# A Review of the Literature for a Comprehensive Study of Visitor Safety in the National Park System

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By

Seth Tuler, Dominic Golding, and Robert J. Krueger
The George Perkins Marsh Institute
Clark University
Worcester, MA 01610

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# 1.0 Introduction

Social scientists have conducted an enormous amount of research on the causes, consequences, assessment, and management of a broad array of natural and technological hazards over the past 50 years. A large body of research has also developed in relation to leisure activities, including safety. This review will be based on selected social science research relevant to NPS visitor safety and a comprehensive review of research that is directly concerned with NPS visitor safety.

The bulk of this report examines the findings of social scientists on the factors that may contribute to visitor risk, including visitor characteristics, environmental conditions, and infrastructure factors. The report begins with brief discussions of NPS policy on visitor safety and definitions of accidents, hazards, and risk. To highlight the role of factors that contribute to accidents, we present an additional framework from the human factors field. A framework on human-activity "mismatches" extends our understanding of contributory factors, and provides an organizing framework for this review. Subsequent sections of this report summarize five categories of research: individual characteristics, social characteristics, environmental conditions, infrastructure/organizational characteristics, and equipment characteristics. The report concludes with a discussion of hazard management research with a special emphasis on the causal structure of hazards and communication. The report does not examine visitor accident data in the national parks. These data are examined in the report *"An Analysis of Visitor Accident Risk in the National Park System."*

## 2.0 Definitions

Consistent with the mission established in the Organic Act of 1916 (16 U.S.C., Sec. 1), the NPS has established policies, plans, and procedures to promote visitor safety. Management Policy states "The saving of human life will take precedence over all other management activities. The National Park Service and its concessionaires, contractors, and cooperators will seek to provide a safe and healthful environment for visitors and employees" (www.nps.gov/planning/mngmtplc/upvu.html).

In an effort to implement this policy and in response to the Government Performance and Results Act GPRA), the NPS developed the 1997 NPS Strategic Plan (NPS 1997). This establishes Mission Goal IIa2 to reduce the visitor safety incident rate by 10% from the NPS five-year (1992-96) average. Accordingly, each park "will determine their five-year (1992-96) average visitor accident rate, based on 100,000 visitor-days, to determine their baseline for their 10% reduction. Analysis of case incident report files will identify the primary sources of accidents and where the greatest improvements in visitor safety can be made" (NPS 1997, 24). These goals have been incorporated into planning documents for many of the individual NPS units.

Two Director's Orders provide operational policies, practices, and procedures to implement these management directives. Director's Order #83 establishes policies regarding public health and the operations of systems such as water supply, waste management, and food services (NPS 1999a). Director's Order and Reference Manual #50B regarding Risk Management is in the final stages of approval. Most of this document addresses occupational safety and health issues, but section 14 deals with public safety and health. The draft document states

It is the policy of the National Park Service (NPS) to provide for an opportunity for the public to have an enjoyable experience while visiting National Park Service sites. Recognizing that accidents and injuries can compromise that experience, the NPS will provide information on risks in the recreating environment, maintain structures and facilities in safe condition, and generally provide for the safety of the visitor while recognizing our mandated responsibility to protect the resources and natural processes which can be inherently dangerous to the unwary. (NPS 1999b, 34-35)

In none of these documents is visitor safety clearly defined. Rather, "visitor safety" is assumed to refer to visitor accidents and all management activities intended to reduce such accidents. While goals have been established under GPRA, these are administrative targets that do not indicate what level of public risk is considered acceptable or safe. Similarly, there is an assumed distinction between safety (accidents/injuries) and health (illnesses), with an emphasis on safety.

Ordinarily, social scientists distinguish between hazards and risks. Hazards may be considered "threats to humans and what they value" (Hohenemser, Kates, and Slovic 1985, 67), including threats to human health, property, and the environment. They arise from the interactions of physical/natural systems and social (human) systems (Burton et al. 1978). Risks are "quantitative measures of hazard consequences expressed as conditional probabilities of experiencing harm," where harm may range from minor injuries to death (Hohenemser, Kates, and Slovic 1985, 68). For example, the risks of dying from boating have been estimated as 5 in 100,000, based on a total of 27 million people who go boating each year and the 1,300 annual average fatalities that result (Crouch and Wilson 1982).

The Canadian Park Service (CPS) has well-developed programs on visitor risk assessment and management. Drawing on the broad literature on risk, the CPS (1996) used the following definitions:

- **Accident**: An unplanned and uncontrolled event in which the action or reaction of an object, wildlife or person has the potential to cause personal injury or property loss.[1]
- **Hazard**: A source of risk. A condition with the potential for causing an undesirable consequence.
- **Risk**: A measure of the probability and severity of an adverse effect to health, property, or the environment. Risk is often estimated by the mathematical expectation of the consequences of an adverse event (i.e., the product of "probability x consequence"). However, a more general interpretation of risk expresses probability and consequence in non-mathematical terms.

In this project, we will use the term "visitor accident" to refer to an accidental event that arises from the direct use of, or interaction with, park facilities or resources and results in the injury, illness, or death of a visitor (including injuries, illnesses, and deaths resulting from vehicle and marine vessel operation). The treatment a person receives after an accidental event has no

[1] More recently, the CPS has moved away from using the term "accident" because they believe that many injuries and illnesses are predictable and preventable. Public safety occurrences/incidents is now their preferred term. See also Langley 1988.

bearing on the definition of an accident. An injured victim of an accident could, for example, require first aid, immediate transportation to a medical facility, ignore the injury, or treat herself. While some accidents are predictable in a general sense, it is rarely predictable which specific individual will be involved or when.

## 3.0 Taxonomies

Social, physical, and biological scientists have examined an array of hazards over the past 50 years. Although the boundaries are fuzzy, hazards research traditionally distinguishes between natural and technological hazards. Natural hazards may be further subdivided (Burton and Kates1964) into:

- geological/physical hazards (e.g., earthquakes, volcanoes, avalanches, etc.),
- meteorological hazards (e.g., fires, floods, fog, snow, etc.), and
- biological hazards (including floral hazards, such as poison ivy, and fauna hazards, such as snakes, bees, bears, and various viral diseases).

Technological hazards are associated with man-made technologies, such as automobiles, airplanes, and structures such as buildings, bridges, and dams. Technological hazards have been classified in various ways. Most notably they have been classified in terms of their degree of voluntariness (Starr 1969), their catastrophic potential (Litai, Lanning, and Rasmussen 1983), their perceived level of dread and the degree to which their risks are known (Slovic, Fischhoff, and Lichtenstein 1980, Slovic 1987, 1992), and their causal characteristics (Hohenemser, Kates, and Slovic 1985). The literature has also distinguished between hazards that vary in their probability of occurrence and level of consequences (e.g., high probability low consequence events vs. low probability high consequence events).

With substantial input from park personnel, the Canadian Park Service (1996) built on these traditional hazard taxonomies to develop its own classification of hazards unique to national parks (Table 1). This classification distinguishes among:

- natural hazards (e.g., geological, faunal, floral, meteorological, topographical, hydrological, insects and parasites);
- cultural hazards (e.g., historic buildings, ruins, landscapes);
- infrastructure hazards (e.g., trails, dams/weirs, boat ramps/docks, roads, buildings, camp sites, swimming facilities, and operational hazards);
- communication hazards (e.g., inaccurate information); and,
- visitor characteristic hazards (e.g., drugs and alcohol, personal equipment, group dynamics, and individual abilities).

The CPS has also inventoried the risks, safety standards, and guidelines relating to 40 allowable activities, ranging from pleasure driving to mountaineering (Ashley Consulting 1993).

**Table 1.**
**Canadian Park Service classification of hazards**

**Natural and cultural hazards**
- topographical hazards (e.g., steep terrain, glacial features)
- geological hazards (e.g., caves)
- hydrological hazards (e.g., coldwater, thin ice, waterfalls, surf)
- meteorological hazards (e.g., black ice, heat exposures, fog, snow)
- faunal hazards (e.g., wild animals)
- floral hazards ( e.g., tree failure, toxic plants, wildfires)
- insect/parasite and disease hazards (e.g., bees, giardiasis, ticks)
- cultural hazards (e.g., historic buildings and ruins)

**Infrastructural hazards**
- trail hazards (e.g., trail surfaces, support structures)
- road hazards (road surfaces, road designs)
- camping and day use hazards (e.g., water quality, fire pits, waste disposal)
- boat launch and dock hazards (e.g., location, traffic congestion)
- building hazards (e.g., dim lighting)
- swimming hazards (e.g., water quality, congestion)
- water regulatory device hazard (e.g., unsafe dam structures)
- operation hazards (e.g., garbage removal, snow removal, road and trail maintenance)

**Communication hazards**
- text hazards (e.g., information not accurate, information not provided at time)
- sign hazards (e.g., information not accurate, defaced or weathered, inappropriate location)

**Visitor characteristic hazards**
- individual characteristics hazards (e.g., age, education, preparedness)
- personal equipment hazards (e.g., condition of equipment)
- drug/alcohol hazard (e.g., poor judgment, dangerous behavior)

[From Canadian Park Service 1996]

## 3.1 The Activity System

The taxonomies described in the previous section are examples of how the range of hazards that, for example, visitors to national parks may face can be delineated. Additional taxonomies can be developed to describe the factors that contribute to an accident event.

"Human error" is often used as a catch-all term for all unexplained causes of accidents. In the field of human factors, errors are characterized as mismatches between humans and their activities, tasks or machines (Capper 1996, Rasmussen 1982). Mismatches can occur as a result of:

- human variability;
- technical variability or failure;
- required interactions that are incompatible with human physical or psychological abilities; and
- required interactions that are incompatible with organizational abilities and environmental conditions.

Literature on human factors suggests that any attempt to eliminate and control contributory causes to visitor accidents must consider a recreational activity within a total activity system (Capper 1996, National Research Council 1988, Robinson 1982). Such systems combine five elements:

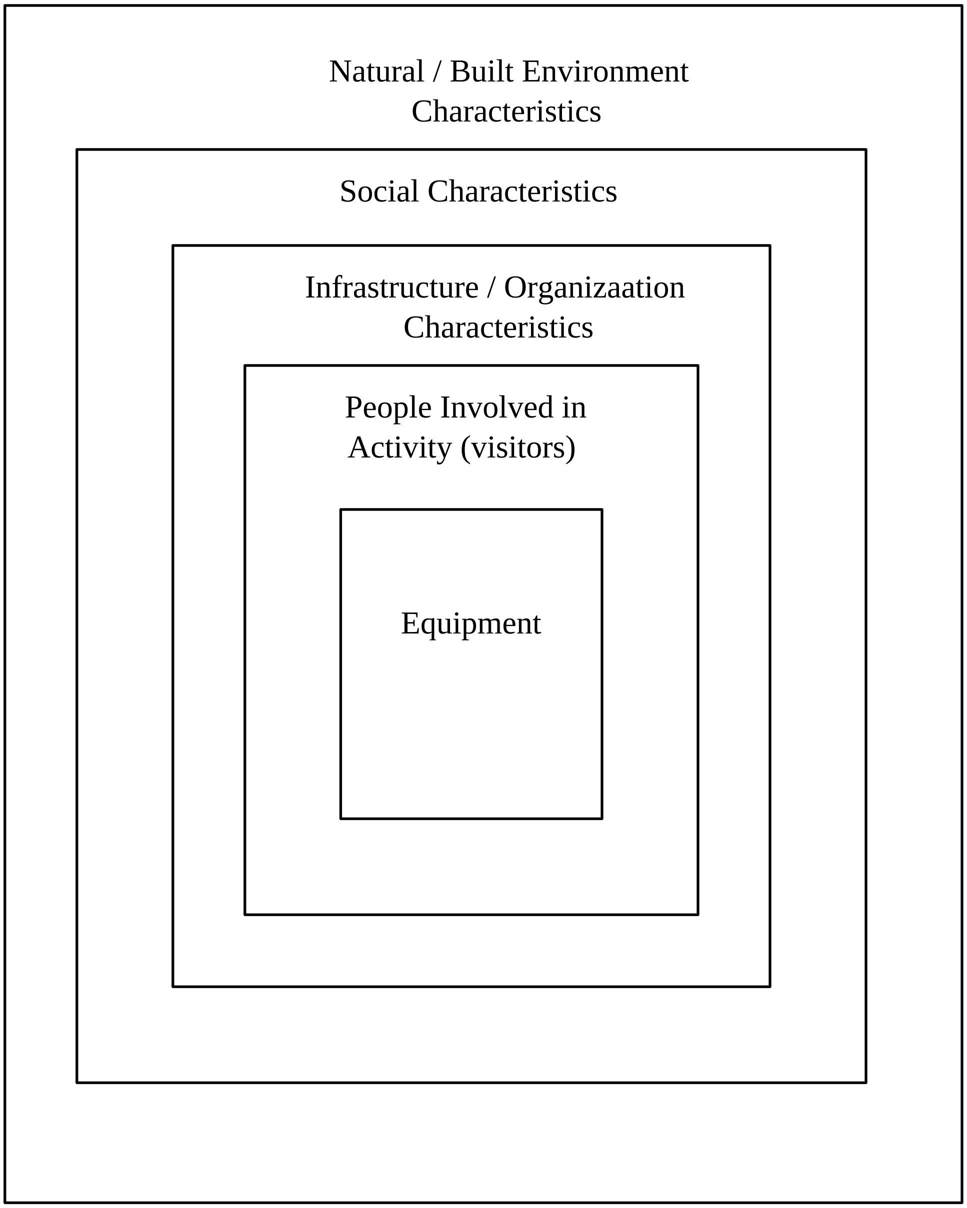
- mechanical and equipment components;
- participating people (individuals and groups);
- organizational and institutional infrastructure;
- social and economic factors; and the
- natural or built environment in which activity occurs.

These features are represented in Figure 1. At each level, and within the interactions among them, are factors that can cause or contribute to accidents/incidents (Rasmussen 1982, Hofmann et al. 1995).

Following Figure 1, organizational, social, equipment, and environmental characteristics may have significant influences on safety in recreational activities. Features of people's recreation environment can contribute to accidents because they influence how the activity is done (Hofmann et al. 1995, Perrow 1984). For example, lighting may be poor in the staircase of a visitor center, trails may be slippery after rain or snowfall, or visibility may be limited due to fog. Inappropriate shoes (i.e., a form of equipment) may be worn by a visitor in wet and slippery conditions. Managerial, bureaucratic, and political pressures can directly affect safety (Capper 1996). For example, management may influence the readiness of search and rescue personnel, and political pressures can affect budgetary allocations for safety-related improvements (Sherwonit 2000).

"Human errors" or mismatches occur every day during the normal activities people pursue. Mismatches can also occur during non-routine activities (e.g., emergency response, search and rescue). Behaviors play an important role in most accidents, which are "typically not due to particularly exotic errors or mistakes, but to slips and misunderstandings which are commonplace in normal human activity and which have their tragic effects only under particular circumstances" (Holmes 1987). In fact, mismatches are often the result of many interacting individual and contributing factors. For example, analyses of motor vehicle accidents have often found the items listed in Table 2 to be contributory causes to accidents. Moreover, the characteristics of mismatches may change as people develop skills, knowledge, and experience (Rasmussen 1990).

**Figure 1.**
Activity System.



Causes of malfunctions combine with additional factors that contribute to an "error" in human action (Figure 2). The final results of the mismatch will depend on the nature of the task. For example, a novice at whitewater rafting may encounter more dangerous rapids than expected due to heavy rainfall. The outcome of the mismatch could be, for example, a very wet rafter or a head injury sustained after capsizing. Thus, attempts to improve safety, reliability, and performance in NPS visitor related tasks and activities are fundamentally linked to the elimination or control of contributory factors.

