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The use of scenarios in land-use planning

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Abstract. Land-development scenarios as a means of representing the future have been in the planner's toolkit for several decades. In this paper we provide a systematic view of four basic issues that concern scenarists and scenario users—the concepts, functions, credentials, and efficacy of land-development scenarios. Drawing upon the wealthy and expanding pool of knowledge and experience as reported in the literature, we put forward the notion that a land-development scenario set is both a bridge that connects the process of modeling with that of planning and a cognitive apparatus that stretches people's thinking and broadens their views in planning. The dual function entitles a scenario set to be a favored member of a family of innate instruments that humans operate in making decisions. Under this overarching framework, we propose three credentials that are by no means exhaustive yet are claimed to be essential for a scenario set to perform best the dual function. These are plausible unexpectedness, informational vividness, and cognitively ergonomic design. After exploring the efficacy issue of a scenario set with respect to its impacts on communities at large, we suggest that basic research efforts be underway that aim at the development of unified theories of land-development scenarios, or even scenarios in general, under a possible name of *scenariology*—the study of scenarios.

1 Scenarios

The word *scenario* comes from the dramatic arts. In the theatre, it is an outline of the plot; for a movie, a scenario sets forth details relevant to the plot, such as the sequence of action, and descriptions of characters and scenes, without repeating the actual script. As an instrument for strategic thinking and option search, its formal intellectual roots trace back to the Manhattan project six decades ago when, in 1942, the world-renowned nuclear physicists Oppenheimer, Teller, and Bethe explored and evaluated the possibility that the energy buildup from a full-scale explosion of the hydrogen bomb, the 'Super', might ignite a devastating deuterium reaction in the skies and the oceans (Davis, 1968, pages 129 – 132). In the 1950s, Kahn and his colleagues at the Rand Corporation used the concept of scenarios in a series of strategic studies for military planning purposes, which were subsequently reported in the late 1960s in a book, *The Year 2000*, by Kahn and Wiener, where scenarios were defined as "hypothetical sequences of events constructed for the purpose of focusing attention on causal processes and decision-points" (Kahn and Wiener, 1967, page 6). In the corporate world, scenario analysis has been a popular tool among business planners and strategists since the early 1970s, when the petroleum industry began to use it to deal with the unpredictability of the Arab oil embargo (Leemhuis, 1985; Millett, 1988; Wack, 1985a; 1985b). The word scenario came to the attention of the general public in 1972, when Meadows and colleagues published their much-debated book, *The Limits to Growth*, and presented selected scenarios for world resource consumption (Meadows et al, 1972).

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Scenarios as a means of representing the future have been in the land-use planner's toolkit for several decades. This is evidenced by the inclusion of land-development scenarios in many high-profile planning documents published since the 1960s. Examples include, but are not, and certainly cannot be, limited to, a regional growth study of the Green Spring and Worthington Valleys of Baltimore County, Maryland (McHarg, 1992, pages 79 – 93; Wallace-McHarg Associates, 1964), an urban development study of the Detroit area (Doxiadis, 1966; 1967; 1970; Schneider, 1972), a study of energy consumption, land-use, and growth policy for metropolitan Washington, DC (Roberts, 1975), an urban sprawl impact study for the town of Burlington, Massachusetts (Fabos and Caswell, 1977), the METLAND comprehensive regional land-use planning methods (Fabos, et al, 1978), a resource accountability assessment for the town of Greenfield, Massachusetts (Gross and Fabos, 1984), an urban development policy assessment for the City of Vasteras, Sweden (Khakee, 1991), the alternative urban futures study for the greater San Francisco Bay region, California (Landis et al, 1993), the New York Regional Plan (Yaro and Hiss, 1996), the American Planning Association's guidebook for sustainable development (APA, 1996), the New Jersey long-range statewide transportation plan study (Bonnett and Olson, 1998, pages 313 – 320), a Central European land-use change study (Prieler et al, 1998), an urban land-development study of the Santa Barbara region, California (UCIME, 2001), a scenario analysis of China's land-use and land-cover change (Hubacek and Sun, 2001), and the Cambridge Futures study for the City of Cambridge, England (Echenique, 1999; Roberts, 2002, personal communication[1]).

At root, land-development scenarios are composed images of an area's land-use patterns that would result from particular land-use plans, policies, and regulations if they were actually adopted and implemented at a certain point of time. Common to land-development scenarios are five components: (1) alternatives, the range of potential *choices* of land-use plans, policies, and regulations; (2) consequences, the immediate and cumulative *effects* (physical, ecological, economical, and social) that each alternative would have on an area's land-development futures; (3) causations, the *causal bonds* between alternatives and consequences; (4) time frames—the *periods of time* between implementation of the alternatives and the unfolding, either full or partial, of their consequences; and (5) geographical footprints, the place-oriented *blueprints* of alternatives, and the *anticipated marks* of their ramifications on the geography of an area. The last component—hardly unique—is so pivotal both to the building (that is, composition) and to the utilization of land-development scenarios that it indeed becomes a hallmark that distinguishes land-development scenarios from their counterparts in business, industry, or even the military. It should be noted that some scenarists used the terms *alternative plans* and *scenarios* interchangeably and have included the above five components in their reports as ingredients of alternative plans (for examples, see Fabos and Caswell, 1977, pages 240 – 241; Fabos et al, 1978, pages 142 – 218; Gross and Fabos, 1984; McHarg, 1992, pages 79 – 93).

Land-development scenarios are neither snapshots nor panoramas. Instead, as the product of an information-compilation process—which many scenarists call *modeling* and cognitive psychologists term *chunking* (for a detailed account, see section 2)—they are *synthesized* images, usually accompanied by iconographical labels and stylized narratives, of what *some*, but not all, future land-use patterns will look like. By selectively depicting hypothetical development contingencies associated with particular combinations of goals and their priorities, land-development scenarios provide a basis for explicit consideration of different assumptions concerning land-development futures,

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and act as a stimulus for critical thinking about land-use planning strategies. This soft, qualitative character—little changed over the past four decades—makes land-development scenarios an attractive heuristic or rhetorical guide in a planning process both for organizational learning and for option searching. As Kaiser et al (1995, page 254) point out, underlying each stage of the planning process are two common threads—a vision of the future and the specification of a means to attain that vision. Both contribute to good planning, but their relative importance changes as the process unfolds. The creation of a vision of the future is stressed more in the initial steps, and the creation of a course of action to guide development and change is stressed more in later stages. Scenarios, then, fall into two general categories according to the role they play in the planning process (Schoemaker, 1995, pages 29–30). Learning scenarios are vehicles for 'ends-oriented' learning and goal-setting or direction-setting, whereas decision scenarios are apparatus for 'means-oriented' plan formation and evaluation (Kaiser et al, 1995, pages 251–256). Examples in the learning-scenario category include APA (1996), Bonnett and Olson (1998), Echenique (1999), Hirschhorn (1980), Jantz et al (2002), Landis et al (1993), and Yaro and Hiss (1996, pages 239–243), whereas the decision-scenario category is exemplified by Fabos and Caswell (1977, pages 240–241), Fabos et al (1978, pages 142–218), Gross and Fabos (1984, pages 35–43), Khakee (1991, pages 464–469), McHarg (1992, pages 79–93), and van Huylenbroeck and Coppens (1995).

With the expanding pool of knowledge and experience, as reported in the literature, and with the growing popularity and interest among planners and academics (Myers, 2001; Myers and Kitsuse, 2000, pages 227–229), a systematic view of the use of land-development scenarios is in order. In this article, we undertake this mission with a more theoretically appreciative approach, one that is aimed at gaining an understanding of how and why land-development scenarios work, how they can be made more effective, and how they might be further developed. More specifically, we focus on four basic issues that concern the scenarists, who compose scenarios, and the scenario users, who exploit scenarios. In addition to the concepts of scenarios discussed above, the following sections are devoted respectively to the functions, credentials, and efficacy of land-development scenarios. Hereafter and throughout the remainder of the paper, we shall use scenarios and a scenario set to represent land-development scenarios and a land-development scenario set, respectively.

2 The dual function of scenarios

Technically, a scenario set is a medium through which a scenarist shares with the scenario users convictions about the land-use futures of an area. This places a scenario set in a unique strategic position that connects two streams of future-oriented human activities: scientific inquiry about the future, and real world planning for the future. [For the sake of discussion, and without loss of generality, we designate them as 'modeling' and 'planning', respectively (see figure 1, over).] In this capacity, a scenario set is entitled to perform two interrelated functions of bridging and cognitive stretching.

