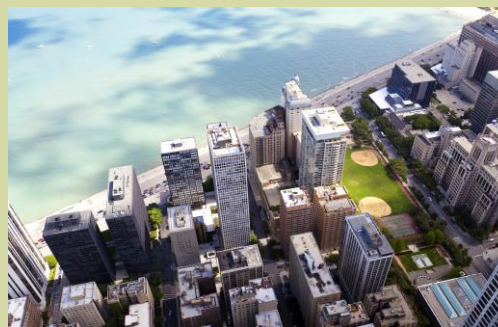
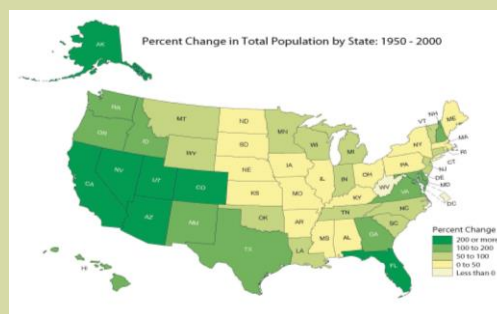


# Towards Scenarios of U.S. Demographic Change: Workshop Report



**July 2015**

Report of a workshop on June 23-24, 2014 organized under the auspices of the Scenarios and Interpretive Science Coordinating Group, U.S. Global Change Research Program, and sponsored by the U.S. Department of Energy and U.S. Environmental Protection Agency.

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## **Disclaimer**

The document was prepared by ICF International, an EPA contractor, as a general record of discussions during the workshop. The document captures the main points and highlights of the discussions and may include brief summaries of work group sessions. It is not a complete record of all details discussed, nor does it interpret or elaborate upon matters that were incomplete or unclear. Statements represent the individual views of the workshop participants and do not necessarily reflect the views of any U.S. federal agency.

## **Acknowledgements**

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## **About the Scenarios and Interpretive Science Coordinating Group**

The Scenarios and Interpretive Science Coordinating Group (SISCG) of the United States Global Change Research Program fosters interagency collaboration with the goal of building the foundations for a coordinated U.S. scenario science enterprise. This effort is motivated by shared agency information needs for quantitative and qualitative scenario-related products aligned around regions, sectors, systems, and topics over spatial and temporal scales of interest. The major objectives of the SISCG include:

- Advancing collaborative science around critical knowledge gaps;
- Enhancing methodologies for use-inspired scenario development, risk framing, and contextual interpretation;
- Developing the next generation of scenario work products for model intercomparison efforts, national and international assessment, and related analyses; and
- Improving interagency communications, coordination, and accessibility to knowledge, work products, and technical resources.

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## List of Acronyms

ACS – American Community Survey

CMIP – Coupled Model Inter-Comparison Project

DOD – Department of Defense

DOE – Department of Energy

EPA – Environmental Protection Agency

GCAM – Global Change Assessment Model

GEO – Global Environmental Outlook

HHS – Health and Human Services

ICLUS – Integrated Climate and Land Use Scenarios

IPCC – Intergovernmental Panel on Climate Change

MA – Millennium Ecosystem Assessment

MAPE – Mean Absolute Percent Error

NCA – National Climate Assessment

NGO – Non-Governmental Organization

RCPs – Representative Concentration Pathways

SISCG – Scenarios and Interpretive Science Coordinating Group

SSPs – Shared Socioeconomic Pathways

SRES – Special Report on Emissions Scenarios

UNEP – United Nations Environment Program

USGCRP – United States Global Change Research Program

USGS – United States Geological Survey

USFS – United States Forest Service

## Executive Summary

The Scenarios and Interpretive Science Coordinating Group (SISCG) is an interagency coordinating group, supporting the U.S. Global Change Research Program (USGCRP). The SISCG convened the *Towards Scenarios of U.S. Demographic Change Workshop* in Rockville, Maryland on June 23 and 24, 2014 to assess key factors in the development of long-term population and demographic scenarios for use in interdisciplinary social and environmental applications, with a strong focus on climate change. The workshop brought together 52 experts from federal and state agencies, non-governmental organizations (NGOs), and research institutions with backgrounds in climate change scenarios, environmental change, demographics, and human health. Over the course of two days, participants explored the needs of the user communities and the capabilities of the modeling community to meet these needs, and identified next steps. This workshop report synthesizes the presentations and discussions held during the workshop (as well as background materials and webinars held in advance of the workshop). The sections below briefly summarize the report, paralleling its organization.

### **Text Box ES-1. IPCC Definitions of Future Characterizations**

Some key terms from the IPCC typology are defined below. More information is available from the IPCC reports.

*Scenario* is a coherent, internally consistent, and plausible description of a possible future state of the world, which may be quantitative, qualitative, or both. The components of a scenario are often linked by an overarching logic, for example a *storyline* that represents a qualitative, internally consistent narrative of how the future may evolve.

*Storylines* describe the principal trends in key drivers and relationships among these drivers. Storylines may be stand-alone, but more often underpin quantitative projections.

*Projection* is any description of the future and the pathway leading to it. In the climate world, projections are often model-derived estimates of future conditions for an element (such as population) of an integrated system. Projections are generally less comprehensive than scenarios. Projections may be probabilistic, while probabilities are not ascribed to scenarios.

*Probabilistic futures* are futures with ascribed probabilities. Conditional probabilistic futures are subject to specific underlying assumptions. Assigned probabilities may be imprecise or qualitative, as well as quantitative.

A *prediction or forecast* is a statement that something will happen in the future, based on what is known today, and on the initial conditions that exist. An important part of a prediction is our degree of belief that it will come true.

Sources: Carter et al., 2007; Solomon et al., 2007; Weaver et al., 2013.

Although often used interchangeably to refer generically to a future characterization, the terms “prediction,” “forecast,” “projection,” and “scenario” have different meanings, particularly for the community involved in climate research (see Text Box ES-1). Moreover, different users may have needs for different types of futures. For example, some users may rely on probabilistic predictions that seek to answer a question of the type of “What will happen in the future?” while others may rely on projections that are more in the nature of “what if” statements, and still others may use scenarios identifying plausible descriptions of future states of the world. Some workshop participants, particularly state and local government researchers, were more familiar with the concepts of prediction or projection, while climate researchers viewed the scenario approach as being more applicable, in part due to the long-term nature of (i.e., 100+ years) of climate change. As discussed below and in the workshop report, over the course of the workshop, commonalities and differences among the approaches and viewpoints were discussed and assessed.

### **Meeting User Needs for Population Projections**

Federal, state, and local agencies and the private sector use population projections to inform a variety of regulatory and programmatic decisions and project design, for budget planning, and to support the development of public policy. For example, population projections may be used to develop estimates of school enrollment or to support annual appropriations within a state. The population series provided by the U.S. Census Bureau are key building blocks for projections of demographic and socioeconomic variables used by federal and state agencies, such as the Old Age Survivors and Disability Insurance (OASDI) program (also known as Social Security), as well as other types of projections, such as the projected demand and use of natural resources developed by the U.S. Forest Service. In addition, climate change researchers inside and outside the government are consumers of population projections; the community conducting impacts, adaptation, and vulnerability (IAV) assessments use long-term demographic changes, which can be challenging to develop at the time scale and granularity needed to support assessment.

The diversity of user communities generates a demand for population projections that span a range of spatial, temporal, and demographic criteria. Different uses will require different demographic details or groups, different time spans for the projection, and different geographic coverage, as well as different levels of resolution and detail (ranging, for example, from national projections all the way down to municipalities or U.S. Census tracts). Some users may need both detailed and aggregate data, and so the capabilities of the user group to further refine or adapt the population projection may also determine data needs.

Conventional population projections focus on demographic variables such as age, sex, and race, and methods for projecting these variables are well understood and commonly applied. For some purposes (e.g., determining environmental vulnerability or projecting health outcomes), demographic projections that include socioeconomic variables—such as income or education—may be needed. These variables can be more difficult to project because they rely on behavioral



factors and future policy decisions. Migration can also be difficult to project, increasing the uncertainty of projections made at small geographic scales. Thus, the uncertainty of a projection will depend on spatial resolution, time horizon, demographic characteristics, and socioeconomic variables. Discussions at the workshop stressed the tradeoffs between different characteristics of projections. Discussions also emphasized that more interaction between users and producers of demographic projections is needed so that they can arrive at a common understanding of the uncertainties and limitations associated with projections of particular characteristics and time/space scales.

### **Capabilities for Developing U.S. Population Scenarios**

Plausible futures can take different forms, and may require particular characteristics in order to meet user needs. Projection is a relatively broad term, representing a description of the future that is conditional on both current conditions and on how future conditions unfold. A projection can be probabilistic or deterministic (without ascribed probability). A prediction, in contrast, is based on what is known today and on the initial conditions, assuming that the future outcome will not be greatly influenced by unpredictable or uncertain future conditions. Climate change researchers also frequently make use of scenarios, which are coherent descriptions of a possible future state of the world in quantitative or qualitative terms. Unlike projections, scenarios do not have ascribed probability.

One of the issues prominent during discussions was the difference between projections and scenarios, and the type of approach that can best serve different user communities. Participants from the climate change community generally prefer a scenario approach because it reflects the greater uncertainty about the future over the very long term and highlights the importance of assumptions about key variables, including climate policies, economic growth, technological change, and migration patterns. However, federal and state agencies may prefer a single projection series on which to base policy and programmatic decisions.

In practical applications of projections to policy issues, the divergence between a scenario approach and a projection approach is not always as great as the above discussion might imply. Planners and other public officials may use scenario building or scenario-based planning. Some users also employ “visioning” to develop different futures on which the projections are based, or to bracket possible futures to reflect uncertainty in key drivers. While discussions and presentations at the workshop clarified the differences and similarities in these approaches, many of the demographers at the meeting expressed significant reservations about making long-term demographic projections, especially for small areas. It will be particularly important to provide context and guidance for such projections.

A range of global scenarios is available for use in climate change research, including the Special Report on Emissions Scenarios (SRES), the Shared Socioeconomic Pathways (SSPs), the Representative Concentration Pathways (RCPs), and scenarios developed for the Millennium Ecosystem Assessment. The workshop explored issues in developing national scenarios and

population projections that are consistent with global scenarios. Discussion included how consistency might be defined, and how to develop national scenarios that reflect national conditions without being overly constrained by global scenarios.

Presentations at the workshop addressed the types of methods that are available to project population at the national and subnational levels, and the strengths and weaknesses of alternative methods. Methods that were discussed included cohort-component methods, proportional scaling, trend extrapolation, and modeling approaches, such as microsimulation. Participants pointed out that different methods (or combinations of methods) may be appropriate depending on the scale of the projection, the demographic and socioeconomic variables to be projected, and available resources and data. Participants also pointed out differences between top-down methods where national or state level projections are distributed to smaller scales and bottom-up methods that aggregate projections made at local levels. While methodological improvements can be made, confidence in projection methods and data generally decreases with smaller geographies and increased demographic detail.

### **Key Insights from Workshop Discussions**

Key insights from the workshop included the following:

- Developing population projections that have a high level of spatial resolution and include socioeconomic characteristics of the population is difficult and sometimes infeasible. Projecting over a long time horizon increases uncertainty.
- Sub-county population projections are needed for climate impacts research and adaptation planning.
- For integrated climate change scenarios, demographic projections are not predictions of the future; however, they should be well-grounded characterizations of plausible future outcomes.
- Maintaining and improving demographic data is essential to producing high-quality population projections for use in global change scenarios.
- Methods for producing national-level, spatially explicit population projections are at relatively early phases of development; efforts to compare methods and model simulations would facilitate further development of methods as well as help define the research agenda.
- Developing plausible alternative futures for migration, particularly internal migration, would provide the most added value to a U.S. population scenarios effort.
- It would be useful for U.S. population scenarios to be consistent with global scenarios; however consistency should not overly constrain the development of U.S. scenarios.

### **Next Steps: Moving Forward with U.S. Demographic Change Scenarios**

U.S. population scenarios would improve the ability of USGCRP to inform ongoing climate impacts research, Integrated Assessment and Impacts, Adaptation, and Vulnerability models, the

National Climate Assessment, and decision making at all levels of government and in the private sector. Such scenarios could also form the basis of quantitative projections using demographic and other modeling techniques.

Workshop participants offered many suggestions for moving a USGCRP scenario enterprise forward. These largely fell in three main categories:

**Adopt measures to improve data coordination and integration.** Recommendations in this area went beyond inventorying and evaluating existing datasets to determine their utility for population scenarios. Several participants noted the need to develop coordinated information networks around demographic and non-demographic factors. For example, collecting demographic and non-demographic data contemporaneously would facilitate pooling data efficiently. Standardized metadata protocols and consistent geospatial data formats would facilitate integration and research on important relationships. Educating users of demographic scenarios about their limitations as well as the need to reach outside of traditional USGCRP communities (e.g., the U.S. Census) were also recommended.

**Conduct research and develop methods.** Workshop participants identified a number of research activities that would advance our understanding and ability to project human populations. These included a Model Inter-comparison Project (MIP) to compare national-scale spatially explicit projection methods, a "bake off" between alternative approaches to allocate populations at sub-county levels, and basic research to discover generalizable relationships between non-demographic variables and how they influence population size/composition/distribution over time. Improving methods to understand U.S. migration dynamics was highlighted by participants as key to reducing uncertainty in spatially explicit population projections. Exploring hierarchical approaches for developing projections with scale-appropriate population characteristics and investigating the utility of new data sources such as social media, "big data," and remote sensing data were additional suggestions by workshop participants. More specifically related to climate change, participants recommended exploring how climate change impacts, especially disruptive events, can be incorporated into demographic scenarios and projections.

**Develop U.S. population scenarios.** Workshop recommendations included an evaluation of IPCC's Representative Concentration Pathways and Shared Socioeconomic Pathways, including comparisons with previous global scenario efforts to identify similarities and points of divergence at national, regional, state, and county levels. A pilot project focused on U.S. scenarios feeding into the next National Climate Assessment was also highlighted. More specifically scenarios of migration between U.S. regions and among states could be used to explore situations of particular interest to regional stakeholders. Scenarios of urban development patterns, such as urban infill, dispersion to exurban and rural areas and consolidation of suburban centers could serve a similar purpose for local and community planners. In efforts to develop

U.S. population scenarios, workshop participants noted it would be important to engage demographers in developing national, spatially explicit population scenarios. Equally important would be to work with end users/local governments to ensure such scenarios can be merged with participatory, bottom-up scenarios that can incorporate detailed, localized data (e.g., zoning changes, housing development, and tax rates/assessments).

