TOOLS FOR COMPREHENSIVE PROACTIVE PLANNING: BACKCASTING LONG-TERM WATER SUPPLY SCENARIOS FOR A LARGE SOUTHEASTERN RIVER

by

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To my Grandparents

Marjorie Trippeer Bennett & Troy Carson Bennett

Sarah Brinn Perry & Jesse Parker Perry, Jr.

whose legacies of
integrity, service, courage, creativity, and critical thinking
continue to challenge and inspire me.

❖ ❖ ❖

And to my Mentors

whose exemplary
wisdom, dedication, and generosity
have opened the way.

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Abstract

Approaches to water planning are increasingly collaborative, watershed-scale, and focused on adaptive management. Such approaches are difficult to implement under the conditions of low certainty and control that typify large watersheds over long time horizons. To achieve comprehensive proactive planning, a toolbox of techniques is needed that can help incorporate new information into plans as the appropriate implementation, framing, and context of management shifts. This study investigated backcasting as one such complementary technique to current water planning strategies.

Backcasting is a planning technique in which participants reconstruct sequences of events that connect future scenarios to near-term actions. This process helps managers to consider a range of possible system futures, links future scenarios to present actions, and understand the policy changes needed. To test this technique, I designed and facilitated a backcasting workshop using participatory methods modified from those used in a similar, larger process in the European Union.

I conducted the workshop once with graduate students and once with policy and management experts in the Cape Fear River basin of North Carolina. The participants used backcasting to articulate several plausible trajectories for water supply in the basin over a 60 year time horizon. Each backcasted trajectory began with a different endpoint scenario for the basin economy and patterns of land use in 2075.

Results confirm that backcasting is useful for identifying priority actions and potential obstacles to desirable outcomes, and suggest that it is a good way to reveal decision-makers' underlying assumptions about system dynamics and the purposes of planning. Backcasting is an important addition to the toolbox of U.S. water planning techniques. Use of this technique has great potential to strengthen collaborative watershed-scale adaptive management of water resources.

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1 Introduction

1.1 U.S. Water Resource Management Trends

1.1.1 Watershed-scale Collaboration and Adaptive Management

Water resources management is by nature a multi-stakeholder task, and agencies responsible for aspects of water resources management are increasingly grappling with the difficulties of multi-stakeholder management. The federal agencies with primary water resource management authority, have historically managed primarily for single purposes such as irrigation for the Bureau of Reclamation (the Bureau), or navigation for the U.S. Army Corps of Engineers (the Corps). More recently, federal and state agencies have been trending toward watershed scale, collaborative, multi-stakeholder management of water resources. This shift has been spurred and reinforced by a growing body of agency policies and federal planning requirements that emphasize the importance of watershed-scale collaborative approaches to water governance and encourage the use of adaptive management.

The Environmental Protection Agency (EPA) has espoused its "watershed approach" since 1991 (EPA 1996), which integrates stakeholder engagement and adaptive management at hydrologically defined watershed scales (EPA 2013). Under Executive Order 13352 (2004), federal agencies dealing with environmental and natural resource issues have been required to employ "collaborative conservation" approaches that formally "involve collaborative activity among federal, state, local, and tribal governments, private for-profit and nonprofit institutions, other nongovernmental entities and individuals." Similarly, a joint memorandum in 2012 from the Office of Management and Budget (OMB) and the Council on Environmental Quality (CEQ) called on federal agencies to "increase the effective use of environmental conflict resolution and build institutional capacity for collaborative problem solving" (OMB & CEQ 2012). In addition to collaboration and stakeholder engagement at watershed scales, adaptive management is also now recommended or required for most federal water resource projects.

Adaptive management takes an iterative scientific approach to managing natural resources by collecting data upon which to evaluate the efficacy of actions, and changing strategies when data indicate that current approaches are not meeting project goals. Section 2039 of the Water Resources Development Act of 2007 addresses monitoring of ecosystem restoration projects, and the Army Corps of Engineers' Implementation Guidelines for section 2039 require the development of adaptive management plans for all ecosystem restoration projects (Brown 2009). The Council on Environmental Quality's Principles and Guidelines for Federal Investments in Water Resources issued in March 2013 include the watershed approach as a guiding principle, and establish collaboration and consideration of adaptive management as requirements for all federal water resource projects (CEQ 2013).

There is clearly growing federal support for collaborative, watershed-scale adaptive management. Indeed, both the Corps and the Bureau now actively engage in projects that apply collaborative watershed scale planning and adaptive management to the management of large river systems for multiple uses over long time horizons. Examples of such projects include the Missouri River Recovery Program (MRRP), Glen Canyon Dam Adaptive Management Program, the Federal Columbia River Power System (FCRPS) Adaptive Management Implementation Plan, and the Comprehensive Everglades Restoration Plan (CERP).

1.1.2 Strengths and Weaknesses of These Approaches

Collaborative, watershed-scale adaptive approaches have tremendous potential to increase the scientific robustness and ecological effectiveness of, and public support for water planning and management projects. Working at the watershed scale ideally makes management more ecologically and hydrologically sound by basing the scope of management on the scale of biophysical causes and effects within the system (CEQ 2013). Increased collaboration and stakeholder engagement can produce more robust decisions by incorporating a greater diversity of knowledge, and reduce uncertainty in the implementation process by minimizing unanticipated resistance (Pahl-Wostl 2009). Adaptive management, when appropriately applied, produces scientifically tested management solutions and allows managers to shift their strategies in response to changing conditions.

However, these approaches also present serious challenges. The defined spatial scale of a "watershed" varies widely depending on management goals, can be so large as to make coordinating management efforts cumbersome, and rarely coincides with existing jurisdictional boundaries. In seeking to address jurisdictional mismatches, actors often confront a tradeoff between resolving spatial jurisdictional conflicts and creating conflicts of authority between the existing governing bodies and new hydrologically defined ones (Pahl-Wostl, 2009). Collaboration and stakeholder engagement can reduce the efficiency of governance and management systems (Pahl-Wostl 2009). Collaborative approaches also require communication and facilitation skills and techniques that managers and policy makers do not always have in order to balance inclusivity and efficacy over the long term. Many projects (e.g. MRRP) engage in capacity building and work with third-party facilitators to make collaborative processes more productive. Thus, capacity building and institutional restructuring may be necessary to effectively implement collaborative watershed scale management.

Adaptive management helps decision makers gather and evaluate evidence about management action effectiveness, but it is fundamentally limited in two ways. First, it assumes a level of control and an ability to detect cause and effect in the system that may not be realistic at a whole-watershed scale. Under conditions of low control and predictability, Allen and Gunderson (2011) suggest that scenario planning—considering a range of scenarios for the future—may be more appropriate than adaptive management because it permits managers to prepare for conditions that may not yet exist to be tested. The second limitation of adaptive management is that it only provides insights into how well particular management strategies are working. It does not enable higher-level evaluation of the framing and context of the system.

Pahl-Wostl (2009) has proposed a framework for analyzing change in natural resource governance regimes that includes attention to three levels of learning. Adaptive management is designed to function on the first level, which involves learning about whether actions are meeting goals. The second level is learning about framing—evaluating the choice of goals. The third level is learning about context—evaluating the conceptualization of the system that underlies decision making. Even flawlessly conducted adaptive management programs inherently fail to incorporate these two higher levels of learning about framing and context, and may therefore totally overlook important emerging trends in the system (e.g. climatological shifts) or waste time and resources to achieve goals that have become less meaningful due to larger-scale alterations in the system. For example, a program of fish habitat creation might appear to be ineffective, when in fact the population's continued decline is being driven by something totally external to the variables being monitored or controlled via adaptive management, such as a disease.

Adaptive management is an important tool, but falls short of evaluating the framing and context of management actions that it tests. Those engaged in collaborative planning need a wide array of tools and techniques that enable them to proactively prepare for unpredictable outcomes, and learn comprehensively about the system at multiple levels. This toolbox of techniques for comprehensive proactive planning is especially necessary in systems characterized by low certainty and low control, such as whole watersheds over long time scales.

1.2 Tools for Comprehensive Proactive Planning

1.2.1 Scenario Planning

Scenario planning is a family of strategic planning techniques used to help organizations envision, prepare for and shape the range of future possibilities for their system of interest.[1] Scenario planning approaches vary widely, from highly qualitative scenario narratives performed by professional storytellers (Bowman et al. 2013) to modeling-oriented processes that produce much more quantitative scenario outputs (e.g. Mahmoud et al. 2011). Some processes rely on experts to develop the scenarios (e.g. Baker et al. 2004), while others take a more collaborative stakeholder-based approach (e.g. Kok et al. 2011).

One of the earliest examples of scenario planning took place in the 1970s when Shell Oil developed a set of scenarios that explored the then-radical idea that oil prices might rise dramatically in the future. One of their scenarios anticipated the formation of an OPEC-like organization, and led Shell executives to strategically invest in shipping and refinery efficiency that allowed the company to adapt to the eventual rise in oil prices (Peterson et al. 2003a). Since emerging in the world of business and military strategy, scenario planning has come into widespread use for regional planning in socio-ecological systems.

For example, Peterson et al. (2003b) used scenario planning to explore and plan for possible changes in the use of ecosystem services in the Northern Highlands Lake District of Wisconsin. Peterson et al. defined and characterized social and ecological aspects of the Northern Highland Lake District system with the help of local experts. Based on this assessment of the system's components and driving forces, they developed a set of three scenarios that varied two key drivers in the region: pace of ecological change and pattern of human settlement. They used both diagrams and written narratives to describe the resulting three scenarios for the region in 2025.

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1 For purposes of this paper, "scenario planning" refers to any planning process that considers more than one future scenario, and "scenario development" denotes the process of articulating a detailed description of a particular scenario.

The first scenario, “Walleye Commons,” imagined an ecological crisis in the form of salmon and human pathogen outbreaks in the region leading to the collapse of the local economy and human population, while the rest of the state experienced growing economic prosperity. The second scenario, “Northwoods.com,” hinged on the development of new community and economic development plans implemented at the state level, which initially led to investment in local businesses, human population growth and increasingly urban settlement patterns, with concomitant ecological impacts on rivers and lakes. In response to fish kills, an effective ecosystem services market was established to protect water quality and ecosystem function. The third scenario, “Lake Mosaic,” saw rapid suburban-style development of vacation homes around the lakes and the formation of new lake associations that made independent development decisions for each lake and took a wide range of approaches to lake management. Overall this scenario saw decreases in fish stocks and ecosystem services, and increasing conflict among residents of the region. Using these three scenarios, the authors identified potential opportunities and pitfalls for consideration in future plans, but hoped to include more stakeholder input in follow-up studies (Peterson et al. 2003b).