2.1 Bridging

Underlying both streams of modeling and planning is an information-compilation process, which cognitive psychologists term *chunking.* In his seminal 1956 article, Miller used the term 'chunk' to denote a basic information-processing unit in human cognition, that is, a cognitive unit (Anderson, 1993, page 26). According to Miller, humans have a remarkable ability to group or compile small and usually less-meaningful pieces of information, that is, small chunks, into larger and more meaningful pieces, that is, large chunks, and then exploit them in reasoning, problem solving, and memory. The process of integrating pieces of the perceived information into meaningful chunks

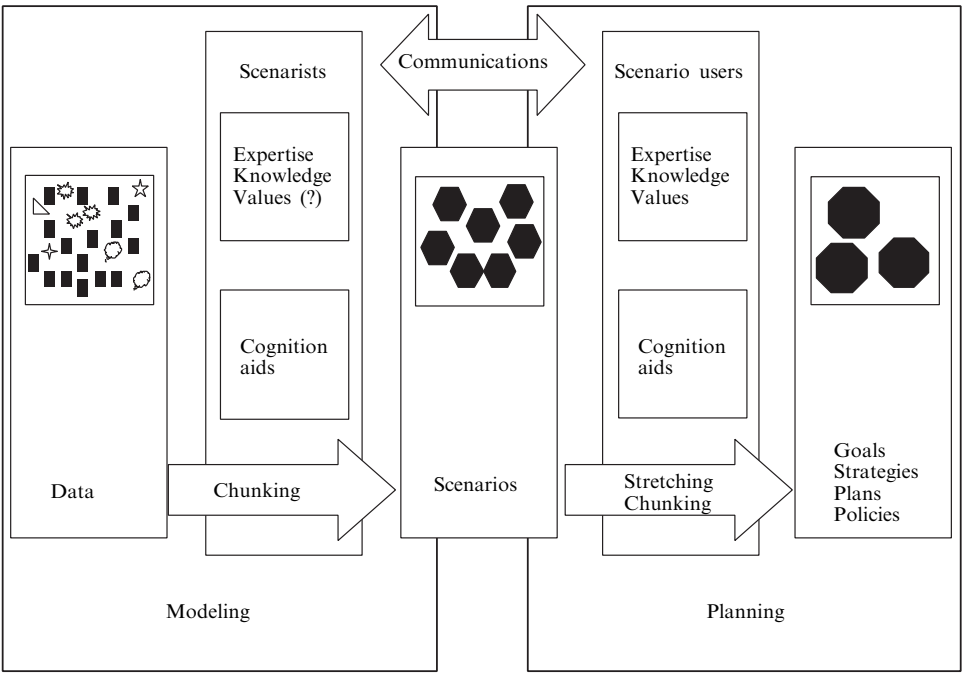

Figure 1. An illustration of the dual function of scenarios. The iconographic shapes in the boxes represent *chunks* at the three different stages of chunking.

is termed 'chunking' (for a succinct account of the properties of chunking, see Newell, 1990, pages 185 – 193). Both the ability to chunk and the process of chunking have been widely recognized in the psychological literature as adaptations to the intrinsic limits on human working memory (Newell, 1990, pages 7 – 9, and 185 – 193; Stillings et al, 1995, page 159), although the mechanisms by which chunking works, what constitutes a 'chunk', and the 'magic number' of chunks that humans are able to handle have been debated (Anderson, 1993, pages 25 – 31; Newell, 1990, page 222; Simon, 1974; Stuart-Hamilton, 1995, page 19).

As illustrated in figure 1, scenarios are the product of one chunking process—modeling—and the raw material of the other—planning. In modeling, a scenarist compiles small and less-meaningful pieces of information (that is, small chunks) with expertise, knowledge, and, arguably, values, as well as various external cognition aids, such as models for calculation and computers for memory augmentation and visualization, into large and more meaningful chunks—scenarios. These are then brought into a planning process by the scenario users and combined with other pieces of information to form even larger and more advanced chunks—goals, strategies, plans, and policies (Kaiser et al, 1995, pages 251 — 256, 261).

The bridging function of a scenario set permits and encourages communication between people from two different communities of modeling and planning. The scenarists, usually specialists, share their knowledge, expertise, convictions, and insights with the often nonspecialist scenario users. The scenario users, usually stakeholders, policymakers, the general public, and planning practitioners, reciprocate by bringing real-world relevance into modeling exercises and by setting up the ultimate benchmarks for composing quality scenarios and the standards for selecting and validating models. Evolving from this reciprocal relationship, which is represented by the two-way arrow in figure 1, is a truly win – win situation in which *both* groups assume ownership of the

emergent scenarios and are eager to put them to work (Schwartz, 1996, page 248). This is exactly why many leading authors, including Schwartz (1996), Wack (1985b), Wilson (2000), and Wollenberg et al (2000a; 2000b), advocate a *scenario process* that intertwines modeling with planning by engaging scenarists and scenario users in 'a permanent strategic conversation' under a 'hospitable', 'collaborative', and 'reflective' climate (Schwartz, 1996, pages xiv, 227 – 239). Schwartz (1996, page 248) even states that "Scenario making is intensively participatory, or it fails".

2.2 Stretching

In addition to the bridging function, many scenarists, cognitive psychologists, and behavioral decision scientists consider scenarios as apparatus for the mental exercises that help 'overcome' (Schoemaker, 1993, page 200), 'debias' (Bazerman, 2002, pages 152 – 167), or even 'repair' (Heath et al, 1998) some of the intrinsic shortcomings of human cognition (Bazerman, 2002; Heath et al, 1998; Hammond et al, 1999, pages 189 – 216; Heuer, 1999; Hoch, 1984; Russo and Schoemaker, 1989; Tversky and Kahneman, 1974).

Psychologists have found that the cognitive processes, in which people collect and combine information and draw inferences, are subject to systematic and thus predictable errors. Evidently, people have a natural tendency to conduct their cognitive activities under ease-based heuristics. These are cognitive procedures or judgmental strategies that are simple, easy, and useful, on the one hand (Nisbett and Ross, 1980, pages 254 – 255), but are narrow, shallow, and often biased or even misleading, on the other (Bazerman, 2002, pages 11 – 40; Heath et al, 1998, page 2; Nisbett and Ross, 1980, pages 17 – 23, and 41 – 42; Tversky and Kahneman, 1974, pages 1130 – 1131). Among the most relevant to futures studies are the heuristics of availability and adjustment (Tversky and Kahneman, 1974, pages 1127 – 1131).

Under the availability heuristic, people's cognitive activities start with, and then zero in on, the pieces of information in the memory and/or the environment that are ready for immediate use (Hoch, 1984, pages 649 – 650; Stillings et al, 1995, page 125; Tversky and Kahneman, 1974, pages 1127 – 1128). This process is influenced by familiarity, recency, salience, and ease of searching, imaging, or use (Tversky and Kahneman, 1974, pages 1127 – 1128) and so these pieces of readily available information cannot necessarily be the *best* or even the *best available*. A cognitive process that relies on the availability heuristic therefore tends to yield premature judgments that are narrow, myopic, and often prejudiced, especially when uncertainty and complexity are high (Bazerman, 2002, pages 41 – 58; Schoemaker, 1993, pages 196 – 199).

In the adjustment heuristic, first described by Tversky and Kahneman in 1974 (pages 1128 – 1130), people make estimates by starting from an initial value point and then extending or adjusting it to a final prediction (Caverni and Peris, 1990, pages 35 – 36; Tversky and Kahneman, 1974, pages 1128 – 1130). As the tasks of setting and extending the origin points are guided by the ease-based availability heuristic, the adjustments are usually insufficient in range and biased toward the initial values. This is known as the anchoring effect (Bazerman, 2002, pages 27 – 33; Caverni and Peris, 1990; Russo and Schoemaker, 1992, pages 11 – 12; Schoemaker, 1993, pages 198, 200 – 201; Tversky and Kahneman, 1974, pages 1128 – 1130), which in fact was widely recognized long before its scientific designation. For example, in an essay entitled *The Hedgehog and the Fox: An Essay on Tolstoy's View of History*, Berlin (1966, page 74) said it all: "the fuller our knowledge of facts and of their connections the more difficult to conceive alternatives".

