scenarios balanced various concerns, and to help them select their favorite scenario.
- Phase 5 developed **Implementation Strategies** to make the plan a reality.

The indicators used to evaluate scenarios fell under the general categories of Regional Growth Patterns; Labor and Prosperity; Housing Choice and Community Vitality; Air, Water, and Wildlife; and Getting Around.

## Tool Characteristics

In 2003, ArcGIS was radically redesigned with a completely new architecture. Since CommunityViz was based on ArcGIS, it too needed to be radically changed. The entire interface and underlying code had to be rewritten, so in many ways CommunityViz 2.x was "new" software, and as such more prone to glitches and bugs. The conceptual and functional attributes, however, remained the same as the original CommunityViz: an open framework for creating scenarios and indicators using fully exposed and customizable formulas and assumptions.[36] In theory, those attributes would translate into flexibility and scalability; however, performance issues hindered the latter. MetroFuture covers a vast area and many jurisdictions, and parcel-level analysis would have overloaded CommunityViz with millions of records. At the time, however, parcel-level data were not always available for all jurisdictions, so Traffic Analysis Zones (TAZ) were used as the geographic units of analysis. Even at this coarse geography, MAPC still had issues with CommunityViz's update speeds, which were too slow to realistically use at public workshops. To get around this, MAPC severely limited the number of variable assumptions that could be changed in the workshops, and in some cases used Excel models in conjunction with CommunityViz to process indicators. Limiting variables was actually considered a "good thing" in the end because if participants were able to change too many variables at once, it would be harder for them to recognize relationships between a few key variables.

This also was the agency's first major project using CommunityViz and the model was very complex.[37] CommunityViz seemed to have problems scheduling which processes to run first, and sometimes updated the same data point multiple times. Subsequent releases of CommunityViz have resolved many of these issues and substantially improved processing time – although it is hard to say if those improvements would have been enough to allow MAPC to use CommunityViz to the extent they originally intended at the public workshops.

## Tool Application

### *Data Gathering and Establishing a Baseline*

MAPC encountered a few challenges gathering the base data because data resources were somewhat limited – much more than they are today. They did not have any parcel data, but they did have a land use layer for the region (a situation that is comparable to many small MPOs today). They also had a statewide zoning layer but it did not include any overlays – which are common and important in Massachusetts. For this reason, their build-out capacity analysis was not as accurate as they would have liked. They had population data at the block level, but employment data were only available at the TAZ level. Given these data limitations and the aforementioned software performance issues, TAZs were chosen as the geographic unit of analysis, which totaled 2,727 for the region.

The baseline or "Current Trends" scenario was not created with CommunityViz. For this scenario, MAPC used a GIS/spreadsheet-based land use model

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[36] It also included a module that produced three-dimensional (3D) visualizations of proposed alternative scenarios. This module was not used for the MetroFuture project although it has been used for subsequent smaller-scale projects at the site level.

[37] More experienced modelers can sometimes wrestle better performance out of CommunityViz through various, more advanced techniques.

(developed prior to MAPC's use of CommunityViz) that distributed growth to the TAZ geographies. Regional population growth was based on birth rates, mortality, and migration rates for age-race-sex cohorts. Regional employment trends were based on national growth projections by industry sector and Metro Boston's estimated share of that growth. Population and employment growth were allocated to individual municipalities based on each community's share of recent growth. Within each municipality, growth was allocated to TAZs based on recent land use trends, developable land, existing zoning, and municipality-specific redevelopment trends. The regional population growth and employment trends were used as control totals for subsequent scenarios developed in CommunityViz.

### *Developing Scenarios*

To create alternative future scenarios, MAPC used CommunityViz to distribute the forecast housing and employment to different TAZs based on assumptions about the share of growth different communities types would receive. MetroFuture identified four basic Community Types: Inner Core, Regional Urban Centers, Maturing Suburbs, and Developing Suburbs. Within each Community Type there were two subtypes identified: communities that fall within development priority zones,[38] and those that do not. Adjusting how much growth went into each subtype could substantially change how growth was allocated across the region, thereby creating alternative future scenarios.

MAPC staff created four alternative future scenarios. They were:

- **"Let It Be" (the Current Trend scenario) –** As previously described, the distribution of housing and jobs to TAZs was based on another model outside of CommunityViz, but the evaluation of impacts was done with CommunityViz indicators that were common to all scenarios.
- **"Little by Little" –** This alternative scenario represented what the region might be like if cities and towns implement many of the "smart growth" tools that already are available regarding land use planning, housing production, land and water conservation, and economic development. In most cities and towns, population and employment growth would be the same as under Current Trends, but communities would take steps to change the location and pattern of growth at the local level, reducing negative regional impacts.
- **"Winds of Change" –** This alternative scenario represented what the region might be like if communities made major efforts to address challenges regionally, with individual cities and towns sharing in the costs and benefits

[38] Community-Oriented Development Areas (CODA) are a MetroFuture designation for TAZs in the modeling region that contain high opportunity areas for development by virtue of existing infrastructure, transportation amenities, and access to destinations. CODAs include city and town centers, areas near transit or other infrastructure, and many major employment centers.

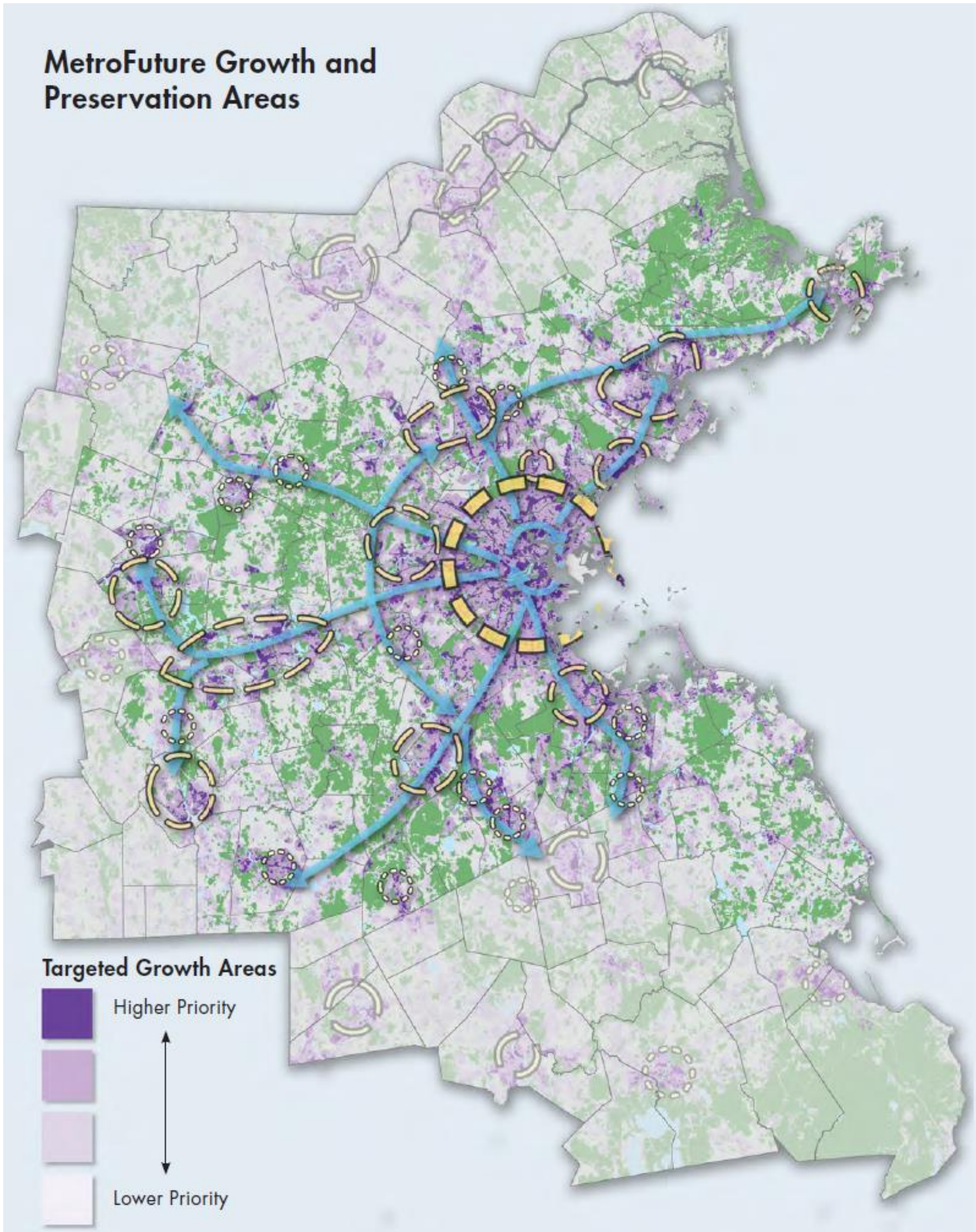
of growth. This alternative would significantly change the regional distribution of growth and would require new land use planning tools and a great increase in regional cooperation, including some regional oversight of local planning and land use decisions.

- **"Imagine" –** This alternative scenario represented what the region might be like if communities prioritized responses to 21st century global challenges such as climate change, energy independence, and growing international economic competition. Almost all new growth would be high-density mixed use, transit-oriented development in town centers and urban neighborhoods, minimizing consumption of open space and maximizing the potential for public transit.

To create the three alternative scenarios, CommunityViz "Assumptions" were created that allowed planners to vary the share of household and employment growth allocated to the predefined geographies of the four Community Types (Figure C.4), and eight Community Subtypes established for the region. Each scenario had to stay within the control totals, so MAPC staff had to go through a number of model iterations to get it right. (CommunityViz did not yet have the Allocation Wizard as a feature but the MAPC planners' scenarios would have needed to override the Allocation Wizard's criteria to impose some of the desired features of the scenarios.)

The three alternative scenarios were presented to the public at two large working sessions held in December 2006, at a series of smaller meetings in early 2007, and on the MetroFuture web site. Overall, participants overwhelmingly preferred the "Winds of Change" scenario. The scenario was modified in response to participant concerns regarding resource conservation and suburban density, and presented at a citizens' seminar where out of roughly 400 participants, 94 percent voted to adopt the plan as the preferred scenario for the Metro Boston Region (Figure C.5).

## Figure C.5 Final MetroFuture Plan




Source: Metropolitan Area Planning Council.

### *Indicators*

About 18 indicators were developed to measure scenario performance in five topic areas (Table C.4). They are noteworthy for the effort to define several equity-related outcomes, always a challenging metric, and usually approached through surrogate measures. The lack of indicators that address traffic congestion, often a feature of scenarios like these, reflects the agency's strong smart growth/ protransit orientation.

## Table C.4 Indicators

| Indicator | Indicator Definition |
|---|---|
| ***Sustainable Growth Patterns*** | |
| **Indicator** | **Indicator Definition** |
| Housing Diversity | New single family homes, as a percent of all new units, regionwide. |
| Landscape Lost | Acres of open space lost to development, regionwide. |
| Growing Near Transit | Percent of new jobs and housing near existing transit, regionwide. |
| New Jobs on Old Land | Percent of new jobs on redeveloped land, regionwide. |
| ***Labor and Prosperity*** | |
| **Indicator** | **Indicator Definition** |
| Importing our Labor Force | Number of workers commuting in from outside the region. |
| High-Skill Workforce | Supply of workers with a two- or four-year college degree. |
| Blue Collar Balance | Supply of workers with a high school diploma or less. |
| Industrial Land Lost | Acres of commercial and industrial land converted to residential or mixed uses. |
| ***Housing Choice and Community Vitality*** | |
| **Indicator** | **Indicator Definition** |
| Housing Within Reach | New units that might be moderately priced for working-class families and fixed-income seniors. |
| Opportunities for Integration | Moderately priced units in suburbs as a percent of all new moderately priced units. |
| Neighborhood Density | Current households in neighborhoods that would experience large increases in density. |
| Lifelong Learning | Percent of working-age population with an Associate, Bachelor, or Graduate degree. |
| ***Air, Water, and Wildlife*** | |
| **Indicator** | **Indicator Definition** |
| Water Shortages | Number of cities and towns that would exceed current water withdrawal limits. |
| Pavement in Paradise | New acres of impervious surfaces (roads, rooftops, and parking lots), regionwide. |
| Energy Demand | Residential energy demand, new housing units only, regionwide (billions of BTU). |
| ***Getting Around*** | |
| **Indicator** | **Indicator Definition** |
| Transit Ridership | Transit use, as a percent of all trips, regionwide. |
| Dividing the Pie | Funding for highways expansion as a percent of available transportation funding. |
| Walking the Walk | Proportion of trips made by walking or biking, regionwide. |

Most of the indicators were straightforward are self-explanatory. Others, particularly those concerning "Housing Choice and Community Vitality," warrant some further explanation. For the "Housing Within Reach" indicator, MAPC created an inclusionary housing assumption, specific to certain housing types, so that the indicator is a function of the overall housing mix and the percent affordable for each type. "Opportunities for Integration" added another layer, by accounting for the geographic distribution of those units. If a greater share of housing – especially multifamily housing – is concentrated in urban communities, then there may be fewer opportunities for low-income households to find housing in suburbs, relative to a more sprawling scenario. The "Lifelong Learning" (education) indicator was based on a simple assumption, and was created at the behest of a member of the advisory committee, who wanted to have a scenario that included 75 percent college attainment. This assumption did show, however, that big labor shortages for low-skill jobs would be created as a result.

The number of indicators, their complexity, and size of the region made for slow processing times. While this was fine for in-house analysis, as mentioned earlier, it was not acceptable for an interactive public workshop and for that occasion MAPC had to restrict the number of indicators used and their related "key driver" variable assumptions that could be changed. Ultimately, six indicators were used where participants could use CommunityViz's "slider bars" to experiment with the key drivers:

- **Landscape Lost –** defined as acres of open space lost to development regionwide. Key driver: Conventional Subdivisions with homes on a half-acre or more, as a percent of all new units in the Developing Suburbs. Driver also affected Moderately Priced Housing and Public Sewer Demand indicators.
- **Suburban Housing Density –** defined as apartments and condos as a percent of all new housing in Maturing Suburbs. Key driver: Growth in Town Centers, and their associated housing units, as a percent of all new units in the Maturing Suburbs. Driver also affected Neighborhood Density and Transit Share indicators.
- **High-Skill Workforce –** defined as the supply of workers with a two- or four-year college degree. Key driver: Community Colleges, as the number of students enrolled over current levels. Driver also affected Total Labor Shortage indicator.
- **Neighborhood Density –** defined as the number current residents who would experience large increases in residential density. Key driver: Housing on Redeveloped Land, as a percent of all new units in Regional Urban Centers. Driver also affected Room for Industry and Transit Share indicators.
- **Water Shortages –** defined as the number of cities and towns that would exceed current state withdrawal limits. Key driver: Water Conservation Programs and the resultant percent decrease in water use per resident and employee. Driver also affected Total Water Demand indicator.

- **Transit Ridership –** defined as Transit use, as a percentage of all trips, regionwide. Key driver: New Urban Residents, represented by residential growth in the Inner Core, as a percent of growth in the entire region. Driver also affected Access to Parks, Housing Diversity, and Water Shortages indicators.

Unfortunately, changing the key driver for the Transit Ridership indicator would trigger an update that took an unacceptably long time to run, so workshop participants were told they could not experiment with that driver "due to time constraints."

### *Output and Graphics*

CommunityViz has basic charting and graphing capabilities, which MAPC found inadequate for their data visualization needs, particularly when dealing with large numbers of indicators over many scenarios. As a workaround, MAPC has developed spreadsheet templates to import CommunityViz output and display the results using the spreadsheet's charting and graphing capabilities.

## Evaluation

Aside from the aforementioned issues with CommunityViz's performance and weak data visualization, MAPC was mostly happy with the tool and continues to use it in-house to this day – albeit for smaller-scale projects. The tool was valuable for generating alternative future scenarios for the region and evaluating their impacts. As for civic engagement, although they were not able to use the tool to the extent they originally anticipated, the exercise where workshop participants could experiment with key drivers of different indicators was invaluable in educating the public about planning concepts and the relationship between various indicators. Stakeholders also seemed to appreciate MAPCs diligence and openness about how the model worked, and were satisfied with the scenarios presented and were easily able to reach consensus on a preferred scenario. This consensus was critical to achieving the buy-in and confidence in the land use policy components of the MetroFuture Plan, and the related goals and implementation strategies that ultimately followed.

**Table C.5 Agency's Perception of Strengths and Weaknesses of the Tool**

| Strengths | Weaknesses |
|---|---|
| ArcGIS-based | Data visualization poor |
| Used by a number of member agencies | Processing time[a] |
| Open framework provides transparency, flexibility and scalability | Major commitment of resources |
| Fully customizable indicators | |

[a] Partially addressed in newer version.