Experiments conducted to test the efficacy of scenario planning have identified several advantages of this technique. For instance, scenario planning is particularly advantageous for situations involving conflict and polarized viewpoints. Scenario planning can reduce planners’ framing bias—the tendency of people to be influenced by how data are presented (Meissner & Wulf 2013)—which is especially useful when dealing with politically charged issues for which data tend to be presented in a biased fashion. By nature, the exploration of future scenarios diverts attention away from current decisions and disputes, instead focusing attention on distant future outcomes where participants can discuss conflicting interests at a more comfortable distance (Bowman et al. 2013).

Past experiments also indicate that scenario planning improves the quality of decisions, both overall and with regard to original objectives and organizational performance as assessed by planners who engaged in the decision making process (Meissner & Wulf 2013). Another strength of this technique, as previously mentioned, is that it does not rely on detailed data-grounded projections and does not assume continuation of current trends or a single most-probable outcome for the system, making it well-suited for situations of high uncertainty (Peterson et al. 2003a, Meissner & Wulf 2013, Warth et al. 2013, Wilkinson et al. 2013). For all of these reasons, scenario planning is an important tool for comprehensive proactive water planning, and is already in use for water planning efforts at global and regional scales as well as at the scale of individual rivers and watersheds (Dong et al. 2013; Caves et al. 2013; Kok et al. 2011; Peterson et al. 2003b).

Scenario planning does have several limitations. Important potential pitfalls include: too much reliance on expert opinion or local knowledge, the difficulty of identifying and questioning underlying assumptions, the potential consequences of being wrong compounded over long timeframes, weighting the present too heavily, and overestimating level of control over the future (Peterson et al. 2003b). Scenario processes must also constantly balance the tendency to get bogged down in technicalities of data and process with the tendency to develop scenarios that are too superficial in nature (Bradfield et al. 2005). Wilkinson et al. (2013) identify five key challenges to scenario practices that all relate to the need for higher-level learning about framing and context discussed earlier (Pahl-Wostl 2009). These five challenges are: *linking* scenarios to subsequent application, *deeper reframing* of assumptions that constitute "business as usual," *relating* to other planning methods, *broadening* to integrate storylines across multiple scenario sets and types, and *engaging* the full diversity of agents in complex systems. Scenario planning is an important addition to the comprehensive proactive planning toolbox, but like adaptive management, it cannot go very far alone. Backcasting is a technique that has been used in concert with scenario planning to address some of the above challenges (Kok et al. 2011).

1.2.2 Backcasting

Like scenario planning, backcasting prepares people to address situations that they would have overlooked if they relied solely on projections of past trends. In addition, it addresses one of the key weaknesses of scenario planning—that of dealing with futures divorced from near-term decisions—by linking hypothetical futures to actionable steps for the short-term (Kok et al. 2011; Vergragt & Quist 2011; Wilkinson et al. 2013). Backcasting emerged in the field of energy development in the 1970s as a way to explore the links between different desirable energy market scenarios and near-term policy choices. The technique has since been applied well beyond the realm of the energy sector and has evolved to be more participatory and in some cases to include both desirable and undesirable system outcomes (Quist and Vergragt 2006).

The use of projections is predicated on the assumption that the future behavior of a variable may be induced from its past behavior. Such reliance on inductive reasoning is common, and represents a major liability in long-term planning because it blinds people to unpredictable or unprecedented changes in a system, thereby limiting the ability to anticipate and prepare for them (Taleb 2007). To circumvent the limitations of planning based on induction, backcasting starts by positing a future outcome, and then uses information about the dynamics of the system in question to reconstruct a plausible sequence of events to explain how that endpoint could be reached. Through this process, it is possible to identify concrete actions, events, opportunities and obstacles that might be associated with the trajectory toward a given endpoint. In this way, the backcasting process allows decision makers to identify points of control in the system for conditions outside the realm of "normal".

In backcasting, the conceptualization of the system and its dynamics are the justification for the sequence of events produced. This provides an opportunity for people to observe and evaluate the way they are thinking about the system and consider the implications and veracity of that conceptualization. Thus, backcasting is one method by which decision makers and stakeholders can engage in higher-level learning about framing and context. Those seeking to plan more comprehensively and proactively for water stand to benefit greatly from the higher level learning backcasting enables and the understanding as well as from its ability to identify specific policy choices for the system.

1.3 Present Study

This study sought to test backcasting as a tool for comprehensive proactive planning in a large Southeastern watershed, the Cape Fear River of North Carolina. To do this, I designed and facilitated a backcasting workshop using methods adapted from a European project called Water Scenarios for Europe and for Neighboring States (abbr. SCENES). The SCENES project is a set of participatory scenario planning studies in the European Union that used backcasting in planning for water supply and water quality at pan-European, regional, and local watershed scales (Vliet and Kok 2013; Kok et al. 2011; Vliet et al. 2007). In applying this backcasting methodology to the Cape Fear, I sought to 1) identify and understand important trends and needs for the Cape Fear over the next 60+ years, and 2) assess the potential of backcasting to contribute to water resource management projects in the U.S.

2 Methods

2.1 Study Area

2.1.1 The Cape Fear River

The Cape Fear River basin is the largest watershed in North Carolina (~2.4 million hectares), and its 10,500 kilometers of streams are fully contained within the state (NCDWQ 2005, NCOEEPA 2013). The two main tributaries in the upper basin, the Haw and the Deep rivers, flow from the Triad region around Greensboro, NC into Jordan Lake, an Army Corps of Engineers reservoir downstream from Durham and Chapel Hill near the Research Triangle Park. From the reservoir, the Cape Fear River flows South to the Atlantic Ocean. It is joined by the Little River before passing through Fayetteville, and by the South, Black, and Northeast Cape Fear Rivers North of Wilmington (NCDWR 2002).

Hydrography in the basin fluctuates seasonally, with peak flows occurring during the winter months and late summer hurricanes. Minimum flows occur in late summer, associated with high evapotranspiration and human consumption rates sometimes compounded by droughts (Figure 1). Though drought has not historically been a major concern in the basin, some recent droughts (e.g. 2002 and 2007) have been very intense (Figure 2). In recent decades, Southeatern U.S. has begun to experience more frequent and intense hydrologic extremes (Wang et al. 2010), which may continue as climate change proceeds (Trenberth 2011).

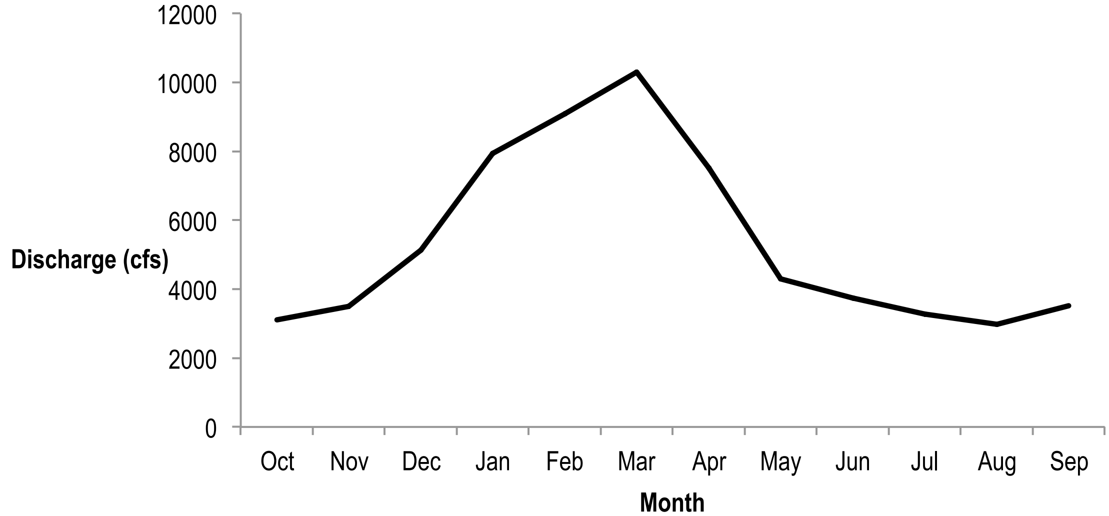

Figure 1. Mean monthly discharge of the Cape Fear River measured by the USGS at Lock and Dam #1 over the period 1969 – 2013.

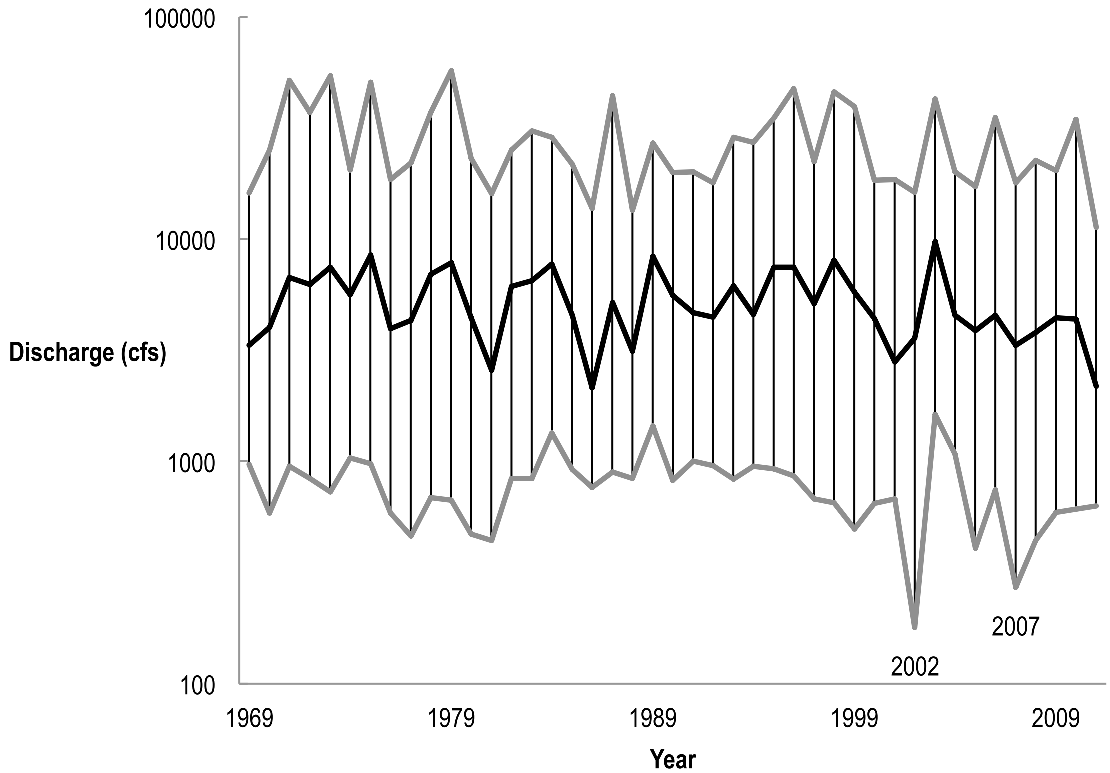

Figure 2. Mean daily discharge (black) and minimum and maximum discharge values (gray) in the Cape Fear River measured by the USGS at Lock and Dam #1 for each year from 1969 – 2011. Note record low flows during the 2002 and 2007 droughts.

