ARTICLE CASE

Engaging Regional Stakeholders in Scenario Planning for the Long-Term Preservation of Ecosystem Services in Northwestern Virginia

IARA LACHER[1], THOMAS AKRE[1], WILLIAM J. MCSHEA[1], MARISSA MCBRIDE[2], JONATHAN R. THOMPSON[3] AND CRAIG FERGUS[1]

[1]Smithsonian Conservation Biology Institute, Front Royal, VA, USA, [2]Centre for Environmental Policy, Imperial College London, London, England, UK, [3]Harvard Forest, Petersham, MA, USA
Email: LacherI@si.edu

ABSTRACT This case study describes the application of a framework for developing stakeholder-driven scenarios of the future. The purpose of these scenarios is to inform land use planning toward the protection of ecosystems and derivable ecosystem services in Northwestern Virginia. We held two scenario development workshops with regional experts in conservation, agriculture, land use planning, policy, and economic development to create scenarios of land use in the northern Piedmont and northern Shenandoah Valley of Virginia. We structured the workshops around a framework that guided stakeholders through several steps eventually resulting in four unique scenarios describing the region in 50 years. Scenario narratives were defined by the intersection of highly influential and uncertain drivers of change relevant to land use planning and ecosystem services. Participants from the northern Shenandoah Valley region selected population growth and climate change adaptation as their scenario defining drivers, while participants from the northern Piedmont region selected planning strategy and climate change impact as their scenario defining drivers. Participants fleshed out scenarios into descriptive narratives that incorporated qualitative and quantitative measures of change. Details from the scenario narratives informed land use change models to further quantify tradeoffs between land use planning decisions and ecosystem services. Individuals interested in using scenario planning to guide research efforts, conservation, or land use planning, or even to broaden perspectives on how to view the future, will find value in this case study.

INTRODUCTION

Scenario planning is an approach that uses alternate visions of the future to guide strategic long-term planning. This case study describes the framework for phase 2 of the scenario planning process, that is, scenario development. We present an example of scenario development completed by regional stakeholders, in which the ultimate purpose is to inform land use planning efforts that would contribute to the preservation of ecosystem services. Additionally, the process outlined in this case study can serve as a framework adaptable for alternative purposes. This case study is directed toward professionals or graduate students with some prior knowledge or experience in scenario planning, conservation or land use planning, and interdisciplinary projects.

CASE EXAMINATION

Background

Clean water and air, productive soils, pollination, climate regulation, and flood control are just a few of the many services human societies derive from healthy ecosystems. We depend on these ecosystem services for survival and overall well-being, and yet globally, opportunistic land use practices destroy or degrade ecosystems until their function ceases to provide these essential services. As our footprint on this earth rapidly grows, so does the need for strategic conservation-oriented land use approaches.

Traditional planning approaches are based on historic trends and consider multiple possibilities for action, but they are restricted in their focus to the most predictable (probable) outcomes. However, the future is rarely a simple reflection of past trends. Improbable events do happen,

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and if we do not consider them as a possibility and plan accordingly, we may be left woefully unprepared [1].

The scenario planning approach utilizes scenarios, or storylines, that provide alternative views of the future. These scenarios are created by the same decision makers they intend to serve. The development of scenarios involves careful consideration of how known agents of change, or drivers, influence present conditions. However, scenario planning is not about predicting the future. Scenarios should represent multiple futures bounded by plausible extremes. The practice of envisioning futures and connecting known drivers of change to the range of their possible influences on the future prompts participants to question their assumptions about the future, improving our ability to prepare for improbable yet potentially highly impactful events [2]. By considering multiple scenarios of the future, scenario planning can help us understand the long-term outcomes of decisions that we make today, improving our ability to create desired futures. This is necessary to promote successful long-term planning, especially in complex or dynamic environments [3].

Scenario planning was originally developed by the United States military and later adopted by the business sector,[1] but it is increasingly employed across a host of other fields, including the environmental sciences. Environmental problem solving is inherently complex, requiring the consideration of ecological and socioeconomic influences, the needs of multiple and diverse actors, and uncertain and potentially devastating outcomes of our choices. The flexible nature, ability to account for improbable outcomes, and input from decision makers and stakeholders make the scenario planning process uniquely suited for environmentally focused planning efforts [1]. For example, precedent has been set in the use of scenarios for guiding land use change models [3, 6], species distribution models [7], climate change [8], impacts to biodiversity [9], management strategies for the protection of intertidal reefs [10], freshwater governance [11], and the future of ecosystem services at both local [12] and global scales [13]. The involvement of experts and decision makers in the development of scenarios is integral to ensuring relevance and application in scenario planning [3]. Furthermore, scenarios bolstered by data for historical trends and measured relationships between the drivers are more credible among decision makers and stakeholders [5]. Involving both these constituencies in scenario development can make scenarios more relevant to existing needs, thus further legitimizing the process and increasing the likelihood of integrating scenario-aided guidance into current and future plans [9].

1. Scenario planning first emerged in the years following World War II as a method used by the United States Air Force to imagine actions of opponents [4]. In the 1960s, Herman Kahn, who had been part of the Air Force effort, refined scenarios for use in foretelling financial growth in business. Later, Pierre Wack, in the newly formed department of Group Planning of the London offices of oil company Dutch/Shell used scenarios to identify events that might affect the price of oil. His work at Shell prepared the company for an energy crisis that negatively affected their lesser-prepared competitors, propelling Shell to become the second largest, and arguably most profitable, oil company worldwide [5].

The Changing Landscapes Initiative (CLI)

The CLI is a research-based collaborative program, based in Northwestern Virginia, USA, which aims to guide regional planning efforts toward the long-term preservation of ecosystem services and the underlying systems that sustain them. The CLI originated in 2015 in response to concerns from a handful of regional stakeholders regarding future land use change impacts on ecosystem services, such as clean air and water, recreation, viewsheds, and historical and cultural sites.