## Resources

| Lead Agency | |
|---|---|
| Metropolitan Area Planning Council | http://www.mapc.org/ |
| **Consultants** | |
| Applied Geographics (AppGeo) | http://www.appgeo.com/ |
| Pete Young | http://www.linkedin.com/pub/pete-young/7/565/795 |
| **Links for More Information** | |
| MetroFuture Home Page | http://www.mapc.org/metrofuture |

# C.4 CommunityViz: Holland, Michigan

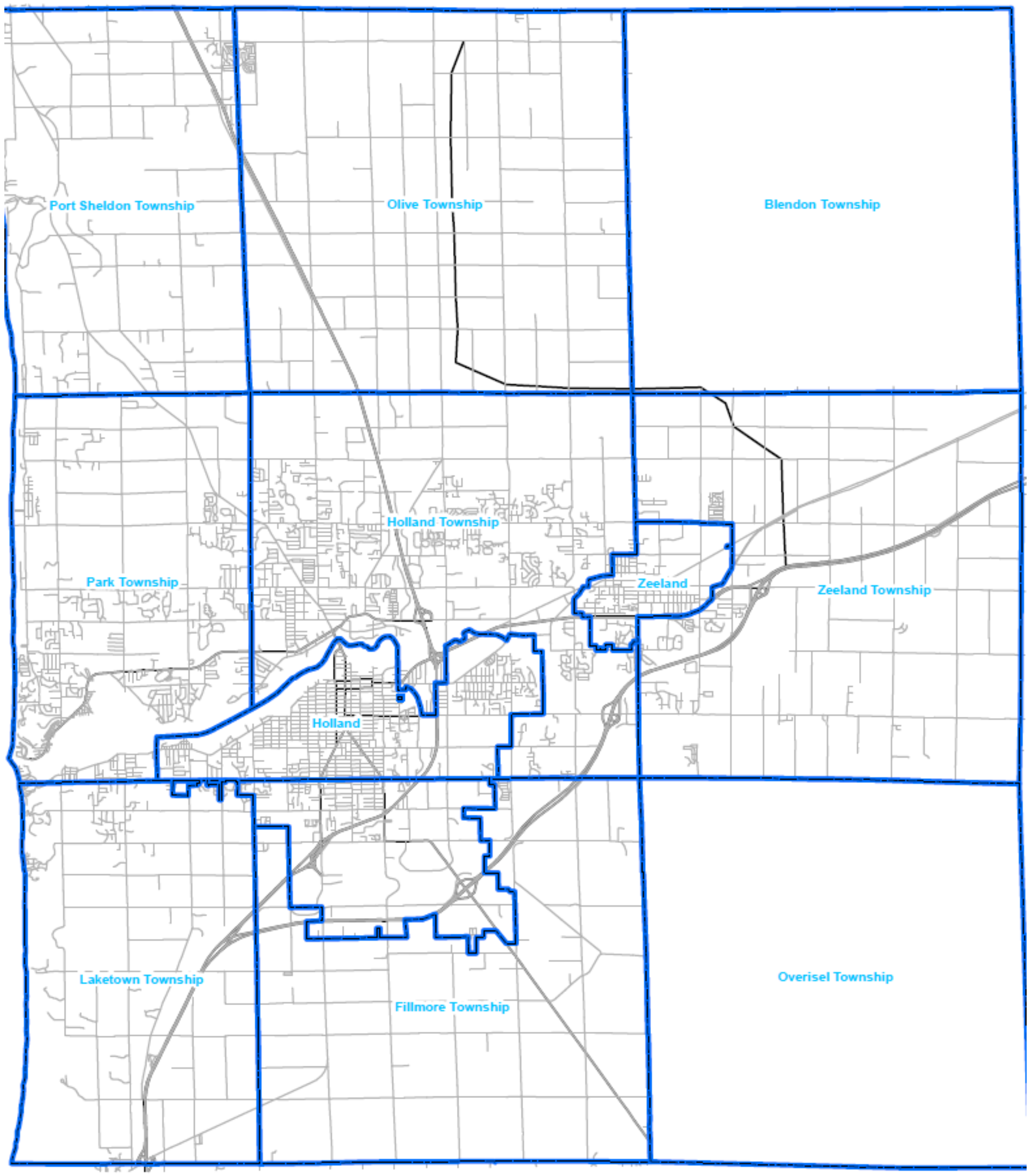
| Lead Organization |
|---|
| Macatawa Area Coordinating Council |
| **Type of Organization** |
| Metropolitan Planning Organization |
| **Organization Jurisdiction** |
| Two cities and seven townships within Michigan's Macatawa watershed (175 square miles) |
| **Geographic Scope of Project** |
| Same as the organizational jurisdiction |
| **Project Timeframe** |
| 2009-2014 |
| **Lead Organization's Prior Scenario Planning Experience** |
| Little to none |

## Project Overview

The Macatawa Area Coordinating Council (MACC) was created in 1993. Its purpose is to encourage cooperation among neighboring governmental units on matters, which have areawide concern. As a metropolitan planning organization or MPO, the Council is the designated local decision-making body that is responsible for carrying out the metropolitan transportation planning process. Members include the Michigan Department of Transportation (MDOT), two counties and their respective road commissions, two cities (Holland and Zeeland), and seven townships, and the regional transit agency.

The MACC has a staff of four full-time planners and one part-time planner. MACC staff, with the help of a consultant, used CommunityViz to create a current conditions scenario and three alternative future scenarios to assist in the development of their 2040 Long-Range Transportation Plan (LRTP). Figure C.6 shows the MACC planning area.

**Figure C.6 Macatawa Area Coordinating Council-Planning Area**




Source: Macatawa Area Coordinating Council.

## Tool and Process Overview

MACC has a Policy Committee whose members aid in the coordination and, where appropriate, the consolidation of plans, programs, services, and activities among the units of government. The Policy Committee consists of a representative from each governmental unit (e.g., cities, townships, and counties) along with a representative of each road commission, the State of Michigan, the Macatawa Area Express, and five representatives from the community at-large.

A study session was held in March of 2014 where members of the Policy Committee used keypad polling to communicate priorities concerning the development and maintenance of the region's transportation system, as well as housing, employment, the environment, and conservation. Recognizing the significant investment that the MACC has made to develop the region's transportation system, there was a clear priority to maintain the transportation network and resurface existing roads. Another priority that emerged was to ensure that the master plan process would accommodate future growth and provide opportunities for future employment.

During the same study session, members of the Policy Committee were asked to help identify where future employment and residential development might occur. Those locations were ranked and loaded into CommunityViz and subsequently used to provide residential and employment development suitability (or "likelihood") scores that were used with other suitability factors to produce an overall development suitability score that was then used to allocate future growth among various alternative future scenarios.

## Tool Characteristics

The MACC staff was initially attracted to CommunityViz because it is an extension to ArcGIS and the staff and several of the municipalities already were familiar with that platform. The staff also wanted to be able to use the tool beyond the life of this project and use scenario planning more extensively for future planning efforts; therefore, the tool's flexibility was appealing in that it can be used to perform very simple to very complex analysis and thus can support a wide variety user skill levels. In addition, the tool and its developer (Placeways LLC) are supported by the Orton Family Foundation, whose mission is "to empower people to shape the future of their communities by improving local decision-making" and has a history of supporting smaller and rural communities in particular. The staff also liked CommunityViz's openness and transparency, facilitating accountability to member municipalities and organizations. Finally, CommunityViz inputs and outputs were very easy to integrate into their existing transportation model.

## Tool Application

MACC staff used CommunityViz to create a current conditions scenario and three alternative future scenarios to assist in the development of their 2040 LRTP. The scenarios were initially set up by the tool vendor. MACC staff assisted with refining the indicators, which included transportation, land use, and environmental indicators. Outputs from the tool (maps, tables, and charts) were produced for in-house use and for use with decision-makers, in public meetings, and in published documents.

### *Data Gathering and Establishing a Baseline*

The two critical pieces of data needed for CommunityViz to establish a baseline and generate alternative future scenarios are 1) the location and number of existing dwelling units; and 2) the location of businesses and number of employees. As typical for many smaller or rural MPOs, much of this data was not readily available or consistent across multiple jurisdictions.

Existing land use and dwelling unit counts had to be estimated. The MACC staff and consultant started with standard Landsat remotely sensed coverages of land use/land cover and, using aerial imagery and local knowledge, expanded residential areas into more specific types (single family, nonsubdivided single family development, duplex, condominiums, apartments, mobile homes, and platted condominiums). They then approximated the density of each type of development to get an estimate of current dwelling units. The data were summed and aggregated to TAZs for comparison to previous estimates. Areas with large discrepancies were adjusted based on MACC's local knowledge.

Businesses and employees were derived from Claritas data, which were geocoded to parcels with the help of MDOT and the consultant. This data was then spot-checked and refined by the MACC to correct large discrepancies in business location and employee counts.

Other critical data layers needed were zoning and/or future land use plans. These layers provided the basis for determining the "ultimate" development capacity, which became the "supply" component necessary for the allocation model that was run. Typical of MPOs everywhere, regardless of size, there were a multitude of zoning ordinances across the planning area, each with different categories and descriptions. CommunityViz's "Land Use Designer" proved useful to generalize the disparate classifications into more generalized zoning types based on use and development allowances. This generalized zoning was then used by the CommunityViz "Build-out Wizard" to determine the maximum allowable residential units and the maximum allowable nonresidential square footage and employees.

### *Developing Scenarios*

Three future land use scenarios for the year 2040 were developed with CommunityViz using the Allocation Wizard. They were:

1. **"Continuing Current Trends."** As the name implies, this scenario was based on continuing to develop as usual. In this scenario, development was allocated to various available (based on the ultimate capacity) parcels using a score for

development likelihood. That score was based on three weighted factors, which were set up as variable slider bar assumptions in CommunityViz:

a. Proximity to Infrastructure – highways and sewer service areas;

b. Proximity to Nonmotorized Facilities – bike paths and transit service areas; and

c. Proximity to Development Centers – existing urban population centers and known growth attractors or "hot spots."

The weights for development suitability for this scenario and the Conservation Scenario (Table C.6) were determined based on the input of the MACC's Technical Advisory Team.[39] The supply component of the allocation model was based on the ultimate development capacity. The demand component was constant across all scenarios, based on the same projections for future population, households and employment needs, which MACC obtained from MDOT.

2. **"Conservation Priorities."** This scenario took into account previously defined land protection priority areas as constraints to future development. These included:

   - Top tier natural land;
   - Top tier agricultural land;
   - Riparian buffer zones of 100 meters; and
   - Wetlands.

   Development capacity (supply) was reduced to zero for any parcels that overlapped these areas and allocation of future households and employment was redirected elsewhere by the allocation model. Development drivers/ suitability remained unchanged from the Current Trends scenario.

3. **"Alternative Transportation Focus."** This scenario looked at an alternative in which development occurs in areas where noncar transportation options are highly accessible. Areas with good access to shared use paths, bus routes, and a good road network will be high-priority areas for future growth. This is simulated by adjusting the weighting of the suitability factors in the model so that "proximity to nonmotorized facilities/public transit" is the strongest influencing factor. In addition, development capacity (supply) was increased in high-priority growth areas.

[39] The Technical Advisory Team consisted of representative stakeholders and units of local government.

## Table C.6 Scenario-Defining Development Drivers and Allocation Methods

| Variables and Methods | Trend/Current Conditions | Conservation Priorities | Alternate Transportation[a] |
|---|---|---|---|
| Proximity to Infrastructure Weight | 5.00 (33 percent) | 5.00 (33 percent) | 1.50 (17 percent) |
| Proximity to Nonmotorized Facilities Weight | 1.50 (10 percent) | 1.50 (10 percent) | 6.00 (67 percent) |
| Proximity to Development Centers Weight | 8.50 (57 percent) | 8.50 (57 percent) | 1.50 (17 percent) |
| Protected Watershed Areas Removed | No | Yes | No |
| Increased Development Capacity in Priority Growth Areas | No | No | Yes |
| Allocation Method | Exponential Probability | Strict Order | Strict Order |

[a] MACC staff preferred scenario.

It is important to note that different allocation methods were used for the Current Trends scenario and the other two scenarios. Exponential probability allocation was selected for Current Trends where it is assumed that policy implementation will be looser than the in other two scenarios. This method allows development to stop before using all of a parcel's capacity, and it provides for spillover development into less likely parcels (Figure C.7). The other scenarios are more aggressively policy driven with a tighter regulatory framework. In those scenarios, strict order allocation was deemed a better fit. In strict order allocation, development is allocated to the most likely locations first and continues until the parcel's capacity is exhausted. No spillover development is allowed.

**Figure C.7 "Probability-Based" Growth Allocation**


Source: Placeways, LLC.

### *Indicators*

Indicators were kept fairly simple and straightforward, focusing on development distribution and its influence on employment, environment, and transportation. CommunityViz was predictably well-suited for generating the indicators summarizing the allocation data it produced; whereas TransCAD (the MPO's travel demand modeling software) was used to produce traffic-related indictors for the congestion and travel times that CommunityViz is not set up to do. However, CommunityViz outputs were used for the transportation inputs and the two modeling systems reportedly integrated nicely.

Table C.7 shows which indicators were produced by the two tools and the results across scenarios. There were a few unexpected outcomes, however. The stakeholder's concerns about having enough zoning capacity to support job growth proved unfounded, with all scenarios producing an oversupply of nonresidential land by orders of magnitude of 8 to 10. Another unexpected outcome was the relatively small difference between scenarios for number of dwelling units within one-quarter to one-half mile of transit. In hindsight, MACC staff noted that most of those areas already were developed areas with relatively little opportunity for infill, and the fact that they did not create any new "greenfields" transit areas. The most dramatic differences between the scenarios tended to occur around the "edges" where the amount of Priority Preservation land consumed dramatically declined in the Alternative Transportation scenario, surprisingly out performing the Conservation Priorities scenario. This was not entirely unexpected though, since development clustered around transportation corridors, which already were bypassing environmentally sensitive lands.

**Table C.7 Indicators Generated by CommunityViz and TransCAD**

| | Units | Trend/Current Conditions | Conservation Priorities | Alternative Transportation[a] |
|---|---|---|---|---|
| **Indicators Generated by CommunityViz** | | | | |
| Total Zoning Nonresidential Capacity | Employees | 1,025,182 | 832,718 | 984,404 |
| Remaining Zoning Nonresidential Capacity | Employees | 972,267 | 781,555 | 931,962 |
| Sum of 2040_Emp | Employees | 92,905 | 92,905 | 92,905 |
| Total Existing Nonresidential Land | Acres | 17,485 | 17,485 | 17,485 |
| 2040 Priority Preservation Developed | Acres | 770 | 596 | 73 |
| Existing Priority Preservation Developed | Acres | 8,465 | 8,465 | 8,465 |
| 2040 DUs < 1/4 Mile of Future Nonmotorized Facilities | Dwelling Units | 52,061 | 52,022 | 52,061 |
| 2040 DUs < 1/2 Mile of Future Nonmotorized Facilities | Dwelling Units | 3,590 | 3,590 | 3,590 |
| 2040 DUs > 1/2 Mile of Future Nonmotorized Facilities | Dwelling Units | 4,316 | 4,355 | 4,316 |
| Sum of 2035 Dwelling Units | Dwelling Units | 58,743 | 58,743 | 58,743 |
| **Indicators Generated by TransCAD** | | | | |
| VMT Increase | Percent | 18.5 percent | 32.0 percent | 14.4 percent |
| Congested Roads Increase, with LRTP | Percent | 8.7 percent to 2.43 percent | 8.7 percent to 2.72 percent | 8.7 percent to 2.38 percent |
| Near Congested Roads Increase, with LRTP | Employees | 2.09 percent to 3.94 percent | 2.09 percent to 6.06 percent | 2.09 percent to 3.12 percent |
| Average Speeds on Congested Roads Decrease | MPH | 36 to 31 | 36 to 28 | 36 to 29 |

[a] MACC staff preferred scenario.

## Evaluation

The MACC staff were very satisfied with the tool, citing ease of use, integration with ArcGIS, and ability to link with their transportation model as key benefits. They have completed two in-house staff trainings and intend to use scenario planning more extensively for future planning efforts.

### Table C.8 Agency's Perception of Strengths and Weaknesses of the Tool

| Strengths | Weaknesses |
|---|---|
| Ease of use | Graphic output quality |
| ArcGIS-based | |
| Open framework provides transparency, flexibility | |
| Built-in allocation wizard | |
| Ability to link with their transportation model | |

## Resources

| **Lead Agency** | |
|---|---|
| Macatawa Area Coordinating Council (MACC) | http://www.the-macc.org/ |
| **Consultants** | |
| Placeways, LLC | http://www.placeways.com/ |
| **Links for More Information** | |
| MACC Long-Range Transportation Plan | http://www.the-macc.org/transportation/long-range-plan/ |
| MACC Public Participation Plan 2013 | http://www.the-macc.org/wp-content/uploads/MACC-Public-Participation-Plan-2013.pdf |

# C.5 Urban Footprint: Sacramento

| **Lead Organization** |
|---|
| Sacramento Area Council of Governments |
| **Type of Organization** |
| Metropolitan Planning Organization |
| **Organization Jurisdiction** |
| Sacramento metropolitan area – 6 counties and 22 cities |
| **Geographic Scope of Project** |
| Same as organization jurisdiction |
| **Project Timeframe** |
| 2012-2015 |
| **Lead Organization's Prior Scenario Planning Experience** |
| Extensive |

## Project Overview

Under the leadership of Sacramento Area Council of Governments (SACOG), the Sacramento region had been conducting regional visioning for well over a decade, first adopting its "preferred Blueprint scenario" in 2004. SACOG has supported the development of state-of-the-art tools to support visioning, including i-PLACE3S as well as various travel demand and land use forecasting models.

Recent State of California legislation has reinforced the importance of addressing transportation and land use planning at a regional scale. All MPOs in the State of California have been mandated by State Bill 375 and Assembly Bill 32 to reduce their greenhouse gas emissions (GHG) and integrate land use and transportation planning as part of a process known as a Regional Transportation Plan and Sustainable Communities Strategy (RTP/SCS). Within this process, these MPOs are required to perform forecasts of future land use and transportation scenarios, using models that provide outputs of vehicle miles traveled (VMT), GHGs, particulate matter, economic impacts, and other indicators.

In order to perform the RTP/SCS analysis, three of the four major California MPOs joined forces to help develop and use the Urban Footprint tool, while the fourth (the Metropolitan Transportation Commission in the San Francisco Bay Area) chose to use UrbanSim, a land use forecasting model. These three, SACOG, the San Diego Association of Governments (SANDAG), and the Southern California Association of Governments (SCAG), received funding for this effort from the Strategic Growth Council (SGC), a cabinet-level state agency composed of agency secretaries and gubernatorial appointees.

The SGC funding was used to hire Calthorpe and Associates, the creator of Urban Footprint, as their consultant in this effort. This SGC-funded tool development collaboration was not explicitly connected to the RTP/SCS or any particular application initially, but each MPO ended up using it for that purpose (which had always been the expected application), at the expense of the tool's refinement itself, as discussed later. This tension between tool refinement and getting results from the tool for the RTP/SCS process should be kept in view as a recurring theme and major contextual aspect of the Urban Footprint case studies.

Each of the MPOs took on a specific role in its use of UF. SANDAG was to focus on the graphical user interface, while SACOG was to focus on the parcel-level (vector) land use inputs as an upgrade to the less detailed raster inputs in early versions of the tool. Finally, SCAG was to focus on subregional applications of the tool. SACOG also had a role in initiating this three-MPO collaboration. SACOG had previously been using i-PLACES for their 2050 long-range planning process. i-PLACE3S was seen by SACOG as a good tool, but it was expensive to maintain and required back-end licenses of Oracle servers. SACOG began looking for other options to perform this work that were open-source licensed. Their planning process further required that, like i-PLACE3S, the tool work at the parcel level and be web-based. During the era in which SACOG used i-PLACE3S as their spatial scenario sketch planning tool, they also used RapidFire – a nonspatial spreadsheet-based tool and a predecessor to UF – to develop climate and energy use indicators, but otherwise did not use it extensively. SACOG also had previously worked with RapidFire to develop climate and energy use indicators for the Vision California and California High-Speed Rail planning process, but otherwise did not use it extensively.

They thus started a conversation with the tool developer about expanding the functionality of the tool for their purposes. They liked that Urban Footprint would be completely open source and not tethered to licenses and with no annual maintenance agreement. SACOG felt this opened the door to other users, to grow a user base with other MPOs, and did not rely on SACOG to develop the functionality alone. This has occurred, with mixed results, through the aforementioned collaboration.

SACOG began using Urban Footprint in 2012 and was planning to continue working with the tool through the spring of 2015. Interviews for this case study were completed in the late summer and fall of 2014.

## Tool and Process Overview

SACOG's initial plan was to use Urban Footprint to update their baseline to the year 2012 for the RTP/SCS, known locally as the Metropolitan Transportation Plan (MTP) and to run all alternative scenarios for the 2036 time horizon. Delays hindered this and so they began work on alternative scenarios just for the MTP. This also encountered delays and so they narrowed the collaboration with the Urban Footprint developer to only the preferred alternative scenario development. The baselines and alternative scenarios were ultimately developed manually in ESRI ArcGIS and spreadsheet tools outside of Urban Footprint. Preferred scenario analysis in Urban Footprint was hoped to be completed by the end of 2014 with final scenario refinement in early 2015.

