CHAPTER 3

Biophilia, Biophobia, and Natural Landscapes

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THE BELIEF THAT contact with nature is somehow good or beneficial for people is an old and widespread notion. The gardens of the ancient Egyptian nobility, the walled gardens of Persian settlements in Mesopotamia, and the gardens of merchants in medieval Chinese cities indicate that early urban peoples went to considerable lengths to maintain contact with nature (Shepard 1967; Hongxun 1982). During the last two centuries, in several countries, the idea that exposure to nature fosters psychological well-being, reduces the stresses of urban living, and promotes physical health has formed part of the justification for providing parks and other nature in cities and preserving wilderness for public use (Parsons 1991; Ulrich et al. 1991). These notions might be considered early forms of the biophilia hypothesis. But E. O. Wilson's interpretation of biophilia (1984) is not limited to the proposition that humans are characterized by a tendency to pay attention to, affiliate with, or otherwise respond positively to nature. His definition of biophilia also includes the proposition that there is a partly genetic basis for humans' positive responsiveness to nature.

This chapter examines the biophilia hypothesis in the context of theory and empirical findings relating to psychological, physiological, and certain health-related responses associated with *viewing* natural landscapes. Much of the discussion focuses on the effects of people's visual experiences with such "nonanimal" nature as landscapes dominated by vegetation, water, or other nature content. The first section outlines an evolutionary perspective that serves in subsequent sections as a framework for examining behavioral science research findings relevant to the biophilia hypothesis. One prominent feature of the conceptual perspective is the position that theoretical arguments for a genetic component to biophilia gain plausibility if a genetic predisposition in humans for *biophobic* responsiveness to certain dangerous nature phenomena is likewise postulated. In line with this position, some of the early sections survey research findings which suggest there is a partly innate basis for negative or biophobic responses to certain nature stimuli such as snakes.

The survey of empirical evidence for a genetic role in biophobia provides a springboard for next advancing theoretical notions concerning biophilia. This exploration leads to some of the major sections of the chapter, which discuss conceptual arguments and research findings relating to three general types of biophilic responses to unthreatening natural landscapes: liking/approach responses; restoration or stress recovery responses; and enhanced high-order cognitive functioning. The discussion of biophilic responses then leads to a consideration of human benefits that might be lost when natural landscapes are eliminated. The final section discusses research that would expand our understanding of nature's beneficial effects on people and suggests research approaches that might shed empirical light on a possible genetic role in biophilia.

An Evolutionary Perspective

The speculation that positive responses to natural landscapes might have a partly genetic basis implies that such responses had adaptive significance during evolution. In other words, if biophilia is represented in the gene pool it is because a predisposition in early humans for biophilic responses to certain natural elements and settings contributed to fitness or chances for survival. A basic conceptual argument in this chapter is that both the *rewards* and the *dangers* associated with natural settings during human evolution have been sufficiently critical to favor individuals who readily learned, and then over time remembered, various adaptive responses—both *positive/approach* (biophilic) responses and *negative/avoidance* (biophobic) responses—to certain natural stimuli and configurations. This perspective explicitly recognizes that the natural habitats of early humans contained dangers as well as advantages. A general argument influencing the content and organization of the chapter is that theoretical propositions for an innate predisposition for biophilia gain plausibility and consistency if they also postulate a corresponding genetic predisposition for adaptive biophobic responses to certain natural stimuli that presumably have constituted survival-related threats throughout human evolution.

The notion that fears and even phobic responses to certain natural stimuli have an evolutionary basis is not new. Perhaps not surprisingly, Charles Darwin (1877) may have been the first to advance this hypothesis. The following sections on biophobia focus mainly on responses to fear-relevant animals and give comparatively little coverage to the physical environment. This approach is in keeping with the point that many risks for early humans were related to predators. By contrast, the later sections on biophilia focus mainly on responses to natural landscapes, an approach which is consonant with the proposition that many critical survival-related advantages for early humans (food, water, security) were tied to characteristics of the physical environment. Important survival advantages were related to animals as well; other chapters in this volume address biophilic responses to animals.

It is suggested that a partly genetic basis for biophilia and biophobia should be reflected in *biologically prepared learning*—and possibly in particular characteristics of responses to certain natural stimuli (such as very short reaction times) that may not be evident for learning and response characteristics with respect to modern and urban stimuli. As initially proposed by Seligman (1970, 1971), prepared learning theory holds that evolution has predisposed humans and many animal species to easily and quickly learn, and persistently retain, those associations or responses that foster survival when certain objects or situations are encountered. For example, it might be hypothesized that humans should readily acquire, and then not forget, adaptive fear/avoidance responses to such risk-relevant stimuli or situations as snakes, spiders, and heights. Although the recent large-scale transformation of environments in industrialized countries has largely eliminated the real danger of the objects of fears and phobias, fear/avoidance responses might nonetheless persist because they are represented in the gene pool. Seligman's theory suggests that prepared learning should not be evident for stimuli that were comparatively neutral during evolution—that is, did not have major importance for survival as either threats or advantages. It is worth emphasizing that prepared learning theory does not postulate that adaptive responses to prepared natural stimuli should appear spontaneously or in the absence of learning. Rather, some conditioning is necessary to elicit a response which is then characterized by resistance to "extinction," or forgetting.

Although Seligman (1970) suggests that positive responses might be biologically prepared for some objects, nearly all empirical tests of preparedness theory have focused on aversive reactions, especially fears and phobias, with respect to fear-relevant stimuli. The following sections survey the findings from preparedness research and from behavior-genetic studies that are relevant to biophobia. The term biophobia is defined here as a partly genetic predisposition to readily associate, on the basis of negative information or exposure, and then persistently retain fear or strong negative/avoidance responses to certain natural stimuli that presumably have constituted risks during evolution. We begin with a survey of biophobia findings because research on biophobia is comparatively advanced, has shed light on a genetic role in responses to nature, and has yielded theory and ingenious research methods that could prove important in future research on biophilia.

Biophobia

There is considerable evidence from clinical psychology and psychiatry (Costello 1982; and McNally 1987) that the majority of phobic occurrences involve strong fears with respect to certain objects and situations that have threatened humans throughout evolution (snakes, spiders, heights, closed spaces, blood). This finding appears to hold across industrialized societies for which data are available. The most common phobic fears in Western societies may be fears of snakes and spiders. For developing nations, sound data are lacking on the prevalence of phobias and the objects of phobias. Here it is relevant to note that in the absence of sound data for a society, one cannot infer from observed cultural practices such as the creation of cobra shrines in India (Chapter 12 in this volume) that snake fears and phobias are not common in that country. To the contrary, there are grounds for arguing on the basis of psychological theory that such shrines and associated rituals may represent complex active coping efforts to reduce the anxiety associated with a dangerous and fascinating creature.

Research Findings

The notion that biologically prepared learning plays a role in biophobia has received support from scores of experiments performed in different countries by several investigators, most notably Arne Öhman and his associates in Sweden and Norway (Öhman, Erixon, and Löfberg 1975; Öhman 1979; Öhman, Dimberg, and Öst 1985). Nearly all studies have used variants of an ingenious Pavlovian conditioning approach pioneered by Öhman. These experiments typically involve comparisons between defense or aversive responses conditioned (that is, learned through repeated exposure or experience) to slides of fear-relevant and fear-irrelevant or neutral stimuli. Responses are usually assessed by recording autonomic nervous system indicators such as skin conductance and heart rate. In the first part of a typical experiment, defense responses are conditioned by showing either fear-relevant stimuli (such as snakes, spiders) or neutral stimuli (geometric figures) and pairing each slide presentation with an aversive stimulus ("unconditioned" stimulus) that usually is an electric shock having some resemblance to a bite. This phase of the experiment makes it possible to compare the fear-relevant and neutral stimuli with respect to the speed and magnitude of acquisition of a defense/aversive response. Following the initial acquisition phase, the same stimuli are presented ten to forty additional times but without the reinforcement of electric shock. This "extinction" phase allows comparison of the fear-relevant and neutral stimuli in terms of resistance to forgetting the defense/aversive response acquired earlier.

In a review of such conditioning experiments, McNally (1987) concluded that, on balance, findings indicate that conditioned responses are sometimes though not reliably acquired more quickly—but are consistently more resistant to forgetting (extinction)—for certain premodern risk stimuli such as snakes and spiders than for neutral or fear-irrelevant stimuli. Put differently, Seligman's prepared learning theory receives at best equivocal support regarding the ease or speed of response acquisition. Biologically prepared learning receives considerable support, however, from the consistently greater resistance to forgetting that is evident for responses acquired to natural stimuli such as snakes and spiders that probably have constituted threats to humans throughout evolution.

At this point it might be argued that the greater persistence of responses conditioned to snakes and spiders stems not from biologically prepared learning but rather from "regular" learning of fear associations, including ingrained cultural conditioning that these stimuli are strongly negative and dangerous. This possibility has been tested in conditioning experiments that exposed individuals to fear-relevant premodern natural stimuli, such as snakes and spiders, and to far more dangerous (and arguably more culturally conditioned) modern stimuli such as handguns and frayed electrical wires (Cook, Hodes, and Lang 1986; Hugdahl and Karker 1981). Findings have provided additional support for the notion of biological preparedness because defense responses conditioned to the dangerous modern stimuli extinguished or were forgotten more quickly than responses to snakes and spiders.

Vicarious Acquisition of Adaptive Responses

A noteworthy aspect of biophobia is that responses can be acquired through various types of "vicarious" conditioning or learning experiences. Several studies have shown that merely telling the subject that shock will be administered is alone sufficient for effective acquisition of responses to fear-relevant but not to fear-irrelevant natural stimuli (see Hugdahl 1978). In a vicarious conditioning study Hygge and Öhman (1978) exposed individuals to an allegedly phobic experimenter/actor who reacted fearfully to slides of either fear-relevant natural stimuli (snakes, spiders, rats) or fear-irrelevant natural stimuli (such as berries). Findings indicated that people acquired much more persistent defense reactions when watching the experimenter's reactions to fear-relevant in contrast to fear-irrelevant slides. Similarly, Mineka and her associates have performed several studies with rhesus monkeys that have yielded strong evidence of vicarious conditioning of fear/aversive responses to fear-relevant stimuli (such as toy snakes, toy crocodiles) but not to fear-irrelevant stimuli such as toy rabbits (Mineka et al. 1984; Cook and Mineka 1989, 1990).

The research on humans suggests that simply observing another person's fearful or strongly aversive reaction to a presumably biologically prepared natural object—or even receiving information regarding a possibly aversive consequence (such as a shock) of exposure to the object—can be sufficient to condition adaptive defense/aversive responses. An important implication of these findings is that vicarious acquisition may greatly enhance the adaptive or survival-related significance of biologically prepared responses for a *group* of humans or primates. To illustrate this argument, consider the example of an early human in a hunting and gathering group who is bitten by a poisonous snake. Although the bite experience would presumably condition in the person a persistent disposition to respond with fear/avoidance to snakes, this response would have no adaptive value for the person if the venom proved fatal. But other members of the group might acquire unforgettable fear/avoidance responses by having witnessed the bite episode, by having observed the effects on the person, or by receiving vivid information from others about the episode and its painful, fatal consequences. To the extent that such vicarious conditioning occurred throughout the members of the band, the fatal episode would conceivably advance the group's survival chances.

In light of the findings indicating the efficacy of threatening information in conditioning defense/aversive responses, it is not too great a speculation to suggest that one critical adaptive function of certain vivid oral folklore (Chapter 7 in this volume), mythology, or other culturally transmitted information focusing on certain dangerous creatures or objects (Chapter 6 in this volume) might be to vicariously condition adaptive fear/avoidance responses. In this way certain cultural traditions, in combination with biologically prepared learning, might serve as highly efficient means for achieving acquisition of adaptive responses throughout a society. Losses in the form of injuries or deaths would be reduced because effective conditioning would occur without the need for people to have direct—dangerous—encounters with biophobic stimuli. Repeated exposures achieved by the telling and retelling of vivid stories or myths in certain cultures about prepared dangerous natural phenomena might be considered to have rough parallels to the repeated acquisition trials in conditioning studies that are so effective in conditioning persistently retained aversive responses to certain natural stimuli.

