5 Ecomyopia Meets the *Longue Durée*

An Information Ecology of the Increasingly Arid Southwestern United States

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INTRODUCTION

Let us begin with a metaphor. There is a ghost that haunts the water policy discourse in the American Southwest. Among the iconic images identifying the American Southwest we see haunting photos of the abandoned pueblo cliff dwellings of the Anasazi (e.g., Figure 5.1, Mesa Verde). They are found above the tributaries of the Colorado and the Rio Grande in northeastern Arizona, northern New Mexico, southwestern Colorado, and southern Utah (Figure 5.2, map). These prehistoric structures symbolize both the attempt to engineer stability under systemic stress and its failure. Their abandonment is

Figure 5.1 Mesa Verde: Perhaps best known to the public, this ancient pueblo with its spectacular setting and multistoried houses was abandoned in the late 1200s, after a prolonged period of severe drought (it is located in southwestern Colorado; see map, Figure 5.2. Photo source: Wikipedia Creative Commons; photo by Lorax (G. Edward Johnson).

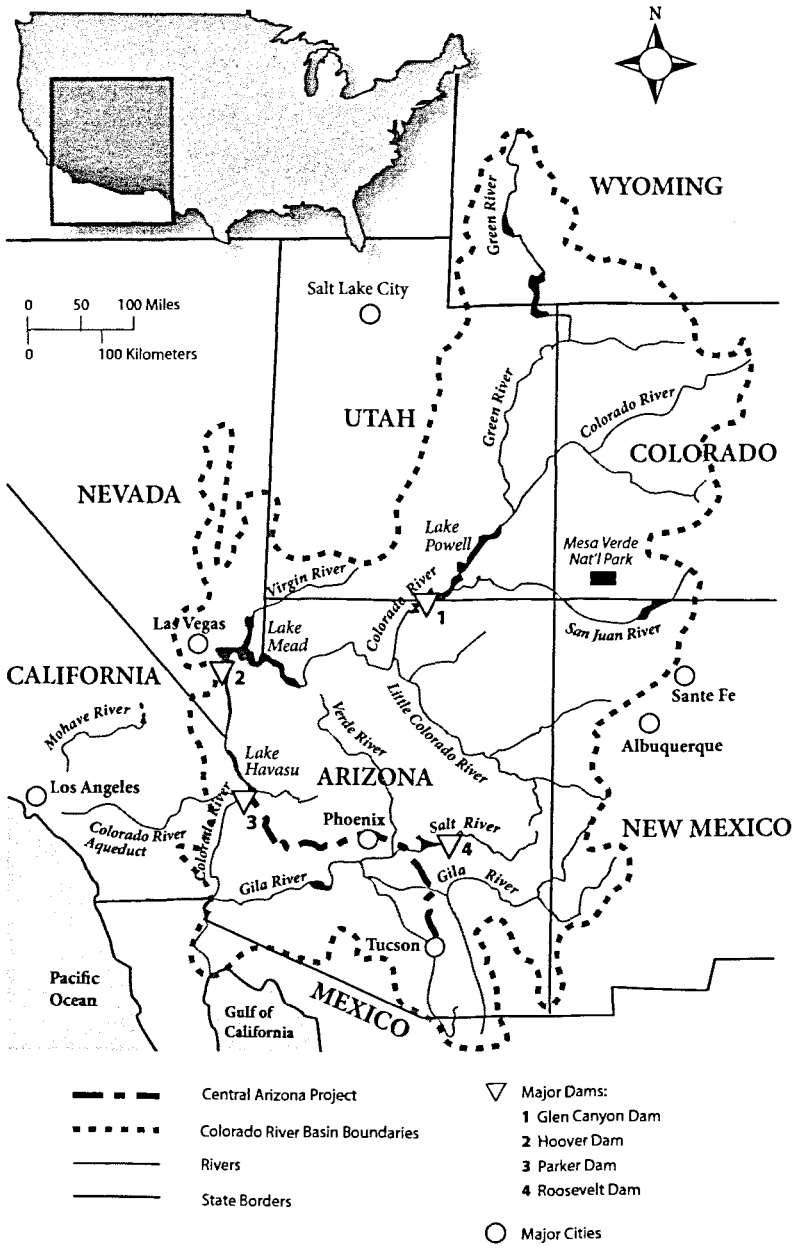


Figure 5.2 Map of the study area with major rivers, dams, cities, and state political boundaries. Mesa Verde is located in southwestern Colorado. The Central Arizona Project transports water from Lake Havasu and the Parker Dam to Phoenix and Tucson. The Colorado River Aqueduct provides water to highly populated counties of the Los Angeles metropolitan area: it ends in reservoirs and local canals just to the east of the metropolis. Cartographic sources: Arizona Department of Water Resources, Artificial Intelligence for Ecosystem Services, Metropolitan Water District of Southern California, and the World Resources Simulation Center.

associated with prolonged, severe drought.[1] This is part of the scientific conclusion that was presented to a public who were recently informed that the Southwest has been characterized by periods of prolonged severe drought throughout most of the past 1,200 years (Kunzig 2008). Such droughts are the norm.[2] The early twentieth century was the wettest in the past 500 years, an anomaly. The principal industries, the proliferation of private swimming pools, and oasis image of the Southwest are built on an anomaly. The region's human population is also one of the fastest-growing in the United States. The *longue durée* of climate (and its extremes of natural variation) is an unwelcome specter in a region where unprecedented economic growth has become dangerously synonymous with the idea of stability. A crash in water consumption or human population seems inevitable.

There are important differences between the current human ecosystem of the Southwest and that of the Anasazi. The governmental environments of the current human ecosystem include not only a hierarchy of organizational levels from the community to the region but beyond that the federal level of the nation-state. Also, the informational environments of the current system now include some long-term data that could be used to inform an adaptive public policy. But the question remains, how will the current system respond differently? From a theoretical and realistic point of view, how can a highly technical democratic society respond to new kinds of information predicting a high risk of partially avoidable re-occurring crises on a transgenerational time scale? We examine this question from the anthropological perspective of information ecology within a human ecosystems theoretical framework, blending traditional ecologies with cognitive psychology, and propose a method for theory using the "increasingly arid Southwest" as a case study.

That North Americans now view the Southwest as "increasingly arid" is a kind of ecomyopia. Contrary to popular assumptions, the southwestern climate has never been in a steady state or equilibrium. For over 1,000 years the Southwest has been subject to periods of prolonged severe drought. The most fundamental and important question we can raise is: Will the people currently most concerned or affected create a learning system at the local to regional scale that can preserve much of their infrastructure and population in the face of long-term water shortages, or will they allow a transgenerational emergency to develop that radically alters their human ecosystem beyond recognition? What are their options?

The idea that climate change has had profound impacts on the stability of previous civilizations has been reinforced by recent research in European historical ecology—for example, the rise and fall of the Western Roman Empire (Büntgen et al. 2011). One value of a long-term study of the Arid Southwest as a living system is the opportunity for environmental anthropology to examine pathways of individual and socially distributed cognitions, along with cultural models as shared schemes of reasoning, in relation to the creation of new ecological knowledge and the civil powers of governmental administrative authority faced with the reality of climate change.

STUDY AREA, METHODS, AND CONCEPTUAL DEVICES

Study Area: Background of the Political Geography, Water Resources, and Water Management Institutions of the Arid Southwest

The Spanish were the first Europeans to explore the Southwest, having established settlements in the early sixteenth century. Los Angeles had developed into a major urban area with a population of 500,000 by 1920; this number has risen to about 18 million today. Phoenix, in contrast, was established after the end of the Mexican-American War (1848), when European-American settlements were developed, especially in the 1860s, to serve Fort McDowell. Its population had grown to 75,000 by 1900 and it grew much more rapidly following World War II. The current population of the Phoenix metropolitan area is about 4.3 million. Los Angeles and Phoenix exemplify the explosive population growth and demand for water that have occurred in the Southwest over the last 100 years.

Our study of the Arid Southwest is focused on the Colorado River watershed and the state of Arizona in particular. The Colorado River watershed covers parts of seven states (Figure 5.2). Major cities in the broader region include Salt Lake City, Los Angeles, Las Vegas, Phoenix, Tucson, and Albuquerque. Water is the central theme in the history of the American Southwest. Rainfall in Phoenix averages only 8 inches (about 20 cm) per year. There is more precipitation, especially snow, at higher elevations. Snowmelt is the major source of the water in the Colorado River and its tributaries.

The Colorado River currently provides water for about 30 million people. Humans consume all of its water. Water from the Colorado River has not flowed into the sea for the last decade. Per treaties, laws, and court decisions, the river's water is allocated between the seven states of the American Southwest and Mexico (Figure 5.2). This is known as "the law of the river" in informal policy discourse. Dendroclimatological studies reveal that the agreements for sharing Colorado River water are historically based on water data that were, as it turns out, collected during an unusually wet period at the beginning of the last century. In-place water-sharing agreements, planning, and development are all based on spurious estimates of the long-term water supply. It is perhaps ironic that much of the impetus for uncovering the new view has come from the region's water managers. They are in the unique position of being able to promote the funding of new scientific research into the region's history, the first to consider its implications systematically, and the first to be concerned as both public policy agents and citizens. Some of this part of their story has been told to the public by Kunzig (2008) in *National Geographic* magazine, which has also featured a number of articles over the years on increasingly human-amplified ecological stress and limits to natural resources. Paradoxically, the region's decision-makers do not appear to have completely absorbed the implications of the new long-term view of the region's climate.

All together, the main sources of water in our study area are underground aquifers, the Colorado River, and its tributaries. Water in metropolitan Phoenix, as a case in point, comes from municipal wells, dammed reservoirs on the Salt River in the Superstition Mountains, and the Colorado River. The Central Arizona Project includes a series of canals, tunnels, and pumps that move water from the Colorado River in northern Arizona 336 miles to Phoenix and Tucson (Figure 5.2). Consistent with what we now know about the climate of the region, the Colorado River Basin is currently in the throes of a severe drought more than a decade long. Many reservoir levels are critically low. A looming Great Drought scenario is darkened further by warming temperatures that increase evaporation and water demand but decrease precipitation occurring as snow, which is crucial for recharging reservoirs (Mote et al. 2005). Thus we see in both the tree-ring studies and the climate models a *longue durée* perspective of prolonged severe droughts as the expected norm for the region. Meanwhile, the growth continues, with the population of Phoenix projected to double by 2050 (Walton, Tomasik, and Anderson 2004).

Who are the stakeholders most haunted by the ghosts of the Anasazi and Hohokam? Those who are most haunted are probably the agents who recognize and *appear to* minimize stress to the current human ecosystem. Paradoxically, they manufacture, promote, or invest in the myopic consensus that metropolitan Phoenix is an oasis in the desert, that unbounded economic growth is sustainable, and that increasing demands for water can be met by more efficient use of existing water resources. It is taboo to question any of these beliefs publicly or to suggest that federal intervention in decision making is needed.

The agents that play various roles in the region's water management form a partially nested hierarchy of decision making (Table 5.1). Federal agencies provide water through large-scale projects that would not exist without federal legislation, but they have no legislated authority over state and local agencies. Arizona's 1980 Groundwater Management Act created districts that are charged with managing water so as not to deplete ground water. These districts are subject to the authority of the Arizona Department of Water Resources. The Multi-State Colorado River Compact is a nominally cooperative effort (although often acrimonious) in which the agencies of the seven southwestern states share Colorado River water (the seven states are shown in Figure 5.2). Federal agencies have direct authority over the compact during times of crisis, but agreements about water allocation have been largely shaped by U.S. Supreme Court decisions. Lower-level courts also influence local policies within states. There is also a loose hierarchical structure of Native American governance within which important decisions about water management on tribal lands are made and negotiations with state and federal agencies are leveraged through tribal cooperation. And, as implied by Table 5.1, none of the rapid economic and population growth in Arizona would have been possible without infusions of capital from hierarchically arranged financial institutions from local banks to Wall Street.

