

# Prospectus for Information Ecology

JOHN R. STEPP<sup>1</sup>

DEPARTMENT OF ANTHROPOLOGY

UNIVERSITY OF GEORGIA

## Opening Statement

Information Ecology (hereafter IE) is a field of inquiry being developed, in part, by members of the Department of Anthropology, University of Georgia (Appendix A). The following prospectus represents a work in progress and is the latest incarnation in a series of revisions since the first IE prospectus was developed in 1990 (Appendix B). The purpose of the prospectus is not to bound what is, admittedly, an eclectic mode of investigation, but rather to outline a field of inquiry that is inherently multidisciplinary and seeks theoretical complementarity both among disparate fields and levels of analysis. The goals are as follows: 1) to suggest some lines of inquiry and thought that might be borrowed from established disciplines and incorporated into IE; 2) to illustrate the breadth and complexity of IE as an approach to human ecology; 3) to provide impetus for establishing consensus as to the domain(s) of IE; 4) to provide an introductory document for those unfamiliar with IE; and finally, 5) to present an outline of contents for a university course of study. This prospectus, like many of the Information Ecology Group's (IEG) projects, was developed in a collaborative atmosphere with input from all participants. After initial discussions on the first hierarchical tier of the outline (Roman numerals I, II, etc.), a healthy debate filled out the remaining structure, which was then subject to further revision and updating.

---

## Contents

Information Ecology Outline	40
Information Ecology Outline with Selected Comments and Citations	42
Acknowledgements	60
Appendix A: Evolution of IE at the University of Georgia	61
Appendix B: 1990 Prospectus for Information Ecology	62
Appendix C: Participants and Selected Bibliography of Works	64
Appendix D: Semiotic Signs and Iconography Used in Graphical Representations	67
References Cited	68

---

<sup>1</sup> This prospectus was developed in collaboration with the Information Ecology Group (IEG) at the University of Georgia and ideas expressed herein are the joint responsibility and contribution of the IEG.

## Information Ecology Outline

### I. Foundational Concepts

#### *A. Definitions and properties of information*

1. definitions of information
2. reduction of uncertainty
3. potential vs. realized information
  - a. unintentional
  - b. intentional
    - i. propaganda
    - ii. restriction of information
4. human cognition in social context
  - a. externalized cognition
  - b. distributed cognition
5. internal vs. external information
6. epistemological filter/field/screen/editor (FFSE)
  - a. hierarchical levels
  - b. active vs. passive
7. information environments
  - a. multiple environments
  - b. input-output environments
8. information flow (communication)
9. information causality

#### *B. General themes*

1. unique properties of human ecosystems
2. expression of complex ideas through graphical representation
3. human ecosystems as information systems
4. scales of increasing social and cultural complexity

### II. Historical Precedents for an Information Ecology

#### *A. Historical overview*

1. the West
  - a. Greek philosophy
  - b. Enlightenment
  - c. Modernity
  - d. Postmodernity
2. non-Western
  - a. Eastern contributions
  - b. 'traditional' societies

#### *B. Contributions and concepts from various disciplines*

1. evolutionary epistemology
2. cognitive science
3. ecosystem ecology
4. general systems theory
  - a. complex systems
  - b. self organization
  - c. emergence

- d. information feedback
      - i. positive
      - ii. negative
    - e. hypercoherence
  - 5. information theory
  - 6. semiotics
  - 7. linguistics
  - 8. noösphere
  - 9. utopias/dystopias and speculative fictions: the big picture
  - 10. political economy
    - a. fetishization of commodities and money
    - b. economic institutions as information systems
  - 11. developmental psychology
  - 12. historical studies
    - a. the *longue durée*
    - b. ethnohistory
- III. Information Biology
  - A. *Ethological considerations of information transmission*
  - B. *Perception and cognition*
    - 1. ethnoecology
    - 2. ethnotaxonomy
  - C. *Anthropological linguistics*
- IV. Information Ecology of Complex Systems
  - A. *Theoretical and general issues*
    - 1. information use, control and power
    - 2. information quality
  - B. *Sociocultural systems*
    - 1. shared representations and consensus
    - 2. belief systems
      - a. regulation of human/earth-systems relations
      - b. ethos and sustainability
    - 3. cultural maintenance of complex knowledge
    - 4. information and political organization
    - 5. evolution of complex societies
- V. Information Ecology in Normal Science Mode
  - A. *Internal coherence of IE paradigm*
  - B. *Quantitative models of information*
  - C. *Potential applications and uses*
    - 1. informing praxis
    - 2. meta-level analyses of the environmental sciences
    - 3. environmental policy and management of global systems
- VI. Information Ecology as Sociocultural Critique
  - A. *Perverse functions*
  - B. *Satire and reflexivity*

## Information Ecology Outline (with selected comments)

The following comments are meant to serve a variety of purposes—to explore and experiment, but especially to provide a partial guide to introductory literature. This literature is viewed as foundational, in part, but more importantly it may serve as a point of departure for this emerging field. In some cases no comments are entered beneath a specific subheading, while others are expanded upon at length. No value judgment is suggested by this disparity, only that some headings are more self-evident than others.

### I. Foundational Concepts

As this entire outline serves as a ‘definition’ of information ecology, it is perhaps unproductive to include a short statement defining information ecology. As a field that takes on so many domains, such a definition will fall short of capturing what IE is. However, it is in the nature of introductory statements to include a broad conceptualization of what is being discussed, with the understanding that what follows will expand and elaborate on the introduction. With this caveat in mind: information ecology is the study of the relationship of environmental information (at least physical, biological, social, and cultural environments) to all that comprises collective and individual processes of knowing and decision making (ideology, values, expectations, beliefs, symbolism).

#### A. *Definitions and properties of information*

##### 1. definitions of information

Among the definitions that are most appropriate here, we cite the following:

From Webster’s Ninth Collegiate Dictionary (Mish 1988): “knowledge obtained from investigation, study or instruction; a signal or character representing data, news or intelligence; something that justifies change in a construct.”

From the Shorter Oxford English Dictionary (Onions 1986): “that of which one is appraised or told (intelligence, news)” [ca. 1450 AD].

##### 2. reduction of uncertainty (see also information theory, II. B. 5.)

Information theory developed originally within the fields of telecommunications and computers (cf. Shannon and Weaver 1949). The early goal was to quantify and model information in an effort to build more efficient communication technologies. Deriving from the notion of entropy, information was defined as the reduction of uncertainty, and systems designers still focus on reducing the uncertainty required to complete computational tasks (i.e., ways to increase information flow). A recent theoretical and mathematical manifestation of this approach uses fuzzy set theory to model reduction of uncertainty (Klir and Folger 1988). Coren (1998) also used a binary measure and argues that information is the definitive variable driving biological, social, and cultural evolution. However, in human contexts it is not always the case that more information reduces uncertainty (see Casagrande, this volume). Hypercoherence in information systems (see II. B. 4.c.) can lead to increased uncertainty, as can prevarication.

**3. potential vs. realized information (Figure 1)**

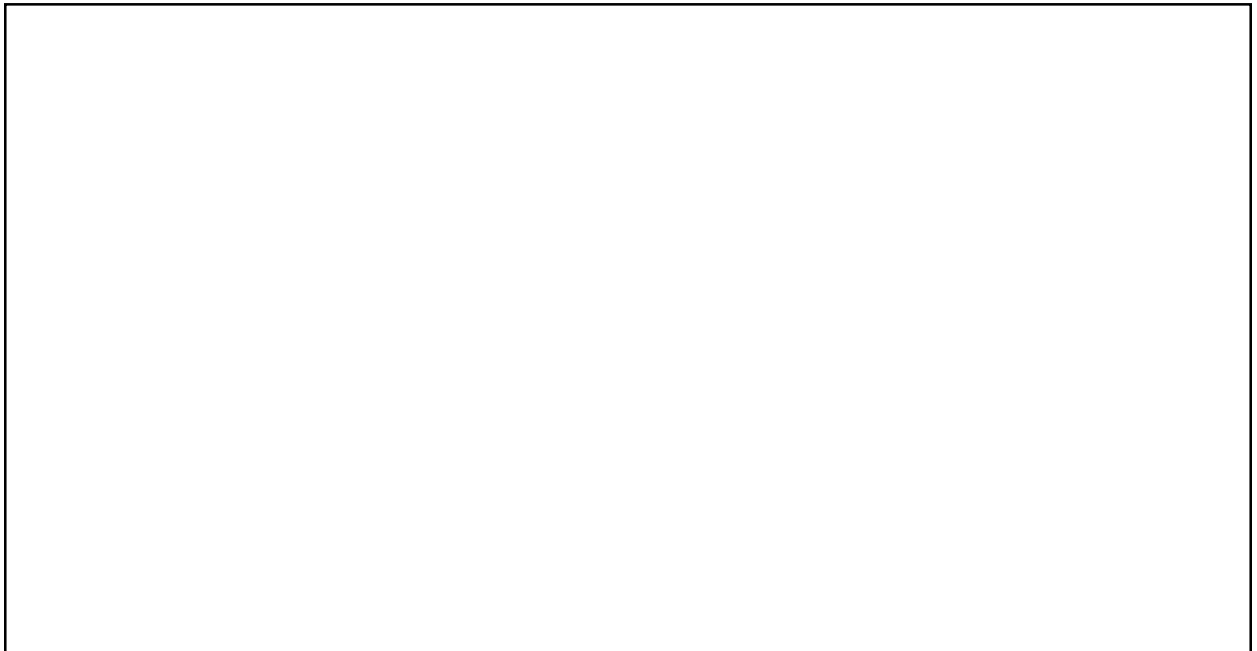
Potential information ( $I_p$ ) is all the information potentially available in a system, whether at the organism level or at broader scales (e.g., a community or ecosystem).  $I_p$  includes all of the potential input and output that comes from the evolutionary sequence of multiple environments (see I. A. 7.)—physical, biological, social, and cultural (see Figure 2).  $I_p$  is the flow stream that is potentially available given the nature of the system in question. For an organism there are biological limitations imposed by the senses and processing limitations imposed by specific cognitive abilities. Realized information ( $I_r$ ) is the information that is put to use, whether consciously or unconsciously.