**Table 2.**
Basic causes of traffic accidents

**Lack of experience driving vehicle**
- road conditions (e.g., loose gravel)
- weather conditions (e.g., rain, snow)

**Psychological stress**
**Personality function**
- risk taker (e.g., speeder)
- previous accidents
- mindset
- overconfidence

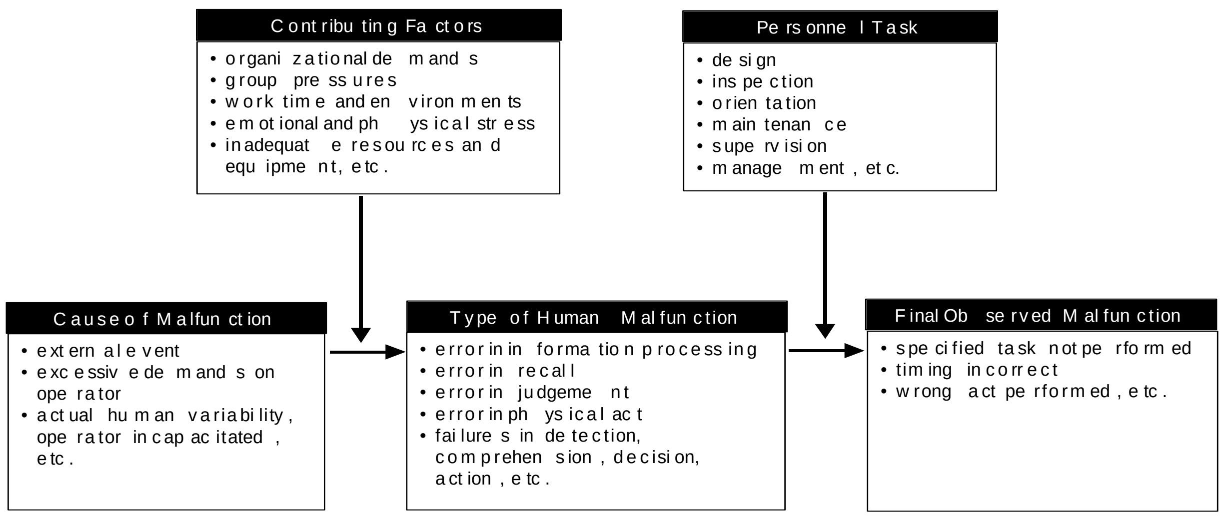
**Preoccupation**
**Sensory input**
- lack of visibility
- noise

**Cultural background**
**Failure of recognition (e.g., of obstacle in road)**
- improper lookout
- inattention
- false assumption

**Failure of understanding (e.g., warning signs)**
**Failure of judgment (e.g., stopping distance)**
**Failure of performance (e.g., improper acceleration)**
- incorrect action
- inadequate implementation

**Physiological stress**
- health
- workload
- fatigue
- medication
- substance abuse

**Figure 2.**
Malfunctions result from the combination of initiating causes, contributing factors and task characteristics




A broad view of safety that looks at the links between equipment, individuals, infrastructure, social, and environmental features has proven useful in the design, evaluation, and management of safety in a variety of large scale technological systems. Examples of such systems include nuclear power plants, chemical processing plants, offshore oil platforms, firefighting, resource extraction, and air, marine, and vehicle transportation systems (Reason et al. 1990, Slappendel et al. 1993, TriData 1996, Tuler, et al. 1993) and "has great potential for delivering results that yield useful recommendations for safety improvements" (National Research Council 1988, pg. 12). This approach has also been used to evaluate the causal factors in the Cave Creek Tragedy in New Zealand where an observation platform collapsed and fourteen visitors fell to their deaths in 1995 (Capper 1996). However, this broad perspective has rarely been explicitly applied to recreation safety. Visitors engage in a variety of simple and complex activities ranging from strolling around exhibits to technical climbing and the operation of complex technologies, such as automobiles, snowmobiles, and motor boats. Visitor safety can be usefully addressed by considering the behaviors of individual visitors, the influences of agency personnel and management on the way activities are performed, environmental and infrastructure conditions, and other contributory factors.

In this report the five elements of an activity system are used to organize the vast body of research findings that are relevant to understanding how visitor accidents occur, and that are reviewed in the following sections.

## 4.0 Contributory factors to visitor accidents

Both the causal model of hazards and the human-factors framework highlight the diversity of factors that can lead to accidents, or contribute to their severity. In the following sections, we discuss the factors that have been identified in the social science research literature. The contributory factors are grouped according to visitor characteristics, social characteristics, environmental conditions, and infrastructure/organizational factors, and equipment characteristics. We do not discuss the literature relating to criminal activities or pre-existing conditions (e.g., heart disease).

### 4.1 Visitor characteristics

A substantial literature has developed addressing the relationships between various characteristics of individuals and safety. In the following sections, we examine the research findings regarding types of visitors, the impact of prior experience, risk perception, hazard recognition, judgment and decision making, action and behavior, sensation/risk seeking, and stress factors.

#### 4.1.1 Types of visitors

Findings on the relationships between individual characteristics and risk are mixed. Some studies show a correlation between certain variables, such as gender, risk perceptions, risk acceptability, and consequences of risk events. Other studies have not found significant correlation among these variables. We can glean several lessons from the risk literature:

- age and gender have frequently been found to be contributory factors in motor vehicle, personal water craft, and snowmobiling accidents (Martin 1999, Lynch 2000, DeJoy 1992, Jonah 1986, Elander and French 1993, Reason et al. 1990). Males (especially young males) are at higher risk. Most believe that age itself is not the primary cause of risk events, but rather the tendency of young males to engage in risky behaviors (e.g., consume alcohol and drive) and their lack of skill that combine to make accidents more likely (Jonah 1986).
- certain groups of individuals are more susceptible to certain kinds of injuries (e.g., falls), illnesses (e.g., heart disease), and environmental contaminants (e.g., lead) depending on innate and acquired attributes, such as age, gender, previous exposures (Calabrese 1978, Golding 1990).
- age and gender have been found to influence sensation seeking behaviors (Galloway and Lopez 1999, Arnett 1996).
- individuals from minority groups and lower socio-economic scales are often found to have different reactions to risk, and be faced with different risks, than others (Cutter 1995, Sjoberg et al. 1996, Vaughan and Seifert 1992).

Research on outdoor recreation has focused on a variety of visitor characteristics (Cheek, Field and Burdge 1976, Manning 1987). Factors considered in prior research include age, gender, educational level, and income level (Johnson and Swearingen 1988, Knopp and Tyger 1973, Manning et al. 2000, Thapa and Graefe 1999). The findings are ambiguous, however. For example, Swearingen and Johnson (1988) found that better educated visitors were more likely to comply with trailside signs at Mt. Rainier National Park, but age, gender, and occupation were unrelated to levels of compliance. Galloway and Lopez (1999) found that males had higher sensation-seeking scores, but age was unrelated to sensation seeking. Other studies have found that sensation seeking declines as people age (Arnett 1996). Thapa and Graefe (1999) found no association between age and tolerance for conflict among snowboarders and skiers.

Much of the literature in this area is concerned with the types of activities chosen by people with different characteristics and their satisfaction with different types of activities. For example, increasing age has been associated with decreasing participation in physical activities (Thapa and Graefe 1999). This literature is relevant to safety because the kinds of activities people choose can influence the kinds of risks they face. For example, if people seek backcountry, wilderness experiences they will face different sorts of risks than those who only explore interpretive trails and visitor centers. Those that visit national monuments and historical sites can face different hazards than those who mountain climb or snowmobile.

Additional research has attempted to classify types of visitors according to dimensions other than age, gender, income, and education. Different types of people may choose different types of activities and they may perform them differently. Lime (1971; see also Jim 1989) distinguishes among four types of recreational resource users: haphazard, experienced, inexperienced, and habitual. Lucas (1986) distinguished among newcomers, beginners, and veterans. Ewert and his colleagues (Ewert 1987b, Ewert and Hollenhorst 1989, Hollenhorst and Ewert 1989) have proposed a risk recreation model that distinguishes among introductory, developing, and committed (see section on risk/sensation seeking below for more detail). The Canadian Park Service (1995) distinguishes among five visitor activity groups (touring recreationalists, passive recreationalists, recreationalists, active recreationalist adventurists, and extreme recreationalist adventurists). In general these classifications refer to an individualís level of experience and skill. Another way of classifying visitors is according to where they come from and where they are visiting, such as urban-proximate and urban-distant wilderness (Ewert and Hood 1995). Some literature has discussed people with disabilities as a distinct category (McAvoy et al. 1995, Park and Robb 1996); this literature has not addressed directly safety of visitors to parks.

Another way of classifying visitors has been on the basis of what they are doing (i.e., what activities they perform and how they perform them). In fact, a variety of factors that are related to the characteristics of an activity can contribute to a person’s exposure or influence the types of initiating or contributory causes of an accident. The nature of the activity will determine the types of hazards they face and the length of time the person engaged in the activity will determine their level of exposure to the hazard. The more a person is exposed to a hazard, the greater will be the chance of harm.

Some studies explore the characteristics of day hikers. For example, in the Smoky Mountains National Park (Burde and Daum 1989) and Grand Canyon National Park (Manning et al. 2000). Findings have implications for safety management. Burde and Daum (1989, 179) report that: “Day hikers are a unique group as compared to backpackers. They are typically older, more likely to be a family, and are likely to include females and children in their group.” They are also likely to be in specific areas and to spend less time engaged in an activity that exposes them to danger. Day hikers go on shorter hikes and spend less time in hazardous terrain than do backpackers. On the other hand, they may be less prepared for unexpected situations.

### 4.1.2 Prior experience

Prior experience is an important part of safe and reliable performance (Brown and Groeger 1988, Summula 1988, Lipscombe 1998, Vogel and Titre 1998, Ewert and Hollenhorst 1989). According to Wilkinson (1999) inexperience was the major contributing factor to climbing accidents in the Tetons. Paradoxically, prior experience can increase or decrease risk. Prior experience contributes to safer performance of an activity. Experience helps one to respond to unforeseen conditions and understand better the implications of different actions. Data from some studies suggests that increased experience decreases the types and frequencies of errors in driving related accidents (Duncan et al. 1991, Brown and Groeger 1988).

On the other hand, familiarity breeds contempt. Prior experience may also contribute to laxity in monitoring or alertness, and it can increase a person's belief that he or she knows what to do or how others (including wildlife) will behave. More frequent encounters with bears can make people complacent. Increased driving experience has been observed to have ambiguous effects on the frequency of errors (Duncan et al. 1991, Brown and Groeger 1988). Experienced drivers may become complacent while driving in familiar areas. In addition, research that shows that people can be over-confident about their abilities (Svenson 1981).

Researchers have considered the role of experience in the kinds of leisure/recreation activities people choose, how they engage in them, motivations, and perceptions of danger (Schreyer and Lime 1984, Hammitt and McDonald 1983, Ewert 1985, Lynch 2000, Manning et al. 2000, McFarlane et al 1998). Research findings are ambiguous, perhaps because of the diversity of activities and groups that have been studied.

Lynch (2000), for example, found that lack of skill was one of the most important contributors to fatal snowmobiling accidents in Michigan. Those involved in fatal accidents were more likely to be operating their snowmobiles beyond their skill level and in ways inappropriate to the road/trail conditions. Ewert (1985) conducted a study of motives and experience level in mountaineering at Mt. Rainier National Park. He found five types of motivational factors: challenge/risk, catharsis, recognition, creativity, physical setting, and control. Moreover, he reported that "while not a strong influence, it appears that experience level does play a role in influencing an individual's motivations for climbing" (Ewert 1985, pg. 244). Such findings about differences in motivations have relevance to an understanding of safety in recreational activities. People can be motivated by a search for thrills or by peer pressures to engage in activities for which they are ill prepared or lack the necessary skills.

One characteristic of prior experience can be recreational specialization (i.e., as individuals become more experienced in and committed to an activity, they specialize.) For example, someone who has fished for a long time may become a serious fly-fisher, and those that initially engage in a variety of water-related activities may eventually specialize in river kayaking on white water. However, we found no research on recreational specialization and its relationship to aspects of safety specifically. Research has been conducted on other aspects of visitor behavior. For example, Wellman et al. (1982) considered individual's perceptions of the seriousness of deprecative behaviors with respect to the degree of specialization of their canoeing activities. Their findings provided little support for the hypothesis that attitudes toward deprecative behavior would vary with specialization.

**4.1.3 Risk perceptions**
The perception of risk has been the topic of an enormous amount of research (e.g., for overviews see Boholm 1998, Renn 1992, Diggs 1988, Kasperson and Dow 1993, Whyte 1986). Risk is often defined narrowly by ìexpertsî as the probability of an event times the magnitude of the consequences (i.e., the expected loss). However, psychologists and others believe that individuals have a much more complicated multi-dimensional view of risk. This belief has been verified in an enormous body of social science research literature. Such studies beg the question: what factors influence individuals' risk perceptions?

In particular, studies have shown that several qualitative characteristics of risks can influence individual perceptions of the severity and acceptability of the risk (Starr 1969, Fischhoff et al. 1978, Slovic et al. 1980, Renn 1992). For example, people are more willing to accept higher levels of risks when:

- the risks are voluntary rather than involuntary activities,
- the immediacy of the adverse effect is further away in time or location,
- the risk is more familiar;
- the risk is more controllable,
- the risk is not fatal, and
- the risk is chronic.

Another important finding from this research is that risk perceptions may not always be consistent or stable within a particular individual. For example, alcohol consumption has been found to influence risk perceptions (Greenfield and Rogers 1999).

These qualitative characteristics have been explained by two underlying factors: the "dread" of the risk and the "knowledge" of the risk (Slovic et al. 1980, Slovic 1987). Many of the risks measured in these studies are of little direct importance to the Park Service. However, several risky activities are found in many of the parks, including scuba diving, surfing, recreational boating, snowmobiles, bicycling, motorcycling, downhill skiing, mountain climbing, hunting, alcoholic beverage consumption, and motor vehicle operation. All these risks scored low in terms of perceived risk. They tend to be old risks that are easily observable, well known to science and those exposed, result in immediate effects (i.e., injuries rather than long-term, delayed impacts such as cancer), are considered voluntary, are generally controllable, and do not lead catastrophic consequences. These risks are not dreaded like the risks of nuclear power.

Numerous studies have been conducted to examine perceptions of and attitudes toward a variety of natural hazards, including:

- riverine flooding (Burton 1962, Kates 1962, Roder 1961),
- coastal flooding (Burton and Kates 1964b, Burton, Kates, and Snead 1968),
- drought (Saarinen 1966), and
- multiple hazards at one location (Hewitt and Burton 1971).

Kates (1970) developed an elaborate model that ties together many of the strands from these previous studies (see also Burton, Kates, and White 1978). In general, these studies found that individual perception of the hazard and awareness of alternative responses varied according to the nature of the human use of the hazard area (e.g., farmer vs. urbanite), the magnitude and frequency of past events, and the personal experience of the individual with previous events. None of these studies, however, found an association with levels of education or social class, although Whyte (1986, 242) claims that many individual characteristics, such as age, gender, and personality, as well as factors in the broader social context of choice, were inadequately explored in these hazard perception studies.