## **I. Workshop Process**

### **Scenarios and Interpretive Science Coordinating Group**

The U.S. Global Change Research Program's (USGCRP) mission is "to build a knowledge base that informs human responses to climate and global change through coordinated and integrated federal programs of research, education, communication, and decision support" (USGCRP, 2014a). Within USGCRP, the goal of the Scenarios and Interpretive Science Coordinating Group (SISCG) is to build a foundation for a science-based scenario enterprise that responds to shared-agency needs for quantitative and qualitative scenarios-related products. In particular, the SISCG aims to:

- Advance collaborative science on critical gaps.
- Enhance methodologies for use-inspired scenario development, risk framing, and contextual interpretation.
- Develop the next generation scenario work products for model inter-comparisons, assessments, and analyses, including coordinated uses such as for the National Climate Assessment (NCA), Intergovernmental Panel on Climate Change (IPCC), and the Coupled Model Inter-comparison Project (CMIP).
- Improve interagency communications, coordination, and accessibility to knowledge, work products, and technical resources (USGCRP, 2014b).

As part of its ongoing efforts, the SISCG is conducting a series of workshops to elicit expert opinion on the state of the science and for further defining long-term needs for the science. In the near term, one of the SISCG's top priorities is to better understand the human dimensions of climate and global change scenarios. To this end, the SISCG organized workshops focusing on land use and land cover change, U.S. demographic change, and is in the process of organizing an additional workshop on regional economics.

### **Background on the U.S. Demographic Change Workshop**

The SISCG convened the *Towards Scenarios of U.S. Demographic Change Workshop* in Rockville, Maryland on June 23 and 24, 2014. The workshop was coordinated and supported by member agencies, including U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Defense (DOD), U.S. Department of Agriculture Forest Service (USFS), and U.S. Geological Survey (USGS).

Acknowledging the need for a coordinated, multi-disciplinary effort across the fields of climate change and demographics, the SISCG planned the workshop in consultation with researchers and decision makers from these fields. The goal of this workshop was to assess key factors in the

production of long-term population and demographics scenarios for use in interdisciplinary social and environmental applications—with a strong focus on climate change.

The objectives for the Towards Scenarios of U.S. Demographic Change Workshop included:

- Expanding the participants’ knowledge of key user needs for population scenarios;
- Exploring new and existing methodologies and data for population characteristics and geographic scales (including the data limitations); and
- Examining the pros and cons of linking U.S. scenarios to global scenarios (USGCRP, 2014c).

To accomplish these objectives, the workshop brought together 52 experts with backgrounds in climate change scenarios, environmental change, demographics, and human health. These experts from state and federal agencies, non-governmental organizations (NGOs), and research institutions, gathered to discuss the current state of the science and clarify both short-term and long-term goals. (Appendix C: List of Participants contains the full list of workshop participants.) In addition to the workshop events on June 23 and 24, 2014, background information was distributed to workshop participants in advance of the workshop, and two webinars conducted prior to the workshop provided information on U.S. socioeconomic scenarios and land change modeling.<sup>1</sup> This information was available to all workshop participants, and is reflected in this synthesis report.

In the workshop, participants sought to identify:

- **End Uses.** Characterizing end uses for population/migration scenarios, and narrowing the set to high-priority end uses that could inform both discussions at the workshop and post-workshop activities.
- **Drivers.** Identifying key natural, physical, socioeconomic, and policy variables affecting population/migration change.
- **Capacity.** Inventorying existing data, modeling, and methodological capabilities that can be leveraged and serve as foundational resources.
- **Gaps.** Identifying key gaps in data, modeling, and analytical capacity related to population/migration to inform future research needs.
- **Observational Intersects.** Exploring the unique contributions and intersections of both observationally-based and modeling-based methods for evaluating population/migration and projecting future change.
- **Opportunities for Scenario Building.** Constructing preliminary population/migration scenarios to gain insights into framing, contextual variations, methodological approaches, and paths forward for developing U.S. population/demographics-focused scenarios.

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<sup>1</sup> Background papers and recordings of the webinars held in advance of the workshop are available on USGCRP’s website for the workshop: <http://www.globalchange.gov/scenarios-workshop>.

- **Community Building.** Creating the foundations for a community of practice and sustained efforts in the science, methodologies, tools, and applications of population/migration scenarios.

Although the workshop was convened to share information so that USGCRP could continue to develop more robust scenario work products, it is important to note that USGCRP did not intend that workshop participants reach consensus in order for the workshop to be considered successful, but rather emphasized the importance of individual contributions and viewpoints.

## **2. Workshop Agenda and the Workshop Report Format**

### **Details of the Workshop Agenda**

The SISCG organized the *Towards Scenarios of U.S. Demographic Change Workshop* with support from various member agencies. A more detailed overview of the workshop agenda, speakers, and organizers is presented in Appendix B. The workshop took place over two days and included general presentations to the entire audience as well as smaller breakout sessions.

The first day of the workshop began with plenary discussions on the background, history, and mission of the USGCRP; the goals for the workshop; and brief introductions on the topics of climate change scenarios and population projections. The majority of first day of this workshop explored the range of potential user needs for climate and demographics scenarios. The discussion centered on determining which characteristics of population, spatial/temporal scales, and types of scenarios are most important to users, and for what purposes. The first day's breakout sessions expanded on the initial objective of determining user needs and then evaluating the feasibility of implementing more discrete data within population projections. The smaller group sizes facilitated discussions that could include a wider spectrum of input on user needs from the workshop attendees.

The second day of the workshop began by contextualizing the user needs explored on the first day by evaluating the data and methodology used to model demographics. The discussion included projections for states and smaller regions of the United States; spatial projections of housing units with the Integrated Climate and Land Use Scenarios (ICLUS) model; and data challenges with spatial population projections. Next, three breakout groups engaged on different areas of interest: consistency across scale; urban community considerations; and rural community considerations. The expert groups considered topics such as the feasibility of projections at sub-national scales, key challenges to addressing user needs, and identifying which types of projections could meet those needs in the near future.

The general presentations in the afternoon shifted the workshop's focus to global scenarios and their relevance to U.S. scenarios. Drawing upon the previous discussions, this session aimed to place U.S. scenarios within a global context by considering the tradeoffs associated with linking

U.S. scenarios to global ones, as well as the role of socioeconomic factors on demographic projections. Breakout groups in the afternoon discussed non-demographic factors within the context of demographic scenarios, as well as the importance of aligning U.S. population scenarios with global scenarios, and vice versa.

The workshop closed with a synthesis of participant suggestions. USGCRP did not intend that workshop participants reach consensus in order for the workshop to be considered successful, but rather emphasized the importance of individual contributions and viewpoints in identifying needs and potential paths forward for the science of climate change scenarios and demographics projections.

### **Structure of the Workshop Report**

The remainder of this report is divided into four sections:

- **Section 3: Meeting User Needs for Population Projections.** This section covers the uses of population projections, user needs for projections, and projection methods for meeting these needs.
- **Section 4: Capabilities for Developing U.S. Population Scenarios.** This section reports on discussions during the workshop as participants considered capabilities for developing U.S. population scenarios, including defining and integrating different approaches, the global context for U.S. scenarios, and current capabilities to meet user needs.
- **Section 5: Key Insights from Workshop Discussions.** This section describes discussions among workshop participants regarding key issues in building scenarios of U.S. demographic change.
- **Section 6: Next Steps: Moving Forward with U.S. Demographic Change Scenarios.** This section concludes with a discussion of next steps on how to move ahead with building U.S. demographic change scenarios for use in interdisciplinary analysis of social and environmental issues.

These sections are followed by references cited and four appendices that provide additional information from the workshop.

## **3. Meeting User Needs for Population Projections**

Federal government agencies, local decision makers, researchers, and private interests use population projections to inform a range of regulatory and programmatic decisions that rely on projecting population and related variables into the future. The workshop was attended by representatives of a number of different user communities. It provided unique perspectives on the needs for population projections and methods available for meeting those needs and engendered a lively conversation on how researchers from different communities value and approach questions of uncertainty. Understanding the context in which population projections are used and the characteristics that are particularly useful for users will be important in determining how



demographic scenarios and projections can be formulated to meet those needs efficiently. This section explores the issue of meeting needs from three perspectives: the role of population projections in supporting decision makers in different user communities, potential user needs for population projections, and methodologies that can be used to develop population projections that are tailored toward user needs.

## **User Communities**

Many federal and state agencies rely on population projections to identify trends in variables and factors of interest to their missions, and as inputs into analyses designed to support the development of public policies. In addition, researchers in a variety of disciplines use population projections for both their own research and to support the development of government policy. To better understand the range of uses, the workshop included presentations and participants from federal and state government agencies and researchers from different fields. In addition, an informal review of federal agency practices with respect to projections was conducted in advance of the workshop. Collectively, the information presented and discussed at the workshop suggests both considerable breadth in the user community and variety in the uses to which population projections are put in analysis and policy development.

The Census Bureau of the Department of Commerce is a widely-used source of national population projections, which embody assumptions and projections about how the U.S. population will age over time (as far out as 2060) and change in terms of sex, race, and Hispanic origin. Population data from the U.S. Census contribute directly and indirectly to the various formulae used to distribute federal funds (Blumerman and Vidal, 2009) and are integral to projecting future funding needs and programmatic costs. Numerous agencies, including NOAA, Bureau of Land Management (BLM), EPA, Department of Transportation (DOT), Department of Agriculture (USDA), Housing and Urban Development (HUD), Social Security Administration (SSA), and Health and Human Services (HHS), use U.S. Census projections to forecast how key drivers and variables will change in the future. In some cases, U.S. Census projections are used directly, and in others, the data provide the building blocks of more detailed projections created and used by other agencies. For example, population projections play a role in the production of DOE's Annual Energy Outlook (AEO),<sup>2</sup> which includes variables such as vehicle miles traveled and freight demand, and in turn help drive estimates of energy use and carbon emissions. EPA uses population projections for a variety of purposes, including estimating population exposure to different pollutants or the incidence of a disease- or health-related event. At the Office of the Chief Actuary at the Social Security Administration, U.S. Census data are used in conjunction with data on mortality rates from the National Center for Health Statistics (NCHS) and the Medicare program and data on immigration to characterize the future solvency of the Old Age Survivors and Disability Insurance (OASDI) program (OASDI, 2014). U.S. Census data, along

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<sup>2</sup> Current and past editions of the AEO are available at: [www.eia.gov/forecasts/aeo/](http://www.eia.gov/forecasts/aeo/).

with other population projections and trend data, contribute to USDA/USFS projections of trends in natural resource demand and use.

In some cases federal agencies may use population projections that span a range of probable outcomes. The 2012 National Projections from the U.S. Census, for example, include a main series and three alternative series, reflecting differing assumptions about net international migration. No alternative series are currently on the Census website for the 2014 projections.

Climate change researchers inside and outside the government are another set of consumers of population projections. As described by one presenter, the community conducting impact, adaptation, and vulnerability assessments, makes assumptions about long term demographic changes in estimating vulnerabilities and impacts (see Text Box 3-1. Demographic Projections in Climate Change IAV Research). Developing population projections is particularly challenging because of the long time frame of these analyses, and a common approach is to develop scenarios that depict plausible future states of the world, in order to capture the unpredictability of the future (these issues are discussed more in Section 4 of this report).

Like federal agencies, state and local governments and regional planners use population projections to support policy and programmatic functions, project design, and budget planning. For example, population projections may be used to develop estimates of school enrollment or to support annual appropriations within a state. State and local governments generally rely on the efforts of state

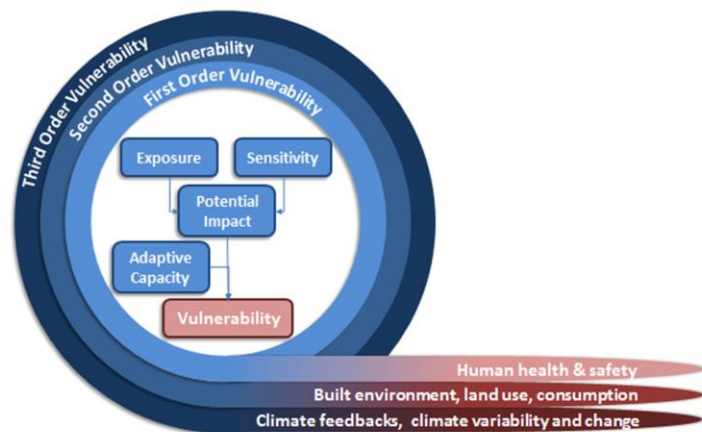
demographers, who in some cases build estimates based on older U.S. Census projections (since the U.S. Census Bureau has not updated its state-level projections since 2005). Also, like

### Text Box 3-1. Demographic Projections in Climate Change IAV Research

One presenter stressed that demography is critical to understanding vulnerability to climate change impacts, but indicated that the IAV community has a distance to go in accounting for demographic change in its research. The presenter included the figure below, which illustrates how demography is a key driver of all types of climate change vulnerabilities:

- Age and sex are key factors influencing human health and vulnerability to extreme events (first order);
- The location of development and the capacity to absorb economic losses shape the vulnerability of the built environment (second order); and
- The growth of urbanized areas drives climate feedbacks (third order).

IAV research is improved by accounting for the influence of demographic change on each of the classes of vulnerability.



Source: Preston, 2014.

national-level uses, businesses may use the projections to estimate future market shares and to plan for demographic changes in the population. According to the U.S. Census, nearly all of the states report producing population projections.<sup>3</sup> One presenter indicated that the resolution available in state projections generally reaches to the county level (although only rarely to the city or municipal level), noting that some detail (on age, sex, or ethnicity) may be lost as the focus narrows. Both the level of detail and the specificity in state projections is variable; some states (such as Connecticut) make use of locally derived data (such as local fertility rates), whereas other states (such as Michigan and Idaho) rely primarily on the last available state-level projections from the U.S. Census Bureau.