**a. unintentional**

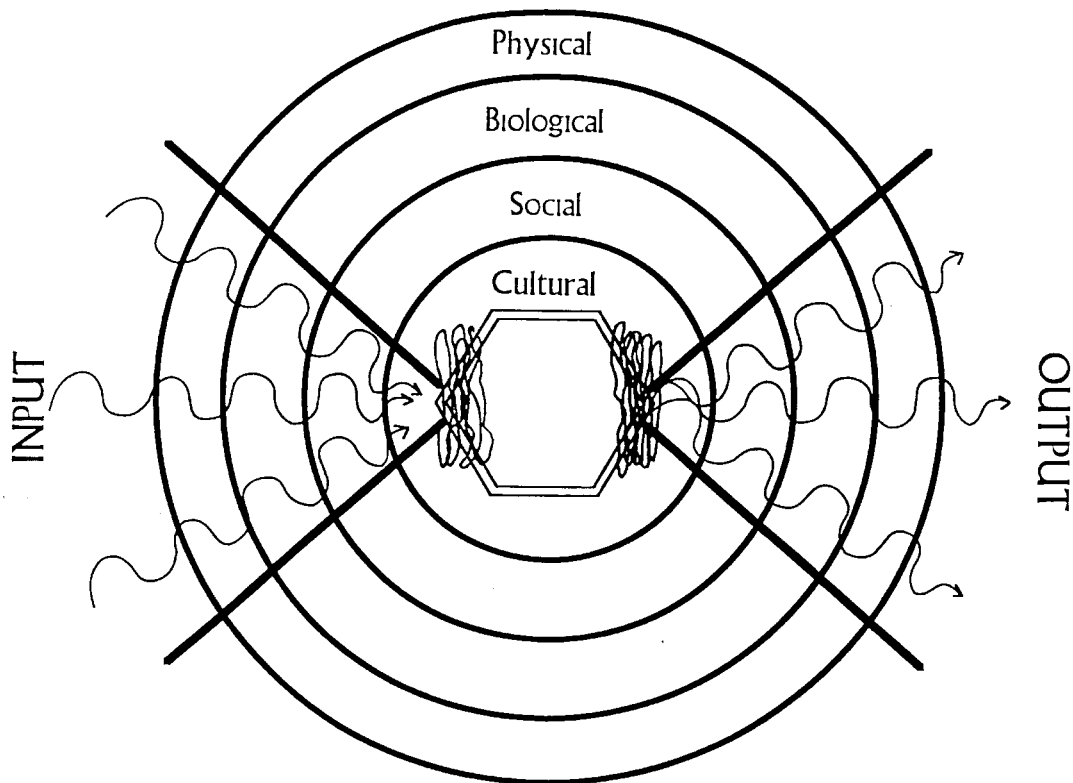
Information from physical (ontic) inputs, from nonliving objects and sometimes, living subjects.

**b. intentional****i. propaganda**

Information sent or spread for the purpose of helping or injuring an individual, a cause or an institution.

**ii. restriction of information****a. secrecy****b. misinformation****c. prevarication**

**FIGURE 1: TAXONOMIC RELATION OF TYPES OF INFORMATION.**



**FIGURE 2: A PARTIAL THEORY OF MULTIPLE ENVIRONMENTS.**

The input-output structure and concept of filters follow Patten (1982; pers. comm.). The hierarchy of spheres is an evolutionary arrangement of the environments; other arrangements are possible. This model appeared as the cover of Volume 1 of the *Georgia Journal of Ecological Anthropology* in 1997.

#### **4. human cognition in social context**

Recent approaches in psychology, linguistics, cognitive science and anthropology have begun to conceptualize human cognition as socially interactive. Humans, as inherently social beings, necessarily possess minds constructed of more than just internal 'representations.' In fact they must share a great deal of information (see cultural consensus, IV. B. 1.). Given the richness of human environments (physical, biological, social, cultural) as well as the complexity of interaction that occurs between people and other living organisms, built objects, artifacts, and symbolic communicative systems, this 'contextual' view of cognition is helpful when considering the flow of information in human systems (Hutchins 1995; Johnson 1987; Zhang and Norman 1994; Scaife and Rogers 1996; Gumperz and Levinson 1991).

##### **a. externalized cognition**

Externalized cognition is the exterior/material manifestation of knowledge in communicative signs. Communicative acts may be unintentional, although they are usually thought of as conscious, purposeful acts. For an interesting overview of topics see Gumperz and Levinson (1991); for applications to pre-history see Leroi-Gourhan (1993). Unintentional communicative signs include the structures of tools and other built objects (Keller and Dixon-Keller 1996). Externalized cognition in its most common form in humans is expressed through speech (cf. Gumperz and Levinson 1991). Individuals can also externalize thoughts and concepts by constructing objects, participating in ritualized acts, drawing, writing, etc. As members of socio-cultural systems, humans utilize a variety of means for sharing information, including lying. This is the domain of interpersonal and superpersonal semiotic relations. Culture is the set of symbolically mediated processes (transgenerationally conventionalized) that move these relations beyond the realm of merely elaborated primate social behavior, and externalized cognition is a key component. Experience has shown that humans can process information more quickly and efficiently if it is externalized in representations, objects, art, etc. (cf. Zhang and Norman 1994).

##### **b. distributed cognition**

Cognitive processing, as indicated above, cannot be fully located within the individual. Hence, information is distributed between internal cognitive processes and external artifacts, representations, and social relations (Zhang and Norman 1994; Hutchins 1995). Concepts of distributed cognition derive from the observation that no one person holds all of the information necessary for reproduction of daily life at the cultural level. Rather, the information is distributed among individuals and/or institutions and may be stored external to all the participating individuals. Distributed cognition is essential for complex social organization and is realized in the development of various forms of writing (see IV. B. 5.).

### 5. internal vs. external information

Internal and external information converge in complex ways to shape human cognition and behavior. See Hutchins (1995) for a critique of the internal-external distinction as it is drawn in mainstream cognitive science.

### 6. epistemological filter/field/screen/editor (FFSE)

Taking a broad biological perspective, all organisms can be said to have an epistemology (Patten and Jørgensen 1995; Patten in press; see also section II. B. 1.). Information inputs and outputs of this epistemology are modified by a phenomena that IEG terms the filter/field/screen/editor (Figure 2). This complex engages information in a continuum from passive to active.

#### a. hierarchical levels

The FFSE works at different levels ranging from basic input to higher degrees of abstraction. With regard to individual human epistemological potential, inputs can be 'upgraded' as depicted in Figure 3 through the levels of raw data to meta levels of reflexivity, followed by marking the intended level of output. This output then allows for the possibility of receiving input that has been marked for a particular epistemological level (cf. Casagrande, this volume). Screening and editing (not depicted in Figure 3) occur at the various levels of both input and output. Current IE theory identifies seven partially nested hierarchical levels: 0) external input (received); 1) raw data; 2) refined data; 3) generative/creative system (imagination); 4) interactive/integrative level (integration of unique and shared knowledge); 5) meta-information; and 6) meta-meta information (Figure 3).

#### b. active vs. passive

The FFSE (Figure 2) also works in a semi-passive sense to simply restrict the amount of information coming into a system. Above a certain threshold, increased input results in stress, while below some minimum level, permanent pathologies presumably develop.

### 7. information environments (Figure 2)

#### a. multiple environments

Information flows within multiple environments are simplified as physical, biological, social, and cultural, and can be arranged in an evolutionary sequence of concentric circles (Figure 2). A physical environment exists prior to biological forms, some of which develop sociality and culture.