An additional factor is related to the way that people recall prior experiences and information. Individuals will often judge an event to be more frequent if it is memorable and easily recalled by an individual. Risks that are more memorable because they are dramatic or spectacular in some fashion are more likely to be overrated in terms of fatalities. Reports of such events in the mass media may enhance the “availability” of such events even though the event was not experienced directly by an individual (Lichtenstein et al. 1978). Risks from more common, familiar hazards may be underestimated. Cheron and Brent Ritchie (1982) found that perceived risk diminished as people became more familiar with and interested in leisure activities. Research has also found that “experts” are influenced in a similar way, so that their estimates of risk may not be accurate (Freudenburg 1992).

Burton and Kates (1964a) found that members of the public tend to try to reduce the uncertainty about hazard events. They may deny or denigrate the existence of a hazard (i.e., “It can’t happen here”), or its recurrence (i.e., “Lightning never strikes twice in the same place”). They may try to eliminate the uncertainty by making it determinate and knowable (i.e., “Seven years of great plenty, and seven years of famine”) or by transferring the uncertainty to a high power (i.e., “It’s in the hands of God,” or “The government is taking care of it”). Similar findings have been observed in relation to technological hazards as well (Renn 1998).

While there has been an enormous amount of research looking at the public perceptions of a variety of risks and hazards, little has been conducted to gauge the perceptions of visitors recreating in national parks (Schreyer and Lime 1984, Cheron and Brent Ritchie 1982, Rentz and Schreyer 1977, Lynch 2000, No Date, Manning et al. 2000).

Two studies have focused on risk/hazard perceptions among visitors to NPS units. Rentz and Schreyer (1977) considered risk perceptions of people visiting three NPS units and a national forest unit (Arches NP, Canyonlands NP, Glen Canyon NRA, and the USFS High Uintas Primitive Area). Visitors to these areas were asked, in interviews and a survey, to name hazards they faced. However, it is hard to interpret the significance of these results because they were not compared with measures of “objective” risk; in part because it is unclear how that would be defined ó and because there no other studies to use as a basis for comparison. Nevertheless, the data do illustrate the range of hazards that visitors perceived, including: heat; tripping, falling, and related injuries; lack of water, poisonous animals; getting lost; flash floods; sunburn; submerged and falling rocks; drowning; hypothermia; blisters and sore feet, tree falling on hikers; exhaustion.

Manning et al. (2000) assessed visitor perceptions of day hikers at Grand Canyon National Park. Respondents were asked a variety of questions related to risk perception, including whether day hiking on the Grand Canyon trails requires special equipment, demands special caution, and whether such hiking is more dangerous than hiking in most other parks and wilderness areas. Respondents were also asked if they thought park rangers exaggerated the difficulty of hiking in the Grand Canyon. Perceptions about factors that affected the length of hikes included weather, heat, fatigue, injury, and trail conditions. The role of visitor risk perceptions in NPS visitor safety is important for developing effective risk management programs. Visitor safety in a wide variety of recreational activities in NPS units can be usefully addressed by considering the risk perceptions of individual visitors.

**4.1.4 Hazard recognition**

Closely tied to risk perception is the recognition of hazards. Much of the risk perception research is concerned with risks and hazards that a person may encounter at some future time. Hazard recognition research, in contrast, has focused more on immediate, actual dangers. In many activities, people are required to monitor their surroundings for signs of potential danger. For example, hikers must monitor their immediate environment for hazards associated with footing, snakes, and other dangerous fauna or flora. Skiers must monitor their surroundings for snow conditions, steepness of slopes, obstacles, and avalanche potential. Failures in detection can be defined as the failure by a person to identify information important to the safe and successful completion of an activity. Failures in comprehension occur when the individual fails to recognize that the observed information carries an important message. For example, while driving a vehicle a detection error occurs when a driver fails to see a warning sign. A comprehension failure occurs if the driver sees the sign but fails to understand that the sign carries a warning of danger ahead (e.g., frozen bridge surface). In this section, research on such issues is summarized.

The issue of hazard identification has received considerable attention in research literature on motor vehicle safety and accidents. Safely driving vehicles requires that the driver identify potential hazards on the roadway, such as stationary obstacles or moving vehicles. Similar demands are also placed on operators of snowmobiles, personal watercraft, and motor boats. Operators of such technologies need to comprehend their danger, often times at great speeds. Such detection and comprehension of potential dangers, according to traffic psychologists, is a learned skill (Brown and Groeger 1988, Rumar 1990, Fell 1976). Consequently, the process by which drivers search for, detect, and comprehend hazards on the roadway will be affected by both general driving skills and prior experience with particular situations.

The difficulties of detection and comprehension of hazard related information is compounded by important human characteristics include natural filtering of information and limitations in attention. Humans unconsciously filter out much of the information that is available to them to avoid being overloaded with information (Tversky and Kahneman 1973, Renn 1992).

Other reasons that may cause people to fail to detect signs of danger or equipment malfunctions include:

- being distracted by other people (e.g., children bickering in the back seat of a car), other tasks (e.g., receiving phone calls while driving), or features of the environment (e.g., nice views and animals at the roadside);
- being preoccupied with a task (e.g., tuning a radio while driving) blocks out other important information (i.e., "tunnel vision");
- inclement weather that decreases visibility (see below, section on environmental conditions for further discussion of weather); and
- other factors that may inhibit the detection of important information (e.g., noise from wind, glare from sun obscuring signs).

An important area of research on traffic safety is concerned with the ability of drivers to see other objects on the roadway, such as signs, other vehicles, and pedestrians. For example, an object's color, brightness, contrast with background, movement, and illumination have all been observed to affect peopleís ability to detect objects (Rumar 1990). Further difficulties arise in adverse weather conditions (e.g., fog, rain, blowing snow) or night driving (Brodsky and Hakkert 1988, Schmieg 1978, Schmidt-Clausen 1976, Tabler 1978). In particular, lack of visibility has been noted as a cause of many vehicle accidents. In adverse weather conditions "because of reduced visibility, drivers cannot judge vehicle separation, vehicle speeds, and vehicle deceleration. As a result they do not have sufficient time to react to stopped or slowing vehicles ahead" (Schmieg 1978, pg. 5). The ways that hazard recognition play a role in increasing or decreasing the safety of visitors is important to ensuring visitor safety in the NPS.

#### 4.1.5 Judgment and decision-making

People engaged in recreational activity must make a variety of judgments and decisions that have implications for safety. For example, they must determine whether their equipment is in good working condition and what repairs are needed. They must make decisions in response to changes in their surroundings, whether in the natural (e.g., weather changes, trail submerged) or built environment (e.g., lights go off, floors wet). Owners of boats must make decisions about where to use them and under what conditions (Siderelis, Brothers, and Rea 1995).

The behavior of human decision makers operating in a variety of situations has been extensively studied (Slovic et al. 1988). The primary lessons from this research are that:

- people often have difficulties making decisions, inferences, and judgments in complex situations, especially when operating under stress (Slovic et al. 1988). For example, in complex situations there is often one simple and obvious solution that is selected. It is, however, often incorrect or inefficient; and
- decision strategies used by people may greatly affect outcomes. Poor decisions can lead to the addition of small errors that can cause a future accident (Telfer 1989).

Empirical observations of human problem-solving and decision-making suggest that people do not always use all the information available to them (Tversky and Kahneman 1974, Svenson 1981, Fischhoff 1986, van der Colk 1988). Among the most important reasons are:

- information quality is often inadequate to fulfill requirements for appropriate decisions and judgments;
- an individualís capacity for processing large amounts of information is limited;

- time delays can be important and can result even when responding to expected information. For example, some studies suggest that drivers are often slow to process information when confronted with unexpected hazards (Olson and Sivak 1986, Office of Technology Assessment 1988);
- people use ìrules of thumbî that, while generally useful and effective, can mislead in certain situations (e.g., the availability heuristic as discussed above; see also Table 2); and
- decisions are frequently made in situations that allow only limited attention to any particular item or issue.

Research on human decision-making indicates that predictable mistakes occur because humans develop biases and “rules of thumb” to simplify a complex world and guide their judgments. Some important ones are listed in Table 3. In general these processes work to people’s advantage, but in certain unfamiliar situations they may lead to inappropriate choices or actions. “Over training” may create problems in novel situations where skills and unconscious reactions suddenly become irrelevant or even detrimental (Svenson 1979, Holmes 1987, Summula 1988). On the other hand, because the biases and “rules of thumb” usually serve the important function of allowing people to operate in different situations with limited information, they cannot be dismissed as dangerous or useless. In addition, decisions and judgments may be based on issues beyond those of correctness, effectiveness, or safety. Other motivating factors may be equally or more important in certain situations, such as speed of performance, fulfilling social expectations, and emotions (Ewert 1986, 1987a, 1988, Manning et al. 2000). “Effective” or safe choices may actually be of secondary importance relative to other goals.

**Table 3.**
Biases and “rules of thumb”

- overconfidence in estimations and plans
- underestimation of time constraints
- attempts to verify previously held beliefs by searching for and accepting confirmatory evidence and ignoring or forgetting contradictory evidence
- exaggeration of personal immunity from threats
- oversimplification of others' behavior
- limited examples used to make statistical inferences
- difficulties assessing probabilities and exponential processes
- ignorance of subtleties
- tendency toward conservatism
- thinking in causal series and ignoring side effects
- previous experiences often used as basis for future choices
- options which are not readily observable may not be considered
- complacency in familiar situations

Few studies have examined judgments and decisions of visitors to national parks in relation to safety. However, regardless of their limited number these studied are critical to understanding the ways that visitors encounter risk. For example, the study by Rentz and Schreyer (1977) considered information processing and levels of preparedness among visitors to three national parks. Manning et al. (2000) studied how information related to temperature and water led to behavior changes among day hikers in the Grand Canyon. Information about hazards was instrumental in changing the behaviors of the day hikers: they hiked at different times (e.g., began earlier in the morning) and made shorter hikes. This brings us to the next step in the process, the actual carrying out of an action.

### 4.1.6 Action and behavior

Decisions to act reach their conclusion in the actual carrying out of the decision. Three levels of behavior have been identified in human action (Rasmussen 1990):

- automatic or routine activities, where performance is automatic, controlled, and skilled (e.g., how to climb stairs or use brakes);
- familiar activities, where performance is based on remembered rules and procedures applied in familiar situations (e.g., how to pass a car);
- new and unfamiliar activities, where performance is based on the use of prior knowledge and may require complex processing of information (e.g., boating in severe weather in an unfamiliar location).

Generally, as people become more experienced they learn to respond on the basis of knowledge and skills at faster levels of behavior (e.g., automatic). Thus, as discussed above, prior experience is important in the type of behavior used in an activity and is an important part of safe and reliable performance (Brown and Groeger 1988, Ewert and Hollenhorst 1989, Lipscombe 1998, Summula 1988).

Research on accidents indicates that incorrect or faulty behaviors are not uncommon. They may occur because of:

- obstacles to the intended action (Reason et al. 1990, Fell 1976). For example, hikers may be unable to complete an intended trip because of a bridge destroyed in a flood or insufficient safety margins may not allow a slow vehicle to be avoided. These types of problems are typically the focus of human-factors engineers that attempt to design systems that minimize their possibility. Actions made at the highest level of behavior (i.e., on the basis of conscious evaluation of information) are susceptible to error because of lack of time, inadequate information, and other similar constraints.
- unintended departures from a planned action or desired goal (Reason et al. 1990). For example, drivers may unintentionally accelerate when their intention was to brake (Schmidt 1989). Hikers in hot weather conditions may see a river and go swimming (Hawkins 2000). Fatigue may slow reaction times needed for difficult maneuvers. At the other two levels of behavior, actions may be inappropriately executed because the context is not appropriate for the selected action.

There is some research on deliberate deviations from practices considered safe (Reason et al. 1990, Herrero 1985, Lynch 2000). Such “violations” are not necessarily illegal or reprehensible. Moreover, interpretations of what are considered violations are likely to differ among people. Thus, “violations can only be described with regard to a social context in which behavior is governed by operating procedures, codes of practice, rules, norms, and the like” (Reason et al. 1990, pg. 1316). For example, drivers may depart from unofficial norms by driving too slowly (e.g., to look at wildlife along the road side) or too fast (e.g., to arrive at a trail head). Moreover, decisions can lead to unintentional violations. For example, a driver may drive too fast if he or she uses the speed of other vehicles on the roadway as an indicator of how fast to drive. When the violation is recognized, however, the driver may still fail to slow down (e.g., Summula 1980).

Researchers have also analyzed non-compliant behavior of participants in an activity, including recreation at parks (Johnson and Swearingen 1988, Swearingen and Johnson 1988, Vande Kamp et al. 1994). Non-compliant visitor behavior is defined as "minor rule violations or failures to comply with minimum impact guidelines" (Vande Kamp et al. 1994). Research has usually focused on the impacts rule violations have on resources (e.g., the effects of off-trail hiking on vegetation). While it has not directly addressed how non-compliant behavior affects safety this literature has some relevance to visitor safety in national parks. For example, visitors going off-trail may put themselves at greater risk. They may get lost and/or they may wander into more hazardous terrain. Chester (1976) found that off-trail hiking lead to more frequent encounters with wildlife in Yellowstone National Park. In their review of the literature, Vande Kamp et al. (No Date) conclude that "the state of current social science research does not support a unified theoretical approach that can motivate and explain the success or failure of interventions designed to deter noncompliance" (pg. 4).

#### *4.1.7 Sensation/Risk seeking behavior*

Frequently, researchers distinguish between risks that are accepted voluntarily and those that are imposed involuntarily (Slovic, Fischhoff, and Lichtenstein 1980). Because dominant characterizations of risk assume that risky phenomena are undesirable, taking voluntary risks are explained because the possible gains (e.g., money, status, and pleasure) are expected to outweigh the possible losses. This conceptualization, however, suggests only a limited view of the factors that contribute to voluntary acceptance of risks. As Heimer (1988) notes, "such a theory cannot explain why people would actively seek chances to face risks, for instance by choosing games with more risk designed into them, by gambling, or by engaging in dangerous sports" (pg. 509). In fact, a growing literature discusses thrill seeking and sensation seeking in "risk recreation." These include activities such as rock climbing, scuba diving, sky-diving, and whitewater rafting. Developing a better understanding of sensation seeking and risk seeking, and how to mitigate their effects is important to ensuring visitor safety in the NPS.

Psychologists and sociologists have long been interested in why people appear to willingly accept or volunteer for risky activities (Greenberg 1977). Recently, sociologists and psychologists interested in risk have extended our understanding of behavior in voluntary risk-taking contexts (Machlis and Rosa 1990, Lyng 1990, Highhouse and Yuce 1996). Anticipated benefits can be a function of the cognitive and emotive aspects of risk experience (i.e., excitement, challenge) or the ends toward which the risky behavior is directed (Lyng 1990). In some cases, risk taking behavior can be influenced by the consumption of alcohol (Cherpitel 1993). "Desired risks" have been defined by Machlis and Rosa (1990) as "activities or events that have uncertainties of outcome or consequence, and where the uncertainties are an essential, sought component of the behavior" (pg. 162). Thus, in contrast with most conceptions of risk, desired risk is not considered to be something negative or dreaded.