Table 5.1 (continued)

	National	*Southwest U.S. Region*	*State*	*Intra-state regional*	*Local*
Private non-profit	Environmental advocacy groups such as the Sierra Club		Environmental groups with landholdings like The Nature Conservancy		Local environmental activists
				Boosters like the Greater Phoenix Chamber of Commerce and Greater Phoenix Convention & Visitor's Bureau	
					Neighborhood home owner associations & individual home-owners[h]

a. The Bureau of Reclamation's historical motivation for building dams was based in part on hubris. The Sierra Club was originally created to challenge water development in the Southwest. No Colorado River water currently reaches the Gulf of California.
b. Prior to the 1922 Colorado River Compact, rivalries between Southwestern states led to a tragedy of the commons in which each state attempted to build infrastructure and appropriate water before another could. Interstate cooperation is still problematic although increasingly innovative.
c. Native American claims to water are poorly defined or currently in litigation, which creates uncertainty for water managers.
d. Tourism is a major component of the Arizona economy.
e. Rural areas lack the political influence of urban areas.
f. Global capital de-localizes decision-making with cultural models not grounded in the realities of community ethics.
g. Del Webb markets retirement "lifestyles" in several states. They created the planned town of Anthem in the middle of the desert 31 miles north of downtown Phoenix. The Phoenix metropolitan area has been successfully marketed as an "oasis in the desert."
h. Sense of place, or local identities, are constructed in neighborhoods with little control over water allocation. Homeowner associations exist to maintain home value, often in conflict with individual quality of life and water conservation.

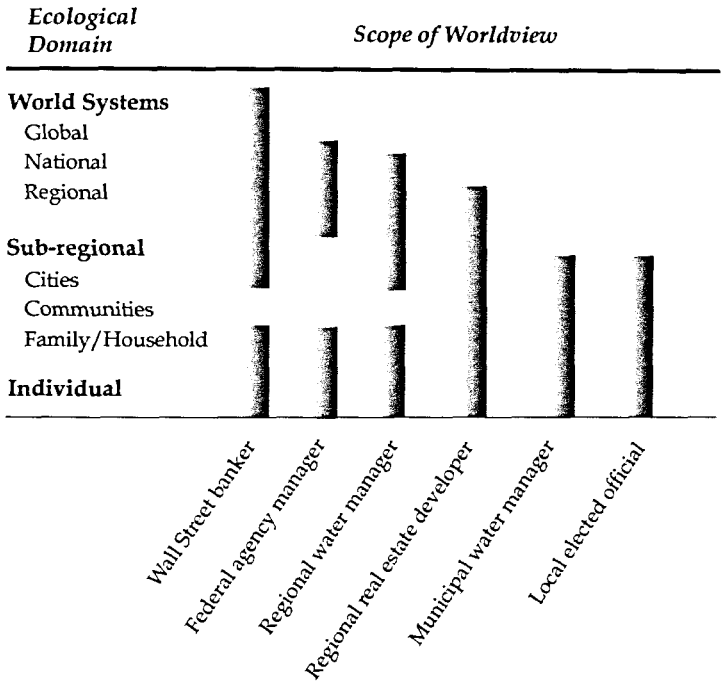


Figure 5.3 Scope of individual worldviews regarding water resources in the Arid Southwest. Different agents operating at different scales maximize different values. A gap in potentially shared understanding occurs at the level of community.

Although few of the agents represented in Table 5.1 are bound directly by the authority of agents at higher levels, they are constrained by decisions made at higher levels by people who are more physically and psychologically removed from local realities. The scope of the worldview on which each of these agents base decisions differs greatly (Figure 5.3). While they may share core values (religious values, for example), the values they seek to maximize in making decisions about the Arid Southwest differ greatly. This is probably quite different from the religious/political ecology of the ancient cliff dwellers, if their descendants can be used as a guide.

Method for Theory

Our method for theory follows Pickett, Kolasa, and Jones (1994) with modifications for human ecosystems (Figure 5.4). Our stage of development in this theory of the Arid Southwest is *intuitive*. It is one stage beyond the initial *pretheoretic* stage (see Figure 5.4), with three more stages of

model inadequately represents the real world, it remains a useful tool in teaching and research if it reveals key components and interactions that merit special attention. In the early stages of theory development, verbal models and graphic models complement each other, and *The Model* is an interactive emergence of understanding that conceptually lies in between, something akin to the *blood in the gutter* in the invisible art of late-modern comics (McCloud 1994).

A graphic iconography is used to externalize our conceptual models as visual caricatures/depictions (see Appendix 5.1). The iconography we use is, for the most part, that of H. T. Odum's energy language (see his 1983 classic *Systems Ecology*).[3] His graphic conceptions have been partially reinterpreted in the context of the ecology of human information systems. In part the graphic signs we use can be seen as (thought of as) graphical tropes analogous to figures of speech (e.g., metonymy), plus key words and phrases (Kuchka 2001, Table 3). Their form should be memorable to unload short-term notational memory and enhance long-term figurative memory. Readers should find that they can easily modify the graphic models, using an evolving sign language to reconstruct them graphically in relation to their own experience. The graphic conventions we use draw upon both the principled solutions of scientific graphics and the psychological conventions of graphic satire and comics. These models serve as both caricatures and heuristic devices, externalizing our intuitive synthesis of field observations, institutional documents, and media expressions related to this arid land's transgenerational crisis.

The cultural models of the Southwest participants are characterized in part by groupthink (Janis 1972) bound very closely to institutions and public notions of citizenry. Individuals are psychologically challenged differently across the scope of their world views (Figure 5.3). This is taken into account to understand cognitive dissonance and creativity at a number of psychological locations. An individual can, for example, follow a different epistemological practice depending upon his or her context-sensitive professional vs. private lifestyles. In our models, multirole psychologies are seen as part of their means to cope with informational stress and conflicts of interest and promote creative problem solving in a variety of environments. Even for one individual, distributed cognition is an inherent feature of fabricated human ecosystems. It is difficult for individuals and society to integrate these cognitions into coherent forms of reasoning without the aid of overarching action-relevant supernatural schemes of belief. Secular schemes may be less effective at integration because of relatively unchecked factors such as social stratification, ethnicity, and organizational specializations. The short and long-term interests of different stakeholders are not necessarily the same. Retirees and investors, for example, both want to get twenty years out of the system, but transgenerational resident families expect the system to be life-sustaining for an untold number of years.

As in any culture, citizens of the Southwest share ways of reasoning about their world, including limited notions of how they know what they know. This is necessary, for example, so that they can understand how other members of their culture reason in order to effectively communicate new ideas. In other words, they share vernacular epistemologies: local, common, or folk grounds of knowledge. These epistemologies are almost entirely tacit, which impedes the ability to evaluate new knowledge that contradicts currently held beliefs, values, and taboos. A generally shared epistemology is different from a cultural model. A cultural model draws on an epistemology to build a framework for reasoning about a particular topic.

Much of our vernacular epistemology is based upon metaphor. For example, public and private boosters have heavily promoted metropolitan Phoenix as an "oasis in the desert." Metaphors are figures of speech that implicitly say "*this is* (or is *like*) *that*" (Chandler 2004). Calling Phoenix an "oasis in the desert" idealizes only the romantic, relaxing aspects of a desert oasis and projects them onto desirable attributes of Phoenix to create a positive emotional reaction. Repeated exposure to, and use of, this trope subtly reinforces tacit agreement with the shared assumptions of the boosters (following Chandler's argument on page 124). Analogies are far more transparent than metaphors. The use of similes ("this is *like* that") engages the reflective critical thinker to ask, "but *how* is it *not* like that?" This opens discourse and the search for information. Drawing analogies is the process that creates openness (Foster 1996). Drawing an analogy between an idealized desert oasis and metropolitan Phoenix would quickly highlight the ephemeral nature of water in the Salt River Valley, deteriorating air quality, increasing crime, and so on. Since unskilled (untrained) fallacy-prone reasoning also tends to be unreflective, the individual duped by metaphor may hold cultural models that are fundamentally relational misunderstandings of reality.

Stress response behavior depends in large part on vernacular epistemologies and shared schemes of reasoning. We take for granted the observation that unreflective and fallacious reasoning is common. In an information system they can serve more than one purpose. Figure 5.5 is an example of a reflective critical thinking epistemological hierarchy. A general rule for its use is that lower levels must be logically kept in mind as one moves up the ladder of increasingly abstract conceptual considerations (Klir and Elias 1985). This is part of our method for theory. But in the case of vernacular epistemologies we commonly see a form of saltation whereby the reasoner moves discontinuously up the ladder, skipping one or more levels and no longer is responsible in any way for relevant information left behind that might have been built upon as a logical foundation. The reasoner may also skip around in a stream-of-consciousness manner, justifying this reasoning in an unpredictable, fragmented, series of discontextualizations. Ellul (1964: 394) notes that to neglect context is to live in a world of dreams,

Level	Scheme	Philosophy of Method
6	**Meta Scheme 4** META-LANGUAGE CRITICAL THEORY OF THEORIES Examination of Implicit Theoretical Framework, Theoretical Potential for One Theory Vs A Family of More Domain Specific Theories	**Higher Order Evaluations** Open-textured expanding contextualization; Comparative perspectives, e.g., sociology of knowledge, anthropology, history, child psychology and evolutionary biology; Natural philosophy Vs theology
5	**Meta Scheme 3** HIGHER ORDER THEORY Upgrade Generative Scheme, Comparison of Generative Schemes That Have Similar And Different Source Schemes, Clarification of Theoretical Relations Between Generative Schemes And Source Schemes, The Upgraded Focal Generative Scheme Is Placed Into This Broader Theoretical Frame	**Second Level of Explanation** Superinduction (consilience) of new conceptualizations; Creation and new integrations of conceptual devices; Explication of diversity of implication/consequentiality; Colligation of facts and confirmed empirical generalizations from different Source Schemes
4	**Meta Scheme 2** META-LANGUAGE METHODOLOGICAL ANALYSES Of SUBSYSTEMS AND OVERALL STRUCTURE OF THE SIMULACRUM Part-whole Relations and Logical Organization, Critical Theory of the Generative Scheme As a First Order Explanation	**First Level of Evaluation** Supplemental-ancillary principles: Clarity; Consistence; Coherence; Insolubilia (paradoxes , logical limits, pyrrhonic tropes); Parsimony; Comparabilities; DIF criteria of evidence; Check for fallacies and self-deception; Reflection on implications and consequences
3	**Meta Scheme 1** FIRST ORDER LOGICAL GENERATIVE SCHEME Conjecture, Generalization, Translation Modalities, Simulation of the Data Scheme	**First Level of Explanation** Colligation of facts and confirmed generalizations; Considerations of taxonomy; Creation of hypotheses about causalities; Simplification and preliminary modeling
2	**Data Scheme** Observations or Specifications of Actual or Desired States, Conditions and Conceptualization of the Source Scheme	**Subject Matter** Questions raised; Claims made; Systematic recording of observations and presentation of relevant information
1	**Source Scheme** Populations, Variables, Multiple Environments, Domain	**Objects of Inquiry** Problems identified; Variables specified; Multiple environments recognized; Preliminary setting of boundaries

Figure 5.5 Simplified minimalist epistemological hierarchy for the systems critic and critical theories of systems. (Ladderized from http://kuchka.org/tool-box; cf. Klir and Elias 1985.)

and that a psychological sense of freedom is always possible in the world of tranquilizing untethered abstractions. Our use of the concepts of individual psychologies in the conceptual models presented below draws on the observation that these vernacular processes of epistemological saltation preempt certain forms of cognitive dissonance—that is, they prevent

probable dissonance from being realized (Casagrande 2004). As an apparent avoidance strategy, this is often combined with the uncritical/unreflective use of metaphor.

Uncritical, unsystematic thinking can also be characteristic of certain expressions of professional role-playing, especially those tied to advertising, territorial academic discourse, and short-term policy development. Some institutional jobs require/foster systematic reflective critical thinking and creativity in pursuit of long-term ecosystem stability, but these can still be combined with uncritical or credulous thinking depending on the scope of one's worldview, multiple role playing, and firsthand experience (for examples see Casagrande et al. 2007). Technological interactions enhance the externalization of much of this thinking but also create certain paradoxes for both the individual and society. Thus we pursue a number of complementary themes in our model building, including the cognitive themes of dilemmas, conflicts in personal interests, comradeship in compromised social cognition, and awareness through language externalizations. Among the related social themes are paradoxes, perverse functions, and administrative compromises.

The heuristic epistemological hierarchy seen in Figure 5.5 was developed for systems critical theory—critical theory that attempts to reflectively unpack what is referred to in the vernacular as "The System." The System is a proper name in the emic vernacular that denotes a larger than life entity. Systems theory at its best is both a caricature and a critique of high-tech civilization, its notions of efficiency applied to all aspects of life, its confusion of technological metaphors with science, its infusion of the life world with *delirium artificialis*. Systems critical theory is more than social critical theory. Social critique is necessarily included, but it is not sufficient for attempting wholistic understandings of The System.

