NATURAL HAZARD PERCEPTIONS, NATURAL DISASTER EXPERIENCES AND RECOVERY AT AMERICAN PUBLIC HORTICULTURE INSTITUTIONS

by

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ABSTRACT

Public horticulture institutions (PHI), as stewards of living plant collections, are threatened by a variety of impacts from natural hazards. Ranging from geological and hydrological events to meteorological events, public gardens must manage the effects of natural forces on plants, structures, and business operations. PHI directors, horticulturists, risk managers and other staff were interviewed at five public gardens that experienced a natural disaster. The results reveal that there are many reactive issues that must be anticipated and managed in the wake of a natural disaster. Also, some opportunities may surface from the same experience. The impacts and issues relating to a natural disaster experience are likely site-specific, although many of the impacts and issues have a commonality to all PHI. One way to help manage the impacts of natural hazards includes the use of a disaster response and recovery plan. A national survey involving 224 PHI across the United States determined public gardens' current natural hazard risk perceptions and recent disaster experiences (1980-1999). This survey revealed that most public gardens do not have a disaster plan, and even fewer have a disaster recovery plan. However, past disaster experiences did result in increased risk perceptions for all natural hazards covered in this study. Further investigation suggests overall impact on historical plants and facilities causes American PHI to develop a disaster response plan, and an overall impact on plant and facilities in general causes public gardens to draft a recovery plan. Results also indicate that there are no differences in the types of losses sustained from natural disasters between governmental and non-governmental (private) PHI. There is also support that there is a relationship concerning the use of

governmental recovery resources to facilitate recovery efforts by both governmental and private PHI. Thus, governmental PHI are more likely to the have the internal resources to recover from a natural disaster.

Chapter 1

INTRODUCTION

Public horticulture institutions are the stewards of living plant collections. Botanic gardens, zoos, historic estates, arboreta, public open spaces and parks are among such institutions that manage plants. Public gardens also have not been spared involvement from the inevitable forces of nature. Weather plays a fundamental part in life on the planet--not only can replenishing rains and warmth promote life, hurricanes, tornadoes and extreme winter storms can just as easily threaten life and property. Seismic activities, such as earthquakes and ground shaking, are realities in some parts of the world; the recurring nature of the hydrological cycle, from drought to flooding is evident at all geographies.

Plants and animals constantly face the pluses and minuses of exposure to the elements. Plant collections are at a higher risk of detriment from natural hazards for a variety of reasons. Plants are not mobile and cannot be easily protected from the forces of nature. Even with the expertise of humans, physical and engineering limitations exist in both man-made structures and the plants themselves that preclude total resistance to natural forces. A plant located within the confines of a public horticulture institution is no more immune to these basic laws of biology and physics.

This thesis explores the perceptions, experiences and recovery efforts of public horticulture institutions in the United States. Chapter One introduces the basic definitions and information central to the thesis, including a literature review. Chapter Two explores the impacts of natural disasters and the role of disaster planning. Research methodology is covered in Chapter Three. Chapter Four lists types of natural hazards and the perceived risks of encountering these hazards by American public gardens. Chapter Five provides information on case study sites, including each site's respective natural disaster experiences and recovery efforts. Chapter Six reveals overall trends in disaster experiences and recovery at the case study sites. The seventh chapter presents the results of a national survey of public horticulture institutions regarding natural disaster experiences since 1980. Discussion of these results is also found in Chapter Seven. Conclusions and recommendations comprise Chapter Eight. Appendices and bibliography makes up the balance of the thesis document.

Purpose

The purpose of this research is to determine risk perceptions and extent of natural disaster experiences and recovery at public gardens in the United States. In order to match this purpose, seven objectives guided the study through the use of both qualitative case studies and quantitative survey measurements:

- Identify characteristics of some natural hazards and learn of their spatial distribution.
- Identify perceptions of risk exposure to natural hazards.
- Identify common losses reported by public gardens from natural hazards.
- Identify common issues faced by public gardens when natural hazard events result in losses and disruptions.
- Identify strategies and processes utilized by public gardens during response and recovery.
- Investigate the role of mitigation.
- Draw conclusions and offer recommendations to assist public gardens recognize risks and needs in disaster recovery.

Three conceptual hypotheses were developed and tested through the use of empirical hypotheses (see Chapter Seven). The first conceptual hypothesis is that losses sustained at public gardens from natural hazards are similar. The second that public gardens are better prepared to handle the process of disaster recovery as a result of a previous natural hazard or disaster experiences. A final hypothesis is that public horticulture institutions do not have the resources within themselves to recover from losses to botanical collections and/or losses to infrastructure as a result of a natural hazard event.

A national, quantitative survey of public horticulture institutions provides insight into current perceptions of natural hazard risks at public gardens across the United States. The survey also furnishes national, collective data on experiences—the disruptions and losses sustained and recovery resources utilized as a result of a natural hazard(s) or disaster(s) from 1980-1999.

Five case study institutions constitute the qualitative portion of the study (Chapters Five and Six). They were selected through consideration of responses from the survey. Fairchild Tropical Garden, Miami, Florida; The Hermitage, Nashville, Tennessee; The Linnaeus Arboretum of Gustavus Adolphus College, Saint Peter, Minnesota; Longwood Gardens, Kennett Square, Pennsylvania; and the Mercer Arboretum and Botanic Gardens, Humble, Texas are located in different parts of the country and represent different governing authorities, natural hazard types, and strategies used for disaster recovery.

The author intended that this thesis would have practical and/or planning applications for American PHI. To begin, there is an aspiration that public gardens will gain an increase in risk perceptions of and awareness of vulnerability to natural hazards from this document. Secondly, this research will identify efforts and issues faced during response and recovery by public horticulture institutions in wake of natural hazard events. Thirdly, recommendations taken from case study site experiences will inform planning and policy at public horticulture institutions. Policy will be informed not only regarding recovery, but also of issues in natural disaster emergency management, including preparedness, response and mitigation. Ultimately, public horticulture institutions will become better prepared for the realities of natural hazards while also becoming leaders in managing loss and disruption to living collections and facilities in the wake of a natural disaster.

Background

Substantial research on the effects of natural hazards and disasters exists and is advanced through both natural and social sciences and the engineering discipline. Physicists and engineers strive to understand physical strengths and thresholds in materials and natural hazards themselves. Meteorologists focus on studying the atmosphere, with intention to better understand and predict weather changes and events. Traditionally, social scientists focused much attention on the effects of disasters on the individual victim. A more recent trend by sociologists is to investigate the effects of disaster on more collective units, such as households, businesses and communities (Dahlhamer 1998). No research specific to public horticulture institutions as a unit of study has been identified to date.

Research and commentary on natural disasters and their effects can be found in several other disciplines. Public policymakers have done considerable investigations on the economic aspects and social responsibilities associated with disasters within a society. In the United States, several governmental bodies, such as the National Research Council (NRC), the United States Geological Survey (USGS), the National Oceanic and Atmospheric Administration, the U.S. Department of Agriculture's (USDA) Forestry Service and the

Federal Emergency Management Agency (FEMA), among others, frequently investigate response and recovery issues and their impacts (*The Impacts of Natural Disasters* 1999; *A Safer Future* 1991).

Historians with the Museum Studies field are well aware of the dangers natural forces can play on delicate historical resources and collections. Barclay Jones' *Protecting Historic Architecture and Museum Collections from Natural Disasters* (1986), Dirk Spennemann and David Look's *Disaster Management Programs for Historic Sites* (1998), and Carl L. Nelson's *Protecting the Past from Natural Hazards* (1991) are frequently cited as preservation and recovery standards for museums. What is noteworthy is that only Nelson addresses basic plant collection issues regarding disasters in his book (unlike Jones), but it is not the foremost concentration. When historians address the horticultural landscape, it is often incorporated into the 'greater landscape' that would include all non-living components of the historic site and surroundings.

Within the biological sciences, considerable attention has been given to individual (or communal) animal and plant responses to the effects of natural disasters or stresses at the physiological and ecological level. Horticulture has particular commentary on plant responses, such as published occasionally in the *Journal of Arboriculture*. Beyond the effects on individual or familial groupings of plants, however, there is no systematic research extant discussing the stewardship and management issues consistently faced by public gardens in the wake of natural disasters.

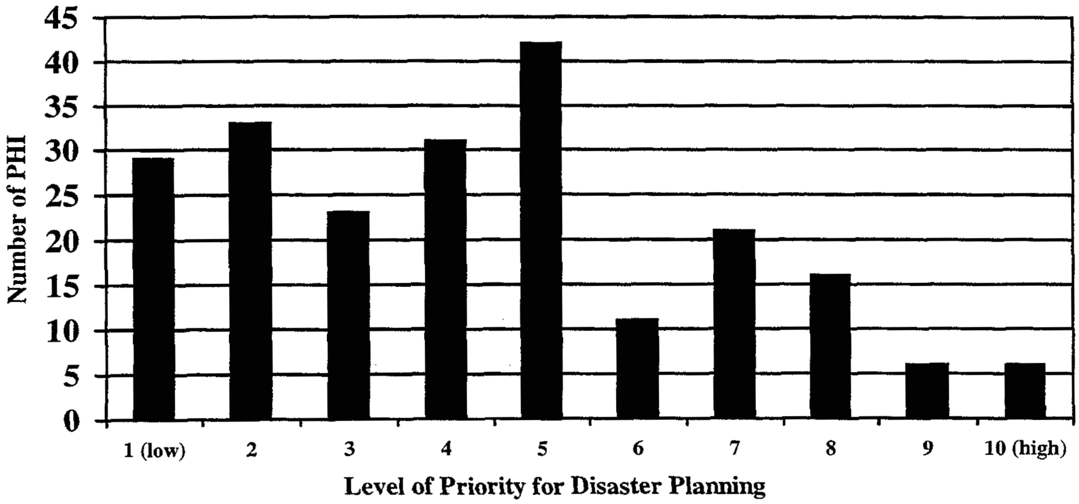
The private sector, however, is not far removed from an awareness of the effects of natural hazards. *Disaster Recovery Journal*, *In Sync Magazine*, and *Contingency Planning & Management* are three periodicals that seek to open the dialog on business continuity and disaster planning and preparedness. *Natural Hazards Observer*, a publication of the Natural Hazards Research Center at the University of Colorado, is a comprehensive newsletter that includes overviews on current hazard research, publications and risk resources available. *National Underwriter* is a publication specific to the property and casualty management fields. All of these publications address disasters and recovery in a non-scientific, case report or editorial format using a conversational tone.

Characteristics of the Public Horticulture Institution

The researcher has defined a Public Horticulture Institution (PHI) as an organization that has a mission statement pertaining to the display, conservation, preservation, research or education practices relating to a living plant collection. Hence, examples of PHI include, but may not be limited to: botanic gardens, zoological gardens, arboreta, historical properties, public open spaces, display and pleasure gardens, nature preserves and amusement parks. Although there are a large number of PHI which are of 501(c) 3 non-profit status of the Internal Revenue code, this definition does not exclude those which may be privately (by individual or corporation) or governmentally owned and managed. In this document, the term 'public garden' is synonymous with the term 'public horticulture institution.'