Prescriptions to offset the undesirable effects of the availability and adjustment heuristics include the idea of reaching and sustaining a 'bigger picture' through

'stretching' and 'focusing' (Bazerman, 2002, pages 152 – 167; Heath et al, 1998; Kahn and Wiener, 1967, page 6; Schoemaker, 1991; 1993; Schwartz, 1996, page 209). Scenarios are one, and arguably one of 'the most powerful' (Schwartz, 1996, page xv), apparatus for these exercises that "aim to stretch thinking about the future and widen the range of alternatives considered" (Porter, 1985). The individual pieces of assembled information in a scenario set, presenting the causal relationships between the alternatives and their consequences both spatially and temporally, are not and, as many scenarists point out, cannot, be available (Bunn and Salo, 1993, page 298; Schoemaker, 1995, page 27; Wollenberg et al, 2000a, page 76), or at least not obvious (Davidson, 1995), in small chunks. They therefore bring flashes of insight to the users, usually marked by an 'Aha!' experience, that stretches their thinking (a thorough discussion of the various aspects of insights can be found in Mayer, 1995). Later, in section 3 of this paper, we will provide a detailed account of the stretching function.

2.3 The dual function and decisionmaking

The two functions of a scenario set are interrelated, and their sphere of influence goes well beyond the limits of modeling and planning. Exchange of information between scenarists and scenario users through an open and participatory scenario process is a prerequisite for stretching, and stretching that broadens people's perspectives not only sets the aims for bridging but also keeps the modeling activities focused. The 'bigger picture' that comes into prominence to scenario users during their stretching exercises is an essential ingredient of an effective decisionmaking process (Hammond et al, 1999, pages 5 – 14; Schwartz, 1996, page 209). As Schwartz put in his widely acclaimed book *The Art of the Long View: Planning for the Future in an Uncertain World* (1996, page 209), the inclusion of such a 'bigger picture' is "one common element to all correct decisions". This ultimate connection to effective decisionmaking through its dual function entitles a scenario set to be a favored member of a family of instruments that are innate to humans, and that they are 'extremely well-equipped' to operate in making decisions (Schwartz, 1996, pages 29 – 31). Schwartz even claims, on the grounds of the latest evidence from neuroscience, that humans are "the scenario-building animal" which has an inbred ability to build scenarios and to foresee the future for decisionmaking (page 29).

An immediate implication of the broader perspective that the dual function of a scenario set contributes to all three streams of future-oriented human activities—modeling, planning, and decisionmaking—is that the quality of a scenario set, that is, its degree of goodness, is no longer a topic that is solely important to modeling and planning, nor can it be adequately represented by conventional standards for modeling and planning, such as accuracy, precision, and efficiency. Instead, it is ultimately related to the quality of decisionmaking and should be measured with respect to the effectiveness of the decisionmaking process (Majone, 1984, pages 17 – 18). In other words, a scenario set may be considered as *good* only when it performs both the bridging function and the stretching function well *and* contributes to an effective decisionmaking process.

3 The credentials of good scenarios

What makes a good scenario set? What credentials should a scenario set possess in order best to play its role in each of the three streams of future-oriented human activities—modeling, planning, and decisionmaking? Little, if any, work has been reported that explores *systematically* what these credentials are or should be. Discussions so far have been informal, sketchy, and often narrowly focused on a set of partial measures. Given the popularity of scenario methods in land-use planning and their connection with

decisionmaking, this missing link most definitely deserves serious attention and warrants a systematic treatment. In this spirit, we propose three credentials that are by no means exhaustive, but that we claim are essential. Neither are they necessarily independent in practice, but they are at least distinct conceptually.

A scenario set may be described as good, that is, as likely best to perform the two functions of bridging and stretching, and likely to contribute to an effective decision-making process, when the land-development futures it presents are *surprising* and *plausible;* when the information it uses and the way it presents the information are *vivid*; and when its design is *cognitively ergonomic*—that is, *effective and safe*.

In the next subsections, we describe these credentials and elaborate their ingredients.

3.1 Plausible and surprising futures

Plausibility and surprises are the defining credential of a good scenario set: "you can tell you have good scenarios when they are both plausible and surprising" (Schwartz, 1996, page 248).

3.1.1 *Plausible unexpectedness*

A good scenario set strikes people with thought-provoking and unexpected futures (Schwartz, 1996, page 59). A 'rational' scenario set that merely confirms conventional wisdom and offers no surprises is most definitely less, if ever, effective in stimulating creative and breakthrough thinking than its 'irrational' and 'disconfirming' counterpart (Schwartz, 1996, pages 60 – 62; Wollenberg et al, 2000a, page 76). A good scenario set creatively incorporates the considerations of the low-probability—even wildly imaginative—outcomes, presents the challenges as opportunities, and suggests policy options that convert a seemingly zero-sum game where there are only winners and losers into a situation where everyone is a winner. Although a presentation of such a scenario set may surprise or even 'frighten' people with the challenges to some of their inbred beliefs and judgments, it is these unexpected surprises that promise to offer the maximum amount of cognitive benefit. Not only do they bring people to the realization of the hidden flaw of overconfidence (Bunn and Salo, 1993, pages 298 – 299; Clarke, 1997, page x; Russo and Schoemaker, 1992), but they also trigger the emergence of brilliant strategies and winning plans (Avin and Dembner, 2000; Bunn and Salo, 1993, pages 300 – 301; Hopkins, 2001; Huffman, 2001). This second benefit is especially important. Huffman (2001, page 16) argues that in games such as chess, where newness is rare, it is the unexpectedness that leads to the winning decisions: "There are not many truly new moves in chess, but chess matches are still won by using standard moves unpredictably." His point is right on target. Land-use planning and decision-making can be seen as a big-stakes game of serious multiparty competition over the future land-use pattern of an area (Kaiser et al 1995, pages 5 – 8) where truly new strategies or principles are rare. A winning plan or correct decision is often the one that uses standard strategies unprecedentedly or even unpredictably.

Of course, surprises alone do not make a good scenario set. The unexpected futures that a scenario set presents must also be plausible, that is, worthy of belief, in order to win people's acceptance. A good scenario set persuades people with the power of coherence, that is, the internal consistency of a scenario (Schoemaker, 1993, pages 195 – 196; 1995, page 29). As a fundamental requirement, coherence guarantees that the causal relationships between an alternative and its consequences are properly maintained within a scenario and ensures that the drivers—interactions among all the agents and forces that contribute to the land development of a region—are identified, represented, and processed without violating the logic of the modeling approach(es) used. It therefore sets the conceptual framework for a systematic, credible, and defensible interpretation of individual scenarios, which is regarded by many as the

sole valid criterion for plausibility (Tversky and Kahnerman, 1974, page 1130; Vlek, 1984, pages 23 – 24). The strong bond between coherence and plausibility has led scenarists to the belief that plausibility appears only in coherent scenarios (Schoemaker, 1993, pages 195 – 196; 1995, page 29). Some even consider coherence as a defining characteristic of 'true' scenarios (for example, Schnaars and Ziamou, 2001, pages 25 – 26; Schoemaker, 1991, pages 549 – 550; 1993, pages 195 – 196).

The ingredients of the plausible unexpectedness include, but are certainly not limited to, diversity in perspectives, inconsistency, and comprehensiveness.

3.1.2 *Diversity in perspectives*

A scenario set should confront the users, who in most cases are stakeholders, the general public, planners, and policymakers, with a diversity of viewpoints (Schoemaker, 1991, page 550; Schwartz, 1996, page 59). The decentralized process of land-use planning and policymaking in a democratic society is participatory and characterized by multiplicities in values, goals, and objectives. The stakeholders may take totally different perspectives about the future from those of the general public, the policymakers, and planners. The affluent and well-represented stakeholders often hold distinctive views from those who are less fortunate, disadvantaged, and underrepresented. Commuter stakeholders, people who commute between places of work and residence, for example, may share little, if any, vision with the noncommuter stakeholders in either place about the futures. Furthermore, participating professionals with different expertise and experience, such as transportation engineers, ecologists, demographers, economists, geographers, and planners, may portray and elaborate the images of future land developments with their preferred tools that are developed under substantially different assumptions. It is indeed this diverse range of opinions and factors that shapes future land-development patterns. Instead of integrating or reconciling, a good scenario set should present the diversity of beliefs, competing perspectives, disagreements, and various analytical results through truly discrete scenario themes in a way that not only brings unexpected surprises to the users but also helps them to take, and potentially become appreciative of, others' perspectives when looking into the future (Becker, 1983, page 98; Bunn and Salo, 1993, page 298; Hopkins, 2000; van der Heijden, 2000, page 36; Wollenberg et al, 2000a, page 75). In this capacity, a scenario set becomes a vehicle for consensus building, collaborative planning (Elkington and Trisoglio, 1996, pages 766, 768; Innes, 1996; Klosterman, 1999; Wollenberg et al, 2000a, page 75), and problem solving (Hopkins, 2000).