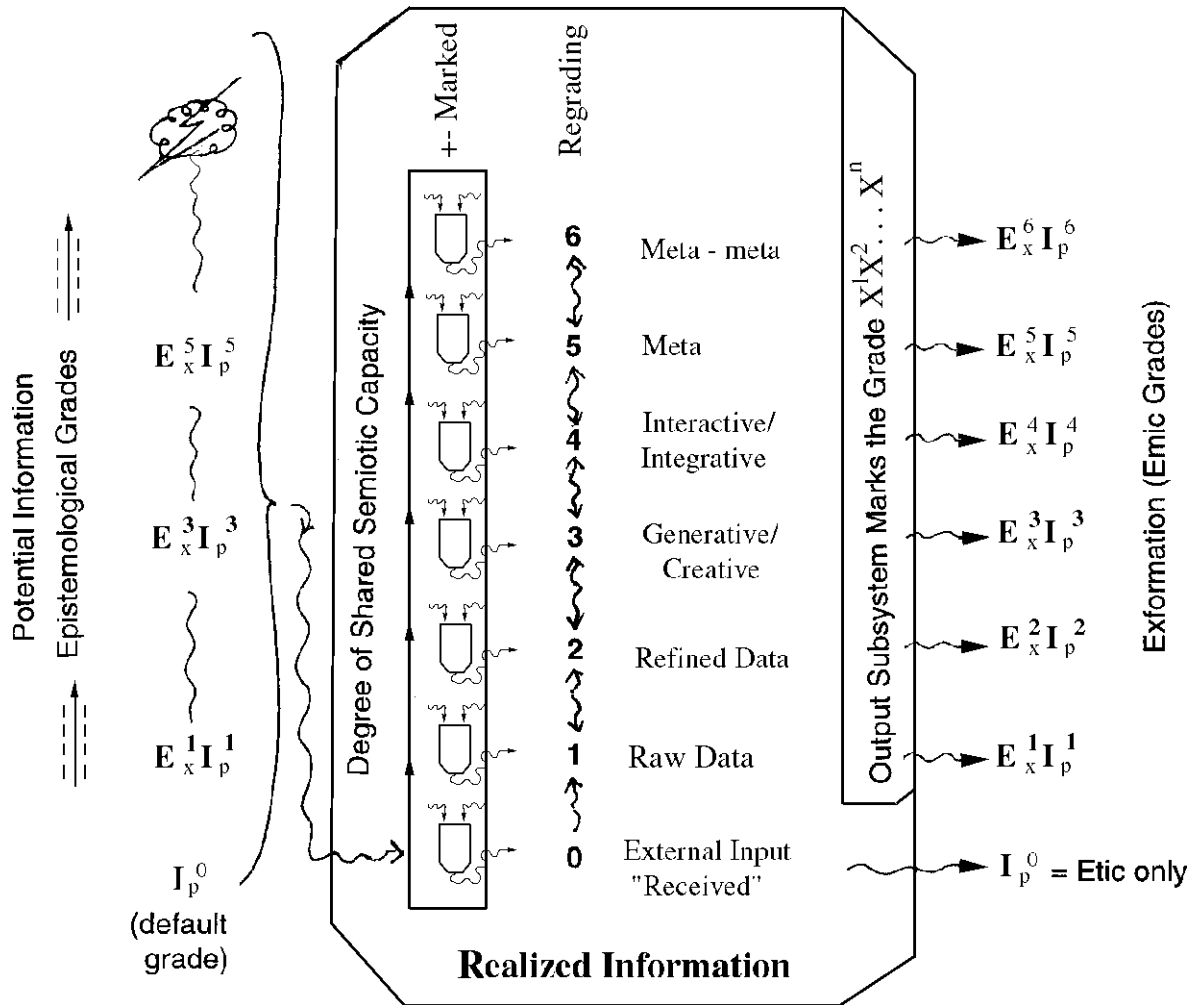
#### b. input-output environments

In systems theory, with a given subsystem as a locus, both input and output environments exist that are unique for that particular subsystem (Patten, in press). Information environments follow the same principle.

### 8. information flow

This refers to  $I_p$  (or  $E_x^n I_p^n$ ) in motion (Figure 3).





**FIGURE 3: HUMAN INFORMATION/EXFORMATION EPISTEMOLOGICAL UPGRADING—PARTIALLY NESTED SCALAR HIERARCHICAL COMPONENTS, LATERAL WEB NOT REPRESENTED.**

A partially nested scalar hierarchy is unlike a control hierarchy in that it allows for information to skip levels as it undergoes processing/transformation. Klir and Folger's (1988) Figure 5.7 was the starting point for this model.  $E_x^n I_p^n$  denotes outputted (potential) information, where the epistemological grade is marked (exformation).

## 9. informational causality

Information can act as a forcing function, determining both the structure and function of the ecosystem (for an example related to linguistics see Whorf 1956; Salminen and Hiltunen 1995; for examples related to World-Systems theory see Willard 1993; Chase-Dunn and Hall 1995).

### *B. General themes*

Our approach to developing an information ecology is holistic, systems and process-oriented, makes the traditional anthropological emic/etic distinction, and places emphasis on case studies.

#### 1. unique properties of human ecosystems

The principle of emergence suggests that human ecosystems have properties that set them apart from non-human ecosystems. This seems especially true with regard to humans' extensive use and reliance upon information. But what is particularly true of humans is the predominant role played by imagination. Human ecosystems have symbolic belief systems, such as religion, that enable them to develop closed semantic loops/domains and are effectively isolated from the 'realities' of the bio-physical environment. Epistemological paradoxes are a related emergent property, and complex dialectical fields are especially characteristic of nation-state ecosystems based upon mega-institutions such as law, formal religion and the military (cf. Jones, this volume).

#### 2. expression of complex ideas through graphical representation (Table 1 and Appendix D)

All my life I have needed to visualize things, even abstractions. Without a visualization in my head I'm lost, and geometry is very visual.

–Physicist Rene Lau on why she finds geometry so compelling

Models, or graphical representations, facilitate comprehension of complex systems by emphasizing essential information, and are evaluated in terms of their predictive ability with regards to other phenomena in the system (Moran 1990; Lave and March 1975:19-20). Graphical conceptualizations in IE are, in part, models, but generally are used in an heuristic manner and not in a formalized predictive way. The conventions used by the IEG (Appendix D) originally took Odum's conventions (1983) as a point of departure, but the graphical iconography was soon extended well beyond the framework of energetics. See Forrester (1961, 1968) for another set of graphical conventions that include information flows, and Dow (1975) for an early attempt at building on Odum's conventions. Graphical representations are both analytic and synthetic, express variety and complexity, provide information that can be remembered and utilized more quickly and easily than text-based information, and ultimately demonstrate emergent properties (cf. Winn 1993; Zhang and Norman 1994). Many of the greatest minds in human history have been known to be visual thinkers; that is, they may have done their best thinking not by writing things down, but by attempting to capture mental visualizations in the form of graphic representations. A vignette that captures this phenomenon is the excited scientist-inventor who scribbles down plans or designs on a napkin or whatever is available because the need to externalize information can not be denied. If asked to explain the drawing through text, the task may be next to impossible for the creator. Examples include Leonardo DaVinci, who was a prolific inventor and sketcher of machines and architecture, and Albert Einstein, who stated that he thought in graphical terms almost exclusively.

**TABLE 1: SOME PRINCIPLES OF CONCEPTION AND REPRESENTATION IN GRAPHICS<sup>2</sup>.**

<sup>2</sup>Sources: Brainerd and Reyna (1990); Hutchins (1995); Johnson (1987); Lock and Peters (1995); Scaife and Rogers (1996); Winn (1993); Zarger (1998); Zhang and Norman (1994).

### 3. human ecosystems as information systems

Information is one of the three major components of an ecosystem; matter and energy being the other two (Margalef 1958, 1968). Beginning in the 1970s a series of programmatic statements were written by ecological anthropologists citing the need to include the role of information in studying human ecosystems (cf. Adams 1973; Alland 1975; Bennett 1976; Butzer 1990; Flannery 1972; Moran 1982).

With regard to humans,

There is a reason why past 'ecological approaches' have failed, and it lies not in ecology but in the self-styled 'cultural ecologists.' Modern ecologists, who not only analyze but even simulate dynamic ecosystems, take into consideration that all populations exchange matter, energy and information with their environments. Up until now, it has mainly been the humanists who have studied the informational aspects of complex societies—art, religion, ritual, writing systems, and so on. The 'ecologists' have largely contented themselves with studying exchanges of matter and energy—the 'techno-environmental' factors as Harris calls them. To read what the 'ecologists' write, one would often think that civilized peoples only ate, excreted, and reproduced; to read what the humanists write, one would think civilizations were above all three, and devoted all their energy to the arts. ...Humanists must cease thinking that ecology 'dehumanizes' history, and ecologists must cease to regard art, religion, and ideology as mere 'epiphenomena' without causal significance. *In an ecosystem approach to the analysis of human societies, everything which transmits information is within the province of ecology.* (Flannery 1972:400; emphasis added)

Another example:

To the powerful theories of chemistry and physics must be added a late arrival: the theory of information. Nature must be interpreted as matter, energy, and information. (Campbell 1982:16)

### 4. scales of increasing social and cultural complexity

Researchers in many disciplines from the 1970s onwards began paying greater attention to spatial and temporal scale in their study of social phenomena, recognizing that at different scales new factors take on significance and thus require different models and methods of analysis (for examples in ecology: Allen and Starr 1982; Müller 1992; in history: Braudel 1972; in geography: Meentemeyer and Box 1987; in sociology: Giddens 1979; in anthropology: Smith 1984; Blanton et al. 1981). One attempt at capturing the 'big picture' comes from World-Systems theory. This corpus explicitly recognizes the need to study sociocultural phenomena at broader scales. The World-System is said to provide the fundamental context within which questions about patterns and processes of social change must be addressed. Chase-Dunn and Hall (1993) initially identified three levels of interaction in World-Systems: bulk goods, military/political interaction, and luxury goods, but recently added a fourth level which they refer to as the information level (Chase-Dunn and Hall 1995).

## II. Historical Precedents for an Information Ecology

Information has been seen as a crucial phenomena in understanding the human experience ever since mental reflexivity became possible with language. The historical notes below are expanded upon in Stepp (1997).

### A. *Historical overview*

#### 1. the West

##### a. Greek philosophy

True opinions are a fine thing and do all sorts of good so long as they stay in their place, but they will not stay long. They run away from a man's mind; so they are not worth much until you tether them down by working out the reason. . . once they are tied down, they become knowledge.

—Socrates

##### b. Enlightenment

When the doors of perception are cleansed the world will appear as it is: infinite.

—William Blake

##### c. Modernity

Modernity is defined as the time period roughly from the first Industrial Revolution (ca. 1750-1850 AD) until 1970.

Upon this gifted age, in its dark hour,  
Rains from the sky a meteoric shower  
Of facts... They lie unquestioned. Uncombined.  
Wisdom enough to leech us of our ill  
Is daily spun, but there exists no loom  
To weave it into fabric . . .

—Edna St. Vincent Millay

The mental characteristics of the system are immanent, not in some part, but in the system as a whole. (Bateson 1972:316)

How is a leaf on a tree similar to a noun in a sentence? Both grammar and biological structure are products of communicational and organizational processes. (Bateson 1972:154)

##### d. Postmodernity

We have transformed information into a form of garbage.

—Neil Postman

The postmodern era begins ca. 1970 and continues until sometime into the third millennium A.D. (e.g., Harvey 1990). It is characterized by the dominance of solipsism and business culture in the West, especially in the U.S. (Frank and Weiland 1997). Additionally, there is a paradox of increasingly large quantities of available information, but a reduction of information quality, except notably, in military processes (see Jones, this volume) and business macroinstitutions.

**2. non-Western****a. Eastern contributions**

This could be a potentially rich area of contribution to IE, but it is almost entirely unexplored.

**b. 'traditional' societies**

Remember what you have seen, because everything forgotten returns to the circling wind.

–Navajo Wind Chant

Pre-literate societies develop an information ecology carried largely by oral traditions and varying degrees of graphical representations (cf. Tedlock 1993)–another rich area for potential contributions to IE.

**B. Contributions and concepts from various disciplines****1. evolutionary epistemology**

For general overviews of the field see Callebaut and Pinxten (1987); Wuketits (1990); Radnitzky and Bartley (1987).