Moreover, public horticulture institutions face the same economic realities and limitations as other business organizations. These realities and limitations carry stewardship and policy implications for plant collection management. Financial and other resources may often be limited. Development of plans and policies specific to natural disasters and related recovery needs may not typically be the foremost priority (Levitt 1997) for these public gardens. Figure 1.1 demonstrates the breakdown of American public gardens' level of priority for disaster planning, based on responses to this research's survey instrument. The

Figure 1.1 American Public Horticulture Institutions' Level of Priority for Disaster Planning (n=224, average priority = 4.3).



majority of PHI rate their priority at a mid-level to the lowest level. The average priority across 224 public gardens is 4.3 on a scale of one (lowest priority) to ten (highest priority).

The Natural Disaster

Many types and scales of disasters occur. What all disasters have in common is concentrated harm to life and/or property, often with incredible death tolls, injury and damage. Damage results in disruption to normal daily routines, activities and administrative functions (Hewitt 1997). Other researchers have defined disaster on a more tangible basis. The Natural Hazard Research Group at the University of Colorado in 1969 purports any of three circumstances connotes a disaster: (1) more than $1 million in damage, (2) more than 100 people dead, or (3) more than 100 injured (Wijkman and Timberlake 1988). Furthermore, in 1972 the United States Office of Emergency Preparedness defined a disaster as "occurrence of imminent threat of widespread or severe injury or loss of life or property resulting from any natural or man-made cause. (Wijkman and Timberlake 1988).

Disasters may be categorized into different typologies: technological, civil, ecological, and natural. Technological and civil disasters involve human actions and decisions. Year 2000 Compliance (Y2K) is one technological disaster example, hazardous chemical spills, transportation accidents, and building collapses are others. A civil disaster includes wars, terrorism, civil riots and other deliberately destructive human actions. Ecological disasters are the result of human actions on the environment and are separated from technological disasters in that humans are not the initial entity affected. These actions affect the atmosphere (e.g. acid rain, ozone depletion) and the earth and its flora and fauna (e.g. rain forest depletion, species extinction). Natural disasters include events that are of meteorological (hurricane, lightning), hydrological (tidal and riverine flooding, droughts), geological (earthquakes, landslides, volcanoes), or biological (pests, pathogens, diseases) origin (Hoetmer 1991).

Geography and/or climatology can contribute to determining where and when natural disasters occur. The impact on humans depends on the disaster's affect on human safety, and the built or cultural landscape, or simply, development. Natural disasters may also cause subsequent disasters. For example, a hurricane can give birth to tornadoes and rains, which result in flooding; or, heavy rains can create conditions favorable for proliferation of pests and diseases (Hoetmer 1991).

This research focuses solely upon the natural disaster. In this investigation's design the natural disaster is further defined by the author as "an actual spontaneous event of meteorological, hydrological, or geological origin(s) that results in damage to/loss of property or business disruption creating inability for the PHI to fulfill its mission." Disasters of biological origin have been excluded. It is the intention that 'natural disaster' will include all magnitudes of nature-induced events that result in loss to PHI plant collections, property and/or business disruption. It is important to note that *peril* and *hazard* are also used frequently in place of or alongside the term *disaster*. However, for this research *natural peril* and *natural hazard* will both refer to the characteristics of and common reference to any type of natural phenomenon with the potential (threat) to cause damage or disruption.

Within the field of emergency management there is effort made to distinguish the difference between "emergency" and "disaster." Emergencies are routine events of adversity that do not have a community-wide impact or do not require extraordinary resources or procedures to bring conditions back to normal. Conversely, a "disaster" results when normal operational procedures are unexpectedly jolted or when circumstances call for obtaining resources outside of a normal (internal) authority. In addition, declaring disaster often depends on the characteristics of the affected entity—resource base, community/organization size and experience with a hazard (Hoetmer 1991). Thus, a small, resource-limited public garden which sustained $15,000 of damages from a natural disaster may view and recall its experience differently than would a large, financially secure public garden that has previously experienced a natural disaster and suffered the same monetary amount of damages.

Natural Disaster Emergency Management

Emergency management is broken down into four primary strategies or actions—preparedness, response, recovery and mitigation. These areas often overlap each other in the field and are interrelated. Preparedness is the process of turning awareness of the natural hazards and risks faced into actions that heighten an entity's capability to respond and recover from a disaster (*A Safer Future* 1991). Response commences as a disaster is detected or threatens. It includes "mobilizing and positioning emergency equipment; getting people out of danger; providing needed food, water, shelter and medical services; and bringing damaged [vital] services and systems back on line" (*About Fema*, 1998). Recovery is "the process of bringing post-disaster conditions to a level exact, similar or better to conditions extant at pre-disaster" (Emergency Management: Principles and Practice, 1991:224). Mitigation encompasses "actions that are taken to prevent or reduce the risk to life, property, social and economic activities, and natural resources from natural hazards (*A Safer Future* 1991)."

This research focuses foremost on disaster experiences, including risk perceptions and recovery, at public gardens. However, as each of the emergency management actions are often interrelated, there is the inevitability that any or each of these actions will be addressed through this research's case study documentation. A [recovery] resource has been defined as anything that may be turned to for support or help in the aftermath of a natural disaster. Thus, a resource may take the form of loans and donations (monetary or equipment, etc.), staff power (employee and volunteer workers, machinery, etc.) and expertise (professional trade consultation), among others.

Chapter 2

IMPACTS OF NATURAL DISASTERS

The losses caused by natural disasters in the United States are not consistently estimated and tallied (*The Impacts of Natural Disasters* 1999). At one public garden, the losses to plant collections may simply be determined by the cost of replacement plants. Another site's losses could be figured based on staff hours worked and the prices paid for rented machinery during clean up. Still another public garden may experience loss of earned income because extensive damage and safety concerns force the closing of the entrance to public admissions. Alternatively, a special fundraising event may have to be cancelled in the wake of a natural disaster and results in a reduced amount of money available for the annual budget.

The dilemma associated with determining the losses from natural disasters is three fold. First, there is no nationally recognized formula to estimate losses. Secondly, there exists no organization with the responsibility to establish loss estimation guidelines; and thirdly, there is varying opinion as to which damage numbers should be used in determining overall losses from a disaster event (*The Impacts of Natural Disasters* 1999).

Various cost estimation terms are used by a variety of experts and disciplines. The Governing Board of the National Research Council brought together several experts to form a Committee on Assessing the Costs of Natural Disasters in 1999. The committee formulated some comprehensive definitions to create future mutual disciplinary understanding:

> The impacts of a disaster is the broadest term, and includes both market-based and non-market effects. For example, market-based impacts include destruction to property and a reduction in income and sales. Non-market effects include environmental consequences and psychological effects suffered by individuals involved in a disaster. In principle, individual impacts can be either negative or positive, though obviously the impacts of disasters are predominantly undesirable. The losses of disasters represents…direct losses that result from the physical destruction of buildings, crops, and natural resources and indirect losses that represent the consequences of that destruction, such as temporary unemployment and business interruption…The costs of disasters, as the term is conventionally used, typically refers to cash payouts by insurers and governments to reimburse some (and in certain cases all) of the losses suffered by individuals and businesses…The damages caused by disasters refers to physical destruction, measured by physical indicators, such as the numbers of deaths and injuries or the number of buildings destroyed. When valued in monetary terms, damages become direct losses (*The Impacts of Natural Disasters* 1999).

Applying these definitions to a hypothetical natural disaster scenario at a public garden may be helpful. A hurricane strikes the Great Botanical Garden and has a variety of *impacts*. *Damages* seen include three buildings destroyed, one employee seriously wounded from wind driven debris, and the felling of twenty-five mature specimen trees. The preliminary *costs*, as noted by State Farm Insurance representatives, are $250,000—the ceiling value of the garden's property casualty insurance policy. Unfortunately, no botanical specimens were covered by the insurance policy. The Great Botanical Garden's *losses* include a historic Lord and Burnam greenhouse, complete uprooting of the magnolia collection and because of safety risks associated with a large number of fallen branches, the site will be closed for two weeks to the public. In addition, contracted masons who were working on the Italian Garden wall renovation will not be permitted to continue work during these two weeks; this postponement on the completion of the wall may affect the near-future availability of the garden for revenue generating weddings and receptions.

In the situation presented at the Great Botanical Garden, additional terms should be included. Direct losses may be further described as being primary direct losses or secondary direct losses (*The Impacts of Natural Disasters* 1999). Therefore, the direct loss of the magnolia collection at the garden was a result of the hurricane's 100 mph winds and secondary direct losses include the loss of a multitude of shade loving perennials and shrubs that grew under the magnolias, now exposed to direct sunlight. An additional secondary direct loss may result from the heavy machinery that will facilitate tree debris removal around the magnolia collection. Soil compaction is likely and accidental trampling of surviving understory plantings may occur.

Indirect losses attributed to natural disasters have not been studied or measured to the same degree as direct losses. As previously mentioned, there are few organizations or programs extant to measure indirect losses; however business interruption and unemployment insurers are two examples (*The Impacts of Natural Disasters* 1999). Indirect losses may also be accompanied by short-term gains as a result of a natural disaster (Table 2.1). In summation, Levitt (1997) states that if considering the impacts, you need to add the costs of the casualties suffered by people with the cost of the damage and harm to the place and the cost of impaired, interrupted or halted processes. Interestingly, then, across an economy, there may be an overall null impact, as the losses of one are negated by the gains of another. Not surprisingly, however, is for any one organization affected by a natural disaster, the impacts most likely will not equate to zero—it may prove to be a substantial burden.

Table 2.1 **Short Term Indirect Losses and Gains Possible After a Natural Disaster**
(Source: Impacts of Natural Disaster 1999: 37)

Possible Short Term Indirect Losses	Possible Short Term Indirect Gains
• Induced losses in sales, wages, and/or profits due to loss of site function and access (this may result from physical damage or infrastructure failures). • Input/output losses to other organizations linked to the affected site's products and services. These slowdowns or shutdowns result from reduced supply and demand. • Spending reductions from site income losses resulting from site closure. Employees of the organization curtail their own departmental spending and instigate an additional round of budget cutbacks.	• Changes in future production, employment and income and/or changes. Current production outside the immediate impact area (i.e. the nearby town) or future production by recovery-supporting businesses (e.g. construction contractors) within the affected region may compensate for immediate disaster-related losses. • Income gains outside the immediate impact area to owners of commodities inflated in price by disaster-induced shortages. • Positive economic stimuli of jobs and production generated from clean-up and rebuilding efforts.

Identifying a particular site's vulnerabilities to a natural disaster logically leads to three administrative outcomes—informing policy regarding assistance available to disaster victims, to determine the inherent value in pursuing natural hazard mitigation, and to plan emergency response programming (*The Impacts of Natural Disasters* 1999).

The Disaster Plan

"An organization without a disaster planning and recovery strategy is abdicating its responsibilities to its people, its customers and other constituencies, its investors and other stakeholders, and to its community. You cannot find HELP in the Yellow Pages—a disaster planning and recovery strategy must be created (Levitt 1997)."

After such a stunning statement, it is troubling to note that the majority of American Public Horticulture Institutions are currently not equal to the task of ownership of disaster response and recovery plans (Table 2.2). This data was collected from this research's national survey to PHI.