The ability of the landscape to provide these ecosystem services is impacted by land use change, which is in turn affected by regional physiography, ecological health, and socioeconomic variables. Changes in total land use area represent only one measure of change. The configuration of these land use changes influences the health (e.g., habitat connectivity, forest quality, and riparian buffers), infrastructure cost (e.g., water access and transportation efficiency), and disaster risk (e.g., flood zones, drought, and fire) of the ecosystem. It is the heightened awareness of these influences that have prompted regional interest in understanding land use change and its impacts on human health and well-being.

Given the unpredictability of long-term land use change and the need for an approach that meaningfully integrates stakeholder feedback, the CLI has adopted scenario planning as an approach. The CLI utilizes scenario planning in a four-phase process (Figure 1). Throughout this process, a highly multidisciplinary group of scientists and stakeholders has contributed their expertise on ecological and socioeconomic issues of regional importance.

Study Area

The Shenandoah National Park (SNP), in the Blue Ridge Mountains of Northwestern Virginia, serves as a geographic focal point for the 17,899 km^2 study area, which includes 15 counties and 5 independent cities (Figure 2).

FIGURE 1. Overview of the scenario planning process. Source: Adapted with permission from Lacher [4].

The study area overlaps portions of the Piedmont, Ridge and Valley, and Blue Ridge ecoregions as well as three subwatersheds (Hydrologic Unit Code 6) that feed into the Chesapeake Bay. This bay is the largest estuary in the United States and is considered to be one of the most productive and species-rich estuaries in the world. The population within the study area totaled 1,096,518 in the 2010 census, with the highest densities located within the independent cities and the stretch of land along the northeastern corner bordering Washington DC and Baltimore. Land cover in the region includes a mix of natural habitat and human land use, the distribution of which is largely driven by topography and elevation. Under most recent available land cover data (2011), over half of the study area is forested [14] and about one-third of that forest is protected under either the SNP or the George Washington National Forest [15]. Forest cover outside these protected lands is patchy and generally of lower quality. Agriculture is the second most abundant land cover class in the study area and is a primary economic driver for much of Virginia [16]. For our purposes, agriculture is represented by the land cover grasses (pasture and herbaceous vegetation), which based on 2011 land cover data covers ~33% of the study area and crop (tilled soils or woody crops), which covers ~5% of the study area [14]. Development (not including open space) is arguably the most impactful land cover class on many ecosystem services. In our study area, development occupies ~7% of the study area and is focused in and around the cities, as well as the westward edge of nearby DC–Baltimore metropolitan areas. There is also valued history in the region in the form of 11 officially recognized Native American tribes and historical sites important to the American Revolution and Civil War.

The population of the region has been increasing steadily, averaging decadal increases of 26% between 1970 and 2010 [17], and is projected to increase by ~620,000 people by the year 2040 [18]. This increase in population will lead to more development in the form of housing, infrastructure, and transportation. Although development does not occupy a large amount of the landscape compared to forest and agriculture, we measured an increase of 17% of total developed area (+22,400 acres) just between the years 2001 and 2011, a trend we expect will continue with higher population numbers. Between 2001 and 2011, this translates into overall losses in private forests (~21,000 acres) and agriculture (~8,000 acres).

Stakeholders

We began soliciting potential stakeholders for this project in the months leading up to the workshops. The stakeholders who initially helped launch the CLI (our core advisory group[2]) provided introductions to our first suite

2. This decision was made based on recommendations from our core advisory group, a collection of four highly knowledgeable and influential

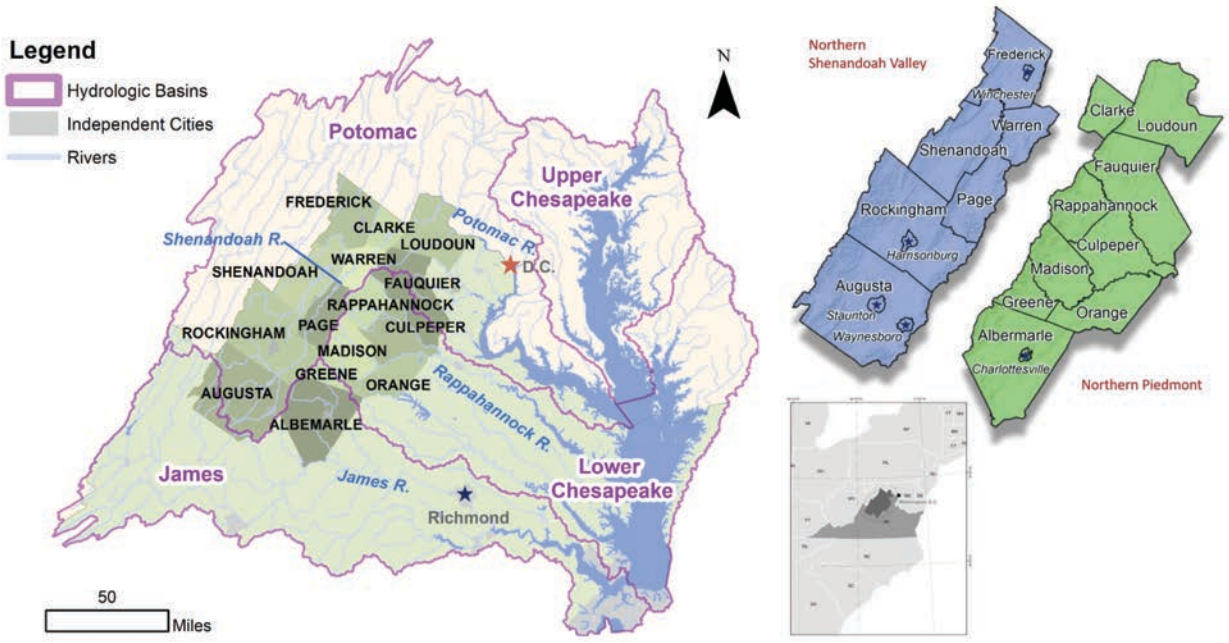

FIGURE 2. The study area in Northwestern Virginia with counties, watersheds, and sub-regional division used to place participants in one of the two workshops: the Valley and the Piedmont.

of contacts, many of them were county and regional planners. We held in-person meetings where we presented our goals for the CLI and listened for feedback on the kind of outcomes that would be useful for their work. We developed additional contacts through these meetings. We purposefully sought out stakeholders who represented a diverse array of expertise (Figure 3, Box 1).