In addition to the alternative scenarios development, SACOG has developed a Rural-urban Connection Strategy (RUCS) module that looks at how to preserve agricultural and rural land. RUCS has employed Urban Footprint to analyze the economics of agriculture and the impact of developing agricultural land. SACOG is beginning to do case studies of this in rural jurisdictions.

SACOG also is involved in developing a public health impacts module. The public health impacts module project is funded primarily by SGC and the Resource Legacy Group, with smaller funding from SACOG and SCAG. The technical coding of this module is being done by another consultant, and the integration of this to the rest of Urban Footprint is overseen by the developer, with SACOG staff input.

## Tool Characteristics

Per description by the tool developer, the UrbanFootprint model is a "land use planning, modeling, and data organization framework designed to facilitate more informed planning by practitioners, public agencies, and other stakeholders." It is built on fully open-source software platforms and tools. The model currently has analytical engines that produce metrics for:

- Land consumption;
- VMT, travel mode, and fuel consumption;
- Transportation GHG and air pollutant emissions;
- Building energy and water consumption, costs, and related GHG emissions;
- Household costs for housing, transportation, and utilities;
- Public health impacts and costs; and
- Local fiscal impacts.

Urban Footprint is a data-driven model, and as such requires geographically specific land use plans, as well as land cover and environmental data, transportation features, and census and related data. UF generally accepts parcel-level land use inputs, but can accept any zonal structure for land use inputs. The model has a translation engine for analyzing existing local and regional plans and stitching them together into a common regional fabric. A web-based painting tool facilitates scenario creation and editing. The model uses 5.5-acre grid cells for analysis.

To estimate transportation-related impacts, the model predicts VMT per capita by place type. Equations in the model relate the seven "Ds" place type characteristics (density, diversity, design, etc.) to travel outcomes using the "MXD" method - equations from "Traffic Generated by Mixed-Use Developments—Six-Region Study Using Consistent Built Environmental Measures." This is the same basic source model as used in ET+, developed by Ewing *et al* at the University of Utah. Travel demand management strategies can also be included. Energy, emissions, and fuel consumption rates include adjustments for California-specific requirements such as zero-emission vehicles and the low-carbon fuel standard.

All of the work in Urban Footprint for SACOG is at the parcel level. The defaults in the UF program aggregate place types from land uses in locations Calthorpe has researched, including San Francisco, Portland, and San Diego. However, SACOG feels the need to refine place types for themselves and is using forecasting and ground-level research on future land uses in the region to determine these place types to be used in their version of the model.

As of this writing, the user interface is not available for real-time workshop interaction and scenario painting. SCAG is working on developing this aspect of UF. For SACOG's public engagement, numeric indicators are the main outputs being used and reported, as well as some visual representations.

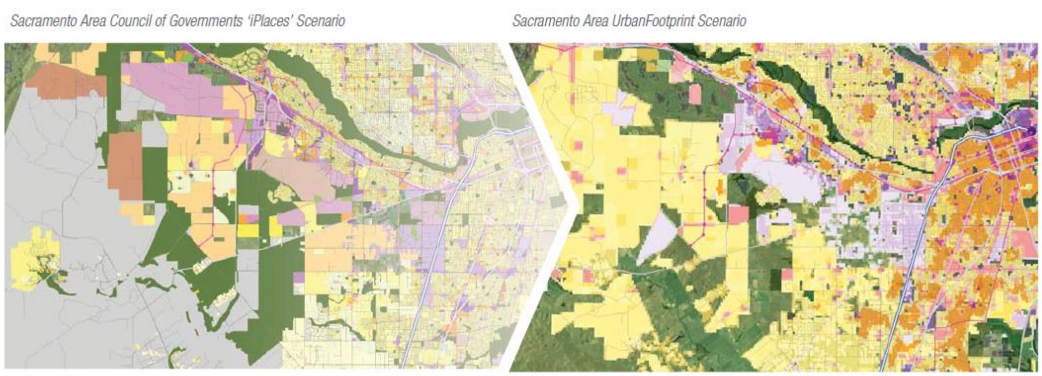
## Tool Application

### *Data Gathering and Establishing a Baseline*

Since the previous MTP and baseline scenario were incorporated as the starting framework, this saved a lot of time for the Urban Footprint effort, as intensive work already had gone into developing these. If these previously developed scenarios had not been used, much more time would have been necessary for scenario creation. Before UF, SACOG used a 2008 base with a 2035 horizon. Now for UF, they updated this to a 2012 baseline with a 2036 horizon. Updating the baseline was minimal work in GIS and did not include much post processing since the updated GIS inputs could easily feed into the existing travel model integrated database developed for i-PLACE3S. SACOG's activity-based travel model, SACSIM, had been integrated with i-PLACE3S, the scenario sketch planning tool used prior to UF. This integrated database allowed for a transition to UF. Figure C.8 illustrates land use scenarios in the old and new tool.

Because SACOG already collaborated heavily with the tool developer while using their RapidFire tool, they felt confident about the calibration of UF. Some skims were updated for UF, but otherwise further calibration was deemed unnecessary at the outset. Further calibration may be necessary after actual scenario results are returned from the model.

**Figure C.8 Translation of SACOG Land Use Scenario in i-PLACE3S to Urban Footprint**




Source: Calthorpe Associates and Sacramento Area Council of Governments.

Four SACOG staff were trained on UF. The developer provided two training sessions to explain what the functions are and how they work. Additional training may be necessary to learn the actual setup of the software and servers and updating of the code. A users' manual had not yet been developed and will be necessary in the future – or occasional consulting from the developer on how UF can be used. With delayed delivery of the full functionality of the tool, SACOG prioritized having the developer advise SACOG staff on the setup of the tool on their servers, inputting the first scenarios and running models to return usable results. They planned to later have the developer focus on providing documentation.

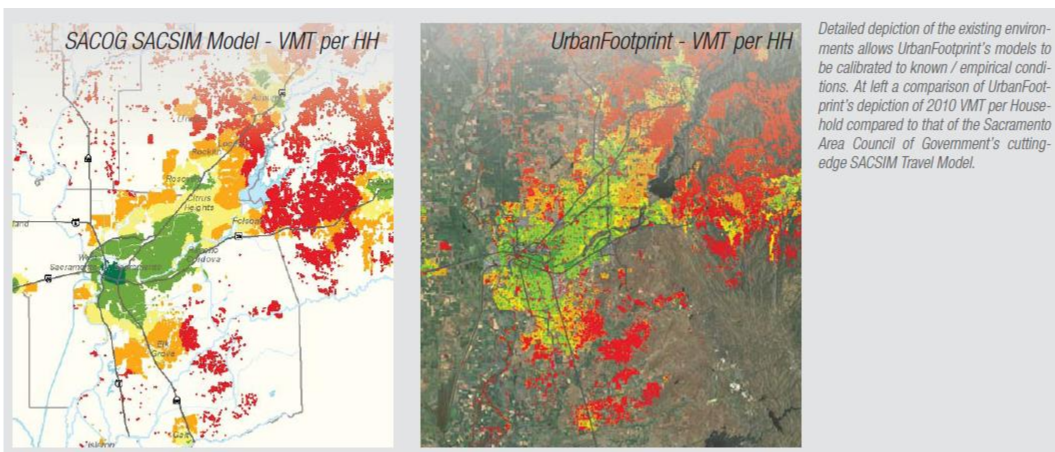
### *Developing Scenarios*

Urban was used to model SACOG's base year scenario and three alternative future scenarios, and to determine a preferred scenario from those three. The last MTP also was to be modeled for comparison.

### *Indicators*

For SACOG's public engagement, numeric indicators were the main outputs being used and reported, as well as some visual representations. This includes general land use indicators, housing types, types of employment, jobs housing balance, travel metrics, VMT, mode splits, GHG emissions, energy used, and public health impacts. An example of VMT outputs is shown in Figure C.9, where the colors indicate VMT per household (green being the lowest and red being the highest). This figure also shows that the pattern of Urban Footprint's modeled VMT per household matches fairly well with the SACSIM travel demand model output.

**Figure C.9 SACSIM VMT Outputs and Urban Footprint VMT Outputs**




Source: Calthorpe Associates and Sacramento Area Council of Governments.

The key modifications in SACOG's application of UF were RUCS, looking at agricultural-economic impacts of rural land being converted to urban uses, and the improvement of public health impact indicators. Regarding the latter improvement, SACOG was working with public health officials to make UF public health metrics useful and smarter at how the tool looks at both the local and regional level, including built form impacts on public health. These improvements were not ready for the most recent round of public workshops, but SACOG intended to use these in future rounds of workshops.

### *Output and Graphics*

SACOG staff reported that stakeholders in their region are highly educated in planning principles and jargon and so little introduction to the outputs of UF is necessary to report indicators. They also observed from their experience in public workshops that citizens are well educated on these indicators and the planning issues and tradeoffs are well understood. This could indicate a pattern of repeat workshop attendees who are very invested in the outcomes and supported by various interest groups rather than a genuinely higher level of stakeholder and citizen awareness of model indicators and planning principles compared to other regions.

While the user interface was not yet ready, this work was to be prioritized after receipt of results on the initial scenario model runs. In theory, this user interface, when finished, should allow for public explanation to less experienced audiences in workshops about the tradeoffs and impacts of various scenarios. Benefits were anticipated from SCAG's early work on UF's user interface. SCAG work was projected to be finished in late 2014 and updates from that instance of the tool were to be seamlessly integrated into SACOG's version.

## Evaluation

Model run output indicators had not yet been received, but SACOG hoped these would be received by year-end 2014. The user interface was not finished and could not be evaluated at this time. The minimal hardware and software costs of Urban Footprint were a plus. As its own stack of open-source software, no software costs are necessary for UF. SACOG already possessed the necessary servers, but otherwise would need to invest in this hardware. The real soft costs are for consulting support contracts and the time of agency staff.

Technical specifications of Urban Footprint already are delivered. The assumptions are known. Metrics, calculations, and how the tool operates internally are all known. However, documentation on the user interface and external operation of the tool are still yet to be produced.

A major advantage of Urban Footprint is the flexibility within the tool to develop new modules such as RUCS and the public health impact indicator improvements.

Much time must be spent in scenario development, but in SACOG's case, this work already was done in GIS tools for the previous MTP, and integrated with travel model outputs for use in the i-PLACES tool. Familiarity with UF's precursor, RapidFire, also saved time and allowed for SACOG to focus on developing new modules.

SACOG reported benefitting from a well-educated group of stakeholders and citizen activists already who understand and appreciate the meaning of various indicators from UF. This level of familiarity comes from years of regional planning activities and public outreach. With a different group of stakeholders or in a different context, much more effort may be needed to bring lay users and consumers of the tool's outputs up to speed on the meaning of various indicators.

A summary evaluation is shown in Table C.9.

**Table C.9 Agency's Perception of Strengths and Weaknesses of the Tool**

| Strengths | Weaknesses |
|---|---|
| Minimal hardware and software costs | Potential time and consultant cost requirements for new scenario development |
| Flexibility to develop indicator modules | User interface and user manual not available/tested at time of writing |
| Ability to incorporate inputs from prior scenario planning work in different tools | |

## Resources

| Lead Agency | |
|---|---|
| Sacramento Area Council of Governments | http://www.sacog.org/<br>Raef Porter, Senior Research Analyst and Climate and Energy Programs Manager, rporter@sacog.org, 916-340-6261<br>Gordon Garry, Director of Research and Analysis, ggarry@sacog.org, 916-340-6230 |
| **Consultants** | |
| Calthorpe and Associates | Joe DiStefano, Principal, joed@calthorpe.com, 510-548-6800 x29 |
| **Links for More Information** | |
| Urban Footprint Technical Summary | http://www.scag.ca.gov/Documents/UrbanFootprintTechnicalSummary.pdf |

# C.6 Urban Footprint: San Diego

| Lead Organization |
|---|
| San Diego Association of Governments |
| **Type of Organization** |
| Metropolitan Planning Organization |
| **Organization Jurisdiction** |
| San Diego metropolitan area – 18 cities and 1 county |
| **Geographic Scope of Project** |
| Same as organization jurisdiction |
| **Project Timeframe** |
| 2012-2013 |
| **Lead Organization's Prior Scenario Planning Experience** |
| Extensive |

## Project Overview

The San Diego Association of Governments used Urban Footprint in 2012 and 2013 in support of their Regional Transportation Plan/Sustainable Communities Strategy for the 2050 horizon year. SANDAG had previously used other scenario sketch planning tools and found difficulties in coordinating the results of these with other California MPOs and statewide efforts when each organization was using a different tool based on different assumptions in the respective models. Through dialogue with other California MPOs, agreement was reached that if they are all going to be using scenario sketch planning tools, they might as well use the same one so that comparisons can easily be made across the different regions of the state. The California Strategic Growth Council, a state cabinet-level committee composed of various state agency secretaries and appointees of the Governor, provided funding for the San Diego, Sacramento, and Los Angeles region MPOs to develop the Urban Footprint tool together, the tool's developer as consultants.

The tool was expected to improve and get stronger over time as all three MPOs could gain from the improvements to the tool made by the other MPOs. Whereas SCAG used Urban Footprint at the county and subregional level, SACOG and SANDAG used it at the full regional level. The SGC grant was supposed to fund the developer's involvement in tool development, with MPO staff time coming out of MPO existing budgets. Each MPO was to focus on a specific functionality of the tool. SANDAG was to focus on the graphical user interface, while SACOG was to focus on the parcel-level (vector) land use inputs as an upgrade to the less detailed raster inputs in early versions of the tool. Finally, SCAG was to focus on subregional applications of the tool.

Initially, the SANDAG effort with Urban Footprint was unrelated to the RTP/SCS, but ultimately was brought to bear exclusively on model results serving the RTP/SCS, at the expense of finishing user interfaces to the tool. The RTP/SCS is a process mandated by the California legislature to be completed by all MPOs every five years, including assessments of current greenhouse gas emissions and planning for future-year GHG reductions through coordinated land use and transportation policy. SGC funding for the developer's work on the tool with SANDAG lasted from October 2012 to December 2013. Interviews for this case study were conducted in the late summer and fall of 2014.

## Tool and Process Overview

SANDAG used Urban Footprint primarily to forecast GHG emissions in future land use scenarios. Models were built directly by the developer/consultant's team, translating sketch vision-level land use scenarios into small area data that could be digested by the model, with results reported in spreadsheet format to the SANDAG team.

Several factors limited the role of Urban Footprint for SANDAG. At the outset of the developer's contract with SANDAG and the MPO's use of Urban Footprint, a user interface was not yet developed and SANDAG made the development of the Urban Footprint models for their three scenarios the priority over the development of a user interface. However, local jurisdictions within SANDAG's constituency often wanted to access a dynamic real-time user interface with the Urban Footprint tool. With limited time and resources, SANDAG chose to focus efforts on land use scenarios as the main variable in the input and GHG emissions as the main indicator in the output.

## Tool Characteristics

UrbanFootprint is described in Section C.5 of the Sacramento case study; the San Diego application is similar.

## Tool Application

### *Data Gathering and Establishing a Baseline*

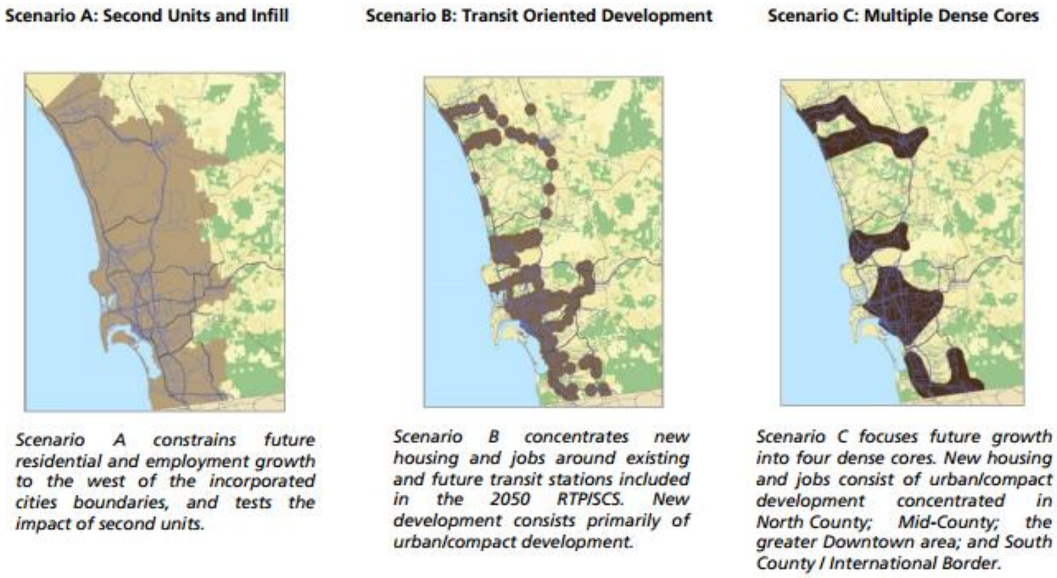
SANDAG wanted to compare new land use scenarios developed for the RTP/SCS with previous forecasts conducted in 1999 for which they did not possess parcel-level data. Instead, SANDAG held Major Geographic Reference Area (MGRA) data for those years and aggregated parcel data in the more recent baseline and horizon years up to these MGRAs. The MGRA zonal structure is more detailed than a TAZ structure, with about 23,000 MGRAs in the SANDAG region. The MGRAs are roughly comparable to census block groups in the level of granularity. SANDAG staff took the three scenario maps developed, overlaid them and spatially joined them onto the MGRAs, and accordingly adjusted the land use densities called for in the MGRA data. The updated MGRA data were given to the developer/consultant to put into the Urban Footprint tool.

SANDAG reported that Urban Footprint is not easy to use off the shelf in the version they used. It is a very data-hungry tool, requiring a lot of preparation work to run. Their staff spent significant time looking at assumptions in the sketch model, which they needed to verify and calibrate in order to respond to critiques and back up the assumptions used. This included general assumptions about fuel costs, public health impacts, water costs, and other variables specific to land use categories such as units per acre. UF also requires travel model skims, which SANDAG staff produced with a traditional trip-based four-stage travel model. Finally, SANDAG staff had to provide population, employment, and socioeconomic data projections for input to the model.