The System is often thought of as evil (perhaps a necessary one), or personified as "The Man." The System has, as it were, a life of its own. We use this reified way of describing it because of the functional limits of referential language. In the light of the epistemological hierarchy laddered in Figure 5.5, we recognize that critical social theory takes us to what in the figure is labeled as the First Level of Explanation, while critical systems theory attempts to take us to what in the figure is labeled as the Second Level of Explanation and on into Higher-Order Evaluations. It would be easier to communicate this if we could simply refer to the concept of a "systems analyst," but we cannot. The vernacular usages of pop culture and the artificially intelligent technician preclude it. Note in particular the logical disjuncture in the online Wikipedia entries for *systems analysis* vs. *systems analyst*. The former includes management cybernetics, psycho-cybernetics, and general systems theory, while the latter is characterized as the liaison between vendors and information technology professionals. Wholistic analysis of this situation invites more than some well-placed deconstructive gestures applied to "the other," or some Dada-like textual performances. It requires critical theory of modern sociocultural systems on the local, regional, and global scales. Part of the goal of the oversimplified epistemology seen in Figure 5.5 is to foster the required

more wholistic, reflective, creative, and critical forms of thinking usually not found, for example, in either the arcane or the informal popular discourses of the sciences and humanities. One must be aware that the skills recommended in Figure 5.5 are only a starting point. The limitations of the ladder formulated there still include those of text-bound reasoning and the referential (as compared with the poetic) function of language.

Stability Theory

This section offers a brief overview of the definition of ecological stress as it applies to our study of the information ecology of long-term water shortage in the Arid Southwest. This definition is critical, since the goal of the first stage of our work is to develop preliminary conceptual models clarifying, and partially operationalizing, the information components, processes, and constraints characterizing a human ecosystem under stress. In this section our initial attempts to conceptualize human ecosystem stress more precisely for the arid Southwest follow Leffler's (1978) general discussion and definition of stress in biological ecosystems (see Figure 5.6), both for ease of reference and because of the clarity of his conceptual treatment.

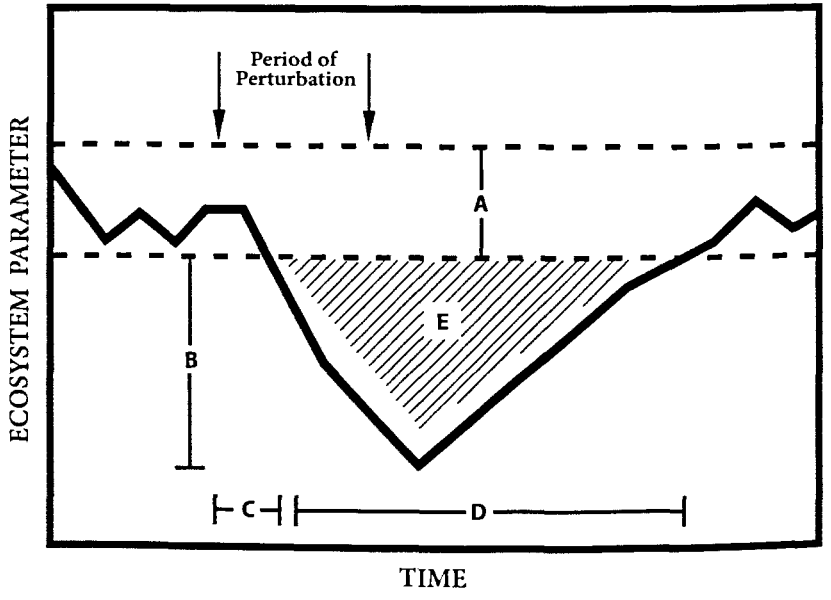


Figure 5.6 Diagram of five aspects of relative stability. Dashed lines represent the boundaries of the system's normal operating range. Letters refer to aspects of stability: A, constancy; B, resistance (low resistance corresponds to greater displacement from normal); C, response time; D, resilience (time to return to normal); and E, total relative stability (a function of resistance and resilience). (Redrawn with minor modifications from Leffler 1978.)

Leffler (1978) defines ecosystem stress as any change in the input variables to a system that produces an output different from the system's normal response. The parameters of the system under stress deviate from normal operating ranges. Model building is inherently simplified when the system being conceptualized is normally in steady state. The human ecosystem of the Arid Southwest is not, however, in steady state.[4] "Normal" for this system has been unsustainable growth—that is, growth in both demand for water and the total population of consumers. The corresponding information system is still characterized (though not exclusively) by high future expectations for current rates of consumption and the "right kind" of population growth. Clearly, as Leffler points out, understanding the stress in a particular ecosystem requires reference not only to the nature of the changing input variables but also to the system's history, the observer's caricature of the system (some biases and limitations of description need to be acknowledged), stakeholder ability to detect changes in the system, and our time-space scale. When we enter the realm of human ecosystems, the meaning of *history* changes, as does the meaning of *normal.* History is continually revised. The normal becomes prescriptive, and delineating the parameters of a "normal" operating range cannot be completely objective. As a first step, for human ecosystems it is prudent to delineate both emic and etic normal operating ranges. Those who make important decisions about water allocation in Arizona, for example, have explicitly defined the emic normal operating range as positive economic growth. The emic system is myopic in its unexamined assumption of infinite potential economic growth. But we assume the stakeholders will not be blind to all future signs of increasing stress or "outsiders'" assessments of the state of their system. This is part of the subject matter of information ecology from an etic point of view.

Resistance is the ability of the system to maintain normal operating ranges under stress. The magnitude of its deflection from normal is a measure of its ability to resist the stress (Figure 5.6). Hierarchically organized human ecosystems create structural programs of resistance at a number of scales. Large programs are commonly assumed to be the most resistive. Notorious examples are the constructions of the U.S. Army Corp of Engineers that are aimed at increasing resistance to flood disasters or Bureau of Reclamation water storage projects like Hoover Dam. A more benign example from the Arid Southwest is the groundwater recharge program.

Resilience is defined in Figure 5.6 as the time required to return to normal operating ranges after these ranges have been exceeded.[5] In the vernacular, *resilience* has more than one meaning. In seventeenth-century English, the term *resilient* meant "to return to an original shape, or position" (as in "to spring back"). In the nineteenth century, this core meaning was extended to include "resistant to setbacks or adversity" (*Oxford English Dictionary*). In post-WWII American English, the central meaning clusters of the term *resilience* are "to recover rapidly" and "to regain original shape or position" (*Webster's 1984 New Riverside University Dictionary*). It is in this sense that Leffler's Figure 5.6 operationalizes resilience of an ecosystem as

the time required for full recovery to original normal operating range. This idealized definition is not characteristic of human ecosystems, however, because "full recovery" is seldom attained and "original normal" is usually incompletely documented and/or politically contested. But human systems do work to return to "normal functioning," as they see it, and in that emic sense they are relatively resilient. Their resilience is also increased by external (especially federal and state governmental) subsidies (relief) allocated in response, for example, to "natural disasters."

Together, resistance and resilience define a system's stability (Figure 5.6). Human ecosystems both resist change and work to get back to "normal" on time scales of a few days to individual lifetimes and longer, with varying degrees of success. They purportedly value total relative stability. The information flows in the human ecosystems of the Arid Southwest often emphasize the importance of stability. The trajectory of the work of propaganda in this context is often aimed toward relative stability. This emic value underlies the models of Arid Southwest information ecology developed later in this chapter. It is caricatured and marketed with the booster metaphor "oases in the desert."

Another point about relative total stability is that, in managed and fabricated environments, resistance structures and programs contribute, even though they are only partially successful, to resilience through shortened recovery times. We do not know if this interaction effect is also characteristic of biological ecosystems.

We are fortuitously positioned to detect changes in our case-study system. The first author has been engaged in policy analysis and ethnography of the Arid Southwest since 2003, yielding a wealth of information about this human ecosystem. We are in the midst of observing how this system is responding to changing input, and we will be able to see significant results within the first, if not the second, author's lifetime. We also have the benefit of a *longue durée* perspective (Redman and Kinzig 2003). We have historical, archeological, hydrological, and dendrochronological data to draw on, which greatly expands the time scale of the etic analysis. The emic system perspective is dominantly short-term, a "fast profit" system, not unlike the current rush to exploit fossil fuels in the Alberta tar sands or Marcellus Shale gas. The *longue durée* perspective suggests that a slow and steady profit system would (*ceteris paribus*) suffer less stress.

Our constructions for understanding the stress response of this ecosystem are a series of conceptual models characterizing the human agents as information consumer/transformers in a nexus of information environments largely of their own creation. Many of the responses of this ecosystem are adaptive only in the short run. Their longer-term apparent maladaptive character can be modeled as a product of self-limiting individually motivated cognition combined with groupthink. These models are contrasted with those of a potentially adaptive nature, at the levels of the individual and regional public, to highlight the diversity of

stress-response options available to an ecosystem seeking long-term stability. These models are presented under "Results: The Conceptual Models," below. It is important to keep in mind that each model is composed of a graphic representation (a graphic caricature) and an explicating text. Graphics and text together constitute the models. Further, the models are not intended to be exhaustive. Instead, they highlight aspects of these ecosystems that we consider reference points in this first stage of developing a theory about the ongoing and future stress-response behavior of the residents of the Arid Southwest.

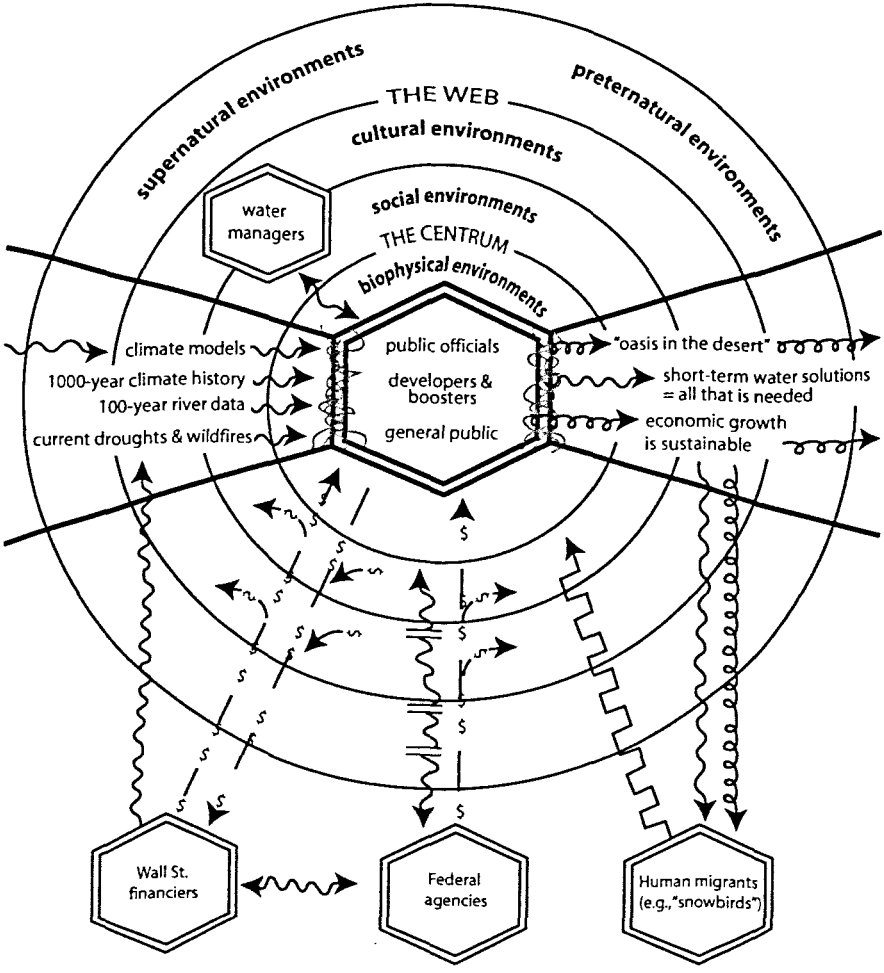
Leffler (1978) notes the unreliability of overgeneralized predictions in models of the stability of biological ecosystems. And, as Levins (1966) has pointed out, it is not possible to simultaneously maximize generality, precision, and realism in biological population models. Models of human ecosystems are no less problematic. But postmedieval western cultures have enjoyed new traditions of speculating about futures in both the religious realm (e.g., the evangelical movement) and the secular realm (e.g., science fiction). Failures of stability and relationships among types of stability are common themes. Inspired in part by the tradition of science fiction, our method of model-building induction is based on an intuitive synthesis of field observations, institutional documents (including mathematical simulations), and media expressions that lends itself to creating multiple working hypotheses and one-off speculations about the likely futures for the Arid Southwest over the next several human generations.[6] We will briefly present some of these in the following sections.