2.1.2 Basin Population, Economy, and Land Use

The Cape Fear basin is home to just over 2 million people (NCOEEPA 2013), or about 20% of the state's population. Population density is higher along the coast and in the upper basin, which encompasses portions of two major population centers, the Triad and the Triangle. Population density is lower in the more agriculturally dominated coastal plain. Land cover in the Cape Fear basin as of 1997 was 56% forested land, 22% agricultural land, 11% urban areas, and 9% other—rural transport, small water areas, lakes and estuaries (NCDWQ 2005)

Manufacturing, technology, research, and healthcare industries dominate the upper basin economy. The middle and lower basin counties are much more agriculturally dominated, including row crops and high density hog and poultry production. U.S. Army Fort Bragg, Pope Air Force Base, and the Marine Corps' Camp LeJeune are all located in the coastal plain. The lower basin is a mix of forested lowlands and small primarily agricultural communities. Economic activities in the lower basin include manufacturing, coastal tourism, agriculture, and shipping. The areas surrounding the city of Wilmington and the coastal towns and beaches are more densely developed than the rest of the lower basin, and see very high tourist traffic during the summer.

The Cape Fear Arch region encompasses the lower Cape Fear basin (including the South, Black, and Northeast Cape Fear tributaries and surrounding coastal areas), and is one of the few national biodiversity hotspots East of the Appalachian range (Morse and Watson 2000). It is home to a number of nationally and state listed threatened and endangered species, including the Cape Fear Shiner (*Notropis mekistocholas*, a fish), which is endemic to the basin (NCOEEPA 2013).

2.1.3 River Governance and Infrastructure

The B. Everett Jordan Dam and Reservoir is managed by the Corps for flood control, with water supply storage space bought and allocated to municipalities by the NC Division of Water Resources (DWR). The Corps also operates three navigational locks and dams in the lower basin, though in recent years non-recreational navigation in the river has been very limited. In addition to the Corps and DWR, the EPA (water quality), USFWS (endangered species protection), NMFS (marine species protection), and FERC (hydroelectric regulation) all play a role in governing water supplies in the basin.

At the sub-basin scale, county and city governments, public and private utilities, soil and water conservation districts, and regional councils of government all impact water supply. Important mechanisms for the assertion of local authority and preferences include local water supply plans, allocation of water supply from reservoirs, establishment of interbasin transfers, water pricing, development and zoning regulations, and implementation of water conservation measures.

2.2 Workshop Protocol and Design

2.2.1 Pre-workshop Interviews and Choice of Scenarios

Over several months leading up to the workshops, I conducted ten informal hour-long interviews with experts in the basin. The interviews covered a list of topics designed to elicit information about the roles of different stakeholders in the basin, the key variables and drivers that should be included in the scenarios, and potential workshop participants (Appendix A). I used chain referral (Newing 2011) to select ten interviewees, who represented the North Carolina Department of Environment and Natural Resources (3), Piedmont Triad Council of Governments (1), The Nature Conservancy (4), Environmental Defense Fund (1), and The Conservation Fund (1). I had hoped to include representatives of the industrial or agricultural sectors, but was unable to reach any members of these groups for the pre-workshop interviews.

Ideally, the identification and articulation of scenarios to be considered should be done collaboratively with the stakeholders as part of the workshop process (Peterson et al. 2003). Doing this helps produce scenarios that effectively capture a full range of possibilities for the system and maximizes the opportunities for social learning via the process of scenario selection. Due to time constraints, and because our study focused on backcasting rather than scenario development, I selected the scenarios in advance of the backcasting workshops without the direct input of workshop participants. Such use of pre-selected (or “fast-track”) scenarios as prompts for backcasting exercises was also used in the EU SCENES project (Kok et al. 2011).

To select the scenario prompts for the Cape Fear workshops, I identified economy and land use as key driving factors in the basin based on the pre-workshop interviews. I then developed three short scenario descriptions as starting points for the backcasting workshops (Table 1). Each scenario prompt is characterized by different departures from the current economic structure and land use patterns in the basin. The workshop participants' subsequent scenario planning and backcasting work in small groups focused exclusively on these three scenarios.

Table 1. Scenario Prompts

New Triangle	Fenced Forests	Park-Industrial Mosaic
In 2075 the Cape Fear basin is dominated by the military activities and associated industry of the "New Triangle" near the coast, consisting of Fayetteville/Ft. Bragg (Army) in the Northwest, port town of Wilmington to the South, and Jacksonville/Camp LeJeune (Marine Corps) to the East (With accompanying maps).	In 2075, the Cape Fear basin is 80% forested land, almost all of which is privately owned.	In 2075, the Cape Fear basin landscape is a mosaic of dense, high-intensity industrial zones and residential biodiversity parks.

2.2.2 Participant Recruitment

I conducted the backcasting workshop twice, once with graduate students and once with experts from the Cape Fear River basin. Each workshop took place over the course of a full day. The student workshop included 8 participants from the Master of Environmental Management program at the Nicholas School of the Environment at Duke University. Students were volunteers recruited via a school-wide email and a request for volunteers from a water resource management course. The expert workshop included 8 participants with experience working for the North Carolina Department of Environment and Natural Resources, the Army Corps of Engineers, the Nicholas Institute for Environmental Policy Solutions, Piedmont Triad Council of Governments, The Nature Conservancy, and the Environmental Defense Fund. Expert participants were volunteers recruited from among the pre-workshop interviewees and individuals they referred, as well as through the Nicholas Institute's network. A representative of the Farm Bureau was recruited, but ultimately unable to attend, so no direct representatives of the industrial or agricultural sectors were present at the expert workshop.

Table 2. Progression of workshop exercises.

Exercise	Grouping	Purpose
A. Introductory Presentation	Large group	Introduce scenario planning and backcasting processes
B. Scenario Development	Small (2 – 3 person) groups	Based on a brief prompt, describe the condition of the Cape Fear River basin in the year 2075
C. Venn Diagram	Large group	Develop shared understanding of river system dynamics by identifying factors as Triggers, Drivers and/or Constraints in the system.
D. Backcasting	Same small groups, different prompt	Identify a plausible sequence of events that could lead from the future scenario as described to the present conditions in the basin.
E. Discussion	Large group	Identify themes that emerged in the three different backcast scenarios. Opportunity for individual and group observations and reflections.

2.2.3 Scenario Development Exercise

Workshops began with introductions of the participants, after which I gave a brief explanation of scenario planning and backcasting (Table 2). The students received a set of background information about the Cape Fear River (Appendix B) with basic facts about the basin and themes gleaned from the pre-workshop interviews for their reference. Following this introduction, the participants began the scenario development exercise.

In this exercise, participants were assigned to small groups of 2-3 people to flesh out one of three scenarios based on one of the brief prompts. I employed a version of the "Rich Picture" method described in the EU SCENES project (Vliet et al. 2007): groups had 30-40 minutes to discuss their prompt and draw a picture of their scenario in as much detail as possible using any visual form (graph, diagram, map, flow chart, *et cetera.*) Starting the exercise with drawing serves as a way to encourage creative thinking and development of shared understanding within the small groups, and as an opportunity to participate for those who might be hesitant to speak (Vliet at al. 2007).

I directed participants to focus on describing the Cape Fear basin in the year 2075, rather than explaining how the scenario could have developed over time. Once the rich picture was complete, the groups translated their picture into written form as a one-page narrative describing the condition of the basin in 2075 without describing a sequence of events leading to that point.

2.2.4 Venn Diagram Exercise

Next, the whole group carried out an activity that designed to encourage thinking about relationships and causality and develop a common understanding of the dynamics of the Cape Fear system. This exercise is an extension of the "Card-technique" used in the EU SCENES project (Vliet et al 2007). In this activity, participants received a set of cards each listing one factor in the Cape Fear Basin gleaned from the pre-workshop interviews.[2] Participants discussed as a group where to place each factor on a physical Venn Diagram laid out on the table, with three overlapping circles representing "Triggers," "Drivers," and "Constraints."

For this exercise, a *trigger* was defined as "a factor or event that suddenly changes the way the system is working." A *driver* was defined as, "a factor or variable that reshapes the system over a long time period." And a *constraint* was defined as, "a factor or variable that limits how or how much the system can change."

Participants placed factors that could fit in more than one category in the corresponding overlap zones of the Venn diagram (e.g. "Connection to global markets" can be a Trigger or a Driver). Participants also added additional factors to the list as they thought of them during the course of the activity. Discussion continued until the group came to a consensus about what factors to include and how to categorize them. The resulting shared understanding of system served as a baseline conceptualization to guide the subsequent backcasting exercise.

2.2.5 Backcasting Exercise

After lunch, everyone returned to their assigned small groups and received the Rich Picture and one-page scenario narrative developed by another group during the scenario development exercise. Thus, at the start of backcasting, each group was familiar with what scenarios were (because they had developed one themselves), and shared the same understanding of the triggers, drivers and contraints in the system. From this common baseline of understanding, each group took on a scenario totally new to them as the starting point for their backcasting work.

To backcast, the groups first brainstormed Actions (things people in the basin do leading up to 2075), Obstacles (aspects of the scenario that make meeting water needs in the basin in 2075

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[2] Based on feedback from the student workshop, participants in the expert workshop had the opportunity to look at the full list of factors in small groups, which were each assigned to identify which factors on the list they thought were the *triggers, drivers* or *constraints*, before actually placing the cards on the Venn Diagram as a group.

more difficult), Opportunities (aspects of the scenario that facilitate meeting water needs in the basin in 2075), and Events (things that happen before 2075 that are beyond the control of people in the basin). These categories were based off those used for backcasting in the EU SCENES project (Kok et al. 2011), though here I used “Events” rather than “Milestones” to reduce the confusion that EU researchers had identified between Milestones and Actions (Vliet and Kok 2013).

Then, the groups placed the Actions, Obstacles, Opportunities and Events they had brainstormed on a timeline, working backwards from 2075 to the present as was done in the EU SCENES project (Vliet et al. 2007). Finally, each small group presented their rich picture and scenario narrative (for one prompt), and backcasted timeline (for another promt) to the rest of the participants, and the whole group discussed themes and trends that they observed across the three scenarios.

2.2.6 Post-workshop Evaluations

At the end of the day, each participant filled out an evaluation of the workshop. The evaluation included five Likert scale questions adapted from the EU SCENES project (Kok et al. 2011), which were designed to elicit participants’ assessment of the workshop itself, of backcasting as a process, and of the potential applicability of backcasting results to management and decision making. The evaluation also included five open-ended questions asking what participants liked about the workshop, what they would improve, strengths and weaknesses of the facilitator, and what ideas they had for next steps or potential uses for the results of the workshop (Appendix C).