Nonconscious Processing of Biophobic Stimuli

Another noteworthy aspect of biophobia has emerged from a few studies that raise the possibility of nonconscious automatic processing for prepared fear-relevant stimuli but not fear-irrelevant stimuli. In a series of publications Öhman has advanced detailed theoretical arguments proposing that as a remnant of evolution, humans have a biologically controlled predatory defense system with a capacity for very quick, automatic, or "unconscious" processing of certain cues—such as paired forward-looking eyes—signaling the presence of approaching snakes and other predators (Öhman 1986). To evaluate empirically the nonconscious processing hypothesis, Öhman and his associates have used a variant of the aversive Pavlovian conditioning approach that incorporates "backward-masking" methods. Most of these experiments begin with a phase in which aversive/defense responses are conditioned in the usual manner to slides of premodern risk stimuli (such as snakes) and slides of neutral or risk-irrelevant stimuli. In a later stage of the experiment, however, the same conditioned slides are displayed ***subliminally*** (15–30 milliseconds) before being "masked" by a slide of another stimulus or setting that can be recognized and otherwise consciously processed.

Findings from these backward-masking experiments have consistently suggested that, following initial conditioning, ***subliminal*** presentations of natural settings containing snakes or spiders can elicit strong defense/aversive reactions in normal or nonphobic persons (Öhman 1986; Öhman and Soares 1993a). In the case of people with animal fears or phobias, it can be assumed that conditioning has occurred long before the experiment. In this regard, a recent study of snake-fearful, spider-fearful, and nonfearful control individuals found that a masked subliminal presentation was alone sufficient to elicit defense responding in the fearful groups to their particular feared stimulus (Öhman and Soares 1993b). These studies suggest the following conclusion: coherent fear/defense responding, evident in both physiological and affective indicators, can occur without recognition or even conscious awareness of quite specific natural threat stimuli. There is no such response to neutral or fear-irrelevant natural stimuli.

Regarding the issue of very quick responses to biologically prepared stimuli, Dimberg (1990) has used the technique of facial electromyography (Cacioppo, Tassinary, and Fridlund 1990) to show that specific emotional reactions to presumably prepared stimuli (snakes, spiders, angry faces, happy faces) are readily detectable within 400 milliseconds or less following presentation of the stimuli. This extremely fast emotional/physiological responding is very difficult to reconcile plausibly with a purely "controlled" conscious cognitive perspective on human/nature interactions (Ulrich et al. 1991).

Preparedness to Depth/Spaciousness in Landscapes

The discussion of biophobia up to this point has focused on biologically prepared responses to animals. A functional-evolutionary perspective, however, implies that certain properties of the physical environments of early humans probably had major influences on risk probabilities and survival chances. In this regard it is reasonable to propose that throughout evolution visual *depth/spaciousness* characteristics of natural environments have affected such important risk-related factors as surveillance, proximity to hidden threats, and escape opportunities. From this argument it follows that humans may be biologically prepared to respond with moderate dislike/avoidance or wariness to spatially restricted settings that might contain hidden dangers and constrain opportunities to escape (Ulrich 1983). A partly genetic predisposition for acquiring *strong* persistent fear/avoidance responses would be maladaptive, however, because it would strongly inhibit exploiting the refuge's advantages (Appleton 1975; Chapter 4 in this volume) and the food opportunities associated with many enclosed settings. These arguments are broadly consistent with findings from many studies of liking or aesthetic preferences for natural landscapes that indicate people in Western and Eastern societies rather consistently dislike spatially restricted environments but respond with greater liking to settings having moderate to high visual depth or openness (Ulrich 1983, 1986a). Arguably, most people at one time or another have experienced a scare or other aversive unconditioned stimulus in an enclosed setting that might condition a prepared disposition to respond subsequently with moderate dislike and wariness to spatially restricted situations.

In the discussion of biophilia in later sections, several arguments will be advanced to explain why people should respond positively to spatially open, savanna-like landscapes. (See also Chapter 4 in this volume.) One critical advantage of open savannas during evolution presumably was the comparatively low risk associated, for instance, with lower probabilities of encountering close hidden predatory threats. Whereas threat-related episodes may have been relatively infrequent on the savanna, an evolutionary perspective implies the hypothesis that in the event an early human did experience a close call, injury, or other traumatic experience (a child lost or separated from its parent, for example) on the open savanna, that person should acquire an "unforgettable" adaptive response disposition of cautiousness and reduced liking. A variation of this argument suggested by Klein (1981) contends that it would be adaptive for infants or small children to associate fear or alarm with being in the open separated from their mothers, where they would be vulnerable to predators and other dangers.

To evaluate the hypothesis that biologically prepared learning may play a role in responses to gross depth/spaciousness properties of natural settings, Ulrich, Dimberg, and Öhman (1993) performed an aversive classical conditioning experiment using a laboratory environmental depth simulator. Through a hooded viewing port, people observed slides of either low-depth (1 meter) or high-depth (more than 100 meters) natural scenes displayed on a large back-projection screen positioned only 1 meter in front of their eyes. All scenes were dominated by green vegetation, and the low-depth and high-depth exemplars were equivalent in complexity and brightness. The subjects' arms rested comfortably on a flat surface that extended forward to the screen, so that their fingertips were positioned near the lower part of the screen but were not visible. Electrodes affixed to the fingertips administered a bite-like shock as the unconditioned stimulus.

The findings suggest that autonomic defense/aversive responses conditioned to the high-depth settings were significantly more resistant to forgetting than for the low-depth settings. For unreinforced (no shock) presentations, affective self-ratings were significantly more positive for high-depth than for low-depth scenes. Following administration of the shock, there were pronounced negative shifts in affective responses to both spatial categories, although ratings remained more positive for high-depth than low-depth environments. The results provide some support for the preliminary conclusion that humans may be biologically prepared to acquire a persistent posture of defense/cautiousness but not strong fear/avoidance following an aversive experience in a high-depth, spatially open, natural environment. The findings appear relevant to our understanding of agoraphobia (interpreted narrowly here as fear of open spaces), which is among the most debilitating and costly of phobias.

Twin Studies and Behavior-Genetic Approaches

In addition to conditioning studies, research on human twins, including studies using behavior-genetic approaches, has yielded convincing evidence that biophobia has a partly genetic basis. As a general context for these findings, it is relevant to mention that during the last decade twin studies have suggested that genetic factors play a major role in a wide range of human characteristics and traits, including obesity, personality, and physiological (autonomic) reactivity. As one example, a review of several twin studies (Loehlin et al. 1988) concluded that genetics may account for about half the variation in neuroticism.

Regarding biophobia, an initial wave of family history and twin studies produced a pattern of evidence suggesting strongly that some fears or phobias are familial and partly genetic in origin (Rose et al. 1981; Moran and Andrews 1985; Fyer et al. 1990). But most of these studies did not use sufficiently advanced statistical methods, or large enough samples, to permit either elucidation of the relative contributions of genetic and environmental risk factors for different types of phobias or an evaluation of preparedness theory. Recently these limitations have been overcome in a few studies using large twin samples and advanced multivariate statistical methods. Before discussing these findings and their implications for biophobia, a brief description of behavior-genetic methods is in order.

Behavior-genetic research typically focuses on a response, trait, or variable of interest (such as snake phobia, agoraphobia, emotionality, personality trait) that is characterized by considerable variability among persons (Gabbay 1992). And if the study is to enable one to make detailed inferences, including insights into causal relationships, a second requirement is a large sample of persons (several hundred to a few thousand) for whom genetic similarity/dissimilarity between individuals or pairs can be determined. The sample typically consists of monozygotic and dizygotic twins, but it is also possible to use a very large sample that includes family members or relatives. If these requirements are met, a data collection phase is undertaken. This process usually involves personal interviews to gain information regarding the presence/absence and magnitude of the variable in question, as well as collecting other types of information such as the person's age at onset of a phobia. Finally, the data are analyzed using multivariate genetic statistical models (such as LISREL) that identify and may allow causal insights concerning the contribution of genetic effects, familial (common) environmental factors, and individual-specific environmental effects (Heath et al. 1989; Neale et al. 1989).

Using the approach outlined here, Kendler and his associates (1992) studied the genetic epidemiology of different types of phobias in a sample of 2,163 American female twins. One-third (33.4 percent) of the individuals gave a lifetime personal history that indicated some type of phobia. Findings from different multivariate models converged generally to indicate that genetic factors play a major role in animal phobias (fears of snakes, spiders, bugs, or bats) and in agoraphobia: estimates of heritability ranged from 30 percent for animal phobias to 40 percent for agoraphobia. Kendler and his associates concluded that the results strongly support an interpretation of inherited biophobia "proneness," because the familial clustering of any type of phobia stemmed in large part from genetic factors but not from familial or common environmental factors (that is, not from environmental factors such as a common home situation experienced by both twins in a pair).

Importantly, the results were consistent with biologically prepared learning theory because "individual-specific" aversive or traumatic experiences appear to play a critical role in the triggering of phobias (Kendler et al. 1992). The traumatic events were highly specific for animal phobias—for example, an aversive experience with a snake would be linked with snake phobia. By comparison, the pathogenic experiences for agoraphobia were less specific. The latter finding is perhaps not surprising from an evolutionary perspective, because aversive or traumatic experiences in the open savanna might stem from widely different events or threats, ranging from predator attacks to being lost as a child.

Finally, the findings confirmed results from previous studies (such as Marks 1969) reporting that the onset ages for different phobias are quite different. For snake, spider, and other animal phobias, onset typically occurred during childhood (about 70 percent of phobias began by ten years of age). Age at onset was latest for agoraphobia (about 60 percent of onsets occurred between fifteen and thirty years of age). It is pertinent to mention that plausible functional-evolutionary explanations have been advanced to account for differences in the onset ages of different phobias. For example, Öhman, Dimberg, and Öst (1985) have argued that a biologically prepared readiness for early childhood onset of animal fears was adaptive for premodern humans because young children are especially vulnerable to snakes and other predators.

Summary of Biophobia Findings

To summarize briefly, findings from many laboratory conditioning experiments support the notion that humans are biologically prepared to acquire and especially to not "forget" adaptive biophobic (fear/avoidance) responses to certain natural stimuli and situations that presumably have presented survival-related risks throughout evolution. It appears that an important adaptive feature of biophobia is that comparatively unforgettable responses to certain fear-relevant but not fear-irrelevant natural stimuli can be acquired through vicarious conditioning or learning experiences. Moreover, recent findings suggest that processing of biologically prepared fear-relevant natural stimuli can be very fast and may often occur automatically or "unconsciously." Although the vast majority of conditioning studies have focused on fear-relevant predatory stimuli, there is limited evidence that humans might also be biologically prepared to acquire a persistent posture of defense/cautiousness following an aversive experience in a high-depth, spatially open environment such as a savanna.

Behavior-genetic studies and other research on human twins have produced convincing evidence that genetic factors play a major role in biophobia. As well, recent behavior-genetic findings support an inherited biophobia "proneness" interpretation and are clearly consistent with biologically prepared learning theory. Accordingly, the notion that biophobia is partly genetic and manifested in prepared learning has received support both from conditioning studies as well as behavior-genetic research. This convergence lends considerable credibility to a biologically prepared learning interpretation of biophobia. It is noteworthy that several investigators working in different fields have used entirely different research approaches (aversive conditioning and behavior-genetic methods) yet have reached broadly similar conclusions.