### **Data Needs for Population Projections**

The diversity of user communities generates a demand for population projections that span a range of spatial, temporal, and demographic criteria. Different uses will require different demographic details or groups, different time spans for the projection, and different geographic coverage, as well as different levels of resolution and detail (ranging, for example, from national projections all the way down to municipalities or U.S. Census tracts). Some users may need both detailed and aggregate data, and so the capabilities of the user group to further refine or adapt the population projection may also determine data needs. Moreover, different user groups may need projections that represent different types of futures, (e.g., business as usual, most or least probable, or best or worst case) depending on the purposes of the projection and the analysis or policy decisions it is intended to support. Different user groups may also have a need for different levels of accuracy and precision in the projection, depending, for example, on the irreversibility of decisions that are being made, or the magnitude of the investments or other costs involved.

Conventional population projections focus on demographic variables such as age, sex, and race, and methods for projecting these variables are well-understood and commonly applied. For some purposes (such as determining environmental vulnerability or projecting health outcomes), demographic projections that include socioeconomic variables—such as income or education—may be needed (see Text Box 3-2. Specialized User Needs: Public Health). These variables can be more difficult to project because they rely on behavioral factors and future policy decisions. Migration can also be difficult to project, increasing the uncertainty of projections made at small

#### **Text Box 3-2. Specialized User Needs: Public Health**

User needs may be more detailed within specialized user communities, such as public health researchers. Health impacts depend on vulnerability, which can differ greatly by age, sex, race/ethnicity, and socioeconomic factors. In the third presentation of the workshop, John Balbus of the U.S. Department of Health and Human Services noted that the health community wants whatever richness of data they can get. However, he noted that the field needs to make more investments in how best to generate and use detailed projections.

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<sup>3</sup> According to the U.S. Census website, all states but Vermont report projections. Available at: <http://www.census.gov/population/projections/data/state/st-prod-proj-list.html>.

geographic scales. Thus, the uncertainty of a projection will depend on the spatial resolution, time horizon, and demographics being projected.

Discussions at the workshop stressed the tradeoffs between different characteristics of projections, as well as the directions in which needs are evolving as human systems evolve, for example, as “the urban form” changes (see Text Box 3-3. Changes in the Urban Form). Discussions also stressed that more interaction between users and producers of demographic projections is needed so that they can arrive at a common understanding of the uncertainties and limitations associated with projections of particular characteristics and time/space scales.

Three key characteristics of population projections are explored below: population characteristics, geographic scale, and time horizons.

### ***Population Characteristics***

The standard suite of variables that demographers project includes age, sex, and in some cases race/ethnicity. For many purposes, one of these variables is sufficient. For example, projections by age will allow planners to examine the future needs of different segments of the population, such as children (at different educational levels), women in their reproductive years, persons in the labor force, or the elderly. Projections by age are also essential for cost estimates and projections related to the OASDI and Medicare programs. Projections by age, sex, and race are important in health research, since dose-response—the statistical relationship between measures of exposure and measures of disease—may vary by age, sex, and race.

User needs for population characteristics range from simple overall projections to projections with considerable demographic and socioeconomic details. Workshop participants identified a variety of population characteristics that go beyond the standard suite of variables, but which could be critical to some analyses and planning efforts. Participants identified variables such as educational achievement (see Text Box 3-4. Challenges and Tradeoffs in Meeting User Needs: Education), urban/rural classifications (see Text Box 3-5. Urban vs. Rural), health status, and income were among those identified. In some cases, the need for population projections can become quite

#### **Text Box 3-3. Changes in the Urban Form**

While the U.S. population is becoming older and more urban, participants also noted that our urban form is changing. It was suggested that there is a need to marry demography with GIS analysis. As demographers develop a better understanding of urban form, demography can be applied in other uses—such as land use and transportation—more effectively.

#### **Text Box 3-4. Challenges and Tradeoffs in Meeting User Needs: Education**

Some participants indicated a strong need for projections of educational attainment, and recent work has shown the importance of education in many analyses, including studies of vulnerability to natural disasters (Butz et al., 2014). However, other participants emphasized the tradeoff between the population characteristics being projected and the geographic scale of the projection; due to data limitations and the increasingly important role of migration, small scale projections cannot reliably include as many population characteristics as larger-scale projections can.

complicated, necessitating more sophisticated methods. For example, analyses involving construction demand, property taxes, or emergency evacuation planning may require data and projections for households rather than simply numbers of people, including information on permanent vs. seasonal residences, households by living arrangement (married, children, single, elderly), and types of housing units. Alternatively, assessing vulnerability to coastal flooding requires understanding and projecting patterns of land use, including transportation modes and usage and trends in urbanization. Even for a given variable, categories of interest may vary significantly from one use to another. For example, one project may rely on total population and housing units for municipalities with particular characteristics (e.g., small vs. large), while another may rely on information on population and housing density on a neighborhood scale.

**Text Box 3-5. Urban vs. Rural**

Some participants noted that it is important to treat urban and rural areas differently, as the processes of change can vary greatly between urban and rural areas. Others felt it was more important to think about an urban/rural continuum, and not separate them.

As projections expand beyond conventional demographic variables to socioeconomic variables, the pathways are less well understood and, consequently, demographers may consider projections to be more uncertain. For some socioeconomic characteristics, it can be extremely difficult to obtain detailed data both at fine scales and for the nation as a whole, further challenging demographers' abilities to meet user needs for data. While users expressed a need for sophisticated and detailed projections, some demographers at the workshop pushed back strongly, questioning whether variables such as education can be reliably projected at the local level. While certain uses may benefit from more detailed population characteristics and more granular availability of data, participants agreed that there is a tradeoff between detail and uncertainty, especially with regard to socioeconomic characteristics such as education, health status, and income. Some participants even questioned why there would be a need for anything more detailed than age, sex, and race, given the inherent uncertainties.

***Geographic and Temporal Extent and Resolution***

The extent and resolution of a projection will influence both its uncertainty and its saliency to its users. Both geographic and temporal extent are important. Presentations and discussants explored these issues in detail, both from the perspective of what user needs are, and how uncertainty necessitates tradeoffs between meeting these needs and providing accurate and precise results.

Potential user needs for population projections cover a broad spectrum of geographical resolutions, including national, state, county, and sub-county outcomes, such as municipalities. Many federal programs and policies use national, regional, or-state-level data. For example, the Energy Information Administration of DOE uses regional (multi-state) and national population projections as inputs into energy demand projections for the *Annual Energy Outlook*. As another example, the USDA's *Southern Forest Futures Project* projects changes in southern forests

between 2010 and 2060 under different scenarios using state population estimates, among other inputs. Analysis and research to support federal programs and policies, as well as “one-off” reports and analyses, may use more detailed county or even sub-county data and projections. For example, at the request of local stakeholders, the Bureau of Land Reclamation conducted a study of water demand and water supply conditions in Coconino Plateau region, out to the year 2050; the study used a combination of U.S. Census, state, and local data sources. Analyses conducted by state and local governments will generally rely on more detailed geographic projections that are informed by a detailed knowledge of local economic and regulatory factors; a national agency may not have a need for the high level of resolution that cities and MPOs will require in approaching and analyzing their study area.

The time horizons over which population projections are used by departments, agencies, and offices within the U.S. Federal government typically range from as short as a decade (i.e., to 2025) to almost a century (2100), according to the informal review conducted before the workshop. The time horizon will be dictated by the analysis or policy that the projection is supporting, or the period for which planning or budgeting activities are being undertaken. For example, the Department of Housing and Urban Development has used short- to medium-term projections (i.e., to the year 2050) of the percentage of the population that will be age 65+, in order to understand the demand for affordable and accessible housing over time. By contrast, studies looking at the solvency of the social security system typically have much longer time horizons (to 2085 or 2100). Similarly, studies and policy analyses looking at climate change, both mitigation and impacts/adaptation, also focus on longer time frames (to 2100 or longer).

Geographically, local level populations are easily affected by specific local land-use policy and local economies; however, these effects tend to even out over larger geographic scales. Consequently, methods for projecting national population may be different from methods to project population at the state or county level, where economic, social, and other factors come into play and detailed micromodels can be employed. Depending on the data inputs, modeling capabilities, and available resources, projections may be more or less uncertain at different levels. Similarly, it is easier to project what will happen to population in the near term than over the long term. Moreover, as described above, expanding the set of socioeconomic categories for which population is projected equally expands the methodological complexity of the projection. At the same time, these layers and levels of detail—geographic, temporal, and characteristics—are often what policy makers and decision makers need.

While national or global projections may sometimes be made over the very long term, projections for smaller areas are generally limited to a decade, or perhaps 30 years at most; as a projection’s time horizon expands and the geographic focus narrows, uncertainty increases. One presenter illustrated the uncertainty of increasing the spatial resolution and temporal extent of a

projection, using mean absolute percent errors.<sup>4</sup> Mean absolute percent errors are a common measure of projection uncertainty, and indicate the reliability with which the user may want to view the projection. In Table 3-1, mean absolute percent errors increase significantly with the length of the time horizon and as the geographic unit shrinks. When time horizon and geographic scale are combined, mean absolute percent errors grow considerably. The presenter indicated that although uncertainty is unavoidable, there are different ways to accommodate it. One method is to include alternative projections; for example, the U.S. Census Bureau releases alternative low, medium, and high series, reflecting different assumptions about migration. Some demographers noted that they might conduct a sensitivity analysis and attach the results to a report. Providing prediction intervals (i.e., an estimate of the range into which future populations might fall based on a certain level of confidence) also provides users with a better understanding of the uncertainty involved in any projection exercise.<sup>5</sup>

**Table 3-1. Mean absolute percent errors of projections, by length of horizon (years) and geographic unit**

Length of Horizon	States	Counties	Census Tracts
5	3	6	9
10	6	12	18
15	9	18	27
20	12	24	36

Source: Smith, 2014.

Presenters and discussants at the workshop discussed the issues of uncertainty and confidence in some depth. Demographers, whose work is commonly used to support policy and budget decisions, were reluctant to make projections that were associated with a high degree of uncertainty, as would be the case for socioeconomic details or projections far in the future. While some participants suggested that scenarios could be useful in managing uncertainty, others were more skeptical, asking “who would actually use scenarios for decision making?” One pointed out that the tradeoff between time horizon and uncertainty is already understood by policy makers, stating that in situations where policy and budget decisions require a relatively high degree of certainty, users rarely look beyond than 20–40 years into the future (e.g., investments in transportation infrastructure); beyond that time period, the uncertainties are too great.

Discussants pointed out that climate change research is one of the exceptions, in that research and analysis of the consequences and policy alternatives for mitigating or responding to climate change generally look far into the future. For example, models such as the Global Change Assessment Model and other integrated assessment models, as well as the reports and analyses

<sup>4</sup> Mean Absolute Percent Error (MAPE) is a common measure of projection error. MAPE is the mean of the absolute percentage errors. The absolute percentage error is the absolute value of the difference between the projected value and the actual value, calculated as a percent of actual. MAPE tells us how large an error we can expect from the projection on average.

<sup>5</sup> The 2012 population projections include the alternative series, but no alternatives are currently available on the Census website for the most recent 2014 projections. See [www.Census.gov](http://www.Census.gov).

generated by the National Climate Assessment, extend to 2100. While participants were concerned about the high degree of uncertainty inherent in long-term projections, many agreed that the long lasting effects of climate change give rise to research questions that can only be answered using long temporal horizons.

As a result of needs specific to long-term studies, some users have adopted the scenario approach as a way to embrace and understand the impact of the uncertainty inherent in long-term projections. These issues are discussed in Section 4: Capabilities for Developing U.S. Population Scenarios.

### **Meeting User Needs: Projection Methods for Estimating Population**

A variety of methods are available that project population at different levels of resolution and scale, and capture different population groups and characteristics. At the national level, population projections in the United States commonly use the cohort-component method. This rather intuitive approach starts with population estimates for the number of individuals of each age in a base year, and then base population is advanced each year using projected survival/mortality rates. Each year, a new birth cohort is added to the population by applying projected fertility rates to the female population, by age. One presenter pointed out that this method is not as robust at the sub-national level, however, because of the difficulty of capturing migration, which is particularly important when projecting spatial detail. Movements from one sub-national area to another are less predictable, and are more likely to be driven by economic or amenity factors. Several of the presenters pointed to a wide variety of methods (see Table 3-2, at the end of this section) that are available for projecting population at the subnational level. These methods range from relatively simple methods based on historical patterns and trends to more sophisticated methods that try to model, or simulate, the changes in the drivers of behavior.

More than one method can be used for a given purpose, and participants at the workshop spent considerable time discussing alternative methods and their strengths and weaknesses, as well as the factors that contribute to selecting a methodology. Key factors identified by participants included the ease of use and transparency of results, the quality of input data available, and the desired scale and time horizon. For example, one presenter noted that trend extrapolation methodology, which is fairly easy to implement, is often used at the local government level for population projections, in part because budgets may not allow for more sophisticated methods. Simpler methods may not only be more cost effective, but they may also be easier to communicate. Approaches are not necessarily mutually exclusive. Moreover, in some cases, a study may use multiple projection methods side by side; for example, the North Central Arizona Water Study (Pinkham, 2002) uses both a cohort-component method as well as a linear extrapolation of current growth to produce separate estimates of population growth that can be compared and contrasted.



### **Key Points: Meeting User Needs for Population Projections**

1. User communities that span all levels of government and the private sector create a need for population projections that span a range of geographic scales and resolutions, time horizons, and population characteristics.
2. Diverse user communities and types of applications of population projections make it difficult for a "one size fits all" approach that satisfies the variety of needs.
3. In some cases, users can include a range of alternative projections, reflecting different futures with respect to migration or other key variables.
4. Increasing levels of uncertainty are associated with projections over a longer time horizon or at finer geographic resolution.
5. The choice of appropriate methodology will depend not only on user needs for specific population projections, but also on resource constraints, data availability, and the importance of communicating methods and transparency.