### *Developing Scenarios*

Without land use planning authority (this resides with the local jurisdictions), SANDAG did not feel comfortable using the tool to direct their constituent members in their land use policies. SANDAG staff conducted public outreach in a concept-gathering fashion, letting the ideas of stakeholders inform three alternative land use scenarios for the year 2050 they developed with the help of a different consultant. Scenario A, "Second Units and Infill," Scenario B, "Transit-Oriented Development," and Scenario C, "Multiple Dense Cores" were developed at the level of a regional vision and illustrated at a level that was intentionally not too specific (Figure C.10). Early in the drafting of these scenarios, maps were produced based on proximity buffers around transit stations or the areas identified for development as dense cores. SANDAG staff requested that sharp boundaries be blurred and directed the consultants to make the maps more fuzzy so as not to appear to mandate specific local land use planning. SANDAG leadership wanted the scenario maps to communicate the general idea of the policy scenario without mandating its application in any particular place.

## Figure C.10 Alternative Scenarios Developed Outside of Urban Footprint

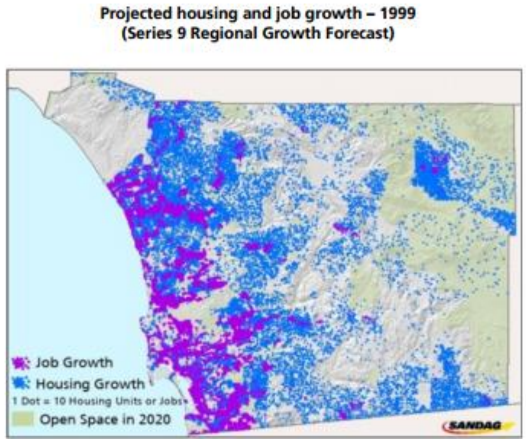



Source: San Diego Association of Governments.

### *Indicators*

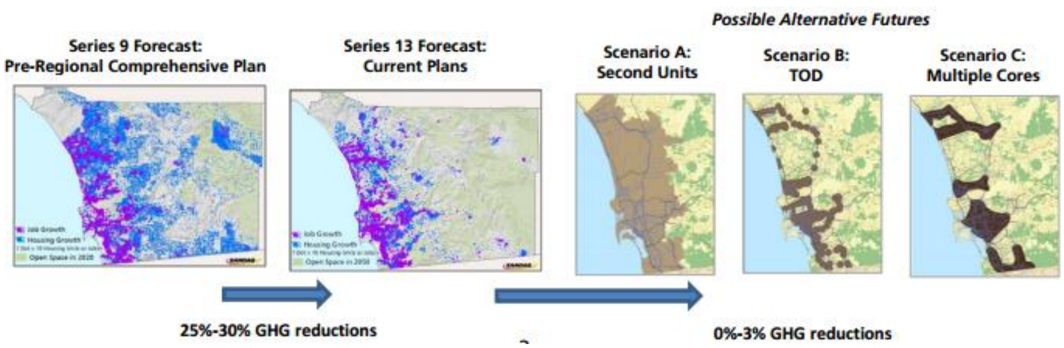
With this MGRA-level land use, the tool indicated that each of the three scenarios would make further GHG reductions of between 0 and 3 percent, as compared with the Series 13 Forecast (using jurisdictions' actual long-range land use plans) to 2050, conducted in 2013, just prior to the Urban Footprint work. Rather than use the tool to produce other indicators such as housing, jobs-housing balance, and water resource impacts from the new alternative scenarios, SANDAG asked the consultant to prepare Urban Footprint model runs of their earlier Series 9 Forecast (looking to a 2020 horizon year, developed in 1999 before the Regional Comprehensive Plan process) and the Series 13 Forecast (incorporating that process). (See Figure C.11 for a comparison of forecasts.) Urban Footprint results showed that from Series 9 to Series 13, with year 2020 results for Series 9 extrapolated out to year 2050, the changes in local land use planning by constituent jurisdictions contributed to GHG reductions between 25 and 30 percent (Figure C.12). SANDAG leadership felt that showing this success of the regional visioning process and the local jurisdictions' land use planning in concert was something to be celebrated and helped to put into context the comparatively modest GHG reductions from the three new scenarios. In other words, most of the gains already had been made from previous land use policy changes.

**Figure C.11 Long-Range Land Use Planning Changes**




Source: San Diego Association of Governments.

**Figure C.12 GHG reductions as forecast by Urban Footprint**




Source: San Diego Association of Governments.

These large GHG reduction results raised the eyebrows of some external and internal observers, however. SANDAG staff wanted to ensure that the results were indeed primarily the result of the land use plans specified, rather than other factors, and have reported a desire to investigate these results further and how Urban Footprint arrived at them. The model runs were handled by the developer team, without a user interface tool for SANDAG staff to make adjustments themselves, so the model is considered somewhat of a black box by the agency staff.

### *Output and Graphics*

The graphical interface was not up to expectations. It was not ready at the outset of the collaboration and few changes were able to be implemented during the course of the contract, due to the shift in focus from improving user features to simply finishing models to provide results for the RTP/SCS. However, SANDAG staff was pleased with the team's work on modeling the three land use scenarios given and their ongoing work on the sketch models. They realize it was an impossible task for them to get the model results and work on improvements to the user interface within the timeframe of the project. At SANDAG's request, user interface improvements were given lower priority. Thus, these improvements never reached a stage where they could be used in public workshops.

The SANDAG public outreach team never worked on the tool itself or piloted any use of it in public meetings. The public outreach team only worked with spreadsheets and comments from the tool and it was the SANDAG GIS team that worked directly with the developer on the technical aspects of the tool.

In the end, what was presented to the public from Urban Footprint was a six-page attachment on the assumptions put into the tool as an appendix to their three-page staff report to their board of directors on the alternative land use scenarios for the 2050 regional planning effort.

## Evaluation

The main takeaway for SANDAG is that the concept of scenario sketch planning being an easy process is a myth. SANDAG initially underestimated how much work using Urban Footprint would be. The GIS staff put in a massive amount of work on providing input to the developer for the tool. The developer said no other COG/MPO user had ever looked at the sketch model to the level of detail that they did. SANDAG's GIS and modeling team felt they needed to really understand the tool to make calibrations. Pat Landrum, the GIS lead at SANDAG, devoted roughly one-third of his time to Urban Footprint-related work over the 16-month period of the collaboration. Two other GIS staff working with him also spent between 10 and 20 percent of their time on the project over the 16-month period. Thus, the project cost SANDAG between 0.5-0.7 full-time employees (FTE) over the duration. The work could easily have consumed many more SANDAG staff hours, if they had availability to do so.

SANDAG's opinions on the overall experience of using Urban Footprint are mixed. Urban Footprint did produce tangible results that could be reported and in this regard, SANDAG staff compared it favorably in relation to i-PLACE3S and CommunityViz, which SANDAG had previously attempted to use without successful conclusion. Technical staff who had not been around during SANDAG's prior use of i-PLACE3S and CommunityViz assessed that all three of these tools seem to operate similarly and have similar limitations. As a data hungry tool, Urban Footprint can only succeed to the extent of staff availability to source and prep all the necessary data inputs and calibrate the assumptions and parameters.

Out of deference to local jurisdictions' authority over land use planning, SANDAG did not talk to the public about specifics at the MGRA level of the land use inputs or of the results beyond the GHG impacts and the general broad strokes land use policy behind this. They hoped local jurisdictions would come to SANDAG to use an instance of Urban Footprint to inform their specific land use planning, but no jurisdictions have requested this. SANDAG leadership felt that grant program criteria already are seen as too complicated (a 300 point system) by jurisdictions. They decided it is not feasible to incentivize Urban Footprint use by including it as added criteria. The legal environment in California also hinders local jurisdictions from adopting and using alternative land use scenario planning. Local jurisdiction staff report to SANDAG they fear being sued by stakeholders who dislike what is done in such planning. These jurisdictions have expressed desires to pursue environmental justice goals, including GHG reductions, but the policymakers are exhausted from getting sued and spending so much effort on California Environmental Quality Act (CEQA) documents and lawsuits. The California planning context is probably the most litigious of any in the nation, hindering the adoption of new tools that have not previously been exhaustively litigated.

Statewide revocation of redevelopment funds also has hit local jurisdictions hard. Reinstatement of the redevelopment program, wherein tax increment financing programs can be assessed on geographies identified for infill and redevelopment, could be a motivator for jurisdictions to use Urban Footprint.

SANDAG was not doing anything further with Urban Footprint after the initial contract with the developer expired. SANDAG had no funding sources to extend the contract to continue improvements to the user interface.

Table C.10 provides a summary evaluation.

### Table C.10 Agency's Perception of Strengths and Weaknesses of the Tool

| Strengths | Weaknesses |
|---|---|
| Produced tangible estimates of GHG reductions for alternative scenarios | Large data requirements |
| Able to incorporate land use data at different geographic scales and compare forecasts from different years | Extensive staff time required to understand tool and calibrate to region |
| | "Black box," difficult to understand inner workings |
| | User interface not fully developed at time of writing |

## Resources

| Lead Agency | |
|---|---|
| San Diego Association of Governments | http://www.sandag.org/<br>Carolina Gregor, Senior Regional Planner, SANDAG, carolina.gregor@sandag.org, 619-699-1989<br>Pat Landrum, GIS Lead, pat.landrum@sandag.org, 619-595-5602 |
| **Consultants** | |
| Calthorpe and Associates | Joe DiStefano, Principal, joed@calthorpe.com, 510-548-6800 x29 |
| **Links for More Information** | |
| Urban Footprint Technical Summary | http://www.scag.ca.gov/Documents/UrbanFootprintTechnicalSummary.pdf |
| Board of Directors Presentation | http://www.sandag.org/uploads/meetingid/meetingid_3479_17075.pdf |

# C.7 ENVISION TOMORROW: SALT LAKE COUNTY

| Lead Organization |
|---|
| Salt Lake County, Utah with Envision Utah |
| **Type of Organization** |
| County government and nonprofit |
| **Organization Jurisdiction** |
| Salt Lake County |
| **Geographic Scope of Project** |
| Ten-county greater Wasatch region (selected subareas) |
| **Project Timeframe** |
| 2011-present |
| **Lead Organization's Prior Scenario Planning Experience** |
| Extensive |

## Project Overview

Wasatch Choice 2040 is a long-range land use and transportation plan covering the Greater Wasatch region of Utah, which stretches from Weber County south to Utah County and from Tooele County east to the Wasatch Back. The plan builds from a history of regional visioning that began in 1997 with the Envision Utah effort that included a series of over 200 public meetings. In late 2005, the Wasatch Front Regional Council (WFRC) and the Mountainland Association of Governments (MAG) adopted the set of growth principles and objectives outlined by Envision Utah, and in 2011 Salt Lake County was awarded a Sustainable Communities Initiative (SCI) planning grant that launched the Wasatch Choice 2040 planning process. While Salt Lake County was the lead agency for the SCI grant, Envision Utah – a nonprofit organization organized to facilitate conversations to explore land use, transportation, and environmental solutions to the challenges presented by growth – has led the scenario planning efforts in the region, working with other regional and local partners. Additional members of the SCI consortium included WFRC, MAG, Utah Transit Authority, Metropolitan Research Center at the University of Utah, the Bureau of Economic and Business Research, the Utah Department of Transportation, and Salt Lake City Corporation.

The plan's agenda is broad and seeks to influence transportation infrastructure, increase housing and transportation choices, improve public safety, foster economic development, and enhance environmental stewardship. In truth, however, Wasatch Choice 2040 is less a plan than a vision; it is designed as a regional growth strategy whose tenets are encouraged for adoption by member jurisdictions through technical assistance and guidance.

## Tool and Process Overview

The SCI grant awarded to Salt Lake County also was designed explicitly to both enhance and apply the EnvisionTomorrow scenario-planning suite. As a part of the grant, Fregonese Associates, developers of EnvisionTomorrow, offered to make the software open-source as a means of providing a matching financial contribution (in the form of intellectual property and foregone revenue). Furthermore, researchers and academics at the University of Utah's Metropolitan Research Center committed to developing approximately 20 additional models based on their academic research. These "apps" would be then integrated into the software to compute additional metrics (such as fiscal impacts or waste generation) and would be applied and tested in the Wasatch region as a part of the grant. The combination of these two processes resulted in the evolution of EnvisionTomorrow into EnvisionTomorrow Plus or ET+.

It is no coincidence that EnvisionTomorrow and Envision Utah share a similar nomenclature. Envision Utah – the nonprofit planning organization that began the first regional visioning effort under the same name – and the ET+ software share a common confidence in the efficacy of a particular kind of scenario planning, and the desire for interactive public visioning to guide urban development decisions. A number of the analytical engines that drive

EnvisionTomorrow in both the original and Plus versions were in fact developed by faculty at the University of Utah. For this reason, it is no surprise that EnvisionTomorrow was selected as the software suite of choice for the Wasatch 2040 effort. Indeed, Utah and the Wasatch region have invested heavily in the EnvisionTomorrow suite; the consortium has held at least four training workshops, each of which comprise a full day, and are both free and open to the public.

The consortium also maintains an informational ET+ page on its web site featuring ten training videos, FAQ resources, prominent links to additional ET+ resources, and downloadable parcel data and excel models that can be input directly into ET+. Finally, the web site has a specific section designed as a tool support forum with information in ET+ installation, general operation, and scenario building. Although the forums appear to generate little user traffic, their existence alone is a strong indicator of the investment the Wasatch region has made in EnvisionTomorrow.

## Tool Characteristics

The basic function of ET+ is rooted in geodesign; users load spatial data into ArcGIS at a given scale (e.g., grid cells, parcels, census geography), which are simultaneously linked to Excel spreadsheets. Users then use a painting function to design alternative development scenarios whose attributes are tabulated automatically in the spreadsheets. Perhaps the essential ingredient in this process is the "Prototype Building Library," which is used as the first building block in designing development outcomes. The building library contains information about typical construction materials and costs, lot and building size, parking requirements, and other standardized development information. Designing a building library is thus among the most fundamental and time-consuming portions of an EnvisionTomorrow exercise.

The SCI grant awarded to the Wasatch region allowed faculty at the Metropolitan Research Center to design a library that accurately reflected local buildings types, which has since been made available for public download. MRC faculty also designed a series of spreadsheet models (or "apps" as they are called in the EnvisionTomorrow terminology). These models are now included with typical installations of ET+, and although they are designed to be used out-of-the-box in any region, some modification may be necessary to ensure that they accurately reflect local conditions. Since the models were built as part of the Wasatch grant, tweaking was unnecessary when they were applied to Utah-centric scenarios. These apps include:

- Growth Location Prediction;
- Building and Land Use Types;
- Building Energy Consumption;

- 7D Transportation Effects (VMT and trips for households and mixed-use developments);
- Return on Investment (financial feasibility of development);
- Housing + Transportation Costs (total monthly household costs);
- Air Quality and $CO_2$ Impacts;
- Fiscal Impact;
- Public Health (physical activity);
- Employment Growth (including impacts of sprawl on growth and resilience);
- Development Capital (costs and revenues for various building types);
- Redevelopment Timing (based on financial flows);
- Water Consumption;
- Transportation Safety;
- Workforce Housing;
- LEED-ND;
- Arts and Public Amenities (number of housing units and jobs within a buffer distance); and
- Local Jobs Housing Balance.

The ET+ transportation estimates employ modifications to standard trip generation and are based on travel characteristics of select mixed-use developments across the United States. Trip generation modifications are based on "7D" models developed by planning professionals (Ewing et al, 2011). Trip modifications are applied to standard singular-use trip generation estimates developed by the Institute of Transportation Engineers. The transportation app presents a summary of results that show the effects on VMT, internal capture, and mode split as a result of enhanced activity density and diversity of land uses within the development.

## Tool Application

### *Data Gathering and Establishing a Baseline*

Given the history of scenario planning in the Wasatch region and its familiarity with EnvisionTomorrow, it benefits from a number of somewhat atypical circumstances. For one, there is a wealth of spatial data that is publicly available at the parcel level for most of the Wasatch region. For another, the SCI funds allocated to the Metropolitan Research Center allowed for the creation of a unique and customized building library that was applicable to each of the scenario planning efforts taking place in the State.

### *Developing Scenarios*

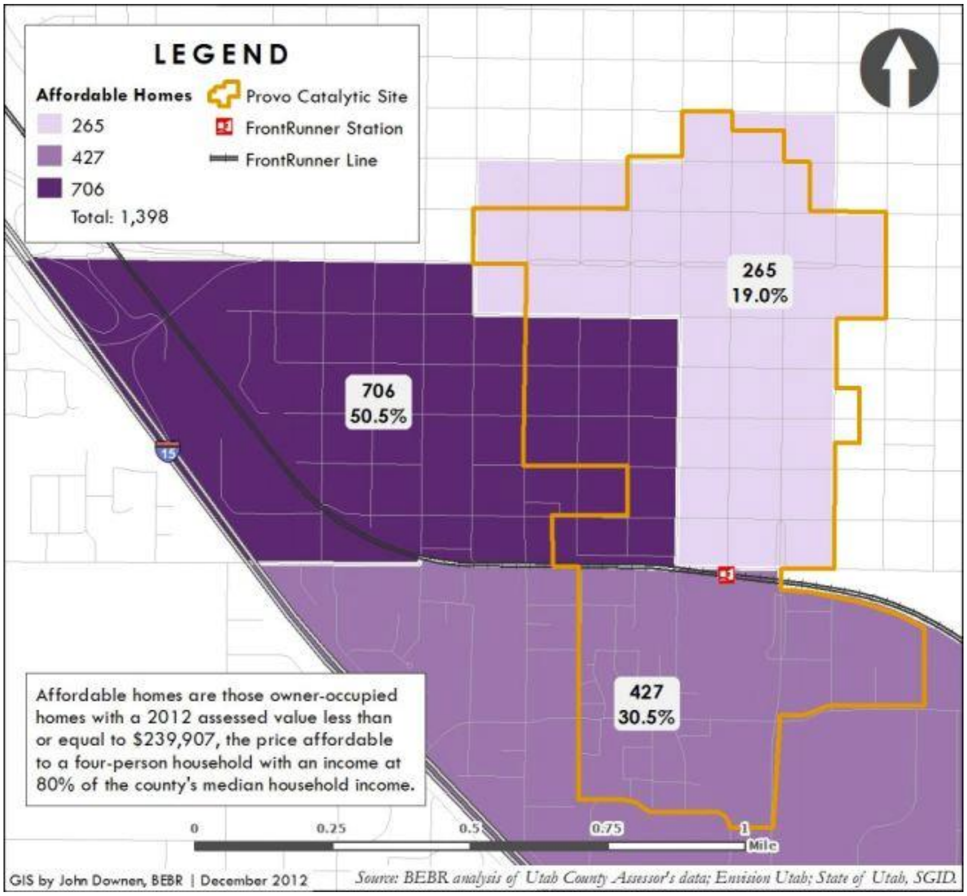
Although the Wasatch Choice 2040 vision is regional in scope, scenarios were not created and compared for the entire region. Rather, a number of demonstration sites were selected, each of which applied ET+ in a smaller jurisdiction. This strategy also was used in the Envision Central Texas effort and reflects the fact that while regional visioning is a useful exercise, regional governments rarely, if ever, have the tools or capacity to enforce planning decisions. Instead, an overall vision is provided and local jurisdictions are given the autonomy to prepare scenarios that (hopefully) conform to the regional vision. The use of demonstration sites also greatly reduces data requirements compared to applying the tool at a regional level, and provides a more concrete illustration of the benefits of land use change at a local level.