If humans have a partly genetic predisposition to biophobia—that is, to respond fearfully or aversively to certain living things and natural situations—should one begin to doubt the plausibility of the *biophilia* hypothesis? In fact, the implications of the biophobia research are quite the opposite. If the many years of sophisticated scientific inquiry into biophobia had instead produced no evidence of a genetic role in negative responses to stimuli that were critical survival-related dangers throughout evolution, it would be implausible now to postulate a partly genetic predisposition for *positive* responsiveness to advantageous natural stimuli. The findings suggesting a robust genetic role in biophobia imply tenability and even optimism for the biophilia hypothesis, which now becomes our focus.

Biophilia and Natural Landscapes

As described earlier, this discussion of biophilia concentrates on natural physical environments rather than animals. At the outset it should be reiterated that theory and research on biophilia are less developed than for biophobia. Approaches such as behavior-genetic methods have not yet been tried that might yield direct evidence regarding the possible role of genetic factors. Moreover, in sharp contrast to the large body of conditioning studies relating to biological preparedness and biophobia, there is a lack of research that has directly tested prepared learning theory with respect to positive or biophilic responses to nature. The latter deficiency is partly due to the fact that *positive* Pavlovian conditioning studies are usually more difficult to perform than aversive conditioning experiments, because producing an immediate, strongly positive, unconditioned stimulus in the laboratory is more problematic than providing an immediate negative unconditioned stimulus.

But there is a more fundamental reason for the lack of scientific research on biophilia: psychology, with its impressive repertoire of theories and scientific research methods, has shown little interest in studying human transactions with natural environments. In this regard, environmental psychology is a small and peripheral subfield within psychology. Disciplines that focus on natural settings, such as landscape architecture, are small and lack expertise in behavioral science methods and other research approaches that are necessary for rigorously investigating many aspects of the biophilia hypothesis. Additionally, no funding agency in the United States (with the limited exception of the USDA Forest Service) has assigned importance to funding or stimulating research on the possibly beneficial human effects associated with experiencing natural environments. These factors help to account for the current embryonic state of much biophilia-related research. Only limited beginnings have been made in investigating certain issues that might have considerable scientific and social significance, such as identifying the human benefits or values that could be lost when natural areas are eliminated.

These obstacles notwithstanding, scientific research on certain aspects of positive responding to natural environments has gradually expanded and improved over the last two decades, especially in the area of aesthetic preferences for landscapes. As will be evident from the empirical findings surveyed in later sections, certain consistent cross-cultural patterns in aesthetic preferences provide circumstantial support for the hypothesis that biophilia has a partly genetic basis. Without studies directly testing the genetic hypothesis and the preparedness notion (such as conditioning experiments), however, the conceptual propositions advanced here regarding biophilia are necessarily more speculative and general than those proposed for biophobia.

Broadly speaking, the conceptual arguments advanced here represent the second half of a "symmetric" biophobia / biophilia framework that assigns major importance to biologically prepared learning. Regarding biophilia, the basic proposition is that certain rewards or advantages associated with natural settings during evolution were so critical for survival as to favor the selection of individuals with a disposition to acquire, and then retain, various adaptive positive / approach responses to unthreatening natural configurations and elements. From this it follows that as a remnant of evolution, modern humans might have a biologically prepared readiness to learn and persistently retain certain positive responses to nature but reveal no such preparedness for urban or modern elements and configurations. This implies that one general approach for scientifically evaluating aspects of the biophilia hypothesis is to investigate possible differential characteristics of positive responsiveness to natural settings and stimuli in contrast to urban or modern environments and stimuli.

It is proposed that biologically prepared learning may play a role in at least three general adaptive positive (biophilic) responses to unthreatening natural landscapes: liking / approach responses; restoration or stress recovery responses; and enhanced high-order cognitive functioning when a person is engaged in a nonurgent task. Although there is considerable research relating to the first type of positive responsiveness—liking / approach—and a limited but growing amount relating to restoration, the presumed role of genetic factors in these two types of biophilic responding has not yet received direct empirical support. The third type of positive response—enhanced high-order cognitive performance—is proposed only tentatively because research to empirically evaluate this response is still in progress. There is no suggestion here that these three types of positive responding represent a comprehensive list of biophilic responses to natural environments. Research on biophilia is at an early stage, and future studies may well reveal other important types of positive responding.

Liking/Approach Responses

It is suggested here that humans have a partly genetic predisposition to readily acquire and then persistently retain liking/attention/approach responses to natural elements and configurations that favored survival because they were associated with primary necessities such as food, water, and security. Orians (1980, 1986) has provided a convincing explanation why *savanna* environments, compared to other habitats such as rain forests and deserts, had major advantages for early humans from the standpoint of providing much more favorable combinations of these primary necessities. (See also Chapter 4 in this volume.) These points are consistent with considerable evidence indicating that much of human evolution took place in savannas. Open savannas were better suited than other habitats to early humans having upright posture, bipedal locomotion, and free-swinging arms. (For an overview of anthropological research on these issues see Lumsden and Wilson 1983.) Compared to the rain forest, savannas offered more abundant plant and animal food for ground-dwelling humans as well as lower risk because of visual openness, escape opportunities (Appleton 1975; Chapter 4), surveillance (Appleton 1975), and lower probabilities of encountering close hidden predatory threats. Put in terms of the earlier discussion of biophobia, most savannas in comparison to rain forests were characterized by lower levels of *biophobic* properties, including less spatial enclosure and fewer close encounters with snakes, spiders, and other fear-relevant stimuli. In view of these important survival-related advantages, Orians (1980), Appleton (1975), and others have proposed that modern humans retain a partly genetic predisposition to like or visually prefer natural settings having savanna-like or parklike properties such as spatial openness, scattered trees or small groupings of trees, and relatively uniform grassy ground surfaces. As suggested in the earlier discussion of biophobia, humans might also be biologically prepared to acquire a persistent posture of cautiousness (but not strong fear/avoidance or dislike) toward savannas in association with a presumably infrequent threat-related episode in a spatially open setting. Although such an episode might "unforgettably" temper a person's liking responses to open scenes, the person should still prefer open savanna-like environments to spatially restricted settings.

A functional-evolutionary perspective further implies that people should respond positively to natural settings having water and spatial openness. There is considerable evidence from excavations in East Africa that even early hominids often located their camps at the edge of water (Leakey 1980; Brown et al. 1985). The survival-related advantages would have included immediate availability of drinking water, security and defense advantages, attraction of animals that could be hunted, and in some locations (seacoast, estuary, salmon river) extremely high food productivity associated with fish, shellfish, and crustaceans. Coss and Moore (1990) have argued that the capacity to find drinking water has acted as a major source of selection during evolution. Accordingly both modern children and adults evidence strong preferences for scenes with water and are sensitive to certain optical properties of water in landscapes, especially glossiness.

A more general functional-evolutionary prediction is that certain broad classes of natural elements—especially water, green vegetation, and flowers—should be visually preferred over most modern synthetic elements such as glass and concrete (Ulrich 1983; Kaplan and Kaplan 1989). These natural elements should tend to elicit liking and attention because throughout evolution they have directly and indirectly signaled either the certain presence or the likelihood of finding two survival necessities: water and food. Regarding vegetation, preferences should tend to be higher for settings having green or somewhat verdant vegetation in contrast to vegetation having colors and forms characteristic of arid or desert environments where food and water would be harder to find.

Research Findings

During the last twenty years a large research literature, running to hundreds of studies internationally, has focused on affective responses to natural and urban landscapes. (For reviews or collections of articles see Zube, Brush, and Fabos 1975; Daniel and Vining 1983; Ulrich 1983, 1986a; Smardon 1988; Kaplan and Kaplan 1989; Nasar 1988; Ribe 1989.) Nearly all these studies have obtained data using affective or emotion-laden rating scales;

among the most common have been preference (liking), pleasantness, and scenic beauty. Findings obtained from these and other verbal scales usually are highly correlated (see Zube, Pitt, and Anderson 1975).

The vast majority of studies have exposed people to *simulations* of landscape scenes, usually color slides or photographs, rather than to real environments. Several studies have assessed the validity of using slides and other simulations by comparing on-site ratings of real scenes with responses to simulations of the same settings. Whereas most studies have found that on-site ratings of settings that are static correlate highly with ratings of color slides, the validity issue has not been fully resolved. (See, for example, Taylor, Zube, and Sell 1987; Hull and Stewart 1992.)

In accord with the conceptual arguments outlined above, several studies of liking/preference for diverse samples of *unspectacular* natural scenes have found that European, North American, and Asian adult groups consistently respond with high liking to environments that are savanna-like or parklike in appearance. (See Rabinowitz and Coughlin 1970; Ulrich 1977, 1983; Ruiz and Bernáldez 1982; Hultman 1983; Yi 1992.) Such savanna-like views, which can be located in rural areas, urban fringe locations, or even cities (as in parts of New York City's Central Park), are typically characterized by moderate to high depth or openness, relatively smooth or uniform-length grassy vegetation or ground surfaces, and scattered trees or small groupings of trees. These findings are paralleled by results from a significant research literature that has focused specifically on liking/preference responses to forest landscapes. (For a review see Ribe 1989.) Many studies carried out in different countries have clearly indicated that observers prefer forest settings having some similarities to savanna-like or parklike settings, including visual openness and uniform ground cover associated with large-diameter mature trees and relatively small amounts of slash and downed wood. (See, for example, Daniel and Boster 1976; Arthur 1977; Patey and Evans 1979; Savolainen and Kellomäki 1984.)

Another reliable finding consonant with the earlier conceptual arguments is that natural settings with water features elicit especially high levels of liking or preference. (See Shafer, Hamilton, and Schmidt 1969; Brush and Shafer 1975; Civco 1979; Penning-Rowsell 1979; Bernáldez, Abelló, and Gallardo 1989; Chokor and Mene 1992.) It should be noted that young children show strong positive responses to water (Zube, Pitt, and Evans 1983). There is considerable empirical evidence to support the conclusion of Zube and his colleagues that water is a dominant element of the visual landscape that nearly always enhances positive responding (Zube, Pitt, and Anderson 1975)—unless the water configuration involves risk (a stormy sea) or contains clearly visible pollution (Ulrich 1983; Lang and Greenwald 1987).

By contrast, some of the properties consistently associated with *low* preference for natural settings include sharply restricted depth as well as disordered high complexity and rough ground textures that obstruct movement (such as a forest setting with small, closely spaced trees, large amounts of slash or downed wood, and a visually impenetrable dense understory). In this regard, Chokor and Mene (1992) found that diverse groups of urban and rural dwellers in Nigeria accorded lower preference to a spatially restricted view of dense tropical rain forest than to more spatially open rain forest scenes. In the case of temperate or northern forest environments, clear-cut areas are very much less preferred by North American and European groups than large-diameter tree stands affording some visual openness. (See, for example, Rutherford and Shafer 1969; Daniel and Boster 1976; Echelberger 1979; Hultman 1983; Savolainen and Kellomäki 1984; Ribe 1989.) Likewise, Chokor and Mene's Nigerian research (1992) found that people responded with low preference to a natural landscape with large areas of vegetation destroyed by oil exploration activities. Another characteristic that can sharply reduce liking in natural physical environments is the presence of a judged threat or risk (Ulrich 1983). But certain people such as sensation-seekers (Zuckerman, Ulrich, and McLaughlin 1993), including many young males (Bernáldez, Abelló, and Gallardo 1989), may respond somewhat positively or with less dislike to risk-evoking properties or to characteristics appraised as challenging (abrupt terrain, turbulent water).