**Table 3.2. A summary of projection methods discussed at the workshop**

Method	Description	Examples of Uses	Key Characteristics	Citation
<b>Proportional Scaling</b>	Use one or more data sets to disaggregate data geographically or interpolate additional population characteristics by scaling proportionally between datasets.	Downscaled global SRES scenarios at the national and grid levels (van Vuuren et al., 2007).	<ul style="list-style-type: none"> <li>• Easy to implement but difficult to capture complex processes.</li> </ul>	Jones, 2014
<b>Trend Extrapolation</b>	Can be used for total population or component (e.g., race). Applied to ratio as well (ratio of county to state). Commonly used for local counties where there may be limited options.	The Hamilton-Perry method for projecting change based over a short period using minimal data inputs (Hamilton and Perry, 1962).	<ul style="list-style-type: none"> <li>• Easy to implement but difficult to capture complex processes.</li> <li>• Assumes past is a good predictor of the future, so it won't capture divergences from past patterns.</li> <li>• May not have variables of interest. Does not capture structural changes.</li> </ul>	Jones, 2014; Smith, 2014
<b>Gravity-based</b>	Gravity models calculate the potential suitability or desirability of each location. Variables for such models usually include total population and geographic suitability. Migration between two geographical points is then determined by these variables.	Spatially explicit interpretations of scenarios from SRES (Grübler et al., 2007).	<ul style="list-style-type: none"> <li>• Accounts for population counts and geographic suitability.</li> <li>• Does not formally account for demographic behaviors, births, deaths, migration—or socioeconomic conditions, but there is potential to.</li> </ul>	Balk, 2014; Jones, 2014
<b>Hybrid Models</b>	Combines multiple methodologies to project demographics.	EPA's ICLUS model combines the cohort-component approach with a gravity model for migration. (U.S. EPA, 2009)	<ul style="list-style-type: none"> <li>• Incorporating multiple methodologies can address limitations of individual methodologies.</li> <li>• More resource intensive to implement.</li> </ul>	Jones, 2014
<b>Cohort-Component</b>	Population is usually divided into age/sex groups. The drivers for each group are: 1. Base population. 2. Baseline fertility, mortality, and migration rates. 3. The future fertility, mortality, and migration rates.  This method is used most frequently.	Census Bureau Projections (U.S. Census Bureau, 2012).	<ul style="list-style-type: none"> <li>• Most data requirements are not too difficult to acquire.</li> <li>• Migration data can be difficult to come by, and migration patterns are not as stable as other variables.</li> <li>• Difficult to incorporate socioeconomic factors, such as employment and economic growth.</li> </ul>	Balk, 2014; Smith, 2014
<b>Structural Models</b>	A demographic variable is projected based on historical values and external variables. Also commonly used. Common variables include job growth, land use, housing, and local services.	Can be applied to projecting populations for small areas, where other techniques are less reliable (Chi and Voss, 2011).	<ul style="list-style-type: none"> <li>• Growth is measured, but demographic components are not.</li> <li>• Better for short-term projections.</li> <li>• Used for local-area projections.</li> </ul>	Balk, 2014; Smith, 2014

Method	Description	Examples of Uses	Key Characteristics	Citation
<b>Microsimulation (Agent-based Modeling)</b>	Used on small areas. Focus on individual households or people. Each individual is separate in the model. Aggregate behavior is based on the sum of individual behavior.	Duleep and Dowhan (2008) proposed improving OASDI projections by adding immigrants to microsimulation models.	<ul style="list-style-type: none"> <li>• Limited in geographic scope and can be expensive to develop.</li> <li>• Able to incorporate much detail through individual decision-making.</li> <li>• Used largely for planning purposes.</li> </ul>	Smith, 2014
<b>Spatial Diffusion</b>	Models spread of population over space and time as population spreads to less populated areas. Accounts for density constraints and other geographical features. Regions react to other regions (used by geographers and planners).	Can be used to understand the effects of social learning and social influence on demographic changes (Montgomery and Casterline, 1996).	<ul style="list-style-type: none"> <li>• Used largely by geographers and planners.</li> </ul>	Smith, 2014

## 4. Capabilities for Developing U.S. Population Scenarios

The need for population projections that span demographic variables, time frames, and geographic scales is as great—and diverse—as the communities that use these projections. The workshop participants focused not only on what user needs were (as presented in Section 3, above), but also on what our scientific capabilities are to meet those needs. The discussion in the workshop report thus far has used “projection” as a somewhat generic term characterizing a population future. In reality, different users may have needs for different types of futures. For example, some users may rely on predictions that seek to answer a question of the type of “What will happen in the future?” while others may rely on projections that are more in the nature of “what if” statements, and still others may use scenarios identifying plausible descriptions of future states of the world. The discussion below distinguishes between these types of futures, and discusses the relationship among different types of future characterizations.

In discussing capabilities, participants and presenters identified a number of difficult challenges, stemming both from the diversity of needs, and from the difficulty of understanding and quantifying the pathways by which socioeconomic and other variables influence changes in populations. As that understanding improves, researchers may become better able to reduce the uncertainty and improve the reliability of projections. One presenter highlighted these issues by looking at what scholars in the 1930s would have needed to project U.S. migration trends (see Text Box 4-1).

This section reports on the discussions that occurred during the workshop as participants tackled this issue from three perspectives: (1) future characterization (how do we define and integrate different approaches to developing projections and scenarios), (2) the context for U.S. scenarios that global scenarios and global demographic changes (e.g., migration) provide, and (3) the “state of the science” and current capabilities to meet diverse user needs. The last subsection then revisits the question of “capabilities,” identifying not only where we have the models and tools we need, but also areas where new tools or sources of data are needed.

### **Text Box 4-1. Backcasting to 1939: A Lesson in Humility**

The story of migration patterns for the last 100 years or so is persistence—e.g., fast-growing places tend to remain fast growing and vice versa. The biggest driver of this persistence appears to be natural amenities (climate, landscape, nice places).

Yet, scholars of the late 1930s would have thought “people follow jobs” not: “jobs follow people.” They would not have understood key drivers in current U.S. migration trends, such as:

- Innovation in public health and air conditioning
- Congestion that closes off city growth
- Rise of information technology on the West Coast
- Pro-business policies in the South after WWII

Source: Partridge, 2014.

## Characterizing the Future: Projections and Scenarios

Analyzing the anticipated effects of policies, programs, and environmental change and other conditions requires a view of what will happen in the future. Different uses may require different types of population futures (Smith et al., 2013). In some cases, a qualitative statement of trends and expected changes in key drivers suffices for planning or analytical purposes. In others, quantitative population projections will be needed; these projections can be deterministic, or may be probabilistic or stochastic. For some decision making purposes, projections can be used to conduct “what if?” analyses, allowing researchers to consider the determinants of population change. Projections can also take the form of scenarios; when there is considerable uncertainty about the future, alternative scenarios can be used to explore the effects of different assumptions about the future.

The IPCC has developed a typology of terms for describing future characterizations, including scenario, storyline, projection, and probabilistic futures (see Text Box 4-2). The terms reflect typical usage in climate change impact, adaptation, and vulnerability (CCIAV) studies (Carter et al., 2007). They describe a range of approaches to describing plausible futures, with one key difference among the approaches being the extent to which probabilities are ascribed to the future.

### Text Box 4-2. IPCC Definitions of Future Characterizations

Some key terms from the IPCC typology are defined below. More information is available from the IPCC reports.

*Scenario* is a coherent, internally consistent, and plausible description of a possible future state of the world, which may be quantitative, qualitative, or both. The components of a scenario are often linked by an overarching logic, for example a *storyline* that represents a qualitative, internally consistent narrative of how the future may evolve.

*Storylines* describe the principal trends in key drivers and relationships among these drivers. Storylines may be stand-alone, but more often underpin quantitative projections.

*Projection* is any description of the future and the pathway leading to it. In the climate world, projections are often model-derived estimates of future conditions for an element (such as population) of an integrated system. Projections are generally less comprehensive than scenarios. Projections may be probabilistic, while probabilities are not ascribed to scenarios.

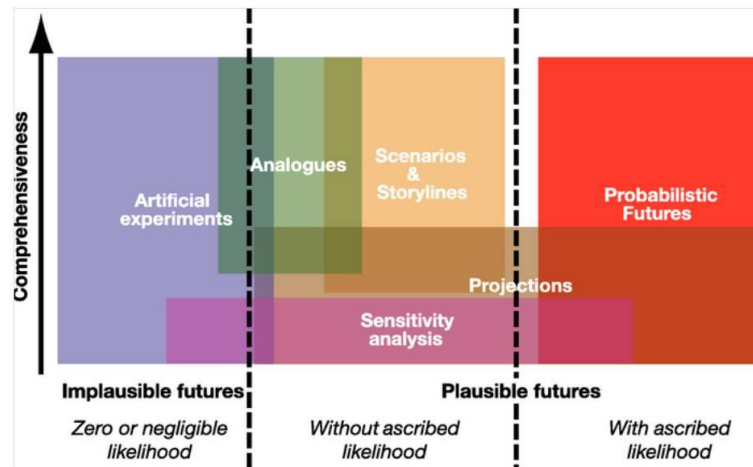
*Probabilistic futures* are futures with ascribed probabilities. Conditional probabilistic futures are subject to specific underlying assumptions. Assigned probabilities may be imprecise or qualitative, as well as quantitative.

A *prediction or forecast* is a statement that something will happen in the future, based on what is known today, and on the initial conditions that exist. An important part of a prediction is our degree of belief that it will come true.

Sources: Carter et al., 2007, Solomon et al., 2007. Weaver et al., 2013.

A projection is not the same as a prediction. A prediction is an attempt to produce an estimate of the actual evolution of the future and is usually probabilistic in nature. A prediction assumes that the future outcome will not be greatly influenced by unpredictable or uncertain future conditions. A projection, in contrast, specifically allows for significant changes in the conditions that might influence the prediction, creating “if this, then that” type statements. Thus, a projection is a statement that it is possible that something will happen in the future if particular conditions (e.g., socioeconomic and technological developments) are realized. A projection is, therefore, subject to substantial uncertainty.

One of the presenters referred to the following IPCC graphic (Figure 4-1), which maps the approaches to characterizing the future described in Text Box 4-2 (among others) into the space



**Figure 4-1. Characterizations of the future**

Figure Source: Carter et al., 2007.

defined by the dimensions of comprehensiveness and plausibility. Comprehensiveness indicates the degree to which the characterization possesses the variety of population attributes (and the level of detail for each attribute), needed by the user community. Plausibility indicates a subjective assessment of whether a characterization is possible; implausible futures are assumed to have zero or negligible probability. As indicated on the graphic, scenarios typically are more comprehensive than projections, because of the greater number of elements they include in describing the future state of the world. However, projections, unlike scenarios, are sometimes assigned probabilities.

One of the issues prominent during discussions was the difference between projections and scenarios, and the type of approach that best serves different user communities. Participants from the climate change community, for example, described an approach that focuses on building alternative plausible futures and quantifying the outcomes for relevant elements of the scenarios. The scenario approach is preferred by researchers and analysts looking at climate change because it reflects the greater uncertainty about the future over the long term and the importance

of assumptions about key variables, including climate policies, economic growth, technological change, and migration patterns.

According to presenters and discussants, many state agencies prefer a single projection series on which to base policy and programmatic decisions; consequently state demographers may have their projections interpreted as predictions, in the sense of representing a most likely outcome, rather than a conditional statement about the future, driven by scenarios, storylines, or other assumptions. In many cases, the discussion indicated that the development of alternative projections by demographers is less a reflection of alternative visions for the future than an intention to bracket the uncertainty in the projection.

In practical applications of projections to state and local policy issues, the divergence between a scenarios approach and a projection approach is not always as great as the above discussion might imply. State and local planners and other public officials may use scenario building, or scenario-based planning, as a systematic approach to understanding current and emerging trends that are shaping the community, with a goal of developing a reasonable, plausible population projection for a community. For example, Franklin County in Florida developed a population growth scenario outlining the type of growth expected in the county and identifying the facts driving growth in the community. The scenario that was then utilized in the preparation of a population forecast for Franklin County (see Text Box 4-3; Chapin and Diaz-Venegas, 2007).

Similarly, some users employ “visioning” to develop different futures on which the projections are based, or bracket possible futures to reflect uncertainty in key drivers. Planning using scenarios may involve an iterative process of defining the vision; coming up with different scenarios that articulate the vision; evaluating, refining, and identifying top priorities; and the turning the findings into an actual plan, typically working with stakeholders like residents and businesses throughout. Envision Utah, for example, works with communities throughout Utah to engage residents in the planning process (see Text Box 4-4). Alternatively, scenarios may be

**Text Box 4-3. A Population Growth Scenario for Franklin County, Florida**

Franklin County developed a growth scenario through the year 2030, using interviews with local experts, reviews of planning documents and print media, and analysis of population and economic data for the county, the region, and the state.

Developing a plausible scenario involved gathering data and trends in key factors, including:

- Dimensions of growth, including historical population growth, emerging development trends, and part-time residents;
- Factors driving population increases, including continued growth of the state and region, and public and private efforts to create regional branding for the Florida Panhandle, and the location of a new state prison; and
- Factors limiting population increases, including infrastructure issues, public land holdings, and county culture.

Source: Chapin and Diaz-Venegas, 2007.

developed that represent aspirational goals, or reflect different policy scenarios (e.g., changes in zoning rules).

Discussions and presentations at the workshop clarified some of the misunderstandings between different groups regarding the differences between projections and scenarios, and highlighted the usefulness of a scenario approach in developing conditional projections. Nonetheless, many of the demographers at the meeting continued to express significant reservations about making long-term demographic projections, especially for small areas. It will be particularly important to provide content and guidance for appropriate use and limitations of such projections.

**Text Box 4-4. Envision Utah’s Process**

Envision Utah uses interviews, mapping exercises, surveys and other means to hear from residents and uses that information to present different community scenarios based on the information gathered. Residents react to the scenarios and choose the future that best matches their vision. Based on public input, Envision Utah's voluntary recommendations for achieving that vision respect private property rights and are grounded in the realities of the local market. Local elected officials, along with residents, have the opportunity to implement the public’s vision as they best see fit.

Source: Envision Utah, 2014.

**Global and Societal Contexts**

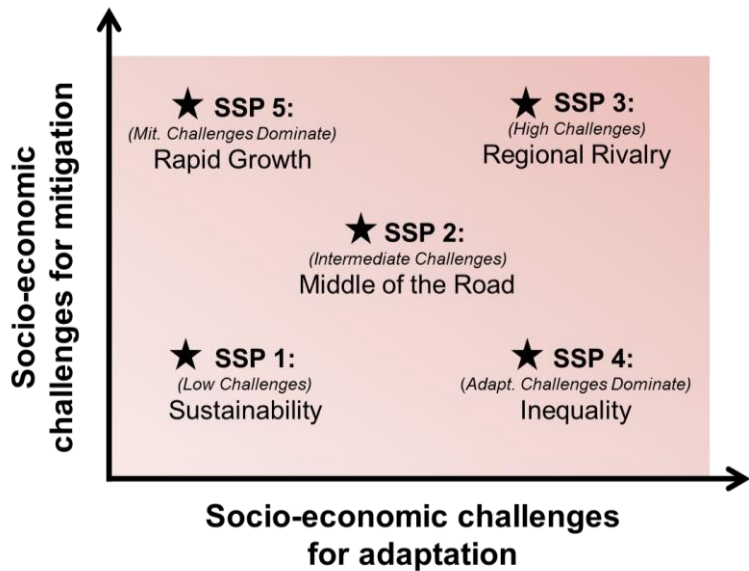
Complications are inherent in developing population scenarios that will meet the diverse user needs for climate change analyses and other uses of population projections, articulated in Section 3 of this report. One set of issues surrounds the nature of global scenarios, which are used extensively in the climate change arena, and may inform—but also can complicate—the process of developing U.S. scenarios. At the workshop, participants explored existing global scenarios and what it would mean for U.S. scenarios to be consistent with these scenarios. Participants also explored how societal considerations and context add another layer of complexity to the process of defining desirable characteristics for U.S. population scenarios. Key discussion questions and responses are summarized below; these reflect the tenor of the dialog among participants.