2.3 Analysis of Results

I did not have specific predictions about the themes I expected to see in our results, so I used standard methods of qualitative analysis to explore the results of the workshops. These results consisted of the written products of the backcasting exercise: the backcasted timeline of events and the lists of actions, obstacles, events and opportunities. I used manual coding (Newing 2011) of the timelines and lists to identify themes within and between the three scenarios and the two workshops. I did not use preconceived coding categories, as I was interested in identifying what the participants saw as important or likely, rather than what I thought to be important. I also employed cross-method triangulation (Newing 2011), comparing the timelines and the lists to the rich pictures to ensure that I had captured all the components and dynamics identified by the two small groups that developed and backcasted each scenario, respectively.

Our analysis of the post-workshop survey results matched the analysis used in the EU SCENES project, to permit comparison with their results (Vliet and Kok 2013). I calculated the percentage of favorable responses (answer of 4 or 5) on the five Likert scale questions and used these data to compare our student and expert workshop participants' responses to the responses of EU SCENES workshop participants. Sample sizes were too small to permit statistical analysis of the post-workshop evaluation results.

3 Results and Discussion

3.1 Participant evaluations and comparison to EU SCENES Responses

3.1.1 Responses

Following each workshop, participants were asked to fill out an evaluation form. Eight students and five experts completed the evaluations. Evaluations used the same wording as the workshop evaluations used in the EU SCENES project (Kok et al.), to permit comparison to their results (Figure 3). Questions 1 and 4 pertained to the workshop as a whole, while questions 2, 3, and 5 addressed the participants' opinions of backcasting as a technique.

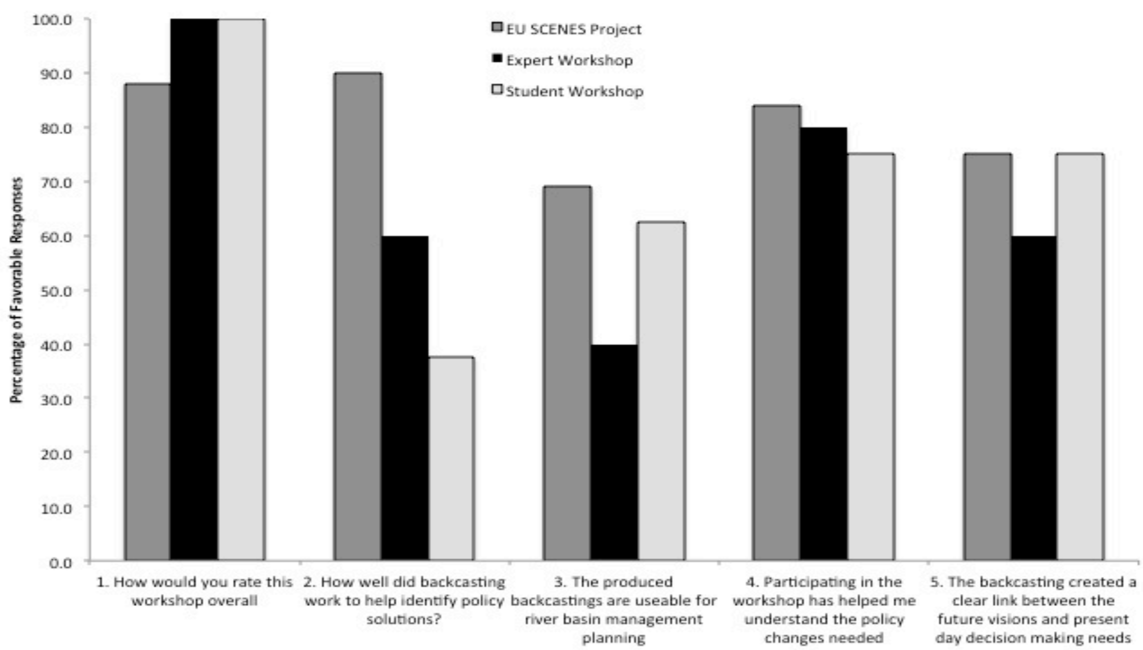

Figure 3. Percentage of favorable responses (4 or 5 on a 1-5 Likert scale) to post-workshop evaluation questions concerning participant assessments of the workshop, backcasting process, and usefulness of backcasting results, comparing responses obtained in the EU SCENES project to those from experts (n = 5) and students (n = 8) in this study.

Question one asked participants to rate the workshop as a whole from 1 (poor) to 5 (excellent). The percentage of respondents who had a favorable opinion of the workshop (answered 4 or 5) was 88% for the EU, and 100% for both students and experts in our study. Overall, participants seemed to think this was a good workshop.

Question two asked how well backcasting worked to identify policy solutions from 1 (poorly) to 5 (excellently). The percentage of respondents who thought backcasting worked well to identify policy solutions (answered 4 or 5) was 90% for the EU, 60% for experts in this study, and 37.5% for students in this study. This suggests that participants in the Cape Fear workshops perceived the workshop to be less effective at helping identify policy solutions than the EU workshop participants did. The EU workshops were conducted as a series of three or four two-day workshops instead of the single one-day workshop conducted in the Cape Fear. The additional time may have allowed participants to go into detail about policy solutions that was not possible in the short workshop I conducted. The less favorable response from students may also reflect students' more limited awareness of existing policy options, compared to the policy knowledge of experts.

Question three asked respondents to agree or disagree with the statement "The produced backcastings are useable for river basin management and planning" on a scale from 1 (strongly disagree) to 5 (strongly agree). Those who agreed (answered 4 or 5) made up 69% of EU respondents, 40% of experts, and 62.5% of students. This was the least positive response to any question from both the EU participants and the experts our study, suggesting that experts were generally skeptical of the usefulness of the backcasting results.

Answers to question four indicated widespread agreement that the workshop as whole helped participants understand needed policy changes. This question asked participants to agree or disagree with the statement "Participating in this workshop has helped me to understand the policy strategies needed" on a scale from 1 (strongly disagree) to 5 (strongly agree). Respondents who agreed (answered 4 or 5) made up 84% of EU respondents, 80% of experts, and 75% of students. Considering results from questions three and four together, it seems that although backcasting specifically did not help as many participants identify policy solutions (Question 3), the insights gained over the course of the whole workshop contributed to participants understanding of policy needs and priorities in the system (Question 4).

Finally, question five asked participants to agree or disagree with the statement "The backcasting created a clear link between the future visions and the present day decision making" on a scale from 1 (strongly disagree) to 5 (strongly agree). The percentage of EU respondents who agreed (answered 4 or 5) was 75%, for experts was 60% and for students was 75%. Of the questions about backcasting specifically, this question had the most agreement across all three workshops. This is a reassuring response as this linking of future scenarios back to the present is one of the primary aims of backcasting as a complement to scenario planning.

3.1.2 Interpretation of responses

Though the same percentage of experts (60%) thought that backcasting helped identify policy solutions and thought backcasting created a clear link between future visions and present day decisions, only 2/3 that number (40%) agreed that backcasting was useable for river basin management and planning. Given that linking future visions to present decisions and identifying policy solutions are both important components of planning and management, it is somewhat surprising that a majority of experts remained dubious of the technique's usefulness. This result may be related to the fact that the Cape Fear workshops did not take place in the context of a larger planning effort or decision-making framework like the SCENES project. Without a clearly defined plan for operationalizing the backcasting results, it makes sense that experts would see them as less useable.

Overall, the results of this survey suggest that participants' view backcasting as an isolated technique less favorably than they view the workshop experience as a whole. What is immediately valuable to participants from the workshop seems to be the overall understanding of the needs in the system. Based on these results, the clearest strength of backcasting as a technique seems is its ability to link future scenarios to present decision making. The responses of the experts suggest that in order for backcasting to be most useful, it should take place in the context of a larger planning or visioning process, with a clearly defined way for backcasting results to link to other techniques within the larger toolbox of strategies for comprehensive proactive planning.

3.2 Scenario-Specific Themes

3.2.1 New Triangle Scenario Results

Both students and experts listed war as an ongoing event in the New Triangle scenario. Students said, " 'war on terror' never ends." Experts explicitly listed fuel and water shortages, as well as increases in fuel imports and exports as events associated with this ongoing conflict.

Participants in both workshops backcasted major shifts in energy sources for the Cape Fear basin driven by the high energy demands associated with increasing population and industrialization, along with unreliable global energy markets. Students listed offshore petroleum drilling and a shift to natural gas obtained via a natural gas pipeline as the primary sources of energy. Experts backcasted construction of additional infrastructure for solar, nuclear and natural gas energy, and a shift away from livestock toward fuel crop production in the basin.

Increasing pressure on water supplies was a theme in this scenario. Students specifically noted reduced groundwater recharge and water quantity requirements as obstacles, and water conservation efforts as an action. Water scarcity also figured into their reasoning about the rise of natural gas, which is a less water intensive energy source than some (e.g. nuclear). They also envisioned increased water flow and flashiness in the basin associated with urban and industrial development, which they listed as an opportunity.

Experts included the action of an Inter-Basin Transfer (IBT) from the Cape Fear Basin to Jacksonville, NC. They also anticipated obstacles in the form of increased conflicts or tradeoffs between human and ecological needs for water, problems of semi-consumptive use and water temperature alterations associated with water use for energy, and the need for additional water infrastructure to serve newly populated areas. They imagined there would be an opportunity for the military to lead the implementation of desalination to reduce some of the pressure on freshwater sources. Experts also imagined that the local water shortages would be nested within global shortages.

Both experts and students saw opportunities for the implementation of increased water conservation measures under this scenario. Students envisioned gray water reuse in new housing developments, specifically. Experts said this scenario presented an opportunity for the military to take a leadership role in encouraging water conservation. Experts also mentioned increased valuation of natural resources “swimming, fish, etc.” as an opportunity in the New Triangle scenario, but did not elaborate on this further.

3.2.2 Fenced Forests Scenario Results

Funding issues only came up explicitly in the Fenced Forest scenario; participants did not specifically cite lack of funds in either of the other scenarios. Students listed funding for infrastructure and research as obstacles, while experts listed increase in state and federal conservation funding as an action. It seems likely that students' tendency to list policy driven changes as obstacles reflects their lack of experience in policy making and regulatory process, or it could reflect a generational shift in assumptions about government funding availability in the post-Recession world.

Participants in the two workshops interpreted human settlement patterns associated with the rising dominance of forested land cover slightly differently. The experts anticipated rural populations moving into cities, and some forested areas being converted into "low density forest enclaves." The students interpreted the rise in forested land to mean that everyone was concentrating in urban areas, with "reduced sprawl" and "concentrated areas of demand" for water.