Extent of Agreement on Liking / Preference

Scientific studies on landscape preferences began to appear about 1970 in various social science and design disciplines that have traditionally emphasized learning and culture as preeminent determinants of human preference, thought, and behavior. Because learning was assumed to be the key mechanism shaping responses to landscapes, it was widely anticipated that studies would reveal great differences between groups and individuals in preferences for natural landscapes as a function of such variables as rural versus urban background and especially culture. Although some studies have reported statistically significant variations as a function of variables such as age (Zube, Pitt, and Evans 1983), ethnicity, and the sensation-seeking personality trait (Zuckerman, Ulrich, and McLaughlin 1993), these differences usually are small compared to the percentage of variance associated with group similarities, which in turn can be related to physical properties of the landscapes. Accordingly, on balance, the pattern of findings that has emerged over the last two decades runs directly counter to the initial expectation of wide differences as a function of learning or experience-related variables. The overarching conclusion supported by this large body of research is that similarities in responses to natural scenes usually far outweigh the differences across individuals, groups, and diverse European, North American, and Asian cultures. (See, for example, Shafer and Tooby 1973; Daniel and Boster 1976; Ulrich 1977; Wellman and Buhyoff 1980; Hull and Revell 1989.)

As an example, a recent study by Yi (1992) investigated the roles of cultural and occupational differences in influencing the natural landscape preferences of diverse groups of South Koreans and Texans, including farmers, ranchers, and nonfarmer urban groups. Individuals were shown a collection of color photographs depicting diverse natural settings in Korea and Texas. The collection included several scenes from Korea and Texas that contained features having strongly positive associations for one of the cultures but not the other—for example, a Korean landscape with a distinctive mountain known to Koreans but not Texans as the site of a famous Buddhist temple. Despite stacking the deck in this manner in favor of cultural influences, Yi's results reveal high agreement among all groups in their aesthetic preferences. Differences attributable to culture and occupation were statistically significant but comparatively minor, accounting for little of the variance. It should be mentioned that the groups were similar in according especially high preference to landscapes having water features or savanna-like characteristics.

A few studies have compared diverse groups or cultures with respect to preferences for *living* in diverse natural landscapes depicted by slides or photographs. Compared to affect-saturated aesthetic preferences, ratings of living preferences probably involve more deliberate cognition or evaluation and, accordingly, should be more strongly influenced by personal experience and other learning. Not surprisingly, some of this research has found comparatively wide variations between different cultures in preferred environments for living (Sonnenfeld 1967). In a study of living preferences that is particularly relevant to the biophilia hypothesis, Balling and Falk (1982) displayed color photographs of diverse natural biomes to American groups that ranged widely in age from young children to adults. Their findings indicate that the most preferred environment for the youngest children in the study (ages seven and eight) was the savanna.

Aesthetic Preferences for Natural vs. Urban Scenes

Findings from scores of studies on preferences for natural versus urban scenes have provided a pattern of circumstantial yet persuasive support for the genetic aspect of the biophilia hypothesis. A clear-cut finding in this research is a strong tendency for diverse European, North American, and Asian groups to prefer natural landscape scenes over urban or built views, especially when the latter lack natural content such as vegetation and water. (See, for example, Kaplan, Kaplan, and Wendt 1972; Zube, Pitt, and Anderson 1975; Wohlwill 1976, 1983; Bernáldez and Parra 1979; Ulrich and Addoms 1981; Hull and Revell 1989.) Even mediocre natural scenes consistently receive higher ratings than do all but a very small percentage of unblighted built settings lacking nature. Levels of preference for natural settings are usually so much higher than for urban views that the distributions of scores for the two domains hardly overlap (Kaplan, Kaplan, and Wendt 1972; Ulrich 1983). This pattern is evident even in a study that compared aesthetic liking for undistinguished natural scenes and comparatively attractive Scandinavian townscapes (Ulrich 1981). Similarly, a study by Chokor and Mene (1992) of landscape preferences in a developing nation—Nigeria—found that diverse groups of urban and rural dwellers responded with higher preference to natural scenes than to various urban scenes lacking nature. In the same study, however, a suburban scene largely dominated by natural content (large trees, flowerbeds, verdant plants, landscaping) but containing upper-income residences outscored certain comparatively wild landscapes such as a view of a dense rain forest (Chokor and Mene 1992).

Several studies have found that the introduction of certain artificial elements into natural landscapes has strongly detrimental effects on visual preference—for example, electrical transmission towers and power lines, large advertising signs or billboards, and prominent concrete or asphalt road surfaces (see Clamp 1976; Hull and Bishop 1988). Further, a person's aesthetic preferences for natural landscapes can be strongly and negatively affected by urban air pollution that discolors the atmosphere in the natural area, degrades visual detail, reduces visual range, and in some instances kills or stunts vegetation, thereby altering the landscape's appearance and perhaps reducing biodiversity (Latimer, Hogo, and Daniel 1981).

This general area of research has also provided strong evidence that people respond in fundamentally different ways to natural versus built contents and settings, irrespective of other visual properties such as depth and complexity. Many studies employing multivariate procedures such as multidimensional scaling or factor analysis have suggested that natural versus built features have a central role in influencing perception and categorization of outdoor environments. (See Kaplan, Kaplan, and Wendt 1972; Ward 1977; Wohlwill 1983.) These methods have shown that for groups studied in different countries, natural versus built groupings of landscape scenes typically emerge as prominent dimensions when affective ratings are obtained for diverse samples of views. This research has also shed light on the visual configurations and elements that people respond to as "natural." In this regard, the "natural" domain appears to be broad for people in industrialized societies, extending considerably beyond wilderness to include many obviously human-made settings such as pastures, fields planted in cereal crops, wooded parks, and even golf courses. In very general terms, European, North American, and Japanese adult groups tend to respond to scenes as natural if the landscape is predominantly vegetation, water, and mountains, if artificial features such as buildings, automobiles, and advertising signs are absent or inconspicuous, and if the dominant visual contours or edges are curvilinear or irregular rather than starkly rectilinear or regular. (See Ródenas, Sancho-Royo, and Bernáldez 1975; Ulrich 1983, 1986a; Wohlwill 1983.)

Several studies performed in the United States, Europe, Japan, and to a limited extent Africa have compared aesthetic preferences for urban scenes with and without natural elements. Most of this work has focused on the preference effects of trees and other vegetation in urban or built environments. In general, findings have shown that people usually accord higher liking to urban scenes containing nature than to similar urban settings lacking nature. (For surveys of studies see Ulrich 1986a; Smardon 1988; Schroeder 1989.) For instance, the presence of trees and associated vegetation substantially increases liking for such urban settings as residential areas and streets, commercial streets and strips, and parking lots. (See, for example, Nasar 1983; Schroeder and Cannon 1983; Anderson and Schroeder 1983; Asakawa 1984; Lambe and Smardon 1986; Sheets and Manzer 1991; Chokor and Mene 1992.) Several investigators have found that urban parks having savanna-like characteristics are especially preferred visual amenities in urban areas. (See Ulrich and Addoms 1981; Herzog, Kaplan, and Kaplan 1982.) Likewise, Kennedy (1989) reports that even long-term residents of the desert city of Tucson accorded high preference to scenes with separated trees, smooth grassy ground textures, and other savanna-like qualities. In the same study, Kennedy found that Tucson residents accorded higher preference to settings containing green, comparatively verdant vegetation than to scenes with cacti and brownish desert vegetation. In certain urban areas where crime is a major problem, learned fear/risk associations intensify negative responding to settings having dense foreground vegetation that blocks surveillance (Schroeder and Anderson 1984; Hull and Harvey 1989).

Implications for the Biophilia Hypothesis

The large research literature on aesthetic preferences for landscapes offers strong direct support for part of the biophilia hypothesis in the sense that diverse groups and cultures have been found to respond positively to unthreatening natural settings. Moreover, the main findings in this area are broadly compatible with the proposition that biophilia may have a partly genetic basis, although the support is indirect or circumstantial. Consistent with an adaptive-evolutionary perspective, the findings reveal a convincing pattern of positive responsiveness to certain natural settings (savanna-like environments, settings with water) that presumably offered major survival advantages for early humans from the standpoint of providing favorable combinations of such primary necessities as food, water, and security. A few studies have converged in reporting that high preferences for savanna-like scenes and water are evident in young children. Moreover, diverse groups and cultures reflect agreement in responding with lower liking to natural environments that would have been less favorable during evolution because of lower availability of food and water as well as greater exposure to ***biophobic*** or risk-relevant properties. There are other salient findings consistent with aspects of the biophilia hypothesis: the strong tendency across different groups and cultures to prefer unspectacular or even mediocre natural scenes over urban settings lacking nature; the pattern for certain broad classes of natural content (vegetation, water) to elicit more positive responses than artificial contents; and the central role that natural versus human-made content appears to play in perceptual categorization of physical environments.

Despite the convincing pattern of evidence indicating positive responsiveness to certain natural settings that would have favored survival during evolution, this research offers at best indirect support for the notion that biophilia may have a partly genetic basis. Some caution in interpreting the findings is warranted in part because of limited data for non-Western cultures. Moreover, the methods used in landscape preference research are inadequate for clarifying the possible role of genetic factors. In this regard, alternative explanations for the findings cannot be convincingly ruled out—such as the argument that learning experiences might be much more similar across different groups and cultures than the anthropological literature suggests. Nonetheless, in the face of steadily mounting evidence that there may be considerable correspondence across Western and some non-Western cultures in terms of positive aesthetic responsiveness to natural landscapes, cultural and other learning-based perspectives increasingly show clear weaknesses. Arguably, the overall record of findings on landscape preferences is more plausibly reconcilable with a conceptual perspective that encompasses both learned and genetic influences than with an exclusively learning-based explanation.

Daily living for early humans was no extended picnic in a serene pastoral environment. It involved fatiguing and often demanding activities to obtain the necessities for survival and sometimes involved stressful encounters with threats. As the earlier discussion of biophobia emphasized, predators were a critical threat. Other risks and stressful episodes were linked directly or indirectly to the physical environment (encountering a violent storm, getting lost, not finding water). Additional stressful situations may have arisen frequently because of aggressive encounters with other humans related to establishing dominance hierarchies and social order (Öhman 1986) and in some instances because of hostile conflicts with other human groups (Chagnon 1977).

Functional-Evolutionary Perspectives

These comments imply that acquiring a capacity for restorative responding to certain natural settings had major advantages for early humans including, for instance, fostering the recharge of physical energy, rapid attenuation of stress responses following an encounter with a dangerous threat, and perhaps rapid reduction of aggression following antagonistic contacts with other humans (Ulrich et al. 1991). In this perspective, one key function of the restorative category of biophilic responses can be characterized as compensatory. That is, a capacity for restorative responding would enhance survival chances in part because of its role in promoting recovery from fatigue and other deleterious effects stemming from behaving adaptively in a previous demanding situation. In this view, restorative responding would have allowed early humans to regain the capacity to respond effectively in a subsequent situation.

To illustrate this line of reasoning, consider the somewhat extreme example of a savanna-dwelling early human who encounters a dangerous carnivore, is pursued by the animal, and escapes by climbing a tree. Following the theoretical arguments of a framework set out in detail elsewhere (Ulrich 1983; Ulrich et al. 1991), it is proposed that a critical part of the individual's initial level of responding would be a quick-onset emotional reaction comprising fear and interest/attention. This rapid-onset emotional reaction would have major influences on subsequent conscious processing and play a central role in initiating adaptive mobilization in physiological systems (such as the autonomic, neuroendocrine, skeletomuscular) and in very quickly motivating appropriate avoidance or flight behavior (Ulrich et al. 1991). The immediate benefit to the individual would be great (survival), but there would also be costs evident in, among other response modes, a strongly negative emotional state and energy-draining physiological mobilization or arousal. If the predator left the area and the threat dissipated, the theory suggests that the adaptive compensatory need would be for restoration—a "breather" from stress (Ulrich 1983; Ulrich et al. 1991). In this example, the several benefits of restoration would include, for instance, a shift toward a more positively toned emotional state, mitigation of deleterious effects of physiological mobilization (reduced blood pressure, lower levels of circulating stress hormones), and the recharging of energy expended in the physiological arousal and behavior. This recharging of energy could in turn be important, for example, in sustaining activities to exploit food, water, or other advantages of the area. Further, because responding to fatiguing challenges or stressors is sometimes accompanied by persistent declines in cognitive functioning or performance (Glass and Singer 1972; Hockey 1983), restoration could be evident in gains in cognitive performance (Kaplan and Kaplan 1989; Hartig, Mang, and Evans 1991).