A broad range of global scenarios is available for use in the CCIAV studies, including the Special Report on Emissions Scenarios (SRES), the Shared Socioeconomic Pathways (SSPs), the Representative Concentration Pathways (RCPs), and scenarios developed for the Millennium Ecosystem Assessment. These scenarios can be used in global assessments and other studies, such as the Millennium Ecosystem Assessment and the IPCC’s Assessment Reports. The scenarios are generated from a set of assumptions about the future, and common drivers include economic development, population growth, technological development, attitudes toward environmental protection, and globalization (Moss, 2014).

One of the most widely used sets of scenarios are the so-called “SRES” scenarios, which were developed for the CMIP and have been the mainstay in climate assessments for more than a decade (Nakićenović et al., 2000). This SRES framework includes four storylines that extend to 2100, each of which is defined along two dimensions: environmental/economic patterns of growth, and globalization vs. regionalization.



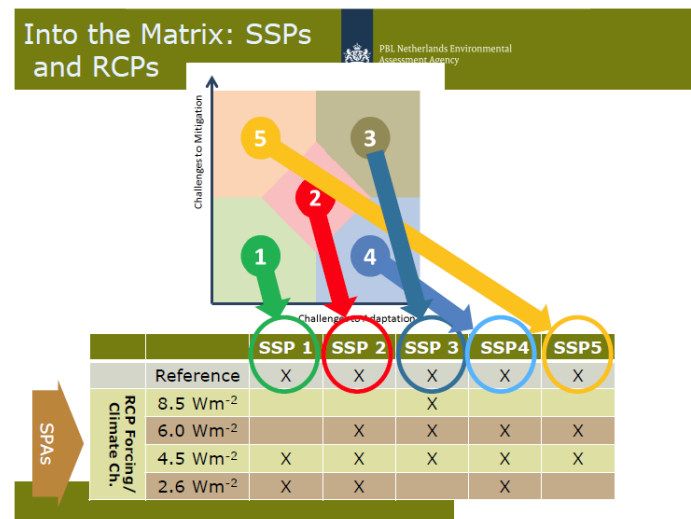
The SSPs are a new scenario framework being developed that includes five separate narratives or storylines (see Figure 4-2). These SSPs are designed to be used in conjunction with the RCPs. The RCPs are a set of four scenarios containing GHG emissions, GHG concentration, and land-use pathways that are driven by underlying scenarios of socioeconomic variables, land-use and land-cover factors, and GHG emissions. The RCPs were developed by selecting and updating scenarios described in the existing literature, and then harmonizing and downscaling emissions and land-use data (van Vuuren et al., 2011). The SSPs are being developed as part of a parallel process to link climate modeling, integrated assessment modeling, and impacts, adaptation, and vulnerability modeling. They represent more detailed socioeconomic pathways that can be used to explore uncertainty in terms of the socioeconomic challenges to mitigation and adaptation shown along the two axes in Figure 4-2. The ways in which different SSPs may be linked to the RCPs are demonstrated in Figure 4-3. Participants pointed out that researchers are already using the SSPs, although many still use the SRES. In addition to the scenarios being designed for purposes of climate change work, scenarios have been developed for the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005) and for the UNEP Global Environmental Outlook (UNEP, 2012), as described in Text Box 4-5.



**Figure 4-2. Qualitative descriptions of the SSPs**

Figure Source: O'Neill, 2014b.

The SSPs are being developed as part of a parallel process to link climate modeling, integrated assessment modeling, and impacts, adaptation, and vulnerability modeling. They represent more detailed socioeconomic pathways that can be used to explore uncertainty in terms of the socioeconomic challenges to mitigation and adaptation shown along the two axes in Figure 4-2. The ways in which different SSPs may be linked to the RCPs are demonstrated in Figure 4-3.



**Figure 4-3. A crosswalk of the SSPs and the RCPs**

Figure Source: Kram, 2012.

In some cases, alternative population projections have been developed to be consistent with scenarios, such as those developed by the IPCC (Nakićenović et al., 2000). For example, the USGS of the Department of the Interior developed population scenarios to predict land use and land cover changes, as well as disturbances to ecosystems in different geographic areas in the United States. These scenarios were developed to be consistent with the qualitative IPCC storylines.<sup>6</sup> Similarly, EPA’s Integrated Climate and Land-Use Scenarios (ICLUS) provide detailed

population and land-use scenarios that are also broadly consistent with the IPCC storylines. The scenarios are modified by adjusting assumptions about fertility, international and domestic migration, household size, and travel time to the urban core. Scenarios, rather than deterministic population projections, are particularly important for analyses involving climate change because of the very long time frame of the analysis, the close linkage between different population metrics and impacts, and the heterogeneous nature—spatially and temporally—of climate-related hazards and demography.

Participants at the workshop discussed the possibility—and importance—of consistency between the national and existing global scenarios, such as the SSPs (see Text Box 4-6). Some stressed that although consistency is important, it should be defined loosely. This viewpoint stressed the importance of consistency of U.S. scenarios with the underlying concepts reflected in global scenarios, rather than the quantitative aspects (e.g., U.S. EPA, 2009; Jiang, 2014). More generally, efforts to maintain consistency should not overly constrain or limit the suite of plausible national U.S. scenarios. Others pointed out that the size and heterogeneity of the United States fosters internal tensions and factors that may not be addressed by the SSPs or other global

**Text Box 4-5. UNEP Global Environmental Outlook**

The UNEP GEO provides another view of global scenarios. While the SRES and SSP scenarios represent pathways in the absence of explicit climate change policies, the GEO produces two storylines (to 2050): one follows a business-as-usual trajectory, and the other follows a path driven by global goals and targets for environmental, social, and economic sustainability.

Source: UNEP, 2012.

**Text Box 4-6. The Quantification of the Shared Socioeconomic Pathways (SSPs)**

The SSP database aims at the documentation of quantitative projections of the Shared Socioeconomic Pathways (SSPs). The database includes quantitative projections for population (by age, sex, and education), urbanization, and economic development (GDP). These quantitative elements have been developed by collaboration among different groups, including the International Institute for Applied Systems Analysis (IIASA), the National Center for Atmospheric Research (NCAR), the Organisation for Economic Co-operation and Development (OECD), and the Potsdam Institute for Climate Impact Research (PIK).

Source: Jiang, 2014. For additional information see also:

[http://www.iiasa.ac.at/web/home/research/researchPrograms/Energy/SSP\\_Scenario\\_Database.html](http://www.iiasa.ac.at/web/home/research/researchPrograms/Energy/SSP_Scenario_Database.html).

<sup>6</sup> Detailed background information on the IPCC storylines is available at: [www.ipcc.ch/ipccreports/sres/emission/index.php?idp=3](http://www.ipcc.ch/ipccreports/sres/emission/index.php?idp=3).

scenarios; consequently U.S.-specific variants or place-specific conditions could lead to storylines that are qualitatively different from global storylines, as well. Still others pointed out that the notion of “consistent” scenarios does not mean the same thing for all types of analyses; some analyses can selectively focus on characteristics that are important for its framing. For example, different aspects of a storyline may be more important for framing a mitigation analysis, while others are critical to impacts and adaptation.

When the underlying concepts supporting scenarios at the national level are consistent with the concepts driving global scenarios, national scenarios can be further tailored to reflect nationally relevant factors. Participants pointed out that migration is one factor driving population scenarios that may manifest differently at the national scale than at the global scale. Some noted that internal migrations may not mirror global migrations; connections exist, but they are poorly understood. Understanding migration patterns in the United States is important for understanding national population distribution, population changes, and rates of population change along the urban-rural continuum. As mentioned in Section 3, users have expressed an interest in having the flexibility to consider different population scenarios that reflect an array of migration patterns.

The second broad type of complication arises from the socioeconomic and societal context within which scenarios and projections are developed. Participants at the meeting identified important categories of non-demographic factors, including governance, and education. They also pointed out that abandonment is less well understood than development. With respect to migration, the discussion identified a number of factors that can drive migration, including housing, zoning, transportation, air quality, gasoline prices, taxes, short-term and long-term economic change, environmental change, land availability, and human behavior. One presenter pointed out that migration patterns in the United States for the past 100 years or so have been remarkably persistent; fast-growing places tend to remain fast growing, and vice versa (Partridge, 2014). The presenter shared tables and maps suggesting that the biggest driver of this persistence appears to be natural amenities (climate, landscape, and nice places). He argued that, while demographers often assume that people follow jobs, in fact the reverse may be true, and jobs follow people.

### **Available Data, Methods, and Tools**

A variety of tools, data, and methods are available to develop projections that incorporate different population attributes, and different levels of spatial and temporal detail. In applying these methods, the user community often faces tradeoffs; some variables (well-understood variables such as age, race, and sex) will be relatively easy to project at the national and sub-national level, but become more difficult as the geographic unit or scale shrinks. The sub-county level can be particularly difficult to work with, especially for less well-understood variables, such as education. Reconciling estimates for different geographic scales can also be difficult; while statewide growth rates, for example, will influence growth rates in many communities, population changes in local communities will also be governed by many highly local factors,

such as development patterns and building plans. Applying existing models, collecting important data, and developing new techniques will all be part of developing population projections to suit a variety of purposes, as well as turning the type of qualitative and quantitative scenarios that are discussed above, into quantitative population projections.

Presentations at the workshop addressed the types of methods that are available to project population at the national and subnational levels, and the strengths and weaknesses of different methods. When developing aggregate national projections that require only core demographic variables (e.g., population by age and sex), the cohort-component technique remains a useful and common approach, as various presenters noted (Balk, 2014; Murdock, 2014; Smith, 2014). Different scenarios can be developed by modifying the rates of change, particularly assumptions about fertility and international migration. However, when a set of projections needs to include socioeconomic variables or spatially explicit information, the cohort-component technique cannot be used alone. It cannot easily be used to project non-demographic variables, nor can it be used to project internal migration, which is critical to spatially explicit projections (Balk, 2014).

As the requirements for a set of projections grow more complex, other methods may be used alone or in combination with one another. Some methods, such as proportional scaling make it possible to develop spatially explicit projections or to incorporate additional demographic detail. Scaling can also help address lack of fine-scale data, while also ensuring consistency between the small scale and aggregate totals (Jones, 2014). Trend extrapolation can be used to develop projections based on a curve fit to historical observations, particularly for variables such as educational attainment, where historical trends can be observed (Balk, 2014; Jones, 2014; Smith, 2014). Other large-scale approaches can address some of the complexities; for example gravity-based approaches can be used to project spatially explicit rates of change; however, while this approach can capture geographic suitability and population counts, it cannot provide demographic or socioeconomic detail (Balk, 2014; Jones, 2014).

These and other models—such as structural models and microsimulation models—provide additional information, but also are data intensive. Consequently, they may be appropriate for projections that are national in scope, yet require spatially explicit detail. Structural models, which project demographic changes based on causal relationships between demographic and non-demographic variables, provide an opportunity to explore the impact of non-demographic drivers on various scenarios. At the same time, these methods do not handle demographic processes, such as fertility and mortality, as easily as the cohort-component method, so hybrid approaches are being used to gain the advantages of different techniques.

Scaling and extrapolation techniques are often used on the sub-county level due to resource or data limitations. More detailed methods to develop sub-county projections typically require detailed local knowledge, such as local economic dynamics, planned infrastructure investments, and land-use regulations. For some climate change assessment, sub-county projections can be

critical, as in the case of sea level rise (see Text Box 4-7). However, many local governments do not have the data or resources to implement more intensive modeling approaches, and it is an open question as to when and whether knowledge-based projections perform better than more simple techniques (see Text Box 4-8).

Participants at the workshop expressed a number of different perspectives on considerations in choosing and applying existing data and modeling approaches. One recurring theme was the importance of “right-scaling.” One participant noted that people have a tendency to think that more resolution is better; in reality, greater resolution may encourage a false sense of precision and accuracy, and may not be necessary for the task at hand. Therefore, “right-scaling” the data and method for what one needs to investigate is an important first step. However, right-scaling can be complicated to determine, when researchers do not have a specific question in mind, but the goal is to develop projections or scenarios that are useful for multiple applications.

When users have different needs and applications, a flexible approach may be needed. In discussing geographic flexibility (and important difference across user needs), participants considered the usefulness of providing data on a common grid, so that users could move between scales more easily. One participant noted that the United Kingdom and some Scandinavian countries conduct their censuses on a geographical grid. Some participants felt that difficulties with gridded data (e.g., the problem that not all data are available at all scales) could be resolved, while other argued that it is unrealistic to project demographics on a grid, preferring the use of

#### **Text Box 4-7. Sub-county Population and Sea Level Rise**

Population projection methodologies for small area units—namely sub-county units—tend to be less robust than projection methodologies at larger scales. While population is particularly difficult to project at the sub-county level, in some cases the distinctions can be crucial, as in the case of sea level rise, which will have the greatest effects on populations and housing near the coast (which may be only a portion of the county's population). Researchers presenting at the 2014 annual meeting of the Population Association of America developed a methodology for population projection suitable for sub-county units based on two other methods, and demonstrated the method's application by combining it with sea level rise modeling in Coastal Georgia (Hauer, 2014). Research of this type may be instrumental in expanding the available methods for projecting population attributes at the sub-county level.