We held two scenario-building workshops in 2016, each representing a subset of the 15 counties,[2] to capture the diversity of values held by stakeholders in the study area. Participants within the northern Shenandoah Valley workshop (hereafter referred to as the Valley; August 25) represented counties that fall primarily west of the Blue Ridge Mountains, while participants in the northern Piedmont workshop (hereafter referred to as the Piedmont; August 30) represented counties east of the Blue Ridge Mountains. Workshop participants included government officials, employees from private sectors, other non-profit organizations, concerned citizens, and volunteers. The workshops benefited from the participants' diverse knowledge and expertise for developing plausible and decision-relevant scenarios of landscape change.

Scenario Development Workshops

Through a series of activities (Sensu 18) outlined below, participants were invited to discuss and explore recent trends in land use, identify and rank driving forces of change, and envision and produce plausible scenarios for their respective regions based on their current understanding of the evolving landscape. While participants were presented with information on their own sub-region (S1 in Supplementary Materials), all questions, activities, and worksheets were the same for both workshops. Participants were divided into four teams with mixed expertise (one for each scenario quadrant; see step 4), within which they collaborated throughout the day.

The day began with an introductory presentation, which provided background information about the CLI and the scenario planning process. These presentations included historical context on the emergence of scenario planning as a method and information specific to the approach of CLI. A historical timeline highlighting significant local and global events over the past 50 years provided participants with a reference for the passage of time.

stakeholders in the region. Members of our core advisory group serve have long been involved in conservation planning in the region. We consult with them for feedback on how to communicate our work to non-scientific audiences, navigate regional politics, and identify respected leaders in the community.

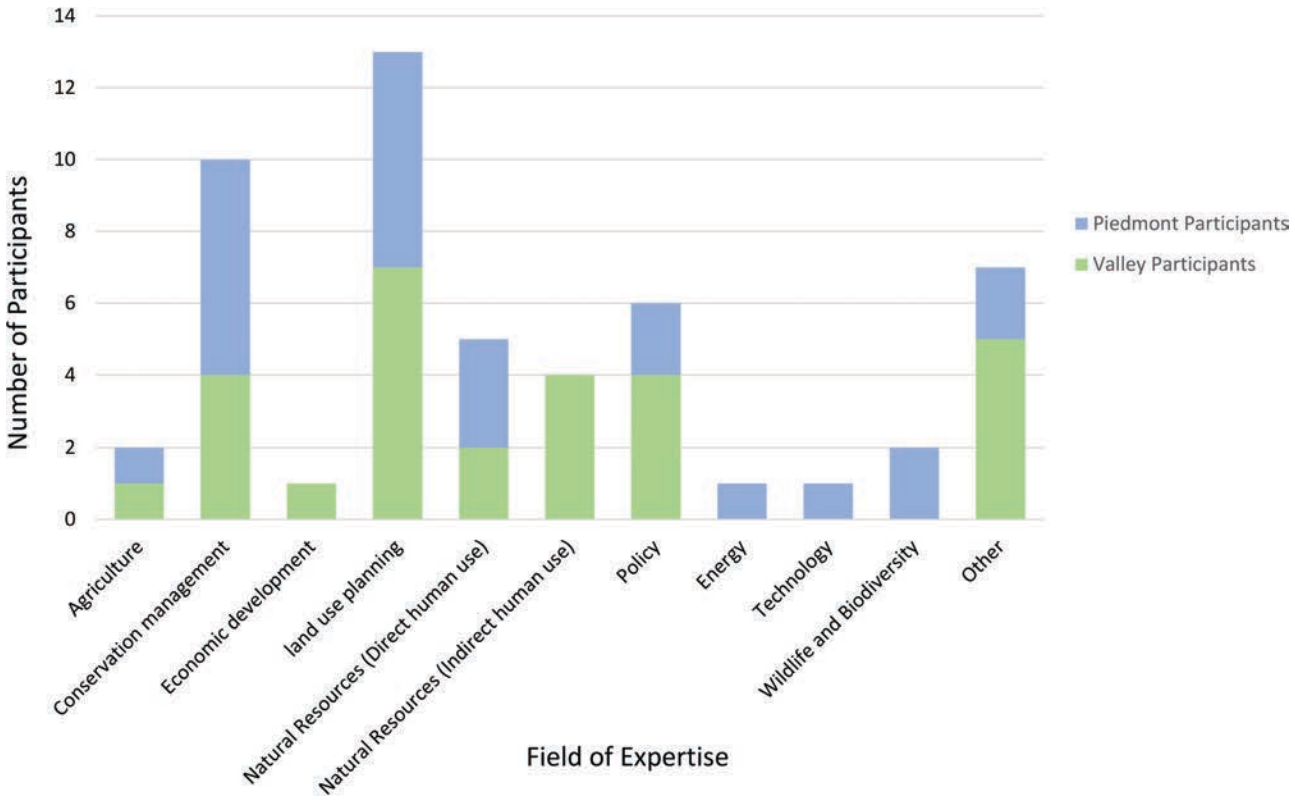

FIGURE 3. Graph displaying the results of a pre-workshop survey question (Box 1) asking participants to identify their area of professional expertise.

BOX 1. Survey questions sent to participants before each workshop.

- What is your primary organization affiliation?
- What do you consider your primary field of expertise?
- Have you ever taken part in a scenario-building exercise before?
- Which geographic scale do you most frequently work in?
- On average, what is the time frame you or your organization frequently plan(s) for?
- What are your opinions about planning for land use change?
- What is the degree to which information and trends from the past, present, and/or expected future would typically weigh in on your decision-making process when developing a long-term oriented strategy?
- What objectives (i.e., goals and aims) would you see as important in guiding a long-term planning process?
- Based on your best understanding of the current situation in the northern Shenandoah Valley or the Piedmont region, estimate the percentage of land that is currently developed, forested, grasses, in agricultural crop production, and held in conservation.
- Estimate plausible future percentages for land uses in the northern Shenandoah Valley or the Piedmont region for the year 2050.
- Which *county*/city do you currently reside in?