RESULTS: THE CONCEPTUAL MODELS

Graphic Model 1 (Figure 5.7) introduces the current human ecosystem of the Arid Southwest in terms of the components of a consumer system, its input and output environments, and an ambient (largely conceptual) multienvironmental surround (the environs). In Figure 5.7, public officials, developers, boosters, and the general public are modeled as the consumers and producers of information and propaganda. Information flow into their system from its input environments is filtered (constrained/limited) primarily by immediately self-serving cultural values and beliefs reinforced by shared forms of reasoning—that is, a vernacular epistemology. Figures 5.8 and 5.9 depict some of the details in this filtering process. Graphic Models 2a (Figure 5.8) and 2b (Figure 5.9) are simplified summaries of cognitive processes underlying stress-response dysfunction (myopia) on the part of uncritically self-limited individuals and special interest groups. These graphic models highlight aspects of the individual and group psychologies of the current system that we theorize about, rendering it, in principle, unable to adapt to the long-term implications of the new information available about the climatic history of the region and by implication resulting in unrealistic

(denial-based) emic institutional cultural models of the water policies in the region that will be needed for the future.

Graphic Model 3a (Figure 5.10) represents important components and processes of individual cognition for an idealized realistic consumer/transformer of information engaging in creative, reflective, critical thinking. Graphic Model 3b (Figure 5.11) represents complementary components and processes of socially distributed cognition for an idealized human ecosystem capable of adapting in a wholistic, realistic, problem-solving manner to the implications of the new information regarding climate and the limitations of the systems represented in Figures 5.8 and 5.9.



Together, all of these graphic models represent an introduction to the evaluation of the Arid Southwest human ecosystem's potential future stress-response behavior to severe transgenerational water shortages—what is becoming for them the looming specter of a Great Drought and a potentially enduring state of emergency. The models are explored below to lay an initial part of the foundation needed for an ongoing study of the options open to the region's long-term residents. In particular, we focus on some of the components, processes, and limitations that must change for the system to be adaptive in the long run.

Figure 5.7 Graphic Model 1 (see opposite page): Simplified components of the Arid Southwest human ecosystem with its information input and output environments strongly filtered by the primary regional consumers of information (represented in part at the center). The information and propaganda input and output environmental fields are represented on the left and the right, respectively, of the centrally depicted consumer system. The absolute distinction between the ambient biophysical and sociocultural environments is not realistic but appears to be realistic to the consumers. Current droughts and wildfires are examples of information input perceived to be produced in the biophysical environments, outside of the sociocultural world, although in fact they are amplified, if not created, by human action. The 100-year Colorado River flow data, the 1,000-year reconstructed regional climatic record, and models of future climate are input information produced at the interface between the biophysical and sociocultural environments. The centrum represents those particular environments that most immediately impact the consumers, whereas the web effects are more indirect. Discursive taboos, vernacular epistemologies, and default cultural models filter input information at the scale of single individuals and organizations of individuals within the region (see Figures 5.8 and 5.9). Information output is largely propaganda; it reflects an emphasis on "practical" (i.e., short-term) compromises and encourages a positive feedback of in-migration and economic involution. The region's water managers are represented as occupying a unique position in this human ecosystem. External inputs (only partially depicted) of capital, energy, food, and other materials from financiers, energy utilities, agro-ecosystems, and federal agencies (in the form of high-end energy/matter and infrastructure) amplify transmogrification of the region's biophysical and sociocultural environments. These outside agents are largely insulated from feedback processes within the regional system. This ecosystem is adaptive only at very short time scales; significant portions, if not all of it, are apparently incapable of learning the wise citizenship that would engender or enhance the virtual stability sought at the regional scale. (See Appendix 5.1 for a key to the semiotic signs used in the iconography of the graphic models.)

Graphic Model 1 (Figure 5.7)

As we write this chapter in the year 2012, much of the United States is experiencing its worst drought in fifty years (*New York Times* 2012). The Southwest remains in a drought that began in late 1999. This drought highlights questions about the long-term climate patterns of the region. A new perspective based on prehistoric data became available to the scientific community beginning in the 1950s (see online supporting material at kuchka.org). Tree-ring studies revealed that the 1922 compact agreements for sharing Colorado River water were based on water data collected during an unusually wet period at the beginning of the last century. In-place water-sharing agreements, planning, and development are all based on spurious estimates of the long-term water supply. Subsequently, the misleading historical estimates of expected long-term water flow for the Colorado River have become a recurring theme in policy discourse (e.g., NRC 2007). The drought has also created public and media interest in these new climate data, now spanning 1,000 to 2,000 years, and the region's climate future (Kunzig 2008; McKee 2002). But these themes almost never appear in public water policy discourse. Clearly some consumers of these data are selectively filtering the information (Figure 5.7). For them, it seems, it is business-as-usual, and no radical new water policies are needed. Paradoxically, this seems to be true of even the region's official water managers. These individuals are in the unique position of being able to promote the funding of new scientific research about the region's history, being the first to be able to systematically consider its implications, and being concerned as both public policy agents and citizens. But they do not openly discuss the implications of the new long-term view of the region's climate. We see on their part what appears to be a delayed stress response to the obvious implications of a need for radically new water policies. It appears that the new information (both climatic and, by implication, institutional) is itself stressful.

Also illustrated in Graphic Model 1 (Figure 5.7) are "information" output tropes that are propaganda. *Propaganda* minimally connotes an intention to use information to shape perception and behavior; it figures prominently in our models. We recognize it as the twin of information in our technological society: "only with the all-pervasive effects that flow from propaganda can the technological society hold itself together and further expand" (quoted from K. Kellen's 1965 introduction to his co-translation of Ellul's 1962 *Propagandes*). Kellen highlights some of Ellul's main theses, noting that most people are easy prey for propaganda because of their firm but entirely erroneous conviction that what is true cannot be propaganda. But modern propaganda operates with many different kinds of truth—half-truth, severely limited truth, truth out of context. And to be effective, propaganda must be as accurate as possible.

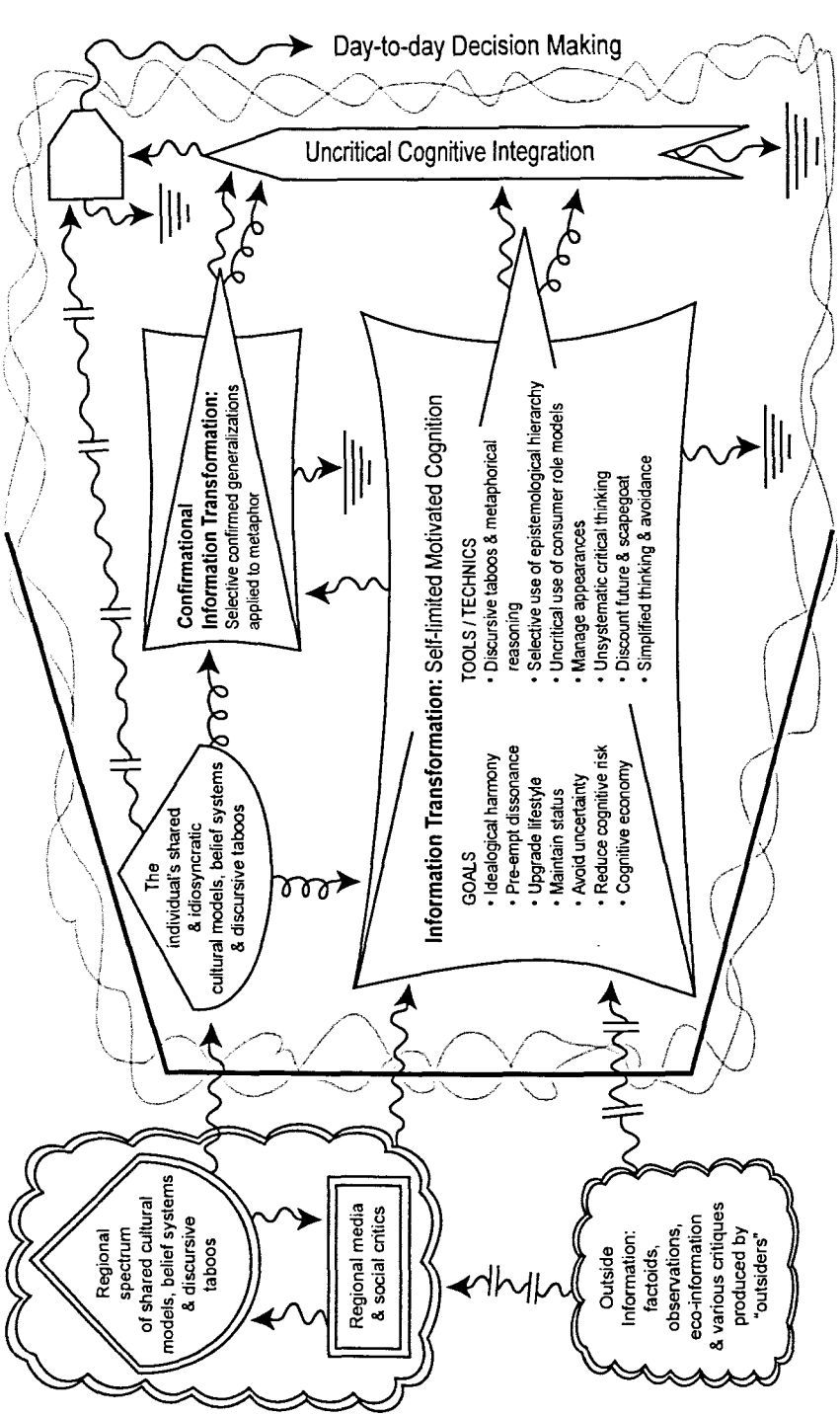
The primary purpose of propaganda is to intensify existing patterns and trends. *Integration propaganda* is the means by which societies create conformity, adherence to stereotypical beliefs and reactions. Individuals are thereby confidently fulfilled through their active and vicarious participation in like-minded special interest groups. One of the goals of this self-reproducing propaganda is to obtain "stability" in the system and to ensure its permanence.

In subsequent models we consider the role of propaganda in more detail. At this point we note that metropolitan Phoenix has been heavily marketed and landscaped as an oasis in a desert (Casagrande et al. 2007), and you can see giant saguaro cacti and palms in the same fabricated public landscape. One advertising campaign by the Greater Phoenix Convention and Visitors Bureau in 2005 boldly proclaimed, "The desert is a myth." The general public lives and reifies the myth of Phoenix as an oasis. Oasis-style landscaping is extremely popular (Larson et al. 2009). One interviewee in 2004 stated, "I arrived in the 1970s. I took one look at the palm trees and fell in love."

Phoenix is a fast-profit, rapid-growth phenomenon economically reminiscent of the Old West boom town it once mimicked. Information-energy-capital subsidies and propaganda support a fallacious belief in human ecosystem stability. The transformation of capital into food into capital is constrained by the laws of marginal return and entropy in an unsubsidized system. The human ecosystem in the Arid Southwest is heavily subsidized. For example, the Arid Southwest does not grow enough food to feed its growing population. And although farming is now a small part of the economy, it still consumes most of the water in the Colorado River and contributes to the growing problem of salinization.