3.1.3 *Inconsistency*

Unlike coherence, which is focused on individual scenarios and measured by the logic of the specific modeling or chunking approach used in scenario composition, consistency is a perception or judgment by the users about the relationships among the scenarios (Becker, 1983, page 98; Bunn and Salo, 1993, pages 300 – 301; Schoemaker, 1993, page 196; 1995, page 30). A scenario set is consistent when none of its component scenarios intuitively conflicts with another or with its environment. According to Schoemaker (1993, page 196), there are three types of consistency: trend consistency among the trends the scenarios represent; outcome consistency among the end-states the scenarios present; and stakeholder consistency between the roles the stakeholders dislike to take in reality and their assumed roles in the scenarios. An emphasis on consistency will undoubtedly supplant the scenarios of competing perspectives and/or unexpected outcomes with mutually compatible perspectives, and will dismiss those that are considered too bold and therefore at odds with the environments. For example, the scenarios that creatively but 'unrealistically' portray the stakeholders, who may or may not be the scenario users, as sticking to a position that is wholly undesirable

for them will likely be rejected for consistency reasons. This, however, may well undo the very purpose of a scenario process—searching for and stretching to unexpected alternative futures. It is, therefore, *inconsistency*, not consistency, that should be sought and preserved.

3.1.4 *Comprehensiveness*
The quality of coherence is dependent upon an understanding of the land-development drivers. The drivers are the interactions among all the agents that shape the future land-development of the region and among the forces behind them. In a broad sense, the fundamental driving forces are found in humans' eternal pursuit of economic efficiency, environmental quality, and social equity. The agents that strive to materialize these goals are from a diverse array of social sectors inside and outside a region, ranging from the market, to governments, and to various interest groups. Their interactions drive land-use dynamics and, to a great extent, prescribe the directions, magnitude, and rate of land-use change. Without an understanding of these interactions, the state of the land development of a region may be incomprehensible, and many possible changes unthinkable (Kaiser et al, 1995, pages 5–31). A good scenario set therefore offers a holistic and insightful view of futures by articulating the knowledge about the drivers with the presentations of the key challenges, the policy responses, and the consequences (Bunn and Salo, 1993, page 299; Schwartz, 1996, pages 100–117). However, a higher level of comprehensiveness often means a heavier information load, at least with respect to the sheer number of original and derived chunks. As illustrated in figure 1, the original chunks are data or 'raw materials' for scenario composition, such as attributes, geographic features, map layers, and even models. The derived chunks, in contrast, are products of the same chunking process, that is, scenarios. The relationship between the number of original chunks and the number of derived chunks is, as discussed in section 3.3.2, at least exponential. An extreme example is the 1960s urban development study of the Detroit area, which analyzed 49 million scenarios (Schneider, 1972, page 332). The pursuit of comprehensiveness should therefore be sensitive to and balanced with considerations of information load. A process of effective scenario composition requires, and a good scenario set contains, only as much information and analysis as is necessary to explore the range of alternative futures.

3.2 Informational vividness
Informational vividness is instrumental to the efficacy of a scenario set. Cognitive psychologists have found that people have a natural tendency to assign inferential weight to information in proportion to its vividness (Nisbett and Ross, 1980, pages 43–62). Simply put, vivid information has a greater impact on inferences than does pallid information because vivid information is more likely to attract and hold people's attention, excite their imagination, and become readily available to them. A good scenario set should therefore use only vivid information in its composition and should present that information in a vivid way.

What are the factors that contribute to informational vividness? According to Nisbett and Ross (1980, page 45), information may be regarded as vivid when it is (1) emotionally interesting, (2) imagery provoking, and (3) proximate in a sensory, spatial, and temporal way.

3.2.1 *Emotional interest*
A scenario set is emotionally interesting to users when it is relevant to their needs, desires, motives, and values. A good scenario set should therefore connect directly with the key issues that are important or urgent enough to "keep the stakeholders, the general public, policy makers, and planners awake at night" (Schwartz, 1996, page 242).

No matter what tactical purpose it serves—whether to form land-use plans, to examine alternative policies, to help an individual or organization learn about and cope with changes, or to provoke discussions for consensus building—strategically a good scenario set has a clear policy orientation and can readily be incorporated, even directly transformed, into land-management strategies, land-use plans, and policy decisions. This connection to land-use decisionmaking, as discussed in section 2, is the ultimate reason and justification for the exercise of a scenario process (van der Heijden, 2000, page 33; Wilson, 2000, page 23). Some scenarists, however, caution, and many scenario users agree, that the purpose of a scenario process is to gain insights and to explore and assess strategies at gross or even 'rough' levels of difference (Gross and Fabos, 1984, page 38; Wilson, 2000, page 25), not to develop or propose the actual future allocations of activities, either on a metropolitan, a jurisdictional, or even a small-area basis (for example, Gross and Fabos, 1984, pages 29–44; Roberts, 1975, page 402).

Another factor that contributes to emotional interest is personal acquaintance, that is, the degree to which scenario users are acquainted with the people who would be involved in the scenarios. Normally, a scenario set is of greater emotional interest when its alternatives would affect, and/or consequences happen to, people that the scenarists and/or scenario users know or have strong feelings about than when they would affect people about whom the scenarists and/or the scenario users do not know or about whom they have only neutral feelings. A scenario set that involves allocation alternatives of locally unwanted land uses (LULUs) is much more interesting to those planning commission members who either represent, or who have relatives or friends who live in, the area where the LULUs would be allocated under one alternative than to other members who do not. Therefore, besides a policy orientation, a good scenario set should have a people focus and a personal 'taste'. It situates the scenarists and the scenario users in a high-stake environment in which they feel obligated to pay more attention to every scenario in the set.

3.2.2 *Imaginability*

Cognitive psychologists found decades ago that information that prompts sensory imagery has a greater impact on inference because it promotes recognition, retention, and recall (Enzle et al, 1975; Nisbett and Ross, 1980, pages 47, 51–53). A leading factor that contributes to the informational 'imaginability' is 'concreteness'—the degree of detail and specificity in the composition and presentation of a scenario set (Nisbett and Ross, 1980, page 47). The scenarists consider concreteness as a key determinant of how much attention a scenario set attracts (Bunn and Salo, 1993, page 299; Schoemaker, 1995, page 29). To make a scenario set concrete and therefore imagery-provoking, scenarists employ highly descriptive scenario titles (labels), compelling narrative lines, and a movie-like series that shows not only the end-states but also the dynamic process that connects the present to the future. However, they are less in agreement on how technically specific or transparent a scenario set should be. Should the scientific concepts and modeling techniques used to develop scenarios—such as bifurcation, dissipative structures, chaos, catastrophes, cybernetics, neural networks, system dynamics, and cellular automata—be made transparent to the scenario users? The proponents consider that a high level of technical concreteness brings a great amount of credibility to the scenario set and therefore helps to win the users' acceptance (Coates, 2000, page 117; Godet, 2000, pages 18–19; Godet and Roubelat, 1996, pages 169–170; Wollenberg et al, 2000a, pages 72 and 75). The opponents, however, worry that a detailed presentation may be counterproductive as it is likely to impose a level of precision that is usually absent in the minds of many, if not most, scenario users. Apparently, also, most users just do not care. As Godet and Roubelat (1996, pages 165–166) point out,

"The container matters little so long as one is intoxicated by the content." Although the answer to the question about how technically transparent a scenario set ought to be relies on how literate the scenario users are technically and whether they are interested in knowing the technical details, the ultimate justification depends on whether the technical concreteness is absolutely necessary for an understanding of the scenario set and whether it adds to the imaginability of the scenario set. One compelling method to ensure an appropriate level of concreteness is to involve the scenario users in the scenario process, at least to the degree that 'buy-in' is achieved in the results.