We used a short visioning exercise to open the activity portion of the workshop and prime the participants to think imaginatively about the future (S2 in Supplementary Materials). During this exercise, participants were prompted to consider what the future of their landscape might look like and why. Participants were asked to close their eyes and imagine that they were standing on top of a mountain looking out at either the Valley or the Piedmont in 2065. After picturing this landscape in their minds, participants wrote or sketched a description of their vision of the landscape in 50 years. Individual visions of the year 2065 varied greatly between the participants, with varying degrees of optimism for the future (Figure 4). Many participants stated that they did not believe very much change would occur within the next 50 years.

The remainder of the day focused on the scenario development process (Figure 5). Activities became progressively more collaborative from step 1 to step 6 as outlined in Figure 5.

THE SCENARIO DEVELOPMENT PROCESS

Step 1: Brainstorm Drivers To begin the process of building scenarios, participants were asked to individually think openly and develop a list of drivers of change[3] (Table 1). We provided a worksheet for capturing external factors within the categories of Social, Technological, Economic, Environmental, and Political (STEEP; Table 2). Each participant completed a worksheet listing drivers of change within each STEEP category, focusing on drivers that were likely to influence land use, specifically development, agriculture, forest, and conservation (Table 2).

Step 2: Describe Causal Chain Acting individually, participants selected two drivers across the different STEEP categories that they considered to be the most uncertain and impactful. They then described the impacts of these two drivers and outlined a causal chain to explicitly link each driver to impacts (Figure 6). This activity was used to help to clarify their view of the cause and effect relationships for each driver.

Step 3: Prioritize Drivers Participants shared their individually selected top two drivers of land-use change with their teammates and, as a team, selected the three drivers from different STEEP categories that they considered to be the most uncertain and impactful. Then, each team worked to define poles describing the extreme ends of each driver. Poles needed to be clearly defined and divergent, with a difference large enough to result in diverse futures. Teams recorded each driver and its associated poles onto a sticky note in preparation for the next step.

Step 4: Choose Scenario Logic Using a self-selected team spokesperson, teams described each of the three drivers and their associated diverging poles for all participants at the workshop. They then placed each sticky note with the driver written on it onto a scale of impact and uncertainty. Each subsequent team ranked their drivers on the same scale of impact and uncertainty in reference to all previously placed drivers, assisted by other participants across all teams. Once all teams presented and ranked their drivers, facilitators selected 3–4 drivers that were collectively ranked high for both impact and uncertainty and created 2–3 large scenario matrices (see Box 2 for definition) with clearly defined drivers and poles.[4] These matrices represented all possible arrangements of each driver and pole combination (e.g., Driver 1 vs Driver 2, Driver 2 vs Driver 3, and Driver 1 vs Driver 3). Participants then voted for their preferred matrix for use in defining four scenarios, and these scenarios would then be the focus of the remainder of the workshop. Each of the four teams was assigned a quadrant of the matrix. The quadrant defined the bounds of their scenario and governed their narrative process. The Valley workshop settled on the drivers and two poles of high or low/stable regional population growth and successful/unsuccessful adaptations to climate change (Figure 7). The Piedmont workshop settled on the drivers and two divergent poles of strategic/ad-hoc planning and minimal/severe impact of climate change (Figure 8).

Step 5: Write Scenario Narrative The narrative building process is designed to bring each team's scenario to life. We prompted participants to describe what life in their scenario would be like, suggesting that they incorporate

3. This is not the first time we brainstormed drivers for this region. In October 2015, we convened a group of regional and national scientists and resource experts for a two-day meeting to identify information relevant to measuring land use impacts. This "Science Advisory Meeting" resulted in a list of regionally significant drivers of change as well as ecosystem services and metrics for measuring ecosystem health and human well-being. We used these lists to direct data collection (mostly from online sources) between the years 2001 and 2011. We presented this as "data" in the form of maps and basic calculations derived as guidance for step 6, Inhabiting Scenarios.

4. In practice, this step was slightly different between the two workshops. This is because, during the first workshop (the Valley), there was much confusion regarding what constituted clear, divergent poles and long discussions between participants offered little clarification. Therefore, for the Piedmont workshop, instead of open discussion, facilitators selected drivers for the creation of scenario matrices. This also allowed more time in the afternoon for the remainder of the steps.

a

"More invasive plant species, loss of endangered species, peppered lights, manicured main streets, elimination of sky night views, more haze"
"Air quality is clear, farmland has grown, solar panels glint in the sun off the roofs of buildings, and hawks and turkey vultures fly above catching thermals, though they do need to avoid the drones"
"The patterns of land use across the landscapes are largely unchanged compared to historic photos from 2016"
"I see larger cities, but less light pollution; taller buildings, more dense development; people still in vehicles, but self-driving, so traffic is flowing more evenly with fewer traffic jams; more trees, less grass as we look to conserve water and fight climate change; agriculture that is more diverse, using land more conservatively—growing more on less land, growing up and inside"

c

"Productive, rain-fed agriculture that supports nearby population centers (DC, Baltimore, Charlottesville, Northern Virginia)"
"No fossil fuel exhaust haze, extensive solar panels"
"Looking down to Winchester and other cities such as Harrisonburg, I envision a smaller, yet just as cramped, New York City: unrestrained development with breaks of green space"
"More sprawl, light pollution, roads, taller buildings, haze"