In the case of Wasatch Choice 2040, six demonstration sites were selected:

- Depot District;
- Salt Lake Streetcar;
- Provo Intermodal Hub;
- Meadowbrook;
- Magna; and
- Downtown Sandy City.

Figure C.13 shows the area of the Provo demonstration site, overlaid with data on the number of affordable homes.

## Figure C.13 Provo Intermodal Hub Demonstration Site




Source: Envision Utah.

Envision Utah worked with local planners and officials to prepare scenarios using EnvisionTomorrow+. Each of the demonstration sites followed a methodical process outlined in the Wasatch Choice vision (entitled Envisioning Centers). The process includes the following ten steps:

1. Create the framework for your process;
2. Set up for scenario planning;
3. Evaluate where you are today;
4. Evaluate what happens if we stay on our current path;
5. Envision with the community and stakeholders;
6. Create alternative scenarios;
7. Share scenarios with the community and stakeholders; get feedback;
8. Create and share the vision;
9. Implement the vision; and
10. Measure progress.

Thus, a baseline scenario was created by planners and staff from Envision Utah, which was then vetted widely during community visioning exercises. The visioning exercises were then used as qualitative input into a set of scenarios (developed once again by Envision Utah). These scenarios were then vetted once again during another round of public meetings, although interactive scenario building was not part of the process. The following excerpt is taken from the Provo Intermodal Hub demonstration site, which is typical of the process:

> "During the Envisioning Center process several analyses were undertaken to assess the capacity and demand for residential and commercial development in downtown Provo. Some of the key factors that were considered included demographics, market demands and physical capacity criteria such as infrastructure and land constraints.
>
> In line with the Envisioning Centers' process and working with our stakeholder group, Envision Utah created four scenarios with differing land uses for the Provo study area to meet the expected growth. The scenarios were derived from our stakeholders' meetings in which stakeholders from the City and community took part in mapping exercises to help guide and to provide input about the future development of Provo. Some of the stakeholder maps displayed fairly aggressive growth with many high-density land uses while other stakeholder maps displayed a more moderate vision of growth.
>
> The scenarios were modeled and refined using Envision Tomorrow Plus to reflect market research and to help create a "Vision Scenario" for the Downtown Provo area, which was then vetted by the Stakeholder group."

### *Outputs and Graphics*

Although the indicators created for each scenario varied by demonstration site, most of the newly created "apps" were utilized, each of which could be explained to the public by breaking down the Excel spreadsheets.

The EnvisionTomorrow suite rests on top of the ArcGIS platform and its visual output is thus exactly the same as one would achieve when designing maps using ArcMap. That is to say, that it is capable of producing aesthetically pleasing maps out of the box, but it is not capable of more advanced visuals. To augment these maps, partners in the Wasatch Choice effort spent a considerable amount of time translating the output from ET+ into SketchUp models that provide a photorealistic sense of different development outcomes (Figure C.14).

### Figure C.14 Sample Output Graphics


Source: Envision Utah.

## Evaluation

Overall, stakeholders in the Wasatch region are quite happy with the EnvisionTomorrow suite and have made a substantial investment to institutionalize the software into planning processes at many levels. Since a great deal of work has been put into creating models that reflect local conditions and designing accurate building libraries, it seems likely that EnvisionTomorrow will remain a useful tool in the Wasatch region and greater Utah since it can draw from the cumulative effort put into each exercise. These characteristics, however, make

Utah unique in that its experience with ET+ may not be generalizable directly to other regions and other jurisdictions who wish to use the software. Considerable effort is required to model local buildings and create visually pleasing output. On the other hand, the iterative and community-driven methodology implemented by the Envisioning Centers as part of the Wasatch Choice 2040 effort appears to be both procedurally adequate and satisfying to community members.

Table C.11 provides a summary evaluation. It is worth noting that the ET+ tool was applied only for specific sites using a "case study" approach, and therefore perspectives on the tool may not be directly comparable to the perspectives on CommunityViz and Urban Footprint applied at a true regional scale of application.

### Table C.11 Agency's Perception of Strengths and Weaknesses of the Tool

| Strengths | Weaknesses |
|---|---|
| Open source, transparent methodologies | Considerable effort required to model local building and development types and create visually pleasing output |
| Large number of indicators; flexibility to add modules | |
| Extensive library of custom inputs for Wasatch region | |
| Options for visualization output | |

## Resources

| **Lead Agency** | |
|---|---|
| Salt Lake County | http://slco.org/ |
| Envision Utah | http://wasatchchoice2040.com/ |
| **Consultants** | |
| Fregonese Associates | http://www.frego.com/ |
| Metropolitan Research Center | http://www.arch.utah.edu/cgi-bin/wordpress-metroresearch/ |
| **Links for More Information** | |
| Wasatch Choice 2040 | http://wasatchchoice2040.com/ |
| Envision Tomorrow | http://www.envisiontomorrow.org/ |
| MIT Department of Urban Studies & Planning | Godspeed (2014). "Planning Support Systems for Spatial Planning Through Social Learning" |
| Mixed-use trip generation report | Ewing, R., et al (2011). "Traffic Generated by Mixed-Use Developments – Six-Region Study Using Consistent Built Environmental Measures." Prepared for U.S. Environmental Protection Agency. |

# C.8 Envision Tomorrow: Austin

| **Lead Organization** |
| --- |
| Envision Central Texas |
| **Type of Organization** |
| Nonprofit |
| **Organization Jurisdiction** |
| Austin/Round Rock/San Marcos five-county Metropolitan Statistical Area |
| **Geographic Scope of Project** |
| Same as organization jurisdiction |
| **Project Timeframe** |
| 2011-present |
| **Lead Organization's Prior Scenario Planning Experience** |
| Extensive |

## Project Overview

The Sustainable Places Project is an ambitious initiative focused on the Central Texas region, specifically the Austin/Round Rock/San Marcos five-county metropolitan statistical area (MSA). The project began in 2011 with the goal of developing a spatial analytical engine that could be used to help build planning capacity in local jurisdictions.

The Central Texas Region has been using decision support systems to assist in scenario planning since the late 1990s. The foundation of this work began with Envision Central Texas (ECT), a nonprofit planning organization that developed a regional vision and preferred growth scenario between 2002 and 2004. The ECT vision was later institutionalized as the basis of the Capital Area MPO (CAMPO) 2035 Long-Range Transportation Plan, which identified 37 regional, mixed-use, mixed-income activity centers. Coordinating investments among these centers by providing housing opportunities, mobility choices, economic prosperity, concentrated growth, healthy communities, and environmental protection became the region's primary focus, and in 2011, the Capital Area Texas Sustainability (CATS) Consortium was formed and awarded a Sustainable Communities Initiative smart growth implementation grant to help execute its regional vision.

CATS steering committee members included the Capital Area Council of Governments (CAPCOG); CAMPO; Envision Central Texas; City of Austin; City of Round Rock; City of San Marcos; Capital Metropolitan Transportation Authority (CapMetro); and Capital Area Rural Transportation Systems (CARTS). Additional partners and members included local cities and counties, academic institutions (namely the University of Texas), major employers, transportation and transit agencies, nonprofit and community groups, and environmental agencies. Further, the consortium was assisted by a number of external contractors.

Unlike many other SCI grant recipients, the CATS consortium did not pledge to develop a Regional Plan for Sustainable Development. Instead, it proposed to develop a "Sustainable Places Analytic Tool," which could be used to guide the development of local sustainability plans in accordance with the regional vision outlined in the CAMPO 2035 Long-Range Transportation Plan. After development of the analytical tool, CATS would execute demonstration projects by helping local jurisdictions conduct scenario planning exercises, and engagement programs.

## Tool and Process Overview

To design and apply the "next generation" of scenario planning software, CATS initially hired IBM, a large local employer and economic anchor, whose Smarter Cities program was designed to "capitalize on new technologies and insights to transform [urban] systems, operations and service delivery."[40] Despite mutual interests and a natural partnership, CATS and IBM eventually parted ways after failing to complete a satisfactory contract.

In search of a new tool developer, CATS sought the advice of the Open Planning Tools Group, a national network of urban planners, academics, and software developers whose mission is to support the research and development of scenario planning software. Two of the group's organizational members offered bids to join the Sustainable Places Project, both of which were accepted. One agreed to build a "data schema wizard" that would help automatically process and clean spatial data (e.g., remove bad geometries, perform topological checks) for rapid deployment into scenarios. The wizard would be a modification of the firm's SPARC platform, which provides cloud-based data transformation services. Although the wizard was developed as part of the Sustainable Places Project, it was, ultimately, of limited value and rarely used in practice, being viewed as too cumbersome and a poor fit for their needs.

The other, developers of the EnvisionTomorrow software package, was hired to expand the capabilities of their existing software – during which time the software would grow into EnvisionTomorrow+, and the source code was to be made public and freely available. CATS chose the EnvisionTomorrow suite because it exists as an add-on to the ubiquitous ArcGIS suite, familiar to most planners, and its analytical engines were developed by well-known academics and calibrated with national data. Furthermore, the current version of EnvisionTomorrow was fast enough to allow scenario creation during planning meetings, and its learning curve was shallow enough to allow for relatively rapid adoption. It also produces a wide range of indicators "out-of-the-box" as listed in Section C.7.

[40] http://www.ibm.com/smarterplanet/us/en/smarter_cities/overview/.

In addition to the built-in indicators, the Sustainable Places Project contracted with the economic analysis firm HDR Decision Economics to develop a series of metrics designed to monetize the social and environmental values that are often ignored in quantitative models. These indicators included streetscape impacts, recreational impacts and disabled mobility impacts among many others. A selection of sample indicators and their descriptions are provided in Table C.12.[41]

### Table C.12 Sample Indicators

| Input Number | Impact Type | Impact Description |
|---|---|---|
| 13 | Commuter Mobility Impacts (Existing Users) | Access to nonvehicle mode of transportation for the purposes of a safe and comfortable commute. |
| 14 | Commuter Mobility Impacts (Induced Users) | Access to nonvehicle mode of transportation for the purposes of a safe and comfortable commute. |
| 15 | Health Impacts (Long-Term Health System Cost Change) | Savings on future health care costs due to accessible recreation activity for new users. |
| 16 | Streetscape Impact | Enhanced value of journey for pedestrians due to improved quality on a route. |
| 17 | Recreation Impacts (Existing Users) | Benefits attributed to increased outdoor bike and pedestrian travel for current user. |
| 18 | Recreation Impacts Induced Users) | Benefits attributed to increased outdoor bike and pedestrian travel for induced users. |

## Tool Characteristics

The EnvisionTomorrow+ platform is based on a micro to macro concept in which individual buildings are modeled using a return on investment (ROI) tool to determine which types of structures are likely to be developed under current (or potential) zoning and land use regulations. Those buildings and their associated attributes are then aggregated into Place Types, which can be painted on a map; the resulting place type coverage is used to generate summary indicators. The software is designed to work “out of the box” with this framework, and comes packaged with a prebuilt library of building types and models that are calibrated using nationwide datasets. The first step in any scenario development process, therefore, is to determine whether the existing building and model prototypes accurately describe local conditions.

In the case of the Sustainable Places Project, a significant amount of work was required to ensure that EnvisionTomorrow could produce realistic indicators for the Central Texas region. The existing building type library needed to be

[41] More information on these metrics is available here: https://docs.google.com/a/divaimaging.com/viewer?a=v&pid=sites&srcid=ZGl2YWltYWdpbmcuY29tfGVudmlzaW9uLXRvbW9ycm93LXdpa2l8Z3g6MmY2NGFlYWFhYzc5MjZkMg.

augmented significantly before any scenario creation was reasonable. Although EnvisionTomorrow comes packaged with a library of building types for which indicators have been modeled and assembled, the library included only 15 building types prior to the Sustainable Places Project, none of which were particularly suitable for the Central Texas region. To address this issue, Fregonese Associates worked with the CATS consortium to develop a new library that included over 150 building types typical to Sunbelt regions, each of which was associated with attributes like building materials and energy consumption.

With the appropriate building types in place, CATS also found it necessary to examine the models and analytical engines that drive indicator creation in ET+. Since the software is designed for ease of use and rapid scenario development, its analytical engines exist as a sort of "gray box." Unlike other scenario tools like CommunityViz that are completely open-ended and require users to input their own indicator formulae, EnvisionTomorrow comes with its own models and equations that are assumed to be appropriate in most locations. The models are not completely "black-box" because they are calculated in Excel spreadsheets that are linked to ArcGIS; this hybrid framework means that calculations are hidden from users who choose not to interact with them, but can be modified by advanced users who have sufficient cause.

During the Sustainable Places Project, many of the engines were allowed to operate untouched because their assumptions were reasonable and the models are relatively simple. Other, more complicated models, such as the MXD (mixed-use) trip generation model, also were applied without modification due to methodology that is well known to planning practitioners (though sometimes challenged in the academic community). Other models, however, were less appropriate because they either produced measures that were too coarse at a subregional scale or were inadequately calibrated to represent local conditions in Central Texas. In the case of the former, the indicators were still computed but had little overall utility; in the latter case, CATS relied on researchers from the University of Texas to develop more realistic models that could be integrated into the software. As an example, a unique fiscal impacts model was developed by UT faculty to replace the existing model that comes packaged with the EnvisionTomorrow suite because the existing model was inadequate at representing local expenditures.

## Tool Application

Although the Sustainable Places Project was regional in concept, its focus was on building capacity at the local level and EnvisionTomorrow+ software was thus applied only at the local level. In fact, it might be more accurate to describe SPP as a collection of five separate but simultaneous scenario projects rather than a single project. For this reason, ET indicators were rarely integrated into larger-scale models and were used primarily as a way of interfacing with the public and communicating the impacts of different styles of development.

Three different scenarios were created for each of the five demonstration sites. The first scenario was a typical "Business as Usual" case in which existing trends are carried out into the future.

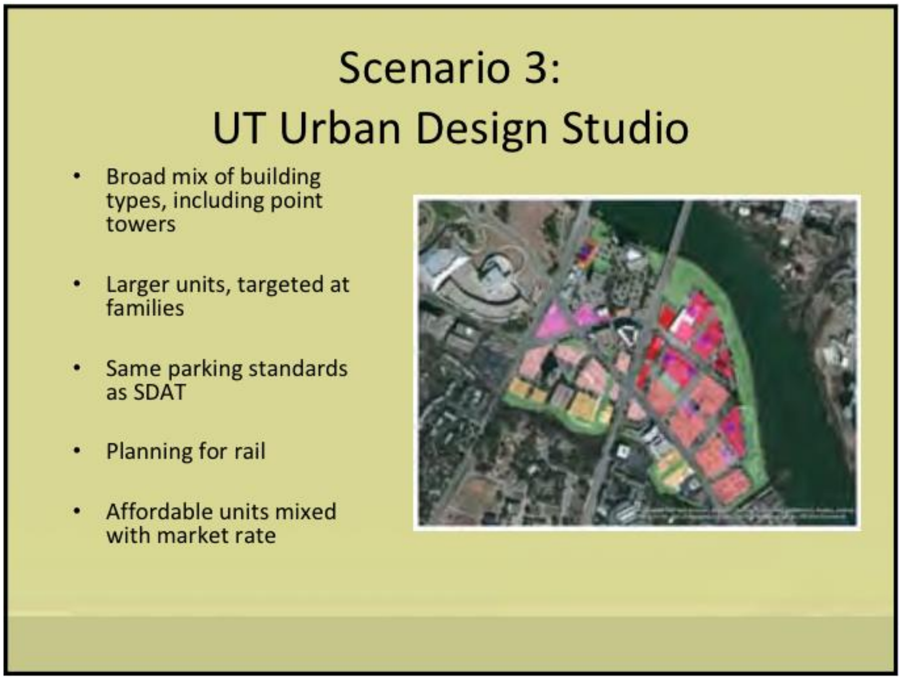
The second scenario was community-driven, and developed during public engagement charrettes (Figure C.15). During these meetings, traditional chip-based growth allocation exercises were used in which citizens were divided into groups and asked to place blocks on a map to represent the locations of jobs and housing. The chips were recorded and combined into average densities that could be represented by Place Types using ET+. Graduate students from the University of Texas would then paint a community-driven scenario into the software during the meetings for semi interactive feedback. This semi interactivity was a key feature of the SPP that allowed the public to evaluate the impacts of their visions during meetings.

**Figure C.15 Public Charrettes to Develop Scenarios**


Source: City of Austin and Austin Sustainable Places Project.

The third scenario, a "sustainable future," was developed by UT faculty and graduate students as part of a capstone studio project. This scenario was designed to include research from best practices in sustainable development, along with contemporary research from scientific journals, and design criteria that harmonize with the regional activity centers vision outlined in the CAMPO long-range transportation plan (see Figure C.16 for an example).

**Figure C.16 Illustrative Example from Scenario 3**




Source: City of Austin and University of Texas.

## Evaluation

In general, planners and community members were happy with the ET suite. The ability to develop new scenarios on the fly during public meetings was invaluable because it gave community members ownership of the scenario process and allowed them to evaluate the impacts of their development choices with interpretable quantitative measures. Per an analysis by Robert Goodspeed (2014), this process facilitated real learning by the public. It also allowed some degree of visual assessment, which was reportedly more useful for some demonstration projects than others. The variation in reviews was likely due to the fact that, in its current form, EnvisionTomorrow's graphical capabilities are limited; both the web interface and the basic desktop install only include support for two dimensional graphics via ESRI's ArcMap (though more detailed visualizations can be built by the user).

To facilitate more realistic three-dimensional visualizations, the Sustainable Places Project intended to fund the integration of EnvisionTomorrow with ESRI's CityEngine platform. CityEngine is a 3D parametric modeling platform that can produce high-resolution (video game quality) architectural models of urban areas. Integration with ET would have meant that indicators and photorealistic images of scenarios could have been generated in concert. Naturally, this would have allowed a much richer interpretation of each scenario and planners, academics, and software developers lamented that integrating the two platforms ultimately proved more difficult and time-consuming that funding would permit.

Table C.13 provides a summary evaluation. It is worth noting that the ET+ tool was applied only for specific sites using a "case study" approach, and therefore perspectives on the tool may not be directly comparable to the perspectives on CommunityViz and Urban Footprint applied at a true regional scale of application.