Table 2.2 **Levels of Disaster Plans Extant at Surveyed American Public Horticulture Institutions: 1999**

No Disaster Plan	61.6%
Disaster Plan (Response Component Only)	22.8%
Disaster Plan (Response and Recovery Components)	15.6%

Pre-disaster planning can, as been found through research, save lives and injuries, limit property damage, and minimize disruptions. Disaster recovery has become a process that combines decision-making and dialog among a variety of people with vested interests in the organization or community affected by a disaster. Further research studies have concluded that recovery is most effective when community-based organizations assume primary responsibility and leadership in their own recovery process, with secondary assistance subsequently coming from external sources (Mileti 1999).

Awareness of the need to plan and prepare for disasters (and their subsequent recovery efforts) is often predictable based on previous experiences. In fact, the best indicator of flood response, for example, is often personal experience (Tobin and Montz 1997). Awareness is certainly heightened after the "near miss" scenario, or when a nearby organization is devastated or a significant, memorable disaster makes the national news. Just as quickly the perception of need for disaster planning can arise, it can quickly fade away from a phenomenon known as "it won't happen to me again" mentality (Levitt 1997). There is also the suggestion that there will be a heightened perception of risk when the natural disaster is more memorable, or simply more severe. Hurricane Andrew was a storm that will be considered the comparative basis for many future hurricanes (Tobin and Montz 1997). Further discussion on the role of natural disaster experience plays with determining risk perceptions is found in Chapter Four: Natural Hazards and Risk Perceptions.

Site planners and administrators should be aware of three myths that could undermine the need for disaster response and recovery planning:

1. We've followed all the appropriate codes and other regulations, therefore
2. It won't happen to us, but
3. If it does, we have insurance (Levitt 1997).

The disaster plan must first consider what natural hazard can hit or impact the people, places and processes at an organization. This may be better known as a risk analysis. Will a snowstorm affect our botanic garden's ability to manage our collections? Will our employees be able to get to work? Further considerations include the intensity and duration of the natural hazard and how the hazard's strength, timing and repetition would have different impacts on the organization (Levitt 1997). Will a snowstorm lasting more than three days with bitter cold have consequences on our greenhouse heater's oil supply and capabilities? What if a disruption or site closure occurs on a busy holiday weekend? Are we at greatest risk of damage when the snow is heavy and wet or when we get dry fluffy snow accompanied by strong winds?

Over the past twenty years (1980-1999), a survey of America PHI reveals that the type of natural hazard that has caused the most damage or disruptions is icestorms. This is followed by strong winds and hurricanes. Further breakdown may be noted in Table 2.3.

Table 2.3 **Breakdown of Natural Hazard Types that Were Described by Surveyed American Public Gardens as Being the Most Damaging or Disruptive (1980-99, n=201).**

Natural Hazard	Number of PHI	% of Total Respondents
Icestorm	41	20.1
Strong Wind	36	17.6
Hurricane	33	16.2
Thunderstorm	19	9.3
Riverine Flooding	15	7.4
Tornado	13	6.4
Drought	12	5.9
Snowstorm	10	4.9
Hail	7	3.4
Lightning	6	2.9
Unusual Freeze	5	2.5
Earthquake	1	0.5
Heatwave	1	0.5
Landslide	1	0.5
Tidal Flooding	1	0.5
No Response	20	8.9

Results from a risk analysis, based on the individual site's circumstances and needs, will create the foundation of the disaster plan--the response procedure and the recovery plan. The response component is "structured in reflection of the nature and the level of the risks, and their potential effects, coupled with the sound business judgments, and the required investments of probably scarce money, time and people resources (Levitt 1997)." The recovery component addresses the likely and deemed necessary inputs to returning the organization to a pre-disaster condition in a responsible and practical manner. Based upon a solid risk and vulnerability analysis, an organization will be able to make assumptions as to which financial, labor, human and community resources that would likely be needed or called upon in the wake of the disaster. Recovery includes addressing and determining the role insurance will play and identifying any opportunities for hazard mitigation (Levitt 1997).

Recovery is advanced by determining the organizational approach to bearing the losses from the natural disaster. One approach is to transfer the loss burden by accepting public assistance or utilizing private subsidies such as grants, loans, donations or insurance. Alternatively, planning for losses can also be used. Insurance policies and contingency funds are two financial planning strategies that can offset the costs of disaster recovery. A final approach is bearing the loss within the organization by altering current budget allocations and modifying future plans and outlooks (Hewitt 1997).

Compared to other businesses, public gardens may have additional issues to consider regarding natural disaster recovery. With living collections, loss assessments can be both immediate and delayed. Trees can be drastically uprooted in a storm or just as easily receive stress fractures from twisting in wind or excessive weight loads from ice accumulations (Hauer, et.al 1994). These internal wounds may not physically manifest themselves for several weeks, months or even years. Moreover, as plants are part of a natural continuum and within a greater ecosystem, many factors could coincide to lead to demise. A plant already under stress or diseased cannot physiologically react and recover from adversity as readily as a healthy plant. Trees defoliated from a hailstorm may not readily re-vegetate if there is lack of ground water or an infestation of moth larvae devours emerging leaves. Plants accustomed to one growing condition may not survive if a sudden environmental change occurs. Seasonal flowers and foliage displays, often central to public visitation and perceptions of public gardens, can be negatively affected. Shade plants will be exposed to scalding sunlight if the protective canopy tree above is toppled during a windstorm. As a result, the recovery period may be prolonged as additional losses are noticed and eventually addressed.

Thus, the steps needed for creation of a disaster plan and recovery strategy go beyond the initial risk and vulnerability analysis. Subsequent steps include determining actual consequences and effects on the organization from a natural disaster, followed by compensation alternatives for the expected consequences and effects. Recovery issues are next addressed by planning, selecting, contracting resources for response, mitigation and recovery opportunities and efforts during or immediately after the natural disaster. Finally, the information collected in the previous steps is incorporated into a manual and is put into practice and tested (Levitt 1997). In summation, the plan formulated:

> should function optimally to (1)prevent; (2) enable you to cope with; (3) survive; and (4) recover from out-of-course events and emergencies that can impact your business processes, and have undesirable consequences on your people, place, and processes. In this formulation process, you must recognize that your organization is unique, and its

> needs are unique; thus, there are no easy approaches, shortcuts, or off-the-shelf solutions. Your site is unique; your building and the space you occupy is unique; the infrastructure is unique; your business processes are unique; the equipment and facilities you use are unique; and, your management's goals and objectives *for* and *in* a planning and recovery strategy are unique (Levitt 1997).

Three ideas were presented in this chapter and will again be noted in later chapters in this document. First, losses and impacts resulting from natural disasters are not consistently tallied. Secondly, both direct and indirect impacts are possible from a natural hazard event. Thirdly, disaster planning is neither typically a commonly found policy, nor a high priority for a business, including public gardens. In order to begin an investigation into natural disaster perceptions, experiences and recovery at PHI, both qualitative interviews and a broad quantitative survey would be needed. The methodology used will be covered in the next chapter.

Chapter 3

RESEARCH METHODOLOGY

This chapter discusses research objectives, information gathering, survey and case study site participant selection criteria and data analysis methods. Both quantitative and qualitative methods were used in the course of this study. A quantitative survey instrument investigated American public gardens' perception of risk to natural hazards and actual natural disaster experiences. This survey provided information into disaster recovery resources used by American public gardens and in addition helped to determine the final selection of case study sites in the qualitative component of the investigation.

As mentioned in the introduction, a substantial amount of disaster related literature and documentation exists through a variety of academic and trade disciplines. However, none of the research, as know to the author, is specific to the leadership and managerial needs of public horticulture institutions (PHI) relating to natural disaster experiences. Therefore, eight objectives were developed to guide the research effort:

- Identify characteristics of some natural hazards and learn of their spatial distribution.
- Identify losses reported by PHI resulting from a natural hazard(s).
- Identify issues facing a PHI's recovery efforts in wake of a natural hazard(s).
- Identify the strategies and resources used by PHI during recovery.
- Determine if there are similarities/differences between governmental and non-governmentally managed PHI regarding recovery issues and resource utilization.
- Investigate the existence of disaster response and recovery plans at PHI.
- Investigate the role of mitigation by PHI.

- Draw conclusions and offer recommendation to assist PHI recognize natural hazard risks, plans, and other considerations in natural disaster recovery.

Voluntary participation in a survey instrument was the first step in investigating natural disaster experience and recovery. Surveys were mailed out to all institutional members of the American Association of Botanical Gardens and Arboreta (AABGA) in the fifty United States. At the time of the mailing, this membership totaled approximately 440 public gardens. Recommendations for drafting the survey layout, timing of mailing and other strategies to increase response rates were gleaned from Dillman (1978). The survey was accompanied with a cover explaining the research and was personally addressed to each institution's official AABGA contact. Thus, the surveys were likely completed by a mix of public garden professionals including directors, risk managers, horticulturists, and/or board members.

The purpose of this survey was to gain data on current perceptions of risk, past natural disaster experiences, past use of disaster recovery recourses, as well as existence of disaster-related planning at PHI. The survey also inquired into the level of interest of PHI respondents to further participate as a case study site. A copy of the survey instrument may be found in Appendix A.

A petition for exemption from Human Subject Review was made through the Associate Provost for Research at the University of Delaware and granted for this portion of the study (Appendix B). Although exemption was made, each survey was specially coded to promote confidentiality and higher response rates (Dillman 1978). Each PHI respondent was grouped according to its location in an appropriate Federal Emergency Management Agency (FEMA) region (Figure 3.1). The survey received slightly over a fifty percent (224 of 441) response rate (Table 3.2). Although raw response rate returns were high across all FEMA regions, no comparison between regions occurred since sample sizes varied considerably. For example, Region VI's 47% response rate included feedback from forty PHI, whereas Region VIII's higher 58% response rate involved feedback from only seven PHI.

Survey data were inventoried and analyzed using the SPSS (Statistical Program for Social Science) database. Chi-square and Pearson's R tests were utilized to determine significance and variable relationships.