3.2.3 *Proximity and directness*

Information is vivid if its content is close in space and/or time to the users (Nisbett and Ross, 1980, pages 49-51). The news that a shopping center will be built near one's neighborhood in a year is more vivid than the news that a shopping center will be built on the other side of town in five years. The first item of news is accordingly more likely to exert an impact on the person's views of the magnitude and rate of commercial development in the area than is the second item of news. Similarly, a scenario set that involves allocation alternatives of LULUs is much less vivid if the alternative allocation plans in the scenario set are 'not in my backyard' (NIMBY). In addition, information obtained first hand, through one's own sensory apparatus for sight, hearing, smell, taste, and touch, is more impressive and recollectable than that obtained from a second hand or third hand source (Larkin and Simon, 1987; Nisbett and Ross, 1980, pages 49 – 51). The effect of informational directness has been widely recognized and is often acknowledged by well-known proverbs, such as 'seeing is believing', 'a picture is worth 10 000 words'. Furthermore, proximity and directness of information themselves can increase vividness and, accordingly, can increase inferential impact, even when the other two ingredients, emotional interest and imaginability, are held constant (Nisbett and Ross, 1980, page 50).

A good scenario set therefore comprises information content that is spatially and temporally proximate to the users, and presents the information in a sensorially direct way. In the scenarios literature, however, spatial and temporal proximities and their cognitive effects have not received the amount of attention that they deserve. In most scenario sets reported, the geographic scope of the study area automatically sets the level of spatial proximity—the larger the study area, the lower the level of spatial proximity in the scenario set, and the smaller the study area, the higher the level of the spatial proximity in the scenario set. Similarly, the level of temporal proximity is usually determined politically by plan-making or review cycles (a five-year or ten-year interval in most cases), or technically by data availability (for example, the ten-year cycle of population censuses in the USA), or, in some cases, even arbitrarily. By contrast, there has been and continues to be a strong interest in pursuing informational directness. Co-evolving with technological advancement in geocomputation (Clarke, 2002), scientific visualization (Batty, 2001; Langendorf, 2001), and spatial multimedia (Shiffer, 2001), this stream of inquiry is exemplified by the inclusion of maps, photos, charts, and diagrams in the pioneering work of McHarg (1992) and Fabos et al (1978), and by the incorporation of videos, movies, sounds, animations, and the Internet in the recent works of Batty (2001), Shiffer (2001), and the 'Urban Change—Integrated Modelling Environment' (UCIME, 2001), among many others.

3.3 Ergonomic design

As an apparatus for the mental exercise of stretching, a scenario set should be designed ergonomically so that it interacts with the users both effectively and safely. More specifically, if each scenario represents a stretch into the future, in order for the scenario users to receive the maximum amount of benefit from this mental workout and to avoid

or minimize potential injuries, the following questions must be addressed in designing scenario sets:

in how many directions should the stretches extend—single or multiple? That is, what is (are) the theme(s) of a scenario set?

how many stretches are necessary? Is there an ideal number of stretches? That is, what is the size of a scenario set?

how far into the future should each stretch extend? That is, what is the timeframe of a scenario set?

There is, of course, neither a single nor a simple answer to any of these questions. In the following subsections, we review and compare different strategies and, in some cases, approaches, that the scenarists and scenario users take to address these issues.

3.3.1 *The theme(s) of a scenario set*

Scenario themes are the topics around which scenarios are composed. A theme can be about a tactical issue, such as development density, riparian buffer width, or zoning for easement. It can also be broadly defined at a strategic level, such as the ratios of mixed land uses, land banking, land-use plan adoption, sustainable development, or transfer of development rights. A scenario set can be built around one or several different themes and therefore falls into one of two categories: single-themed or multiple-themed.

A single-themed scenario set is typically arranged sequentially with regard to gradations of difference along a single thematic dimension. For example, a set of four land-development scenarios are formed under a common theme of 'expanded growth 1963–2000' in a regional growth study of the Green Spring and Worthington Valleys of Baltimore County. Each represents a possible incremental stage of land development between the years 1963 and 2000 (McHarg, 1992, page 84). In an assessment of future residential development in Santa Barbara (Aubry et al, 2002), in another example, three scenarios are created to show the possible stages of future residential development on existing vacant land. These are: (1) the residential build-out scenario that results if all the vacant land that is zoned for residential development is developed; (2) the commercial or light industrial to residential build-out scenario that depicts an image in which all the vacant land that is currently zoned for commercial and/or light industrial but permitted for residential development is actually developed into residential; and (3) the agricultural to residential build-out scenario that shows residential development taking place on those agricultural lands that are permitted for residential development. A third example is from the Central European land-use change study (Prieler et al, 1998, pages 14–28) in which the three scenarios are arranged according to a ratio between forest and agricultural lands and named as 'increase in wooded area', 'alternative agricultural products', and 'Europe as food exporter'.

A single-themed scenario set can also be arrayed over a thematic dimension according to the acceptability of these dimensions to the scenario users and/or scenarists. The two scenarios in the New York Regional Plan (Yaro and Hiss, 1996, pages 239–243), for example, are constructed around one theme to illustrate the effects of policy change on land-development patterns in the New York–New Jersey–Connecticut metropolitan region. They are arranged dichotomously as the de facto (the existent) plan scenario and the Regional Plan Association alternative (the *ben trovato* plan) scenario, respectively, with a clear bias towards the last of these. In an urban futures study for the Washington, DC, area (Jantz et al, 2002), three scenarios were formed showing urban growth patterns under different management strategies. Arranged from the least to most favorable these are (1) current trends; (2) managed growth with minimum protection placed

on resource lands, such as riparian areas, wetlands, forests, and agricultural areas; and (3) managed growth with maximum protection (Jantz et al, 2002, page 5).

It should be noted that despite their popularity in planning, the cognitive effectiveness of the single-themed sets of 'gradation or increment scenarios', that is, their stretch effectiveness, has been seriously debated (for example, Hammond et al, 1999, page 48; Heath et al, 1998, pages 9 – 10; Schnaars and Ziamou, 2001, pages 27 – 28).

In a multiple-themed scenario set, each scenario is composed along a unique thematic dimension that emphasizes a specific pathway into the future, and each of the scenarios in the set are radically different from one another dimensionally. Besides the single-themed scenario set that represents possible stages of land-development between 1963 and 2000 (McHarg, 1992, page 84), the three scenarios formed in the regional study of the Green Spring and Worthington Valleys of Baltimore County are named 'uncontrolled', 'linear arterial', and 'plan for the valleys and metrotowns', each showing significantly different patterns of future growth (page 86). The scenarios that are created in an urban land-development study of Santa Barbara (UCIME, 2001), in another example, are labeled as 'no new commercial', 'unrestricted growth', 'environment friendly', 'follow current trends', 'improve roads', and 'enforce growth boundary'. The three land-development scenarios in the METLAND comprehensive regional land-use planning methods (Fabos et al, 1978, pages 142 – 200), as a third example, are structured around the themes of 'composite landscape value', 'status quo', and 'community preference'. The future transportation choice scenarios in the New Jersey Long Range Statewide Transportation Plan study (Bonnett and Olson, 1998, pages 313 – 320), as yet a further example, are arranged along four distinctive dimensions: 'muddling through: the status quo continues', 'gateway to the world: a dynamic, high-tech future', 'bad news: the worst plausible future', and 'pushing the envelope: a sustainable future'. In the Cambridge Futures study for the City of Cambridge, England (Echenique, 1999), as a last, but certainly not least important, example, the scenarios are composed into seven thematic dimensions, and titled: 'minimum growth', 'densification', 'necklace', 'green swap', 'transport links', 'virtual highway', and 'new town'. In these examples, there is little if any overlap among the scenarios thematically although there is some overlap geographically (for example, see the figures on pages 158 and 164 in Fabos et al, 1978, and the three maps on page 86 in McHarg, 1992).