Both students (explicitly) and experts (implicitly) noted an increase in the value of forest as a necessary action in the Fenced Forest scenario. Students said there would be "Higher valuation of passive and active forest values e.g. biodiversity, recreation" perhaps manifest in payment for ecosystem services markets (PES). Experts listed "high end development" as an action, referring to the high property values associated with "low density forest enclaves."

Both students and experts also specifically listed establishment of a Carbon market as an action in the Fenced Forest scenario. The backcastings did not specifically address the directionality of causation related to the carbon market. Would establishment of a carbon market lead to more forested land, or would increased forest land pave the way for a carbon market? This result also seems particularly reflective of the environmental orientation of most of the workshop participants.

3.2.3 Park-Industrial Mosaic Scenario Results

Experts and students both interpreted this scenario as highly contingent upon policy change. Experts envisioned the implementation of a "highly geographical" state level water-use permitting scheme that created two different categories of river: "working rivers" and "natural rivers." They imagined that permitting would lead to increased water reuse, and seemed to think that this policy would lead directly to the mosaic pattern of development and conservation that characterizes this scenario. Students envisioned that the mosaic would form under a new regime of tax incentives for residential biodiversity parks, coordinated regional zoning, and PES markets.

Biofuels emerged as an alternative energy source in the Park-Industrial Mosaic scenario in both the student and expert workshops. It is unclear exactly why this emerged as an opportunity for this scenario in both workshops Perhaps because fuel crop production, fuel refinery processes, and energy consumption could all take place relatively close to one another in the different parts of the mosaic.

3.3 Overarching Themes and Patterns

Table 3. Abbreviations used to cite results from a specific scenario in a specific workshop.

Scenario	Student Workshop (S)	Expert Workshop (E)
New Triangle (NT)	NT-S	NT-E
Fenced Forests (FF)	FF-S	FF-E
Park-Industrial Mosaic (PIM)	PIM-S	PIM-E

3.3.1 Food footprint

Students in the Park-Industrial Mosaic scenario (PIM-S, Table 3) and experts in the New Triangle scenario (NT-E) each noted a shift toward less resource intensive food sources. In the expert workshop, the shift was toward vegetarianism. Experts seemed to see the reduction of food footprints as necessary in the New Triangle in order to meet water demands in the basin given the shifts in land use away from agriculture and increased demand for water and energy in the lower Cape Fear basin. They imagined that supplementary global food imports would be restricted, if there were global water and fuel shortages associated with war. In the student workshop, the shift was toward totally new food sources including farmed insects and "petri-dish bacon." This was driven by food and water demands from the growing human population, and supported by ongoing research and development.

3.3.2 Technology and Infrastructure

Research and technological innovation came up in both workshops and in every scenario. Specific types of technology mentioned included water purification (NT-S, NT-E), water conservation (PIM-E), military (NT-E), and biotechnology research supporting forest resilience to climate change (FF-S). Desalination of sea-water, specifically, came up in every scenario during the expert workshop, and in the student workshop under the New Triangle scenario.

Infrastructural changes were included in among the backcasted actions, obstacles, opportunities or events for every scenenario in both workshops. Changes to existing infrastructure included additional roads (NT-S and NT-E), expansion of Shearon Harris Nuclear plant for energy and the associated Harris Lake for water supply (FF-E), dredging or expansion of the Port of Wilmington (NT-S and NT-E), and expansion of the rail system (NT-E and FF-E). New infrastructure took the form of additional power plants (NT-E), an Interbasin Transfer to Jacksonville from the Cape Fear (NT-E), general investments in public infrastructure (NT-E and FF-S), creation of a natural gas pipeline (NT-S), a new dam near Wilmington for water supply (PIM-S), and as previously mentioned, desalination plants. One group backcasted a reduction of infrastructure in the action of removing in-stream structures (FF-S). The experts did not propose any new dams, only the expansion of Harris Lake, which is an interesting given that dam construction has historically been the primary mode of provision new water supply in the basin (1962 study).

3.3.3 Culture and Politics

Cultural shifts and presence or absence of public support for various changes were cited in all scenarios in both workshops. The Park-Industrial Mosaic and Fenced Forest scenarios in particular seemed to hinge on public support in both workshops. Backcasts of the Park-Industrial Mosaic scenario included a shift to a “moderate political” environment (PIM-S) as an event, and “conservative influence” (PIM-S), environmentalist objections (PIM-E), and public “resistance” to gray-water reuse (PIM-E) as obstacles. The Fenced Forest scenario included increased “watershed awareness” (FF-S) as an event, and “politics” (FF-S), “cultural shifts” (FF-S) and “social resistance” to a nuclear plant expansion (FF-E) as obstacles. In the New Triangle scenario, students imagined that the changing demographics and political environment associated with an increasingly militarily dominated lower basin would have negative environmental impacts (Figure 4). However, there is a history of collaboration between The Nature Conservancy and the Army at Fort Bragg and Marine Corps at Camp Lejeune on environmental protection efforts (McIver 2013) that suggests these concerns may be somewhat unfounded.

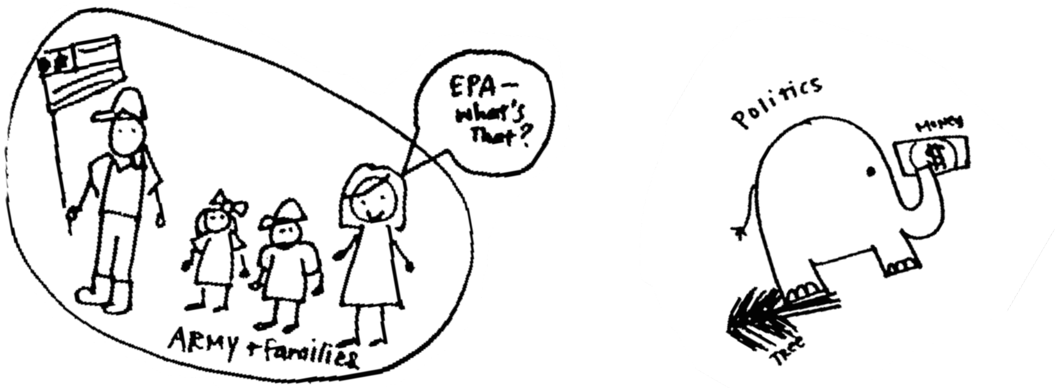

Figure 4. Excerpts from student New Triangle scenario picture showing imagined lack of environmental awareness in military families (left) and Republican prioritization of economic over environmental interests (right).

Regardless of the accuracy of these students' specific predictions and associations, it is unsurprising that the influence of politics and culture would be on the minds of the workshop participants considering recent changes in the state political landscape. The 2010 state elections established a Republican majority in both houses of the NC General Assembly for the first time since the 19th century (Bonner and Biesecker 2010). In 2012, Republicans obtained a supermajority (greater than three-fifths) of seats in both houses of the legislature and elected North Carolina's first Republican governor since since 1988 (Frank 2012).

This new Republican leadership has spearheaded major changes in state environmental regulations that impact water resources. In the first half of 2013, the Senate passed the Regulatory Reform Act of 2013, which sought, among other provisions, to require the "repeal or revision of existing environmental rules more restrictive than federal rules pertaining to the same subject matter." Specific to the Cape Fear, in 2013 the N.C. General Assembly ratified Jordan Lake Water Quality Act, which delays "additional implementation of measures to address water quality issues in Jordan Lake in order to allow for further evaluation of those measures and further exploration of other measures and technologies to improve the water quality of the Lake." These and other changes with implications for water management were in process or had only occurred a few months ago at the time these workshops took place, so it is unsurprising that participants imagined political and cultural factors impacting many of the scenarios.

3.3.4 Incorporation of Trigger Events

Though North Carolina's recent political changes seem to have brought cultural and social factors to the forefront in the workshops, not all recent changes in the system impacted experts' thinking about the future of the Cape Fear. In particular, the total omission of hydrologic extremes from expert backcastings is noteworthy. Two of the students' scenarios (New Triangle and Park-Industrial Mosaic) included a trigger event—a hurricane in both cases. The inclusion of a trigger event makes particular sense for the PIM scenario because it hinges on the opening of a "policy window" (*sensu* Kingdon 2011) in which policy changes and philosophical shifts lay the foundation for a new spatial organization of industry and green space. The trigger event, in this case a hurricane, mobilized the necessary support for those shifts.

In contrast, none of the expert timelines for any scenario included trigger events, despite the fact that the groups had just created a list of potential trigger events during the Venn Diagram exercise immediately preceding the Backcasting (Appendix D). This was also surprising given that many of the experts worked in the Cape Fear basin during the record droughts of 2002 and 2007. Consideration of previous plans that have shaped these experts' thinking about water planning suggests that the omission of trigger events may reflect the dominant conceptualization of planning in North Carolina.

4 Conclusions

4.1 Insights from Backcasting for the Cape Fear Basin

4.1.1 Near-Term Policy Considerations

Backcasting is touted as a means to connect distant future scenarios back to present-day decision-making (Kok et al. 2011). For this study, I have identified three factors that may be important for policy makers in the basin to consider as they develop plans and make near-term policy decisions, in addition to the specific elements of each scenario and the overarching themes already discussed. These three factors—the role of industry, technology-facilitated behavior change, and the level of decision-making in the basin—all profoundly shaped the way the scenarios played out.

While the impacts of industries like agriculture and manufacturing are readily apparent, others may be less obvious. Yet, the overall balance of industrial growth and decline in the basin has major impacts on patterns of land use change. Incorporating perspectives from the private sector into decision-making processes could be helpful to ensure that these impacts can be managed. The research and technology industry, currently flourishing in the upper basin, is one such sector.

As discussed previously, technological innovation played an important role in these scenarios. Overwhelmingly, water supply needs were not met through large-scale infrastructural changes, but more through local changes made possible as a result of research and the development of new technologies. In the closing discussions participants also noted increased prevalence across scenarios of certain technology-facilitated lifestyle shifts, such as telecommuting and commuting via high speed rail. Changes in behavior associated with technological change have serious potential implications for how land is used and the spatial and temporal patterns of water demand. It is important that decision-makers keep in mind these causal links between technological change and water resources.

The level of jurisdiction at which policies were made and enacted in each scenario fundamentally shifted the trajectory for the basin. The New Triangle Scenario emerged largely as a result of federal-level decisions about investment in military installations. The Park-Industiral Mosaic developed via coordinated regional zoning and water permitting policies. The Fenced Forest scenario was partly a market-driven change in landscape, with settlement patterns determined at a more local scale by landowners and developers (e.g. private forest enclaves). The backcasts suggest that patterns of land use and water need are directly related to the scale of policy-making in the basin. Awareness of this link could help policy makers be more strategic about what types of policies are made at what level. These three factors are examples of the types of insights that backcasting can provide to decision-makers seeking to plan more proactively in the face of inevitable and unpredictable change.