### Table C.13 Summary Evaluation

| Strengths | Weaknesses |
|---|---|
| Ability to generate scenarios and indicators "on the fly" | Significant work to customize building types for local application |
| Options for visualization output | Limited graphical capabilities |

## Resources

| Lead Agency | |
|---|---|
| Envision Central Texas | http://www.soa.utexas.edu/csd/research/sustainable-places |
| Capital Area Council of Governments | Chad Coburn |
| **Consultants** | |
| Fregonese Associates | John Fregonese, Alex Joyce |
| University of Texas | Bob Patterson, Sarah Wu |
| McCann Adams | Jana McCann |
| **Links for More Information** | |
| Envision Central Texas | http://www.soa.utexas.edu/csd/research/quality-growth |
| Envision Tomorrow | http://www.envisiontomorrow.org/ |
| MIT Department of Urban Planning | Godspeed (2013). "Planning Support Systems for Spatial Planning Through Social Learning" |
| Mixed-use trip generation report | Ewing, R., et al (2011). "Traffic Generated by Mixed-Use Developments – Six-Region Study Using Consistent Built Environmental Measures." Prepared for U.S. Environmental Protection Agency. |

# Appendix D

*Comparative Tools Descriptive/ Evaluative Matrix*

# D. Comparative Tools Descriptive/Evaluative Matrix

## Table D.1 Comparative Tools Descriptive/Evaluative Matrix

| Category/Subcategory | Envision Tomorrow | CommunityViz | UrbanFootprint | Comments |
|---|---|---|---|---|
| **Conceptual Attributes** | | | | |
| **Types of scenarios supported**<br>• Predictive<br>• Exploratory<br>• Normative | Normative | Normative, with the ability to create somewhat exploratory and predictive scenarios through user-defined suitability factors and its built-in allocation tool. | Normative | |
| **Approach to scenario creation**<br>Place Types<br>• Predefined<br>• User-defined | Place Types and Building Types – complete with type specific assumptions about energy/water use, GHGs, costs, etc.;<br>Users choose from preexisting building library or create from scratch. Place types are assembled by defining mix of building prototypes | 10 predefined Place Types with generic (national-based) assumptions about energy use, water use, and GHGs;<br>Unlimited user defined, or rule-based from existing places | Place Types (35) and Building Types – complete with type specific assumptions about energy/water use, GHGs, costs, etc.;<br>Translation Engine to interpret parcel and land use data and place type inputs from other formats and convert into base raster grid. This engine is currently a back-end feature that is in development for inclusion in the UI wherein user as needed can adjust definitions and assumptions going into the Place Types. | |
| **Method of Place Type/ land use distribution**:<br>• "Painting" – applying attributes/placed types to existing geographic units (like parcels).<br>• "Sketching" – the ability to create new geographies (e.g., subdivide a parcel).<br>• Rule-based<br>• Model-based | A few methods supported:<br>• "Painting" place types/ attributes to existing geographic units.<br>• Sketching new geographic units and painting them with place types/attributes.<br>• Links to external models. | Many methods supported:<br>• Painting place types/attributes to existing geographic units via "Land-Use Designer" tool.<br>• Sketching new geographic units and painting them with place types/attributes.<br>• Allocation to geographic units by suitability/rules- based scores.<br>• Links to external models. | Several methods supported:<br>• Painting - rule-based query tool "paints.<br>• Sketching – Only in a pixelated, raster based way where individual grid cells could be repainted as a different place type | Important differences here! |

| Category/Subcategory | Envision Tomorrow | CommunityViz | UrbanFootprint | Comments |
|---|---|---|---|---|
| • Others – e.g., contingent or conditional scenarios | | | | |
| Other (contingent or conditional scenarios) | | Allocation models and suitability scores can be iterative. | Existing plans – translation into common language | |
| **Sustainability Framework**<br>• Environmental, Economic, Equity? | • Prototype Builder-<br>– Spreadsheet-based ROI model used to test the physical and financial feasibility of development<br>• Scenario Painter<br>– Geodesign-based tool for allocating development and computing indicators<br>• Apps and Indicators<br>– 20 built-in "apps" for computing common scenario indicators<br>• Unlimited user-defined indicators via spreadsheet-based models | • Common Impacts:<br>– 13 simple demographic/ economic and GHG impact that work with Land-Use designer defaults.<br>– 5 additional economic/ environmental that require additional data.<br>• 360 Indicators:<br>– Up to 101 additional indicators in land use, demographics, transportation, recreation, environment, housing, and employment (based on base data availability).<br>• Unlimited user-defined indicators. | Primarily Environmental; some Economic<br>1) Land Consumption: greenfield versus infill, agricultural and environmentally sensitive lands consumed;<br>3) Building Energy: total energy use converted to cost and GHGs;<br>4) Water: Total use converted to cost;<br>5) Public Health: obesity and respiratory diseases, collisions converted to costs<br>6) Transportation: VMT, mode share, vehicle fleet characteristics, fuel mix, origin-destination pair travel time skim matrices from travel model | ET has ROI, UF not; CV limited fiscal; ET has good range on paper, including workforce housing; ET/ UF have good energy variables/inputs, CV's unclear<br>UF requires user suggestions of new indicators to be coded into the model by Calthorpe staff. As an iterative process working with clients, Calthorpe attempts to roll out new modules with additional indicators.<br>Both ET and UF have public health, not CV as of now |
| | Economic (out of box)<br>• Employment Growth<br>• Employment Resilience<br>• ROI<br>• Fiscal Impacts<br>• Development Capital | Economic (out of box)<br>• Jobs – basic counts<br>• Fiscal impacts – property tax revenues only<br>• ROI's – None<br>• Economic (custom): unlimited | • Fiscal: Capital, O&M, and Revenues. UF allows for impact fee data, general fund expenditure data, and property tax data to be used along with one-time capital costs and O&M costs to determine cumulative revenues and costs of scenarios. | |
| | Equity (out of box)<br>• Public Health<br>• Workforce Housing | Equity (out of box)<br>• Amenities<br>• Worker Housing | • Transportation: VMT, trips by mode, congestion converted to auto ownership and | |

| Category/Subcategory | Envision Tomorrow | CommunityViz | UrbanFootprint | Comments |
|---|---|---|---|---|
| | • Transportation and Safety | | maintenance costs, pollutant emissions, fuel costs, GHGs;<br>• Public Health: Weight/Activity related disease, respiratory impacts and ped-auto | |
| **Inclusion of nonspatial parameters, policies**<br>• Converted to spatial effects<br>• Maintained in parallel form in tool | • Housing, transportation, and energy costs<br>• Redevelopment Timing<br>• Building Energy Consumption<br>• Street Life<br>• Retail Sales-as part of a basic fiscal model | Internal assumptions and linked external look-up tables can be<br>• Transportation<br>• Energy consumption<br>• Economic impacts. | 1. Vehicle policy: fleet mix and efficiency;<br>2. Fuel policy: fuel economy, costs and carbon intensity;<br>3. Energy Generation:<br>4. Fuels mix and carbon intensity;<br>5. Building Policy: rates applied to new, existing, and replacement buildings. | |
| **Regional adjustments**<br>• Designed for region or subarea or scalable with different attributes by scale? Does software allow combining values and averaging them? | Regionwide or Subarea, depending on chosen base geography (e.g., parcel versus TAZ) | Regionwide, Subarea | Developer has worked on specific modules for individual regions that are then offered to other regions | |
| | | Combinatorial and Average methodologies | | |
| | Same for all scales | Can work at all scales. What matters for performance/accuracy is number of features and complexity of model. | | |
| **Educational Aspects**<br>• Opportunities for feedback and double loop learning<br>• Real-time updates of indicators?<br>• Entertainment Quotient<br>• Presentation Tools? | Real-time updates of computed indicators; new data must be input manually | Real-time updates of computed indicators through changes of assumptions, painting attributes, editing features | No, user must manually input new datasets<br>Calthorpe support often necessary for input of new datasets and running of models, though some clients being trained to do this independently. A function of both agency staff availability and budget given to Calthorpe. | |