Graphic Model 2a (Figure 5.8)

This graphic model represents some important aspects of information filtering in uncritical individual cognition. At the lower center of the model is a large information transformation icon labeled "Self-limited Motivated Cognition." *Motivated cognition* in this case refers to purposeful bias in which individuals selectively use information to confirm existing beliefs and achieve goals of limited self-interest. Our data suggest that one important psychological goal is evading cognitive dissonance (Casagrande 2004; Scher and Cooper 1989). The first author attempted to steer interview conversations with residents of Phoenix so that potentially conflicting statements would become closer to each other in the awareness of the interviewees. In one example, in January of 2004, a woman talked about her swimming pool, which consumes a good deal of water owing to evaporation. Later, she was talking about the nearly empty nearby reservoirs she had seen, which


Day-to-day Decision Making
Uncritical Cognitive Integration
Confirmational Information Transformation: Selective confirmed generalizations applied to metaphor
Information Transformation: Self-limited Motivated Cognition
GOALS
• Ideological harmony
• Pre-empt dissonance
• Upgrade lifestyle
• Maintain status
• Avoid uncertainty
• Reduce cognitive risk
• Cognitive economy
TOOLS / TECHNICS
• Discursive taboos & metaphorical reasoning
• Selective use of epistemological hierarchy
• Uncritical use of consumer role models
• Manage appearances
• Unsystematic critical thinking
• Discount future & scapegoat
• Simplified thinking & avoidance
The individual's shared & idiosyncratic cultural models, belief systems & discursive taboos
Regional spectrum of shared cultural models, belief systems & discursive taboos
Regional media & social critics
Outside Information: factoids, observations, eco-information & various critiques produced by "outsiders"

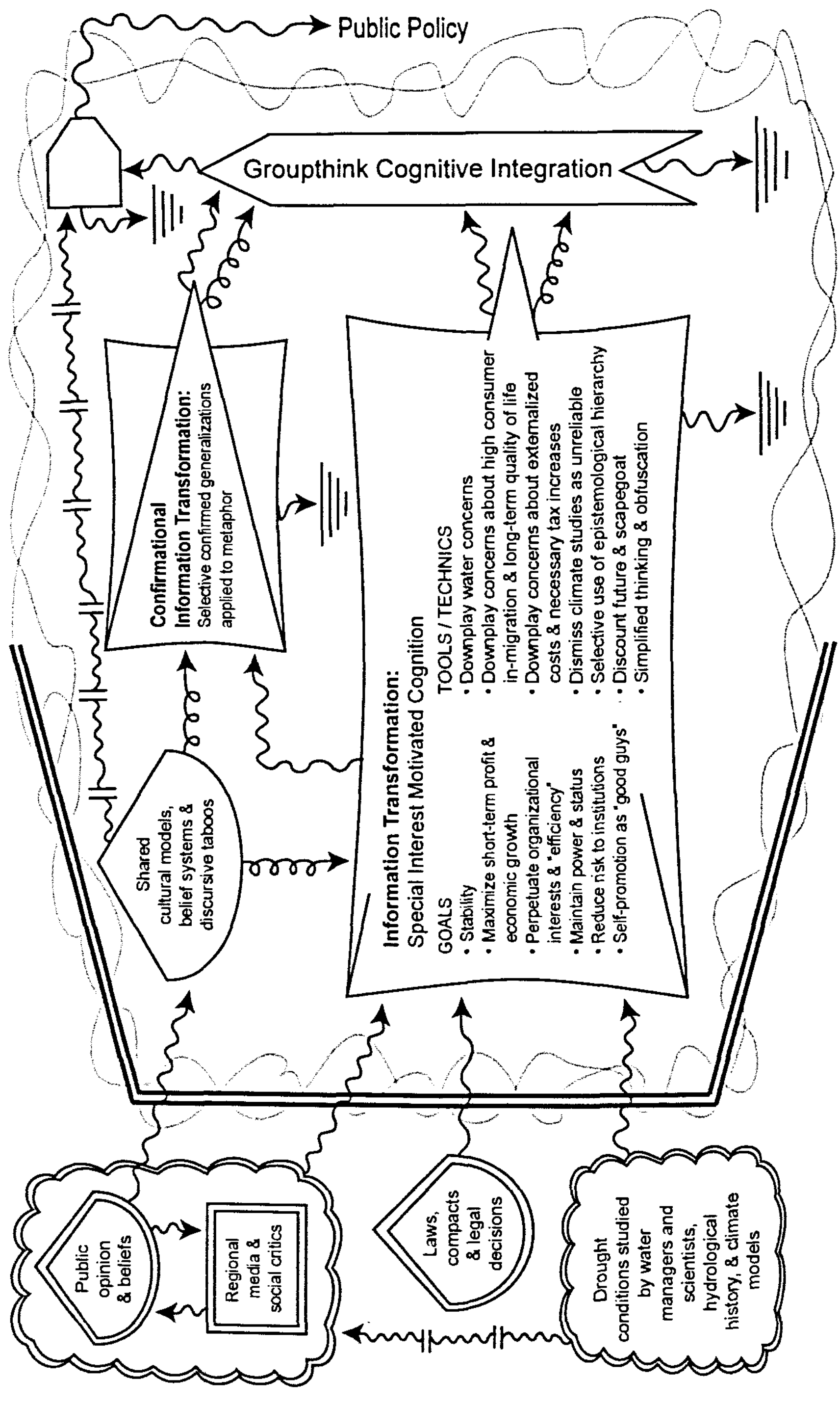
she attributed to the drought and people's excessive use of water. After a slight pause, Casagrande reintroduced the topic of the swimming pool as follows:

Q: . . . so you have a pool . . .
A: yeah. It's small.
Q: . . .but does it use a lot of water?
A: (hesitating, then) You know . . . here's what I don't understand, why are they spending all this money on Mars? Why don't they build a . . . uh . . . a big plant to change salt water?

As the interviewee began to become aware of the logical inconsistency of being concerned about drought and having a water-wasteful swimming pool, she shifted the discourse to the widely shared cultural model of "the technological fix." This is but one example of the various tools or technics people are seen to use in this type of motivated cognition (see Figure 5.8 for others). The interviewee in our example is not reconciling information at one epistemological level before moving to another. Instead, what we see is saltation, whereby the individual leaps up the epistemological ladder (Figure 5.5), unconcerned with the apparent illogical (and unrealistic) nature of the move. This is more than a lost opportunity for critical thinking and the identification of important information. It is a lost opportunity to begin to see the big picture.

The input environment of individual cognition represented in Figure 5.8 includes information sinks at several points. The interviewee in the example above includes use of the self-limiting-sink attached to the main transformation icon, in what we interpret as a preemption of cognitive dissonance. The information filtering process occurring there limits integrated reflective decision making and evaluation of beliefs in a realistic manner.

Figure 5.8 Graphic Model 2a (see opposite page): Some components, processes, and constraints for the individual as an uncritical information consumer/transformer and his or her individual self-limited motivated cognition as a maladaptive information input filter. Input (and output) information is filtered/transformed by, for example, generalized discursive taboos (e.g., "never question the concept of economic growth"), vernacular epistemologies, and default cultural models used to escape and preemptively evade cognitive dissonance. Critical information is also lost to idiosyncratic individual cognition. Such information sinks (where information is lost) appear throughout the model. Overall, this individual information ecosystem is adaptive only at very short time scales and is apparently incapable of learning new ways of thinking. (See Appendix 5.1 for a key to the semiotic signs used in the iconography of the graphic models.)


Public Policy
Groupthink Cognitive Integration
Confirmational
Information Transformation:
Selective confirmed generalizations
applied to metaphor
Information Transformation:
Special Interest Motivated Cognition
GOALS
• Stability
• Maximize short-term profit & economic growth
• Perpetuate organizational interests & "efficiency"
• Maintain power & status
• Reduce risk to institutions
• Self-promotion as "good guys"
TOOLS / TECHNICS
• Downplay water concerns
• Downplay concerns about high consumer in-migration & long-term quality of life
• Downplay concerns about externalized costs & necessary tax increases
• Dismiss climate studies as unreliable
• Selective use of epistemological hierarchy
• Discount future & scapegoat
• Simplified thinking & obfuscation
Shared cultural models, belief systems & discursive taboos
Public opinion & beliefs
Regional media & social critics
Laws, compacts & legal decisions
Drought conditions studied by water managers and scientists, hydrological history, & climate models

Graphic Model 2b (Figure 5.9)

This graphic model represents the information input filter of the special-interest group. The individual cognitive processes seen in Figure 5.8 contribute to the collective forms of cognition represented in Figure 5.9, but group cognition is different because collaborative groups "have cognitive properties that are not predictable from a knowledge of the properties of the individuals in the group" (Hutchins 1995: xiii). In this regard Figure 5.9 represents *groupthink* (Janis 1972). We find this evident, for example, in the Southwest's water policies. In groupthink, not taking action in the light of new information is justified because in the group's pursuit of consensus it is believed that the response of inaction is the correct one. And, in this case, the motivating morally correct goal is believed to be the promotion of unbounded economic development. Discursive taboos are particularly relevant in this case. While discursive taboos may not filter the individual's consumption of information, in this case of special-interest collective cognition they clearly do so at the level of the group. A good example is the contrast of questioning economic growth on an individual alone vs. on a collective basis. One interviewee was a realtor who, as a professional, was not in a position to question new housing construction. But here is a revealing interview excerpt from 2004:

Q: Do you think there's enough water?
A: When I moved here, there was a 250-year water plan. There was enough water for the amount of people in Phoenix at the time to survive 250 years with no rainfall. It wasn't but 10 years later it was a 50-year plan. We don't even have a 5-year plan now. [In] five years we could be completely out of drinkable water. Five years. Do I think there's a water shortage? To go from 250 to 50 to 5 in 20 some years? Yes.
Q: To what do you attribute that?
A: Misuse, overuse, overpopulation, overgrowth. Look at the growth.

Figure 5.9 Graphic Model 2b (see opposite page): Groupthink as a maladaptive information input filter for elected officials, developers, and boosters. Crucial information is lost in the uncritically self-serving special-interest organizational dynamics of socially distributed consensus-cognition. Input (and output) information is filtered/transformed by, for example, discursive taboos, vernacular epistemologies (e.g., scapegoating), and default cultural models (e.g., "We are the good guys") used to escape and preemptively evade threats to shared goals. Overall, this information ecosystem is adaptive only at very short time scales, in large part because the need for agreement takes priority over the motivation to obtain accurate information appropriate to the broader long-term functional context of decision making. (See Appendix 5.1 for a key to the semiotic signs used in the iconography of the graphic models.)

Economic growth was never questioned in a public meeting or public interview. In the public arena only a few newspaper editorials addressed it minimally. But in private, one municipal water manager confided to the first author in 2004: "I don't think we have enough water for the kind of growth people are talking about. But to say that in public is suicide." He also alluded to the prehistoric Hohokam: "there were people here before us. You can see the canals. What happened to them? They ran out of water." Many policy makers have seen the ghost of the Anasazi and Hohokam, but to discuss it in public has been taboo.

Through a variety of shared discursive tools/technics (summarized in Figure 5.9), individuals acting as part of the collective cognition of special interest groups will ignore, suppress, or transform new information that does not conform to current organizational priorities. The new information may be perceived as a threat to the organization, or it may simply contradict the group's cultural models and beliefs (e.g., socially valued moral directives like economic growth). In groupthink among decision makers, only the minimal amount of information needed to create consensus is considered. Important information produced within the organization often ends up "taking space on shelves." Examples of information lost to sinks include unused archives, reports consigned to landfills, much of the information on the Internet, and the missed opportunities of alternative forms of economic development. Information sinks (Figure 5.9) illustrate the failure of the current system to learn to adapt to critical changing ecosystem input parameters in a long-term realistic manner.