4.1.2 Insights into System Framing and Planning Context

The omission of any kind of hydrologic extreme or other sudden change on the part of the experts in this workshop is consistent with the predictable, linear conceptualization of change reflected in the Division of Water Resources' 2002 Cape Fear Water Supply Plan (NCDWR 2002). This plan assessed the balance of water supply and water demand expected over 30 and 50-year timescales in the Cape Fear basin by making predictions of supply and demand using linear projections of ten years of previous data. This type of assessment may be an important initial step in comprehensive planning. However, it does not sufficiently account for the inevitable occurrence of conditions other than the projected "normal" conditions as represented by the previous decade of data. The report itself notes the need for additional plans (e.g. for drought mitigation) to complement the 2002 Water Supply Plan. Not until the state had suffered two record droughts did decision-makers see fit to develop a robust state-level system of drought monitoring and local drought response plans.

Interestingly, the 1962 Cape Fear River study of the Cape Fear basin by the Corps took a more comprehensive look at the economic and population trends in the basin than the 2002 Water Supply Plan does (USACE 1962). However, it only considered structural solutions (i.e. dams) to address the predicted future flood and water provisioning challenges and did not study hydrologic variations. This study is a perfect example of how assessment and planning processes reflect the dominant narrative of normalcy in the system. For the Corps study, floods (but not droughts) were considered a "normal" anomaly worth planning for. This mindset was at least partly fueled by the occurrence in 1945 of a record-breaking flood associated with a tropical storm, which caused extensive damage, especially around Fayetteville (Hudgins 2000). In 1946, the push began for flood control measures to be taken in the basin (USACE 1962). The 1945 flood effectively established a new boundary for the definition of a "normal" anomaly in the Cape Fear and was used as the standard to assess the ability of the proposed dam to accommodate flood waters (USACE 1962).

4.1.3 Need for Comprehensive Proactive Plans

This history of reactive changes to management in the Cape Fear and the failure of experts to incorporate trigger events in their backcasting both reflect a conceptualization of planning as a preparation for the "normal" future that has heretofore guided water management in the Cape Fear basin. Limited resources and knowledge certainly preclude planning for every possible event that could occur in the system. Yet, it seems foolhardy not to plan for events like floods and droughts that will inevitably occur, though at unpredictable frequencies and magnitudes. Ignoring whole categories of inevitable hydrologic events and waiting for catastrophe to strike before initiating the development of monitoring and management efforts does not constitute comprehensive proactive planning.

Such approaches seem particularly ill-advised in light of the frequency and severity of droughts and floods that may be associated with climate change (Trenberth 2011) and the scientific rejection of the idea that climatological patterns are effectively stationary over timescales relevant to management (Milly et al. 2008). To weaknesses in the current approach to planning, decision makers should employ an array of techniques that permit them to incorporate new information about the system all three levels (implementation, framing and context) and to update the kinds of uncertainties that are accounted for in the plan before catastrophic damage occurs.

4.2 Situating Backcasting in the U.S. Water Planning Toolbox

At the national scale, water-planning efforts seek to more proactively engage with uncertainty at hydrologically comprehensive scales and in democratically comprehensive ways. The use of adaptive management and scenario planning already help achieve these goals to some degree, yet they are not sufficient to achieve the multi-level learning and identify the array of policy options necessary to effectively manage complex dynamic systems. This study demonstrates the ability of backcasting to complement adaptive management by revealing the underlying patterns in how people conceptualize the system to be managed. This study has also confirmed the ability of backcasting to complement scenario planning by identifying specific trends and potential near term policy changes for a system. In addition I have shown that it is possible to conduct backcasting without major investments of time and resources—with as few as eight people meeting for a single day. Given the benefits of this technique and its relative ease of implementation, backcasting holds great potential to augment future water planning efforts in the United States.

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Appendices

Appendix A: Pre-Workshop Interview Guide

The following topics were discussed in pre-workshop interviews to gain an understanding of different stakeholders in the basins, to identify factors and dynamics that affect river management generally and the future of the Cape Fear specifically, and to identify potential interviewees and workshop participants.

1. Individual's role or organization's role in managing North Carolina rivers

2. Examples of natural or human initiated changes that the individual has observed in her/his work related to river systems

3. Most important variables or issues in the Cape Fear basin over the coming decades

4. Main players and stakeholder groups in the basin

5. Other potential contacts

Appendix B: Cape Fear Information Sheet for Students

Length longest in the state at 6,204 miles

Land area largest watershed in the state at 9,324 square miles;16.5% of NC

Major Cities Greensboro, High Point, Burlington, Durham, Chapel Hill, Cary, Fayetteville, & Wilmington

Human population 2.07 million in 2010, Projected to be 3 – 5 million by 2030

Major Tributaries Deep, Haw, Little, South, Black, and NE Cape Fear

Major In-stream Infrastructure
3 navigational locks and dams in Lower Cape Fear, Jordan dam and reservoir in the Triangle area (USACE)

Federally Listed Endangered Species
Cape Fear Shiner (endemic), shortnose sturgeon, red-cockaded woodpecker, Saint Francis' satyr butterfly, manatee (visits occasionally)

Federally Listed Threatened Species
American Alligator, Loggerhead sea turtle

Important Activities Recreation, Irrigation and other agricultural use, Industrial use, Energy production (hydro and cooling), Ecological conservation, Municipal/household use, Navigational activities are still an official use, though shipping is essentially non-existent on the river.

Land Cover as of 2000 56% forest land, 24% agricultural lands, 9% urban areas, and 11% other (rural transport, small water areas, lakes and estuaries

Entities whose authority has direct bearing on water supply decisions

Federal

US Army Corps of Engineers (USACE)—harbors and reservoirs
US Fish and Wildlife Service (USFWS) via Endangered Species Act (ESA)—wildlife protection
National Marine Fisheries Service (NMFS) via ESA
Federal Energy Regulatory Commission (FERC)—hydroelectric dams
Clean Water Act (CWA)—water quality

State

Department of Environment and Natural Resources' Department of Water Resources (DWR)
Inter-basin transfer (IBT) certification statutes—require registration of IBTs with the State
NC does not require registration of surface water withdrawals <100,000 gpd (or 1 mill. gpd for agriculture)

Local

County governments and public utilities
Soil and Water Conservation Districts
City/Town governments and public utilities

Cape Fear Hydrographs: 1969-Present (USGS Data)

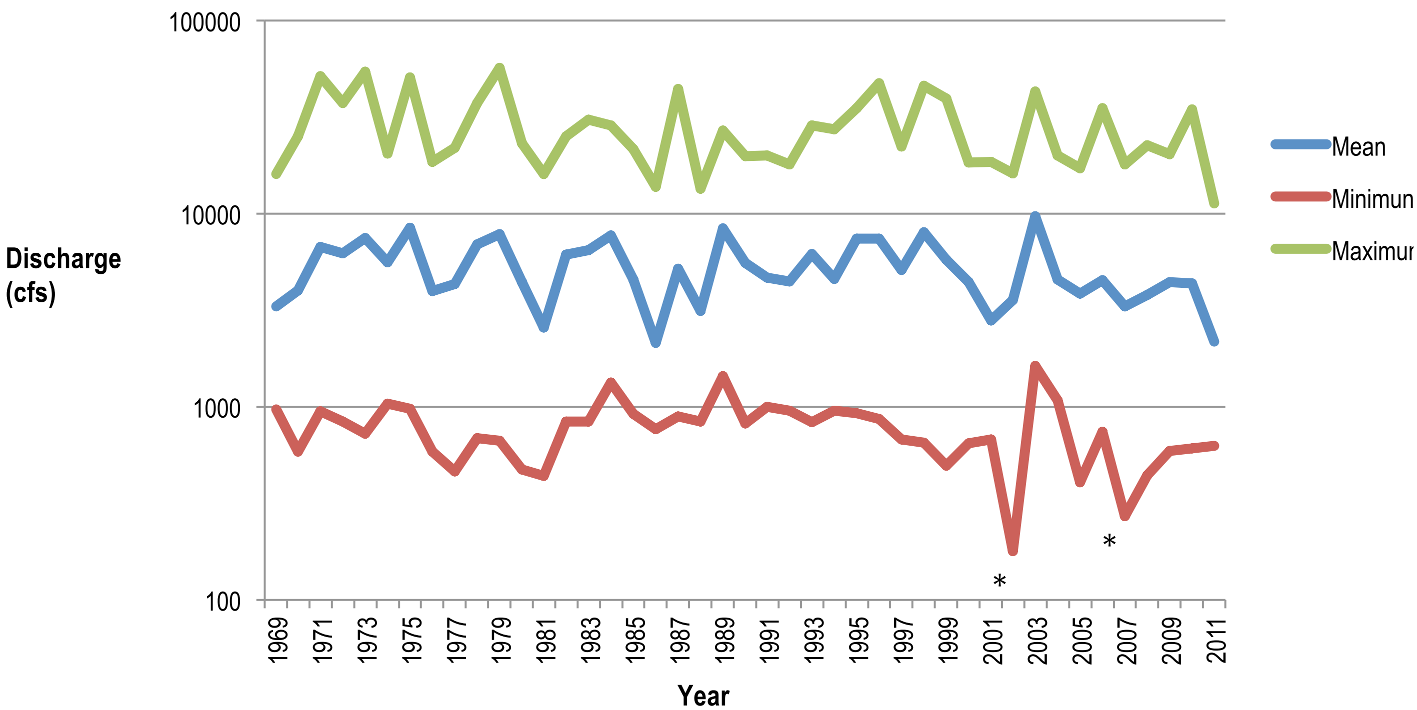


Figure A. Annual mean, minimum, and maximum discharge in the Cape Fear River, NC at Lock & Dam #1 for the period 1969 to 2011. Note extreme 2002 and 2007 droughts.