Among the components of an adaptive constellation of restorative responses in many contexts should be attention/interest to the natural setting accompanied by liking or increased levels of positive affects, reduced levels of negatively toned feelings such as fear and anger, and reductions in physiological arousal (such as sympathetic nervous system activity) from high levels to more moderate ranges (Ulrich 1979, 1981, 1983). Following a functional-evolutionary perspective, it can also be predicted that such restoration should occur fairly rapidly—often within minutes rather than several hours, depending on the intensity and duration of the demanding situation and associated stress response (Ulrich et al. 1991). Because of the major advantages for early humans of restorative responding, it is proposed that modern humans might have a biologically prepared readiness to acquire, and then retain, restorative responses to many unthreatening natural settings but reveal no such prepared responsiveness for most urban or built elements and configurations.

Although most natural scenes should tend to be more effective than most built settings or modern stimuli in fostering restoration, certain natural settings should not be relaxing. A setting that contains a biophobic stimulus such as a snake, for instance, should elicit fear/avoidance responding that is stressful rather than restorative. On the other hand, properties linked with security or low risk should be characteristic of natural visual settings that are effective in producing restoration. Some of these security-related properties may include spatial openness, calm or slowly moving water, and conceivably a small contained fire. (It is perhaps justified to speculate that the safety and other advantages of a campfire for early humans were sufficiently critical to favor individuals with a predisposition to respond to such stimuli with attention, liking/approach, and restoration.) Along with security, perhaps restoration would be fostered by settings associated with comparatively high availability of food and water (savanna-like settings, for example). It seems warranted to speculate that for early humans this property might have contributed to restoration in part because there would be less anxiety about what would be eaten tomorrow.

Stress-Reducing Effects of Outdoor Recreation

Although stress can be defined in a number of ways, here it is construed as the process by which a person responds psychologically, physiologically, and often with behavior, to a situation that is demanding or threatens well-being (Evans and Cohen 1987). Whereas certain short-term, mildly stressful situations can sometimes improve human performance (Hockey 1983), stress is interpreted here mainly as a negative condition that should be mitigated over time to prevent detrimental effects on psychological well-being, performance, and health. Although the terms *stress recovery* and *restoration* are used interchangeably, restoration is a broader concept that is not limited to stress recovery situations or to recovery from excessive physiological arousal and negatively toned emotional "excitement" (anxiety), but could also refer to recuperation from understimulation or prolonged boredom (Ulrich 1981, 1983; Ulrich et al. 1991).

A large body of research on recreational experiences has shown convincingly that leisure activities in natural settings are important for helping people cope with stress as well as in meeting other needs unrelated to stress. Findings from more than 100 studies of recreationists in wilderness areas have shown that stress reduction consistently emerges as one of the key perceived benefits. (For surveys see Knopf 1987; Ulrich, Dimberg, and Driver 1991.) Similarly, most studies on urban parks and other urban natural settings have found that restoration from stress is a key perceived benefit (Ulrich and Addoms 1981; R. Kaplan 1983; Schroeder 1989). Although this research offers strong evidence that outdoor recreation fosters restoration, the role of the natural environment per se has not been clarified. Recreation experiences are usually complex, and it is difficult to disentangle the stress-mitigating contribution of the natural environment from the effects of other mechanisms such as physical exercise. Moreover, the extent to which restorative effects may hold across diverse groups of people is clouded in many studies because of the use of self-selected samples of recreationists.

Nonetheless, there are indications in some recreation studies that part of the restoration benefit stems from exposure to natural surroundings (Ulrich and Parsons 1992). These findings tend to confirm the earlier conceptual argument that certain natural configurations and elements are more effective than others in eliciting restoration. Specifically, recreationists tend to report such states as "relaxation" and "peacefulness" in association with exposure to settings having savanna-like properties or a water feature. In this regard, a few park studies have found significant associations between stress mitigation ratings and questionnaire items relating to an area's savanna-like appearance and natural content—scattered trees, grass, open space (Ulrich and Addoms 1981). Schroeder (1986) has found that the most common feelings reported by visitors to the Morton Arboretum near Chicago were tranquillity or serenity, feelings most often linked to experiences with areas having openness, lush vegetation, and large trees. A Swedish study of a wide variety of park types found that diverse groups of users responded to savanna-like settings, including those with water, as "peaceful" (Grahn 1991).

Hartig and his associates have reported the restorative effects of experiencing a parklike nature area while controlling for certain stress-reducing variables such as physical exercise (Hartig, Mang, and Evans 1991). They first produced stress in individuals with a demanding cognitive task and then measured recovery effects of either (1) a forty-minute walk in an urban fringe nature area dominated by trees and other vegetation, (2) walking for an equivalent period in a comparatively attractive, safe urban area, or (3) reading magazines or listening to music for forty minutes. Their findings suggest that people randomly assigned to the nature walk reported more positively toned emotional states than those assigned to the other two conditions—and performed better on a cognitive task (proofreading).

Using quite a different approach, Francis and Cooper-Marcus (1991) studied a sample of university students living in the San Francisco area to ascertain the settings they sought out when they felt stressed or depressed. A considerable majority of them (75 percent) cited outdoor places that were either natural environments or urban settings dominated by natural elements or configurations (such as wooded urban parks, places offering scenic views of a natural landscape, locations at the edge of water such as lakes or the ocean).

Restorative Effects of Viewing Natural Settings

Direct evidence of the restorative influence of natural settings has come from a few studies that have analyzed the effects on stressed individuals of viewing different outdoor scenes. Consistent with the functional-evolutionary perspective outlined earlier, these findings suggest that viewing unthreatening natural landscapes tends to promote faster and more complete restoration from stress than does viewing unblighted urban or built environments lacking nature. Some of this research has controlled for the possible effects of relatively content-independent visual properties of outdoor settings (complexity, information rate, depth), and accordingly it appears that differences in natural versus human-made contents play a role in the differential restoration influences reported. In general, this small but growing area of research suggests that biophilic responding to natural landscapes extends far beyond aesthetic preference or liking to include broadly positive shifts in emotional states and positive changes in activity levels in physiological systems.

One early restoration study focused on groups of American university students who were experiencing mild stress because of a challenging final exam (Ulrich 1979). A self-rating questionnaire was used to assess stress recovery associated with either viewing a diverse sample of color slides of rather ordinary rural natural settings dominated by green vegetation (no savanna-like settings were included) or exposure to unblighted urban views lacking natural elements such as trees and water. The findings suggest that the undistinguished natural views held the subjects' attention more effectively and fostered greater psychological restoration—indicated by greater reductions in negative feelings such as fear and anger/aggression and much greater increases in positive affects. Honeyman (1992) has replicated this study with the addition of a third recovery condition consisting of urban scenes containing prominent vegetation. Her results suggest that these urban settings produced more recovery than the urban scenes lacking nature. In a study performed in Sweden using *unstressed* university students (Ulrich 1981), self-rating data similarly suggest that everyday natural scenes held the subjects' attention more effectively through a lengthy viewing session and produced more positively toned emotional states than did Scandinavian townscapes lacking nature. Importantly, these self-rating findings were broadly convergent with results obtained in the same study by recording brain electrical activity (EEG) in the alpha frequency range. These electrocortical data suggest that people were more wakefully relaxed during exposure to the natural landscapes. Sheets and Manzer (1991) also used unstressed subjects in an investigation of emotional responses and cognitive appraisals of American urban street scenes with and without prominent trees and other landscaping. Their results suggest that the presence of vegetation subtantially and positively changed responses to street views and that higher levels of positively toned feelings were reported during exposure to scenes with vegetation. Herzog and Bosley (1992) found that a group of unstressed American students' affective appraisals of landscapes for "tranquillity" were highest for scenes depicting large bodies of water with relatively calm surfaces. (Savanna-like scenes were not evaluated in the study.)

In a study that used a number of measurement techniques for assessing the stress-reducing effects of experiencing natural versus urban environments, 120 persons were first shown a stressful movie and then randomly assigned to a recovery condition that consisted of viewing one of six different color/sound videotapes of natural settings or urban environments lacking nature (Ulrich et al. 1991). Data concerning stress recovery during the environmental presentations were obtained from self-ratings of affective states and four physiological measures: heart rate, skin conductance, muscle tension (frontalis), and pulse transit time (a noninvasive measure that correlates highly with systolic blood pressure). Findings from all measures, verbal and physiological, converged in indicating that recuperation from stress was much faster and more thorough when people were exposed to the natural settings (a grassy, parklike landscape and a setting with a prominent water feature). Regarding the self-rating findings, people exposed to the natural settings, in contrast to the urban environments, had much higher levels of positive feelings and lower levels of anger/aggression and fear. In the case of the physiological indicators, greater recovery influences of the natural settings were suggested by lower levels of skin conductance fluctuations, lower blood pressure (longer pulse transit times), and greater reductions in muscle tension. It is noteworthy that there were directionally different cardiac responses to the natural versus urban settings, suggesting that perceptual intake/attention was higher during the exposures to nature. The overall pattern of physiological findings raises the possibility that responses to the natural settings may have had a salient parasympathetic nervous system component. Parasympathetically dominated responding is associated with sustained yet nontaxing perceptual sensitivity with respect to the external environment, as well as restoration or maintenance of bodily resources (Lacey and Lacey 1970). There was no evidence of pronounced parasympathetic involvement during the recovery phase presentations of urban environments. Another finding warranting attention is the rapidity with which restoration occurred during the exposures to nature. After only four to six minutes of exposure to natural versus urban settings, significantly greater recovery was evident in all physiological measures.

The finding that even short-term visual contacts with unthreatening natural landscapes can promote stress recovery has also emerged from a few studies in which acutely stressed patients in health care settings were exposed for short periods, such as ten minutes, to views of nature. In a pilot study by Heerwagen and Orians on patient anxiety in a dental fears clinic (Heerwagen 1990), data that included heart rate measurements as well as affective self-ratings suggest that patients felt less stressed on days when a large mural depicting a spatially open natural landscape was hung on a wall of the waiting room in contrast to days when the wall was blank. Coss (1990) has studied the effects of displaying different ceiling-mounted pictures to acutely stressed patients who were lying on gurneys in a presurgical holding room. His findings suggest that after only three to six minutes, patients exposed to "serene" pictures (primarily displaying water or other aspects of nature) had systolic blood pressure levels that were 10 to 15 points lower than patients exposed to either a control condition of no picture or an aesthetically pleasing "exciting" outdoor scene (such as a sailboard rider leaning into the wind). In a study of patients who were about to undergo dental surgery, Katcher and his associates found that a short period of visual contemplation of a different configuration of nature content—an aquarium with fish—significantly reduced anxiety and discomfort and increased scores for patient compliance during surgery (Katcher, Segal, and Beck 1984).

A preliminary study of the effects of different types of wall art on psychiatric patients in a Swedish hospital has yielded additional insights concerning the positive influence of natural scenes (Ulrich 1986b). Short-term patients, some of whom were clinically anxious, were studied in a ward extensively decorated with paintings and prints reflecting a wide variety of styles and subject matter. Interview data suggest that patients responded positively to wall art dominated by natural content (a rural landscape, a vase of flowers) but tended to react negatively to abstract paintings and prints in which the content was either ambiguous or unintelligible. An analysis of records kept during a fifteen-year period yielded information regarding strongly negative patient responses and actions directed to paintings and prints. These actions included strong complaints to the staff and even physical attacks (such as tearing the picture from the wall and smashing the frame)—dramatic actions given that these patients were considered to be unaggressive and not at all prone to violence. (The ward was not locked.) Seven paintings and prints had been the targets of such attacks, and all of them showed a consistent pattern of abstract content. During the fifteen-year history of the ward, apparently no attack had been directed at a picture depicting nature.