Figure 3.1 **Regions of Federal Emergency Management Agency Used for Survey Respondent Groupings and Number of PHI Respondents per Region**

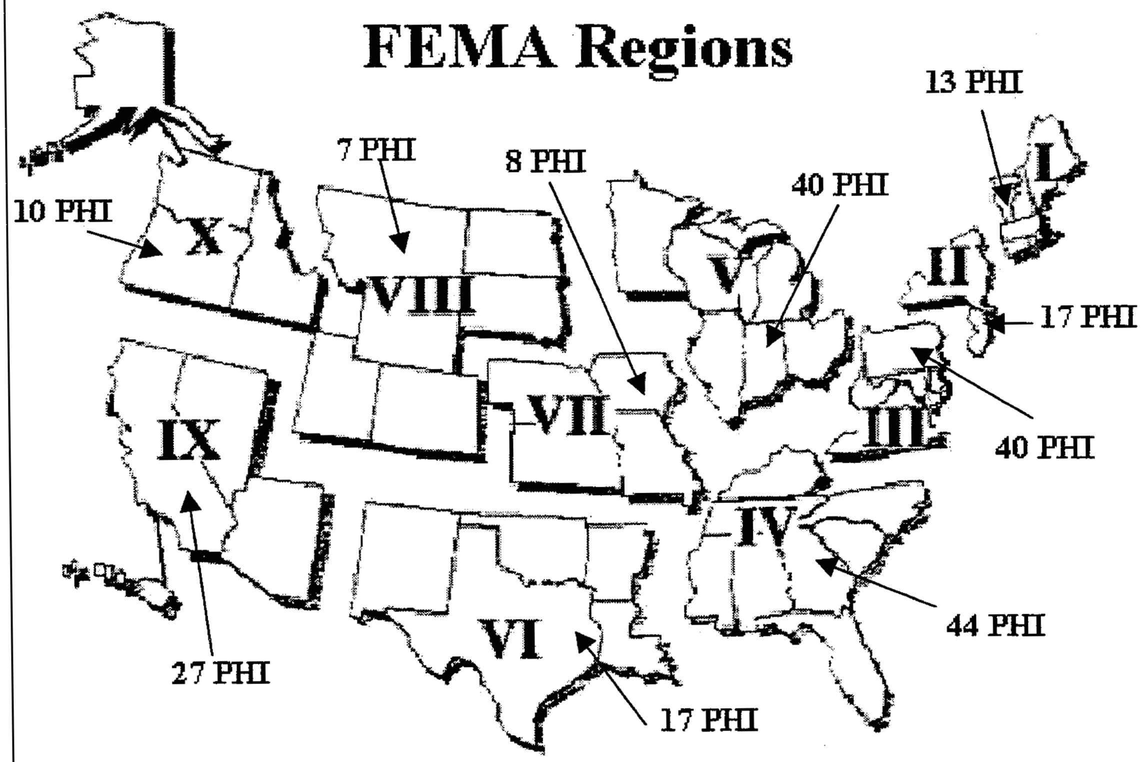


Table 3.1 Breakdown of Survey Respondents by FEMA Region (n=441)

FEMA Region	Number of Respondents
I	13
II	17
III	40
IV	44
V	40
VI	17
VII	8
VIII	7
IX	27
X	10
TOTAL	224 (51% response rate)

Further criteria were used if a PHI indicated interest in acting as a potential case study site. A site was considered a finalist for case site selection if all of the following conditions were met:

a) current, active member of the AABGA as of January 1, 1999.
b) The institution has a living plant collection/management responsibility.
c) The site is physically located within the Eastern United States (east of the 100°W meridian).
d) Physical or financial losses were sustained from a natural hazard event since January 1, 1990.
e) This natural hazard was meteorological or hydrological in type.

Although a majority of respondents were 501(c)(3) non-profit organizations, no criterion was used to preclude participation of governmentally or privately owned public gardens in this study, including colleges and universities (Table 3.2). Several PHI met the selection criteria. Further filtration of possible case sites occurred by examining written comments (question eight in the survey, see Appendix A) on losses and disruption; those with more described losses and disruptions were given additional consideration. General geographic proximity of potential case sites led to removal of sites that were affected by the same natural hazard event or type of event.

Table 3.2 **Distribution of Respondent PHI by Governance**

PHI Governance	Number of Respondents	% of Total
Private Non-Profit	104	49.7
University/College	61	29.1
Municipal Government	21	10.1
County Government	11	5.3
Corporate/For-Profit	6	2.9
State Government	3	1.4
Federal Government	2	1.0
Public-Private Partnership	1	0.5
Did not respond/missing	15	-
TOTAL	**224**	**100.0**

Through the review of disaster literature, most notably Levitt (1999) and Kaplan (1996), a semi-structure interview schedule was created. Two organizational disaster plans were perused to gain insight into issues that PHI may encounter, as based on issues addressed in the extant disaster plans. The schedule contained questions that would reveal a case site's natural disaster event characteristics, sustained losses and business disruptions, loss assessment procedures, selecting and using recovery resources, length of the recovery, mitigation, and institutional learning. A copy of the schedule is attached as Appendix C .

The schedule was submitted to the Associate Provost for Research; the Human Subjects Review Board approved the qualitative instrument with modifications (Appendix D). As site interviews with directors would be audiotaped and certain questions regarding mitigation may affect that individual's future employability, PHI directors were informed of the risks and benefits of their participation in case site interviews and were to sign a Research Consent Form (Appendix E). In the event a director referred certain interview questions to another staff member, the same principles of ethics and confidentiality were applied as described in the consent form during the subsequent interview(s). In addition, directors of each case study site did not object to the researcher using the institutional name during presentation and discussion of the qualitative research.

Five case sites were selected for case site visits and interviews. The most suitable public gardens were: Fairchild Tropical Garden in Miami, Florida; The Hermitage in Nashville, Tennessee; The Linnaeus Arboretum of Gustavus Adolphus College in St. Peter, Minnesota; Longwood Gardens in Kennett Square, Pennsylvania; and the Mercer Arboretum and Botanical Garden in Humble, Texas. These public gardens supply good variances in governance, natural hazards, plant collections and mission statements to provide a broad base to inquire on natural disaster experiences and recovery efforts.

After receipt of a signed consent form and a verbal invitation to the case site was received, the author conducted a site visit complete with interviews, tours and collecting of pertinent site records documenting the natural disaster and recovery efforts. A site visit lasted for two business days.

Limitations to this study have been identified by the author. Firstly, the survey results are based on the responses of only 224 PHI, a relatively small sampling size. Completed and return surveys may have been more consistently completed and returned by PHI that have disaster planning documents. PHI with no plans may have determined that their participation in the survey was not warranted. In addition, the responses to the survey are the result of one person—thus, a caveat can be placed on the responses truly reflecting the overall staff and organization's perceptions and experiences. The timing of the survey in the busy spring months of the year may also have affected the ability of PHI to complete and return the survey. Finally, the author tried to diminish any personal note-taking or questioning biases while collecting data during case study interviews through the use of an interview guide, transcriptions of all audio tape recordings and the use of published written documentation of the disaster experiences from case study sites.

The information collected during the site visit was compiled and analyzed as recommended in literature (Psychology of Interviewing 1999; Seidman 1991; Lofland 1971). The case studies are presented and analyzed in Chapters Five and Six. Qualitative results, as presented as observed reactive trends and opportunities, were used along with the statistically tested survey results (Chapter Seven) to offer explanations of PHI disaster experiences and to formulate recommendations and conclusions (Chapter Eight) about natural disaster perceptions, experiences and recovery at American PHI.

Chapter 4

NATURAL HAZARDS AND RISK PERCEPTIONS

Chapter four focuses on natural hazard characteristics and their distribution in the United States. The natural hazard itself may not necessarily equate to a natural disaster, as first discussed in "The Natural Disaster" section of Chapter One. However, the characteristics of any particular natural hazard can have damaging results to both plants and structures at PHI. This chapter aims to present information on natural hazards in the United States in an effort to help the reader(s) become familiar with hazards later presented in the results and case study chapters. To begin, the effect of past natural hazard experience on risk perception is presented. Next, the physical strengths and distribution of natural hazards are discussed both in the narrative and with figures. Finally, PHI experiences and risk perceptions for each respective hazard are revealed, as determined from this study's survey instrument. This chapter will provide a solid foundation into understanding disaster impacts on the five case study gardens presented in Chapter Six. The data on PHI experiences and perceptions presented graphically in this chapter will also be used for statistical testing of hypotheses in Chapter Seven.

The geographic size, location and diversity makes the United States a haven for a broad range of natural events. America experiences flooding, earthquakes, hurricanes, excessive heat, bitter cold, extratropical cyclones, wildfires, tropical humidity, thunderstorms, droughts, and the world's most numerous and strongest tornadoes. These natural phenomena are a reality and have been occurring on the planet for millennia. As human populations and development expand, the natural events become potential threats to life and/or property. When these natural hazards impact the realm of human activity or natural world they often are termed natural disasters. Consider a few of the documented American natural disasters in the twentieth century alone: the Great 1906 Earthquake in San Francisco; The Labor Day Hurricane of 1935 which devastated the Florida Keys; The Dustbowl Drought of the 1930s in America's Heartland; The Super Tornado Outbreak of 1974; an extreme winter in the East in 1977-78; and the Mount St. Helen eruption in 1980.

The final decade of the twentieth century was no less destructive or diverse in terms of natural disasters. Hurricanes and tropical storms assaulted the southern and eastern states and Hawaii: Andrew and Iniki (1992), Fran (1996), Bonnie (1998), Floyd (1999). The Midwest endured significant flooding events in 1993 and 1997; the Northeast and Mid-Atlantic States experienced widespread flooding in 1996, followed by drought in 1998 and 1999. The length of the Eastern seaboard experienced tornadoes, rain, snow, ice and winds from a nor'easter in 1993 coined "The March Super Storm." California was hit with the Northridge Earthquake in 1994. In 1998 the West Coast felt the effects of El Niño with increased rains and related flooding and landslides. Conversely, parts of the East were affected by severe drought that same year. At least two urban centers encountered tornadoes in their central business districts: Nashville (1998) and Salt Lake City (1999). Certainly, no area of the country can be considered completely immune to a threat or reality of a natural hazard.

The Role of Experience

Experience plays an integral role in creating a person's perception of risk to a natural hazard. Cumulatively, in an organization, an expanded base of personal perceptions may assist in the risk analysis and vulnerability inventory. Five statements on the role experience plays in natural hazard risk perceptions can be made:

1. Greater personal experience with hazards results in more accurate risk assessments and better responses.
2. Recency of the natural hazard affects awareness. Although some disaster events are so memorable and devastating, time softens memory, and the acute awareness immediately after the disaster may fade from the mind twenty years onward.
3. Strength and timing of a natural hazard affects perceptions. A first experience may never be forgotten, but more recent hazard events, especially if severe, may diminish earlier recollections on disaster experiences.
4. Experience in itself cannot guarantee awareness of hazard risks. It is difficult for any one person to know of all strategies and situations likely for any one hazard; this creates a situation where one cannot act appropriately after a hazard event all of the time. In other words, experience in itself does not automatically create a situation where the best or appropriate actions and responses will be used the next time.
5. People will retain, organize, and learn from their hazard experiences in different ways. As many natural hazards are low-probability events for any one site, it is likely that perceptions constantly remain sharp on a person's schedule. Common sense dictates that those living in high risk areas should be preparing more than those in little or no risk regions. There is also the phenomenon of "gambler's fallacy" which is a belief that once the disaster occurs, chances for a repeat event are not high, or at least another disaster won't happen for a significant amount of time. There is the unfortunate belief that disasters happen in cycles, based on the law of averages (Tobin and Montz 1997).

Natural Hazard Characteristics and Distribution

Physical processes (Table 4.1) normally classify natural hazards. In addition, spatial and temporal relationships are considered in the defining characteristics of the hazard. Combining these three components, it is possible to better understand a specific location's risks and vulnerabilities (Tobin and Montz 1997).

The physical dynamic of a hazard involves scientific measurements of comparative strength. Such defining descriptors include such things as amount of rainfall, wind speed, atmospheric pressure, etc. A hazard's characteristic can also be augmented with spatial and temporal measurements; that is, measurements of size and duration (Tobin and Montz 1997). The effects of a drought, for example, are often felt across an appreciable land mass. The ferocity of a thunderstorm may be equated to the size of the cloud deck or length of its squall line. Moreover, each of the aforementioned hazards can be measured by time.