| Category/Subcategory | Envision Tomorrow | CommunityViz | UrbanFootprint | Comments |
|---|---|---|---|---|
| • Charrette tools? | Moderate feedback/learning opportunities (runtime constrained, but generally software is fast enough to allow some iteration of land use design with a limited number of analysis features.) | Moderate feedback/learning opportunities (runtime constrained, but generally software is fast enough to allow some iteration of land use design with a limited number of analysis features.) | Developer intends to develop functionality so scenario painting can happen at presentation by user and sensitivities to changes can be quickly visualized. This functionality has yet to be completed and has not been tested in "live" environments. Run-time constraints are to be addressed with forthcoming cloud-based computational scaling. | |
| **Expert Aspects**<br>• Quality of assumptions, algorithms<br>– Precise?<br>– General/rule of thumb? | User defined but defaults are generally "rule of thumb" and simple methods. Models can range from simple and coarse to intricate and precise. | User defined but defaults are generally "rule of thumb" and simple methods. Models can range from simple and coarse to intricate and precise. | Place Type translation engine uses state of practice for defining 35 specific place types. | |
| Transparency of assumptions, algorithms | Transparent; because models are configured in Excel, they should be understandable to any moderately advanced excel user | Highly transparent. | Translucent. There is some documentation, but not easy to look at actual relationships embedded in in tool. | UF less transparent currently because unable to view formulae as in Excel tables. |
| • Linkages to econometric, travel and other m | Easy to link external data from ArcGIS or other generic table formats.<br>Linkages to econometric, travel, and other models feasible as long as external source provides tabular data. | Easy to link external data from ArcGIS or other generic table formats (see below).<br>Linkages to econometric, travel, and other models feasible as long as external source provides tabular data. | Automates input of census, land use, and transportation network data.<br>Supports cross-environment input and output data transfer.<br>Built on open-source tools rather than ESRI-based, which solves run-time and system crash issues of working with very large datasets in ESRI products. Future updates to tool intend to implement ESRI interoperability. | Open-source tools only a net benefit if agency staff are used to working with them. For less equipped staff, ArcGIS based tools can be easier to use out of the box. |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| **Functional Attributes** | | | | |
| **Getting started – Data requirements, management, and organization**<br>Minimum amount of data required to create and run scenarios<br>• Existing land use and future land use (describe for tool) | Varies:<br>• Building prototype data is necessary to perform basic analyses. These prototypes may be recycled from templates or built from scratch. Building templates from scratch can be time consuming and data intensive<br>• Additional data (e.g., detailed household and employment) may be included for more complex analyses | Varies:<br>• Minimal data can be used to create simple analyses with "Common Impacts." More complex models require more data. | • High – parcel and TAZ level land use and sociodemographic data; census data; transportation networks<br>• Out-of-the-box land cover data built on CA datasets –may not be comparable starting points in other states. As UF is deployed outside of CA, the base data will be built up and the analysis engines will be calibrated.<br>• Outside of CA, baseline growth projections and policy assumptions need to be input, whereas they exist as default for CA locations. | |
| Format<br>• Native (Most data can stay in original format and tool can be adapted to match)<br>• Specified (Most data can stay in original format but must have specific fields)<br>• Imported (Data must be imported into a new file/ format) | • Simple (Native) – In most cases, data can stay in original excel templates; templates automatically import building prototypes. Other data can be linked via excel tables. Field conversions for common data sources (e.g., LEHD) are provided via software web site. | • Simple (Native) – In most cases, data can stay in original format and "wizards" or templates can be used to link existing fields predefined formulas/indicators, or formulas/indicators can be written from scratch to reference native data. | • Simple (Native) – Native data is translated into UF Place Types. Can work at any geography – parcel, block, grid, custom. But background operations still often normalize to raster grid for analysis, making run-time more efficient. | |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| Data quality required<br>• (descriptive categories) | • Moderate – Data faults will not prohibit analysis, but faults (e.g., missing data for some geographic units) may not be detected by the software | Varies –<br>• In some cases, invalid data may not be detected until run time, causing script failures. In other cases, invalid data may not cause script failures, but produces erroneous results.<br>• Errors in formulae syntax are automatically detected and mechanisms to correct them exist. | Moderate – Scripts normalize data of varying quality, type, and scale from a wide variety of sources to import them into the model analysis grid. Since most client agencies have relied heavily on Calthorpe to do everything up through model runs, these scripts are developed as needed to apply to the specific nature of the inputs and are not standardized scripts that can truly be applied out of the box to any input files. Does use MPO control data to check inputs. | Only CV has built in checks on data correctness |
| Ability to organize and convert data and mapping inputs<br>• Land use classifications<br>• Infrastructure mapping/ data | • Moderate – developer provides translation tables for common data sources (e.g., converting assessor LU classifications into ET+ classifications) | • Excellent | • Excellent | UF's Place Type library of 35 place types would seem to be sufficiently complex, but is only a net advantage if the inputs being translated are equally complex. |
| Ability to link to/import other data sources<br>• (describe) | • Excellent – Ability to link/import data from data services (ArcGIS Server, ArcIMS, WCS, WMS) and a variety of tables (TXT, CSV, DBF, and Excel) | • Excellent – Ability to link/import data from data services (ArcGIS Server, ArcIMS, WCS, WMS) and a variety of tables (TXT, CSV, DBF, and Excel) | • Low – many California specific datasets already loaded, but not setup to automate linking to comparable datasets outside of California | |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| Linkages to econometric, travel and other models<br>• (describe) | • Moderate – Other models must output tabular or GIS data | • Moderate – Other models must read file geodatabase directly and/or tables/indicators must be. Does not allocate exported to a table format. | • Low – tabular and graphical outputs currently available only from Calthorpe running models for MPOs. No automatic functionality "out of box" for linking to other models. | UF progressing towards "out of the box" functionality that can link to other models is contingent upon ongoing agency funding for this development. |
| **Creating scenarios**<br>• Set range of Place Types<br>• "Core" Place Types with basic attributes<br>• "Core" with detailed attributes<br>• Extended set of Place Types<br>• Large collection of Place Types with basic attributes<br>• Large collection of Place Types with detailed attributes | • Moderate place types are created by defining the mix of prototype buildings | • Moderate 10 "core" place types with basic attributes. | • High- 35+ place types calibrated from CA and other western state environments | |
| • Ability to add customize land use/place type | • Customizable via table | • Easily customizable ("Land Use Designer" GUI for creating custom place-types.) | • Easily customizable (GUI) | |
| • Non – place type approaches (e.g., allocation routines) | • N/A | • Allocation model built-in | • Query tool that allows for rule-based painting via queries, joins, etc., option. | |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| Soundness of allocation methods | • Does not allocate except via Place Types | • Strict-order or probability-based. Probability-based can be either linear or exponential, with "randomness" settings (similar to deviation of probability distributions). | • Does not allocate except via Place Types | |
| **Creating a baseline**<br>Existing conditions<br>• Can use LU/LC data "as is"<br>• Must convert/match existing LU/LC to Place Types | • Moderate – Must convert existing LU/LC to place types | • Easy – Can point to fields that contain household and employment information. | • Easy – "Existing plan translation" tools | |
| Assumptions<br>• Preloaded/templates<br>• Customizable<br>• From scratch | • Customizable. | • Easy – assumptions for each core place type already loaded but can be easily be customized. Interface also allows easy creation of assumptions from scratch. | • Easy – assumptions for each place type already loaded, automatically creates base grid of existing conditions from land use and parcel data inputs and transportation network. Can modify the assumptions and Place Types according to specific needs. | |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
| --- | --- | --- | --- | --- |
| Trend scenario generation<br>• Methodology (description – e.g., manual, assisted, defaults built in etc.) | • Moderate – software does not allocate future growth. Instead, a cooperative forecast can be added as a potential scenario | • Good – Typically assisted via regional forecast control totals distributed using the allocation tool and/or user-defined rules. No built-in calibration tools although that could be done using older data sets. | • Moderate – e.g., in transportation module: base year and forecast data inputs and through MXD tool with "8 D's" and sensitivity impacts of assumptions about impact of 8 D's (density, diversity, design, development scale, distance to transit, destinations, demand management, and demographics)<br>• Good – Trend scenarios in UF are developed by manual user inputs (usually based on regional forecast control totals) | . |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| **Creating alternative scenarios**<br>Number of scenarios supported/Limitations on numbers and scales of scenarios compared simultaneously<br>• Number of scenarios supported<br>• Maximum number of features (related to time to process)<br>• Practical number of features | • Number of Scenarios – no limit<br>• Number of Features – no limit | • Number of Scenarios – There is no limit to the number of scenarios but in practice it is impractical to create any more than 3-5. After that, charts become almost impossible to read and manipulating the interface is tricky.<br>• Number of Features – Again, there is no limitation to number of features but as the number of features increase and/or the complexity of formulas increase, the slower the tool runs. This is also dependent on the hardware. So if an agency wants to use the tool in a real-time workshop the number of features would need to be kept low (generally under 10,000) and formulas simple (not a lot of spatial and branching queries). | • Number of Scenarios – no limit<br>• Number of Features – no limit | While ET and CV technically have no limits to number of features and scenarios, they both are frequently constrained by the performance limitations of ArcGIS running on desktop hardware. UF plans to support processing on multiple CPUs over "the cloud," which could make the number of features virtually irrelevant. |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| Incremental/end-state?<br>• Are scenarios end-state only or do they have the ability to create incremental snapshots? | • End state | • Scenarios can be run incrementally using the allocation tool, but are generally end-state. Both kinds of scenarios can be evaluated "incrementally" using the "Time Scope" tool that basically filters results by only running those features that have a time/date attribute equal to or less than a given time/date. In that respect it is not iterative but is a slice in time. | • Currently outputs are dependent upon tool developer running model, so incremental outputs would also be so dependent. | |
| Real-time feedback (painting and sketching only)<br>Types of feedback ("real-time" indicators, alerts and/or warnings, error checking, others?) | • No | • Yes – Real-time calculation of attributes/indicators runs by default – however, if there are a very large number of features and complex calculations, "real time" can be potentially too long in, for example, a public workshop setting. Real-time calculation can be turned off for the entire analysis or specific attributes/indicators and then run all at once. (This is useful when making a large number of edits.) The software also creates alerts based on specific attribute and/or indicator values. | • Yes (under development) – To overcome hardware/software limitations that currently challenge the notion of "real-time feedback" with desktop-based scenario planning tools, UF's cloud-based implementation should be able to take advantage of distributed computing to produce almost instantaneous results. | |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| Regional adjustments<br>• Regionwide and/or subarea analyses concept<br>• Combinatorial and averaging methodologies<br>• Multiscalar capabilities (same approach at all scales or modified by scale?) | • Software is agnostic to geographic units, so subarea analyses can be performed using parcel boundaries and regional analysis can be performed with aggregate geographies like Census Blocks or Traffic Analysis Zones | • Software is agnostic to geographic units, so subarea analyses can be performed using parcel boundaries and regional analysis can be performed with aggregate geographies like Census Blocks or Traffic Analysis Zones | • UF works the same at all scales. Existing plan inputs can come from any scale/ format and be translated into the standard place types and raster format. | |
| Changing assumptions<br>• Easy to do/on the fly<br>• Hard to do/separate process | • Moderate – changes are made in excel templates, which then propagate through the scenarios | • Easy to do/on the fly | • Painting “levers” can be adjusted for density, gross-to-net, and development percentage. Real-time feedback functionality still under development, including ability to change assumptions. Under full-functionality, UF will allow for changing of assumptions of different place types or of different policies with almost instantaneous feedback. | |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| **Evaluating scenarios and making decisions**<br>Range of indicators produced<br>• Default/natively<br>• With additional inputs (To get more types indicators additional types of data would be required)<br>• Customized | • 24 built-in indicators with preexisting formulas. Formulas can be edited in included excel tables | • Common Impacts:<br>13 simple demographic/ economic and GHG impact that work with Land-Use designer defaults.<br>5 additional economic/ environmental that require additional data.<br>• 360 Indicators:<br>Up to 101 additional indicators in land use, demographics, transportation, recreation, environment, housing, and employment (based on base data availability). The majority of indicators are straightforward calculations like distances, totals, averages, and percentages.<br>• Extensive formula capabilities with over 90 built-in functions that be used to create a wide variety of custom indicators | • Generally covers indicators of interest – land, fiscal impacts, building energy (+GHG), water (+energy/GHG), transportation (+ AQ, energy, GHG), public health<br>• Equity via HH costs for transport and utilities, as well as comparison of housing supply/demand by type. Next update will include accessibility model.<br>• Additional indicator modules can be developed | |
| Ability to add stakeholder "values" to indicators<br>• Weighting<br>• Rating<br>• Prioritization routines | • Indicator values could be weighted within Excel. | • Can add weighting as a multiplier assumption to an indicator or performance measure. | • Not designed as a weighted scoring tool – outputs raw indicator values that could be fed into such a weighted performance measure tool (external to UF). | |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| Ability to normalize indicators/create a performance "Dashboard"<br>• Method (e.g., better than/worse than today, normalized against benchmarks, normalized for range (worst = 0; best = 100) | • Output could be normalized within Excel. | • Yes, can be normalized by range within program. | • | |
| Benchmarking<br>• Peer-based (relative to peer communities).<br>• Value-based (e.g., based on, say, plan goals) | • Either peer-based or value-based – set as an assumption. | • Either peer-based or value-based – set as an assumption. | • Benchmarks results against existing MPO or state forecasts. | |
| Technical quality of indicator calculations<br>• Give a general overview (algorithms are simple rule-of-thumb with coarse "ballpark" figures, or they are highly complex and precise etc.) | • Simple and transparent defaults. Can be customized to more complex and precise. | • Simple and transparent defaults. Can be customized to more complex and precise. | • Generally reports using high quality/state of practice methods, but cannot be verified as methods are not yet well documented or transparent. | |
| **Presenting Scenarios and Indicator**s<br>Map outputs<br>• One at a time/single<br>• Side-by-side | • Map outputs are displayed one at a time | • Map outputs can be displayed one at a time or two side-by side on monitor or using the report generation tool. | • Outputs currently delivered by Calthorpe, end-user functional tool still in development. | CV differentiator; problem currently with UF |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| Indicator format<br>• Table<br>• Charts<br>• Export to other apps supported<br>• Thematic maps | • Indicators are calculated in excel tables – charting is customizable with standard excel toolset | • Tables, charts, thematic maps. Charts tend to be rather crude so many users export results to Excel. | • Tables, charts, thematic maps output in open-source database tools, can be exported into standard Excel and ESRI formats. | |
| 3D Visualization<br>• Regional scale<br>– Thematic 3D maps<br>– 3D maps with charts<br>• Local scale<br>– Parametric-generated building massing models<br>– Parametric-generated building textured models | 3D Visualization<br>• For Regional scales, any ArcGIS 3D tool as well as Google Maps can be used to create thematic maps.<br>• For local scales, developer is currently adding the ability to generate procedural 3D buildings via export to ESRI CityEngine | 3D Visualization<br>• For Regional scales, any ArcGIS 3D tool as well as Google Maps can be used to create thematic maps.<br>• For local scales, CommunityViz provides "Scenario 3D" provides either Local scale or simple parametric-generated building massing models – although any tool that uses ArcGIS data can be used. Scenario 3D, however, provides added functionality for alternative scenario viewing. | 3D Visualization<br>• For Regional scales, currently, any ArcGIS 3D tool as well as Google Maps can be used to create thematic maps. The developer is "looking into" on-board 3D data analytics in 2016. | |
| Reporting tools<br>• Summary of inputs, assumptions, algorithms<br>• Summary of results<br>• Static or dynamic<br>• Story-boarding/saved views<br>• Web-based<br>• Printer-friendly | Moderate – Excellent<br>• Summary of analysis inputs, assumptions (separate excel tabs)<br>• Summary of results (excel worksheet tab) | Good – Excellent<br>• Summary of analysis inputs, assumptions, algorithms (HTML, printer)<br>• Summary of results (HTML, printer)<br>• Saved views<br>• Simple web reports (HTML, printer) | Good<br>• Summarizes indicators for each module/engine. Done via open-source database tools and queries to export to standard Office and ESRI formats. | |
| Public comments | No | No | No | |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| **Implementation Attributes** | | | | |
| **Access**<br>Platform<br>• Free-standing desktop app<br>• Desktop GIS extension<br>• Desktop GIS extension and spreadsheet models<br>• Self-hosted Web/Cloud based<br>• Vendor-hosted Web/ Cloud based | • Desktop GIS (ESRI) extension and spreadsheet (Microsoft Excel) models. | • Desktop GIS (ESRI) extension | • Currently web/cloud based "Software as a Service" (SaaS) hosted by vendor delivered via "thin" web-based client.<br>• "Self-hosted" – The software itself is open-source and freely available on the Internet, so theoretically can be self-hosted or "self-administered" (see comment) if an agency has the hardware, expertise, and wherewithal (see also under Prerequisites below) | There are several ways to implement open-source applications:<br>"**Self-hosted**" – The software and the hardware (servers) it runs on is hosted and administered by an agency.<br>"**Self-administered**" – Instead of maintaining the necessary hardware with all the maintenance and update issues that go along with it, an agency could utilize cloud computing services to run the open-source software.<br>"**Software as a Service**" (SaaS) – a vendor administers an application on behalf of clients, on their own servers or a cloud vendor's servers. |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| Distribution<br>• Shrink wrapped (license, installer)<br>– Fixed seats<br>– Floating Seats<br>• Software as a Service (SaaS)<br>• Open-access (free software, installer, closed code)<br>• Open-source (free software, components, open code) | • Open-source, but built on ESRI GIS and Microsoft OS platforms and therefore requires licenses for each to operate. | • Shrink wrapped with installer/ licenses for fixed or floating seats. Built on ESRI GIS and Microsoft OS platforms and therefore requires licenses of each to operate | • Open-source – but still under development for end-user full functionality. No need for proprietary software licenses (such as ESRI), but large stack of open-source software to install and maintain.<br>• Software as Service – New updates being developed that will be served over web to clients as a SaaS model. | |
| **Prerequisites**<br>Hardware | **Self-hosted:** Mid-range<br>Business-class desktop/laptop computer:<br>• RAM – 1 GB<br>• Processor – 2 GHz<br>• Hard Disk Space – 5 GB<br>• Dedicated graphics card with 64 MB texture memory.<br>• 3-button mouse<br>Ideal configuration:<br>• RAM – 1+ GB<br>• Processor – 2+ GHz<br>• Hard Disk Space – 5+ GB<br>• Dedicated graphics card with 128+ MB texture memory.<br>• 3-button mouse | **Self-hosted:** Mid-range<br>Business-class desktop/laptop computer:<br>• RAM – 1 GB<br>• Processor – 2 GHz<br>• Hard Disk Space – 5 GB<br>• Dedicated graphics card with 64 MB texture memory.<br>• 3-button mouse<br>Ideal configuration:<br>• RAM – 1+ GB<br>• Processor – 2+ GHz<br>• Hard Disk Space – 5+ GB<br>• Dedicated graphics card with 128+ MB texture memory.<br>• 3-button mouse | **SaaS**: Minimal<br>• Any computer/tablet with a good Internet connection.<br>Self-hosted: High-end<br>• Enterprise-class servers<br>Self-Administered: Mid-Range<br>• Business class computer/ laptop with a good Internet connection.<br>• Would need to "lease" hardware indirectly for cloud-computing services. | |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| Software<br>• List, including any open-source stack components | **Self-hosted**: Several<br>• Microsoft Windows OS<br>• ArcGIS desktop<br>• Microsoft Excel | **Self-hosted:** A few<br>• Microsoft Windows OS<br>• ArcGIS desktop | **SaaS:** Minimal<br>A web-browser<br>Self-hosted or Self-Administered: A lot<br>• Ubuntu Linux<br>• PostgreSQL<br>• PostGIS<br>• GOAL<br>• PGSQL<br>• Python<br>• Apache<br>• Django<br>• SQL<br>• Celeryr<br>• Redis<br>• OpenLayers web maps<br>• Jquery<br>• Highcharts | |
| Staff Expertise<br>• (describe expectation/ assumptions) | **Self-hosted**: Varies<br>• Skilled ArcGIS/Excel user to set up analyses.<br>• Google Maps user-skills to create/evaluate scenarios | **Self-hosted:** Varies<br>• Skilled ArcGIS user to set up analyses.<br>• Basic ArcGIS skills needed to create/evaluate scenarios. | **SaaS:** Minimal<br>Google Maps user-skills to create scenarios<br>Self-hosted: A lot<br>• Data, GIS, and coding experience, along with IT support to set up servers.<br>**Self-administered:** A lot, minus the IT support on servers<br>• Data, GIS, and coding experience. | |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| **Costs**<br>Hardware | **Self-hosted:** Moderate<br>Cloud-hosted: Unknown | Self-hosted: Moderate<br>Cloud-hosted: NA | **SaaS**: Minimal<br>Self-hosted: High<br>Self-Administered: Mid-Range | |
| Software<br>• Base software<br>• Application Initial Costs<br>• Application Ongoing/ updates | **Self-hosted:** Minimal<br>• Base<br>– Microsoft Windows<br>– ArcGIS<br>• Application, initial:<br>– Free/Open-Source<br>• Application, ongoing:<br>– Free/Open-Source<br>**Cloud-hosted**:<br>• Cloud veil hosting of the analytical tool by UT Austin for project | **Self-hosted:** Moderate<br>• Base<br>– Microsoft Windows<br>– ArcGIS<br>• Application, initial<br>– Commercial, full support: $1,400<br>– Government, full support: $875<br>– Government, self support: $525<br>• Application, ongoing (annual upgrades and support)<br>– Commercial: $950<br>– Government: $675<br>**Cloud-hosted:** NA | **SaaS**: Minimal-Moderate<br>• You will not own any software, but will have to pay a monthly fee for the service.<br>**Self-hosted:** Free/Open-Source<br>• Self-Administered: Free/ Open-Source | UF does not require expensive ESRI licenses. All open-source tools are freely available. Open-source definition of tool means that updates (which are not necessarily guaranteed) can be accessed on web, with or without a support contract with Calthorpe. Ease/ difficulty of implementing these updates may require support contract depending on agency staff capabilities. |
| Support | • Consultant support helpful, but not required | • Consultant support helpful, but not required | • Consultant support currently required | |
| Training | • Training by vendor or authorized consultants: | • Training by vendor or authorized consultants: | • Consultant training currently required | Contact vendors to get cost of training |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| **Performance/Robustness**<br>Speed | • Varies depending on number of models and hardware power. Generally fast enough to run large regional models in a live setting. | • Varies depending on number of features and hardware power. Generally, too slow to run large regional models in a live setting. | • Built using open-source GIS tools rather than proprietary GIS software in order to speed performance significantly and be able to handle complicated datasets and algorithms. Too slow at present to run in live settings, but the move to cloud-hosted servers that can be accessed in live settings via web-client is intended to allow for this functionality in the future. | |
| Stability | • Good | • Fairly Good | • Unknown, yet to be run by client without tool developer support | |
| Methods and assumptions clearly documented | • Good, clearly documented. | • Good, clearly documented. | • Moderate – Technical Summary has documentation of methods, but not detailed instructions. Best documentation available is through a UC Davis course on UF. | |
| Quality of graphic output | • Moderate/High – charts and visualizations configured with standard excel toolkit | • Medium – limited control over charts; however CV has far more reporting tools that the others with various web reports, output to ArcGIS Online, Google Earth. | • High | |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| **Ease of Use**<br>Skill level to create/ evaluate scenarios | • Low – users familiar with Google Maps should be capable of creating/evaluating new scenarios | • Takes moderate staff training and time to become familiar (e.g., 12 hours with intermediate GIS users to learn basics and then function with intermittent guidance) | • Fair - Takes significant staff training and time to become familiar. At minimum requires one half-time person and a couple quarter-time persons devoted to UF from an agency – one FTE. In order to be more independent and not requiring ongoing Calthorpe support, likely requires more staff time availability.<br>• Future editions of software may become more user-friendly to less expert staff over time. | |
| Skill level to set up application | • Requires knowledge of ArcGIS and Excel to become adept | • Takes significant staff training and time to become familiar | • Takes significant staff training and time to become familiar<br>• Future versions will only require login to SaaS model web browser, thus no server setup required | |
| **Support**<br>Help files<br>• Context accessible<br>• Manual-based<br>• Wiki-based<br>• Updates | • Manual-based help files, detailed web site | • Excellent **–** Context accessible help files, on-line versions too. Updates on regular basis. | • Still under development, yet to be delivered. Best documentation currently available is a UC-Davis jointly produced user guide for a UF course UC Davis runs. | |

| Category/Subcategory | EnvisionTomorrow Plus | CommunityViz | Urban Footprint | Comments |
|---|---|---|---|---|
| Tutorials<br>• Free/web-based<br>• Vendor-supplied<br>• Workshops available? | Tutorials<br>• Free/web-based tutorials and data provided on web.<br>• Short video tutorials on vendor's web site.<br>• Workshops available through vendor or authorized consultants. | Excellent<br>• Free/web-based tutorials and data provided on web.<br>• Short video tutorials on vendor's web site.<br>• Workshops available through vendor or authorized consultants. | • Manual/tutorials not yet available – need consultant assistance | |
| One-on-one support<br>• Dedicated support staff/ line<br>• Vendor consulting-based<br>• Email/web form-based<br>• Wiki/discussion board-based<br>• None | • Wiki/discussion board-based<br>• Email/web form-based<br>• Vendor consulting-based | • Good – Dedicated support staff for one-on-one support (available only with subscription versions). | • Vendor consulting-based | |
| Maintenance/updates<br>• Manual<br>• Automatic<br>• Semi-automatic<br>• Host application – done by vendor<br>• Self-hosted – must update all stack components | Manual | • Easy – Semi-Automatic: selecting menu item checks for new versions and notifies if new is available. | • Updates include new modules developed for other MPOs | While ET+ has a packaged installer, it does not have automatic update checking like CV does, which means the user has to keep checking the web site to see if there are new versions. This could change in future versions |

# Appendix E

*Description of Tools*

# E. Description of Tools

## E.1 CommunityViz

### *Conceptual Approach*

CommunityViz provides a framework of core components and built-in "Decision Tools" that allow for scenarios to be created in a number of ways. The built-in tool that directly supports the creation of "place types" is the "Land-Use Designer." The Land-Use Designer creates has a default palette of 10 typical land-use or place types with associated attributes that define the characteristics of a given land use, such as building density, demographics, and resource utilization rates. Variable factors (called "Assumptions") such as children per dwelling unit (DU), waste water generated, tax rates, etc., are preset based on common planning values in the U.S. but can easily be changed to reflect local conditions. The 10 default place types are:

- Government;
- Commercial;
- Industrial;
- Mixed use;
- Office;
- Parks and recreation;
- Residential high density;
- Residential low density;
- Residential medium density; and
- Rural.

These default models can be customized/modified with more local/accurate data using a graphical user interface (GUI). The properties of each model are organized in a tabbed dialog box where building info, per feature, per DU, per commercial area, and per employee data can be set. In addition to modifying the default land use models, custom land use models can be deleted or added.

### *Scenario Creation*

The Land-Use/Place Type ("Style") is applied to geographic areas on a map using the "Painter Tool" from the Scenario Sketch Tools palette, and the associated socioeconomic and environmental impacts of the scenario are updated immediately using the "Common Impacts" tool. Community input can be solicited for this task and the Scenario Sketch Tools can be used in a public workshop setting.

Other methods of scenario creation and evaluation are supported using CommunityViz's core components of user-defined "dynamic" attributes, assumptions, and indicators. Any existing or new GIS layer could be used as the basis for a scenario provided it has features with demographic attributes (e.g., population, jobs) or features from which demographics can be inferred (e.g., land use, density, buildings). Then impacts can be assessed by creating customized "per unit" assumptions (e.g., energy consumption by household, trips per job) and corresponding summary indicators. "Rules-based" scenarios can also be generated using the built-in suitability and allocation tools.

### *Software Requirements and Platform Specifics*

CommunityViz is a proprietary platform that requires its own paid license to function. Licenses come in a variety of levels ranging from single seat installations for consulting or other commercial work, to large 24 seat academic lab licenses intended for education and training. Functionally, CommunityViz operates as an extension to the ESRI ArcGIS platform, which also means that it requires an up-to-date ESRI license to function. Many of the modules in CommunityViz, particularly the 3-D viewer, also depend on the Microsoft dotNET framework, a programming model available for free download from the Microsoft web site. Due to these software dependencies, CommunityViz is not platform independent, and must be run via the Windows operating system. The software also includes the optional ability to interface with the Python programming language, a free open-source component that is also the default scripting language for ArcGIS.

### *Data Requirements*

Because CommunityViz is a primarily open-ended platform that encourages users to build their own models, its data requirements are less stringent than many other tools, depending largely upon the types of models, and indicators the user wishes to generate. The only data requirement specified by CommunityViz is "at least one dynamic point or polygon layer with a Projected Coordinate System." An existing land use or zoning layer can serve as the base case, but that layer will need basic demographic attributes (households, jobs) and/or need to be "painted" with corresponding Land Use Designer styles. The layer can start out partially or completely empty and new features can be sketched using the standard ArcMap Create Features window, which is also populated with Land Use Designer styles.

### *Evaluation, Indicators*

The Land Use Designer can automatically create summary indicators "Common Impacts" for all the land use attributes associated with the Land Use Models (e.g., Total School Children, Total Waste Water Generated, Residential, and Commercial Taxes). The user checks off which indicator they would like to track and CommunityViz creates both the indicator and a chart for that indicator. Alternately, indicators can be created "from scratch" using the tool's indicator, formula, and charting components.

### *Documentation*

- Placeways (2013)

# E.2 ENVISION TOMORROW PLUS

### *Conceptual Approach*

Place types in Envision Tomorrow Plus (ET+) are created with two Excel spreadsheets: The Prototype Builder and the Scenario Builder.

The Prototype Builder serves as the template for creating a library of building types to be used in the scenario planning process. It can also be used as standalone tool for evaluating the financial feasibility current or proposed zoning. Users build prototype buildings by inputting various physical and fiscal properties of each building from zoning or building regulations. The number of buildings within a project's Prototype Library can range from only a few generic building types to 40 to 50 very specific building types.