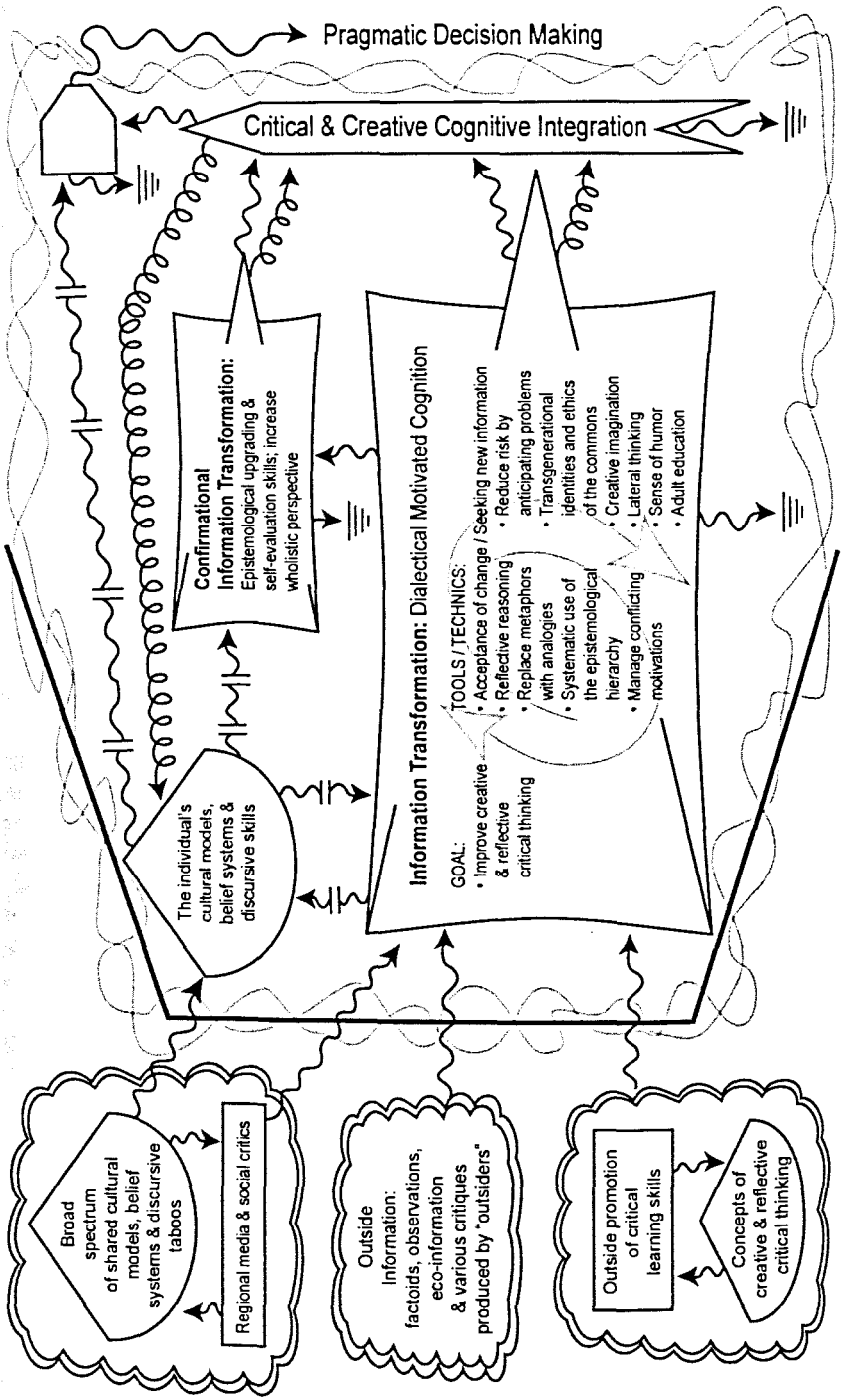
One goal of groupthink in this case is to maintain institutional autonomy. This includes avoiding federal intervention and justifying the existence of institutions like the Arizona Department of Water Resources. "Water banking" provides a good example. States have a sordid history of competition and conflict over water (Reisner 1993). States that don't consume their complete allocation of Colorado River water will often use it to recharge underground aquifers rather than allow another state to use it. On December 9, 2004, the Arizona Water Banking Authority announced a new and innovative agreement with the state of Nevada. Nevada's unused water allocation would be moved via the Central Arizona Project (see map, Figure 5.2) and stored underground in Arizona. This required considerable legal and technical innovation. The public discourse surrounding this agreement indicated that the innovation was encouraged by (1) the drought that began in 1999; (2) recognition of the erroneous estimates of flow in the Colorado River and the need for more interstate cooperation; (3) a repeatedly expressed desire to avoid federal intervention; (4) pride in the ability of state, municipal, and other organizations to be innovative; and (5) the desire of political appointees to produce results. But when asked about the probable long-term scenario of severe water shortage implicated by the reconstructed climate record based on tree-ring data and spanning more than 1,000 years, an

important political appointee said: "We can't worry about that now. We have to deal with the situation we have now and worry about that later." See Figure 5.9 for this and other tools/technics employed to achieve groupthink goals.

The information transformations that take place as group products drive informational output, as noted in Figure 5.7. An individual might personally question economic growth, but the result of collective consumption and interaction with others can bolster myths that contradict those individual beliefs. Three of the most important maladaptive themes promoted as by-products of this collective process are that metropolitan Phoenix is an oasis in the desert, that unbounded economic growth is sustainable, and that we must focus management efforts on short-term water solutions (Figure 5.7).

We see in Figures 5.8 and 5.9 reminders of the important overarching role played by propaganda in the current human ecosystem of the Arid Southwest. Following Ellul's (1965) analyses of the American system, we recognize that the presence and effects of propaganda in this system are usually understated. Part of the explanation for this is Ellul's observation that educators and intellectuals are virtually the most vulnerable of all to modern propaganda. They would likely contest this confirmed generalization, however, and their self-perceived untarnished status in the denial logic of the system's information ecology should be acknowledged in the models. In this regard we have adopted the emic notion, for example, that "information" flowing from the ambient regional media, unfiltered by the consumers of Figures 5.8 and 5.9, is not propaganda.

In Figures 5.8 and 5.9 our etic depiction of the role of propaganda acknowledges the irony that uncritically minded consumer/transformers mirror the ambient system by their *self-propagandizing* technics. This is part of what Ellul uncovers in his description of the psychological need on the part of the "propagandee" for propaganda. Temporary absence or withdrawal from propaganda is not only psychologically stressful for the individual and special interest group but they also work to eliminate that possibility by facilitating a more or less constant flow of propaganda from their storehouses of cultural models, belief systems, and discursive taboos. It is almost a side effect that this obsession permits them to resist new unanticipated facts and the pressures of contrary information. The consumers/transformers of the essentialized special interest group depicted in Figure 5.9 also send out a flow of propaganda to the regional media and public opinion cloud from what is labeled "Information Transformation of Special Interest Motivated Cognition." This outward flow is not depicted in Figure 5.9 because it occurs from the output portion of the system, which can be imagined by the reader to be to the right of the "Public Policy" label. The effects of this meta-feedback loop can also be easily imagined to be an outside (i.e., "objective") informational confirmation of special interest cultural models and beliefs.


Pragmatic Decision Making
Critical & Creative Cognitive Integration
Confirmational
Information Transformation:
Epistemological upgrading & self-evaluation skills; increase wholistic perspective
Information Transformation: Dialectical Motivated Cognition
GOAL:
• Improve creative & reflective critical thinking
TOOLS / TECHNICS:
• Acceptance of change / Seeking new information
• Reflective reasoning
• Replace metaphors with analogies
• Systematic use of the epistemological hierarchy
• Manage conflicting motivations
• Reduce risk by anticipating problems
• Transgenerational identities and ethics of the commons
• Creative imagination
• Lateral thinking
• Sense of humor
• Adult education
The individual's cultural models, belief systems & discursive skills
Broad spectrum of shared cultural models, belief systems & discursive taboos
Regional media & social critics
Outside Information: factoids, observations, eco-information & various critiques produced by "outsiders"
Outside promotion of critical learning skills
Concepts of creative & reflective critical thinking

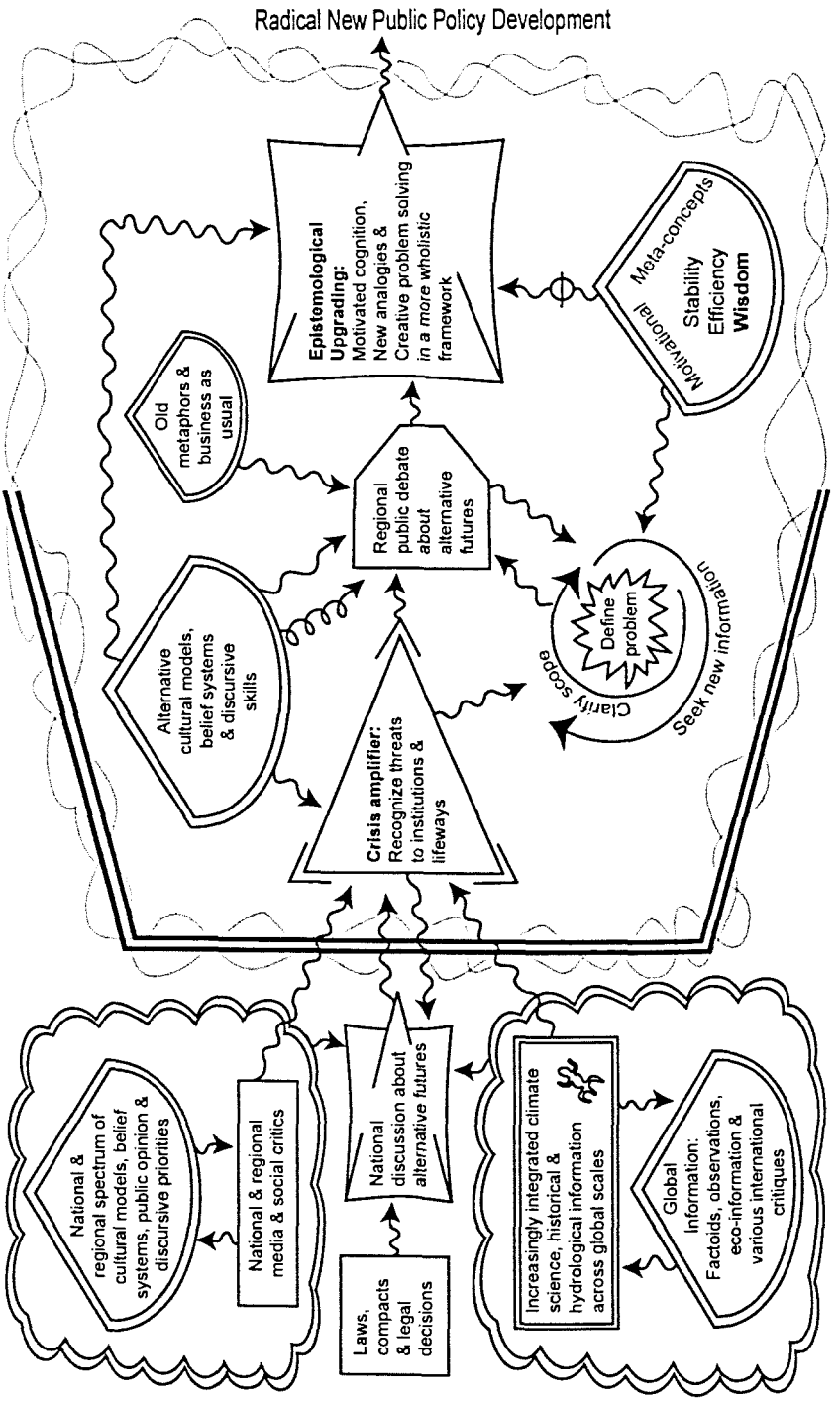
Ellul (1965) outlines the procedures of propaganda technic: (1) reduce doctrines to programs, (2) reduce programs to slogans, and (3) reduce slogans to pictures that are direct reflex-stimulating images (e.g., the "oasis in the desert"). For historical perspective he notes that persuasive political propaganda lagged behind big business advertisement as late as World War I: soon thereafter, however, the public sector was systematically subject to the conditioned reflex actions inculcated by adroitly combined media technology and psychological technic. The power of the media rests on its promotional mandate to provide "balanced" views of the "news" (the ethics of western journalism) along with investigative reporting, plus its technical ability to create the illusion that it "directly" communicates its products to a very large number of people collectively while simultaneously addressing each individual consumer in that collectivity. This provides extraordinary outreach and a remarkable capacity to bring psychological and intellectual persuasion to bear. Externalized differentially distributed cognition achieves a purposeful broad-scale organization in a society that is otherwise largely socially fragmented.

In contrast to the above, Graphic Models 3a and 3b (Figures 5.10 and 5.11) are etic illustrations of the potential for creating reflective critical thinking and realistically adaptive learning systems. Figure 5.10 depicts the idealized individual consumer/transformer, and Figure 5.11 depicts idealized socially distributed cognition at the regional scale.

Graphic Model 3a (Figure 5.10)

A central point of Graphic Model 3a is that people can and do train themselves to think in creative and reflectively critical ways by altering their information input environments and their filter/editing capacities to privilege ethical wholism and constructive self-transformations. The historian Marc Reisner is

Figure 5.10 Graphic Model 3a (see opposite page): Some components and processes of the individual as an idealized reflective critical thinker and their creative dialectical motivated-cognition as a realistic adaptive information input filter. Reflective critical reasoning involves the practice of a number of analytical skills, from clarifying one's purpose, questions, and assumptions, through evaluation of relevant concepts, points of view, and evidence, to logically drawing conclusions and considering the implications/consequences of the resulting decisions for action. Another part of dialectical cognition is creativity. This means to show imagination as well as routine skills—that is, to bring together imagination and craft skills in decisions for action. Dialectical cognition also requires the individual to both acknowledge and psychologically manage, in constructive ways, uncertainty and conflicting motivations. As an information ecosystem this individual is potentially realistically adaptive (e.g., able to effectively plan) across a range of space-time scales, and capable of learning relevant new ways of thinking. (See Appendix 5.1 for a key to the semiotic signs used in the iconography of the graphic models.)