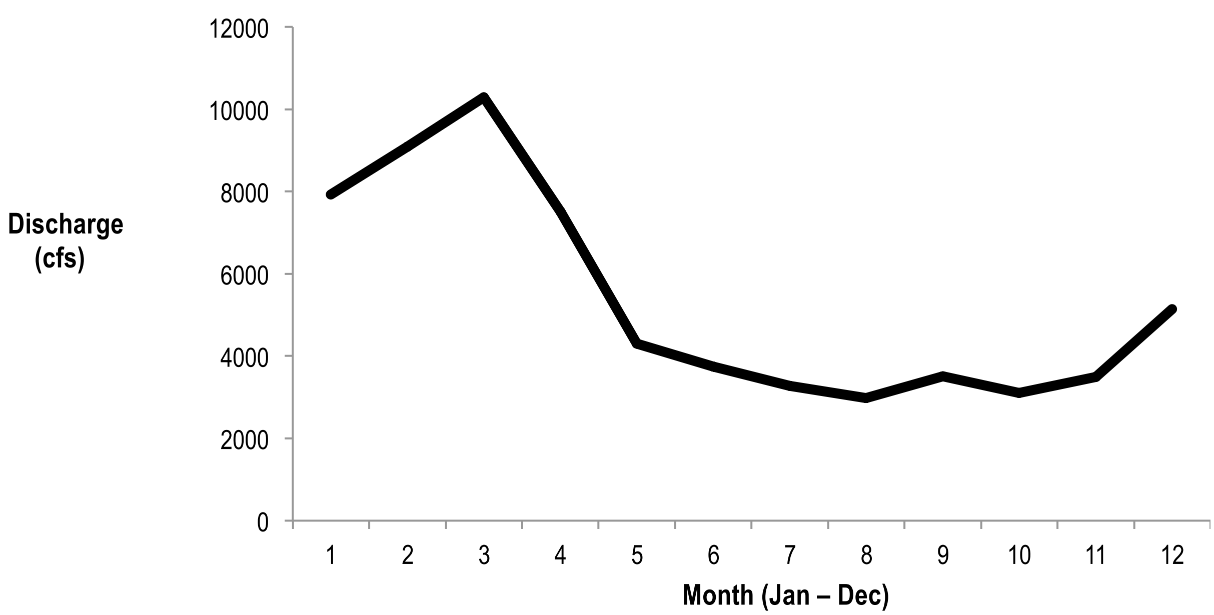


Figure B. Mean daily discharge for each month in the Cape Fear River, NC at Lock & Dam #1 averaged over the period 1969 to 2011. Slightly higher average for September is due to infrequent very high flows during hurricanes.

Major patterns [as identified in pre-workshop interviews]

- Shift to basin scale planning at the State level since 1980s
- Increasing human population and accompanying increase in demand for water for M&I use
- Positive feedbacks between economic development, investment in water supply infrastructure, and water demand
- Large scale industrial agriculture in coastal plain—some of the most intensive hog and turkey production in the country
- International industry: manufacturing throughout, high tech in RTP, agriculture in the coastal plain, shipping at the mouth
- Energy-water nexus: cooling for Sharon Harris nuclear plant, hydropower
- Intense negotiations among municipalities over allocation and IBTs
- Reactive decision making in response to natural disasters (Jordan dam built in response to floods, new monitoring and conservation protocols implemented after '02 and '07 droughts)
- Negotiation of authority among Federal, State and Municipal governing entities
- Increasing prominence of stakeholder involvement as a norm in decision making
- Aging and repurposing of early 1900s textile infrastructure and mid-century locks and dams
- Shift from groundwater to surface water sources in many counties

Emerging factors [as identified in pre-workshop interviews]

- Fracking
- Academic and Conservation interest in ecosystem services
- Pushback on some of the strong state level environmental protections due to economic downturn and Republican control of the legislature
- Increased frequency and intensity of major hydrologic events with global warming
- Increasing salt water intrusion into coastal regions (both groundwater and estuarine) with sea level rise, and desalinization as an increasingly viable response
- Expansion of wood pellet production for export to EU with associated shipping and deforestation activities
- Growth of Ft. Bragg/Fayetteville area due to Army base consolidation
- Percentage based flow rules (as in Charlottesville, VA)
- Gray water reuse (being piped for in new developments in Cary)
- Conservation measures implemented during recent droughts have "stuck"—people are still using less

Appendix C: Post-Workshop Evaluation Survey Questions

1. How would you rate this workshop as a whole?

1	2	3	4	5
poor				excellent

comments:

2. How well did backcasting work to help identify policy solutions?

1	2	3	4	5
poorly				excellently

comments:

3. The produced backcastings are useable for river basin management planning

1	2	3	4	5
strongly disagree				strongly agree

comments:

4. Participating in the workshop has helped me to understand the policy strategies needed

1	2	3	4	5
strongly disagree				strongly agree

comments:

5. The backcasting created a clear link between the future visions and the present day decision making needs

1	2	3	4	5
strongly disagree				strongly agree

comments:

6. What did you like about this workshop?

7. What could be done to improve the workshop?

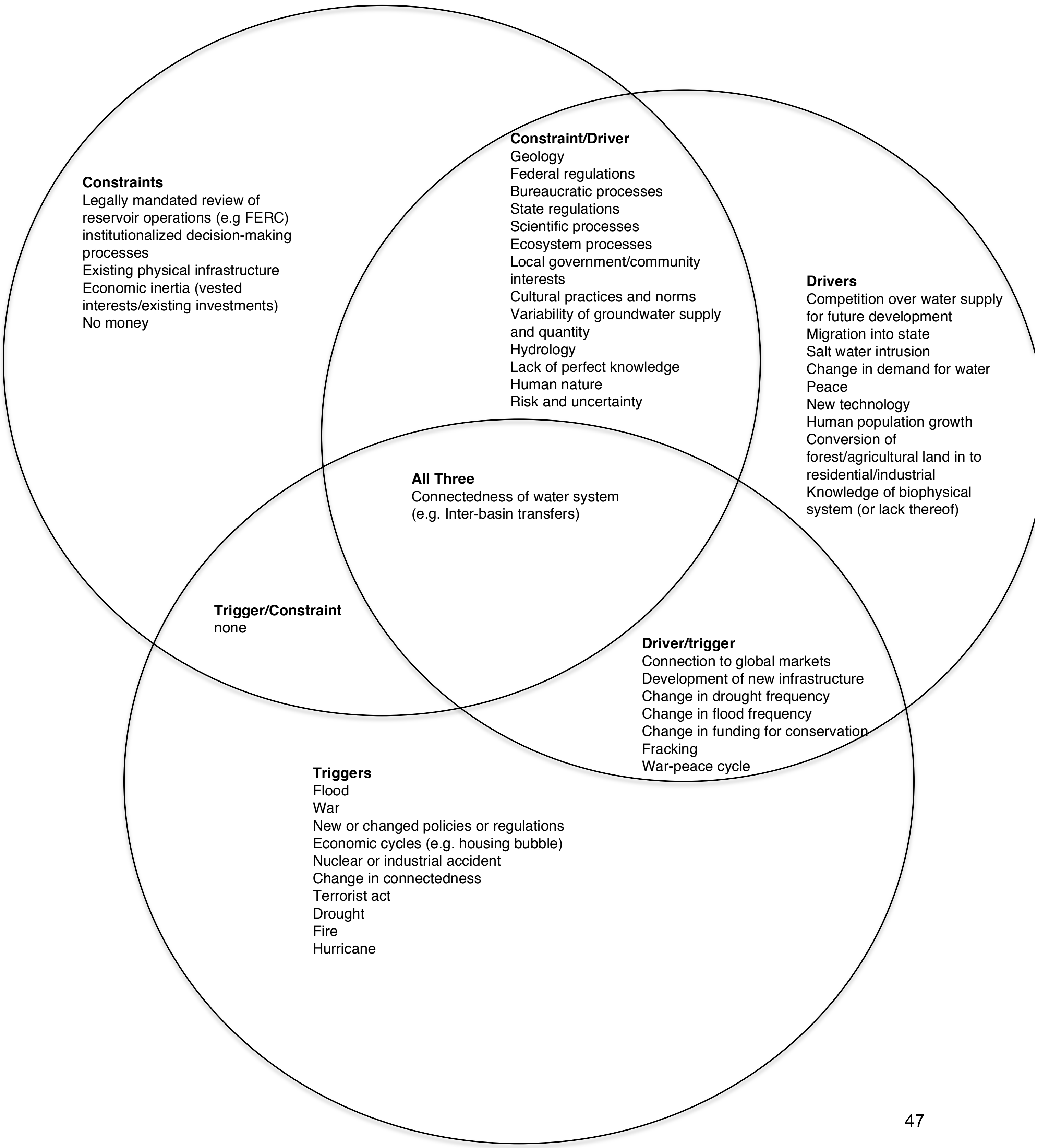
8. What did the facilitator do well?

9. What could the facilitator do to improve?

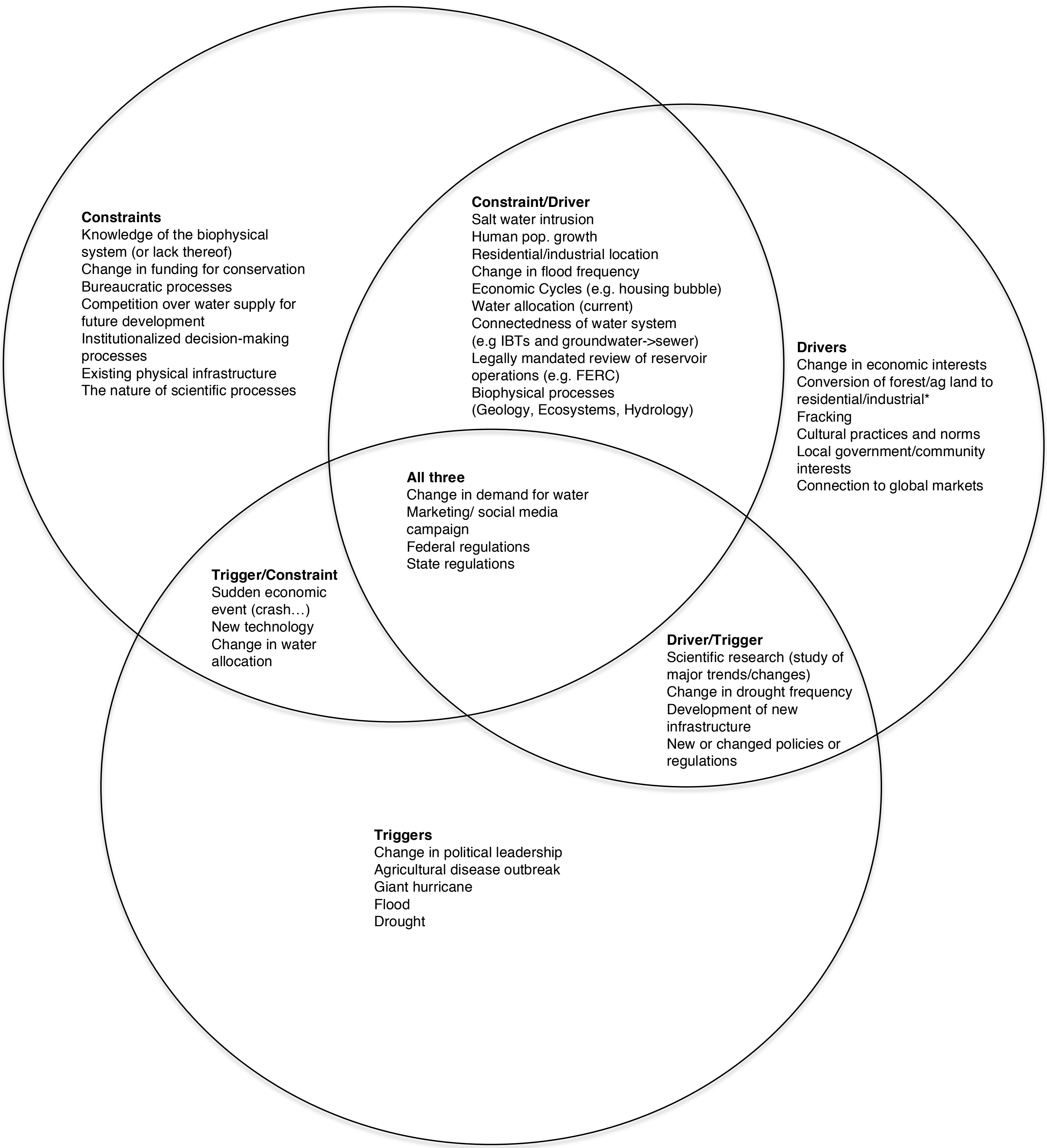
10. What would you like to see happen following this process? What ideas do you have about how the results of this workshop could be used in river management?