Table 4.1 **Natural Hazards Classified by Physical Processes**
(Adapted From: Tobin 1997:50)

Category of Hazard	Types of Event
Geological	Earthquakes Volcanoes Tsunami Landslides Mudflows Sinkholes
Hydrological	Floods Drought Wildfires
Meteorological	Tropical cyclones/hurricanes Thunderstorms Tornadoes Lightning Hailstorms Windstorms Ice storms Snowstorms Blizzards Cold Waves Heat Waves Avalanches Fog Frost

Drought may last for eight months, an earthquake tremor for two and one-half seconds, a thunderstorm "live" for several hours. Although standard physical, temporal or spatial measurement standards for natural hazards may be developed for use in comparison, these measurements cannot be automatically used for comparison of impacts and losses. The natural hazard's effects on human activity, values and property determines the resulting impacts and losses.

Geological Hazards

Earthquakes

Earthquakes are perhaps the most feared geological events. The theory of plate tectonics, which states that the earth's crust is a series of plates that are in motion, is considered a satisfactory explanation for the phenomena of both earthquakes and volcanoes. Seismic events are most pronounced along the edges of these plates—where "rubbing" and/or collisions are occurring. The Pacific Northwest is a region comprised of several small plates moving at different rates. Hawaii is famous for its Mauna Loa and Kilanea volcanoes; California for its plethora of "San" faults.

Surprisingly, then, is that earthquakes do not only occur at or near plate boundaries, but also in intraplate regions (Tobin and Montz 1997). Two notable examples of intraplate seismic events are the 1811-1812 earthquakes centered in the New Madrid, Missouri vicinity and the 1886 Charleston, South Carolina earthquake. Across the contiguous United States, the highest ground-shaking hazards remain in the extreme West and in localized areas near Memphis, Tennessee and Charleston, South Carolina (Figure 4.1).

An earthquake's severity is expressed in intensity and magnitude. Intensity is based on the observed physical effects of the ground's shaking on people, buildings and natural features such as trees and animals (Hoetmer 1991). Intensity is measured with the Mercalli Scale (Table 4.2). Magnitude is based on the amount of energy released at the area of the fault where the quake physically takes place, often under ground. The Richter Magnitude Scale is measured and recorded mathematically with seismographs (Hoetmer 1991).

Based upon responses from this study's qualitative survey instrument, PHI experiences with earthquakes (1980-1999) is limited (Figure 4.2). Most PHI (81%) across the

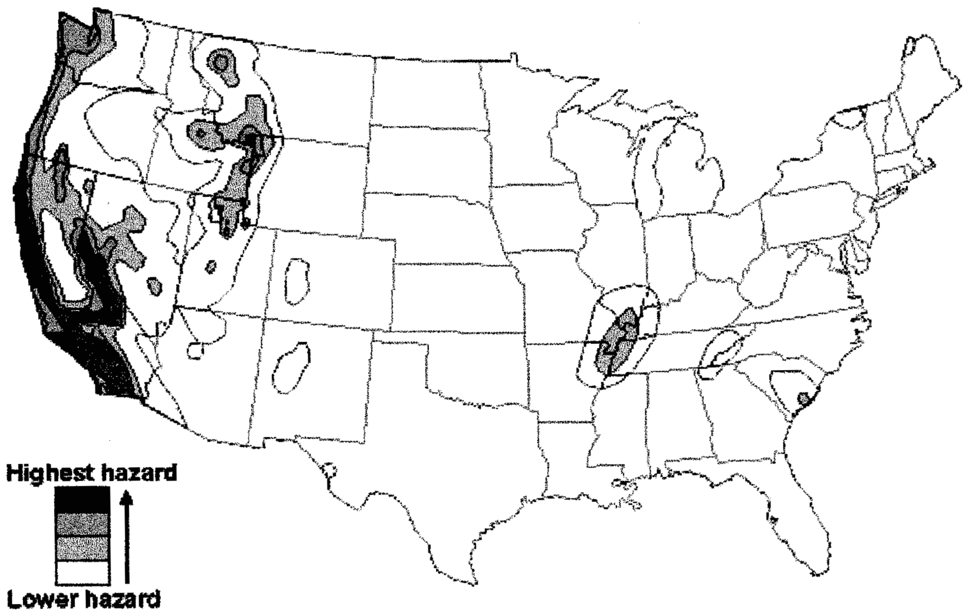


Figure 4.1 Distribution of Ground-Shaking Hazards from Earthquakes in the Contiguous United States
(Source: U.S. Geological Survey)

United States have not encountered an earthquake. Also, less than one-third of PHI surveyed (31.2%) believe that they will encounter an earthquake in the future (Figure 4.3).

Table 4.2 **The Modified Mercalli Intensity Scale with Corresponding Richter Scale Magnitude**
(Source: West 1999)

Mercalli Intensity (at epicenter)	Richter Scale Magnitude	Witness Observations
I	1 to 2	Felt by very few people; barely noticeable.
II	2 to 3	Felt by a few people, especially on upper floors.
III	3 to 4	Noticeable indoors, especially on upper floors, but may not be recognized as an earthquake.
IV	4	Felt by many indoors, few outdoors. May feel like heavy truck passing by.
V	4 to 5	Felt by almost everyone, some people awakened. Small objects moved. Trees and poles may shake.
VI	5 to 6	Felt by everyone. Difficult to stand. Some heavy furniture moved, some plaster falls. Chimneys may be slightly damaged.
VII	6	Slight to moderate damage in well built, ordinary structures. Considerable damage to poorly built structures. Some walls may fall.
VIII	6 to 7	Little damage in specially built structures. Considerable damage to ordinary buildings, severe damage to poorly built structures. Some walls collapse.
IX	7	Considerable damage to specially built structures, buildings shifted off foundations. Ground cracked noticeably. Wholesale destruction. Landslides.
X	7 to 8	Most masonry and frame structures and their foundations destroyed. Ground badly cracked. Landslides. Wholesale destruction.
XI	8	Total damage. Few, if any, structures standing. Bridges destroyed. Wide cracks in ground. Waves seen on ground.
XII	8 or greater	Total damage. Waves seen on ground. Objects thrown up into air.

Figure 4.2 Experience with Earthquakes at American PHI

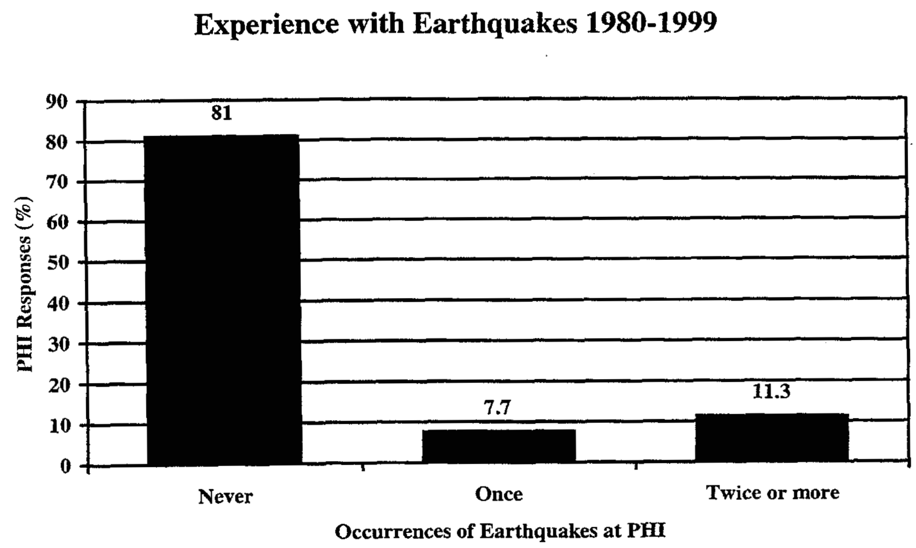
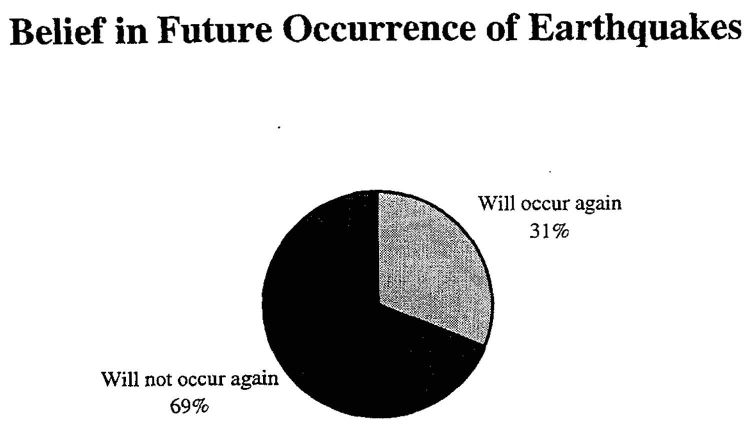


Figure 4.3 American PHI Belief in Future Occurrence of Earthquakes



Landslides

Landslides can result from seismic events (ground failures) and non-seismic events. In mountainous regions, where great variability in topography is the rule, mountainsides and valleys are prone to rapid drainage flows of water. "Steep slopes, heavy rains or compressed seasonal snowmelt, and large variations in sunshine and temperature, result in large, sudden changes…(Hewitt 1997)." Of course, such highly variable topographic regions may not be precluded from experiencing rockslides, mudflows, or avalanches as well.

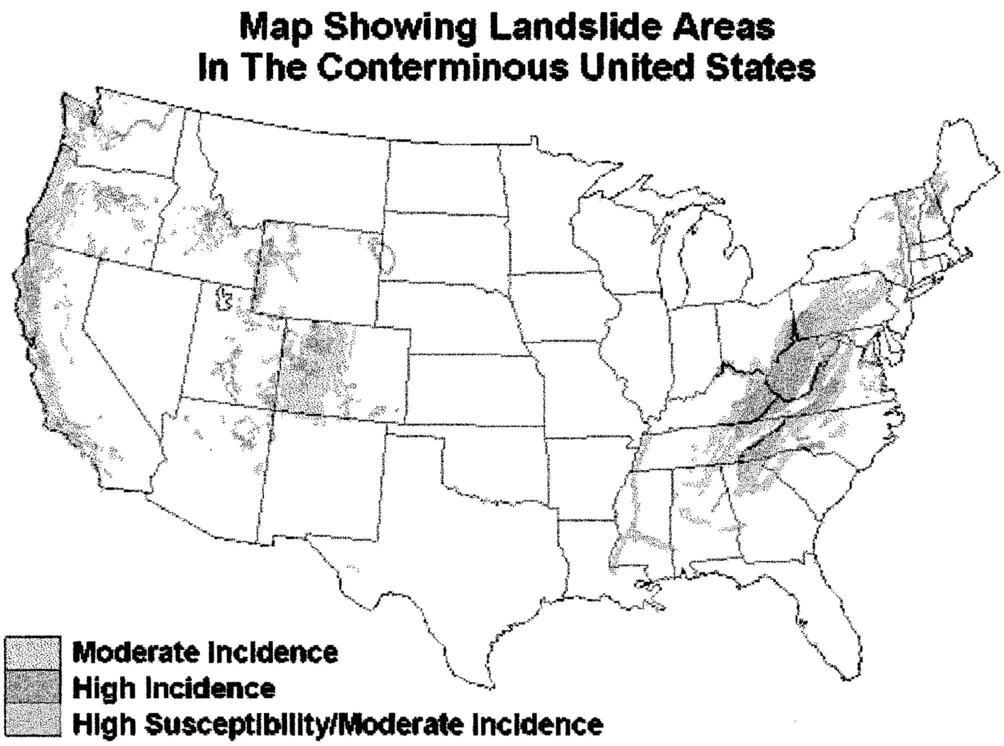


Figure 4.4 **Distribution of Landslide Areas Across the Contiguous United States**
(Source: U.S. Geological Survey)

Across the United States, the susceptibility and occurrence of landslides is localized, especially in regions with greater changes in elevations. The Appalachian Mountains and ranges within the Rocky Mountains are most notably susceptible (Figure 4.4). The most widespread region of high landslide susceptibility is in the central Appalachian Mountains, in the states of North Carolina, Kentucky, Pennsylvania, Virginia and West Virginia. A vast majority (93.7%) of American public gardens have not experienced a landslide (Figure 4.5) and about one-eighth (12.2%) of public gardens belief a landslide will occur again (Figure 4.6), as based on results from this research's survey.