Despite the criticisms of single-themed scenario sets, especially of sets of 'gradation scenarios', with regard to their cognitive effectiveness (for example, Heath et al, 1998, pages 9 – 10), there is no report of a systematical investigation of the issue of whether a multiple-themed scenario set offers users a greater amount of stretching benefit (Schnaars and Ziamou, 2001, pages 27 – 28). Generally speaking, the scenarios in a multiple-themed set are likely to attract the same amount of attention from the users, as they are readily perceived as independent, individualistic, and equally likely futures. Their counterparts in a single-themed set, in contrast, are usually viewed as interdependent when they are sequentially arranged, as complementary when two scenarios are dichotomously structured, and as different in terms of likelihood when an odd number of scenarios are presented. The difference in likelihood among the scenarios, however, is often a result of misperception or illusion. In a single-themed scenario set that comprises an odd number of scenarios, whether that be three, five, or seven, the middle-ground scenario will almost 'inevitably' attract users' attention as the 'most likely' future and will thus negate the others (Schnaars and Ziamou, 2001, page 27; Schwartz, 1996, page 247). This compound effect of scenario themes and numbers on the perceived likelihood will be further discussed in the next subsection.

3.3.2 *The size of a scenario set*

How many discrete land-development scenarios—scenarios with unique land-use patterns—can possibly be generated? The answer is *myriad* (Harris, 1967). To illustrate, assume that the modeling process shown in figure 1, that is, the chunking process through which scenarios are composed, involves only a simple operation of map overlays; assume also that the land-development scenario presented on a map is a result of a series of map overlays. Then, the quantity of the original chunks, including both the number of parent maps involved in the overlay process and the gradations on each parent map, dictates the number of the derived chunks, that is, the size of the scenario set. On the one hand, a single parent-map alteration can cause a radical change in the number of discrete scenarios. A simple overlay of three parent maps, each having three gradations, for example, can bring about 499 discrete scenarios, in striking contrast to the set of 9 scenarios that an overlaid map of two parent maps can produce (Diao and Xiang, 2002). On the other hand, two parent maps with five gradations each will form an overlay map that can supply 25 discrete scenarios, representing a much smaller but still significant increase from 9 discrete scenarios in the case of three gradations. In practice, as the generation of land-development scenarios most likely involves more parent maps with finer gradations each, the compound effect will be even more dramatic (Gross and Fabos, 1984, page 29; Pomerol, 2001, page 198; Schoemaker, 1991, pages 550 – 551). The urban development study of the Detroit area, for example, began with the conceptualization of 49 million scenarios (Doxiadis, 1967; Schneider, 1972).

No individual or organization does or can plan for so many possible futures, nor may a pursuit of an all-inclusive scenario set be desirable (Amara, 1988; Schwartz, 1996, page 247; Vlek, 1984, page 24). There is evidence that there comes a point beyond which the quality of the decision starts to decline yet the confidence in the decision still increases with the amount of information gathered. There is also evidence that even experts are usually unaware of how they make their inferences and use typically much less information than they believe they do (Bunn and Salo, 1993, page 299). No scenarist therefore composes panorama scenarios (Schwartz, 1996, pages 243 – 244). The fundamental issue he or she must address is not about *why* but *how* and *how much* the immense universe of scenarios should be reduced, or, equivalently, *how many* scenarios should be selected from the immense universe and presented to the scenario users (Becker, 1983, page 102; Brill et al, 1990; Doxiadis, 1967; Hofmeister et al, 2000; Pomerol, 2001, page 200; Schoemaker, 1993, page 196; Schnaars and Ziamou, 2001, pages 28 – 29; Schneider, 1972; Vlek, 1984, page 24).

Although there is no golden rule on the number of scenarios in a scenario set, a range of two to seven scenarios is considered generally acceptable. This range is definitely within the cognitive limit of human comprehension, which has been widely believed to be around 'the magical number of seven plus or minus two' (chunks) ever since the publication of Miller's 1956 article (Godet, 2000, page 20; Godet and Roubelat, 1996, page 170), although recent findings suggest a smaller 'new magical number four plus or minus one' (for example, see, Broadbent, 1975; Cowan, 2000). The range of two to seven is also consistent with the well-established size standards in the multiattribute assessment and evaluation literature both for objective – attribute hierarchies and for preference sets (for example, see Saaty, 1980, page 57; Xiang and Whitley, 1994, page 281; Yoon and Hwang, 1995, pages 8 – 10).

Usually, a single-themed scenario set comprises two or three scenarios, and a multiple-themed scenario set between two and seven. The two scenarios in the New York Regional Plan (Yaro and Hiss, 1996, pages 239 – 243) are generated around one theme and arranged dichotomously. The three scenarios in the urban futures study for the Washington area (Jantz et al, 2002), those in the Santa Barbara residential

study (Aubry et al, 2002), and the trio in the Central European land-use change study (Prieler et al, 1998) all correspond to gradations of difference along a single theme. The three scenarios in the urban sprawl impact study for the town of Burlington are arranged along one thematic dimension of development density: an implicit status quo scenario of low density, a mid-density traditional suburban development scenario, and a high-density planned unit development scenario (Fabos and Caswell, 1977, pages 240 – 241). Multiple-themed scenario sets with one scenario per theme are found in the regional growth study of the Green Spring and Worthington Valleys in Baltimore County, (three scenarios), in the urban land development study at Santa Barbara, (six; UCIME, 2001), in the METLAND comprehensive regional land use planning methods (three; Fabos et al, 1978), in the metropolitan Washington study of energy-consumption, land-use, and growth policy (Roberts, 1975) that created a set of six multiple-themed scenarios, in the New Jersey Long Range Statewide Transportation Plan study (four; Bonnett and Olson, 1998, pages 313 – 320), and in the Cambridge Futures study for the City of Cambridge (seven; Echenique, 1999).

Within the range of two to seven, there is no consensus among the scenarists about the optimal number of scenarios. Many believe that three scenarios are advantageous. In representing the range of possible futures they are adequate but not overwhelming, brief but not oversimplifying—at least not as much as their dichotomously structured counterparts. However, this is exactly what the proponents consider the real strength of the paired two-scenario approach. It coincides with people's attitudes toward risk—optimistic versus pessimistic, and confronts forcefully the users with their worst-case scenario. Furthermore, critics of the three-scenario sets, or any sets with an odd number of scenarios, maintain that the image the middle-ground scenario presents to the users as the most likely or the most balanced is so powerful that it overshadows the other scenarios. Consequently, the design of an odd-numbered scenario set in general deteriorates to a single point-estimate forecast, which negates the very purpose of a scenario process, that is, to bound the range of future uncertainties and alternatives. A growing number of scenarists prefer the multiple-themed scenario sets mainly because their appearance of even likelihood forces the users to view every scenario equally. However, although keeping itself away from the controversies around the two-scenario and three-scenario sets, this approach brings about new challenges. It charges the scenarists and the scenario users with a variety of challenging tasks not required in the two-scenario and three-scenario cases. One such task is the construction of a panoramic framework for the comprehension and comparison of the multiple futures along different thematic dimensions.

One reasonable and, perhaps, ultimate arbiter on the size and the theme(s) of a scenario set is the effectiveness of its stretching function—that is, whether or not the number of scenarios and their thematic dimensions adequately represent or bound the zone or range of fundamentally different futures, no matter how slim or great the likelihood may be (Schoemaker, 1993, pages 195 – 196).

3.3.3 *The timeframe(s) of a scenario set*

Scenarios are apparatus for mental exercises that help stretch and focus people's views into the future. Yet how far into the future should each stretch extend in order for the scenario users to receive the maximum amount of benefit? There are three major stretching strategies that scenarists use in designing scenarios. They are, in descending order of popularity, anticipatory, exploratory, and a hybrid of both (Becker, 1983, page 99).

Under the *anticipatory* strategy, the scenarists design scenarios that stretch people's views from the present state all the way to some point in the future directly. Examples include those in the 1975 metropolitan Washington study of energy-consumption,

land-use, and growth policy that depicted 'the future history' for the year 1992 (Roberts, 1975, page 4-2), the two scenarios in the New York Regional Plan that stretched people's views to the year 2020 (Yaro and Hiss, 1996, pages 239–243), and the three scenarios for the year 2010 in the alternative urban futures study for the greater San Francisco Bay region (Landis et al, 1993).