Systems ecologist Bernard Patten (in press) attributes unique epistemologies to all biota; so why not apply IE to the most primitive of organisms? The main question posed by IE is: Given the uniqueness of each input, of each individual organism, and each set of coordinates defining a locus in the environment(s), how does consensus about the nature of 'reality' evolve? See Allen and Hoekstra (1992: 169-174) for a discussion of organismic input/output environments related to their 'umwelt' or self-worlds, and Gibson's (1979) work dealing with the concept of affordances.

**2. cognitive science**

Much like IE, cognitive science is a loose amalgam of disciplines united through a shared view of relevant research questions and methodologies; only some of which overlap with IE. For example: cross-cultural patterns in human cognition (Berlin 1992; Berlin and Kay 1969), fuzzy-trace theory (Brainerd and Reyna 1990) and externalized cognition (cf. Gumperz and Levinson 1991). For some history and a criticism of traditional cognitive science see Hutchins (1995).

**3. ecosystem ecology**

For overviews of the influence of systems ecology on anthropology see Moran (1990) and Blount (in press). Golley (1993) and Hagen (1992) deal with the history of the ecosystem concept in ecology. The main limitation of this approach for IE has been its failure to explicate the information flows and subsystems that dominate the human condition.

**4. general systems theory**

A few of the most relevant and salient principles of general systems theory are listed below. General systems theory was born prematurely and with an excessive amount of hubris, both of which contributed to its decline. What can IE learn and borrow from this? For an accessible overview of general systems theory during its formative years

see von Bertalanffy (1950). For more updated overviews see Weinberg (1973), Rapoport (1986), Kramer and DeSmit (1977), Bowler (1981), and Laszlo (1972). The main contribution of systems theory, according to Klir (1972), is that it gave us a new way of thinking about the world— a world in which holism and complexity can be described and modeled. Isomorphism of systems concepts has also encouraged its use in many disciplines. More recently, systems theory has been largely associated with the fields of artificial intelligence, engineering, ecology, management, and computer modeling. For overviews of systems theory in anthropology see Plog (1975) and Rodin et al. (1978).

#### **a. complex systems**

Complex systems, particularly living systems, exhibit the following characteristics: they have spontaneous self-organization; they are open (both process and form can change with time); they are adaptive and maladaptive (due to active organization and incomplete reorganization); they exhibit dynamism (i.e., unpredictability); and exist at the edge of chaos (e.g., the balance between lock-in and turbulence) (Waldrop 1992; Casti 1993).

#### **b. self-organization**

This is the spontaneous creation of macroscopic order from microscopic disorder (Kay 1984).

#### **c. emergence**

Phenomena at one hierarchical level can not be predicted from phenomena at another level, and exhibit properties that are more than the sum of their components.

#### **d. information feedback**

Cybernetics had developed largely out of the wartime problem of designing an automatic control system for anti-aircraft guns. (Hagen 1992:71)

##### **i. positive**

##### **ii. negative**

Notions of positive and negative information feedback allowed for the conceptualization of processual links between humans and their environment (Rappaport 1984 [1968]).

#### **e. hypercoherence**

Increased pathways and interactions lead to instability because localized pathologies can extend throughout the entire system (Rappaport 1977, 1984 [1968]).

### **5. information theory**

With its unlikely origins in the laboratories of the Bell telephone company, information theory (Shannon and Weaver 1949) has gone on to become (among other things) a measure of diversity in ecosystems, a use that has been widely debated and criticized (Margalef 1958, 1968; Pielou 1966). Shannon's index of information can also be

applied to ethnographic data to measure informant consensus. IE (Casagrande, this volume) has raised several of its own concerns about the applicability of Information Theory such as the reduction of uncertainty as the sole metric of information, the limits of using binary logic, its failure to model semantics and pragmatics and its limits in conceptualizing shared and externalized cognition.

### 6. semiotics

Semiotics, or the 'science of signs,' is an extremely broad discipline, concerned with the study of communication and the externalizations to which we ascribe meaning and significance (art, media, advertisements, gestures, language, architecture). Peirce's (1931-1958) three modes of signs are: symbolic—a sign which is arbitrary or conventional (such as  $x$  in the equation  $x=yc^2$ ); iconic—a sign that recalls or resembles the signified (portrait, x-ray); and indexical—a sign connected either causally or existentially to the signified (smoke signifies fire, thermometer indicates temperature). Semiotics provides insights into the categories of human communication and the human methods for sharing, depicting, and storing information. (For a general overview of historical and current approaches in semiotics, see Blonsky 1985; Cobley and Jansz 1997; Sebeok et al. 1972; Nöth 1990. For a more thorough treatment see Eco 1977, 1984.)

### 7. linguistics

See Lock and Peters (1996) for a number of points at which linguistics and IE are interrelated. Evolutionary and ontogenetic approaches towards linguistics (Rolfe 1996; Holland and Valsiner 1988; Chomsky 1986) have yielded insights into the structure of informational environments. They especially illustrate the limits of concepts of internal cognition.

### 8. noösphere (Figure 4)

This concept has been understood in various ways (see Birx 1972; Naveh and Lieberman 1994; Teilhard de Chardin 1966, 1975; Vernadsky 1945; Barrett 1985). But all approaches have at least this much in common: human ecosystems evolve to impact the entire biosphere and through information begin to develop a kind of global consciousness.

### 9. utopias/dystopias and speculative fictions: the big picture

The purpose of a thought experiment, as the term was used by Schrödinger and other physicists, is not to predict the future—indeed Schrödinger's most famous thought experiment goes to show that the 'future,' on the quantum level, cannot be predicted—but to describe reality, the present world. (Le Guin 1976:ii)

Despite its association with pulp paperbacks and the commodification of the military-industrial complex, speculative, or 'science' fiction (at least the exemplary works) can contribute to IE. At its best, speculative fiction is a portrait that changes particular aspects of the human equation and plays out the plausible implications. It is a humanistic method for broad scale theory, and, in that sense, it is descriptive anthropology. Some examples: Bradbury (1953) on the implications of censorship of text, Huxley (1956) on freedom and desire; Heinlein (1961) on xenophobia and religion; Le Guin



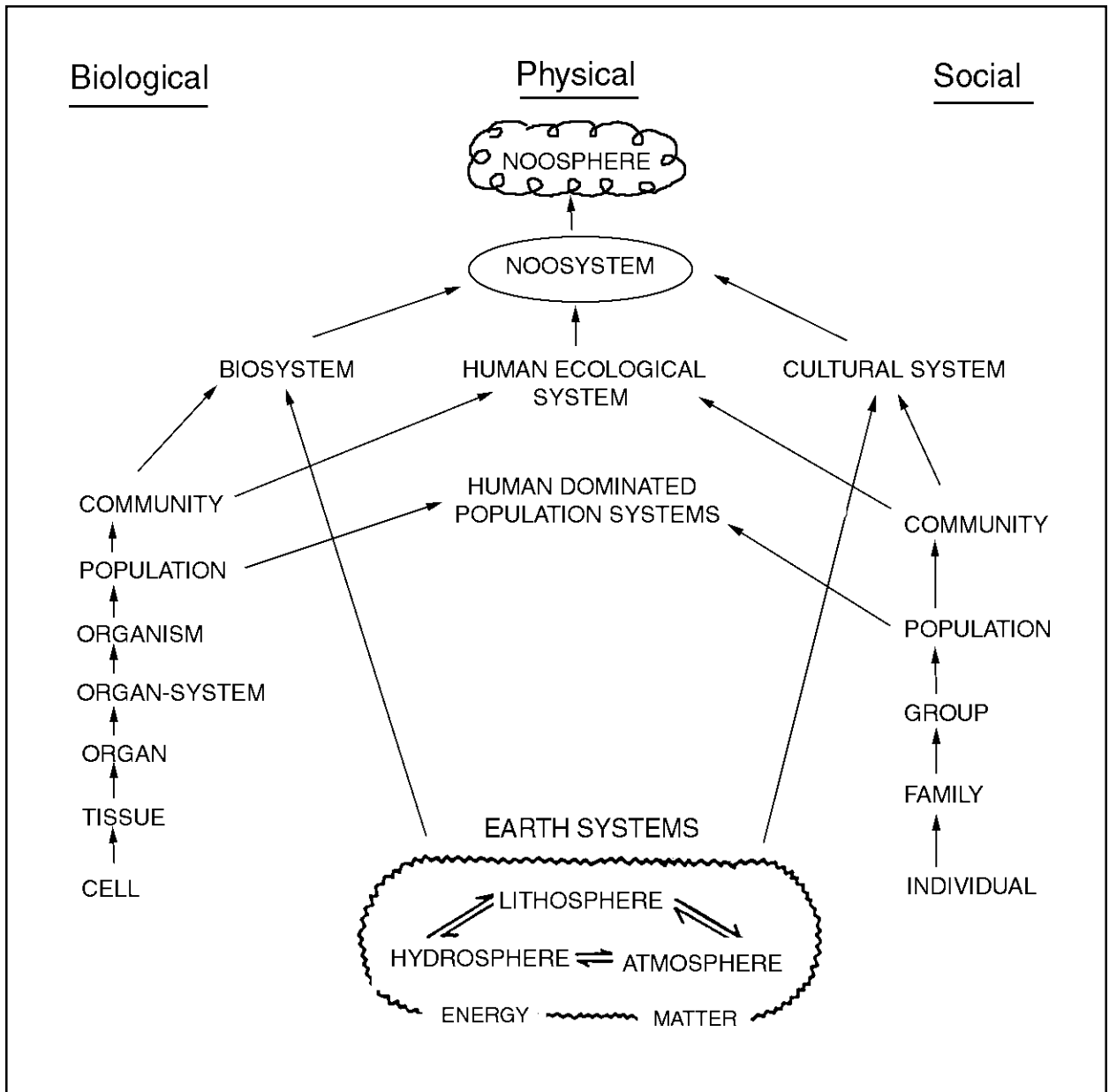


FIGURE 4: NOÖSPHERE (MODIFIED AFTER BARRETT 1985).