Figure 4.5 Experience with Landslides at American PHI

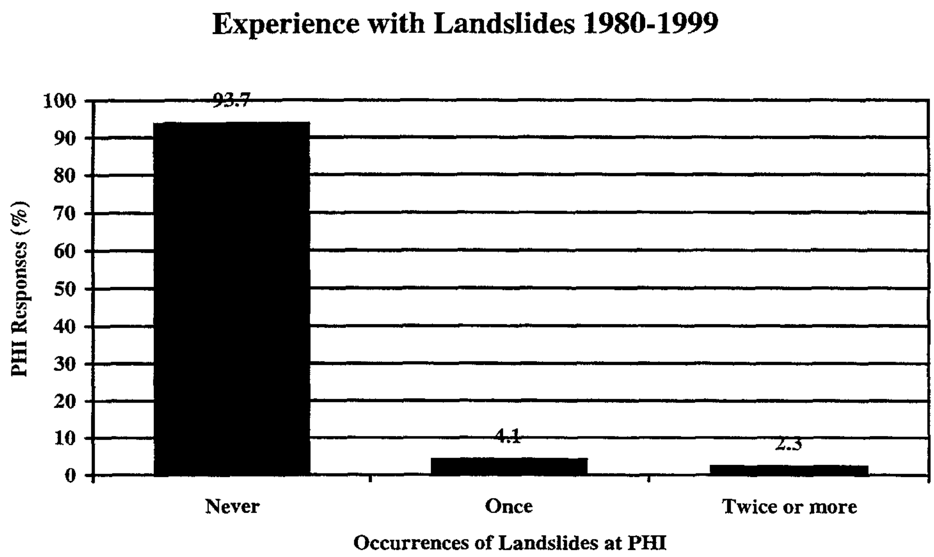
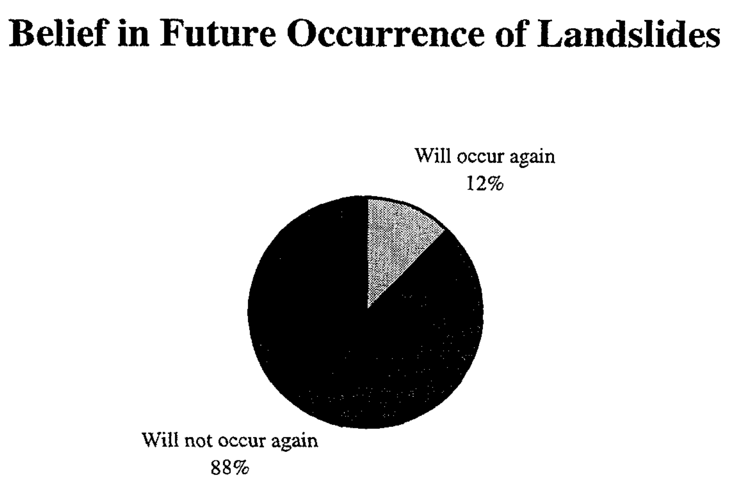


Figure 4.6 American PHI Belief in Future Occurrence of Landslides



Hydrological Hazards

In speaking of hydrological hazards and disasters, it is important to realize that the cycle of drought to flooding event is often the direct result of a meteorological event. Depending on location in the United States, floods and droughts can be discussed using comparisons of precipitation (or its absence), high and low river flows, and lake and ground water levels. However, the effect of hydrological disasters on humans centers around river and shoreline activities, wells and soil moisture, and plant growth or failure (Hewitt 1997).

How does one collectively talk about hydrological hazards in the United States? There are several core differences between flood and drought, let alone the vast geographic expanse and diversity of the nation:

> The flood hazard may be about water. It is not about water supply, whereas that, or its insufficiency, is the essence of the drought hazard. Drought risks are integral to the needs and patterns of water consumption, and arise directly from them. Flood involves water supply only indirectly, to the extent that it puts people and property in the path of excessive

> moisture...Flood and drought often have directly opposite spatial patterns of development and incidence. Floods are linear or patchy in spatial extent, mostly following watercourses or coastal zones, reflecting their topography. Severe drought events invariably embrace extensive regions, partly because of the climate conditions giving rise to them, partly because local water shortages can be readily offset. Areas most prone to drought, or feel its effects earlier, such as well-drained parts of farmland, are often the opposite of those [areas] most prone to floods. Poorly drained and flood plain areas, for instance, tend to feel the greatest flood effects (Hewitt 1997).

There are instruments used in the United States that monitor and measure the overall hydrological status of regions. The Palmer Drought Severity Index (PDSI), also being used in Australia, China and South Africa, among others, combines a number of physical attributes to determine the "dryness potential" level (Tobin and Montz 1997). There also exists the Standardized Precipitation Index (SPI), which looks at the probability for precipitation for a given time frame. Drought indices assimilate thousands of bits of data on rainfall, snowpack, streamflow and other water supply indicators into a comprehensible big picture (Hayes 1999).

These indices provide current regional precipitation regimes and have tremendous potential for guiding flood and drought preparedness strategies for individuals and reducing impacts on businesses, public gardens included. For example, the Palmer Drought Index revealed that severe drought was extant in central Florida in the summer of 1999 (Figure 4.7). By the turn of the year, this same area was experiencing near normal soil moisture, which acted as an indicator that many horticultural planting and seeding activities would be favorable.

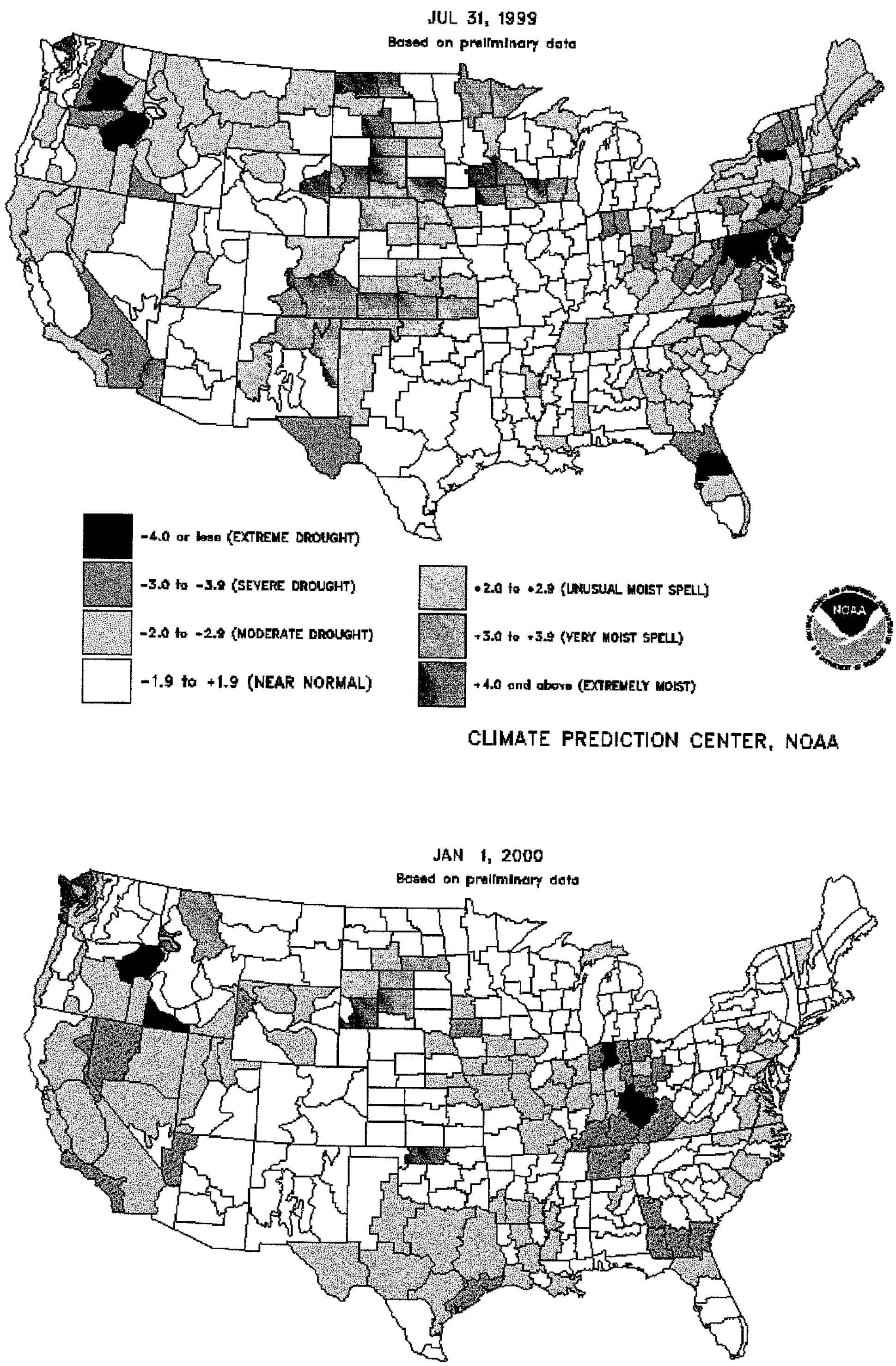


Figure 4.7 **Comparison of Drought Severity (Palmer Index) Across the Contiguous United States: July 31, 1999 and January 1, 2000** (Source: NOAA)

Floods

All rivers flood, although they do not flood in the same manner. The outcomes of a rainfall or snow melting event determines the characteristics of a flood—the river basin's geology, vegetation, soils, and size. If the river's discharge increases rapidly, a flash flood results. Conversely, rivers that have broad, slow running waters that collect and increase discharge slowly, an extensive, perhaps regular seasonal riverine flooding regime is evident. Moreover, flash floods do not provide for much warning; whereas the more gradual, extensive increase in flow in riverine flooding allows for forewarning and precautionary measures (Tobin and Montz 1997).