The concept of "sensation seeking" has a longer history in psychological research (Zuckerman 1971, 1979, Slanger and Rudestam 1997, Galloway and Lopez 1999, Arnett 1994). It has a clear connection to risk research. Early work on sensation seeking centered on measures of individual differences in levels of arousal and stimulation and the relationship of these optimal to performance. Arnett (1994) wrote that "sensation seeking is not only a potential for taking risks, but is more generally a quality or seeking intensity and novelty of experience which may be expressed in multiple areas of a person's life" (pg. 290). The results of prior research suggest that sensation seeking is related to:

- attraction to intense experiences (Arnett 1994, 1996, Lipscombe 1999);
- dislike of repetition and structured, formal situations (Cronin 1995, Babbitt et al. 1990);
- tendency to disclose personal feelings and thoughts (Franken et al. 1990);
- tendency toward uninhibited behavior (McCourt et al. 1993);
- feelings of self-efficacy (Slanger and Rudestam 1997); and
- age and gender (Galloway and Lopez 1999, Arnett 1994, 1996, Zuckerman et al. 1978).

Sensation seeking has been studied in relation to various risky recreational activities, including mountaineering, auto racing, hang gliding, sky diving, snowmobiling, skiing, scuba diving, visiting national parks, rock climbing, and kayaking (Ewert 1987b, Ewert 1988, Ewert and Hollenhorst 1989, Wilkonson 1999, Hollenhorst and Ewert 1989, Lipscombe 1998, 1999, Lyng and Snow 1986, Slanger and Rudestam 1997). Injuries and fatalities result from such activities in national parks (The Economist 1999, Wilkonson 1999). A clear understanding of how sensation seeking influences the choice of activities and the behavior of specific individuals in different conditions is important to the mitigation of risk and management of NPS visitor safety.

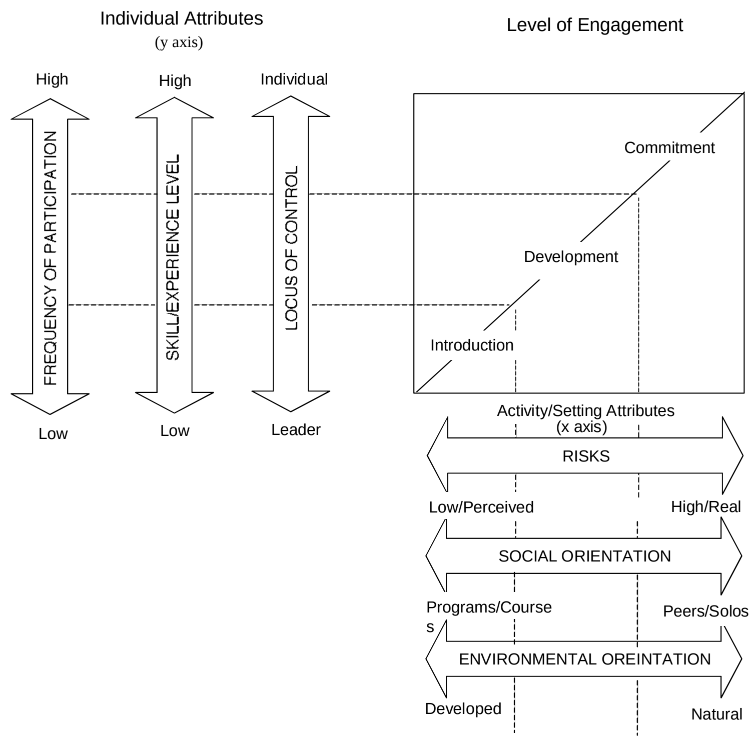
"Risk recreation" has been defined by Ewert as: "a variety of self-initiated activities utilizing an interaction with the natural environment, that contain elements of real or apparent danger, in which the outcome, while uncertain, can be influence by the participant and circumstance" (Ewert 1988, pg. 7). Key features of risk recreation are that risks may be objective or perceived and that they can be controlled to some extent but not completely. Risk and danger are positively evaluated. Ewert and his colleagues have proposed and tested a model of adventure recreation (Ewert and Hollenhorst 1989, Hollenhorst and Ewert 1989). The model is used for both descriptive and predictive purposes (Figure 3).

The model highlights that individuals engaged in adventure recreation follow a progression in levels of skills and preferences. Introductory level participants have little experience, low skill levels, and adventure recreation is not their primary interest. Committed individuals prefer high levels of risk and are characterized by high levels of skill and commitment. Developing individuals are those that are learning skills and whose interest is in encountering more risk in adventure recreation. The level of engagement (introductory, developing, or committed participants) is influenced by personal attributes and the attributes of the activity or setting. Personal attributes refer to characteristics of the person, including frequency of participation, skill level, prior experience, and locus of control. Attributes of the activity/setting refer to social and environmental factors. Those included in the model are:

- individual preferences for risk (low versus high),
- social orientation (formal courses or programs versus solo or small groups), and
- environmental preference (natural versus developed settings).

It should be emphasized that the activity/setting measures are related to the ways that participants perceive social and environmental features. Thus, what is considered a high risk to one person may be considered an activity with low risk to another. Similarly, what one person considers a "developed" area may be considered rather primitive by another.

**Figure 3.**
Adventure risk model




[From: Ewert and Hollenhorst 1989]

The authors use this model to argue that opportunities for adventure recreation must be available at a variety of involvement or engagement levels (introductory, developing, or committed). Congruence is achieved if individual attributes are balanced with appropriate activity/setting attributes. That is, a matching of capabilities, preferences, and activity features lead to "quality" experience (Hollenhorst and Ewert 1989, pg. 333). While the authors do not make this argument, there is a parallel with frameworks on human error: mismatches can lead to errors or failures and mismatches arise from interactions of elements within an activity system.

Galloway and Lopez (1999) explored the relationships among visitor attitudes toward national parks (in Australia) and individual propensities toward sensation seeking. They found that measures of sensation seeking were related to:

- decrease in reluctance to visit remote parks,
- decrease in preference for structured tours,
- decrease in likelihood of avoiding areas where dangerous animals may be encountered,
- increase in preference to actively seek wildlife,

- increase in preference to engage in stimulating and challenging activities,
- increase in preference to meet interesting, similar-minded people, and
- increase in preference for eating in “untouched” areas.

It is important, however, not to assume that individuals who engage in activities that can be risky, do so solely because of their desire for risk. For example, in their study of day hikers in the Grand Canyon, Manning et al. (2000) found that taking risks was not an important motivating factor. There can be other motivating factors that influence choices. In the case of day hikers in the Grand Canyon these included being close to nature, to be with members of one’s family or group, to enjoy views, to learn, and to relax and reduce tension.

### 4.1.8 Stress factors

The ability of people to make judgments, solve problems, and make decisions may be influenced by a variety of stress factors arising during an activity. The same stress factors can also play a role in risk perceptions and in how well intended actions are carried out. Stress factors can compound difficulties of performing routine, familiar, and unfamiliar actions. A variety of stressors can be contributory factors to NPS visitor safety and risk, as defined in the causal model. They can affect NPS visitors by influencing the characteristics of the activities they want to do and how they react to expected physical conditions and unforeseen events physical conditions.

Illustrative stress factors that have been observed in many types of work and recreational activities are listed in Table 4.

**Table 4.**
Factors Contributing to Stress

**Physical/Physiological**
- noise
- vibration
- hot or cold (e.g., protective clothing)
- temperature
- comfort (e.g., back ache)
- visual illusions (e.g., “flicker”)
- disorientation
- inadequate nutrition
- dehydration, heat exhaustion
- caffeine, alcohol, nicotine
- muscle fatigue
- sleep cycle disruption, inadequate rest

**Psychological/Social**
- mental workload, mental fatigue
- boredom
- anxiety, concern for safety, fear
- anger, frustration
- sensory overload, sensory deprivation
- time pressure
- previous errors
- domestic social problems
- marital/family problems, separation from family
- financial problems
- legal problems
- safety/organizational culture

Stress factors result from differences between the demands of an activity and a person's ability to respond. Stress factors have been documented and studied in a large number of contexts and include physical, physiological, psychological, and social factors (Anderson et al. 1995, Faff and Tutak 1989, Hockey 1983). For example, extreme hot or cold conditions can increase stress (Mekjavic et al. 1988). Task requirements such as mountain climbing and activities at high altitudes can lead to hypoxia and physiological stress that can degrade performance in physical activities (Skjenna 1981). Alcohol, caffeine, and nicotine can have similar effects on a person (Oborne 1983). Experience with injuries or accidents can increase job-related stress (Rundmo 1995). An understanding of their effects and how to mitigate their effects is important to ensuring visitor safety in the NPS.

Research results are ambiguous in part because the stress felt by individuals depends on perceptions and specific contexts of the situation. People respond to stress in a variety of ways (Mann 1993). For example, dangerous situations can cause personal anxiety and fear (Idzikowski and Baddeley 1983, Ewert 1986, 1987a, 1988). In addition, stress levels can differ among individuals in the same situation (Luczak 1991). For example, one person may be afraid of heights, while others are not. Some research suggests that the degree of situational fear felt by an individual may be related to gender and age (Ewert 1988). Moreover, multiple stress factors are often present simultaneously in a situation: NPS visitors can be exposed to multiple stress factors such as dangerous weather conditions, fear of getting lost, fatigue, and unfamiliar situations. The combinations of stress factors depend on the character of the five levels of an activity system: equipment (mechanical components), system personnel (individuals and groups), organizational and institutional infrastructure, social and economic factors, and the natural or built environment in which an activity occurs. For example, they can include:

- background stress from day to day living;
- characteristics of the activity;
- characteristics of the social environment, including peer pressures; and
- characteristics of the equipment used.

The importance of these stress factors hinges on their ability to:

- increase workload and decrease coping ability;
- impair the perception of hazards;
- impair decision-making and judgments;
- lead to inappropriate avoidance behavior; and
- lead to fatalities or injuries, such as acute or chronic back pain.

On the other hand, some stresses, such as fear, may have positive impacts on levels of safety. It has also been reported that experience with stressful situations/activities can reduce stress in activities that occur at a later time (Ursin et al. 1978, Ewert 1986, 1987a, 1988). For example, research on outdoor recreational activities suggests that fear may cause some people to be more cautious (Ewert 1986, Sipprell 1978). In part, the affect stress has on an individual is related to the character of that individual. All these types of outcomes have important implications for visitor safety in the NPS. A clear understanding of how they influence the behavior of specific individuals in different conditions is important to the mitigation of risk.

### 4.2 Social characteristics

Individual risk preferences, risk perceptions, risk acceptability, risk-related behaviors, and concerns about safety do not occur in isolation. People are social, and attitudes and behaviors often reflect this social character. Much of the social science research on risk has addressed social factors, including the ways that views about risk emerge from social interaction (Dake 1992, Wynne 1992, Kasperson et al. 1988, Kasperson and Kasperson 1996). Group interactions can influence individual attitudes and behaviors, and the sources of information people use to assess risks (e.g., newspapers, friends). In this section we review literature about the social factors that can influence risk and safety of visitors to national parks. In particular, we review literature about social groups, crowding, and recreational conflict. Finally, we briefly discuss the social amplification of risk framework.

#### 4.2.1 Social groups

Risk perceptions and risk behaviors have been associated with an individual's membership in particular groups. For example, people may be categorized according to their cultural group characteristics (Rayner 1992, Wynne 1992). They can also be categorized according to their worldviews (Dake 1991, 1992, Slovic 1999). Research in this vein suggests that people in different groups will have different attitudes toward risk and they ways that they react toward risk. Other research has considered the ways that membership in certain subpopulations can play a role in risk related perceptions and behaviors. For example, Vaughan and Seifert (1992) studied risk perceptions among ethnic minorities and migrant farmworkers.

In general the role of social groups in regard to risk-related recreation has been largely unexplored (Ewert 1993). However, the ways that social groups, and interaction among members within a group, can affect risk have been studied in other areas. While necessary, interactions of people in groups can also create conditions that lead to accidents or mishaps. Group interactions can lead to risk-taking, "faulty," or incorrect decisions in different situations (Hare et al. 1997, Hirokawa and Scheerhorn 1986). Researchers have suggested several factors that may lead to faulty decisions in a group. They include:

- improper assessment of a situation,
- establishment of inappropriate goals and procedures,
- improper assessment of alternative decisions,
- establishment of faulty information on which to base a decision, and
- faulty reasoning.

A particular research theme in the recreational context has explored the extent to which visitors are alone, with family members, with friends, with a guide, with organized groups, or with informal groups (Burch 1969, Hollenhorst et. al. 1995, LaPage and Ragain 1974, Schuett 1995, Manning et al. 2000, Borrie et al. 1997). In fact, Cordell (1989) has noted that most wildland recreation occurs in groups. The ways that group behaviors may affect safety is an important issue to consider:

> if one weighs the uncertainties that are involved in adventure recreation participation (e.g., foul weather, equipment failure, accidents) and the specialized knowledge that is needed for a safe experience (e.g., trip planning, rescue skills, first aid) the type and/or composition of a social group can be critical. (Schuett 1995, pg. 43, emphasis added)

Ewert (1985) conducted a study of motives and experience level in mountaineering at Mt. Rainier National Park. He found five types of motivational factors: challenge/risk, catharsis, recognition, creativity, physical setting, and control. Recognition, from peers, family, etc. can play a role in risk-related behaviors. People can be motivated by peer pressures to engage in activities for which they are ill prepared or lack the necessary skills.

Individuals can enable faulty decisions by paving the way for errors in group decision-making (Hare et al. 1997). In particular, faulty group decision-making can often be traced to the influences of specific group members on communication and different social factors, such as deferment to peers. Individuals also can prevent faulty decisions by counteracting negative influences, such as by convincing others to reject flawed beliefs, perceptions, and inferences. Similarly, individuals can influence a group to accept correct assumptions before negative influences occur.

Faulty decisions by groups may be a result of different kinds of behaviors that occur in groups (Hare et al. 1997). They include:

- the "risky shift" phenomena in which a group chooses more risky alternatives than its individual members,
- group polarization, whereby the choice of a group is more extreme than the individual choices,
- "groupthink," where a group arrives at a consensus decision without adequately evaluating all alternatives,
- false consensus, where individuals of a group falsely believe that a consensus has been reached, and
- pluralistic ignorance, where group members believe that they are alone in their beliefs.

In some cases, pressures for group consensus may be very strong. They result from the characteristics of the group and the social environment in which they interact (Swap 1984). The characteristics fall into several categories:

- composition (e.g., group size, individual personalities, isolation of a group),
- leadership characteristics (e.g., centralization of authority, style of leadership),
- task characteristics (e.g., demands and requirements of task, timing of task demands, interdependencies among different tasks),
- decision rules (e.g., ability to reverse decisions, criteria used for making decisions, social context of group decision-making).

The form of consensus generated by groupthink is of particular concern because it may contribute to more risky decisions (the "risky shift" phenomenon). In groups experiencing groupthink "the powerful forces of perceived 'togetherness' act in concert to render the possibility of failure unthinkable -- and if not unthinkable, then certainly unspeakable" (Reason 1987, pg. 124). For example, accidents in nuclear power plants have occurred after frequent statements that they were impossible. General beliefs that severe accidents are not possible or rare may lead to inadequate planning for safety.

In addition, familiarity among members of a group may result in negative consequences, such as groupthink. However, research also suggests that familiarity is important in group behavior because it can decrease misunderstandings between individuals and improve the reliability of communications. An understanding of group and social interaction effects and how to mitigate their effects on risk is important to ensuring visitor safety in the NPS.

### 4.2.2 Crowding

A growing body of research considers visitor perception of crowding in parks and wilderness areas (Inglis et al. 1999, Manning 1985, Shelby 1980, Manning et al. 1996, Hammitt 1983, Kennedy 1974, Gramann 1982). Researchers have explored the ways that perceptions of crowding are structured, including social norms, situational influences, and cognitive factors. In particular, crowding is not an objective feature of an environment. Rather, people perceive an area to be more or less crowded depending on their prior expectations (Shelby 1980, Shelby et al. 1983, Inglis et al. 1999). The research shows that many recreationists have strong preferences about the numbers of other people they wish to encounter when engaging in various activities, including hiking, fishing, hunting, camping, and snorkeling.