Health-Related Effects of Viewing Natural Scenes

Some of the studies surveyed in the preceding section suggest that short-term exposure to unthreatening natural scenes can promote recovery from mild and even acute stress. Conceivably the restorative effects of natural views are often greatest when people experience high levels of stress or anxiety and are obliged to spend long periods in confined situations such as hospitals, prisons, and certain high-stress work environments (Ulrich 1979). In these and other settings, long-term or frequent views of unthreatening nature may have persistent positive effects on psychological, physiological, and even behavioral components of stress. In time, these effects may be manifested in higher levels of wellness.

In this regard, findings from a few studies of hospitals and prisons suggest that prolonged exposure to window views of nature can have important health-related influences. Prisons and especially hospitals provide some of the best opportunities for scientific research in real environments on the effects of viewing nature, because it is sometimes possible in these settings to control for other variables that influence wellness (such as exercise) and to use a variety of health-related data that are collected as a matter of routine. A study examined patients recovering from gall bladder surgery in a Pennsylvania hospital to evaluate whether assignment to a room with a window view of a natural setting might have therapeutic influences (Ulrich 1984). Recovery data were compared for pairs of patients who were closely matched for variables that could influence recovery such as age, sex, weight, tobacco use, and previous hospitalization. The patients were assigned essentially randomly to rooms that were identical except for window view: one member of each pair overlooked a small stand of deciduous trees; the other had a view of a brown brick wall. Patients with the natural window view had shorter postoperative hospital stays, had far fewer negative comments in nurses' notes ("patient is upset," "needs much encouragement"), and tended to have lower scores for minor postsurgical complications such as persistent headache or nausea requiring medication. Moreover, the wall-view patients required many more injections of potent painkillers, whereas the tree-view patients more frequently received weak oral analgesics such as acetaminophen. Somewhat similarly, findings from a questionnaire study of patients who were severely disabled by accidents or illness (and hence were presumably stressed) suggest that an especially highly preferred category of hospital window views included scenes dominated by natural content (Verderber 1986).

In a prison study, Moore (1982) examined the need for healthcare services by inmates whose cells looked out onto the prison yard versus those who had a view of nearby farmlands and forests. He reported that the inmates with natural views were less likely to report for sick call. Likewise, West (1985) found that cell window views of nature—compared to views of prison walls, buildings, or other prisoners in cells—were associated with lower frequencies of health-related stress symptoms such as headaches and digestive upsets.

In an extension of this line of research, Outi Lundén and I (1990) investigated whether exposure to visual stimulation in hospital intensive care units, including simulated natural views, promotes wellness with respect to the postoperative courses of open-heart surgery patients. At Uppsala University Hospital in Sweden, 166 patients who had undergone open-heart surgery involving a heart pump were randomly assigned to a visual stimulation condition consisting of a nature picture (either an open view with water or a moderately enclosed forest scene), an abstract picture dominated by either curvilinear or rectilinear forms, or a control condition consisting of either a white panel or no picture at all. Our findings suggest that the patients exposed to the open view of water experienced much less postoperative anxiety than the control groups and the groups exposed to the other types of pictures. The comparatively enclosed forest setting with shadowed areas did not reduce anxiety significantly compared to the control conditions. The rectilinear abstract picture was associated with *higher* anxiety than the control conditions. Future reports stemming from this research will present findings based on a wide variety of indicators of wellness, both physiological (such as blood pressure) and behavioral (such as use of painkillers and postsurgical length of stay).

Implications for the Biophilia Hypothesis

Research on recreation experiences in wilderness and urban parks has yielded evidence consistent with the biophilia hypothesis by suggesting that restoration benefits stem at least partly from exposure to natural surroundings. These findings are compatible with earlier conceptual arguments in the sense that restoration tends to be linked especially to natural settings having savanna-like properties or nonturbulent water features. Convincing evidence of restoration has emerged from a smaller body of research that has analyzed the emotional and in some cases physiological effects on stressed and unstressed persons of viewing outdoor environments. This area of research has shown that restorative responding to natural landscapes involves a shift toward a more positively toned emotional state and may include positive changes in physiological activity. These changes tend to be accompanied by sustained attention or perceptual intake that may block or reduce stressful or worrisome thoughts. Findings from a few studies suggest that in certain prolonged high-stress situations, restorative biophilic responding may include important health-related influences.

Restorative or stress-reducing responses to natural scenes have a number of characteristics consistent with the functional-evolutionary perspective outlined earlier. These features, which presumably have been exceedingly adaptive during human evolution, include the quickness of recovery influences, effective reduction of negatively toned affects such as fear and aggression, reduction of taxing and deleterious sympathetic nervous system mobilization (such as reduced blood pressure), and the possibility of pronounced parasympathetic nervous system involvement that would be associated with the maintenance or recharging of energy. Another finding consistent with the functional-evolutionary perspective is that unthreatening natural settings foster more complete and faster stress recovery than built or modern settings lacking nature. Moreover, the conceptual arguments are reconcilable with indications from a few studies that spatially open natural settings, including those with savanna-like properties or relatively calm water, are more effective in eliciting restorative responding than natural settings having properties associated with lower security, such as low depth.

These findings are also broadly consonant with the proposition that restorative responding to unthreatening natural landscapes might have a partly genetic basis. It should be mentioned that one influential theoretical perspective in psychology—arousal or stimulation theory (Berlyne 1971; Mehrabian and Russell 1974)—has been directly tested as an alternative explanation for the restorative effects of nature and found to have major shortcomings (Ulrich 1981; Ulrich et al. 1991). And on the basis of limited evidence from analysis of cardiac responses, it does not appear that restorative influences stem from an elaborated, active process of cognition entailing positive associations or memories with respect to natural environments (Ulrich et al. 1991). Additionally, certain cultural and other learning-based arguments—such as those which take into account presumed positive conditioning effects of media advertising for automobiles, retail stores, and other modern elements—are difficult to reconcile with the findings suggesting greater restorative effects of natural compared to urban settings. This area of biophilia research is still at an early stage of development, however, and findings are too sparse to cast serious doubt on certain other learning-based explanations. In this embryonic area there is a conspicuous lack of research on different cultures, diverse demographic groups, and young children. More fundamentally, no study has yet used a conditioning approach to test the prepared learning hypothesis, nor has any research employed behavior-genetic methods that would enable a comparatively direct evaluation of whether genetic factors play a role in restorative responding to nature.

Effects on High-Order Cognitive Functioning

It has been known for decades that the negative manifestations of stress can include reduced performance on cognitive tasks (Glass and Singer 1972; Hockey 1983). Most studies have investigated performance declines for "low-order" cognitive tasks such as proofreading that require narrowly focused attention to a restricted set of information and do not involve the integration of diverse information. As might be expected, this research has also shown that recovery from stress can be accompanied by gains in performance on low-order tasks. Concerning nature and cognitive performance, the influential nineteenth-century landscape architect and planner Frederick Law Olmsted wrote presciently about his intuitive conviction that viewing nature could produce stress recovery and lead to restored mental performance or recovery from mental fatigue (1865). Somewhat similarly, R. and S. Kaplan (1989; R. Kaplan and Talbot 1983) have speculated that exposure to nature can promote recovery from mental fatigue stemming from work situations involving prolonged, directed, effortful attention. A study by Hartig and his associates suggests that greater restoration from stress fostered by natural versus urban settings is manifested in performance gains for a low-order task, proofreading (Hartig, Mang, and Evans 1991).

Quite apart from performance gains related to recovery from stress and fatigue, it is proposed tentatively that because of critical survival-related advantages during evolution, humans might have a partly genetic predisposition for enhanced *high-order* cognitive functioning when engaged in nonurgent tasks (such as toolmaking) in certain natural settings. "Higher-order" cognitive functioning involves integrating diverse material or associating in a flexible way previously unrelated information or concepts. Higher-order functioning is required for forming remote associations and for creative problem solving. Effective associational functioning is widely considered to have a central role in creativity, as reflected in the associational theory of creativity (Mednick 1962). Put simply, this influential theory holds that creativity involves the novel combination of typically unrelated elements.

The notion that exposure to natural settings may enhance high-order cognitive functioning is proposed tentatively as a "candidate" category of biophilic responding. The previous discussions of restorative and liking/approach responding were able to draw on considerable empirical research. As research to evaluate the cognitive integration or creativity hypothesis is still in progress, however, this section will be largely speculative. Despite the lack of relevant empirical evidence, it seems warranted to discuss the conceptual arguments because of their far-reaching implications in terms of possibly justifying substantially higher estimates of the value, both nonmonetary and monetary, of natural environments.

A Functional-Evolutionary Perspective

Many have emphasized that increases in cognitive resources, such as the capacity for long-term memory and language, have been critically advantageous during evolution and have played a central role in the rapid progress of humans and culture. (See, for example, Lumsden and Wilson 1983.) Arguably, along with these and other advances in cognitive capacity, an increased capacity for high-order cognitive functioning or creativity must have been critically important in the progress of humans and culture. An increased ability for flexibly integrating diverse information, for applying previously learned information in effective ways to new situations, and for creative problem solving must have played an absolutely central role in the crescendo of innovation that has driven much of human progress, especially during the last 50,000 years or so. Put differently, in the absence of a capacity for high-order cognitive functioning or creativity, other important advances such as long-term memory, capacity for language, brain specialization, and knowledge transmission through culture together seem inadequate for explaining how so much impressive innovation has occurred through human history: in toolmaking, weapons, hunting strategies, food storage and transport, plant domestication, and so on. Other advances account for the remembering, transmission, and often the application of innovations, but they neither explain creativity nor adequately account for the origin of innovations. Postulating an increased human capacity for high-order cognitive functioning quite plausibly accounts for much technological and other innovation.

Arguably, the advantages of high-order cognitive functioning during evolution have been so critical as to favor the selection of creative individuals. In a hunting and gathering band of early humans, one person capable of advanced creative problem solving and integrative thinking could increase the survival chances for the entire group. Groups with creative members would presumably advance more rapidly and have better survival chances than groups comprised of individuals whose cognitive functions were restricted to low to moderate-order tasks.

If natural selection has favored the development of high-order thinking capabilities in humans generally, what role might natural physical surroundings play both in fostering and perhaps hindering a person's performance on high-order tasks? To answer this question, it is necessary to digress briefly from these functional-evolutionary speculations and discuss cognitive science research showing that one's emotional state has a profound effect on virtually all aspects of thinking, including performance on higher and lower-order tasks. The basic underlying argument, proposed recently by a colleague of mine (L. G. Tassinary, pers. comm., March 1991), is that because certain natural settings have been found to elicit positive emotional states, exposure to such environments may facilitate creative problem solving or high-order cognitive functioning via their ability to alter one's emotional state.

Effects of Emotional States on Creative Problem Solving

A growing series of studies, notably by Isen and her colleagues, have demonstrated convincingly that positive versus negative emotional states have reliably different effects on the recall of information from memory and on creative problem solving in general. (For a survey see Isen 1990.) Positive emotional states readily cue a diverse range of information with positive associations as well as considerable "neutral" information or associations. Negatively toned feelings are much less effective in cuing the recall of information. Negative emotions such as sadness cue a comparatively small amount of negative—but not neutral—information that has little connection with other information (Isen 1985).

A second important finding regarding positive emotional states is that in addition to cuing the retrieval of much larger amounts of better-interconnected information, positive feelings in contrast to negative feelings facilitate remote associations, integration, perception of relatedness among different material, and creativity (Isen et al. 1985). Different studies have found that positive feelings significantly increase people's scores on tests of creativity and high-order functioning, whereas negative feelings *lower* performance (Isen 1990). Negative emotions restrict the focus of attention, impede the integration of information, and accordingly hinder creativity. Positive feelings do not, however, appear to increase performance on lower-order tasks that require a narrow focus of attention and rejection of associations. In some cases, positive emotions may actually reduce performance on lower-order tasks.