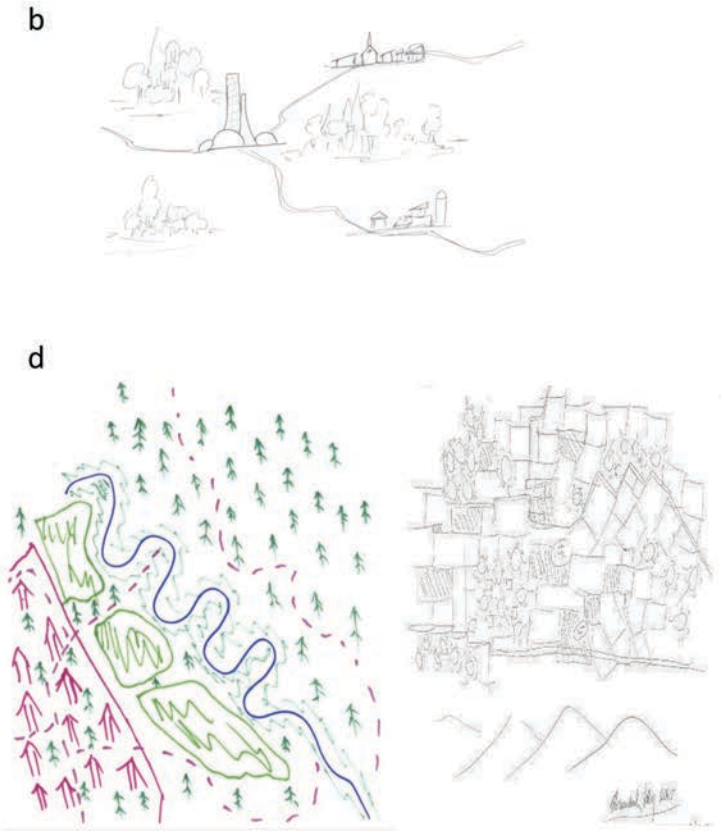

FIGURE 4. Examples of participant visions of the future resulting from the envisioning exercise including descriptions (a) and illustrations (b) from the Piedmont workshop, and descriptions (c) and illustrations (d) from the Valley workshop.

TABLE 1. Drivers brainstormed by participants from each of the two scenario development workshops

Drivers from the Valley workshop	Drivers from the Piedmont workshop
Climate change†	Climate change†
Conservation incentives	Demography
Demography	Economic disparity
Energy development	Energy development
Income	Planning and zoning
Infrastructure development	Political will†
Planning and zoning	Technological innovation
Political stability	Transportation cost
Political will	
Population†	

†Drivers used in the final scenario matrices.

details about society, technology, politics, economy, environment, and well-being. To avoid bias, we communicated the importance of avoiding value-laden terms and stated that they must "live in the scenario, but not necessarily love it." These scenarios were meant to capture a range of possible outcomes, some desirable, some less so, but all equally important in capturing the potential consequences of planning decisions made today. Teams elaborated on

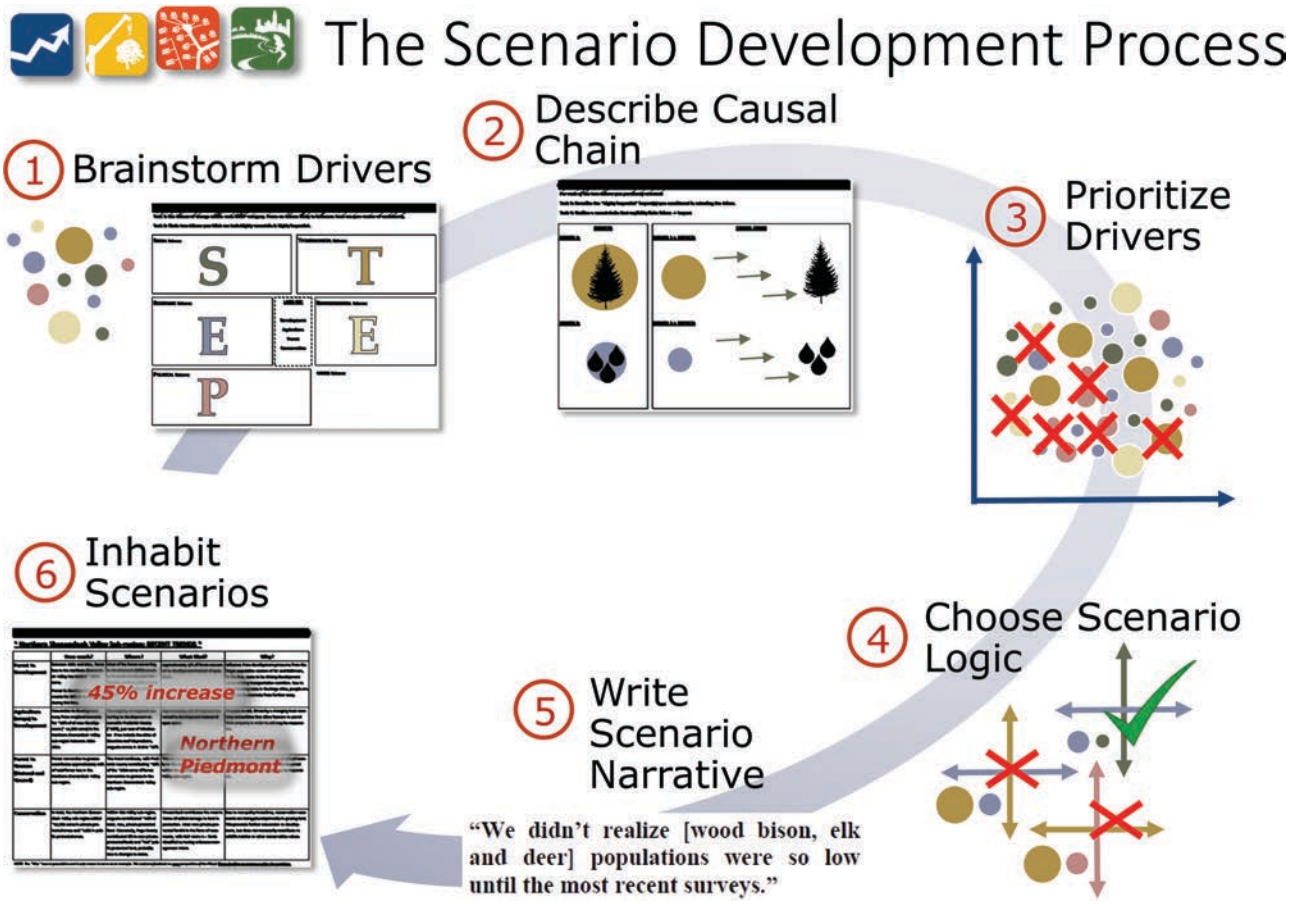

FIGURE 5. Flowchart of the scenario development process used in the workshops. Participants brainstormed drivers of change, created causal links between drivers and impact, ranked these drivers by a scale of impact and uncertainty, selected a scenario matrix of focus, and composed storylines and quantitative estimates of land use change for each scenario. Source: Example scenario narrative from Beach and Clark [19].