#### **Text Box 4-8. How Can We Project the Future at a Sub-county Level?**

A study in *Demography* (Chi, 2009) focused on the need for more accurate population projections at sub-county levels, as well as a consideration of interactions among population growth, traffic flow, land use, and environmental impacts. The study asked whether more knowledge, especially that of non-demographic factors (such as socioeconomic conditions, transportation accessibility, natural amenities, and geophysical limitations) could improve sub-county population projections. The study found that knowledge *did not* improve population projections at sub-county levels, when compared with statistical and mathematical methods of extrapolation that do not depend on outside knowledge, but also acknowledged that knowledge-based approaches provide other useful information for planners, including the investigation of "what if" scenarios that can be used to devise development and other strategies.

administrative units as the basis of projections. Participants also debated the question of whether it is more appropriate to develop county-level projections and aggregate them, or to develop national/state projections and distribute them downward. In both cases, additional research is needed on resolving differences across scales, particularly in cases where metropolitan areas cross state lines. Last, the discussion also touched on issues of how to provide flexibility in methods across time and geography, with participants making several proposals about how different approaches could be combined to provide coverage over different time scales and/or geographies. Ultimately, incorporating flexibility into a scenario enterprise so that it meets the needs of multiple research communities is a challenging task, and may require using different methods at different scales. More research is needed to understand how to effectively balance these considerations.

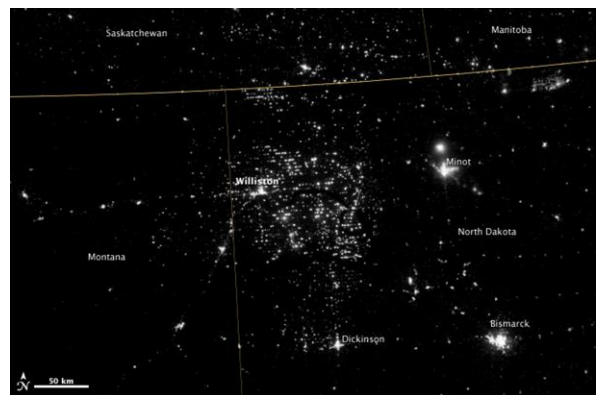
Data availability was a key concern for many of the participants. In some cases, data availability limits potential applications. For example, small counties may have insufficient data available for use in structural models, where independent drivers for key variables are needed. Some were concerned about the continued availability of data from the U.S. Census and the American Community Survey due to funding uncertainty. The U.S. Census, for example has not released state projections since 2005. Several participants agreed that a credible set of state-level projections from the Census would be a welcomed resource, as they are the definitive source for data. Offering new options for the future, “big data,” and new forms of private data have the potential to generate new insights, although there are limitations and more work needs to be done to understand the potential in this area (see Text Box 4-9).

#### **Text Box 4-9. New Opportunities and Challenges**

There was interest in “big data” and social media, in which some participants saw a potential opportunity to capture data in new ways. For example, cell phone or other records could help capture seasonal or day/night migrations in a way that U.S. Census data cannot. However, there are availability and privacy concerns limiting broader use at this time.

Furthermore, they highlight the need to maintain adequate representative sampling, as the population of cell phone users, for example, may behave differently from the rest of the population. It is important to articulate these biases. One presenter also cautioned how new techniques need to be carefully considered.

Nighttime light mapping has been used in a number of applications recently, but a night light map of western North Dakota reveals an unusual and extensive pattern of lights that is explained by oil and gas extraction activities, and not permanent urban settlements.



Source: NASA Earth Observatory and NOAA National Geophysical Data Center.

## Capabilities: Revisiting the Issues

Particularly at the national level, researchers have many of the capabilities needed to project population and provide support for climate change assessments and policy development and to meet other governmental policy and planning needs. However, researchers do not always have a lot of confidence in these projections, particularly at fine geographic scales and over long time periods, both of which are critical to climate change studies. Moreover, there is a lack of systematic understanding of how non-demographic factors influence population, as well as how to project these factors; if these factors are as important as some researchers believe (see Text Box 4-10), then developing new methods that can project these population characteristics with low uncertainty will be important to developing long-term population projections that meet a variety of user needs.

### Text Box 4-10. Adding Education as a Standard Demographic Dimension

Canadian demographer Nathan Keyfitz wrote a famous paper (1981), in which he expressed the view that demographic trends are easier to forecast than many social and economic trends. However, socioeconomic variables may be important to understanding demographic trends, as well as key drivers of impacts or other outcomes (see Text Box 4-4).

A recent paper by Lutz & Skirbekk (2014) provides evidence of a causal relationship between education and health and fertility-related outcomes, making the case that education should be systematically added to age and sex as a third standard demographic dimension.

At larger geographic scales, researchers have confidence in these projection methods and data, but uncertainty increases with smaller geographies and increased demographic detail. One of the presenters at the workshop illustrated the current state of the science using Figure 4-4 (see next page).

In Figure 4-4, the green areas represent the standard demographic variables (age, sex, and race), for which well-understood and commonly applied methods

(such as the cohort-component method) exist to project population at the national, state, and even county levels.

The yellow cells represent socioeconomic variables, such as health, status, education, and income, which (as described above) are more difficult to project, even at the national level.

Going beyond the county level, to develop sub-county projections, presents its own set of complications; many of the methods that can be applied at higher geographic scales break down at the sub-county level, as uncertainty increases at smaller scales.

Population Characteristic	Geographic Resolution			
	National	State	County	Sub-county
Size	Green	Green	Green	Orange
Age/Sex	Green	Green	Green	Orange
Race/ethnicity	Green	Green	Green	Orange
Urban/rural	Orange	Orange	Orange	Orange
Education	Yellow	Yellow	Yellow	Grey
Health Status	Yellow	Yellow	Yellow	Grey
Income	Yellow	Yellow	Yellow	Grey

**Figure 4-4. Projection feasibility by population characteristic and geographic resolution**

The gray areas indicate the greatest challenges—projecting socioeconomic characteristics at the sub-county level. Yet, as described previously in Text Box 4-7, sub-county projections may be essential to some user communities, such as those conducting climate impact assessments, and so new methods may need to be developed and applied.

Scenarios may be able to inform population projections where uncertainty is high, such as sub-county projections of socioeconomic variables. Since the future remains uncertain, scenarios can be used to consider the impact of specific changes (i.e., “what if?” scenarios) or various potential futures based on combinations of assumptions.

### **Key Points: Capabilities for Developing U.S. Population Scenarios**

1. Scenarios and projections differ in terms of plausibility and comprehensiveness: scenarios typically are more comprehensive than projections because of the greater number of elements they include in describing the future state of the world. However, projections, unlike scenarios, are sometimes assigned probabilities. Scenarios are one way of handling the large uncertainty about future conditions that can be associated with projections.
2. Practically speaking, scenarios can be as important as projections for state and local policy issues: scenarios can assist the researcher in quantifying a plausible storyline, bracketing a range of outcomes, or supporting planning to achieve aspirational scenarios.
3. Global scenarios can inform and support the development of national and sub-national scenarios; however, consistency should not constrain national scenarios from reflecting nationally relevant factors and conditions.
4. The user community faces tradeoffs when applying existing tools, data, and methods to projections that incorporate different population attributes and different levels of spatial and temporal detail.
5. Applying existing models, collecting important data, and developing new techniques will all be part of developing population projections to suit a variety of purposes, as well as transforming qualitative and quantitative scenarios into quantitative population projections.
6. Scenarios can play a useful role in exploring projections of socioeconomic, spatial, or temporal detail where confidence in data and methods is low.

## **5. Key Insights from Workshop Discussions**

- Developing population projections that have a high level of spatial resolution and include socioeconomic characteristics of the population is difficult and sometimes infeasible. Projecting over a long time horizon increases the uncertainty.

Many users indicated a desire for higher resolution projections as well as a list of population characteristics. Small-area or higher-resolution (i.e., sub-county) population projections are used for a variety of planning and budgeting purposes (e.g., land use, public school construction, conservation strategies, future water consumption). Population characteristics that were frequently mentioned included age, sex, urban/rural or density, education, health status, and



income. However, the production of well-grounded projections involves a tradeoff between spatial resolution and population characteristics; this tradeoff becomes even more pronounced when projecting on the time scales typically used in global change assessments. In particular, many workshop participants expressed unease in projecting non-demographic characteristics at sub-national scales. Even for projections based on demographic factors, there is strong evidence that projection uncertainty grows with finer spatial resolution and with longer time horizons. Trying to do all three—non-demographic factors, fine resolution, and long time frames—is challenging and may not be feasible with current understanding and available data.

- Sub-county population projections are needed for climate impacts research and adaptation planning.

Although projecting sub-county populations over longer time periods poses significant challenges, they are needed for understanding the implications of climate change for the United States. Hierarchical approaches have been used to develop such fine-scale population estimates and forecasts for a wide array of analyses. In this approach, national, state, or county projections are developed by authoritative sources (e.g., U.S. Census or state demographers), typically using some variant of the cohort component method. Higher resolution projections for specific small areas are made using a variety of approaches including trend extrapolation and ratio methods, cohort-component methods (e.g., Hamilton-Perry), housing unit allocation approaches, structural or “knowledge-based” models (e.g., economic-demographic, urban systems), and microsimulation or agent-based models. Sub-county population projections are available for many states, and there are guidelines for preparing these projections (see, for example, Smith et al., 2013; Chapin and Diaz-Venegas, 2007). In some states, local knowledge about future development and other factors is used to adjust sub-county projections.<sup>7</sup> The private sector also prepares localized population projections. Currently, however, there is no uniform method used across the country for sub-county population projections.

Projecting sub-county populations has become increasingly important as understanding climate change impacts on human populations and adaptive decision making have become new foci for the climate change community. For example, sea level rise will not affect coastal county populations equally; communities closer to the ocean will be more impacted and have a greater need to adapt than those further away (within the same county). Sub-county population projections are an active area of research and investigators are evaluating the usefulness of new data and methods such as satellite remote sensing, cell phone data, and multiple regression approaches. Given the need for high spatial resolution population data, research to address concerns about uncertainty is a priority. A systematic evaluation of the various approaches and their utility for specific applications would provide important insights for projecting sub-county populations for climate impact studies.

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<sup>7</sup> See, for example, Arizona population projections at: <https://population.az.gov/population-projections>.

- Demographic scenarios and projections are not predictions of the future; however, they should be well-grounded characterizations of plausible future outcomes.

Criteria for judging the quality of a scenario or projection should be based not on whether it is an accurate and precise *prediction* of future conditions, but on whether it is plausible, grounded in data, developed using trusted methods, and internally consistent. For many demographers and practitioners, this may involve using their methods in different ways than is typically the case. Current practice focuses on developing a population forecast (i.e., the most probable future) and using alternative specifications of demographic components (e.g., using high/low fertility rates, mortality rates, or migration) to bracket the forecast in order to account for uncertainty. In some cases, the effects of differing assumptions on future populations are explored to illustrate the sensitivity of the forecast to these assumptions. Population scenarios and projections can also be used to support particular political, economic, or social goals through, for example, the development of aspirational views of the future. Population scenario efforts may include non-demographic variables (e.g., education, health status, income), as well as alternate ranges of demographic variables—“what if”-type scenarios—to describe a broader range of future populations. Engaging additional communities beyond demographers—such as regional economists, urban planners, and GIS experts—will be necessary to design broader scenarios of societal changes that are capable of informing demographic projections. Climate offices in large cities are another source of scenario information; they may offer additional insights for understanding how to move forward with scenarios and projections.

- Maintaining and improving demographic data is essential to producing high-quality population projections for use in global change scenarios.

The importance of preserving and strengthening existing data collection efforts and datasets, such as the American Community Survey (ACS), IRS datasets, National Center for Health Statistics, and state offices of vital statistics, was noted by several workshop participants. Consistent and cohesive collection of population, social, housing, and economic characteristics facilitate the development of population projections. Moreover these data are familiar to many users as they are routinely used by a wide range of groups including Federal, state, and local agencies, NGOs, emergency planners, the private sector, and the general public. The ACS, in particular, was mentioned as it is an important source of non-demographic information critical for advancing our understanding. However, the ACS collects these data through surveys and there is interest in developing more efficient and effective ways to get at the same data.

Participants noted that changes in information technology are opening up new possibilities. Big data could be potentially quite useful, although data quality may be an issue. For example, these data may not be representative of the whole population and therefore may not be suitable for scientific uses. There are also privacy concerns and potential restrictions on sharing data. The widespread use of GPS, such as in cell phones, may provide data for tracking temporary migration, such as vacation travel and commuting patterns (i.e., day vs. night populations).

Satellite remote sensing has also opened new opportunities to track urban change (e.g., National Urban Change Indicator) and inform population projections.

- Methods for producing national-level, spatially explicit population projections are at relatively early phases of development; efforts to compare methods and model simulations would facilitate further development of methods as well as help define the research agenda

Nationally benchmarked, spatially explicit population projections would provide data needed for climate impacts research, development of adaptation options, and the National Climate Assessment. The climate change science community has used formal processes to compare model simulations to observations and to each other. The current Coupled Model Inter-comparison Project (CMIP5) provided critical support to the 5th Climate Assessment Report of the United Nations (IPCC AR5) and along with the previous CMIP (CMIP3), the National Climate Assessment. The CMIP process has resulted in significant improvements in our understanding of underlying processes, identification of key uncertainties in climate modeling, and increased the usefulness of General Circulation Model (GCM) simulations for climate impacts research and assessment. There exists a sufficient nucleus of national, spatially explicit population modeling efforts to make a “PopMIP” a worthwhile endeavor, providing insights and progress similar to those for the CMIP effort. Although the U.S. Census Bureau has not been involved much in USGCRP, it would be a central player in any PopMIP exercise.

Another outcome of a PopMIP would be a rigorous identification of highly influential yet uncertain population drivers, pointing the direction to the most important research areas. Hybrid modeling approaches (combining top-down and bottom-up, and merging gravity- and agent-based modeling) could also be evaluated relative to existing methods. A PopMIP would also promote sharing and transparency of data inputs, assumptions, modeling approaches and simulation results.

- Developing plausible alternative futures for migration, particularly internal migration, would provide the most added value to a U.S. population scenarios effort.

Migration continues to be the most uncertain demographic factor affecting population projections at sub-national scales. Extrapolation of historic trends, simple rule-based methods such as gravity models, and ad hoc assumptions relating population movement to other, especially economic, variables have all been used to project population movements between regions and states and within states. The danger of these approaches is that major shifts in population migration patterns that could be important for climate impact studies and assessments would be missed. More sophisticated modeling approaches have not been used; this is due, in part, to a lack of understanding of the dynamics of population migration and the influence of factors such as regional economics, income, environmental amenities, density/congestion, public

policies, and housing markets. Further, these influences may not exhibit the same structural relationships with population in different parts of the country. At the sub-county level, applied demographers have generally ignored such models when developing population forecasts for sub-county areas, as they do not perform better than simpler models.