(1976) on the implications of simple changes in human reproductive physiology. These works are heuristic in the sense that they challenge the reader to consider the big picture and the implications of present phenomena when extended into the future. For an example of envisioning the future from a developmental perspective see Norgaard (1994). Utopias can play a similar role, but they give voice to the idealistic side of human aspirations. Naveh (1998) is a recent example of the utopian perspective in restoration ecology that includes also the concept of the noösphere.

## 10. political economy

### a. fetishization of commodities and money

The concept traces back at least to Marx (1967 [1867]). An historical example is provided by MacKay (1980[1841]) who looks at the commercial fetishization of tulips in Holland during the 16<sup>th</sup> century. Money plays a unique role in human ecosystems as the universal sign/token of equivalent value. It is re-fetishized in ways that increase the variety of its impacts on the noösphere.

### b. economic institutions as information systems

Economic information seems to have replaced religion as the hyperconsciousness of the noösphere.

## 11. developmental psychology

Vygotsky's concept of 'mediating device' provides an ontogenetic basis for culture and the power of symbols (Holland and Valsiner 1988). Classification of biological kinds also depends on ontogenetic experience (Dougherty 1978; Stross 1973; Hunn 1989), and this can influence human-environmental relations. See also Roberts (1997) and Gibson (1979).

## 12. historical studies

### a. the *longue durée*

Collective cultural features that accumulate and persist over time are both limiting and facilitating factors that act as a framework within which changes take shape. The *Annales School*, exemplified by Braudel (1980), has pursued the development of this approach in history.

### b. ethnohistory

A good example of an ethnohistorical approach influenced by the *Annales School* is Etheridge (1998).

## III. Information Biology

### A. *Ethological considerations of information transmission*

Among organisms, competition and cooperation can be based on symbolic communication. Ethological examples range from bees and parrots sharing knowledge of resource locations (von Frisch 1954; Chapman et al. 1989), to tacit communication of political alliances among non-human primates (Byrne 1995). Communication that transcends direct physical confrontation, and thus lays the foundation for symbolic communication, is exemplified by the 'epideictic display' (Wynne-Edwards 1967), in which population systems are regulated by synchronized behaviors of little immediate benefit to individual participants.

***B. Perception and cognition***

A domain that has been heavily explored within ecological anthropology and that has led to generalizable principles: among them that salient morphological features in the plant and animal world lead to similar taxonomic divisions cross-culturally (Berlin 1992) that are presumably constrained by 'hard-wired' cognitive processes (Miller 1956) and an external biological reality (Berlin 1992:8). Other examples of perception and cognition related to Western culture are Atran (1990) and Schiebinger (1993).

**1. ethnoecology**

Information processing models in ethnoecology reveal the "repositories of information about the environment essential for ecologically effective choices of action" (Hunn 1989:131).

**2. ethnotaxonomy**

Classificatory schemes can reveal changes in human systems when combined with etic data (Conklin 1967).

***C. Anthropological linguistics***

The Sapir-Whorf hypothesis is based on two principles: 1) linguistic determinism—the way a person thinks is determined by the language(s) they speak, and 2) linguistic relativity—differences among languages are reflected in differences in the worldviews of their speakers (Whorf 1956). While contemporary evidence suggests that this is only partially true (Gumperz and Levinson 1991), it continues to provide stimulus for debate on the nature of distributed cognition.

**IV. Information Ecology of Complex Systems*****A. Theoretical and general issues*****1. information use, control, and power**

Control of information can form the basis for control of power (Gramsci 1971; Foucault 1980; Wolf 1990). Economic and ecological-evolutionary explanations of reciprocity and altruism often consider arrangements of information sharing (Agrawal 1994). Bourdieu's elaboration of the concept of 'symbolic capital' provides an apt example of how differential access to non-material forms of capital privileges some members of society, stratifying the control over social reproduction (Bourdieu 1977). For Bourdieu, control of 'symbolic capital' is a major component of political power and requires a theoretical understanding of knowledge: "the theory of knowledge is a dimension of political theory because the specifically symbolic power to impose the principle of the construction of reality— in particular, social reality— is a major dimension of political power" (1977:165).

**2. information quality**

Social interaction depends on the evolutionary development of cognitive mechanisms for guessing what beliefs other individuals hold (Machiavellian intelligence hypothesis), and tactical deception implies the ability to hold false beliefs (Dunbar 1998).

***B. Sociocultural systems***

This has been the subject of intensive ethnographic investigation by anthropologists. IE seeks to connect this area to the broader systemic context, by promoting a human ecology that considers the macro institutions of the nation state and modern world system, as well as the finer scale microinstitutions of customary practice.

**1. shared representations and consensus**

Cultural constraints on human ecology have been theorized to depend on consensus (Romney et al. 1986). When does consensus matter?

**2. belief systems****a. regulation of human/earth systems relations**

Rappaport's predatory model of the Maring system (1984 [1968]) is perhaps the best and most well-known investigation from this point of view.

**b. ethos and sustainability**

How would a model like Rappaport's Maring model configure the ideology of nation-states and capitalist/earth-systems relations?

**3. cultural maintenance of complex knowledge**

Ethnobiological systems of classification persist through generations and are a human universal. How are these maintained and systematized, and how do they evolve? 'Cultural transmission' involves specialized knowledge, skill, and techniques articulated in both macro and microinstitutions. 'Invention of tradition' (Hobsbawm and Ranger 1983) involves creating and recreating connections/ascendancy to an imagined, real or partly real past.

**4. information and political organization**

The nation state as an enduring informational system: see Jones (1998) for a treatment that extends the boundaries of 'political anthropology' by evaluating the crucial nature of informational components in the state. The viability of the state, in terms of control over information flow, has been examined by Cohen (1993).

**5. evolution of complex societies**

With the development of nation states, information systems are driven primarily by military institutions, secondly by commerce, and thirdly (more recently) by capitalist institutions and transnational corporations. It is the development of 'objective' discourse that enables a frame of dialogue suitable for externalized cognition of the level required for the development/maintenance of the state (Rolfe 1996).

**V. Information Ecology in Normal Science Mode**

In what ways can this theoretical model be tested and applied in the 'real world?' As a new and only partially developed endeavor, IE lacks ethnographic studies developed within its paradigm. However, transitional examples can be seen in Rappaport (1984 [1968]), where information regulates energy flow, and Leaf (1972) who puts information into a human ecosystem context.

***A. Internal coherence of IE paradigm***

As previously stated, IE takes the view that information is one of three main components in human ecosystems. In many examples throughout this prospectus, information takes on a primary role and regulates matter and energy flows. Oftentimes, information is the variable that humans attempt to maximize over both energy and matter.

***B. Quantitative models of information***

Information Theory (see II. B. 5.) provides the most well known foundation for a quantitative study of information. Can IE build on this? See Vayda (1983) for an argument on why precise metrical measurement is not always a desirable goal in developing explanatory models for processes in human ecosystems.

***C. Potential applications and uses***

The domain of applied information ecology; possibly the 'small picture.' The IE group is involved in (among other things) an examination of the world economic situation, an analysis of the Indonesia crisis, and the development of possible global outcome models.

**1. informing praxis**

Differential access to information can be a positive feedback that increases social differentiation (Nazarea-Sandoval 1995).

**2. meta-level analyses of the environmental sciences**

Vayda's (1983) progressive contextualization is useful as a method for understanding increasingly larger and more complex environments in problem-oriented inquiries.

**3. environmental policy and management of global systems**

IE's holistic approach can inform projects such as inclusion of humans in natural areas management, environmental policy, and addressing global warming.

**VI. IE as Socio-Cultural Critique**

If, to quote Eric Wolf (1964), "anthropology is the most scientific of the humanities and the most humanist of the sciences," then IE shares a similar dualism. The humanistic side of IE lies in its application to socio-cultural critique.

***A. Concept of perverse functions***

Hallpike's (1988) concept of the survival of the mediocre becomes relevant here. How does the information ecology of human systems contribute to the survival of the mediocre and perverse function (as both an emic and etic concept)? Rappaport's later work on maladaptation (1977) shifted away from hyperfunctionalism to dysfunctionism—an implicit recognition of perverse functioning in human ecosystems. Also, see Puleston's (1979) work in which he explains the Maya collapse, in part, as due to what he called 'epistemological pathologies.' Change often comes in the form of transmogrification, which results in features that are absurd, unstable and deleterious, and may lead to their own demise (Etheridge 1998).

***B. Satire and reflexivity***

Herein lies the realm of contemporary critique, for example, in the tradition of Twain and Mencken whose salvos are continued by Thomas Frank and company in the journal, *The Baffler*. Frank and Weiland (1997) is a compendium of journal articles over the last ten years. By identifying the perversities and inequities present in human ecosystems, IE can contribute to this tradition of exposing the 'naked emperor.' The graphical tradition of satire through political cartoons is also incorporated into IE and provides another expression of reflexivity (see Last Bite, this volume and Zarger 1998 for a review).

---

**Acknowledgements**

An intellectual pursuit of this sort is necessarily transgenerational and involves multiple collaborators. Substantial contributions and editorial assistance came from the following participants in the Information Ecology Group: David Casagrande, Eric Jones, Suzanne Joseph, George Luber, Felice Wyndham, and Rebecca Zarger. Most important are the contributions from Charles Peters, who developed the initial framework for information ecology in 1990 and provided mentoring and creative insights that guided this prospectus to its present form. Special thanks to Greg Guest who provided comments and suggestions for improvement.