The available research suggests that there may be important connections between perceptions of crowding, risk taking behavior, and safety. For example, as crowding increases people may feel their safety decreases (Kennedy 1974). Similarly, as people perceive an area to be too crowded, they may be motivated to seek more remote, less crowded areas in a park. This may lead them to increase their risk of accident, injury, or fatality, either because of the environmental conditions (e.g., more risk of avalanche or rock slide) or because of limits in skill, knowledge, or preparedness (e.g., of hypothermia in more elevated areas, swimming further from shore). Referring back to the causal model, crowding may influence a person's choice of activity, the way an activity is performed, contributory causes to an accident event, or the characteristics of an outcomes. An understanding of crowding effects and how to mitigate their effects is important to ensuring visitor safety in the NPS.

### 4.2.3 Recreational conflict

Associated with research on crowding is the question of recreational conflict (Schneider and Hammitt 1995). Conflict occurs when different individuals or groups use the same resource for different purposes and their goals interfere. Schneider and Hammitt (1995) define outdoor recreation conflict as "a disruptive, stressful occurrence in the visitor's recreation experience involving a person-environment relationship that taxes a person's psychological resources" (pg. 229). Conflicts can occur when people are engaging in different activities (e.g., skiing and snowmobiling) or the same activity (e.g., boaters encounter other boaters). As visitation rates increase in national park units recreational conflict may grow as a problem. Visitor safety in a wide variety of recreational activities in NPS units can be usefully addressed by considering recreational conflict among visitors.

Research has addressed trends in conflict, causes of conflict, responses to conflict and management opportunities to reduce conflict, both theoretically and empirically (Hendricks 1995, Watson et al. 1997, Schneider and Hammitt 1995, Jacob and Schryer 1980, Thapa and Graefe 1999, Borrie et al. 1997). A large body of empirical work in a variety of settings has been conducted on recreational conflict, including:

- mountain biking and hiking (Chavez 1996, 1997, Ramthun 1995, Hendricks 1997, Watson et al. 1991);

- walkers, in-line skaters and bicyclists (Moore et al. 1998);
- pack animals and hiking (Blahna et al.. 1995);
- fishing and water skiing (Gramann and Burdge 1981);
- rock climbing and hang gliding (White and Schreyer 1981);
- canoeing and motorized boating (Adelman et al. 1982);
- snowmobiling and ski touring (Knopp and Tyger 1973); and
- hikers and horseback riders (Blahna et al. 1995).

The theoretical basis for much of the research on recreational conflict derives from an understanding of goal interference (Jacob and Schryer 1980), whereby conflict occurs from either direct or indirect social contact: indirect social contact occurs when people have knowledge about each other's actions. Direct social contact occurs during face-to-face contact. Jacob and Schryer (1980) proposed four factors that influence perceptions of conflict:

- activity style,
- resource specificity,
- mode of experience, and
- tolerance for lifestyle diversity.

Usually, more than one factor is present in a social encounter that leads to conflict. However, any one factor by itself can be enough for a person to experience conflict. Others have noted that the list suggested by Jacob and Schryer (1980) is not complete (Owens 1985, Blahna et al. 1995). Other factors include:

- normative differences in participants,
- institutional failures,
- institutional inequities, and
- direct competition for resources.

Schneider and Hammitt (1995) have proposed a theoretical framework for understanding individuals' responses to outdoor recreation conflict. They base their framework on how humans respond to and cope with stress. According to this framework, responses are mediated by a combination of personal and situational factors that influence perceptions of stressful conflict incidents. Consequences of conflict can be short term (e.g., affecting quality of experience) or long term (e.g., reluctance to revisit area).

Important findings from the research on recreational conflict are that:

- groups involved in conflict often have different sensitivities to each other and the conflict. For example, hikers were more sensitive to mountain bikers in the Rattlesnake NRA (Watson et al. 1991) and fisherman were more sensitive to canoeists on the AuSable river in Michigan (Driver and Bassett 1975);
- conflict is frequently experienced when motorized and non-motorized activities occur simultaneously (Adelman et al. 1982);
- skill level may affect perceptions and experiences of conflict (Thapa and Graefe 1996, 1998, 1999). The authors suggest that low-skilled skiers may lack the control necessary to avoid conflicts and they may have more encounters with snowboarders, relative to skiers with more skill;

- gender and age are not clearly linked to perceptions and experiences of recreational conflict (Thapa and Graefe 1999).

Recreational conflict is associated with visitor safety. First, conflict may increase perceptions of crowding, which, as discussed above, may lead people to seek more dangerous areas to engage in their activity of choice. Second, conflict may result in physical harm. For example, collisions may occur between mountain bikers and hikers or bikers and motor vehicles. Chavez (1996) conducted a study of USDA Forest Service managers and found that 59% percent surveyed reported safety problems related to mountain bike use. Examples of problems associated with mountain biking, and related to recreational conflict, included excessive speed of bikes, bikes too quiet, and bikers being careless around motor vehicles. Forty eight percent of those surveyed in this study reported observing or receiving complaints about accidents involving mountain bikes (although we don't know if they were all due to conflicts). The research team found no studies that specifically focused on recreation safety and recreational conflict.

#### 4.2.4 Social amplification of risk

Drawing on the psychometric research, Kasperson et al. (1988; Kasperson and Kasperson 1996) develop the social amplification framework to try to explain why some hazards (e.g., bear attacks) generate much more public concern than other hazards (e.g., motor vehicle accidents) that kill and injure many more people each year. The authors use a metaphor that draws on communication theory to illustrate how "signals" (i.e., information about risks) are processed through a variety of social "amplification stations," such as scientific groups, the media, government agencies, and politicians. These amplification stations may amplify or attenuate the signals. This framework has not been applied to studies of NPS visitor risk specifically or recreational risk in general. However, it can be a useful tool for understanding the ways that individual perceptions, social conditions (e.g., group memberships), media, and other sources of information can combine to strengthen (i.e., amplify) or weaken (i.e., attenuate) the consequences of risk events.

### 4.3 Environmental conditions

Aside from visitor and social characteristics, environmental conditions are fundamental contributors to visitor accidents. Engineers and physical and biological scientists have conducted considerable research to aid understanding of environmental conditions. We confine our discussion, however, to the social science research findings pertaining to natural hazards, wildlife, and viruses, bacteria, and parasites.

#### 4.3.1 Natural hazards

Physical geographers, geologists, meteorologists, and others have studied the physical characteristics of various natural hazards, often with the goal of improving the prediction of hazardous events. Social scientists have examined human perception and response to natural hazards. Gilbert White (1961) adopted an "ecological" approach that portrayed natural hazards as the result of interactions between human and natural systems. Natural systems (e.g., avalanches, floods) become hazards only when they interact with humans. For any given hazard there is a theoretical range of responses of adjustments from which individuals choose a subset (i.e., the practical range of choice).

Kates (1962) developed an elaborate model that captures the major elements of hazards research. The model portrays natural hazards as "extreme events of nature that exceed the capabilities of the system to reflect, absorb, or buffer them." According to the model, an individual will begin the search for adjustment responses only when his/her hazard perception threshold has been crossed. This threshold will vary according to the individual's personality traits and his/her previous experience with hazardous events. If the hazard event is sufficient (in terms of magnitude, location, speed of onset, etc.) to exceed the individual's hazard perception threshold, then the individual will begin to search for possible adjustment strategies.

Generally, an individual faced with a hazard will search for a solution (adjustment) that is "good enough" rather than necessarily optimal. The adjustments can be of three kinds: emergency adjustments (e.g., evacuation), modify natural events (e.g., dams, levees), or modify human use (e.g., modify buildings, ban certain activities in hazard area). Given the limits of the individual's knowledge and other constraints, the ultimate choice will be rational but will usually not maximize expected utility (also see above discussion on "heuristics"). The individual's perceptions of the threat of flooding and his/her knowledge of the range of choice of adjustments available is based on past experience and the frequency and magnitude of flood events. Kates (1970) found that the greatest variation in adoption of adjustment occurred in those communities that suffered neither very frequent nor very few floods. In these communities, some people would adopt adjustments but others would not. In communities with very few flood events most people would adopt few if any adjustments. In communities with numerous events, most people would adopt a range of adjustments. The understanding of how people respond to natural hazards is important for improving NPS visitor safety. NPS visitors may be exposed to volcanic eruptions, floods, wildfires, hurricanes, and other natural hazards. Few studies have focused on natural hazards and visitor safety in national parks (Dingwall et al. 1989).

Another important aspect of environmental conditions that is relevant to visitor safety is weather. Inclement weather (e.g., fog, rain, snow) increases the frequency of driving accidents (Brodsky and Hakkert 1988, National Transportation Safety Board 1980). Visibility can be further inhibited because of blowing snow (Thompson 1980). Issues of visitor preparedness are critical to the way that inclement weather is handled and contributes to safety and human-activity mismatches. The role of weather in visitor risk and safety is important for mitigating visitor accidents.

**4.3.2 Wildlife**

Visitor injuries and fatalities caused by wildlife in parks have been a subject of research. While wildlife attacks generate considerable attention in the media, very few injuries and fatalities result from these encounters. For example, between 1993 and 1998 only 4 fatalities resulted from wildlife attacks, compared with 286 motor vehicle deaths and 166 deaths from accidental falls. Most of the available research has considered conflicts and confrontations between humans and bears (Hererro 1984, Gunther et al. 1998, Jope and Shelby 1984, Chester 1976, Gunther and Hoekstra 1998, Gunther 1994, Gunther 2000, Rogers et al. 1991). Very little other research is available about human interactions with other wildlife (Bryan and Jansson 1973, Knight and Gutzwiller 1995). This lack of attention to other wildlife-human interactions that affect human safety may occur because they are even more rare than bear attacks (Chester 1976).

Visitor safety in a wide variety of recreational activities in NPS units can be usefully addressed by considering visitor-wildlife interactions and visitor attitudes toward wildlife.

Generally, encounters with bears are understood to arise from four primary factors:

- sudden encounters;
- protective behavior, including disturbance of a mother with cubs or protection of a food source (e.g., carcass on which a bear is feeding);
- habituation, including bears who are foraging for garbage and food in campsites; and
- provoked attack.

Although the most developed area of research on human-wildlife interactions, the research on bear attacks is not conclusive. Examples of the ways that research is inconclusive include:

- much research suggests that bear habituation with humans (or their food and garbage) can increase human-bear interactions, and thus the likelihood of an attack. Jope and Shelby (1984) reported on research, however, that suggests that bear awareness and habituation to human presence may reduce the possibility of (grizzly) attacks.
- since the 1970s the use of pepper spray has been promoted as a deterrent to bears. Evidence suggests that the use of pepper spray can be effective in warding off aggressive bears and reducing the consequences of an attack (Herrero and Higgins 1998, Gunther et al. 1998). However, recent research suggests that pepper sprays may attract brown bears because of the smell (Smith 1998).
- no patterns in bear attacks on campers have been found, although some patterns associated with causes and the success/failure of visitor responses (e.g., playing dead) have been found in relation to hikers (Hererro 1984, Jope and Shelby 1984). Those who fight back are more often seriously injured or killed.
- in some cases the use of noise was observed to decrease the frequency of bear encounters (Jope and Shelby 1984) while in others it had no observable effect (Chester 1976).
- several techniques that people can use to eliminate or reduce the consequences of a bear attack. These include playing dead, making noise, running, climbing trees, using pepper sprays. However, no technique offers a guarantee of protection; in some cases they may actually lead to more harm because the attacking bear is further aggravated (Herrero 1984).

As one leading researcher on bears has written, bear personality, bear life experience, human actions, and specific situational conditions all interact to cause injury, fatality, or no negative interaction (Hererro 1984). There are “antecedent” factors, but rarely clear, unambiguous causes. At the same time, prior experience hiking in bear country, the size of hiking parties, increasing human use of bear habitat, and other variables have been observed to attitudes toward bear risks and affect the likelihood of an attack, or if an attack occurs, the type of injury or fatality (Bryan and Jansson 1973, Jope and Shelby 1984, Hererro 1984). Attitudes toward bears have also been the subject of some research. Attitudes of visitors toward bears can be related to visitor safety because they can increase or decrease the likelihood of exposure to the hazard. For example, if people are afraid of bears, they may not visit areas frequented by bears. Or, people may feel that bears can be dangerous, but “not to me.” Similar effects may be an issue in relation to other wildlife. For example, during the late 1980ís visitors to Yellowstone National

Park were handed flyers warning of risks from approaching buffalo. However, we found no research on the relationship between attitudes toward non-bear wildlife and visitor safety.

### 4.3.3 Viruses, bacteria, and parasites

Some research has addressed hazards associated with viral, bacterial, or parasitic contamination, particularly in water sources used for drinking or recreation (Perry and Swackhammer 1989, Pruss 1998). Other hazards may arise from (non-aggressive) contact with animals or their scat (Mills et al. 1998, Aguirre et al. 1993, 1994, Henderson 1998). Exposure to such hazards is common to visitors to national parks (O'Dell et al. 1988, Cowdin 1986, Mills et al. 1998, Henderson 1998). For example, Henderson (1998) found that human infection from hantavirus from contact with small mammals is a risk in many national parks. One common parasite found in water is Giardia; another is Cryptosporidium. Various procedures are recommended to backcountry visitors, for example, for treatment of water (e.g., boiling, use of filters) to reduce or eliminate hazards (Perry and Swackhammer 1989). Visitor safety in a wide variety of recreational activities in NPS units can be usefully addressed by considering visitor exposure to viruses, bacteria, and parasites.

We identified one study that was conducted on animal diseases in the National Park System. A mail survey was distributed to national park managers (n=179), as well as staff and researchers at state and federal agencies, and universities (n=324); the response rate was 70%. Information was gathered on human health issues from exposure to animal diseases, including park wildlife, pack animals, and pets. Human health issues were reported by 61% of the parks surveyed. In some cases, animal-related diseases caused fatalities, such as one case of Rocky Mountain Spotted Fever in Cape Code National Seashore in 1990. The researchers also gathered information about avoidance techniques. Some park units restricted visitor access to reduce contact with wildlife and reduce disease transmission.

One finding from the study was that park managers in about one-third of those units responding to the survey considered the diseases and parasites in park wildlife as part of the naturally functioning ecosystem. They did not believe that such diseases should be eradicated from park ecosystems, even though they pose risk to visitors: "native diseases should only be managed to protect adjacent areas or to preserve ecosystems...for public health reasons...to the extent that treatment does not detract from the appearance of naturalness" (Aguirre et al. 1994, pg. 15; see also Aguirre et al. 1993). On the other hand, those diseases introduced by pets or livestock should be eradicated from national parks, according to the respondents.

## 4.4 Infrastructure and Organizational Characteristics

Visitors often recreate within an infrastructure that is created by the Park Service. They walk in buildings, they travel on roads, and hike on trails that are built and maintained by the Park Service. Research suggests that infrastructure and organizational characteristics can influence safety and risk (Capper 1996). There is a potentially large literature on these subjects, ranging from technical studies of building safety to the role of organizational guidelines and procedures for interacting with visitors/customers. In this section we provide a limited review of three areas. First, we review literature about road and signage conditions and their relationships to driving safety. Second, we review limited literature about trail conditions and safety. Finally, in this section we also review the potential role of NPS employee behaviors on visitor safety.