Developing such knowledge-based projections would be particularly useful for adaptation studies. Additional “levers” would allow the analyst to explore feedbacks from climate change and adaptation policies to population growth and economic development. Engaging additional social sciences disciplines—such as human ecology, regional economics, population geography, environmental sociology, and urban planning—could provide fresh views on modeling population migration. In addition to research to develop such models, a scenario effort to explore the effect of major population shifts is also needed to support the National Climate Assessment.

- It would be useful for U.S. population scenarios to be consistent with global scenarios; however consistency should not overly constrain the development of U.S. scenarios.

Consistency with global scenario efforts, such as SRES, SSPs, and RCPs, is beneficial.

Consistency with these efforts provides important context for interpreting results from analytic studies and assessments. It also promotes internal consistency of climate impacts studies, i.e., the scenario that drove the climate model and simulation results is consistent with the scenario that drove the population projection results. Climate assessments are facilitated when the climate impacts literature uses consistent scenarios as they can be compared and combined to yield important insights. However, the flexibility to tailor U.S. scenarios to various needs, especially at the finer geographic resolution needed for adaptation, needs to be preserved. The challenge for the U.S. scenario enterprise is to develop methods such that top-down and bottom-up merging of qualitative scenarios and quantitative simulation results are feasible and credible.

Selecting the appropriate global scenario that may be used to align a U.S. scenario effort can be complicated. The SRES are widely known and used; given the time lags in publishing research results, it seems prudent to maintain some connection with or acknowledgement of these global scenarios. Newer generation scenarios (RCPs) are being used to drive global climate simulations and maintaining internal consistency would suggest an embrace of these scenarios. Yet a third option is the SSPs, which are designed to better link to mitigation and adaptation decision making. It would be helpful to determine how much these scenarios overlap in the population dimension so that equivalencies can be determined. Developing such a crosswalk would be a useful first step in understanding which global scenario is preferable for a given purpose.

Another important issue related to the first question is how population information is to be passed from global models to national, state, and county levels—i.e., how “tight” linkages should be across geographic scales. One approach would be to hard-link national population totals only and let sub-national models distribute population across the landscape without further guidance from global scenarios. A second approach would go further and use “soft” linkages from global

scenarios to guide the spatial distribution of populations or to adjust demographic components of change. The ICLUS projections are an example of such soft linkages. This approach could be further augmented by developing relationships between global scenarios and localized features not captured in a global setting. How information from global scenarios informs national, state, and county projections (i.e., through hard and soft linkages) has implications for how uncertainty is characterized. There are also path independence issues to overcome. It is important to note that not everything needs to be carried across from global scenarios in order for it to be consistent with U.S. scenarios.

## **6. Next Steps: Moving Forward with U.S. Demographic Change Scenarios**

U.S. population scenarios would improve the ability of USGCRP to inform ongoing climate impacts research, both Integrated Assessment models and Impacts, Adaptation and Vulnerability models, the National Climate Assessment, and decision making at all levels of government and in the private sector. Such scenarios could also form the basis of quantitative projections using demographic and other modeling techniques.

Workshop participants offered many suggestions for moving a USGCRP scenario enterprise forward. These largely fell in three main categories: 1) Adopt measures to improve data coordination and integration, 2) conduct research and develop methods, and 3) develop U.S. population scenarios.

### **Adopt Measures to Improve Data Coordination and Integration**

- A. Inventory and evaluate existing datasets (e.g., ACS) and observations to determine how they might be deployed to support development of spatially explicit population scenarios for the United States. A robust data collection effort is necessary for the development of high-quality population forecasts. The evaluation should include a characterization of data availability, strengths, and limitations as well as identification of significant data gaps.
- B. Develop coordinated information networks around demographic and key non-demographic factors, such as regional economics, income, environmental amenities, density/congestion, public policies, and housing markets.
  1. Coordinate data collection: Collect data contemporaneously for demographic and non-demographic factors, with the goal of collecting comparable data that can be pooled efficiently.
  2. Standardize metadata protocols: Standardize summary information and put datasets into context in order to facilitate research on important relationships.
  3. Make geospatial population data available in consistent data formats: Developing gridded data for demographic and non-demographic data would facilitate integrated research.

- C. Educate users and developers of demographic scenarios about the current levels of uncertainty in data spanning various spatial, temporal, and demographic detail dimensions.
- D. Reach outside of traditional USGCRP communities to demographers and state and local planners. An ongoing dialog would inform both groups about the feasibility and utility of scenario approaches.

### **Conduct Research and Develop Methods**

- A. Develop an MIP to compare national-scale spatially explicit projection methods including Proportional Scaling, Trend Extrapolation, Cohort- Component/Economic hybrids, Gravity-based, and Cohort Component/Gravity-based hybrids.
  - MIP should also compare against historical data and against aggregate projections.
- B. Conduct a "bake off" between alternative approaches to allocate populations at sub-county levels, such as the distributive housing unit method, various extrapolation techniques, multiple regression (knowledge-based) approaches, cohort-change ratios methods (e.g., Hamilton-Perry), integrated land use models, and grid cell extrapolation.
- C. Conduct basic research to discover generalizable relationships between non-demographic variables and how they influence population size/composition/distribution over time.
  - ACS could be important for the development of this knowledge.
- D. Improve methods to understand the dynamics of U.S. migration between regions, states, counties, and sub-county areas.
- E. Explore a hierarchical approach (i.e., adaptive mesh) for developing population projections with scale-appropriate population characteristics.
  - Investigate city growth approaches/detailed agent-based modeling to determine whether they can be scaled up to larger geographic areas.
- F. Investigate the utility of new data sources, such as social media, "big data," and remotely sensed data, for observing, understanding, and projecting population.
- G. Explore how climate change impacts, especially disruptive events, can be incorporated into demographic scenarios and projections. Direct effects, behavioral responses (i.e., secondary effects), and indirect effects from teleconnections should be evaluated.

### **Develop U.S. Population Scenarios**

- A. Evaluate the Representative Concentration Pathways and Shared Socioeconomic Pathways to determine their utility for a U.S. scenario enterprise. Evaluation should include comparisons with previous global scenario efforts (e.g., IPCC Special Report on Emissions Scenarios, Millennium Ecosystem Assessment) to identify similarities and points of divergence at national, regional, state, and county levels.
- B. Engage demographers in developing national, spatially explicit population scenarios.
- C. Focus developmental efforts on a pilot project: U.S. scenarios feeding into the next National Climate Assessment.
  1. Develop alternative scenarios focused on:

- a. Migration between regions (e.g., migration between the Northeast and Southwest regions) and among states. These scenarios can be used to explore “what if” situations that are of particular interest to regional stakeholders.
  - b. Urban development patterns (e.g., urban infill, dispersion to exurban and rural areas, consolidation of suburban centers).
2. Work with end users/local governments to ensure top-down, demographically driven, spatially explicit population scenarios can be merged with participatory, bottom up scenarios that can incorporate detailed, localized data (e.g., zoning changes, housing development, and tax rates/assessments).

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## **Appendix A: Committees**

### **Scientific Steering Committee (SSC)**

Brian O'Neill (Chair), *National Center for Atmospheric Research*

Deborah Balk, *CUNY Institute for Demographic Research*

Budhendra Bhaduri, *Oak Ridge National Laboratory*

Roger Hammer, *Oregon State University*

Ken Johnson, *University of New Hampshire*

Mark Montgomery, *Stony Brook University/Population Council*

Richard Moss, *Joint Global Change Research Institute, Pacific Northwest National Laboratory/University of Maryland*

### **Federal Coordinating Group (FCG)**

Anne Grambsch (Co-Chair), *U.S. Environmental Protection Agency*

Bob Vallario (Co-Chair), *U.S. Department of Energy*

Thomas Cuddy, *U.S. Department of Transportation*

Philip Morefield, *U.S. Environmental Protection Agency*

Libby White, *U.S. Department of Energy*

### **U.S. Global Change Research Program Scenarios and Interpretive Science Coordinating Group**

Bob Vallario (Co-chair), *U.S. Department of Energy*

Linda Langner (Co-chair), *U.S. Department of Agriculture Forest Service*

Susan Aragon-Long, *U.S. Global Change Research Program*

Virginia Burkett, *U.S. Department of the Interior Geological Survey*

Alison Delgado, *U.S. Global Change Research Program/Joint Global Change Research Institute*

Dave Easterling, *National Oceanic and Atmospheric Administration*

Anne Grambsch, *U.S. Environmental Protection Agency*

John Hall, *U.S. Department of Defense*

Allison Leidner, *National Aeronautics and Space Administration*

Fred Lipschultz, *U.S. Global Change Research Program*

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### **ICF International (ICFI) Production Team**

Anne Choate

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Tara Hamilton

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Marybeth Riley-Gilbert

Dana Spindler

Frances Sussman

## **Appendix B: Workshop Agenda**

### **Towards Scenarios of U.S. Demographic Change**

Hilton Washington DC/Rockville Hotel & Executive Meeting Center

1750 Rockville Pike, Rockville, MD 20852

June 23–24, 2014

#### ***Overview and Objectives***

The purpose of this workshop is to assess key factors involved in the production of long-term scenarios of U.S. demographic change for use in interdisciplinary analysis of social and environmental issues. The workshop will identify key user needs for demographic information; assess observational, data, and modeling capabilities to produce such long-term projections; and consider the relevance of non-demographic factors and global context for U.S. demographic change.

The workshop is intended to bring together a group of experts from different backgrounds. Anticipated outcomes are focused on improving our understanding of:

- Key user needs for population scenarios, in order to guide the scenario production effort,
- Feasibility of producing projections of various population characteristics and geographic scales, limitations and opportunities in terms of data and methods, and
- Pros and cons of linking U.S. scenarios to global scenario exercises, consider what other socioeconomic factors would be important to demographic projections, and recommend process for carrying forward the U.S. scenarios activity.

#### ***Day 1: June 23, 2014***

##### ***I. Monday a.m.: Welcome and overview (11:00–12:00)***

***Session Chair: Richard Moss, Joint Global Change Research Institute, DOE Pacific Northwest National Laboratory***

**11:00–11:10 Welcome and USGCRP perspective** (Bob Vallario, U.S. Department of Energy)

**11:10–11:20 Welcome, meeting goals, overview of agenda** (Brian O’Neill, National Center for Atmospheric Research – NCAR)

**11:20–11:40 Overview of use of population projections in global and environmental change applications** (Brian O’Neill, NCAR)

**11:40–12:00 Overview of challenges in projecting demographic change** (Deborah Balk, Baruch College/ The City University of New York – CUNY )

**12:00–1:00 Lunch**

***II. Monday p.m.: User needs (1:00–5:30) Session Chair: Mark Montgomery, Population Council***

*Session goal: Understand key user needs for population scenarios, in order to guide the scenario production effort.*

***1:00–3:00 Plenary Talks***

**1:00–1:30 An initial view on user needs from a state demographer** (David Egan-Robertson, University of Wisconsin-Madison)

**1:30–2:00 Use of population projections in climate change impacts and vulnerability research** (Ben Preston, Oak Ridge National Laboratory)

**2:00–2:30 Population scenarios to inform predictive health models of climate change impacts** (John Balbus, U.S. Department of Health and Human Services)

**2:30–3:00 Break**

**3:00–4:30 Breakout session: user needs**

**Group 1 Chair:** Anne Grambsch, U.S. EPA

**Group 2 Chair:** Richard Moss, Joint Global Change Research Institute

**Group 3 Chair:** Budhu Bhaduri, ORNL

**Key questions to address:**

What characteristics of population, spatial/temporal scales, and types of scenarios are most important to users, and for what purpose?

1. **Population characteristics:** size, age, sex, urban/rural, income, education, etc.
2. **Spatial scales of interest:** national, state, county, grid, eco-region, etc.
3. **Temporal scales of interest:** <1 year, 10 years, 50 years, 100 years, etc.
4. **Types of scenarios:** central/business as usual, extreme outcomes, types of variants, uncertainties that are important to cover, etc.

***4:30–5:30 Report back to plenary***

***Day 2: June 24, 2014***

***III. Tuesday a.m.: Methods and data (8:30–12:00) Session Chair: Budhu Bhaduri, DOE Oak Ridge National Laboratory***

*Tuesday a.m. session goal: Understand feasibility of producing projections of various population characteristics and geographic scales, limitations and opportunities in terms of data and methods.*

**8:30–10:00 Plenary Talks**

**8:30–9:00 Approaches to projections for states and smaller regions** (Stan Smith, University of Florida)

**9:00–9:30 Spatial projections of housing units with the ICLUS model** (Dave Theobald, Conservation Science Partners)

**9:30–10:00 Data challenges for spatial population projections** (Bryan Jones, The City University of New York – CUNY)

**10:00–10:30 Break**

**10:30–12:00 Breakout session: methods and data**

- Group 1: Focused on consistency across scales – Chair: Roger Hammer, Oregon State University
- Group 2: Focused on urban community considerations – Chair: Deborah Balk, Baruch College/CUNY
- Group 3: Focused on rural community considerations – Chair: Ken Johnson, University of New Hampshire

**Key questions to address:**

- 1. What approaches to projections at sub-national scales are available or on the horizon?**
- 2. What are the key challenges to producing projections for different population characteristics, and spatial/temporal scales?**
- 3. Given user needs, what types of projections appear to be feasible and most likely to meet those needs?**

**12:00–1:00 Lunch**

***IV. Tuesday p.m.: Global and societal context (1:00–5:15) Session Chair: Deborah Balk, Baruch College/ The City University of New York***

*Tuesday p.m. session goal: Understand pros and cons of linking U.S. scenarios to global scenario exercises, consider what other socioeconomic factors would be important to demographic projections, and recommend a process for carrying forward the U.S. scenarios activity.*