Under the *exploratory* strategy, the scenarists design sequentially arranged scenarios that stretch people's views incrementally. In the regional growth study of the Green Spring and Worthington Valleys of Baltimore County (McHarg, 1992, pages 79–93), for example, McHarg and his colleagues developed a series of exploratory scenarios under the theme 'expanded growth 1963–2000'. From the 'existing' land-use pattern, which is a mosaic of four broad categories of residential, commercial, industrial, and institutional uses, they formed three scenarios of land development along a time series. Each represents a possible stage of future urban growth: 1963–70, 1970–80, and 1980–2000 (McHarg, 1992, page 84).

Some scenarists have used a *hybrid* of the exploratory and anticipatory strategies. In their resource accountability assessment for the town of Greenfield, for example, Gross and Fabos (1984, pages 42–43) developed three exploratory scenarios within each of the four anticipatory scenarios. These exploratory scenarios showed three levels of development, marked by the acreage of land consumption.

Scenarists often advise publicly that the users should not take the time frames within which the scenarios are formulated too precisely nor too seriously. They certainly do not themselves. Roberts, for example, stressed that the years '1976' and '1992' that set the time frames for his scenario study should be "used in a hypothetical sense only" for the possible land developments might be "realized in 1976, 1992 or some other year, if ever" (1975, page 4-3). Many scenarists simply do not attach any schedules to their scenarios. For example, the anticipatory scenarios in the METLAND comprehensive regional land-use planning methods (Fabos et al, 1978, pages 142–200) are structured around three themes without an explicit timetable. There is no schedule, to the another example, attached to the hybrid scenarios in the resource accountability assessment for the town of Greenfield (Gross and Fabos, 1984, pages 42–43). One possible explanation for the hesitation among scenarists to connect a precise timeline with the scenarios is that attaching a specific schedule is like assigning probability to the scenario set, which essentially converts scenarios into forecasts (Wilson, 2000, pages 25–26).

3.4 Trade-offs among the credentials

The three credentials, though conceptually distinct, are by no means independent of one another. Many of their intertwining ingredients are oriented towards different, even opposite, directions. Take the two credentials of informational vividness and ergonomic design as an example. On the one hand, more vivid information generally involves more information. The sheer number of chunks in a scenario set increases with greater concreteness, closer spatial and temporal proximities, and more sensory directness. On the other hand, ergonomic information generally involves less information. An ergonomically designed scenario set is aimed at giving a rich and insightful account of the futures with the fewest possible chunks. Reflecting this general principle are: the device of using the magical number (7 ± 2); the three strategies for stretching (anticipatory, exploratory, and the hybrid); and the various ways of setting up scenario themes. Because of this difference in orientations among the ingredients, an ideal combination of the three credentials, in which all of their ingredients reach the highest levels possible, is simply not attainable. Trade-offs then become inevitable in composing and evaluating scenario sets. For example, comprehensiveness, which contributes to plausibility but is likely to cause a hike in information load, must be balanced not

only with emotional interest—an informational vividness ingredient—but also with ergonomic design principles. The cognitive benefits of the three stretching strategies, to take another example, should be evaluated against, among other factors, temporal proximity.

In conclusion, instead of an ideal combination of all three credentials, a good scenario set possesses a balanced combination that is achieved through a series of trade-offs among the credentials and their ingredients.

4 The efficacy of scenarios

During the preparation of this paper we found and enjoyed reading a number of stories of successful scenarios that are exclusively from areas outside land-use planning. The scenarios in these tales are efficacious in that they all have reportedly made not only tangible but also positive impacts on communities' pursuits for brighter futures. In addition to those briefly mentioned at the beginning of the paper, we attach a summary of a tale entitled *The Battle of Dorking* as it exemplifies what a truly good scenario set is really about and how much impact it can have on a community as large as a nation (see the appendix).

We admire the authors of these stories, most of whom are journalists and novelists, for their audacity. They are committed to the same mission that social scientists undertake. That is, to query insights into the futures for, *and* to communicate convictions about these discoveries with the communities. "Our business", as author H G Wells wrote, "is to see what we can and render it" (Wells, 1980, the front flap page). Unlike social scientists, however, the majority of them are armed with only personal experience, imagination, and literary skills. Without most weapons and ammunition in the social scientist's arsenal, they have little if any protection and, luckily, burden of statistics, scientific models, controlled experiments, objective functions, and logical constraints. Without much financial support in research grants or contracts, most of them started and completed their work either for a modest compensation or simply gratis.

Nevertheless, we are most impressed by and even feel jealous of the impact of their work on the aspirations and actions of individuals and communities at large. Through the two scenarios in the totally untrue tale of a German invasion, for instance, the author of *The Battle of Dorking* alarmed the entire British nation about the hypothetical, astonishing, yet plausible, consequences to be expected from the defects in Britain's military establishment (Clarke, 1992, page 34; 1997, page ix). In the months following its publication in May 1871, the national panic and political sensation that arose from the story were so high that then Prime Minister Gladstone made a public speech to warn the nation against the dangers of such 'alarmism' (Clarke, 1992, page 34). The wide-ranging debate that the tale stirred about the state of national defense went on and led to some significant policy changes before the outbreak of the First World War in 1914 (Clarke, 1992, pages 36–45). In addition, the story was immediately reprinted abroad in almost all the major English-speaking countries (pages xi–xii). There was also a flood of counterattack stories, some eighteen in all, by 1885 (Clarke, 1997, page xii).

It is disconcerting to contrast these stories to some of the high-profile scenario studies in the planning arena with respect to their impacts on society. One example is the 1960s urban development study of the Detroit area (Doxiadis, 1966; 1967; 1970). On the promise that "it could provide guidelines for the growth of Detroit Edison and others, serving the needs of planning authorities and all who are concerned with the advancement of human as well as economic values" (Cisler, 1966, page iii), this five-year project was financed by the Detroit Edison Company with the generous support of three million dollars committed *prior* to its 'kick-off' in 1965. George Tomkyns Chesney, in contrast, received a modest amount of £279 in a final settlement in

April 1872 (approximately US$1395 according to Krause and Mishler, 1993), about a year *after* the first publication of his *The Battle of Dorking* (Clarke, 1992, page 37). In a 1972 review of the Detroit project's three-volume report, Schneider (1972, page 332) raised the question whether the study, which "will certainly be remembered for its analysis of 49 million alternatives" (compared with two scenarios in *The Battle of Dorking*), would "have any impact on the evolution of the spatial and functional structure of the Detroit region", and rightly suggested that it "must await the passage of time for answers". Thirty years later in 2002, Schneider concluded that the study did "not have much impact on the development process" (Schneider, 2002, personal communication). A more recent yet equally disappointing example is from Myers and Kitsuse (2000). They wrote,

> "Despite the increased exposure conferred upon scenarios by their inclusion in these official documents [that is, the New York Regional Plan (Yaro and Hiss, 1996) and Growing Smart Legislative Guidebook (APA, 1996)], these scenarios are largely gratuitous. The very placement of the scenarios outside the main body of the publications suggests the lack of serious intent attached to them" (Myers and Kitsuse, 2000, page 228).

However, people should not always be regretful about the inefficacy of scenario sets. One rather extreme but certainly not rare situation was described by Batty (1994, page 10) in a review on modeling and scientific planning. He stated that many 'model-builders' (that is, scenarists in our case), who are "more interested in scientific questions than in practical and professional uses of their models", are tempted into an eternal pursuit of a perfect representation of reality and they often generously spend time and other resources, which would otherwise be available for exploring insights, on "ever more detailed refinements" of the models (Batty, 1994, page 10). However, as a perfect representation is fundamentally impossible (Ackoff, 1979a; 1979b), their efforts "often produce very poor results" (Batty, 1994, page 10). But they could not bear to admit defeat. As a way "of camouflaging the venture", they simply "bash" the models they keep refining on "into a shape that might produce 'reasonably-looking results' ". Consequently, "models simply were not used to meet the tasks they had been originally legitimated upon" (Batty, 1994, page 10). Needless to say, without influences from scenario sets of this kind, the scenario users will be less likely to get confused, and the processes of planning and decisionmaking less likely to be misled.

Why are journalists and novelists more successful in writing scenarios of high impact? What are their 'secrete weapons'? What can social scientists learn from them to advance futures studies with scenarios? Without launching a full-scale investigation into these questions, we offer the following observations.