Nature, Positive Emotional States, and Creativity

As discussed in earlier sections, a growing number of studies have found that unthreatening natural environments are effective in eliciting broadly positive shifts in emotional states among unstressed as well as stressed individuals (Ulrich 1979, 1981; Hartig, Mang, and Evans 1991). These findings, in combination with the cognitive science research just surveyed, suggest the plausible hypothesis that exposure to unthreatening natural environments should facilitate creativity and high-order cognitive functioning in general.

Returning to one of the main functional-evolutionary arguments in the chapter, recall that during human evolution the environments that were preferred and restorative were those that offered abundant primary necessities such as food and water in combination with security. Arguably, such environments would probably also be those in which early humans experienced positive emotional states more frequently and those which allowed more opportunity for focused but nonurgent tasks where creativity was extremely advantageous (as in toolmaking). Perhaps it is not too great a speculation to propose that individuals would have been favored who experienced positive feelings and accordingly were significantly "smarter," in terms of creativity and high-order functioning in general, when they engaged in nonurgent tasks or activities in savanna-like environments, in open settings with nonturbulent water, and conceivably in proximity to a small fire. Perhaps modern humans, as a partly genetic remnant of evolution, tend to have more positive emotional states and accordingly are "smarter" in creative thinking when exposed to most unthreatening natural settings compared to most built environments lacking nature—especially when exposed to natural environments with the features just cited.

If these notions were to receive empirical support in future research, it would then be reasonable to investigate, for instance, whether researchers in high-tech firms might tend to be more creative and hence often more productive in workplaces having, say, extensive window views of a parklike (savanna-like) landscape or a view with a water feature. Likewise, it might be conjectured that these employees would tend to be smarter in creative problem solving on a Monday following a weekend trip in a natural environment that produced lingering positive feelings. Do molecular biologists working at the Salk Institute in La Jolla have better ideas if their windows overlook the Pacific, for instance, or if they take a morning walk on the beach before going to the laboratory? There is anecdotal information suggesting that several Nobel Prize–winning ideas may have occurred to researchers during walks or other contacts with nature. Perhaps a parklike or savanna-like college campus yields benefits that go beyond aesthetic preference and in some cases restoration from stress and fatigue to include the advantage of supporting positive emotional states that facilitate creativity. These speculations aside, I am currently involved in a research project directed by L. G. Tassinary that is investigating the basic hypothesis that exposure to unthreatening natural settings, including savanna-like environments, induces positive shifts in emotional states and accordingly increases scores on an associational test of creativity. Research is needed to determine whether nature is as effective as, or possibly more effective than, other types of positive stimulation or reinforcement (eating a tasty dessert, listening to certain works by Mozart) that have been shown in previous studies to elicit positive feelings and produce *short-term* increases in creativity (Isen 1990). If nature is shown to enhance creativity during short-term exposures, the central issue will then become whether nature scenes are more effective in sustaining higher creativity during experiences of long duration. It seems likely that the creativity enhancement effect fairly soon wears off, for instance, if a worker listens to the same work by Mozart all day. In the event that humans have a partly genetic predisposition for higher creativity when exposed to nature, however, the enhancement effect might not attenuate completely if one's work environment provides visual access to a savanna-like setting or a spatially open nature area with a water feature.

Implications for Nature Valuation

What do the foregoing sections on biophilic responses to natural landscapes imply for the nonmonetary and monetary valuation of nature? A starting point for this discussion is provided by the widely accepted position in valuation and economic theory that to make a sound comprehensive estimate of the social or monetary values of any "good"—whether a public or private good—it is necessary to have information regarding the good's various attributes or dimensions of value (Ulrich 1988). In the case of many natural environments, whether the settings are public or private goods, one can fairly easily define a limited number of economic value attributes and on this basis generate sound estimates concerning certain *short-term* economic benefits that can be realized by eliminating, developing, or exploiting natural resources. Examples of such economic values include revenues derived from clear-cutting old-growth forest in the American Northwest, lease revenues associated with coal strip-mining on wilderness lands, or clear-cutting an area of tropical rain forest, selling the timber, and using the land for pasture.

In sharp contrast to these well-defined short-term economic values, we know little about most of the long-term monetary and nonmonetary values that are lost when natural areas are eliminated or seriously damaged. Many natural environments are goods that almost certainly have numerous important nonmonetary and monetary value attributes about which little information is available and which in many cases have not even been identified, much less measured with any precision (Ulrich 1988). Our present state of knowledge means that neither decision makers nor the public can make well-informed assessments regarding what may likely be large nonmonetary and often monetary value losses that accompany the elimination of nature—losses that may often considerably outweigh the short-term economic gains. If natural environments have values that are not identified—or if they yield important benefits that are not considered in value estimates because they are poorly understood—then it follows that natural environments may be grossly undervalued. In this perspective, research on several important types of biophilic responding should contribute to a deeper understanding of some of the nonmonetary and monetary values of nature and accordingly provide the basis for sounder value estimates that will often be far higher than previous estimates.

In assessing the values of any physical environment, whether natural or urban, it is relevant to evaluate the extent to which substitutes are available that can generate benefits or values similar to those of the environment. If the environment is distinctive, or if substitutes are not readily available, the environment typically will be assigned greater value. The research surveyed in earlier sections on various biophilic responses provides the basis for insights concerning the availability of substitutes for some of the many value attributes of natural environments. In the case of visual or aesthetic preferences, recall that there is a consistent tendency across diverse groups and cultures to prefer even mediocre natural scenes over the vast majority of urban or built views lacking nature. Certain natural views—such as savanna-like scenes and settings with water features—elicit much higher aesthetic liking than nearly all urban landscapes; indeed, only a relative handful of urban views (such as New York City's skyline at night) achieve comparable scores. Hence the overwhelming majority of urban landscapes lacking prominent nature are clearly not substitutes for natural environments from the standpoint of the liking / preference category of biophilic responding. To the extent that natural areas in different countries are eliminated by most forms of urban development, there is a largely nonsubstitutable loss of landscape visual quality or aesthetic preference benefits.

Regarding the substitution issue and restorative biophilic responding, recall that even unspectacular natural settings can promote stress recovery faster and more completely than urban environments lacking nature. During exposure to unthreatening nature, the constellation of restorative responses involves, among other components, a broad shift in feelings toward a more positively toned emotional state, sustained attention or perceptual intake, and positive changes in activity levels in different bodily systems. In terms of the general magnitude of recovery suggested by physiological measures and affective self-ratings (Ulrich et al. 1991), certain nonenvironmental substitutes are available for natural settings. Oral tranquilizers can produce greater relaxation, for instance, although the onset is not as rapid as for exposure to natural views. Moreover, after receiving training in self-relaxation techniques, some people are able to achieve restoration from stress similar to or greater than levels elicited by unspectacular natural environments.

The question of finding substitutes for nature becomes more problematic, however, if consideration is restricted to physical environments (Ulrich 1988). Although research currently is limited to a few studies, the findings intimate that it may prove quite difficult to identify urban settings lacking nature that have stress recovery effects matching those of even everyday natural settings. Irrespective of whether the built or modern content is, for instance, a lively city street or a well-designed architectural facade, it seems unlikely that such visual stimuli will prove to be adequate substitutes for, say, a natural setting with slowly moving water from the standpoint of eliciting a parasympathetically dominated response. Few built or urban settings lacking nature may match the capabilities of most natural landscapes from the standpoint of eliciting a combination of responses that includes positive feelings, sustained yet nontaxing perceptual intake, and recharge or maintenance of energy. If future behavior-genetic studies or other approaches were to show that restorative biophilic responses have a partly genetic basis, then one could expect to find that certain response characteristics are largely unique to natural elements and configurations. Savanna-like views and natural scenes with water, for example, might prove to be consistently more effective than urban or built content in eliciting attention / interest and positive emotional responses that are comparatively sustained or resistant to habituation. Again, if urban scenes are found to be unsatisfactory substitutes with respect to producing restorative influences, then it would often be warranted to assign considerably higher values to natural environments when the issue is the proposed destruction of nature and its replacement with, for instance, urbanization.

Biophilia, Biophobia, and Preservation

There is a growing recognition that the earth is experiencing an unprecedented crisis with respect to the destruction of biodiversity in innumerable ecosystems and geographical areas (Wilson 1992). Among the many issues relevant to preserving biodiversity, the public's emotion-laden attitudes toward different natural environments play a role in motivating political and other support for reducing the destruction of nature and the extinction of living things. The earlier sections on biophilic and biophobic responses imply that it might be comparatively easy to educate or foster positive emotion-saturated attitudes with respect to certain environments. It may be more difficult, however, in the case of the terrestrial environment that is most critical for preserving biodiversity: the tropical rain forest.

Early forms of humans left the rain forest and moved out into the savanna for a number of sound adaptive reasons (Orians 1980, 1986). For a bipedal, ground-dwelling creature with upright posture, savanna environments were much more advantageous than either rain forests or deserts from the standpoint of offering more abundant food and water. Although savannas have much less biodiversity than rain forests, their biomass productivity can be rather high, and this is related to the high productivity of food that is readily accessible to ground-dwelling humans. By contrast, much of the great biodiversity and biomass of tropical rain forests are concentrated in the forest canopy far above the ground, a location that represented a disadvantage for ground-dwelling early humans. In other words, the great biodiversity of rain forests that is so valued today for a number of very important reasons (Wilson 1992) did not represent a correspondingly high survival-related advantage for early humans.

The high biodiversity of rain forests undoubtedly had another drawback for early humans: its association with greater risk because of its higher levels of ***biophobic*** properties, including spatial enclosure and higher probabilities of encountering close hidden threats, including snakes, spiders, and other fear-relevant stimuli. By comparison, most savannas probably were characterized by lower levels of biophobic properties and risk, including much less spatial enclosure, more surveillance and escape opportunities, and fewer close encounters with snakes and other predators. As well, certain diseases may have presented a greater risk in hot moist rain forests than in the drier savannas. On the basis of these arguments, it was proposed early in the chapter that modern humans may retain as a remnant of evolution a partly genetic or biophilic disposition to respond positively to environments with savanna-like properties and to spatially open natural settings with water features. This implies the possibility that it might prove comparatively easy to foster public support for preserving such environments by providing information and visual images that elicit feelings and perhaps emotion-laden attitudes that are distinctly positive and tend to be persistently retained because they are in part genetically primed or biologically prepared.

But this functional-evolutionary perspective also implies that biologically prepared learning may hinder (or at best play a mixed role in) attempts to foster public appreciation for tropical rain forests. One reason is that rain forests lack certain combinations of visual properties, such as spatial openness and uniform grassy ground cover, for which humans might be biologically prepared to acquire and persistently retain positive responses. Another important reason is that visual images and ecological information about rain forests are likely to elicit certain genetically primed *biophobic* responses and possibly affect-saturated attitudes that are negatively toned. Recall that there is convincing evidence that fear / avoidance responses to risk-relevant stimuli such as snakes and spiders are partly genetic and manifested in prepared learning. Accordingly, it seems likely that exposing the public to images of spatial enclosure, creepy-crawly creatures, snakes, or other fear-relevant stimuli may elicit strong attention with respect to tropical rain forests, but the emotional tenor of people's responses, attitudes, and knowledge will often be partly negative. In light of research suggesting a robust genetic role in biophobia, even well-conceived education programs may achieve only limited success in fostering public appreciation of certain risk-relevant properties and living things in the rain forest because of the difficulty in overcoming a biologically prepared disposition to respond negatively.

Attempts to promote public appreciation for tropical rain forests probably will be more successful if visual images and other information about the *biophilic* properties of rain forests are also given prominent attention. These elements include, for instance, verdant vegetation, flowers or blooms, and benign attractive animals such as birds. It would be appropriate to include visual images and other information that clearly depict the environmental harm that accompanies the destruction of rain forests and living things. In this regard, recall that scenes of clear-cut settings or barren deforested areas—including rain forests—are disliked. Views containing dead animals elicit strongly negative emotional responses, even disgust

(Lang and Greenwald 1987). Hence it seems likely that portraying in a vivid but accurate manner the consequences of destroying tropical rain forests could produce strong emotion-saturated public attitudes against such destructive activities.