**Appendix A: The Evolution of Information Ecology at the University of Georgia****A Brief History**

In 1989, the Department of Anthropology at the University of Georgia underwent a transformation into a program focused almost exclusively on ecological/environmental anthropology. During this time numerous discussions and meetings were held amongst faculty and with outside consultants from the field of ecological anthropology, as to what form and direction this program might take. A series of graduate core classes were envisioned as comprising the foundation of the program, and much thought went into what the content of these courses might be. A proposal was made for a set of three core courses: one covering human population ecology; a second on the evolution of human ecosystems; and a third to focus on information ecology (IE). While these ideas for core classes were generally well received (some of the external consultants especially liked the idea of IE; one prominent ecological anthropologist described it as “taking the intellectual high ground”), it was ultimately decided that IE would not become a core class for a variety of reasons; some of them valid intellectual concerns, while others arose from more mundane institutional concerns and fears of engaging in a synthetic, creative pursuit while the program was still in its infancy. The core class “Evolution of Human Ecosystems,” which was accepted by the faculty, initially drew upon some of the original IE prospectus (Appendix B), but emphasized the temporal scale and the stasis and/or change orientation of evolving human ecosystems. Charles Peters taught this course for the first three years and it became a springboard for the development of the IE working group. This course introduced a variety of concepts that later became core features of the IE approach—among them: graphical representations of informational processes in human ecosystems, an emphasis on creativity and lateral thinking; collaborative intellectual synergy; and a desire to ask ‘big questions’—questions that are nomothetic, generalizing and that cross human spatial and temporal boundaries. IE has been an attempt to develop a framework that can encompass the entire domain of what is termed ecological/environmental anthropology— a framework that attempts to explain human behaviors as emergent phenomena in large part due to symbolic culture and the volume of information characteristic of human ecosystems. Such a potential explanatory paradigm does not seek to dismiss the role of matter and energy flows in influencing or determining the structure and function of human ecosystems, but rather to encompass them within a holistic view of human ecosystems, one that emphasizes the role of information. Of course one might wonder if such an approach reeks of hubris in the classical Greek sense. The answer is yes, it does. And we know too well the ultimate fate that results from having hubris. However, in the meantime we hope to contribute, at least a little, to the revitalization of ecological anthropology.

**Appendix B: 1990 Prospectus for Information Ecology**

INFORMATION ECOLOGY

Possible Topics

**I. Basic concepts**

A. Definitions of information (properties of events vs. reduction of uncertainty, etc.), information environments, information flow (communication), informational causality, belief systems

B. Environmental information and indigenous knowledge: temporal and spatial concepts of the environment; spatial organization of ecological information, e.g. architecture and landscape design

C. Themes throughout

1. Biocultural ecology; species comparisons and cross-cultural perspectives
2. Environmental change
3. Scales of increasing social and cultural complexity

**II. Some contributions from other disciplines**

E.g. evolutionary epistemology, cognitive science, sociology of knowledge related to environmental information

**III. Anthropological perspectives on creation, representation, communication, and storage of environmental information**

A. The socio-cultural construction of environmental information

B. Cultural maintenance of complex knowledge: e.g. ethnotaxonomy / ethnosystematics; curated information and embodied knowledge

C. Environmental education

**IV. Information use, control and power**

A. Information's role in strategies for coping with environmental stress: e.g. coping strategies for dealing with risk and uncertainty

B. Information quality: e.g., does information, disinformation and misinformation travel at the same speed?

C. Information control and power: e.g., early state formation; views of the natural environment and changing metaphors of system function and power



Appendix B: (continued)

V. Information and environmental impacts

- A. Evolution of cognitive technology: impacts of changes in information technology on human-environment relations
- B. Information revolutions: transformations of human ecology

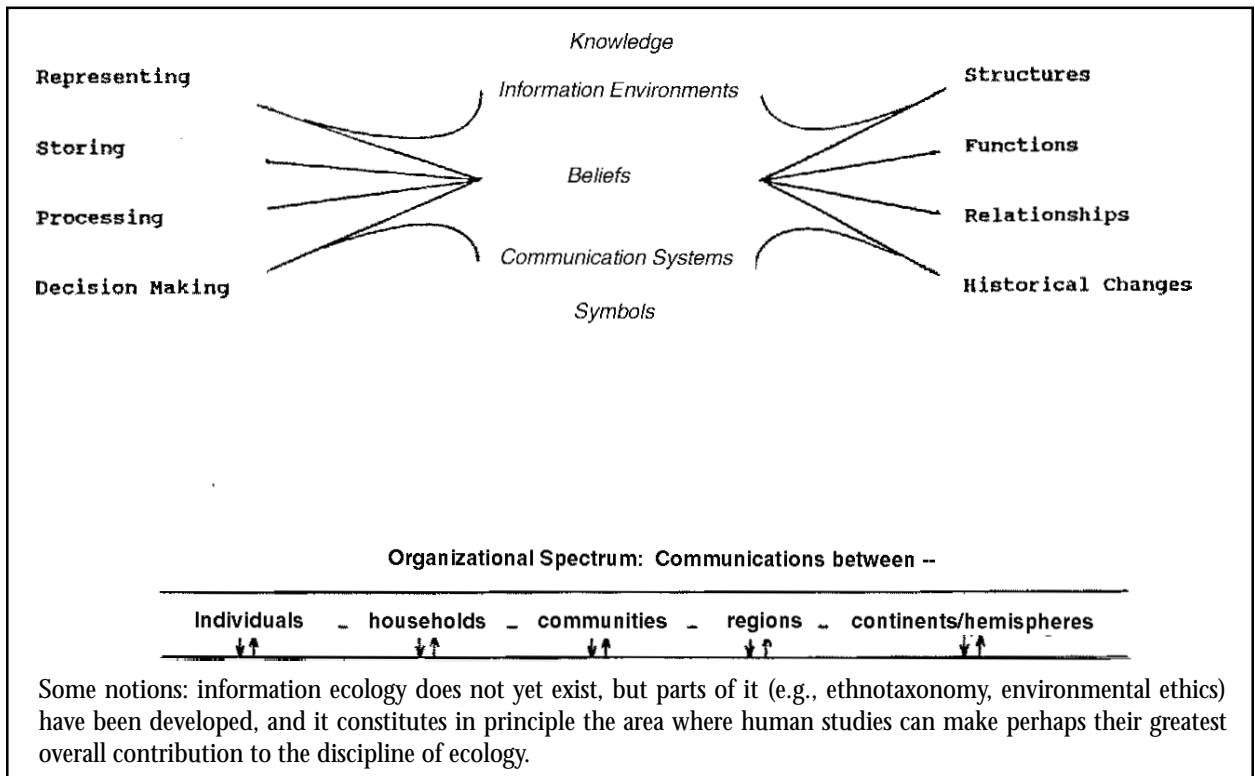
VI. Belief systems and environmental ethics

- A. Ritual and belief as regulators of human-environment relations
- B. Belief systems vs. actual behaviors: individual and societal levels of accountability
- C. Theories of value and cultural concepts of ownership for natural resources (incl. non-renewable, potentially renewable, and perpetual resources)
- D. Ethos and sustainability

VI. Environmental futures

Anthropological perspectives on environmental policy and management of global systems

FIGURE B1.



**Appendix C: Participants and Selected Bibliography of Works**

What follows is a summary of the participants in IE (and its previous forms) along with a listing of manuscripts and conference papers developed under the IE seminar umbrella.

**Core Course: Evolution of Human Ecosystems*****Fall 1993***

John Burroughs  
 Mark Dailey  
 Nancy Feinstein  
 Robbie Etheridge<sup>3</sup>  
 Daniel Hickerson  
 Greg Keyes  
 David McKivern  
 Nelly Robles-Garcia  
 William F. Stanyard

***Fall 1995***

Laura German  
 Greg Guest  
 Melissa Melby  
 Stephanie Paladino  
 Warren Roberts  
 Sammy Smith  
 Eleanor Tison  
 Julie Wieczkowski

***Fall 1996***

Cameron Adams  
 Gabriela Flora<sup>4</sup>  
 Mikell Gleason  
 Ramie Gougeon  
 Shannon Gray  
 Krystof Obidinski  
 Jim Riach  
 Jennifer Snoddy  
 John R. Stepp  
 Swis Stockton  
 Neeraj Vedwan  
 Chris Tarnowski<sup>5</sup>

**Spring 1997: Information Ecology Seminar*****IE project papers***

Eric Jones, *A Discourse on the State, Pluralism, Population Dislocation and Information Ecology*  
 Suzanne Joseph, *Creativity: Transformation/Invention of Information and Informational Environments*  
 Warren Roberts, *Perspectives on Lifespan Development from the Perspective of Information Ecology*<sup>6</sup>  
 John R. Stepp, *Information Ecology in Historical Context*  
 Rebecca Zarger, *Preliminary Inquiry Into Collective Historical Representations of the Green Movement in the United States*

<sup>3</sup>See GJEA 1998, volume 2 pp. 53-67.

<sup>4</sup>See GJEA 1997, volume 1 pp. 21-27.

<sup>5</sup>See GJEA 1997, volume 1 pp. 8-20.

<sup>6</sup>See GJEA 1998, volume 2 pp. 96-106.

## Appendix C (continued)

## Spring 1998: Complex Systems Seminar

*IE project papers*

David Casagrande, *Information as Verb: Quantitative and Diagrammatic Modeling of Information Processes for Ecology and Cognitive Science*<sup>7</sup>

Eric Jones, *Towards Understanding the Military, its Actors, Functions and Tendencies*<sup>8</sup>

Suzanne Joseph, *An Essay on International Financial Cycles as Ritual Cycles*

John R. Stepp, *Prospectus for an Information Ecology*<sup>9</sup>

Felice Wyndham, *Some Heuristic Devices Towards Understanding Change and Persistence in Social Systems over the Longue Durée*

Rebecca Zarger, *Some Observations on Exelligence, Graphicons, and Paradoxes in Human Informational Environments*

## Fall 1998: Information Ecology Seminar II

*IE Working Group and project papers*

David Casagrande, *Cognitive Dissonance and Consensus in Social Reproduction*

Eric Jones, *The Transition to Flexible Accumulation: Modeling the Most Recent Transformation in Capitalism*

Suzanne Joseph, *Models of Social Reproduction and Decision-making with Regard to Fertility*

George Luber, *The European Union's Transition to the Euro*

John R. Stepp, *A Comparison Between Forrester and Odum Modeling Conventions*

Felice Wyndham, *Involution and Paneling: Modeling the Indonesian Financial Crisis*

Rebecca Zarger, *Graphical Representations of Complex Human Systems: Principles, Techniques, and Trajectories*

## Conference Papers

CASAGRANDE, D.