Radical New Public Policy Development
Epistemological Upgrading: Motivated cognition, New analogies & Creative problem solving in a more wholistic framework
Old metaphors & business as usual
Meta-concepts
Motivational
Stability
Efficiency
Wisdom
Alternative cultural models, belief systems & discursive skills
Regional public debate about alternative futures
Crisis amplifier: Recognize threats to institutions & lifeways
Define problem
Clarify & focus
Seek new information
National & regional spectrum of cultural models, belief systems, public opinion & discursive priorities
National & regional media & social critics
Laws, compacts & legal decisions
National discussion about alternative futures
Increasingly integrated climate science, historical & hydrological information across global scales
Global Information: Factoids, observations, eco-information & various international critiques

severe, multi-year drought in the Southwest, and to assess alternative policy responses to such a drought for the Colorado River basin (Young 1995). This effort aimed to integrate long-term climate research with organizational behavior research. A growing interest in pre-historic climate, increasing awareness of the disconnect between data and decision-making, and external financial support from the Arid and Semi-Arid Lands Directorate of the Man and the Biosphere Program, U.S. Department of State, all contributed to what is labeled "Crisis amplifier" in Figure 5.11. Redefining and clarifying the scope of the climate variability problem led to seeking new information, including in the form of long-term climate and stream flow data. In another example, the Decision Center for a Desert City (DCDC) was created in metropolitan Phoenix in 2005 specifically as an attempt to engage policy makers, academics, and the public in discussion of alternative futures. DCDC methods have encouraged collaborative learning (Crona and Parker 2012)—a form of epistemological upgrading (Figure 5.11). Whether stakeholders are sufficiently altering the information input filters of their distributed cognitive system remains to be determined: dominant discursive taboos appear to remain intact (e.g., publically questioning growth); meaningful public contribution to decision-making has been limited; and use of metaphor instead of analogy continues.

Among the motivational metaconcepts recognized in Figure 5.11 (see lower right "storage" icon), the most difficult to operationalize is that of wisdom (bolded in the graphic). In the eightfold path of Buddhism, *wisdom* implies right views and right intent (Rahula 1959). In American English, *wisdom* refers to understanding, good judgment, and common sense about what is true, right, or lasting. As Eiseley (1960: 150–160) notes, "We who are engaged in the life of thought are likely to assume that the key to an understanding of the world is knowledge, both of the past and the future . . . that if we had that knowledge we would also have wisdom." We see ample evidence, however, that in the Arid Southwest the disposition to "blind faith" knowledge, commonsense

Figure 5.11 Graphic Model 3b (see opposite page): Some components and processes of socially distributed cognition as an idealized creative realistic problem-solving ecosystem. In this case, the collective wisdom of a regional water management regime allows for self-reflective adaptation to new information. Problems are defined at the appropriate scope of analysis. Public debate helps overcome the metaphorical obfuscation of groupthink to enable reflective epistemological upgrading. The need for agreement is important, but does not override other goals (particularly realism) because there is broadly distributed complementary reflective critical thinking, and creativity in the management of conflicting motivations. Discursive taboos become taboo in metalevel group epistemology. Out of systematic public debate about alternative futures, the search for new information, and wise means of valuation, constructive radical new public policies emerge as a result of creative problem solving in a more wholistic framework. (See Appendix 5.1 for a key to the semiotic signs used in the iconography of the graphic models.)

knowledge of the importance of maintaining unbounded population and economic growth, for example, precludes wisdom (including adaptation to new and contradictory information). In particular, this "commonsense" sustains discursive taboos against questioning this nominally "stable" type of regional growth and fully considering future scenarios, especially the problem of increasing demand for water in a (already over-allocated) limited supply. This applies to all agents, from the general citizenry to water planners. This effect is amplified by a lack of shared multigenerational experience/identity and the ephemeral nature of residency (snowbirds, migrants, opportunists who only "park their capital" in places like Phoenix) and external drivers like Wall Street investment in short-term development with no need to consider future scenarios. Figures 5.8 and 5.9 partially reveal how sociopsychological processes in these business-as-usual propaganda-dominated systems encourage the proliferation of metaphorical information but preclude wisdom. They also preclude the concept of honorable sacrifices and sharing the burden of limitations to natural resources.

There is a not uncommon cultural model which recognizes that wisdom requires a multigenerational sense of place—for example, Basso's "Wisdom Sits in Places"(Basso 1996)—and that encourages a more wholistic consideration of the past and the future. Part of this emic view includes the idea that the apparent notable stability of old-time human ecosystems was a product of wisdom. Berry (1988) explicates this, and by implication the unique role that wisdom plays in Figure 5.11. Imagine, if you would, that the word *wisdom* in the graphic is colored green and represents a portal into another world, a critical gateway to the storehouse of humanity's understanding of good judgment about what is true and lasting. First of all, the individual must stay in one place long enough to experience and understand the consequences of his or her behavior. This is highlighted in Figure 5.10 in the dialectical tool of "Transgenerational identities and ethics of the commons." What Berry refers to as an individual's *character* (patterns of value and restraint, along with memory, familiarity and understanding) is assumed in the agents of Figure 5.11. This allows these stakeholders to leave behind the superstitions of industrial optimism (e.g., our problems will be solved by "technological breakthroughs"). Applied to the inner workings of the regional system ideally represented in Figure 5.11, this motivates the most important creative first step, definition of the problem (in this case over consumption and a long-term crisis of water shortage), and indirectly motivates (along with the metaconcepts of stability and efficiency) the regional public debate about realistic alternative futures. Many different individuals with different individual skills and expertise will be involved in this debate within that network/matrix of socially distributed cognition. What will make it work (if it does in fact work) will be a sense of *community*, or that aspect of worldview seen as largely lacking in Figure 5.3 in national and some regional agents. It is, of course, lacking in some of the local agents as well. As Berry argues, for human life to continue to be productive through successive generations there must be neighborhoods of people that know each other, understandings of mutual dependency, shared

identities, shared memories preserved consciously in instructions, stories, and song. Wisdom accumulates in this multidimensional actualization of community. As Berry concludes, these connections, and the work that joins people together with the land, cannot be understood or described by information. It is like a love affair with continuity, tangibly in sight, embodied in every generation's children and grandchildren, with living memory lengthened by the landscapes of those who came before. All this can be communicated in poetic prose, analogy, and the imagined harmony of dance, but not by information.

Comparing at a glance Figure 5.10 with 5.8 and 5.11 with 5.9, we see an apparently diminished role for propaganda in the future. This is an illusion easily adopted by the idealistic intellectual. In fact, propaganda is notably present in Figure 5.10, and its role in the system of Figure 5.11 is just around the corner, immediately off-page to the right in the undepicted output filter/editor subsystem and its new production output environment.

Paradoxically the adaptive ecosystem partially depicted in Figure 5.11 will need the tool of propaganda even more than did the business-as-usual system of Figure 5.9. Theoretically this is true for at least two reasons. First, and perhaps the more obvious, these future managers will seek to democratically implement new public policy with the cooperation of the vast majority of its citizens. As part of this process they will, for example, attempt to integrate the growing, newly Mexican-derived population into American identity politics and social citizenry. Since many Mexicans see the American Southwest as a part of northwest Mexico, the creation of a new regional identity will necessarily deal with the perceived need by regional managers for ways of encouraging overlap in identities between all the region's long-term residents—this with respect to their cultural models of attachment to the land, historical memories of in-migration, and social inclusion in the negotiation of an adaptive regional future in the face of a probable transgenerational Great Drought.

Second, and perhaps not so obvious, the day-to-day experience of living out one's life in a high-tech society bathed in continuous flows of propaganda (cool advertising inducements, partisan politics of media personalities, etc.) is such that most (if not all) of its citizens become dependent to one degree or another on the consumption of propaganda for their sense of well being. Ellul (1965) summarizes the nature of this psychological dependency. Briefly included are the following.

In an anxious world propaganda offers the (illusion of) certainty. In that certainty, propaganda permits the consumers to assert themselves, and thereby satisfy their need for active participation. Propaganda also gives the consumer a feeling of self-importance, and a satisfaction in their belief in the effectiveness of their participation. Moreover, propaganda gives the consumer a sense of justification, a confidence in (or guarantee of) the rightness of their actions. When the consumer is cut off from familiar propaganda their sense of participation stops, their sense of uncertainty and a certain powerlessness increases. The result is increasing anxiety, apathy or withdrawal, and despair.

The implication of all of this for our model of a realistic adaptive future for the Arid Southwest human ecosystem is that, paradoxically, the systemic role of propaganda will not diminish. It cannot. But its content will shift. And, if anything, the amount of propaganda will increase in the overall public information program paving the way for radically new doctrines of water management. Following Goebbelian principles, the shift in content will occur in two phases. First there will be a propaganda of disquiet and fear (i.e., the specter of a looming Great Drought of historically unprecedented proportions). Second there will be the propaganda that eases this disquiet and fear of the "preternatural" threat to the human system. It will show the consumer how to respond creatively to the needs of society at large, at the household, neighborhood, community, state, and regional scales. It will console consumers and help them resolve their guilt feelings and conflicts of interest with good conscience. Otherwise it will not be realistic.

New Hypotheses as an Emergent Property of Model Building

Model building (a combination of graphics and text) is a complex process of cognitive externalization whose implications their creators only partially anticipate (Kuchka 2001, Table 3). As a result of this process, new (unanticipated) reflections emerge whose properties lie well beyond the scope of creative narrative in linear discourse; they are closer to the heartbeat of lateral thinking (de Bono 1990). An important instance of this, directly relevant to the completion of this section on Results, is that our etic model building has precipitated hypotheses unforeseen but implicated by the workings visualized in Figures 5.10 and 5.11. This is to be expected in the development of theory: model building enriches the conceptualization of hypotheses (Figure 5.3). In our case we are virtually forced to hypothesize that the dialectical cognition referred to in Figure 5.10, and its contribution to the distributed adaptive-futures cognitions referred to in Figure 5.11, oblige policy makers (because of the impetus of managerial practices) to create at least five emic metamodels. In this futures scenario the transformative processes of their dialectical cognition must create cultural models of the following: (1) the ideal futures these policy managers wish and pray for ("stored" in the upper left storage icon of the individual in Figure 5.10); (2) the practical futures they imagine can be realistically engineered; (3) the common schemes of reasoning recently practiced by the main social variants of regional consumer/transformers scopewise, with possibilities (options) for notable individualizations taken into account by the managers (at minimum some emic avatar of Figure 5.8); (4) the special-interest business-as-usual system, dominated by selectively unused and lost information, and resulting public policy based on short-term compromises that discount the future and scapegoat (some emic avatar of Figure 5.9); and (5) at least the centrum and outsider system components of the Southwest's citizenry as consumer/producers (some emic avatar of Figure 5.7). Unlike our etic models, these emic models will probably be constructed in more Jakobsonian language forms than simply the referential form of language.[7]

We recognize that the five hypothetical emic models of the currently career-developing, longer term future-oriented, water managers may still be only partially externalized (various taboos may still be in place). The same applies to the informed citizenry, but they may be conceptually ahead of policy managers in important ways (see Casagrande et al. 2007 for examples). Interviews with a sample of articulate southwesterners who consider themselves to be realistic reflective critical thinkers would be one place to start the collection of data on this topic. We hypothesize that the web in Figure 5.7 will not be well articulated because of the dominance of its indirect effects. We expect that as a systems problem solver, the "ideal" policy manager caricatured in Figure 5.10, will also be functioning as a critic and information engineer at the fourth level of the systems epistemological ladder (labeled Meta Scheme 2) depicted in Figure 5.5. We do not know if the emic models they create will use the modernist concept of mass society, with McDonaldization of its citizenry, or destabilized postmodern fragmented-heroic models (in the postenlightenment German Romantic tradition). But as the Southwest's aridity crisis deepens, we can ask what policy managers critically think of or formerly thought of the compromised business-as-usual stress responses that turned them toward acknowledging the need for a new learning paradigm.

DISCUSSION: TOWARD AN EPISTEMOLOGICAL TRANSITION

Our approach has been to experiment, bringing together a diversity of potentially complementary conceptual views from a number of theoretical disciplines, and to begin to integrate these into a multifaceted framework applicable to this case study. The conceptual context of the models is the epistemology of theory. Some of the jobs of theory are (1) clarifying thinking about method and technic, (2) motivating alternative working hypotheses, (3) introducing conceptualizations and model building relevant to the state of development of a discipline, (4) creating new interpretations while evaluating old ones, and (5) helping to push back the boundaries of the unknown and the apparently unknowable.