Research Needs and Promising Directions

E. O. Wilson's biophilia hypothesis can be interpreted as consisting of two broad propositions: first, that humans are characterized by a tendency to respond positively to nature; second, that this disposition has a partly genetic basis. At a very general level, this definition implies two corresponding categories of research needs regarding natural landscapes: studies to increase our understanding of the benefits associated with exposure to natural landscapes and research that tests the proposition that biophilic responses are partly genetic. These two basic research needs represent largely different agendas with respect to the questions addressed and especially the most appropriate research methods. Certain research methods have excellent potential for shedding light on possible health-related benefits of experiencing natural settings, for instance, but are ineffective for investigating the genetic component of the biophilia hypothesis.

The first category of research would involve a program of studies to extend and deepen our understanding of the positive responses cited in this chapter, especially restorative and health-related effects. This direction warrants high priority because of its great promise for identifying key human benefits derived from contact with nature, as well as strengthening the rationale for preserving nature by establishing credible links between natural environments and public health. As an example, one potentially important line of research is suggested by previous findings showing that the stress-reducing effects of viewing natural settings are evident in central nervous system indicators such as blood pressure. These findings make it very likely that future studies will find that restorative or stress-reducing effects are also expressed in the endocrine system as salutary reductions in levels of stress hormones such as cortisol, epinephrine, and perhaps norepinephrine (Parsons 1991; Ulrich et al. 1991; Frankenhaeuser 1980). High levels of circulating stress hormones have a variety of deleterious health-related effects, including suppression of immune system functioning (Parsons 1991; Kennedy, Glaser, and Kiecolt-Glaser 1990). Accordingly, if restorative responses were found to involve the neuroendocrine system, then it could be reasonably anticipated, for instance, that people experiencing stress for a lengthy period would benefit from frequent or prolonged exposure to natural environments with their stress-reducing influences that produce enhanced immune system functioning and hence over time foster higher levels of wellness or health. If a program of future studies were to demonstrate that these stress-reducing influences involve positive physiological changes such as reduced blood pressure, lower levels of stress hormones, and even enhanced immune system function, then in many countries it would be relatively straightforward to reconcile the human benefits of nature contacts with legal interpretations of public health and welfare. In this way the legal system could become a more effective vehicle for preserving natural environments. As an important accompaniment to this general research direction, there is a conspicuous need for studies that examine restorative and health-related benefits across different cultures and diverse demographic groups and among young children. It will also be important to discover which natural environments are especially effective in eliciting restorative or health-related responses.

Broadly speaking, research is needed to identify as yet unknown positive responses to nature. In this regard, the hypothesis that exposure to unthreatening natural settings may enhance creativity and high-order cognitive functioning is plausible and warrants evaluation. If the nature / creativity hypothesis were to receive empirical support, this research direction could evolve toward studies demonstrating that in certain situations natural environments can play an important role in generating significant economic value. For all types of biophilic responses, studies are needed to assess the extent to which biodiversity is related to the effectiveness of natural environments in eliciting positive reactions. Another question that warrants much research attention is whether the positive influences of viewing natural settings (restoration, creativity) are considerably attenuated—or not produced at all—by exposure to seriously damaged natural settings such as clear-cut forests or to urban environments lacking nature. While there is considerable knowledge about this issue in regard to aesthetic preferences, much more research is needed on restorative and health-related responses, as well as possible biophilic responses such as enhanced creativity. If built scenes and degraded natural settings are found to perform poorly in eliciting restorative and other positive responses, then one would often be justified in assigning markedly higher values to preserving nature in many decision-making contexts. As an example, if research indicates that views of old-growth forest stands have stress-mitigating influences that include lower blood pressure and reduced levels of stress hormones but views of clear-cut stands do not have these positive effects, then the potential loss of important public benefits relating to physiological well-being would constitute an argument against clear-cutting.

Finally, an important research issue concerns the effectiveness of *simulations* of natural environments (color photographs, videotapes), compared to real environments, in eliciting restorative and other positive responses. There is evidence that simulations can sometimes be at least partial substitutes for real nature in terms of eliciting short-term aesthetic liking and restoration. Studies are needed to evaluate the extent to which real settings may outperform simulations, for instance, in producing stress recovery during short-term exposure. Might simulations lose much of their effectiveness in long-term exposure contexts? It seems likely that, over a long-term exposure situation, real environments may be much more effective than simulations in sustaining positive responding owing to the ongoing visual changes and multisensory stimulation inherent in real environments (such as vegetation changes associated with seasons).

Research on biophilia is at a relatively early stage of development, and no findings have yet appeared that constitute convincing support for the proposition that positive responding to nature has a partly genetic basis. Perhaps the most persuasive findings currently available are the striking patterns across diverse groups and cultures revealing a preference for everyday natural scenes over urban scenes lacking nature, as well as the especially high preference for certain natural settings that presumably offered major survival-related advantages as habitats for early humans. While more cross-cultural and cross-group studies are needed for a number of reasons, this general approach can at best yield a provocative pattern of circumstantial support regarding the genetic hypothesis. Cross-cultural studies have limitations for resolving the genetic question—not only because of the control problems that typically accompany cross-cultural research, but mainly because such studies have not obtained genetic information which in turn can be linked directly to biophilic responding.

From the standpoint of efficacy and feasibility, behavior-genetic methods may offer the most promising approach for evaluating the genetic hypothesis. This approach to biophilia research would require an interdisciplinary team of investigators; it would be rather costly, but it could take advantage of the excellent twin registers that exist in different countries. Although the application of behavior-genetic methods to biophilia questions would be straightforward in most respects, sound research based on smaller twin samples would require focusing on a response characterized by wide variability among persons. In the case of aesthetic preferences for natural landscapes, the moderate to high similarity that usually characterizes different people's preferences would work against the statistical power of a behavior-genetic approach. This drawback, however, could probably be overcome by using a very large sample of twins. To fully exploit the considerable strengths of behavior-genetic methods, it would be advantageous first to perform studies that identify a biophilic response (or specify a particular aspect of a positive response) which exhibits high variability across individuals. Examples of such variables might include intensity of positive emotional responses, interest, and possibly differential rates of response habituation. It might be possible to develop questionnaires for screening people and assigning them to groups that are likely to vary widely in terms of a certain response. The development of such questionnaires might be based on the work of Kellert and others on group differences in certain emotion-saturated attitudes toward nature (Kellert 1980).

Another research approach that holds promise for addressing the genetic aspect of the biophilia hypothesis is *positive* in contrast to aversive Pavlovian conditioning. This laboratory method could be used to test the proposition that biophilic responses may be manifested in biologically prepared learning. Hence a positive conditioning experiment could evaluate, for instance, whether positive responding is conditioned more readily, and is more resistant to extinction, for certain premodern advantageous natural stimuli such as savanna-like views or settings with water than for neutral premodern stimuli or modern advantageous stimuli. Physiological techniques such as facial electromyography (EMG) could be used to measure the magnitude of conditioned positive emotional responses. Whereas positive conditioning studies hold promise and certainly should be attempted, this approach probably will be less efficacious for investigating biophilia than aversive conditioning has been for biophobia: producing an immediate positive stimulus in the laboratory is more problematic than providing a strong immediate negative stimulus.

A comprehensive program of biophilia research would also include studies of the responses of young children, including infants, to natural stimuli. The field of child development has generated an impressive repertoire of nonverbal methods for measuring responses such as attention/interest and emotions. If very young children are shown slides of unthreatening natural stimuli, abstract stimuli, and modern stimuli that are comparable in information rate, brightness, and perhaps color, do the children evidence, for instance, greater perceptual intake for natural settings? If they do, the findings would constitute more convincing evidence of a partly genetic basis for biophilia than, say, cross-cultural studies of adults. Studies are also needed of children in different age groups—if genetic factors do play a role in biophilic responding, there is a distinct possibility of developmental characteristics in terms of an age-related proneness for acquiring a certain biophilic response. Here it is relevant to note that many other types of human behavior which apparently have a partly biological basis—such as phobias and the appearance of emotions during infancy—have clear age-related onset characteristics. In the event that one is indeed more likely to acquire biophilic responses at a certain age, deprivation of nature learning experiences (lack of direct contact, lack of vicarious learning, inadequate education) during such periods conceivably could be an important factor in the development of adults who are "bio-indifferent."

One other research approach that warrants consideration is the use of a high-resolution PET scanner (positron emission tomography—Druckman and Lacey 1989; Zappulla et al. 1991) to investigate the possible differential location of brain activity during processing of natural versus modern or built stimuli. Compared to the three research approaches discussed here—behavior-genetic, positive conditioning, and studies of young children—PET studies would be more of a long shot from the standpoint of shedding light on the genetic aspect of the biophilia hypothesis. Nonetheless, substantial differences might be found in the location of brain activity (metabolism, blood flow) as a function of viewing different stimuli that could be interpreted as evidence for a biological role in responses to nature. The efficacy of PET studies for addressing the genetic issue could increase if advances in technology are achieved that enable high-resolution scans of deep (and older) brain structures. Irrespective of the genetic issue, PET studies should eventually be performed because they are likely to yield important information regarding responsiveness to natural environments.

If biophilia does have a partly genetic basis, it might be speculated that the genetic contribution is roughly in the range of 20 to 40 percent and will vary for different biophilic responses. Moreover, there might well be age-related or developmental onset characteristics. Certain functional-evolutionary arguments imply the possibility of differences as a function of gender in the role of genetic factors. (Gender differences have not been addressed here because this would entail a discussion of research on a number of topics that are outside the scope of the chapter.) The theoretical propositions advanced here imply that partly genetic biophilic reponses should not appear spontaneously or in the absence of learning; rather, some learning or conditioning is necessary for acquiring biologically prepared positive responsiveness which is then marked by persistent retention. There is certainly no suggestion here that biophilia might be genetic in any deterministic or overriding sense. Learning is required for acquiring a positive response that is only partly predisposed by genetic factors, and the response is modified by conventional learning, experience, and culture.

If a behavioral scientist had argued seriously twenty years ago that humans have a partly genetic predisposition to respond positively to nature, the proposition would have been met with skepticism by most psychologists. Only a few years ago, if a researcher had advanced the theoretical proposition that genetic factors play a salient role in alcoholism among females, for instance, or that infants have a biological or innate capacity for mathematics, the ideas would have been received with derision by many social scientists. Recently, however, the mainstream theoretical orientation of the behavioral and brain sciences has been altered by a cascade of studies showing convincingly that biological or genetic factors play a role not only in alcoholism and math skills but in numerous other aspects of human behavior and response. For many important issues, the debate has shifted from bipolar nature/nurture distinctions to discussion of eclectic perspectives that recognize the crucial roles of both learning and genetics. In several key areas, the main question is no longer whether genetic factors play a role. Rather, the mainstream theoretical and research debate increasingly accepts the role of genetics but asks: is the genetic contribution 20 percent or 50 percent?

Against the background of this profound conceptual shift, the proposition that humans may have a partly genetic predisposition to respond positively to nature now seems plausible to many scientists. Natural settings provided the context of everyday experience throughout human evolution and were the source of critical advantages as well as challenges and risks. To propose that evolution might have left its mark on modern humans in the form of a partly genetic response disposition to nature is at least as plausible as expecting to find, for example, that genetics plays a role in cigarette use or personality. The need to expand our understanding of positive human responsiveness to nature, and to assess the question of its partly genetic basis, represents a major new direction for scientific research—one that can help us to learn more about ourselves as humans, to discover the key benefits that people derive from natural environments, and to gauge the losses in human benefits that result from the destruction of nature.

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