TABLE 2. The STEEP framework with broad examples of drivers [20]

Social	Technological	Economic	Environmental	Political
Demography	Innovation	Gross domestic product	Air quality	Laws
Gender roles	Adoption	Industries driving growth	Water quality	Regulations
Ethnicity	Application	Funding	Arable land	Elections
Culture	Business models	Business cycles	Climate change	Power distribution
Tastes			Resources	
Behaviors				
Beliefs				

their assigned scenario by discussing the pros and cons of their scenario and imagining day-to-day life for scenario inhabitants. We also instructed teams to incorporate drivers generated in activities from earlier in the day in development of a vivid narrative of the future of the region. Example narratives were provided to participants [12], and we guided participants to write these as newspaper articles to encourage their imaginative spirit and encourage fun in envisioning the future landscape (S3 in Supplementary Materials).

Step 6: Inhabit Scenarios For the final step, each team was asked to "inhabit" the resulting scenarios. This step links the

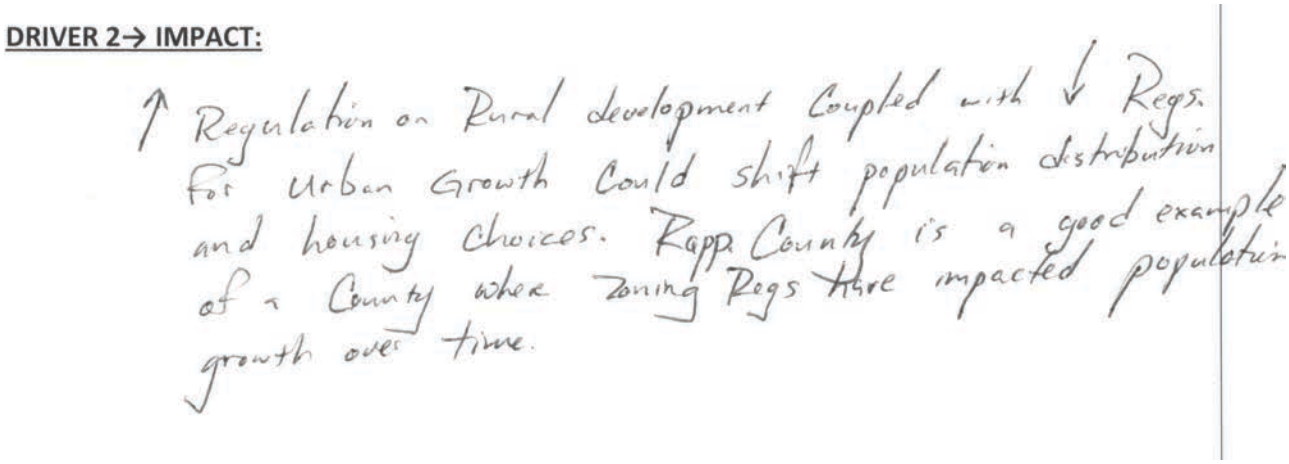

FIGURE 6. Example of a causal chain from the workshop describing the connection between regulations (political driver) and the changing geographic distribution of populations and choice of housing (societal impact). The text reads: "Regulation on rural development coupled with (decreased) regulations for urban growth could shift population distribution and housing choices. Rappahannock County is a good example of a county where zoning regulations have impacted population growth over time."

BOX 2. Definitions of terms provided to participants during scenario development workshops.

Working landscapes: The human contribution to landscapes and ecosystems that provide ecosystem services and market goods, which interact in a mutually beneficial manner.

System: A set of interacting or interdependent components that together form a complex.

Ecosystem: A community of living organisms that interact with each other as well as with non-living components in their environment. A healthy ecosystem is one that efficiently recycles energy and nutrients between living and non-living components.

Ecosystem function: The process of moving energy and nutrients (within the physical environment and between the organisms interacting with each other).

Ecosystem services: Positive outcomes that humans can benefit from due to properly functioning ecosystems. They are divided into four different classes: provisioning, regulating, supporting, and cultural.

Scenario: A possible future state that represents *plausible* conditions under different assumptions. It is not a prediction or forecast, because it is not based on any probabilities. Each scenario is a snapshot of what the future may look like.

Driver: An environmental or human agent that causes an indirect or direct change to one or more ecosystem functions.

Uncertainty: A situation in which there is imperfect or unknown information, and the likelihood of a future outcome is incalculable or indefinite.

Causal relationship: Linkages describing the relationship of cause and effect.

Scenario matrix: The intersection of two perpendicular lines, each representing one driver with divergent poles, which results in four uniquely defined quadrants.