Appendix D: Venn Diagram Exercise Results

Expert Workshop Venn Diagram Exercise Results



Student Workshop Venn Diagram Exercise Results



Appendix E: Backcasting Results

Results of Student Workshop BACKCASTING: Actions, Obstacles, Opportunities, and Events

Scenario	Actions	Obstacles	Opportunities	Events
New Triangle	-(Pentagon)bureaucratic decision to consolidate military bases -Congress reduce funding overall, more to NC -Reduced water use/increased water conservation -Citizen opposition to environmental conservation efforts -State/fed funding to develop Wilmington Port -State Legislation on offshore petroleum drilling -Federal funding for infrastructure to support military	-High water needs upstream for agriculture→ poor water quality downstream at population centers -More efficient water purification technology (desalinization and pollutant removal) -Reduced groundwater recharge -Major land use change (Ag→ urban) -Major pop increase and water quantity requirements -Lots of new infrastructure (tech, port, highways) and lots of funding required -Source for food	-Efficient affordable desalination technology (R&D) -Less ag water required in downstream and more upstream -Gray water implementation in new housing developments -Natural gas increase from fracking (pipeline, not drilling in NC)—increased local E, decreased water use -Increased surface water flow (incr. imperv. Surfaces and deforestation, and runoff, decreased lag time between precip and river flow), incr. deforestation -Large tax-base (more people working and pay income tax in NC) -New food sources that are less space, energy and other resource intensive (insects? Petri-dish "bacon"?)	-Military conflict/long term global conflict (later) -Consolidation of military operations (now) -"War on terror" never ends -Transition of energy type (to Natural Gas) -Increasing concentration of conservative people (military families) →lack of support for env. conservation -Decline of ag industry
Fenced Forest	-Carbon marketplace -Higher valuation of passive and active forest values e.g. biodiversity, recreation (PES) -Shift from groundwater to high quality surface water sources -Removal of in-stream structures -Watershed awareness	-Substantial infrastructure -Irregular climate patterns -Politics -Cultural shifts -Perception of wood industry -$ to build new infrastructure -$ for R&D	-Water quality improved due to forested land -Reduced sprawl—concentrated areas of demand reduced required infrastructure -Governance/municipality cooperation -R&D (i.e. tree species that are hardier and require less water)	-Increasing population in cities (domestic and global) →increased demand for wood/timber and paper products -Expanded wood export industry -Decreasing population density, esp. in rural areas -Political support for changes

Results of Student Workshop BACKCASTING: Actions, Obstacles, Opportunities, and Events (Continued from previous page)

Scenario	Actions	Obstacles	Opportunities	Events
Park-Industrial Mosaic	-State policy: tax, ecosystem services, industry -grassroots/community opinion: to moderate political -Catchment-wide planning: enforceable, zoning	-Aggregation—pt. source pollution impact -Able to balance development? -Political environment: conservative influence -Location of zones -Coordination! -Imposing boundaries—containment of natural systems -Increasing population -Quell the frack -Climate/biophysical/stationarity—will the plan be good in 2100?	-Aggregation: technology and idea sharing -Ecosystem services -Commitment to profitable industry -Water awareness and funding stream -Biofuel	-Tax incentives for biodiversity residential parks -Dam near Wilmington -Seawall for salt water groundwater intrusion control -Plan—housing infrastructure -Threshold event—“natural”

Notes from discussion at the end of the Student Workshop

Robust Elements (Things that came up in all scenarios)	Patterns/Observation/Insights (other thoughts)	Questions	Not Addressed (major factors that didn’t come up)
-Industry as important player in land use change -Increase in human population -Political Climate [as driver?] -Conception and valuation of “environment” shapes decisions -Funding need→ constraint? Driver? -Legislation required to allocate funds -Need for R&D/innovation -[Need for] increased understanding and prioritization of water resource management -Import/export to global markets	-Land use change has a major impact across the board -Change is inevitable, especially with water quality, [so will it be] good or bad? -Trigger event needed for change -Awareness of and reliance on ecosystem services -Hurricane Colin—Increased frequency and magnitude of large storms -Different scales of governance have different impacts -Importance of public engagement in Water Resources Management (especially implementation)—community, corporations, other stakeholders	-What does increasing population bring in terms of human capital? Innovation? Demand? -Will larger more frequent storms be incorporated into plans soon? -What will have to occur to plan proactively? A series of trigger events? One large event? -How will current legislation impact development around wetlands and how will this legislation change over time? -How are water needs changing with population? -What current water commitments exist? For how long? What shape is the box we’re working in?	-Sea level rise -Changes in flow regimes -Large hydrologic events -Annual variability in precipitation (spatially and temporally) -Significant federal legislation (current and future)

Results of Expert Workshop BACKCASTING: Actions, Obstacles, Opportunities, and Events

Scenario	Actions	Obstacles	Opportunities	Events
New Triangle	-Elon Musk→ rail system -innovation in military technology (DOD, NSA, Army, Navy) -Community college system→support jobs -Private Sector→innovation to draw military investment, cooperate with NCCU, NCA&T -Major technological innovation required -port of Wilmington needs to be dredged→all of fed. And state govt -Jacksonville needs IBT from Cape Fear (NC DENR LG) -Shift from livestock to fuel crops→ncsu, nca&t, farm bureau -more power plants→Duke, NC DENR, EPA	-population demand v. ecological demand for water -cooperation from agriculture -IBT at Jacksonville -Port of Wilmington dredging -Technological innovation -no existing rail infrastructure -highly impoverished, undereducated population -more power demand = more water use→semi consumptive and temperature issues -desalinization wastewater disposal -infrastructure investments→roads, water, schools, support sector -NCDOT resistance to public rail systems	-leadership from military re:water conservation and quality -less agriculture impacts -less traffic on highways = less water pollution -greater value of natural resources (swimming, fish, etc.) -De-sal is less consumption of fresh water	-major technological innovation of value to military -investment in rail system→ C-based fuel costs too high -war -increased demand for fuel imports/exports in feedback with war) -national/global move to crop-based fuels -national/global move to vegetarianism -global water/fuel shortage (related to war)
Fenced Forest	-Expansion of Shearon Harris [nuclear plant] -Expansion of Harris Lake for water supply -build desal plant/expand nuclear power to run plant to supply tourism center -high end development occurs -increase state/federal conservation funding -creation of carbon offset market	-Nuclear plant expansions require more water supply and may meet social resistance -lack of conservation funding -agriculture will be very resistant to market transition from livestock	-forestry is a low-intensity water use -low density development reduces pressure on regional water systems -increased global demand for wood pellets -use of forested areas for carbon offset	-Animal agriculture either leaves the area or is significantly diminished -extension of RR and internet connectivity made it possible for low density forested enclaves possible -jobs moving to urban manufacturing areas and military communities de-populates rural/small town areas
Park-Industrial Mosaic	-permitting→reuse -investment in tech and desalinization infrastructure -requires increase in efficiency and tech for water use -philosophy of water permitting : highly geographical, working rivers vs. natural rivers -shift in crops to water efficiency	-resistance to reuse -industry increase and energy increase and biofuels increase = increase water demand -environmentalists -CWA (fishable swimmable in all streams)	-high density housing = decreased water demand -cheap clean energy →gas, biofuels -permitting philosophy	-re-shoring manufacturing -cheap energy locally -new permitting adopted

Notes from discussion at the end of the Expert Workshop

Robust Elements (Things that came up in all scenarios)	Contingent Elements	Adaptive Management	Process	Didn't come up
-permitting (2) and water allocation -energy water nexus -deep water port (2) -social stratification (2) -reurbanization -nuclear energy -desalinization (2) -water conservation -reduced agriculture -biofuels (2) -continued robust growth in the triangle -military expansion -sea level rise -gated community natural areas (2) -high speed rail (2) -telecommuting (2)	-War -land use patterns -reurbanization -fracking -state political environment (new triangle) -natural versus working river permitting scheme -increased conservation acquisition? -NC industry competitiveness	-can't assume stationarity of system during experiment→conclusions may not apply, need simultaneous experiments -subbasin scale wil be best unit of experiment -need for more intensive monitoring ($ for sampling stations and more abient stations) -need favorable political and regulatory structure: trust in NC and local agencies -problem of investment needed to develop different water supply strategy -often falls to underfunded local govt to bear burdens -Business model for infrastructure development→ incentives don't separate use and infrastructure costs (e.g. flat rate fee for h2o service does do this) -balkanization of planning and supply hinders basin scale efforts -loot to private sector (department of commerce) for landuse/economic trends, esp. housing market -state level policies/laws are a major variable—not controlled or intentionally experimental -favorable political env. = consistency, recognizing need for local decision making authority, regional needs and coordination at subbasin scale	-Hard to remember ecological/biophysical [aspects] -what if scenario were a biophysical one? Extrapolate to other forces? -exacerbation and reaction to specific events -outcome depends on goal: interested in scenario itself or thinking about possibilities -allocating water under water stress: we didn't have to do -keeping track of terminology, differing definitions→consider simplification -timeline: where to place things was hard -hard to incorporate unexpected events -unknown unknowns -ag/industry/energy interests→we didn't incorporate -process didn't force us to incorporate big trigger changes -board game style→cards for events	-Reducing population -a "pig scenario" or "pigs, pines and people" -hydrologic triggers -development/agricultural lobbying power -incorporating alternative energy -disease –tropical diseases w/climate change -Raleigh and military water demand →how to meet? Role of Jordan lake/USACE? -Dams, sedimentation -aging infrastructure -fish run restoration → makes money - federal and NC policy changes and existing constraints