In the Scenario Builder, building prototypes are used to create Development Types that are used by Envision Tomorrow as the basis for its scenario development. They describe the different types of land uses that exist, or are planned for the future, within the planning area. Each Development Type is comprised of a mix of different types of buildings along with development character assumptions such as the amount of land devoted to streets, parks, and civic areas. The Development Types represent the places people are familiar with, such as main streets, town centers, and residential neighborhoods and serve as a basic unit for "painting" scenarios.

The advantage of using spreadsheets to create buildings prototypes and development types is that most planners already are familiar with Excel spreadsheets and all the assumptions algorithms to create Place Types are fully exposed. The Prototype and Scenario spreadsheets are linked, so that a change in any building will propagate to the Development Type.

### *Scenario Creation*

"Painting" scenarios happens in the ArcGIS interface, or through an on-line tool still in development. The user simply selects the Development Type from a palette and "paints" the parcels, grids, traffic analysis zone (TAZ), or whatever unit of analysis they are using with the new Development Type. This can be done in-house or during a community workshop. The feature takes on all the associated attributes of the Development Type and impacts are calculated accordingly.

### *Software Requirements and Platform Specifics*

Functionally, ET+ exists in two modules: an extension to ArcGIS, and a series of linked Microsoft Excel spreadsheets. As part of its transition from Envision Tomorrow to Envision Tomorrow Plus, the software was made open-source, however, while the platform currently is free to download, the underlying source code has not yet been made available via popular channels such as GitHub. Also, while ET+ itself may be open-source, it depends on two proprietary platforms: ESRI ArcGIS and Microsoft Office, both of which require their own paid licenses to function. Thus, although ET+ is technically Free Open-Source Software (FOSS), there is a significant cost associated with the platform because pieces of the software "stack" are expensive. Reliance on ESRI products also means that ET+ is not platform independent, and can only be run on the Windows operating system (at least until the web-based version is released).

### *Data Requirements*

There are two core sets of data required to operate ET+, which are added to the software as shapefiles or geodatabase feature classes. The first set of data focuses on land use characteristics and requires the user to define a level of spatial precision. In other words, users must first choose the set of polygons onto which scenarios will be painted. For small areas, these polygons may be parcels or small grid cells; for larger applications they may be census tracts or TAZs; for still other applications, users may opt for hybrid geographies that permit parcel painting at certain extents, and TAZ painting at others. Additional data in this category include constraint layers, such as floodplains, wetlands, or transit lines. Finally, an existing land use layer is used to help define the baseline scenario and codify existing Place Types.

The second category of required data focuses on transportation characteristics and is used to drive the MXD model built into ET+. The MXD model uses so-called "D variables" as inputs for modeling household travel outcomes, including vehicle trips, walk trips, bike trips, transit trips, and VMT. "D variables" used by ET+ include:

- Demographics of households (size, workers, and income);
- Density (population and jobs within one-quarter and one-half mile);
- Diversity (land use entropy within one-quarter and one-half mile);
- Design (intersection and four-way intersection density within one-quarter and one-half mile);
- Destination accessibility (percent of regional employment within 10, 20, and 30 minutes by auto and 30 minutes by transit); and
- Distance to transit (transit stop density and presence of rail station within one-quarter and one-half mile).

With the release of EPA's Smart Location Database, many of these variables have been computed for major metropolitan areas, providing a standardized and authoritative data source that can be used across the nation. Alternatively, the variables can be computed manually using local datasets or other national data such as the Census Bureau's American Community Survey, Longitudinal Employment Household Dynamics, or regional travel models.

### *Documentation*

- Fregonese Associates (2012)
- Ewing, R. (2012)
- Kim, K. (2013)

# E.3 I-PLACE3S

## *Conceptual Approach*

Place Types in PLACE3S are user-defined. They are created and managed from the Place Type Manager, which lists all the Place Types within the project along with summary information for each Place Type:

- Dwelling units per acre;
- Employees per acre;
- Percentage of use in each general sector (residential, retail, office, industrial, public, other); and
- Floor area ratio.

Detailed assumptions include:

- Place type name;
- Affordable housing;
- Transit friendliness;
- Pedestrian friendliness;
- Default percent development;
- Image;
- Place type legend;
- Mixed use (yes/no);
- Percent of place type by six land use sectors:
  - Residential;
  - Retail;
  - Office;
  - Industrial;
  - Public; and
  - Other.
- Square footage by sector:
  - For residential, this is the average square footage per unit; and
  - For all other sectors, this is the average number of square feet per employee.
- Parking ratios per 1,000 square feet or per dwelling;
- Parking types distribution (number of levels);
- Landscaping/setback (percent);
- Square feet per parking space;
- Residential type;
- Average lot size;
- Maximum lot size;

- Number of bedrooms;
- Accessory units;
- Existing units accessory ratio; and
- New units accessory ratio.

Place Types can be generated from Existing Land Uses, a General Plan, or completely from desired attributes. Starting with Existing Land Uses is recommended, since Existing Land Uses have to be matched to a Place Type anyway during setup. The user also can create "Blended" Place Types mixing percentages of multiple Place Types.

### *Scenario Creation*

Scenarios are created out of Place Types assigned to parcel polygons. There are three ways to do this:

11. Interactively by selecting from a menu and clicking on the map. This is typically how the tool would be used to solicit community input during a workshop.
12. Interactive Query, where criteria values for multiple fields can be set, selecting all the parcels that meet the criteria and assigning a Place Type to all the parcels at once.
13. Uploading a shapefile.

### *Software Requirements and Platform Specifics*

Not available.

### *Data Requirements*

Not available.

### *Evaluation, Indicators*

When a Place Type is assigned, the assumptions that are associated with the Place Type are transferred to the parcels and summarized across the entire scenario into indicators.

### *Documentation*

- PLACE3S (2010)
- A useful overview, application examples and assessment of this tool is provided at http://www.urbansimUrbanSim.org/pub/Documentation/Classroom/WebHome/IPLACE3S.pdf.

# E.4 SPARC/INDEX

### *Conceptual Approach*

Place types are created in INDEX Online, which is an optional add-on to SPARC. SPARC stands for "Scenario Planning Analytical Resources Core," which is an open-source, cloud-based GIS data schema, warehouse, quality transformation, and tool interoperability service. SPARC is meant to address the issue of data interoperability across jurisdictions and allows multiple agencies to upload and efficiently use multiple data sets with a variety of sketch tools.

In INDEX, place types are created by populating a table with "paint" attributes, that is, attributes that describe a particular place type. Typical attributes are:

- Connectivity
  - Intersections/square mile
  - Bicycle route miles/square mile
  - Transit stops/square mile
- Single-family and multifamily residential
  - Units/net acre
  - Percent units occupied (households)
  - Persons/household
  - Energy per unit per year
  - Water per unit per day
- Nonresidential
  - Percent of land area nonresidential
  - Employees/net acre

typical place types might include regional centers, town/community centers, commercial activity centers, multifamily neighborhoods, compact neighborhoods, suburban neighborhoods, rural residential, and open space, to name a few. The user can create as many place types as they wish.

### *Scenario Creation*

Scenarios are created in INDEX Online by "painting" place types, which involves selecting the desired place type, then clicking on the feature intended to receive the place type. Any number of scenarios can be created.

### *Software Requirements and Platform Specifics*

SPARC/Index is both a data transformation engine and a scenario evaluation tool. It is a sever-based platform built with a fully open-source software stack that can be run Linux Ubuntu/CentOS servers with Apache 2.2 (although other Linux flavors may be possible as well). All calculations and heavy lifting are performed by the server, meaning that end users need only a JavaScript-enabled web browser to upload data and manipulate scenarios. There are two options for getting started with a SPARC/INDEX server: users, planning agencies or MPOs can choose to host their own instance of the platform using their own hardware and network infrastructure, in which case there is a one time fee to set up the database and application servers. Alternatively, users can opt for a cloud hosting option, in which case Criterion Planners manage the SPARC/INDEX servers, and users pay a monthly service cost. Despite its reliance on open protocols, the source code for SPARC/INDEX has not been made available via popular code hosting channels such as GitHub or Google Code, and it appears that users are not permitted (or at least, not intended) to deploy their own version of the platform, outside the guidance of Criterion.

### *Data Requirements*

The SPARC/INDEX platform includes a sophisticated data transformation engine that standardizes user data into a common schema. The database comes preloaded with several widely used national datasets, including Census, HUD, U.S. EPA, U.S. DOT, and OpenStreetMap. In addition, users can upload their own localized data for creating more detailed scenarios, which might include transportation networks, existing land use, planning boundaries, etc. The system is intended to be flexible; users can upload as much or as little additional data as they see fit, and because they system automatically performs error-checking and standardization, there are no specific requirements for particular layers or spatial resolution. Also, because its database is powered by the versatile and open-source PostGIS backend, it can accept spatial data in a variety of formats, such as ESRI, GeoJSON, or OpenLayers, and is not locked down to any particular one. As data are uploaded and standardized by the SPARC/INDEX platform, they are automatically added to the application's map server, and can then be used by any other platform that accepts standard web-mapping protocols, such as ArcGIS, UrbanFootprint or ET+. This openness helps set SPARC/INDEX apart from other platforms, in that it is designed specifically for interoperability with other scenario and sketch tools. Figure 5.1 shows the SPARC/INDEX dataflow.

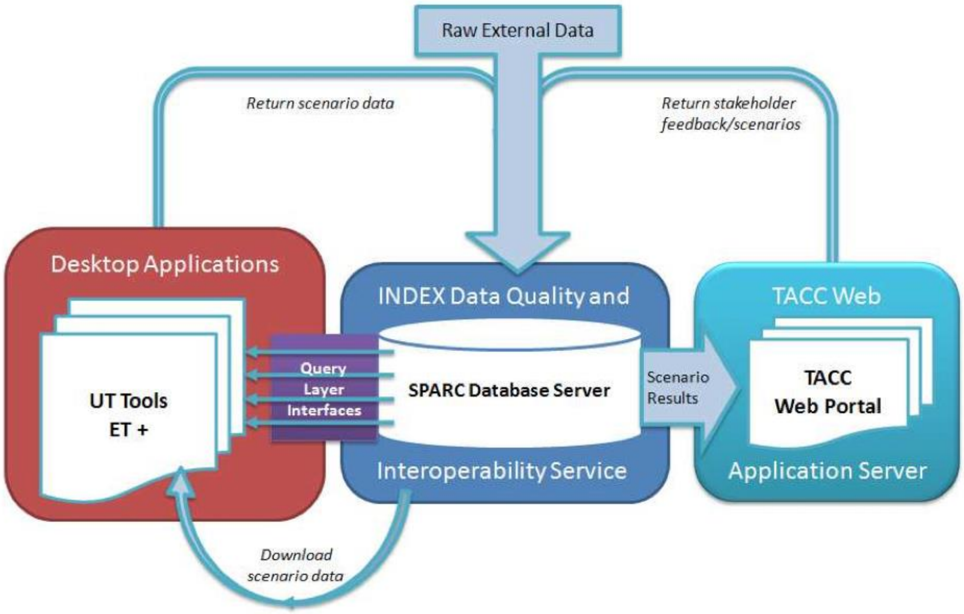
### *Evaluation, Indicators*

When Place Types are "painted" on to a geographic feature, all associated Place Type attributes are copied to that feature and impacts on land use, environment, transportation, etc., are calculated accordingly.

### *Documentation*

- Criterion Planners (no date)

**Figure E.1 SPARC/INDEX Dataflow**




Source: Criterion Planners.

# E.5 UPLAN

## *Conceptual Approach*

UPlan comes with seven default Land Use Categories (place types):

- Industrial;
- Commercial high;
- Residential high;
- Commercial low;
- Residential medium;
- Residential low; and
- Residential very low.

The user needs to match their general land use plan categories to UPlan categories. If different land use categories are desired the user has to set up and use a variant model schema. This is accomplished through the Data Loader interface. Because UPlan is an allocation model, the parameters for land use categories/place types are oriented towards spatial rules (e.g., average lot size, percentage of new jobs or housing allocated to each category, attraction, discouragement and exclusion buffers around certain features and weighted allocation based on these, and priority among categories).

### *Scenario Creation*

To change the scenarios, the user needs to change the General Plan layer that the run is based on. The user does not "sketch" directly into this tool, but is able to indirectly "sketch" by creating alternative General Land Use Plans, then loading them into the system. This is typically an in-house activity and not suited to a public workshop. The user can also toggle the spatial rules mentioned above and rerun scenarios. Depending on the run-time for a given scenario, this could be appropriate to a public workshop. Run-times vary between five minutes and two hours, depending on how large the study area is and how detailed the general plan and other model inputs are.

### *Software Requirements and Platform Specifics*

UPlan is an aging platform in terms of its programming architecture. Functionally, it is an extension to ESRI ArcGIS and requires an ArcInfo license to function, and can only run on the Windows operating system. It also requires the Spatial Analyst and Visual Basic extension licenses. Unlike other tools, UPlan was written in the Microsoft Visual Basic for Applications (VBA) programming language, and has not been ported to a more modern language. Although VBA was formerly the primary scripting language for ArcGIS, both Microsoft and ESRI have ended their support for the antiquated platform. Starting with version ArcGIS 10.0, VBA is no longer a default platform installation, as it has been replaced by the more versatile and ubiquitous Python. VBA is still available for use with newer systems via a separate installation, but it requires the additional licensing file that must be requested specifically from ESRI. Since UPlan depends on VBA, this additional burden is placed on each end-user before it is possible to run the software.

### *Data Requirements*

The UPlan allocation model translates land use plans (or scenarios) into a type of suitability surface in which the attributes of each grid cell are used to determine the supply of available land and under what order of priority each grid cell would be developed, pending demand. UPlan calls for a wide ranging set of data inputs to develop its attraction, discouragement, and exclusion grids, but the user is able to choose what and how many datasets to include. The only required inputs for the UPlan model to run, then, are GIS layers for the general land use plan, the slope/elevation, and the study area boundary (such as the county), as well as numerical inputs for base year and future year population, jobs, average household size, residential lot sizes, and average space per employee at different density categories the user specifies. The software helps users classify the layers into typologies that the allocation model can understand. All of the GIS datasets must be input as rasters. Possible inputs for development attraction or exclusion might include:

**Attraction**

- Freeway ramps;
- Highways;
- Major arterials;
- Minor arterials;
- Cities;
- Passenger rail stations;
- Airport; and
- Port.

**Exclusion**

- Land use plans;
- Rivers (a user-specified distance buffers the rivers before they are added to the Mask Grid. This precludes development from occurring too close to waterways);
- Lakes (buffered);
- Vernal pools (seasonal wetlands; buffered);
- Floodplains;
- Slope (steep slopes are used to mask out areas that are too steep to develop, and moderately steep slopes are used as a discouragement factor for areas that remain. The discouragement factor works by dividing the sum of the attraction grid weights by values >1, taken from a lookup table);
- Public lands;
- Existing urban (this grid is often constructed using satellite data. This layer can be corrected and updated with parcel data, where such data exist);
- Permanent open space; and
- Farmlands (the "exclusive agriculture" designation in a local land use plan).

## *Documentation*

- Johnston et al. (no date)

# E.6 URBANFOOTPRINT

## *Conceptual Approach*

UrbanFootprint has a library of more than 35 Place Types and 50 Building Types used to represent existing land use plans and build new scenarios. Place Types are composed of a mix of Building Types and represent the full range of development patterns that make up existing land use and future scenarios. These range from a variety of mixed-use centers to industrial, public, or residential neighborhoods of different types and densities. UrbanFootprint's Place and Building Types "are calibrated based on studies of exemplary places across California and the U.S., as well as detailed studies of a complete range of building types across California and the West." However, the unique sets of assumptions that go into each building and place type can be customized for any community.

Assumptions that go into buildings generally include building energy and water consumption, building-related greenhouse gas emissions, infrastructure cost/ burden (including operations and maintenance costs), and household costs and tax burden for utilities. In addition to the buildings that comprise them, assumptions related to places include density, location, transportation network, and demographic context.

UrbanFootprint includes tools to help translate any existing plan or scenario into the model's common language of Place and Building Types.

## *Scenario Creation*

Once an existing plan is translated into UrbanFootprint, various scenarios can be created by editing or "painting" new place types over the original Place Types.

## *Software Requirements and Platform Specifics*

UrbanFootprint is based on a fully open-source software stack that does not include any proprietary components. This means that it will in theory be possible for users to implement a fully operational instance of UrbanFootprint without the need to purchase a single software license. Although UF has created a GitHub repository where it will eventually be hosted, the existing source code for the software has not been uploaded or otherwise made public.

Unlike CommunityViz or the current version of ET+, UrbanFootprint is not a desktop-based platform, and relies instead on a server/client architecture that imposes some unique characteristics. On one hand, this means that UrbanFootprint has a simple user interface (UI) that is web-based, platform independent, and can be run in any modern web browser. This helps lower the learning curve for UF users, as they do not need to be familiar with existing GIS platforms such as ArcGIS. Additionally, because the models and analytical engines are hosted and executed on a server rather than the user's computer, there are minimal hardware requirements for end-users looking to create and evaluate scenarios. On the other hand, UrbanFootprint's server-based architecture means that MPOs or planning agencies must have a dedicated Linux server on which the platform will be deployed. This means that, depending on the scale of the deployment, planning agencies must have access to an appropriately powerful computer that can act as a server, and a sufficiently robust network infrastructure capable of processing multiple simultaneous data exchanges. These are not trivial requirements, but once the infrastructure is in place, additional users (e.g., planners or citizens) can contribute to scenario creation, needing only a URL to do so. UrbanFootprint's developer is also developing a cloud-based service to be offered on the SAAS model to agencies that do not wish to host on their own servers.

### *Data Requirements*

UrbanFootprint uses algorithms to standardize data into consistent 5.5-acre grid cells that are used to drive the baseline scenario. Any geographies (census tracts, blocks, parcels, custom size grid cells, etc.) can be used, but calculations in the background will still convert to raster grid cells to speed run-time performance. Data required to develop the baseline scenario includes land cover and environmental features data; parcel-based data on housing, employment, and population; Census population, housing, and jobs characteristics; control total data from MPOs or other agencies, generally at the TAZ resolution; and roadway and transit data.

Like ET+, UrbanFootprint relies on the MXD transportation model to compute trip generation rates from each grid cell. To do so, UrbanFootprint's analytical engines compute eight "D variables," from the user uploaded data, including:

- Demographics of households (size, workers, and income);
- Density (population and jobs within one-quarter and one-half mile);
- Diversity (land use entropy within one-quarter and one-half mile);
- Design (intersection and four-way intersection density within one-quarter and one-half mile);
- Destination accessibility (percent of regional employment within 10, 20, and 30 minutes by auto and 30 minutes by transit);
- Distance to transit (transit stop density and presence of rail station within one-quarter and one-half mile);
- Development scale (critical mass and magnitude of compatible use-specific metric(s) are not identified in the documentation); and
- Demand management, which is quantified separately from the land use variables, based on guidance published by the published by California Air Pollution Control Officers Association.

Note that unlike ET+, UrbanFootprint computes two additional D variables: Development scale and Demand management.

### *Documentation*

- Calthorpe Associates (2012).