- 1998 Information as Verb: Quantitative and Diagrammatic Modeling of Information Processes for Ecology and Cognitive Science. Paper presented at the 97th annual meetings of the American Anthropological Association. Philadelphia, PA.

JONES, E.

- 1998 The State as an Informational Environment. Paper presented at the 97th annual meetings of the American Anthropological Association. Philadelphia, PA.

JOSEPH, S.

- 1998 Fertility and Decision-making Models: Potential Uses of Information. Paper presented at the 97th annual meetings of the American Anthropological Association. Philadelphia, PA.

ROBERTS, W.

- 1998 The Emergence of Symbolic Behavior in an Information Ecological Perspective. Paper presented at the 97th annual meetings of the American Anthropological Association. Philadelphia, PA.

<sup>7</sup>See GJEA, this volume.

<sup>8</sup>See GJEA, this volume.

<sup>9</sup>See GJEA, this volume.

Appendix C (continued)

STEPP, J. R.

- 1997 Information Ecology: An Integrative Theoretical Approach to Understanding Human Ecosystems. Paper presented at the 96th annual meeting of the American Anthropological Association. Washington, D.C.
- 1998 Antecedents for an Information Ecology. Paper presented at the 97th annual meetings of the American Anthropological Association. Philadelphia, PA.

ZARGER, R.

- 1998 Graphic Representations and the Role of Information in Human Ecosystems. Paper presented at the 97th annual meetings of the American Anthropological Association. Philadelphia, PA.

**Appendix D: Semiotic Signs and Iconography Used in Graphical Representation**

## References Cited

- ADAMS, R. N.  
1973 *Energy and structure*. Austin: University of Texas Press.
- AGRAWAL, A.  
1994 Mobility and control among nomadic shepherds: The case of the Raikas II. *Human Ecology* 22(2):131-144.
- ALLAND, A.  
1975 Adaptation. *Annual Review of Anthropology* 4:59-73.
- ALLEN, T. F. H., AND T. W. HOEKSTRA.  
1992 "The organism criterion," in *Toward a unified ecology*. Pp. 159-200. New York: Columbia University Press.
- ALLEN, T. F. H., AND T. B. STARR.  
1982 *Hierarchy: Perspectives for ecological complexity*. Chicago: University of Chicago Press.
- ATRAN, S.  
1990 *Cognitive foundations of natural history: Towards an anthropology of science*. Cambridge: Cambridge University Press.
- BARRETT, G. W.  
1985 A problem-solving approach to resource management. *BioScience* 35(7): 423-427.
- BATESON, G.  
1972 *Steps to an ecology of mind*. New York: Random House.
- BENNETT, J. W.  
1976 *The ecological transition*. London: Pergamon.
- BERLIN, B., AND P. KAY.  
1969 *Basic color terms: Their universality and evolution*. Berkeley: University of California Press.
- BERLIN, B.  
1992 *Ethnobiological classification*. Princeton: Princeton University Press.
- BIRX, H. J.  
1972 *Pierre Teilhard de Chardin's philosophy of evolution*. Springfield, IL: Charles C. Thomas.
- BLANTON, R. E., S. KOWALEWSKI, G. FEINMAN, AND J. APPEL.  
1981 *Ancient Mesoamerica: A comparison of change in three regions*. Cambridge: Cambridge University Press.
- BLONSKY, M. EDITOR.  
1985 *On signs: A semiotic reader*. Oxford: Blackwell.
- BLOUNT, B.  
In press "History and application of the ecosystem concept in anthropology," in *Integrating social science with ecosystem management*. Edited by H. K. Cordell and J. C. Bergstrom. New York: Sagamore Press.
- BOURDIEU, P.  
1977 *Outline of a theory of practice*. Translated by Richard Nice. Cambridge: Cambridge University Press.
- BOWLER, T. D.  
1981 *General systems thinking: Its scope and applicability*. New York: Elsevier.
- BRADBURY, R.  
1953 *Fahrenheit 451*. New York: Ballantine Books.
- BRAINERD, C. J., AND V. F. REYNA.  
1990 Gist is the grist: Fuzzy-trace theory and the new intuitionism. *Developmental Review* 10:3-47.
- BRAUDEL, F.  
1972 *The Mediterranean and the Mediterranean world in the age of Phillip II*. Translated by Sian Reynolds. New York: Harper and Row.  
1980 *On history*. Translated by S. Matthews. Chicago: University of Chicago Press.
- BUTZER, K. W.  
1990 "Archaeological epistemology," in *The ecosystem approach in anthropology: From concept to practice*. Edited by E. Moran, pp. 91-130. Ann Arbor: University of Michigan Press.

- BYRNE, R.  
1995 *The thinking ape*. New York: Oxford University Press.
- CALLEBAUT, W., AND R. PINXTEN. EDITORS.  
1987 *Evolutionary epistemology: A multiparadigm program with a complete evolutionary epistemology bibliography*. Boston: Kluwer Academic Publishers.
- CAMPBELL, J.  
1982 *Grammatical man: Information, entropy, language and life*. New York: Simon and Schuster.
- CASTI, J. L.  
1993 *Complexification: Explaining a paradoxical world through the science of surprise*. New York: Harper Perennial.
- CHAPMAN, C. A., L. J. CHAPMAN, AND L. LEFEBRE.  
1989 Variability in parrot flock size: Possible functions of communal roosts. *Condor* 91:842-847.
- CHASE-DUNN, C., AND T. D. HALL.  
1993 Comparing world systems: Concepts and working hypotheses. *Social Forces* 71:851-86.  
1995 "Rethinking the evolution of world-systems: Another round," Paper presented at the World System History: The Social Science of Long Term Change Conference. University of Lund, Sweden.
- CHOMSKY, N.  
1986 *Knowledge of language: Its nature, origin and use*. New York: Praeger.
- COBLEY, P., AND L. JANSZ.  
1997 *Semiotics for beginners*. Cambridge: Icon Press.
- COHEN, R.  
1993 The state: A lenticular perspective. *Political and Legal Anthropology Review* 16(1):1-7.
- CONKLIN, H.  
1967 Some aspects of ethnographic research in Ifugao. *Transactions of the New York Academy of Sciences, Series II* 30(1):99-121.
- COREN, R.  
1998 *The evolutionary trajectory: The growth of information in the history and future of earth*. Newark, NJ: Gordon and Breach.
- DE BONO, E.  
1970 *Lateral thinking: Creativity step by step*. New York: Harper Collins.
- DOUGHERTY, J. W. D.  
1978 Saliency and relativity in classification. *American Ethnologist* 5(1):66-79.
- DOW, J.  
1975 Systems models of cultural ecology. *Social Science Information* 15: 953-976.
- DUNBAR, R. I. M.  
1988 The social brain hypothesis. *Evolutionary Anthropology* 6:178-190.
- ECO, U.  
1977 *A theory of semiotics*. London: Macmillan.  
1984 *Semiotics and the philosophy of language*. London: Macmillan.
- ETHERIDGE, R.  
1998 The evolution of human ecosystems during the period of European colonization and mercantile expansion: A preliminary assessment. *Georgia Journal of Ecological Anthropology* 2:54-68.
- FLANNERY, K.  
1972 Cultural evolution of civilizations. *Annual Review of Ecology and Systematics* 3:399-426.
- FORRESTER, J. W.  
1961 *Industrial dynamics*. Cambridge, MA: MIT Press.  
1968 *Principles of systems*. Cambridge, MA: MIT Press.
- FOUCAULT, M.  
1980 *Power/knowledge: Selected interviews and other writings, 1972-77*. Edited by C. Gordon. New York: Pantheon Books.
- FRANK, T., AND M. WEILAND. EDITORS.  
1997 *Commodify your dissent: Salvos from the Baffler*. New York: W.W. Norton.

- GIBSON, J. J.  
1979 *The ecological approach to visual perception*. Boston: Houghton Mifflin.
- GIDDENS, F.  
1979 *Central problems in social theory: Action, structure and contradiction in social analysis*. Berkeley: University of California Press.
- GOLLEY, F.  
1993 *A history of the ecosystem concept in ecology: More than the sum of the parts*. New Haven: Yale University Press.
- GRAMSCI, A.  
1971(1929-35) *Selections from the prison: Notebooks of A. Gramsci*. New York: International Publishers.
- GUMPERZ, J. J., AND S. K. LEVINSON.  
1991 Rethinking linguistic relativity. *Current Anthropology* 32(5):613- 622.
- HAGEN, J.  
1992 *An entangled bank: The origins of ecosystem ecology*. New Brunswick, NJ: Rutgers University Press.
- HALLPIKE, C. M.  
1988 *Principles of social evolution*. Oxford: Clarendon Press.
- HARVEY, D.  
1990 *The condition of postmodernity*. Cambridge: Blackwell.
- HEINLEIN, R. A.  
1961 *Stranger in a strange land*. New York: Putnam.
- HOBBSAWM, E., AND T. RANGER.  
1983 *The invention of tradition*. New York: Cambridge University Press.
- HOLLAND, D. C., AND J. VALSINER.  
1988 Cognition, symbols and Vygotsky's developmental psychology. *Ethos* 16(3):247-272.
- HUNN, E.  
1989 "Ethnoecology: The relevance of cognitive anthropology for human ecology," in *The relevance of culture*. Edited by M. Freilich, pp. 143-160. New York: Bergin and Garvey.
- HUTCHINS, E.  
1995 *Cognition in the wild*. Cambridge, MA: MIT Press.
- HUXLEY, A.  
1956 *Brave new world*. With a special foreword by the author. New York: Bantam Books.
- JOHNSON, M.  
1987 *The body in the mind: The bodily basis of meaning, imagination and reason*. Chicago: University of Chicago Press.
- JONES, E.  
1998 The State as an informational environment. Paper presented at the 97th annual meetings of the American Anthropological Association. Philadelphia, PA.
- KAY, J. J.  
1984 Self-organization of living systems. Ph.D. diss., University of Waterloo.
- KELLER, C. M., AND J. DIXON-KELLER.  
1996 *Cognition and tool use: The blacksmith at work*. New York: Cambridge University Press.
- KLIR, G. J.  
1972 *Trends in general systems theory*. New York: Wiley-Interscience.
- KLIR, G. J., AND T. A. FOLGER.  
1988 *Fuzzy sets, uncertainty, and information*. Englewood Cliffs, NJ: Prentice Hall.
- KRAMER, J. T. A., AND J. DESMIT.  
1977 *Systems thinking: Concepts and motions*. Leiden: Martius Nijhoff.
- LASZLO, E.  
1972 *Introduction to systems philosophy*. New York: Gordon and Breach.
- LAVE, C., AND J. MARCH.  
1975 *An introduction to models in the social sciences*. New York: Harper and Row.
- LEAF, M.  
1972 *Information and behavior in a Sikh village*. Berkeley: University of California Press.