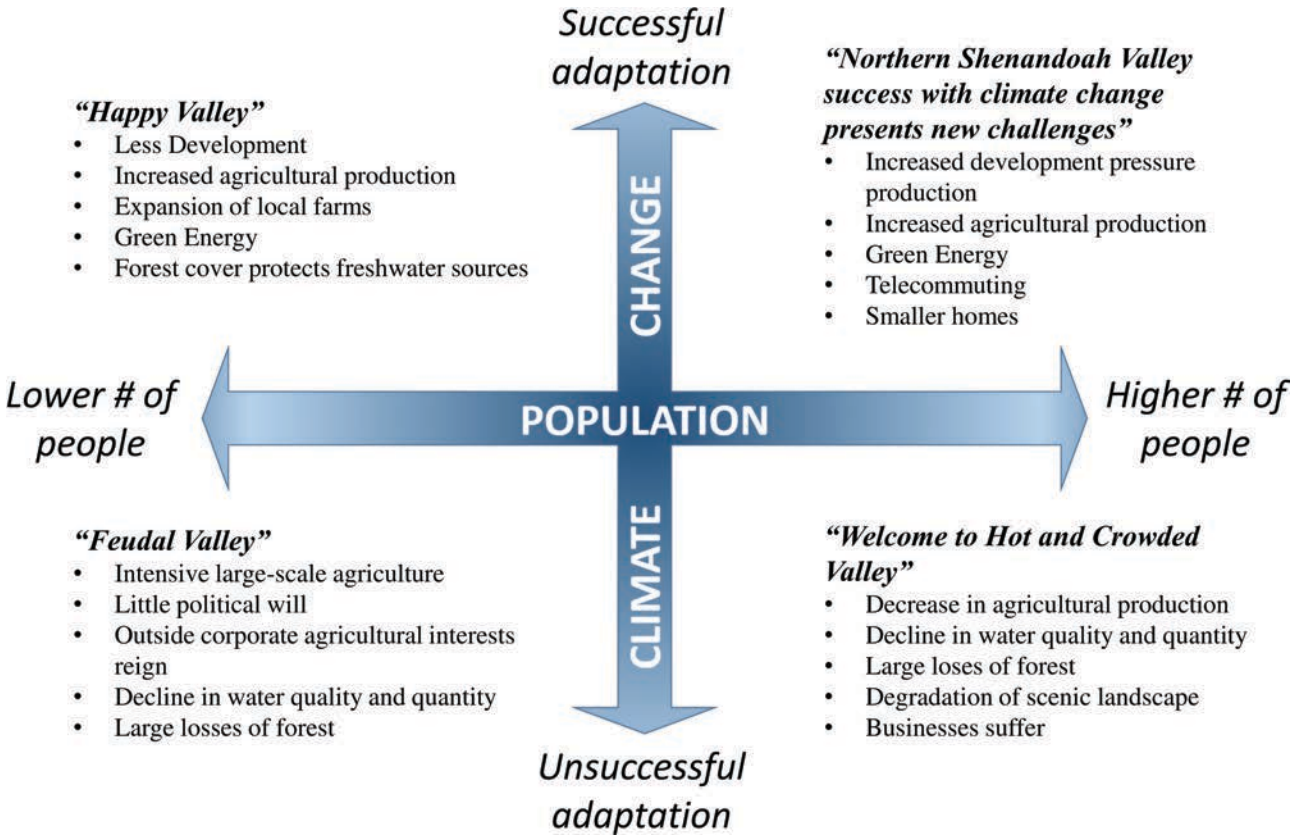

FIGURE 7. Scenario matrix for the Valley workshop with highlights from each scenario narratives.

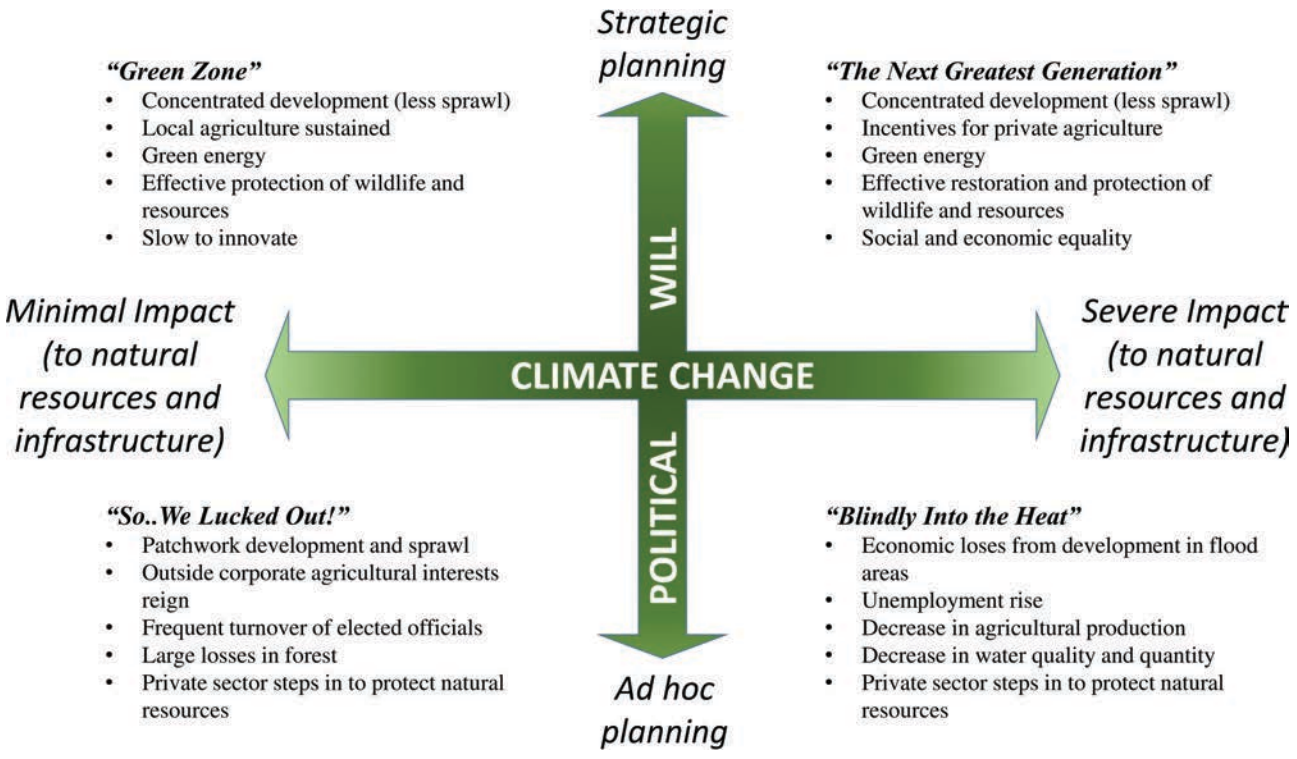

FIGURE 8. Scenario matrix for the Piedmont workshop with highlights from each scenario narratives.

qualitative scenario narratives to quantitative values of land use change for use in future model development. To approximate how scenarios conditions would affect rates of land use change within each scenario, teams completed a worksheet that prompted them to estimate gains and losses for development, forest, agriculture (crops and grasses), and conservation. Teams were instructed to estimate geographic location, type, and rate of change in land use across their portion of the study area and to explain their rationale behind each estimate (S4 in Supplementary Materials). To guide this activity, participants received information regarding decadal trends in the Valley and the Piedmont regions between the years 2001 and 2011.