First, in undertaking the same mission as social scientists do, the journalists and novelists take a quite different yet arguably more balanced approach, one that concentrates on the union of the discovery and communication of insights in a way that vivifies both. A relevant case, which is about the study of history, instead of 'future history', is made by Berlin (1966) and Bear (2001). Comparing Tolstoy's *War and Peace* with scholarly accounts of the Napoleonic invasion of Russia, they both found that the histories documented by contemporary historians and military specialists present an accurate yet rather pallid succession of events, whereas Tolstoy, who does not deny the efficacy of science in its own sphere but firmly believes that the social, moral, political, and spiritual worlds are permanently out of the reach of science, and cannot be sorted out, described, and predicted by any science (Berlin, 1966, page 70), wrote history as a novel, using storytelling with many surprising but plausible plots to arrange the facts in a way that gives them meaning (Bear, 2001, page xi). The same contrast seems to exist between the two groups of scenarists. The journalist or novelist scenarists, whether

sharing Tolstoy's belief or not, are apt at expressing their convictions to a larger portion of a society, academic or not, through their literary expertise—through surprising yet plausible plots, vivid presentations, and eloquent writings. The scientific or academic scenarists, by contrast, are more interested in and skillful at the scientific inquiry into insights but much less so in communication with communities outside the academic circle. Their scenarios are typically filled with aggregated, statistical data summaries that are evidentially valuable but cognitively pallid. In the eyes of those from nonacademic communities, these scientifically rigorous scenarios are often too abstract to be comprehensible, too pale to be imaginary, and too predictable to be surprising. We suspect that this is a main reason, though not necessarily the only reason, why many seemingly highly probative scenario sets produced through well-funded and modeling-intensive projects have had little effect on real-world planning and decisionmaking.

Second, although both groups share the same belief that only time can and will tell how efficacious scenarios really are, the journalist and/or novelist scenarists demonstrate a greater commitment to the continuity of scenario studies than do their colleagues from the science camp. They are genuinely interested in, and graciously willing to be held accountable for, the efficacy of scenario sets. They make an effort to record, track, and assess scenarios' impacts, both immediate and cumulative, on the scenario users and their courses of actions (Carlson, 1977; Laszlo, 1977; Phelps et al, 2001). The schedules for these follow-up activities vary significantly, exemplifying the level of their commitment. For example, a sequel to *The Limits to Growth* entitled *Beyond the Limits* was published twenty years later in 1992, in which Meadows et al concluded that the global conditions are worse than those imagined in the 1972 scenarios. A full-page drawing, for another example, appeared on *Punch*, a major British magazine during that period of time, about four months after *The Battle of Dorking* was published in May 1871. The caption was "*All's* (*Pretty*) *Well!*", summing up the feeling of a country recovering from the alarm of the *Battle of Dorking* episode (Clarke, 1992, page 36). Other follow-ups to the tale came much later—even over a hundred years later (for example, Briggs, 1972; Clarke, 1992; 1997). This magnitude of long-term commitment made either individually by scenarist(s) who composed the scenarios, or collectively by their colleagues across different generations, is, to the best of our knowledge, rarely, if ever, seen within the circle of academic or scientific scenarists, at least in the arena of land-use planning.

5 Scenariology: the study of scenarios

For the advancement of futures studies in land-use planning, we hereby advocate a balanced approach to the study of scenarios. This is an approach that values both the scientific discovery and the artistic expression of insights; one that not only concentrates on the union of unexpectedness and plausibility in a scenario set but also integrates principles of informational vivification and cognitive ergonomics into the practice of scenario design, composition, presentation, evaluation, and efficacy assessment. Our discussion in the preceding sections about the concepts of scenarios, their dual function, and the three credentials of a good scenario set are intended to be part of this endeavor. Taking them as a necessarily initial step, we further suggest that basic research efforts be sent underway that aim at the development of unified theories of land-development scenarios, or even scenarios in general, under a possible name of *scenariology*—the study of scenarios. There could not have been a better time for such a long-overdue development—there is a wealth of research findings in many related disciplines that we can benefit from, such as cognitive science, behavioral decision science, business, and marketing; there is a rich heritage of fictional literature

from authors all around the world from which we can borrow ideas as well as literary techniques; there is a huge and ever-expanding arsenal of scientific weapons and ammunition for modeling, planning, planning-support, soft computation (Zadeh, 2001), and communications to which we have access; and, most encouragingly, there have been and continue to be sustained waves of interest in scenario studies from the academic and professional camps—a most recent example is from the United Kingdom. In 2000, the Royal Town Planning Institute recognized the Cambridge Futures study for the City of Cambridge, England, with a prestigious Innovation in Planning Award (Echenique, 1999). The theories of scenariology, however, should be parsimonious—offering the fewest possible structures, mechanisms, and principles yet giving rise to rich and full accounts of scenarios—and focused on strategic issues that are integral to a balanced approach to scenariological studies. With this paper, we hope that the seed of such a development has been planted and that further research can nurture it to bloom.

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APPENDIX

The Battle of Dorking

The year 1872, according to the 'historian of the future' George Tomkyns Chesney (1871), saw a German invasion of Britain. At that time, the majority of the British armies and especially the Fleet were deployed abroad to protect the nation's interests across the world, protecting Canada from the United States, guarding Ireland against an attack by Louis Napoleon, quelling an Indian rebellion, and checking privateers in the China Seas. The Germans seized this moment of minimal British homeland defenses and launched an invasion they had planned for many years. One March morning, German boats, with their secretly developed mines and torpedoes, crossed the North Sea and destroyed the entire Royal Navy left in British waters. The Germans then defeated the British ground troops that had suffered not only from their lack of numbers, training, and discipline, but also from an outdated philosophy of warfare. A last stand at the Battle of Dorking failed. The Germans conquered (Chesney, 1871; 1997; Clarke, 1997).

This totally untrue tale of *The Battle of Dorking* was first published anonymously in the May issue of *Blackwood's Edinburgh Magazine* in 1871 and was immediately reprinted abroad in almost all the major English-speaking countries. With a clear intention to stir the military establishment into rectifying its many defects, the story alarmed the entire nation about the hypothetical, but plausible, consequences to be

expected from such shortcomings (Clarke, 1992, page 34; 1997, page ix). In the following months, the national panic and political sensation that arose from the story were so high that then Prime Minister Gladstone made a public speech to warn the nation against the dangers of such 'alarmism' (Clarke, 1992, page 34). Although by October, the 'Dorking incident' came to an end when the success of the closely watched autumn army maneuvers showed that an invading force had little hope of leaving its beachhead (Clarke, 1992, pages 34 and 36), the *Battle of Dorking* episode was not forgotten (Clarke, 1997, page xii). The wide-range debate about the state of the fleet and of national defense went on and led to some significant policy changes before the outbreak of the First World War (Clarke, 1992, pages 36 – 45). In addition, there was a flood of counterattack stories, some eighteen in all by 1885 (Clarke, 1997, page xii).

This, in essence, is what scenarios are all about. First, they are apparatus that stretch people's thinking with hypothetical but plausible surprises. In *The Battle of Dorking*, Chesney presented two distinctive futures. The status quo scenario outlined above offered a clear and merciless demonstration of the devastating consequences to be expected from a feckless and ill-prepared national defense system. By contrast, at the beginning of the story, he described implicitly a 'proud-and-happy-country' scenario in which a strong national defense system had made the attempted invasion impossible and in which prosperity and peace were well protected (Chesney, 1997, pages 3 – 4). Second, scenarios are a device of communication about the futures between the specialists and the general public. As pointed out elsewhere (Clarke, 1992, pages 40 – 41), Chesney had by chance introduced a new device in the communications between a specialist group and a nation. As an engineer and a lieutenant colonel, he belonged to the then still small group of well-educated officers in the British Army. When he suggested to John Blackwood, the publisher of the *Blackwood's Edinburgh Magazine*, that his idea for a tale about an imaginary invasion might be "a useful way of bringing home to the country the necessity for a thorough reorganization", he was looking for a suitable medium through which he could communicate the convictions of a professional to an influential section of the society represented by readers of a monthly such as *Blackwood's Edinburgh Magazine*.

The impact of *The Battle of Dorking* was immediate but also long lasting. As Briggs pointed out (1972, page i):

> "*The Battle of Dorking* still reads remarkably well in 1972. It is called a 'myth', and it has mythic qualities which continue to give it significance in circumstances very different from those of 1871".

Winston Churchill, for example, could hardly have been ignorant of the work and its impact when facing the similar scenarios in 1940.