**4.4.1 Roadway conditions**

The conditions of roadways and their contributions to accidents has been a subject of research. For example, location (e.g., urban, rural) and design (e.g., divided, undivided, turn-offs) of roads can affect visibility and driver behavior (Shinar et al. 1980). Some limited research has focused on signage on roads in public lands (Sheehy and Krueger 1999). Researchers have also studied a variety of methods to improve detection and comprehension of driving hazards (Transportation Research Board 1981, Transportation Research Board 1983, MacDonald and Hoffman 1991, Sivak and Ensing 1989). They include improved:

- illumination on slow moving vehicles and signs;
- warning signs to alert drivers of potential dangers ahead;
- improving driver visibility with rearview and side-view mirror defrosters; and
- redesign of roadways and reflection lights.

In park environments dangers associated with slow moving vehicles are important to consider. For example, drivers may be looking at views or wildlife along roadways or moving slowly as steep roads are passed. Studies have been performed to evaluate methods for reducing such risks. For example, the Federal Highway Administration (1979) evaluated different techniques for slow moving vehicle warnings. They found that:

- flashing lights were an effective means of reducing accident potentials between fast and slow moving vehicles; and
- roadside signs were relatively ineffective as warning devices except at the instant of seeing the sign. Drivers apparently tend to forget the warning after short periods of time.

**4.4.2 Trail safety**

Trails form an essential part of many visitor activities to NPS units. Trails are used by day visitors to interpretive, front-country areas of parks. They are used by bicyclists (Cape Cod National Seashore 1987). Growing visitations rates have put pressure on ensuring safe trail design and maintenance (Gold 1991). As well, the types of visitors are diverse, including elderly, disabled, and other special populations. Limited research has considered the components of trail safety programs and visitor risk management (Gold 1991). Some research has identified the ways that organizational factors can influence the quality of construction and maintenance of, for example, trails, platforms, bridges (Capper 1996). The main point of such evaluations is that standards for appropriate construction are not enough by themselves –social (e.g., employee, managerial) factors must also be considered to ensure the park infrastructure is safe. This research is part of a larger body of research that addresses methods for infrastructure and equipment design and maintenance (Gael 1988, Senders and Moray 1990).

**4.4.3 NPS employees**

The decisions and behaviors of NPS employees are fundamental to visitor safety, and poor decisions may contribute to the likelihood of visitor accidents or the severity of the consequences. For example,

- park rangers are an important source of safety related information for visitors (Manning et al. 2000);

- park rangers can model appropriate or inappropriate behaviors to visitors by, for example, carrying water and not hiking during mid-day heat (Singer 2000 personal communication);
- inexperienced park employees, such as seasonal workers, can increase the risk to visitors. For example, two inexperienced seasonal employees on a search and rescue operation died while enroute to a climber on Mount Rainier (Clifford 1997);
- employee operation of equipment can influence visitor risk. For example, unexpected encounters with snow removal equipment combined with frequently insufficient visitor experience in winter driving has lead to many accidents at Mt. Rainier National Park (Tuler et al. 1993). Risks to employees as well as visitors were influenced by, for example, employee fatigue from working long hours with early starts; decisions to open the road to visitor traffic based on incorrect assessment of road conditions; and driver errors when operating snow removal equipment on a narrow roadway with limited visibility.

Contributions to risk are not, however, necessarily a direct cause of employee decisions or behavior. Risk is affected by interactions between visitors and park employees. For example, during winter snow removal at Mount Rainier National Park visitorís may have insufficient knowledge of how to drive vehicles in adverse weather on narrow and curved mountain roads. When they encounter heavy snow removal equipment they may react in ways that put them (and employees) in danger. The ways that visitors encounter, interact with, and respond to NPS employees, concessionaires, etc. can be helpful for understanding and improving visitor safety in the NPS. There is limited discussion of this issue in the research literature, however.

### *4.5 Equipment characteristics and availability*

In this section we discuss equipment and technology. Equipment and technology can play a key role in the characteristics of human-machine interactions (National Research Council 1988, Rasmussen 1982). In fact, there is a very large literature on this issue related to human factors and ergonomics research. In the context of visitor safety in the National Park System, social influences can make a technology (e.g., personal water craft) or equipment (e.g., gortex clothing) more available. These, in turn, can make an activity more accessible or desirable (Chavez, Winter, and Bass 1993). Little research has addressed either the availability or influence of new technologies or equipment specifically. However, this issue is important to an understanding of visitor risk and safety. Equipment characteristics and availability can influence the choice of activity, as well as how an activity is performed.

The observation that technology and equipment are relevant to safety is underscored by studies of accidents, injuries, and fatalities. For example, personal watercraft have become increasingly common, and represent the fastest growing part of the boating industry measured in terms of sales (Whiteman 1997). Estimates suggest that at Olympic NP their use increased by 30% between 1993-97 and doubled at Lake Mead between 1993-94 (Whiteman, 1997, 22). PWCs are allowed in thirty-six national park units (e.g., Olympic NP and Lake Mead NRA), although they have been banned in some parks (e.g., Glacier NP, Yellowstone NP, Everglades NP) and restricted in others (e.g., Grand Teton NP). While PWCs represent only 9% of all registered marine “vessels” in the US, they are involved in 36% of all boating accidents, 46% of all boating injuries, and 8% of all boating fatalities (Martin 1999). Numerous injuries now occur to young children (Branche et al. 1997). Another example of how technology can affect safety is related to the use of cell phones. In an article about two deaths among seasonal NPS rangers at Mount Rainier National Park, the author wrote “many of the newer climbers know little about the wilderness and rely on technology to get them out of trouble. Portable telephones give visitors the impression that help is just a call away at Mt. Rainier, climbers have use cellular phones in lieu of a map. One climber reached an area in the park and simply telephoned headquarters to ask where to go next” (Clifford 1997).

Changes to technologies may also change risk. Ewert and Schreyer (1990, pg. 484) write that new developments in risk recreation will be influenced by the technology and perceived demands by the public. Technology has already produced lighter weight, stronger materials that have revolutionized many outdoor activities...In essence, what technology has done in the area of risk recreation is increase the safety factor and made the activities more accessible to more people.

However, this does not mean that safety is actually increased. First, those using the technology or equipment need to use it properly. Second, technology and equipment can create the illusion of safety, thus changing risk perceptions. Table 5 illustrates the range of risk recreation activities that have been influenced by innovations in equipment. Other issues that have been discussed in the literature include:

- technological advances in the design of personal watercraft (PWC) have allowed operators to sit rather than stand, which makes them easier to operate. This has encouraged greater use by young and inexperienced riders (Vogel and Titre 1998);
- Lynch (2000) has noted that recent technological innovations to snowmobiles allow them to obtain much faster speeds; and
- Chavez, Winter, and Baas (1993) discuss the role of new mountain bike designs that allow riders to travel further into more remote areas and at faster speeds.

**Table 5.**
Technology contributions to adventure risk

| **Innovation** | **Impact** |
|---|---|
| Sticky synthetic rubber | rockclimbing |
| Plastic boots | mountaineering |
| Chemical lights | SCUBA, spleunking |
| Dry suits | kayaking, white water, SCUBA |
| Parapentes | mountaineering |
| Pile garments | outdoor clothing |
| Roto-molded plastic | kayaking |
| Colored chalk | rockclimbing |
| Avalanche locators | backcountry snow travel |
| Foot fangs | ice climbing |

[Adapted from Ewert and Schreyer 1990, pg. 489.]

# 5.0 Hazard Management

In this section we discuss hazard management and its role in ensuring visitor safety in the National Park Service. We present the "causal model" framework to highlights how management interventions can be used to eliminate or mitigate undesirable outcomes at each step. The section ends with a review of research on risk communication, as it applies to visitor safety. Risk communication related to emergency events is included.

Kasperson (1985, pg. 43) defines hazard management as "the purposeful activity by which society informs itself about hazards, decides what to do about them, and implements measures to control them or mitigate their consequences." Hazard management comprises several functions that operate at the different stages in the causal sequence of hazards. Hazard assessment and control analysis are processes of data gathering to determine the nature of the hazards and the options for controlling them. Implementation, evaluation, and strategy selection are management actions that can be undertaken once the hazards are understood.

## 5.1 The causal sequence of hazards

While taxonomies are important tools for in making sense of the mix of hazards that exist, it is also important . The "causal chain model" provides a means for examining the underlying structure of different kinds of hazards. This framework enables the mapping of the causal sequence of individual hazards (Kates, Hohenemser, and Kasperson 1985). Most importantly, the causal model assists in the identification of alternative management interventions to control hazards and their consequences. It was developed in studies of natural hazards (Kates 1970), but has also been used to study other hazards, such as the hazards of automobiles, nuclear power, airborne mercury, and the Bhopal chemical accident (Kasperson, Kates, and Hohenemser 1985, Bowonder, Kasperson, and Kasperson 1985).

A visitor who became injured by falling down steps, though a common occurrence in the National Parks, illustrates how the causal model may be used to tease apart a hazardous sequence of events (see Figure 4). The diagram begins with the "choice of activity" on the left side and ends with a set of consequences on the right. In this case the choice of activity is "viewing exhibits." Most visitors will complete their visit to the park without adverse consequences (i.e., the pathway at the top of the diagram). For some small fraction of visitors, however, there is a set of necessary and sufficient initiating events or conditions (i.e., wet steps, visitor fatigue, and inappropriate foot-ware) that lead to an outcome (i.e., a fall) with a set of adverse consequences (i.e., abrasions and a broken ankle). Without appropriate intervention and medical treatment, these primary consequences could lead to secondary consequences, such as an infection and long-term disability. This describes the primary causal sequence.

Figure 4 illustrates possible management interventions to prevent or remedy subsequent consequences. Attempts to improve safety and reliability in the performance of activities and tasks (e.g., vehicle driving, rock climbing, canoeing) are fundamentally linked to the elimination or control of factors that may contribute to accidents (Kasperson, Kates, and Hohenemser 1985, National Research Council 1988). In general, exposure to a risk can be limited or eliminated and consequences of the risk can be mitigated or controlled (Kasperson et al. 1985, Bick et al. 1985). Activities can also be structured so that they are less sensitive to errors and by providing opportunities for activity participants to correct errors before an accident occurs. All of these options are important for promoting visitor safety in the national parks. Figure 4 also illustrates how hazards arise can arise from interactions of physical/natural systems and social systems -- and that management interventions can focus on the physical/natural system, the social system, or their interactions in efforts to reduce or eliminate consequences.

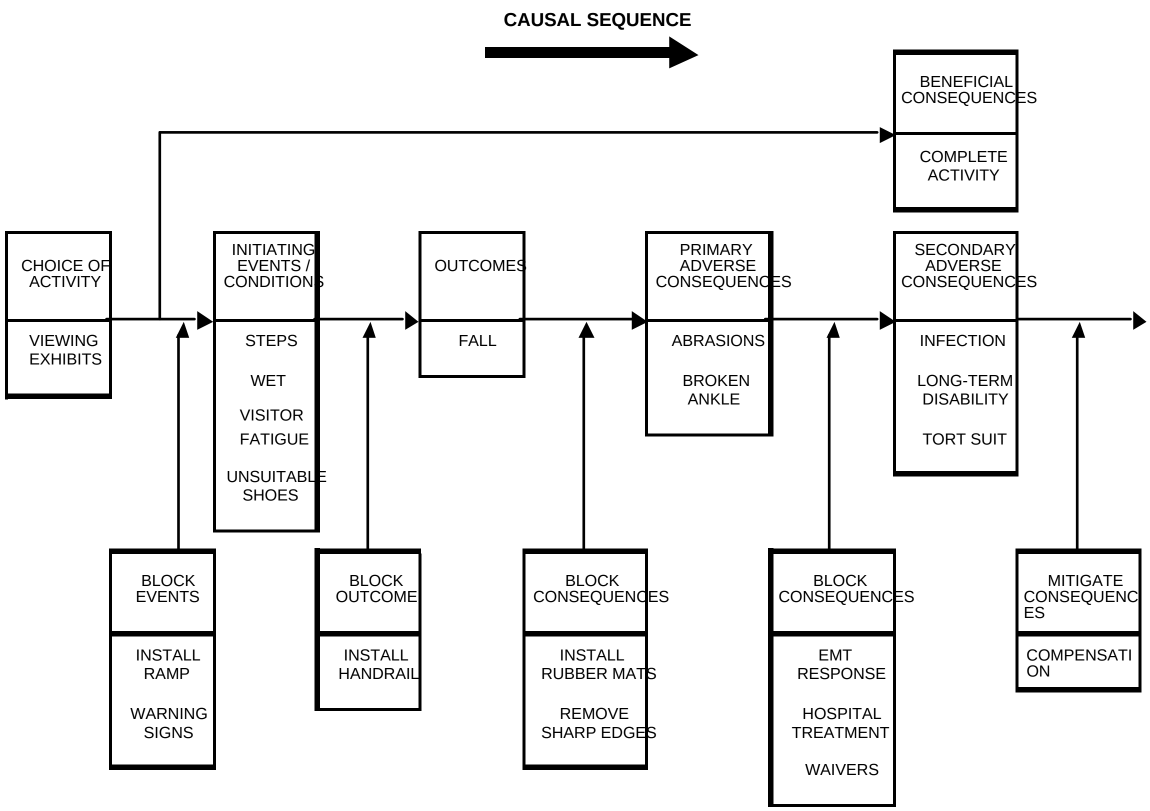



**Figure 4: Management Interventions to Prevent Falling on Steps**

In our example, replacing the steps with a ramp, improving lighting, and adding warning signs may help to prevent the initiating events and block the causal sequence, thus pushing the sequence of events to the upper branch. Adding a handrail may not prevent the initiating events, but it may prevent the outcome (i.e., a visitor falling). Redesigning the steps and changing the materials may help to minimize the adverse consequences if someone does fall. Prompt and appropriate responses by park personnel may help to prevent secondary consequences. For completeness, we include compensation of the injured party as the management option of last resort.

Figure 4 illustrates a fairly simple hazard sequence. The model can be expanded extensively to accommodate more complicated hazard sequences. For example, Figure 5 illustrates another hypothetical example involving a boating accident. In this case, the release of energy (kinetic and thermal) and materials (oil and smoke) may lead to adverse consequences for humans and environmental resources, depending on the route of exposure. Thus, it is useful to add a "stage" for exposure. The exposure stage highlights the pathways by which humans, flora, fauna, and other parts of the environment may be exposed to the energy and materials released. Humans involved in the crash may suffer traumatic injuries from the kinetic energy of the crash and burns from the ensuing fire. They may also be drowned by inhalation of water. Flora and fauna may suffer adversely from oil released into the water. People nearby may suffer adversely from inhalation of smoke in the air. The primary reason for adding another stage for exposure is to elucidate the hazard sequence in more detail and to identify distinctive management interventions that may be possible. For example, to minimize inhalation exposures to the smoke people can be evacuated from the immediate area of the accident. Finally, one management option available here that was not available in Figure 5 is the possibility of banning the activity in question.