- LE GUIN, U. K.  
1976 *The left hand of darkness*. New York: Ace Books.
- LEROI-GOURHAN, A.  
1993 *Gestures and speech*. Cambridge, MA: MIT Press.
- LOCK, A., AND C. R. PETERS. EDITORS.  
1996 *Handbook of human symbolic evolution*. Oxford: Clarendon Press.
- MACKAY, C.  
1980 [1841] *Memoirs of extraordinary popular delusions*. London: Tobias.
- MARGALEF, R.  
1958 Information theory in ecology. *General Systems* 3:36-71.  
1968 *Perspectives in ecological theory*. Chicago: University of Chicago Press.
- MARX, K.  
1967 [1867] *Capital: A critique of political economy—Volume I: The process of capitalist production*. Translated by S. Moore and E. Aveling. New York: International Publishers.
- MEENTEMEYER, V., AND E. O. BOX.  
1987 "Scale effects in landscape studies," in *Landscape heterogeneity and disturbance*. Edited by M.G. Turner, pp. 15-34. New York: Springer-Verlag.
- MILLER, G. A.  
1956 The magical number seven, plus or minus two: Some limits on our capacity for processing information. *The Psychological Review* 63:81-97.
- MISH, F. C. EDITOR.  
1988 Webster's ninth new collegiate dictionary. Springfield, MA: Merriam-Websters.
- MORAN, E.  
1982 *Human adaptability: An introduction to ecological anthropology*. Boulder: Westview Press.
- MORAN, E. EDITOR.  
1990 *The ecosystem approach in anthropology: From concept to practice*. Ann Arbor: University of Michigan Press.
- MÜLLER, F.  
1992 Hierarchical approaches to ecosystem theory. *Ecological Modelling* 63:215-242.
- NAVEH, Z., AND A. S. LIEBERMAN.  
1994 *Landscape ecology: Theory and application*. New York: Springer-Verlag.
- NAVEH, Z.  
1998 Ecological and cultural landscape restoration and the cultural evolution: Towards a post-industrial symbiosis between human society and nature. *Restoration Ecology* 6:135-143.
- NAZAREA-SANDOVAL, V.  
1995 "Decision making as interface," in *Local knowledge and agricultural decision making in the Philippines: Class, gender, and resistance*. Pp. 142-181. Ithaca: Cornell University Press.
- NORGAARD, R. B.  
1994 *Development betrayed: The end of progress and a co-evolutionary revisioning of the future*. New York: Routledge.
- NÖTH, W.  
1990 *Handbook of semiotics*. Bloomington: Indiana University Press.
- ODUM, H. T.  
1983 *Systems ecology*. New York: John Wiley and Sons.
- ONIONS, C. T. EDITOR.  
1986 *The shorter Oxford English dictionary on historical principles*. Etymologies revised by C. W. S. Friedrichson. Oxford: Clarendon Press.
- PATTEN, B.  
In press *Holoecology*. New York: Columbia University Press.  
1982 Environs: relativistic elementary particles for ecology. *American Naturalist* 119:179-219.
- PATTEN, B., AND S. E. JØRGENSEN. EDITORS.  
1995 *Complex ecology: The part-whole relation in ecosystems*. Englewood Cliffs: Prentice-Hall.

- PEIRCE, C. S.  
1931-58 *Collected papers. Eight volumes*. Cambridge, MA: Harvard University Press.
- PIELOU, C.  
1966 Shannon's formula as a measure of specific diversity: Its use and misuse. *American Naturalist* 100:463-465.
- PLOG, F. T.  
1975 Systems theory in archaeological research. *Annual Review of Anthropology* 4: 207-224.
- PULESTON, D.  
1979 "An epistemological pathology and the collapse, or why the Maya kept the short count," in *Maya archaeology and ethnohistory*. Edited by N. Hammond and G.R. Willey, pp. 63-71. Austin: University of Texas Press.
- RADNITZKY, G., AND W. W. BARTLEY.  
1987 *Evolutionary epistemology, rationality, and the sociology of knowledge*. La Salle, IL: Open Court.
- RAPOPORT, A.  
1986 *General system theory: Essential concepts and applications*. Kent: Tunbridge and Wells.
- RAPPAPORT, R.  
1977 "Maladaptation in social systems," in *Evolution of social systems*. Edited by J. Friedman, pp. 49-71. London: Duckworth.  
1984 *Pigs for the ancestors: Ritual in the ecology of a New Guinea people (A new, enlarged edition)*. New Haven: Yale University Press.
- ROBERTS, W.  
1997 "Symbolic play and the evolution of culture: a comparative life history perspective," Paper presented at the Annual Meeting for the Association for the Study of Play, Tampa, FL.
- RODIN, M., K. MICHAELSON, AND G. M. BRITAN.  
1978 Systems theory in anthropology. *Current Anthropology* 19: 747-762.
- ROLFE, L.  
1996 "Theoretical stages in the prehistory of grammar," in *Handbook of human symbolic evolution*. Edited by A. Lock and C. R. Peters, pp. 776-792. Oxford: Clarendon Press.
- ROMNEY, A. K., S. C. WELLER, AND W. H. BATCHELDER.  
1986 Culture as consensus: A theory of culture and informant accuracy. *American Anthropologist* 88:313-338.
- SALMINEN, S., AND E. HILTUNEN.  
1995 "Cultural differences in occupational accidents. Part II: A case study of Finnish- and Swedish-speaking workers in Finland," Paper presented at 44<sup>th</sup> Nord. Meet. Work Environ., Naantali, Finland.
- SCAIFE, M., AND Y. ROGERS.  
1996 External cognition: How do graphical representations work? *International Journal of Human-Computer Studies* 45: 185-213.
- SCHIEBINGER, L.  
1993 *Nature's body: Gender in the making of modern science*. Boston: Beacon Press.
- SEBEOK, T. A., A. S. HAYES, AND M. C. BEATON.  
1972 *Approaches to semiotics*. The Hague: Mouton.
- SHANNON, C. E., AND W. WEAVER.  
1949. *The mathematical theory of communication*. Urbana: University of Illinois Press.
- SMITH, C. A.  
1984 Local history in global context: Social and economic transitions in western Guatemala. *Comparative Studies in Society and History* 26: 193-228.

- STEPP, J. R.  
1997 "Information ecology: An integrative theoretical approach to understanding human ecosystems," Paper presented at the 96th Annual Meetings of the American Anthropological Association, Washington, DC.
- STROSS, B.  
1973 "Acquisition of botanical terminology by Tzeltal children," in *Meaning in Mayan languages*. Edited by M. S. Edmonson, pp. 107-141. The Hague: Mouton.
- TEDLOCK, D.  
1993 *Breath on the mirror: Mythic voices and visions of the living Maya*. New York: Harper Collins.
- TEILHARD DE CHARDIN, P.  
1966 *Man's place in nature*. London: Collins.  
1975 *The phenomena of man*. New York: Harper and Row.
- VAYDA, A. P.  
1983 Progressive contextualization: Methods for research in human ecology. *Human Ecology* 11: 265-281.
- VERNADSKY, W. I.  
1945 The biosphere and the noösphere. *American Scientist* 33:1-2.
- VON BERTALLANFFY, L.  
1950 An outline of general systems theory. *The British Journal for the Philosophy of Science*. 1:134-165.
- VON FRISCH, K.  
1954 *The dancing bees*. London: Methuen.
- VON UEXKULL, J.  
1926 *Theoretical biology*. London: Kegan Paul, Trench, Trubner & Co.
- WALDROP, M.  
1992 *Complexity: An emerging science at the edge of order and chaos*. New York: Simon and Schuster.
- WEBSTER, F.  
1995 *Theories of the information society*. New York: Routledge.
- WEINBERG, G. M.  
1973 *An introduction to general systems thinking*. New York: Wiley-Interscience.
- WHORF, B.  
1956 "The relation of habitual thought and behavior to language," in *Language, thought and reality: Selected writings of Benjamin Lee Whorf*. Edited by J. B. Carroll, pp. 134-159. Cambridge, MA: MIT Press.
- WILLARD, A.  
1993 Gold, Islam and camels: The transformative effects of trade and ideology. *Comparative Civilization Review* 28:80-105.
- WINN, W.  
1993 An account of how readers search for information in diagrams. *Contemporary Educational Psychology* 18: 162-185.
- WOLF, E.  
1964 *Anthropology*. New York: W.W. Norton and Co.  
1990 Old insights, new questions. *American Anthropologist* 92:586-596.
- WUKETTITS, F. M.  
1990 *Evolutionary epistemology and its implications for humankind*. Albany, NY: State University.
- WYNNE-EDWARDS, V. C.  
1967 *Animal dispersion in social behavior*. New York: Hutner Publishing Co.
- ZARGER, R.  
1998 "Some observations on exelligence, graphicons, and paradoxes in human informational environments," Information Ecology Group Working Paper, University of Georgia.
- ZHANG, J., AND D. A. NORMAN.  
1994 Representations in distributed cognitive tasks. *Cognitive Science* 18:87-122.