Limits to Stability Theory: The Known, the Unknown, and the Unknowable

The future of the Arid Southwest depends in large part on its relations to the broader geographical context of the political economy of the United States of America and Mexico. Outside subsidies of labor, money, and so on keep this human ecosystem from realizing the implications of its severe limits-to-growth trajectory. The U.S. federal government, for example, has extensive military infrastructure investments in the Arid Southwest (including its old atomic bomb testing facilities). The federal government has perhaps the greatest interest of any of the stakeholders in keeping the current regional system afloat.

The total relative stability (Figure 5.6) of this human ecosystem in the future depends not only on outside subsidies (e.g., U.S. military, tourism, upper-class retirement venues) but also on the relative size/mass of the system (Figure 5.2) and its internal organization/informational capabilities (Table 5.1). Its relatively large size/mass (Arizona alone is 113,595 square miles with a population of 6.5 million and a GDP of $227 billion in 2011)—combined with the information ecology sketched in Figures 5.7, 5.8, and 5.9—suggest, paradoxically, the possibility for both low resistance and low resilience in its stress responses. As private sector investment decreases and costs increase, the federal government will play an increasingly important role in stability efforts. The legitimacy of a government ultimately depends on its ability to deal effectively with extreme crises. The federal government will likely be increasingly challenged by "natural disasters" the size of Hurricanes Katrina (2005) and Sandy (2012), or larger, over the next fifty years. These are among the costliest "natural disasters," and Katrina one of the five deadliest hurricanes, in the history of the United States. Following Katrina there was a loss of innocence in the view many Americans held of the ability of their federal government to respond effectively to extreme crises. This loss of innocence was further amplified by the 2008 American financial crisis. Accordingly, in 2011 the president of the United States responded to the threat of Hurricane Irene by warning people along the East Coast, and in particular the residents of North Carolina, to prepare for the worst. In preparation, 2 million people were relocated, and the New York subway system was closed for the first time in its history. As it turned out, the hurricane weakened, and although was a costly disaster (financially and in human lives), it was not the serial killer it might have been. It does not appear, however, that American confidence in The System was fully restored. For an artistic expression of this that draws upon the experience of Katrina, see the popular dystopic postenlightenment sci-fi-futures film *Beasts of the Southern Wild*. Similar to Irene, the federal government took extensive measures to prepare for Sandy. It remains to be seen whether preparation and recovery efforts after Hurricane Sandy (2012) have significantly affected American confidence in The System.

Crises such as the Great Drought, confined to the Southwest or on a subcontinentwide scale, will likely consist of a series of acute and chronic stress "events." Total relative stability will likely decrease across the series. But the probable combinations of high and low degrees of change in the resistance and resilience components of relative stability in the system as the future unfolds are unknown and unpredictable at present. And the potential of promoting wisdom in an advanced technological society (Figure 5.11) is unknown in a more profound sense than we usually acknowledge. It is, for all intents and purposes, unknowable except in hindsight some centuries after the fact. What Figures 5.10 and 5.11 begin to provide, however, are reference points for seeing how well the current system is improving its stress-response skills—how it is developing its stress-response options realistically. The study of this living system in transition can lead to a clearer view of many aspects of the response behavior of a complex human ecosystem under severe prolonged climatic and

information ecostress—views that are not available to the methods of history and archeology. In particular, we have been able to highlight psychological aspects of stress response behavior, for individuals and groups in the living ecosystem, at the epistemological levels of both social critical theory and systems critical theory.

The Future as More Than an Information Environment

The ability to envision alternative futures from a secular perspective, as opposed to supernatural, is a relatively recent development. In its historical development, this ability first required a scientific theoretical understanding of the earth's past before there could be a history-like future for the planet. Eiseley (1960) traces this unfolding conceptual development in the earth sciences and biology as an epistemological sequence. Many recent information-based transformations in knowledge have paved the way, in the dialectic-of-enlightenment tradition, for a renewed secular vision of a future under human control. The view of the individual and society as the ultimate victims of *The System* was popularized for the middle class by books like Orwell's *1984* and became a central theme in cultural models by the 1970s. Science fiction has often portrayed alterative futures in terms of technology run amok, or systems of our own creation beyond our understanding and/or control, as most recently exemplified by belief in the Technological Singularity.

Political stability in the face of climate change, globalization, and the whole-earth context of the Anthropocene demand an epistemological transition in which broad-scale human systems are not perceived as uncontrollable but as transformable from within by creative, reflective, critical thinking coupled with realistic future-oriented planning and action. Currently this is the epistemological world of ExxonMobil, the Central Intelligence Agency, and the military-industrial-congressional-academic complex as self-interest futures operatives. Within the next decades we will see to what degree it can also become the world of local to regional ecological crisis management.

CONCLUSION

As we write this chapter in the year 2012, the Southwest is in the thirteenth year of its current drought. In this context, it is perhaps ironic that in 2007 there emerged a broad consensus by American future-climate-model analysts that the worst droughts of the twentieth century (e.g., Dust Bowl conditions) will, within the time frame of years to decades, become the new climatology of the Southwest. The projected future climate of the Southwest will be worse than any since the medieval period. Combined with continued population growth, and increasing demands for water (DOI 2012), the Great Drought is imminent or already under way.

The American public became aware, through popular media such as *National Geographic* magazine, of these developments before the end of

the first decade of the new millennium. But the realistic implications of the combination of drought and increased consumption needs for a region experiencing some of the nation's fastest population growth have yet to become the focus of a sustained public discourse, even within the region. With few exceptions, it appears to be business as usual in the arid Southwest: corporate interests are still more concerned with quarterly or annual profits (and the illusory perceptions of shareholders) than with the long-term welfare of the local communities that the business world profits from in the Southwest; elected officials still focus their public discourse in terms of time scales of one or two election cycles; policy development is still primarily a short-term political process of compromise if not obfuscation; public agencies engage in long-term planning but focus primarily on developing technics for achieving goals that are mandated by other agents engaged in politically derived short-term goals, and they are penalized if they seriously question those goals.

Our anthropological models reveal the unrealistic structures and processes of propaganda and information ecology that dominate the vernacular epistemologies of individuals and special interest groups in the predominantly business-as-usual stress-response behavior seen both in private and public southwestern discourse. So far, there has been no concerted or systematic incorporation of the new climate information (prehistoric or future) into relevant public cultural models and belief systems. This is a by-product of information stress coupled with self-limiting psychological practices and groupthink. An "oasis in the desert" still dominates public imagery.

Our models of future stress-response capabilities focus on the development of skills in the citizenry and public agents that can promote creative, reflective critical thinking and constructive psychological stress management in the context of socially distributed cognition. Engagement of the public and experts in cooperative debate about the pathways to alternative realistic futures (and policy development) will require a new emphasis on wholism and wisdom, if not a refinement of propaganda, in order to make the difficult transitions to the imminent future take place in the least stability-disruptive ways.

ACKNOWLEDGMENTS

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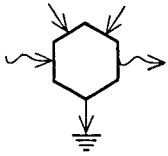
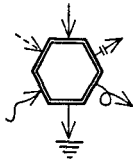
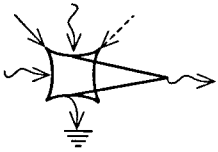
information source: imagination, beliefs, observations, etc.



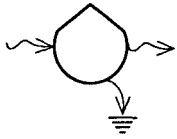
consumer of energy, all manner of matter, and/or information



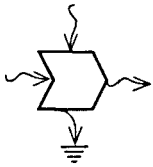
organized group of consumers or an institution



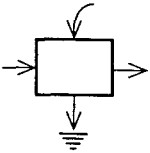
a transformation (including synergism, syncretism, and transmogrification)



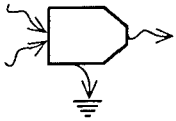
storage (energy, matter, information)



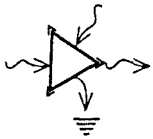
interactive intersection = two paths coupled in outflow



generic sign for subsystem

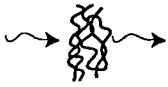


comparison of inputs (resulting in an output)



amplifier

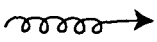
dialectical field: unification of opposites, the action of opposing forces, and inherent contradictions in being and knowing



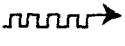
information filter or editor

sink = heat sink, opportunity cost, *information loss*, spontaneous chaos

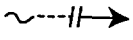
information pathway/flow



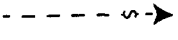
propaganda



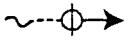
geographic movement of individuals/groups



episodic or periodic output or flow



material or capital pathway/flow



information take-off parameter that acts as a constant

Figure A5.1 Semiotic signs used in our human ecosystems graphic models, including entity icons, function icons, and flow icons (originally from H. T. Odum's energy circuit signs and the University of Georgia Information Ecology Group's modeling iconography). The "information take-off parameter that acts as a constant" is from Forrester 1971. Several of the signs used by the Human Ecosystems Kuchka are not included here (see http://kuchka.org/tool-box). Neither are additional signs in the richer version of the graphic language we use in teaching conceptual graphics to undergraduate students in anthropology (see http://kuchka.org/gallery).

NOTES

1. In the 1920s, Andrew Douglass discovered the Great Drought of the thirteenth century American Southwest while developing the master tree-ring chronology (700–1900 CE) for the Pueblo region (Douglass 1929). Recent work has shown that during the thirteenth century in the Mesa Verde area there was a convergence of climatic conditions unfavorable to agriculture that resulted in abandonment of the Mesa Verde by the end of that century, along with directed migration southeast to the northern Rio Grande in the subregion that now includes Santa Fe, NM (Cordell et al. 2007). The climate stress came in two direct forms: (1) a prolonged period of highly irregular seasonal precipitation conditions that began in the mid thirteenth century (1250–1450 CE) and (2) a Great Drought from ca. 1275–1299 CE (Dean 1996, Van West & Dean 2000). The final decades of the thirteenth century in the Mesa Verde subregion saw increased violence and decline in health status, along with bioenvironmental deterioration and economic uncertainty before the area was abandoned (Cordell et al. 2007; Kohler 2000; Kuckelman et al. 2000).
2. Dendroclimatological reconstructions show that prolonged severe droughts have occurred in the Southwest each century in the past 500 years (Fye et al. 2003). Broader analysis of the Western USA for the past 1,200 year period confirms this pattern and reveals that these droughts were especially widespread in the Western States during the so-called Medieval Warm Period from ca. 900–1300 CE (Cook et al. 2004a). In the future such droughts are likely to be exacerbated by climate change. Some climate models predict "permanent dust bowl conditions" over much of the Southwest within a few decades (Seager et al. 2007). As of September 11, 2012, the U.S. National Drought Monitor had designated the Southwest as "in long-term moderate to extreme drought" (U.S. Drought Monitor n.d.). This condition has changed little since 1999. This thirteen-year drought is forecast to continue for the near-term. The American Southwest may be entering a period of megadrought, experiencing the beginning effects of climate change, or both.
3. Several of the Forrester (1971) signs in the Club of Rome graphic models of systems dynamics also recommend themselves as concepts, but they are easily forgotten as iconography.
4. Rappaport's (1979) cognized and operational models assume steady-state operational ranges. We consider this an unnecessary as well as an unrealistic assumption.
5. Frequently and currently in technopopular literature, the term *resilience* has become operationally meaningless, apparently through the obfuscation required for its popularization (e.g., Walker et al. 2004).
6. The field observations derive from the first author's extensive ethnographic investigation of public beliefs and the policy process in central Arizona. Between 2002 and 2004, Casagrande held a postdoctoral research appointment through Arizona State University's Central Arizona-Phoenix Long-Term Ecological Research program—a program funded by the National Science Foundation to study metropolitan Phoenix as an urban ecosystem. Casagrande also collaborated in the creation of ASU's Decision Center for a Desert City, which integrates water managers, elected officials, and academics into policy design. Since 2002, Casagrande has completed about

75 hours of interviews with 63 people and attended thirteen public meetings, all of which were digitally recorded and transcribed. He completed a content analysis of historical and institutional documents and news media coverage of drought and water policy between 2001 and 2005. He also collaborated in an experiment in which the landscapes of twenty-four home renters were manipulated to determine effects on water use and recreational behavior (Casagrande et al. 2007; Cook et al. 2004b). His participant observation included policy design through the Decision Center for a Desert City as well as engaging with the daily routines of residents in the Phoenix area.

7. The Jakobson (1968) form/functions model of verbal language adopted here can be seen in Chandler (2004, Table 6.1). The Jakobson language functions also characterize graphics such as our etic models. We expect the hypothesized emic models will be communicated in a mix of referential, expressive, conative, metalingual, and poetic forms, including rich graphic engagements of the forms complementing verbal language and text.

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