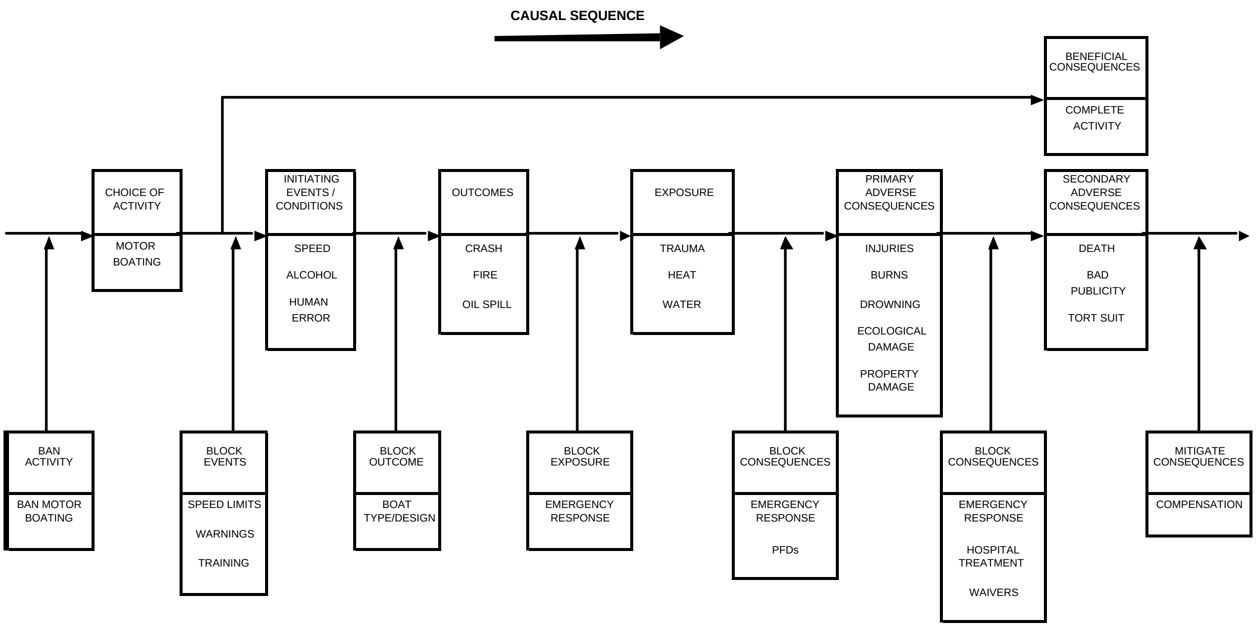



**Figure 5: Management Interventions to Prevent Boating Accidents**

As illustrated by Figures 4 and 5 the causal model can be used to map out the myriad factors that can contribute to visitor accidents and to indicate some of the ways they can be eliminated or controlled through hazard management activities. (Figure 6).

Following Figure 6, hazard assessment begins with the identification of the hazards of concern. In the National Park Service, this might involve an analysis of past accident data, as well as an inventory of current conditions. Once identified, quantitative estimates of the magnitude and likelihood of the risks are necessary to allow priorities to be set. Priority-setting, however, is seldom simply a matter of ordering risks from the highest to the lowest, since there are often conflicting values and objectives. For example, some hazards may result in a relatively few injuries or fatalities, but command considerable public attention (e.g., wildlife attacks). Some hazards may be ranked relatively high in terms of risk, but it is either technically, socially, or financially difficult for the hazard manager to do much about them (e.g., consuming alcohol while operating a boat).

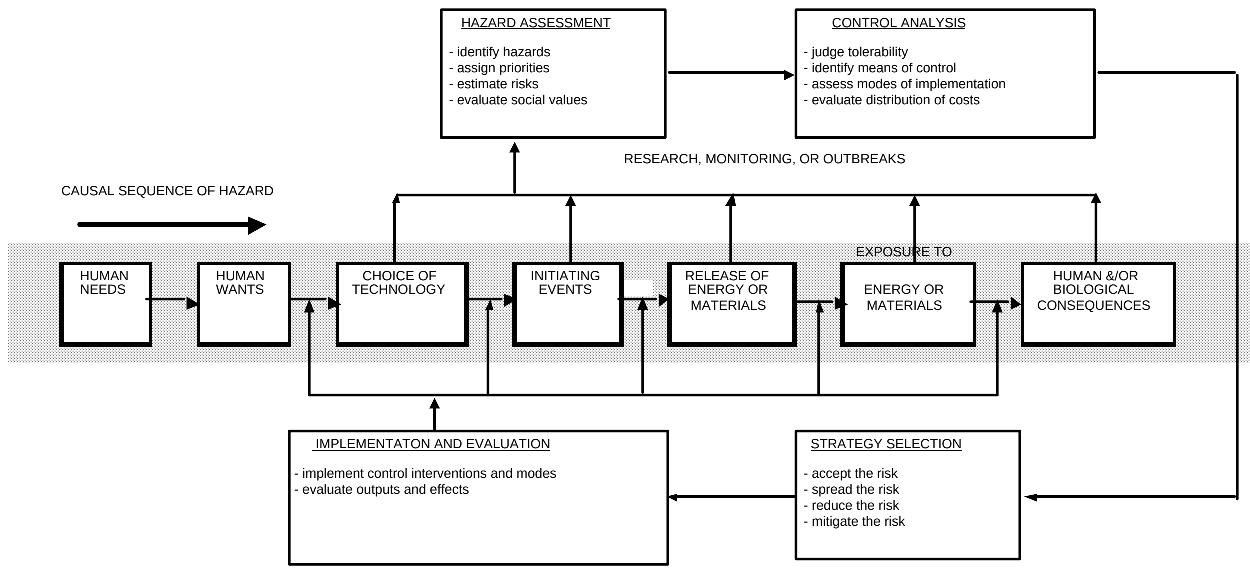



**Figure 6: Flow Chart of Hazard Management (Source: Kasperson, Kates, and Hohenemser 1985)**

In theory, the control analysis follows hazard assessment, although in reality many of the steps in the model become more convoluted and the process of hazard management is often iterative. Having assessed the risks of the various hazards in question, a judgment has to be made as to whether a particular risk is tolerable. If it is tolerable then there is no need for further effort aside from monitoring for future changes. If a risk is deemed to be intolerable, then the risk manager must examine the control options. Determining tolerability or acceptability of risk can be a difficult problem (Kasperson 1983) and has been the subject of enormous debate within the risk community (Covello, Menkes, and Mumpower 1984, Schwing and Albers 1980, Wilson 1984). Suffice it to say here that determining tolerability involves making tradeoffs between different kinds of risks, risks and benefits, and risks and costs.

If certain risks are deemed intolerable, the risk manager will need to identify their means of control. In the causal sequence of hazards, the means of control are the points of intervention that break the sequence of events (Figures 4 and 5). In addition, there are three primary modes of implementing these controls: mandate, encourage, and inform. For example, the NPS might exercise mandatory control by banning a particular activity, such as the use of PWCs, or it might regulate a particular activity by requiring permits. In laying trails that avoid obvious hazards the NPS attempts to lessen visitor risk, but this requires voluntary compliance. Alternatively, the NPS may encourage compliance with posted speed limits by issuing fines for speeding. One of the primary methods for controlling visitor risk, however, is providing information. In risk parlance, this is called risk communication (see below).

To complete the picture of hazard management (Figure 6), the risk manager must devise a strategy that incorporates a package of controls (means and modes of intervention). This strategy may accept some risks, attempt to reduce others, and mitigate their consequences (e.g., through prompt medical attention). Spreading the risk does not really apply in the case of the national Park Service, since it refers to the strategy of diluting pollution in larger amounts of air or water to reduce the risk, or the use of insurance to spread the costs. Finally the strategy must be implemented and periodically evaluated.

Considerable research has shown that it is possible to control factors that may contribute to accidents. Mismatches may occur at any time. The best way to decrease their effects are to design systems that remove the opportunities for weaknesses to matter. Such systems provide a "buffer zone" for human variability in performance (Pitz 1992, Rasmussen and Goodstein 1987). These controls can be achieved by removing the contributing factor, by making the "activity system" less sensitive to errors, and by providing opportunities to correct errors before they result in an accident. The Canadian Park Service (1995, 2) identifies a similar breakdown of options: eliminating the hazards; imposing barriers between visitors and hazards; regulating visitor behavior and access; and using persuasive safety messages. These are all options that can be important to the promotion of NPS visitor safety. They are important in both normal "routine" conditions and unexpected or emergency situations (e.g., backcountry avalanche). As discussed above, factors that may contribute to mismatches and error recovery are found at all levels of the "activity system" (Rasmussen 1982, Reason et al. 1990, Slappendel et al. 1993; see Figure 2 above).

**5.2 Risk communication**

Diggs (1988, pg. v) notes "As a hazard management concept, risk communication has evolved almost exclusively in relation to hazards associated with human technology." Nevertheless, risk communication has been a priority in the field of natural hazards for over four decades "under the guise of perception and awareness studies, educational materials, and prediction, warning, and evacuation programs" (Diggs 1988, pg. v).

Risk communication has been defined as "any purposeful exchange of information about health and environmental risks between interested parties" (Covello, von Winterfeldt, and Slovic 1986). The National Research Council (NRC) has defined risk communication as "an interactive process of exchange of information and opinion among individuals, groups, and institutions" (NRC 1989, 2). Over the past 20 years, risk communication has evolved from early efforts based on the simple source-message-channel-receiver model to more recent efforts to involve members of the public in complex participatory exercises that seek to make the public part of the decision-making process (Fischhoff 1995, Renn 1992). Thus, risk communication covers a wide array of methods, including warning signs and labels, informational brochures, public service announcements, public meetings, and citizen advisory boards. Whatever the method used, there are four primary objectives (Covello, von Winterfeldt, and Slovic 1986):

1. to inform and educate (e.g., about the risks of nuclear power);
2. to change behavior and encourage protective actions (e.g., to encourage people to wear seatbelts);
3. to warn people about disasters and other emergencies (e.g., floods, earthquakes, tornadoes); and,
4. to involve the public in joint problem solving and conflict resolution (e.g., public meetings about a new hazardous waste facility).

While some risk communication programs will have one primary goal, others may have multiple goals.

Researchers in the field of technological hazards have conducted an enormous amount of research on how to inform the public, how to influence behavior, and how to engage the public in problem solving. Reflecting the emphasis of the research, the report by the National Academy's Committee on Risk Perception and Communication (NRC 1989) focuses largely on the purposes and problems of risk communication in larger public debates over controversial issues such as nuclear power, health risks from toxic chemicals, and the siting of noxious facilities. Much of this work is therefore of limited direct relevance to the National Park Service since the problems of concern are quite different. Nevertheless, the report does give some attention to risk communication efforts aimed at personal actions (i.e., changing behavior and encouraging protective action). The Committee notes that much risk communication in this regard "takes the form of messages directed at the public offering information, advice, warnings, or recommendations regarding risky individual actions" (NRC 1989, 78). The Committee also notes "Getting recipients' attention and comprehension poses significant barriers to risk communication, especially in the arena of personal action, where many recipients customarily act without carefully considering risks and benefits" (NRC 1989, pg. 79).

The Committee concludes: "We consider risk communication in the setting of personal choice successful only if it adequately informs the individual for making a choice among alternatives" (NRC 1989, pg. 78). The Committee points out, however, that it is insufficient to assume that a change in behavior implies that an individual is fully informed, and conversely that a failure to change behavior implies that an individual is not fully informed. The Committee identified a variety of methods that may be used to influence decisions and behavior, such as the way information is framed, making risk comparisons, and appealing to emotions. For most of the problems that the park service encounters, the choice of what information to highlight and in what ways will be the most pertinent method. The research on heuristics (see above) suggests that such highlighting may enhance the availability of the relevant information. The Committee, however, was most concerned that "Governmental attempts to influence citizens' beliefs and actions can be justified only to the extent that some legitimate public process has culminated in a decision that using risk messages to influence behavior serves an important public purpose" (NRC 1989, pg. 90).

Fischhoff (1989) summarizes many of the research findings that are significant in communication design:

- people simplify;
- once people's minds are made up, it is difficult to change them;
- people remember what they see;
- people cannot readily detect omissions in the evidence they receive;
- people may disagree about what the risk is than about how large it is; and,
- people have difficulty detecting inconsistencies in risk disputes.
- An understanding of these issues is important to NPS design of effective hazard communications programs that improve visitor safety.

Several manuals have been written that offer advice to government officials, industry representatives and others about how to design and implement effective risk communication (Covello and Allen 1988, Hance, Chess, and Sandman 1988; Lundgren and McMakin 1998).

Much of this advice is aimed at the more controversial kinds of hazards. The typical hazards found in the national parks tend to be less controversial, and the problem is not how to calm down an angry and outraged public (Sandman 1987), but rather how to ensure that members of the public pay attention to the messages and change their behavior accordingly.

Lundgren and McMakin (1998) synthesize many of the major findings from the literature into sets of guidelines for practitioners. They identify several principles of presentation, including the following:

- know your audience,
- don't limit yourself to one form, one method,
- simplify language and presentation, not content,
- be objective, not subjective,
- listen and deal with specific concerns, and
- convey the same information to all segments of your audience.

Lundgren and McMakin (1998) also present detailed information about how to develop informational materials, such as pamphlets, brochures, posters, and fact sheets, and how to use pictorial representations and face-to-face communication effectively. Finally, the authors also present guidelines for dealing with the media.

A growing body of theoretical and empirical research exists on the communication of information to recreationalists (Manning et al. 2000). Studies have addressed the sources of information (Schuett 1993, Cole 1998, Cole et al. 1997), characteristics of the visitors that influence reception and understanding of messages (Trafimow and Borrie 1999, Manning et al. 2000), and different approaches to providing information (Manning et al. 2000, Martin 1992). This research is not always focused on risk and safety, but both types of research have been applied to issues of risk and safety. Other applications of the research include influencing visitors to use low-impact resource use, theft of natural resources (e.g., petrified wood), and off-trail hiking (Swearingen and Johnson 1988).

While the research results are not always consistent, they provide important insights into the importance of information programs and the factors that influence their success. For example, prior research has found that:

- visitors to parks obtain information from a number of sources, including those provided formally by the park (e.g., bulletin boards, brochures) and informally by sources outside a park (e.g., newspapers, friends; see Schuett 1993, Manning et al. 2000);
- information can be effective at changing the behaviors of park visitors (Manning et al. 2000). However, information programs are not always effective at changing behaviors (Swearingen and Johnson 1988);
- characteristics of visitors can influence the ways that information is given attention, understood, and remembered. For example, prior experience can play a role in how safety-related and visit-related information is understood and remembered (Schuett 1993). The size of a group can influence the effect of information sources (Roggenbuck and Berrier 1982); and
- information received prior to a visit can influence visitor preparedness (Rentz and Schreyer 1977). When information is received after a visitor has arrived or begun an

activity, it may have less of an effect on safety-related behaviors. For example, learning that water should be carried on a day hike when a visitor is beginning the hike may not change the visitor's behavior because they are unable to obtain additional water-carrying equipment.

Much of the recreation-related research research is based on standard model from risk communication theory, the "sender-receiver model" (Braithwaite 1989). A second set of research is based on notions of persuasion (Cole et al. 1997, McCool and Braithwaite 1992, Roggenbuck and Manfredo 1989). In the following two sections we describe how each of these theoretical approaches has been applied to risk and safety communication in recreational and park use settings.

### 5.2.1 Standard risk communication approach

Ashley Consulting recently conducted a needs assessment for the Canadian Park Service with regard to risk communication (Canadian Park Service1995). This assessment formed the basis for a new Public Safety and Communication Plan (Canadian Park Service 1997). The findings and recommendations of these documents are instructive.