Invasion of seawater onto the coastline from a storm, most notably a hurricane, is referred to as storm surge, and will be included in the forthcoming discussion on hurricanes in the Meteorological Hazards section in this chapter. Coastal or marine flooding may result at or near the mouths of tributaries. Several events may cause coastal flooding. High and neap tides can extend higher than normal water levels onto a river, and if coupled with a windstorm or hurricane, more significant seawater can be driven upstream. Acute localized flash floods often result from rainfall downpours from thunderstorms or tropical storms (or hurricane remnants) in widespread locations in the United States. In the West, where topography and drier soils are more common, rainfall may not have the opportunity to be soaked into the soil and rushes into streambeds. Similar conditions arise in urban areas where vast networks of concrete and asphalt result in mass water movements directly into storm sewers and drainage canals. In the Eastern U.S., flash floods are most likely to result when the local soils are already saturated from previous rainfall and more precipitation occurs, or soils are still frozen in the early spring and an early thaw takes place (Williams 1992).

The Midwestern Floods of 1993 were of the extensive, riverine type because they were the result of an increased rainfall regime over a broad area of the Mississippi and Missouri River basins. Likewise, the floods resulting from Hurricane Floyd's visit to the Eastern Seaboard in 1999 were the result of river systems being inundated with a tremendous amount of rainfall runoff. The heavy and constant rate of rainfall coupled with dry (hydrophobic) surface soils in the Mid-Atlantic region lead to flash flooding initially in many streams and rivers as well. Figure 4.8 demonstrates the widespread affects of flooding across the United States in a five year period alone.

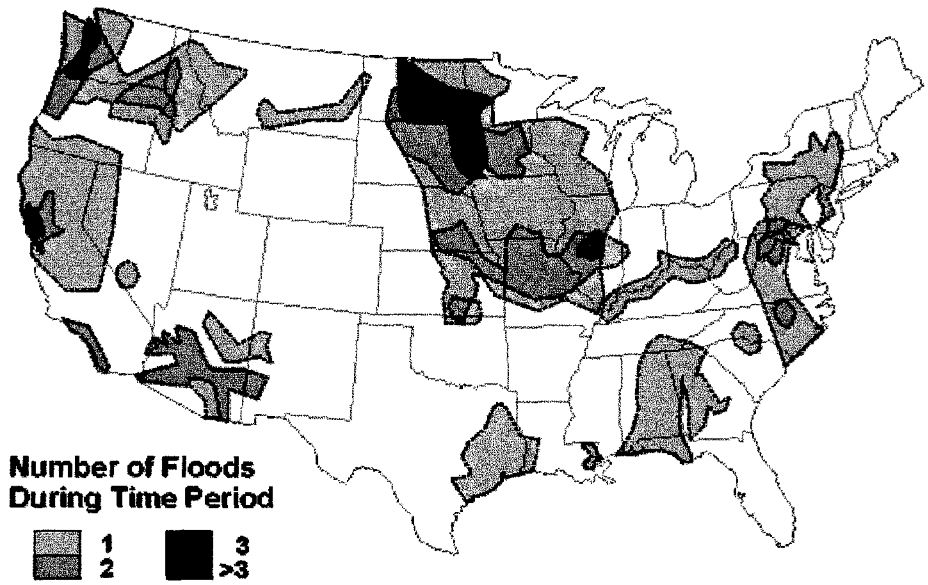


Figure 4.8 **General Areas of Major Flooding in the Contiguous United States During the Five Year Period January 1993-December 1997** (Source: U.S. Geological Survey)

A slight majority (54.5%) of American public gardens have not experienced flooding during the 1980-1999 period. (Figure 4.9). A substantial majority (57.2%) of public gardens do feel that flooding will occur again (Figure 4.10), as based on results from this research's survey.

Figure 4.9 Experience with Flooding at American PHI

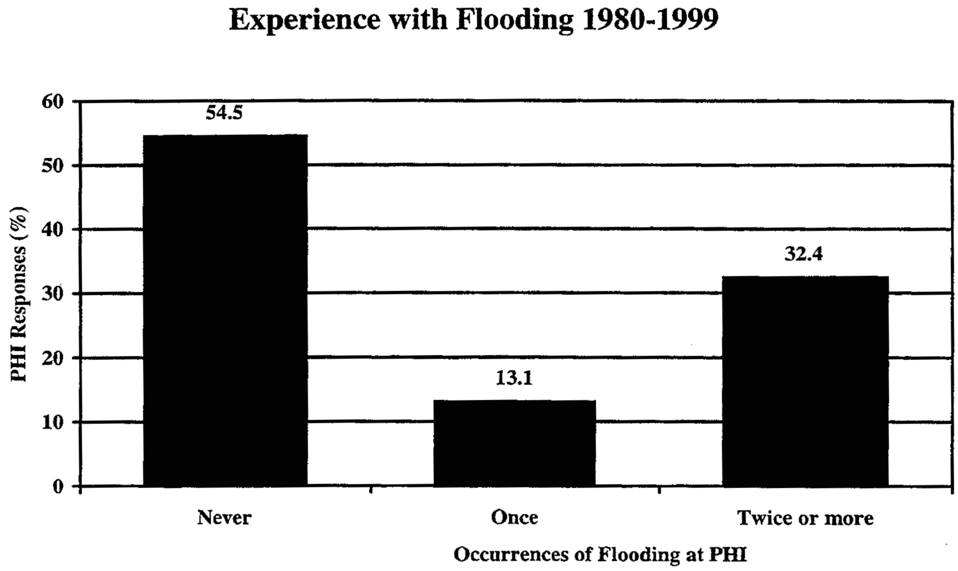
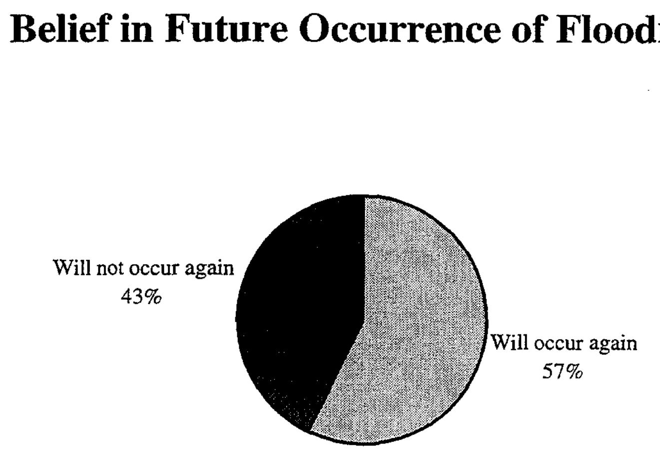


Figure 4.10 American PHI Belief in Future Occurrence of Flooding



Droughts

Unlike most other natural hazards, droughts last for appreciable amounts of time, often over comparatively large geographic regions. Interestingly, human societies have been able to respond and mitigate drought effects before true "disaster" occurs. Since droughts occur over a prolonged and increasingly intense timeframe, humans have the chance to modify water usage or supplement water supplies from nearby regions. For this reason, water's value is determined by the needs of a society, and equates to the level or perception of drought (Tobin and Montz 1997).

Although drought often seems to simply stem from lack of rainfall, warm temperatures, increased evaporation (from direct sunlight) and lack of vegetative cover, as in hardscaped urban centers, can all exacerbate the drought hazard. Timing of precipitation for desired human activities could also affect what determines declaration of a drought. For example, a public garden with a significant collection of drought tolerant trees may not see a time of below normal rainfall as detrimentally as the garden nearby with a huge collection of shade and moisture-loving shrubs and perennials. These factors in and of themselves do not connote drought, they add to the dilemma of defining a universal parameter of the start and end points to a period of "drought," even within a relatively small geographic region (Tobin and Montz 1997).

Droughts inevitably will lead to the demise of plants, from the drying and drop of leaves to death of branches and entire plant death. Dry plant materials are flammable and an increased amount of dry material in a landscape increases the potential fuel for wildfires. Although the threat of wildfire is included with the discussion of drought, naturally occurring wildfires result from lightning strikes and play a central rejuvenation and maintenance role in a natural ecosystem. Man-induced wildfires, arson and automobile sparks, etc., cannot be considered 'natural', but they nonetheless impact lives and property in a manner equal to a natural wildfire. In some plants, essential oils within the live plant are flammable, as in the case of many native and exotic evergreens. For this reason, average soil and plant moisture levels does not necessarily prevent the start or spread of a wildfire.

According to results from the national survey, most PHI (79.3%) have experienced drought at least once during the period 1980-1999 (Figure 4.11) and most (84.7%) believe they will encounter drought in the future (Figure 4.12). When mentioning wildfire hazards, a substantial majority (91%) of PHI had not experienced that hazard (Figure 4.13). Less than one third (30.3%) of PHI feel that they are at risk of encountering wildfire hazards in the future (Figure 4.14).