WORKSHOP OUTCOMES Overall, we succeeded in creating a platform for interdisciplinary productive discussion on the varied perspectives of the current and future states of Northwestern Virginia. Both workshops delivered our desired outcomes as measured by the engaged collaborative work of all participants. There were some overlaps in driver selection between the two workshops. Interestingly, both workshop groups decided on climate change as a primary driver for their scenario matrices, with poles defined by either outcome (Valley) or adaptation (Piedmont) responses to change. Not all teams fully completed scenario narratives by the end of the day. Therefore, after the workshops, we followed up with team leaders from the workshops to fill in gaps and ensure that the narratives we presented them held true to their original vision.

Comments recorded from participants of both workshops illustrated a shift in tone throughout the day, from more positive to negative as activities forced them to connect drivers to impact and measurable land use change. For some teams, fleshing out the scenarios proved challenging simply because of their lack of desire to see them come to fruition. For example, one team in the Valley workshop stated, "We are depressed. We do not want to be living in this scenario." Others did not see the scenario as realistic, e.g., "We are all in agreement that we do not see this scenario as feasible. We are 'happy' to say that this is not going to happen." These comments highlight the importance of emphasizing that scenarios are not meant as a prediction of the future, rather to prepare us for those improbable yet potentially highly impactful events. Evaluations distributed at the end of each workshop day revealed that most participants found themselves thinking beyond the bounds of their expectations for the future. As for organization and facilitation of the workshop, there were overwhelmingly positive responses. Although, some participants commented that they would have preferred prior reading materials or exercises to be provided to allow them to prepare better, something we would recommend for future workshops.

FUTURE USES Outputs from the scenario development workshops have already been used to inform the creation of four land use change models that represent stakeholder-driven scenarios for the entire study area (the combined Valley and Piedmont subregions). The outputs from these land use models are being used to investigate how the different scenarios might influence ecosystem services, such as freshwater quality and quantity, recreation, viewsheds, and biodiversity. As part of leveraging the scenario planning platform, CLI will continue ongoing efforts to engage the regional community. Results of our work will be disseminated to regional policy and planning entities and the scientific community in formats varying from intuitive interactive web mapping tools to detailed databases and geospatial mapping products to support the conservation of resources vital to the economic and social well-being of northern Virginia people and wildlife.

CONCLUSION

This case study summarized the steps involved in scenario development using two regional workshops in Northwestern Virginia as examples. The workshops engaged regional stakeholders, from an opening visioning exercise to the development of scenario narratives, to the guidance on how to translate qualitative stakeholder inputs into a quantitative information relevant for the building of land use change models. The contribution of participating stakeholders is important for connecting land use change to potential pathways for how policy and planning decisions may influence planning trajectories. The process of scenario development provides a platform upon which to build new connections, identify shared conservation and planning goals, locate information needs and gaps in knowledge or data, and highlight key opportunities for the sharing of limited resources. In addition, we feel it is important to communicate that scenario development is only one piece of the scenario planning process, which can and should be iterative in nature. If we want to use this approach for policy change, we must maintain connections with stakeholders in the region and continually keep pace with changing policies and ideals. We believe that scenario planning is a powerful tool that can be useful

in various other conservation efforts from projects more tightly focused on individual communities [21] to global studies responding to climate change [8] or broad scale ecosystem services [13].

CASE STUDY QUESTIONS

1. While participants represented a diverse array of expertise and backgrounds, individuals from the conservation and natural resources sector were most heavily represented at the workshops, while sectors, such as land development and energy, were comparatively underrepresented (Figure 3). Why might this be? What are some approaches to engaging a more diverse group for subsequent workshops and meetings?

2. Workshop participants expressed a desire to better understand the process of scenario development and how they fit into the overall goals of CLI. Background information on the project was disseminated beforehand, but not information on the scenario development process. What are ways to more effectively prepare workshop participants for the activities of the day? What is the benefit/cost of workshop participants knowing what the activities would entail before the workshop?

3. The two workshops diverged in their selection of drivers. Why might this divergence occur? What is the significance of this divergence if it (A) represents a regional difference in how participants perceive risk and uncertainty? And (B) represents the effect of the views of an influential workshop participant?

4. The goal of the CLI is to provide information to influence decision-making related to land use and ecosystem services. What are some ideas for making the outputs of the CLI more accessible and relevant to individuals responsible for land use planning in the Valley and the Piedmont regions? To effectively achieve this goal, products from the CLI must relate to stakeholder values. How can these values be identified?

5. Regional and local politics may make open and honest communication difficult as agencies, planning groups, local government, and conservation organizations vie for attention and funding. Even with like-minded goals, it can be challenging to overcome decades of status quo. How could challenges like this influence the outcome of a program like the CLI?

6. The eventual outcome of the scenarios developed at the workshops is integration into land use change models. These models output projections, not predictions, of the future at a resolution of 30 m × 30 m pixels for each land cover class. What are the potential challenges with communicating the model outputs to stakeholders? The general public? How might these challenges be overcome?

AUTHOR CONTRIBUTIONS

IL – project lead, investigation, formal analysis, and writing. TA – project administration, investigation, and funding acquisition. WM – project administration, resources, and funding acquisition. MM – framework methodology and writing. JT – conceptualization and resources. CF – data analysis, curation, and investigation.

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COMPETING INTERESTS

The authors have declared that no competing interests exist. IL is a Section Editor at Case Studies in the Environment. She was not involved in the peer review of this article.

SUPPLEMENTARY MATERIALS

S1. Descriptive maps illustrating background variables as provided to workshop participants.

S2. Worksheets for scenario development activities. These include envisioning practice, driver selection and impact, and inhabiting scenarios. Adapted and used with permission from McBride et al. [22].

S3. Scenario narratives are written as newspaper articles for each workshop and scenario.

S4. Completed inhabiting scenarios tables from both the Valley and the Piedmont workshops.

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