**1:00–1:45 Report back from morning breakouts**

- 1:45–3:00**     *Plenary talks*
- 1:45–2:00**     **Overview of global scenarios and the new climate change scenario process**  
(Brian O’Neill, NCAR)
- 2:00–2:20**     **Demographic components of the new societal scenarios for climate change research** (Leiwen Jiang, NCAR)
- 2:20–2:40**     **Determinants of U.S. national population change** (Steve Murdock, Rice University)
- 2:40–3:00**     **Determinants of U.S. regional population change** (Mark Partridge, Ohio State University)
- 3:00–3:30**     **Break**
- 3:30–4:30**     **Breakout session: global and societal context** – addressing the questions below, each taking a different one as a starting point.  
**Group 1 Chair:** Mark Montgomery, Population Council  
*How important would it be to have U.S. population scenarios that are consistent (in some way) with global scenarios? What global scenarios might it be useful for U.S. scenarios to be consistent with? What forms of consistency are possible and appropriate?*  
**Group 2 Chair:** Brian O’Neill, NCAR  
*What non-demographic factors would be most important to consider in producing demographic scenarios?*
- 4:30–5:15**     **Report back to plenary**
- V. Closure: Workshop Synthesis*  
*Session Chair: Brian O’Neill, National Center for Atmospheric Research*
- 5:15–6:00**     **Synthesis of meeting recommendations and discussion of possible next steps**



## **Appendix C: List of Participants**

**Susana Adamo**, CIESIN – Columbia University

**Susan Aragon-Long**, U.S. Global Change Research Program

**John Balbus**, NIEHS

**Deborah Balk**, CUNY Institute for Demographic Research

**Budhendra Bhaduri**, Oak Ridge National Laboratory

**Britta Bierwagen**, U.S. Environmental Protection Agency

**Eddie Bright**, Oak Ridge National Laboratory

**Brigitte Brunelle**, U.S. Department of Defense

**Tess Carter**, U.S. Global Change Research Program

**Guangqing Chi**, South Dakota State University

**Steven Carter Christopher**, National Geospatial–Intelligence Agency

**John Coulston**, USDA Forest Service

**John Cromartie**, Economic Research Service, USDA

**Thomas Cuddy**, U.S. Department of Transportation

**Alex de Sherbinin**, CIESIN, Columbia University

**Alison Delgado**, USGCRP / PNNL

**David Easterling**, NOAA/National Climatic Data Center

**David Egan-Robertson**, UW-Madison Applied Population Lab

**Ilya Fischhoff**, U.S. Global Change Research Program

**Gerald Geernaert**, U.S. Department of Energy

**Bryce Golden-Chen**, U.S. Global Change Research Program

**Anne Grambsch**, U.S. Environmental Protection Agency

**Elizabeth Grieco**, U.S. Census Bureau

**Philip Groth**, ICF International

**John Hall**, U.S. Department of Defense

**Linda Jacobsen**, Population Reference Bureau

**Cory Jemison**, ICF International

**Leiwen Jiang**, National Center for Atmospheric Research

**Ken Johnson**, University of New Hampshire

**Bryan Jones**, CUNY Institute for Demographic Research

**Mike Kuperberg**, U.S. Department of Energy

**Linda Langner**, U.S. Forest Service

**Allison Leidner**, NASA Earth Science  
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**Fred Lipschultz**, U.S. Global Change  
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**David McGranahan**, USDA Economic  
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**Mark Montgomery**, Stony Brook  
University/Population Council

**Phil Morefield**, U.S. Environmental  
Protection Agency

**Richard Moss**, Joint Global Change  
Research Institute

**Steve Murdock**, Rice University

**Brian O'Neill**, NCAR/IAM Group

**Mark Partridge**, Ohio State University

**Marc Perry**, U.S. Census Bureau

**Benjamin Preston**, Oak Ridge National  
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**Robert Scardamalia**, RLS Demographics,  
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**Adria Schwarber**, University of Maryland

**Stan Smith**, University of Florida

**Steve Smith**, Joint Global Change Research  
Institute

**Dave Theobald**, Conservation Science  
Partners

**Robert Vallario**, U.S. Department of  
Energy

**Stephen Verzi**, Sandia National  
Laboratories

**Chris Weaver**, OSTP/ USGCRP

**Libby White**, U.S. Department of Energy –  
BER

## Appendix D: Summary of Findings from Workshop Background Research

Prior to the workshop, a review was conducted to identify the uses of population projections by federal government agencies. This revealed which agencies used the projections and what type of projections were favored by those agencies. Through this review, several key roles for population projections emerged.

### *Federal Government Users of Population Projections*

A wide variety of users of population projections exist within the federal government. A review of federal agencies revealed 22 agencies and 52 projects that use long-range population projections—defined as projections to 2030 or beyond. Presumably many of these agencies would benefit from the development of U.S. demographic scenarios. Table D-1 provides a breakdown of the number of projects by agency.

**Table D-1. Users of population projections within the federal government**

Federal Agency	# of Projects	Example Use for Agency
Department of Energy (DOE)	7	Forecasting motor vehicles on a county basis to look at electricity demand from electric vehicles.
Environmental Protection Agency (EPA)	6	Determining the risk of water stress for certain regions.
Health & Human Services (HHS)	5	Health implications for an aging and more diverse nation.
Department of Interior (DOI)	4	Predicting future land use and land cover change.
Department of Commerce (DOC)	3	Human impacts and vulnerabilities of growth on the coast.
Department of Transportation (DOT)	3	Growth of traffic in the gulf coast region.
Department of Housing and Urban Development (HUD)	3	Need for future affordable housing near transit for an aging population.
National Aeronautics and Space Administration (NASA)	3	Land use planning and resource management for urban development.
U.S. Department of Agriculture (USDA)	3	Forecasting changes in southern forests.
Social Security Advisory Board (SSAB)	2	Examining the solvency of Social Security.
Congressional Budget Office (CBO)	2	Projecting long-term government revenues and expenditures.
Social Security Administration (SSA)	1	Examining the solvency of Social Security.
U.S. Geological Survey (USGS)	1	Examining the effects of future development on sub-basin stream flows.
Congressional Research Service (CRS)	1	Showing how shifts in future population demographics will shape economic and social forces.
Tennessee Valley Authority (TVA)	1	Forecasting electricity demand.
Susquehanna River Basin Commission (SRBC)	1	Forecasting water demand.

Federal Agency	# of Projects	Example Use for Agency
Government Accountability Office (GAO)	1	Projecting the number of people turning 65 each year and budget implications.
Department of Treasury (DOT)	1	Examining an aging population's effects on national spending and debt.
Department of Veterans' Affairs (VA)	1	Projecting veteran population trends in different geographical regions.
Department of Homeland Security (DHS)	1	Evaluate impact of climate change and population growth on the National Flood Insurance Program (NFIP).
Bureau of Labor Statistics (BLS)	1	Examining the size and demographic make-up of the future labor market.
Federal Aviation Administration (FAA)	1	Projecting passenger demand for aviation services.
<b>Total (22 agencies)</b>	<b>52</b>	

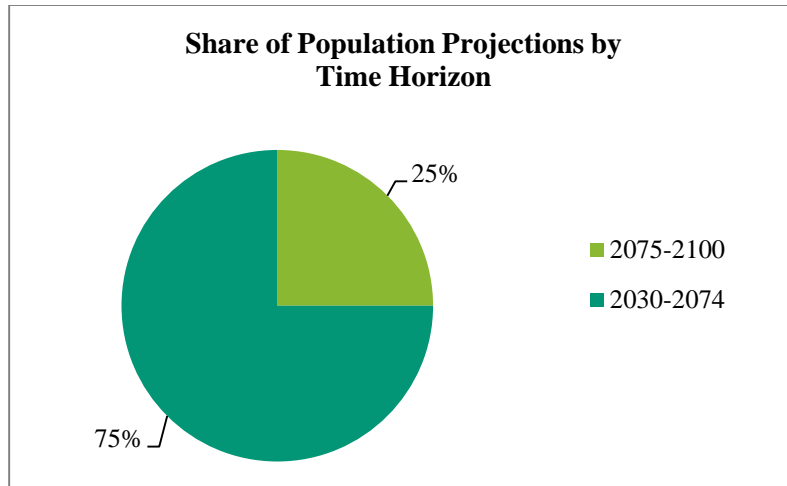
Although the review reveals that a wide range of agencies use population projections, suggesting that the uses and needs may vary; several recurring themes cut across multiple agencies. Population projections are important for the following tasks:

- Determining impacts on the Federal budget (primarily Social Security and Medicare)
- Projecting natural resource demand
- Understanding the impacts on land use and land cover
- Evaluating climate change impacts

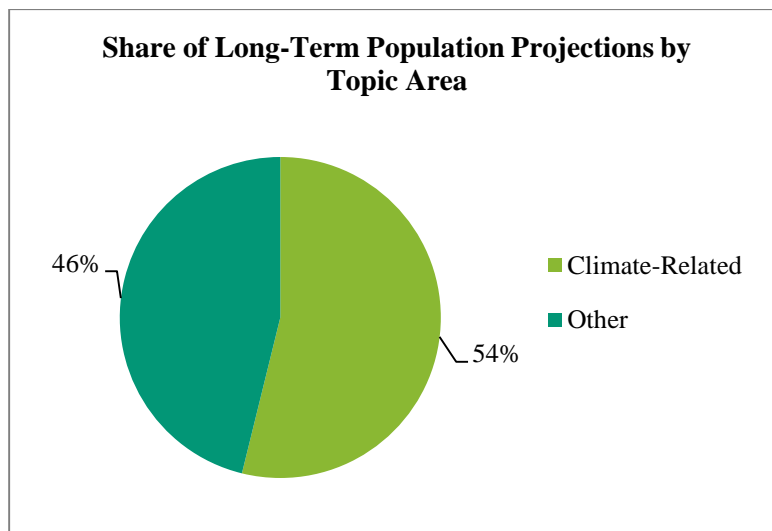
***Length of Projections***

For the purpose of the review, long-term projections were considered those that extended to 2030 or beyond. The longest projections of the projects assessed went to 2100, which included a wide variety of projects including the Department of Energy’s Climate Change War-Games, the ICLUS model, the National Climate Assessment, and the Social Security Advisory Board’s assessment of the Impact of Immigration on Social Security and the National Economy.

The State Centers and U.S. Census Bureau’s State Population projections go out to 2030. Of the projects assessed, many of the shorter projections (2025–2030) had a state or local focus that relied on these data sources. An example of a locally focused with a shorter-term projection is the U.S. Geological Survey’s report on the Simulated Effects of Year 2030 Water-Use and Land-Use Changes on Streamflow for Eastern Massachusetts. As the figure below shows, three-quarters of the remaining projects assessed included projections that ended between 2030 and 2074. The other projects included projections out to 2075 to 2100.

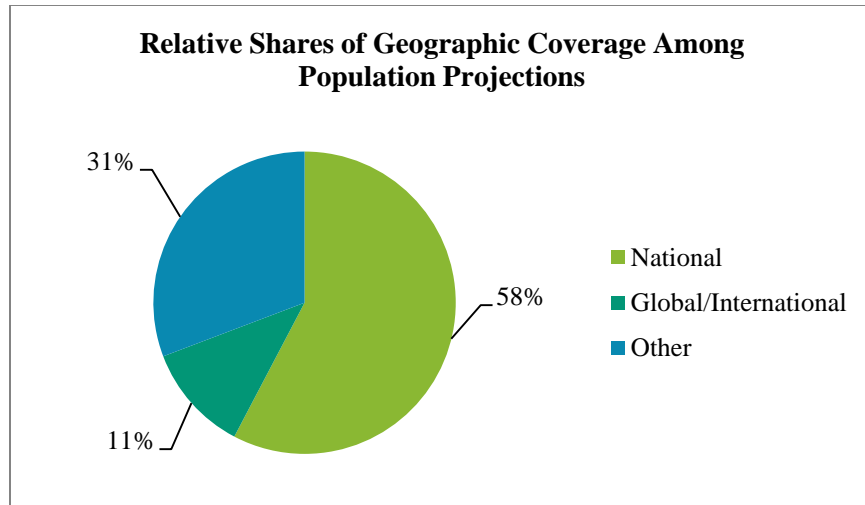


As the figure below shows, a slight majority (54%) of the long-term projections (2075–2100) were used in climate change–related models or projects. The remaining 46% of projects that used long-term projections involved analysis of the Federal budget with respect to Social Security, an aging population, and immigration.



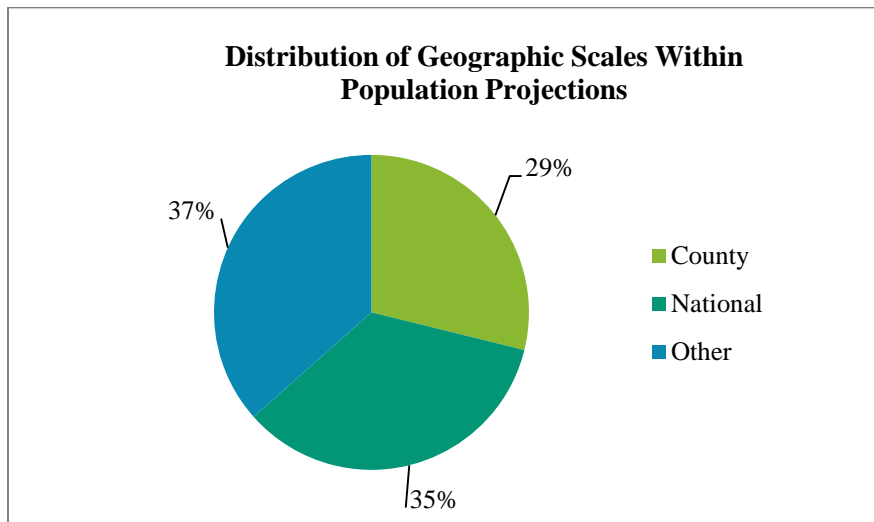
***Geographic Scope***

A significant majority (58%) of the projects assessed used national-level population projections. Only 11% of the projects used a global scope. The remaining projects used local level, regional scale, or land area (e.g., GIS model relying on satellite imaging) projections.



***Geographic Scale***

The distribution of projections showing population growth on large and small scales was evenly distributed. Just under 30% of the projections quantified results on a county-level scale, despite being national, regional, or local in scope, whereas 35% of the projections provided results at a national scale.



The remaining projects used a mix of scales including land area, state, census tract, or project-specific regions.

***Underlying Source Data***

Almost two-thirds (69%) of projects assessed either drew solely on data from the U.S. Census Bureau or the U.S. Census Bureau in conjunction with another data source to underpin their projections. State- or local-level projects use State Data Centers for population projections. The remaining population baseline data came from a variety of sources, including international data sources, state and local data sources and project-specific survey data.