The needs assessment used the standard model from risk communication theory as an organizing framework. This model asserts that changing attitudes and behaviors depends on the manipulation of four key factors: source; message; channel, and receiver. While the "sender-receiver" model has taken a number of forms in the literature, they all share basic assumptions about the characteristics of communication and it has informed a wide variety of communication research, including negotiation, media analysis, risk and hazard communication, and policy-making (Kasperson et al. 1988, Renn 1992). In this model of communication a listener is joined to a speaker via a communication channel and a common language code. This model conceptualizes communication such that a speaker composes and encodes a message, which is then transmitted through a channel (a "conduit") in a particular language code to a listener: Listeners receive the message and must then decode it to obtain its intended meaning. Problems in communication, such as errors and misunderstandings, are viewed as a result of distorted or ambiguous messages (Renn 1992).

The Canadian Park Service assessment attempts to characterize each factor, with the implicit assumptions that effective risk communication needs to target particular audiences with tailored messages using multiple appropriate channels. The assessment distinguished between five visitor activity groups (touring recreationalists, passive recreationalists, recreationalists, active recreationalist adventurists, and extreme recreationalist adventurists). Profiles for each group were compiled, including information on visitor activities, expectations (including acceptance of risk), preparedness, and safety message/information requirements. Three components to safety messages were defined as follows (Canadian Park Service1995):

- self-reliance: the need for responsibility, good judgment and self-rescue skills when visiting protected heritage areas;
- risks: hazards and the probability and severity of an adverse effect to health, property, or the environment; and,

- preparedness: measures the visitor can adopt to lessen the probability and severity of the risk.

Existing materials and programs were examined for messages about self-reliance (or responsibility awareness), hazards, and preparedness. The inventory of messages distinguishes between internal messages (i.e., brochures, posters, signs, exhibits, videos, staff contacts, etc.) put out by the Park Service and external messages put out by groups such as the Canadian Red Cross and the Alpine Club of Canada. These internal and external messages were organized according to the five visitor activity groups and "trip cycle" (awareness, pre-trip, en route, reception, park or site activities, departure). The needs assessment also examined data on socio-demographics, activity-participation, and accident rates.

Based on these analyses, the needs assessment recommended that the objective for the safety communication program should be to change visitor awareness and attitudes about safety and self-reliance in order to change visitor behavior. To achieve this objective, the program should target messages to each of the five visitor activity groups at specific stages of the trip cycle. Furthermore, given the accident and activity data, group-specific safety messages should be designed for water-based activities, land-based activities, and vehicle activities.

In its Public Safety Communication Plan, the Canadian Park Service (1997) agreed with the principle of targeting risk messages, but wanted the targeting to incorporate other socio-demographic variables. The Plan identifies two primary targets and one secondary target. The first primary target is males aged 15-40, especially males aged 15-24, who live in urban areas within three-hours drive of national parks. The second primary target is males and females aged 20-40, who have already visited a national park. This group was chosen because the CPS believes that it represents the largest group of visitors; contains the largest number of visitors likely to be involved in accidents; can be reached by communication efforts; and its knowledge, attitudes, and behaviors may be more easily changed.

### 5.2.2 Persuasion-based research

A large body of research in psychology has focused on the ways individuals form new attitudes. The ways that information can persuade people to adopt new opinions has also been a topic of much research. The theories and findings from such research have been applied to risk-related communication programs (Renn 1992, Renn and Levine 1991) and to recreational information programs (Cole et al. 1997, McCool and Braithwaite 1992, Roggenbuck and Manfredo 1989). Additional research literature on "social marketing" has addressed how behaviors can be changed through persuasive communication programs on public health and environmental issues (Andreasen 1995, McKenzie-Mohr 2000). However, it has not been applied directly to recreational safety in the research literature.

Research on attitude and persuasion has identified a variety of factors that can influence individuals' attitudes and motivations, including credibility, attractiveness, sympathy, and expertise of information sources, being explicit about the persuasive intent of the messages, and openness to new and "unlikable" sources of information.

One of the most widely used models of persuasion is the Elaboration Likelihood Model (Petty and Cacioppo 1986, Renn 1992). This model describes people as using one of two route of information processing:

1) the central route of information processing is used when the topic or information is considered very relevant to the listener and he/she is highly motivated. In this case the listener forms opinions by evaluating competing arguments and evidence presented by different information sources. For example, congruency with personal values, credibility of arguments, and social desirability are used to evaluate pros and cons. It demands high levels of attention from those receiving the information.
2) the peripheral route of information processing is used when the topic or information is not considered very relevant by the listener. In this case the listener forms opinions using relatively simple cues and rules of thumb (heuristics), such as: reputation of the information source, social attraction to the information source, message length, and perceived impartiality of the information source.

Each of these routes of information processing can play an important role in persuading people to adopt new attitudes or behaviors, depending on the goals of the information program and the characteristics of the recipients of the information.

The use of the elaboration likelihood model has been applied to the study of wilderness education on low-impact use (Cole 1998, Cole et al. 1997). These researchers studied the ways that messages can be more effective at gaining visitors' attention on trailside bulletin boards in a wilderness area in Montana. They found that messages with more elaborate appeals for attention were no more likely to lead to visitors reading the messages than simple appeals for attention. Moreover, when a larger number of messages were posted, their effect decreased, perhaps as a result of an overload of information. A positive association was found between the attention given to a sign-based message by a visitor and the retention of that information. However, results of studies about the effectiveness of sign-based messages are mixed (Stubbs 1991, Fazio 1979, Thorn 1995, Swearingen and Johnson 1988).

### 5.3 Risk communication in emergencies

Many parks face the prospect of having to communicate with the public about emergencies such as floods, hurricanes, tornadoes, and volcanic eruptions (Dingwall et al. 1989). There exists an extensive literature on human responses to disasters that can inform these activities. Much of this literature is based on studies of natural disasters, although findings from technological disasters are included. Sorensen and Mileti (1991) provide a concise review of the literature. They divide the literature into pre-emergency and emergency risk communication. Pre-emergency risk communication includes informing and educating the public in advance of an emergency about the nature of the hazard, ways of mitigating losses, and protective actions that may be pursued. Emergency risk communication involves the provision of emergency warnings during or shortly before an emergency.

Sorensen and Mileti (1991) identify several stages in the emergency warning process. Members of the public must receive, understand, believe, personalize, and respond to risk information, and they may seek additional information from various sources. The information received may include warnings from park rangers and other government officials, but it may also include other cues such as spotting funnel-shape clouds. These stages apply to both pre-emergency and emergency risk communication.

During pre-emergency communication most people receive most of their information on a range of hazards from the popular media, such as television news, newspapers, and radio (Sorensen 1983, Turner et al. 1979). Official sources of information, such as pamphlets, phonebook instructions, or civil defense programs have not been found to be significant sources of past learning (Sorensen 1983). Few receive "official" information without significant filtering and reinterpretation by the media (Turner et al. 1979), and special programs may only reach the intended audiences with special efforts at targeting (Sorensen 1983). Even with efforts to target special programs, the public's ability to learn and retain information is limited. Palm (1981) found that only 45% of the people living in areas at high risk of earthquakes were aware of a special earthquake awareness program, and Waterstone (1978) found that public awareness of a flood brochure declined from 63% one month after distribution to 37% after one year.

Studies about the impact of hazard awareness programs are mixed. Roder (1961) found that distributed maps had no impact on public awareness of flood hazards in Topeka, Kansas. Haas and Trainer (1974) found that a targeted educational program had little impact on tsunami awareness. On the other hand, several authors have found that flood information programs increased public knowledge and awareness (Baumann 1983, McKay 1984, Waterstone 1978). Regarding the nature of the information program conducted, Baumann (1983) found that the amount and intensity of information had no effect on the level of knowledge, and McKay found that personalized information is more effective. Christensen and Ruch (1980) and Ruch and Christensen (1981) found written information to be more effective than electronic media.

Several authors found that informational programs increased public concerns about hazards (Baumann 1983, Haas and Trainer 1974, McKay 1984, Waterstone 1978). Ruch and Christensen (1981) found that television communications led to higher perceptions of risk, whereas radio spots and brochures reduced perceptions of risk.

Risk communication that occurs during an emergency has also received much attention in the research literature. The mass media in general, and radio and television in particular, are the most effective channels for the dissemination of emergency risk information (Perry, Lindell, and Greene 1982b, Quarantelli 1980, Turner 1983). Some suggest television is more effective than radio (Turner et al. 1979, 1981, Baker 1979), although others suggest radio is more effective than television (Dillman, Schwalbe, and Short 1982, Dynes et al. 1979, Drabek and Stevenson 1971). Factors that have been found to enhance the likelihood of receiving and hearing emergency warnings include:

- the use of multiple channels (Turner et al. 1981);
- proximity to the potential impact site (Rogers and Nehnevajsa 1984, Landry and Rogers 1982, Frazier 1979, Mileti et al. 1975);
- membership in voluntary organizations (Perry, Lindell, and Greene 1981);
- level of community involvement (Perry and Lindell 1986, Perry and Greene 1982; Turner et al 1979, 1981, Sorensen and Gersmehl 1980; Scanlon and Frizzell 1979);
- frequent interactions among kin (Landry and Rogers 1982; Perry, Lindell, and Greene 1981);

- being younger (Rogers 1985, Perry, Lindell, and Greene 1981, Turner et al. 1979, Turner 1976, Mileti 1975);
- higher socioeconomic status (Perry and Greene 1982, Turner et al. 1979, 1981);
- being a woman (Turner at al. 1979);
- having children (Turner et al. 1979, 1981); and
- prior experience with disasters (Perry and Lindell 1986, Landry and Rogers 1982, Turner et al. 1981).

Research indicates that three attributes of the message enhance the believability of emergency messages and the likelihood that they will be understood:

- messages with greater specificity about the nature of the hazard, the time and location of impact, and recommended protective actions will be more believable (Quarantelli 1984a, Perry and Greene 1982, Perry, Lindell, and Greene 1982a, Sorensen 1982, Greene, Perry, and Lindell 1981, Drabek 1969);
- consistency within and between multiple messages will enhance believability (Sorensen 1982, Turner et al. 1981, Foster 1980, Mileti 1975); and
- the greater the certainty of the probability of impact as specified in a warning, the greater the level of belief (Mileti, Hutton, and Sorensen 1981, Perry, Lindell, and Greene 1981, Turner et al. 1979).

Believability of emergency messages is enhanced if:

- warnings are delivered through personal contacts (Perry and Greene 1983, Sorensen 1982, Perry, Lindell, and Greene 1981);
- recipients receive additional warnings (Perry and Greene 1983, Turner 1983, Sorensen 1982; Perry, Lindell, and Greene 1981, Mileti 1975);
- the warning is from an official source (Rogers 1985, Rogers and Nehnevajsa 1984, Perry and Greene 1983, Sorensen 1982, Flynn 1979, Mileti 1975, Drabek 1986);
- the warning is from a credible source (Perry 1982, Perry and Greene 1982; Mileti, Hutton, and Sorensen 1981, Turner et al. 1979, 1981);
- there are confirmatory environmental cues, such as rain and high winds prior to hurricane landfall (Saarinen and Sell 1985, Perry and Greene 1982, Sorensen 1982, Quarantelli 1980, Mileti 1975, Drabek 1969); and
- if the recipient is able to confirm the warning message (Quarantelli 1984b, Perry and Greene 1982, Perry, Lindell, and Greene 1981, Mileti and Beck 1975, Drabek 1969).

Personalization of emergency messages increases with greater message specificity (Perry and Greene 1982, 1983, Perry, Lindell, and Greene 1981, 1982a, Lindell, Perry, and Greene 1980), consistency across messages (Lindell and Perry 1983), and increasing number of messages (Perry, Lindell, and Greene 1982b, Perry 1979b, Mileti and Beck 1975).

Sorensen and Mileti (1991, pg. 371) conclude,

> These studies illustrate the need for multiple channels of communication in a hazard information program. People rely on, and pay attention to, different sources of information. Specialized programs may be more effective if linked with the general media, which is how people acquire information. Each channel provides differing types and levels of information that will reach different audiences. Furthermore, best results

are obtained when multiple messages are provided that are consistent and give specific information about the nature of the hazard, the location and time of the impact, and appropriate protective actions that can be undertaken.

## 6.0 Conclusions

*What is known?*
There has been considerable research on hazards, risk, and safety in a broad variety of activities. Theoretical frameworks have described the ways hazards can lead to adverse outcomes. An important lesson from prior research is that accidents arise from many interacting factors. The "steps" involved have been described by the causal model. Contributory factors arise 'early" in the causal chain, when a person chooses an activity and the activity or technology is designed. Risks of undesirable outcomes are also affected by the way a person is exposed and reacts to an accident. The social sciences have devoted much attention to these issues and they provide a useful perspective from which to assess and improve safety in recreational activities, including those of visitors to national park units.

Visitor safety and risk in the National Park System can be usefully addressed by considering recreational activities as part of an "activity system." Individuals interact within the context of equipment, other personnel, organizational and institutional infrastructures, social and economic factors, and the environment. At each level, and within the interactions among them, are factors that can cause or contribute to accidents. Numerous studies have found that individual, social, environmental, and organizational/infrastructure characteristics contribute to risk in human activities, through interaction of elements in the total 'activity system." Much of this work is concerned with the variety of factors that can influence perception, judgment, comprehension, communication, decisions, and behavior in positive or negative ways.

Many studies have shown that people are capable of completing complex activities in difficult environments. However, evidence from the studies also shows that people are variable in their capabilities. Such variability can interact with activity requirements and equipment in such a way that accidents and mishaps occur. As activities are made more complex and occur in more difficult situations, the likelihood grows for accidents or mishaps. In fact, any person can contribute to or cause an accident at any time, regardless of his or her skills and experiences. Yet, they can also contribute to the mitigation or prevention of accidents/incidents. The causal model is also used to identify management interventions that can mitigate or prevent accidents, or the severity of their consequences when they do occur.

Individual and group capabilities are degraded in unfavorable situations. Many studies have shown that harsh environments, physical stress and fatigue, mental workload, time pressure, and a variety of other factors can limit capabilities. Many of them have been described here, with special emphasis on those that are most relevant to they types of activities performed by NPS visitors. While they are often found to be contributors to accidents, their effects are not the same for all individuals. In addition, individuals do not always react to these "stressors" in the same manner; other factors, both within and outside of the work environment can affect how individuals react to and attempt to overcome them.

Because of variability among individuals' behaviors, it is impossible to eliminate all sources and causes of accidents. Consequently, it is impossible to predict when all accidents and mishaps can occur. In fact, it has been observed that the only way to avoid potentially harmful effects of "human errors" is to make systems "goof proof" so that they do not fail in ways that can cause serious accidents. Identifying methods for creating activity systems for NPS visitors with such characteristics is an important area for further research.

Considerable knowledge has been gained about methods for communicating and educating people about hazards. Experience has shown that using multiple sources and channels of information can increase the effectiveness of communication programs.

*What is unknown?*

Research on hazards and their causes are not capable of explaining exactly why or when "mismatches" may occur, how the effects of prior experience, risk perceptions, and stress factors influence particular individuals or groups, or fully explain why the reactions of individuals and groups can vary when exposed to similar factors.

Much of what is unknown is related to the many variables that influence the reactions of specific individuals in specific situations. Limitations in research occur because certain behaviors or situations have not been studied in detail. Little research focused on NPS visitors specifically. Limited research has addressed the unique combinations of activity requirements, social and physical environments, and individuals and group behaviors that occur in many of the activities performed by the NPS. Limited research is also available about the effect of different hazard management strategies (e.g., hazard communication) for park specific contexts.

Hence, the literature review offers an extensive body of findings, with many important gaps. These gaps suggest a research agenda for NPS visitor safety social science.

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