Figure 4.11 Experience with Drought at American PHI

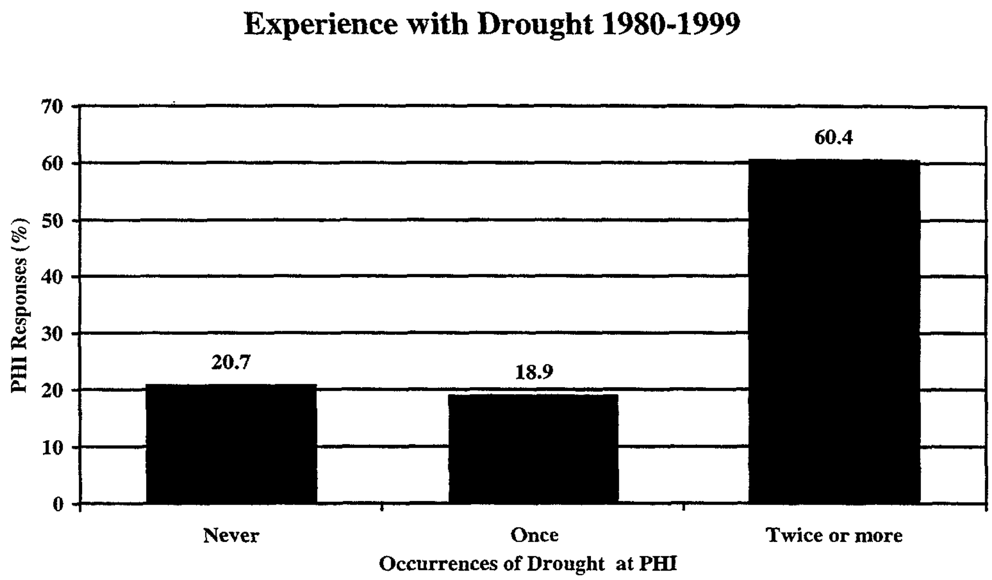


Figure 4.12 American PHI Belief in Future Occurrence of Drought

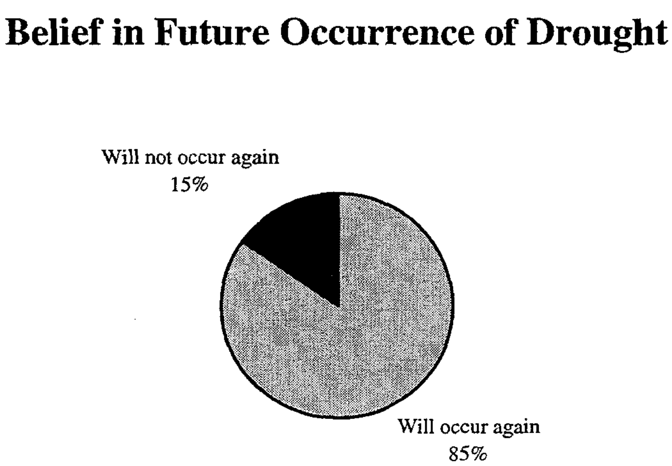


Figure 4.13 Experience with Wildfires at American PHI

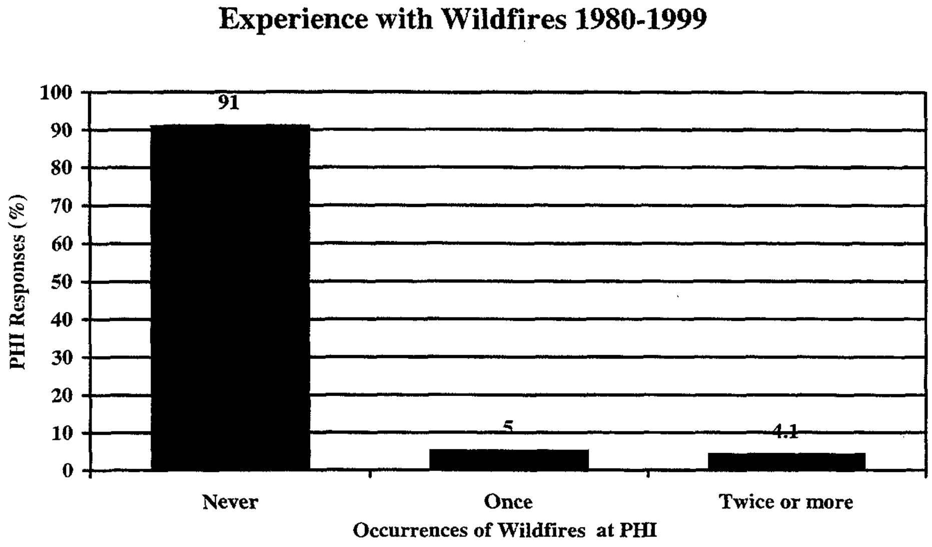
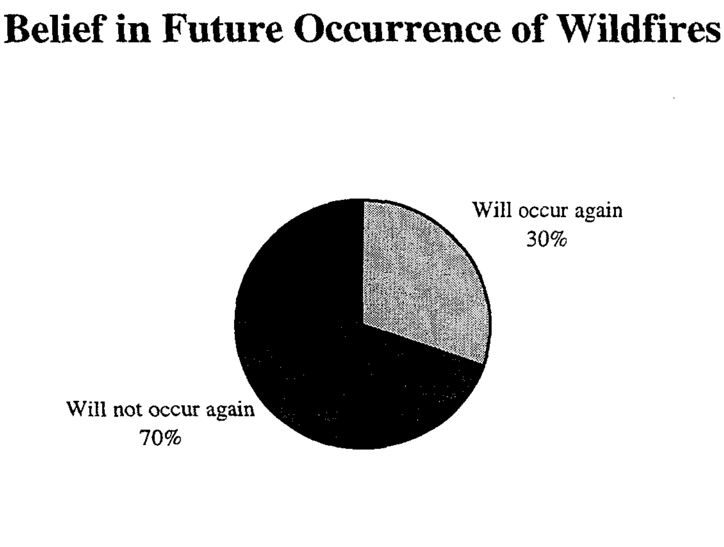


Figure 4.14 American PHI Belief in Future Occurrence of Wildfires



Meteorological Hazards

The air that blankets the earth is constantly in motion, and creates our weather. Cold air from the polar regions advances toward the equator as the warm air from the tropics tries to moves back towards the poles. In a complex physical process described with terms such as 'jet streams,' 'convergence zones,' 'cold and warm fronts,' and 'storms,' large-scale weather systems affect every human on the planet, sometimes with violent consequences to life and property. As Jack Williams (1992) writes: "the word 'storm' is used in so many ways, however, that it's often confusing. The large scale weather systems can be the cause of snowstorms. They can cause small-scale thunderstorms or dust storms…we'll use "storms" to refer to these large-scale systems…"

To most efficiently address the meteorological hazards used in this research, "large scale weather systems" or rather, "storms," will be discussed as groups: hurricanes, thunderstorms and winter storms. Collectively, each of these weather systems will mention, in varying degrees, some of the primary "storm" characteristics and spatial relationships across the United States as well as any accompanying weather phenomena that can affect life and property.

Hurricanes

Hurricanes are masses of warm, moist air rotating around a low pressure area. These storms develop and grow over warm tropical waters. When young, they may be called tropical depressions; as they intensify to winds of thirty-nine m.p.h., they graduate to become tropical storms. Ultimately, when internal winds of the tropical storm reaches seventy-four m.p.h., a hurricane is born. A hurricane's threats are rain, wind and seawater.

Within the hurricane's bands, localized hazards can arise that may result in losses to life and property. Lightning, hail, and tornadoes are spawned from the greater hurricane event. Wind-carried ocean water, known as salt spray, can affect plant and animal ecosystems as far as fifty miles inland from the ocean (Siegendorf 1984). Storm surge is another potent threat. The strong winds associated with hurricanes can create large wind-driven walls of ocean water to collide and inundate coastal beaches and into bays and rivers. Coastal waters rise high above usual sea levels; simultaneous occurrence of high tide alongside a storm surge can result in even more flooding inland (Frazier 1979). Hurricane Camille provided Pass Christian, Mississippi with a storm surge that rose twenty-four feet above usual ocean levels (Williams 1992).

Beach erosion and wind and water driven debris can accentuate the damaging potential associated with storm surges. Coastal areas are at greatest risk, as are any low-lying areas along flood-prone rivers. For instance, New Orleans is considered the U.S.'s most dangerous area for storm surge, as its relatively low elevation could easily be overcome with twenty feet of wind-driven waters. Southwest Florida is also at great risk since of the high human population "near the coast and the shallow slope of the ocean bottom, which makes storm surges rise higher (Williams 1992)."

The Saffir-Simpson Scale measures the hurricane intensity on a category one to five rating system (Table 4.3). Those at or above a category 3 rating are called 'major hurricanes.' As hurricanes move across land, they weaken, normally dropping copious amounts of rainfall. In the case of weaker hurricanes and tropical storms, the threat simply may be rainfall and subsequent flooding as compared to wind damage (Frazier 1979). Hurricane

Diane in 1955, Camille in 1969 (Frazier 1979) and Floyd in 1999 caused significant flooding damage and disruption to areas far from the coast.

Table 4.3 **The Saffir-Simpson Hurricane Damage Potential Scale** (Adapted from Williams 1992: 137)

Storm Type	Category	Winds (m.p.h.)	Storm Surge (ft.)
Tropical Depression	TD	<39	-
Tropical Storm	TS	39-73	< 3
Minimal Hurricane	1	74-95	4-5
Moderate Hurricane	2	96-110	6-8
Extensive Hurricane	3	111-130	9-12
Extreme Hurricane	4	131-155	13-18
Catastrophic Hurricane	5	>155	>18

Hurricanes that affect the mainland United States originate in the Eastern Atlantic Ocean. Fortunately, the life span of a hurricane is several days to weeks, and allows for monitoring and tracking, and appropriate precautionary measures to be taken if landfall is likely. All eastern coastal states can be affected by a hurricane, although the greatest likelihood of a hurricane strike is in the Southeast (Figure 4.14). Texas knows too well its hurricane encounters: the 1900 Galveston Hurricane, as well as eight unnamed category 3 storms from 1909-1942, and Alicia in 1983. New England's worse hurricane this century was

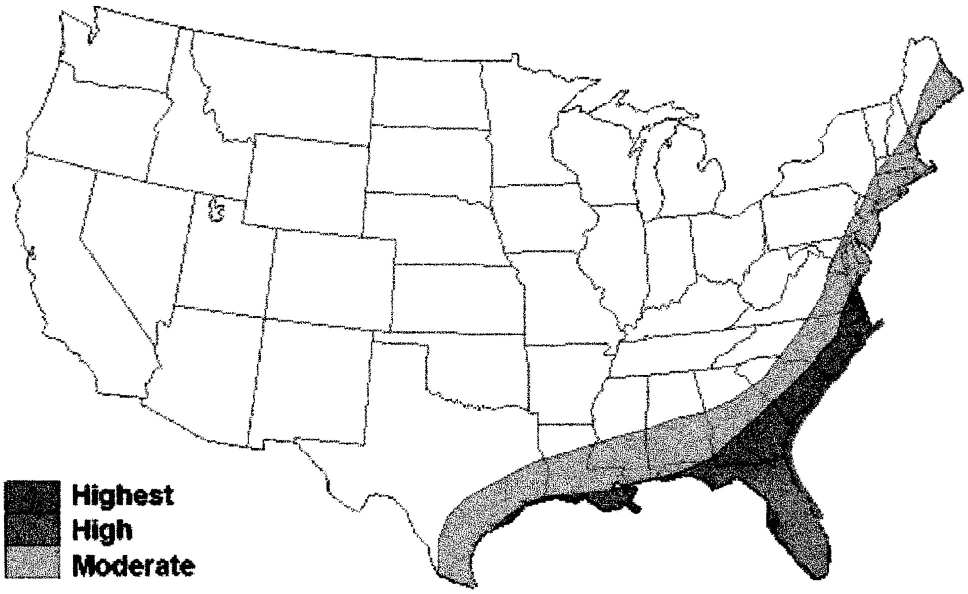


Figure 4.15 Hurricane Activity in the Contiguous United States (Source: U.S. Geological Survey)

in September 1938. Storm surge and high winds affected areas from New Jersey to Maine. More recently, Hurricane Gloria was a strong category 3 storm that affected Long Island and southern New England in 1985 (*20th Century Hurricanes* 1999).

Hurricanes also arise in the eastern and central Pacific Ocean and can affect California and Hawaii, although these storms normally strike Mexico. Since the ocean water temperatures around Hawaii and California are relatively cool, hurricanes typically dramatically weaken and fail to affect the Islands. There are exceptions. Hawaii has been hit by three hurricanes since statehood: Dot (1959), Iwa (1982) and Iniki (1992). Although no hurricane has made landfall in the southwestern United States since record-keeping began, a tropical storm with fifty m.p.h. winds did come ashore between Los Angeles and San Diego in September 1939, killing approximately forty-five people. Even though more southerly located hurricanes rarely reach the western United States; storm remnants certainly can bring heavy rains to California, Arizona and other parts of the Southwest--as far east as Oklahoma (Williams 1999).

Survey responses reveal that most American PHI (59%) did not experience a hurricane from 1980-1999 (Figure 4.16). Also, only a small majority of PHI (55.9%) across the U.S. believe that they are not at risk of experiencing a future hurricane (Figure 4.17).

Figure 4.16 Experience with Hurricanes at American PHI

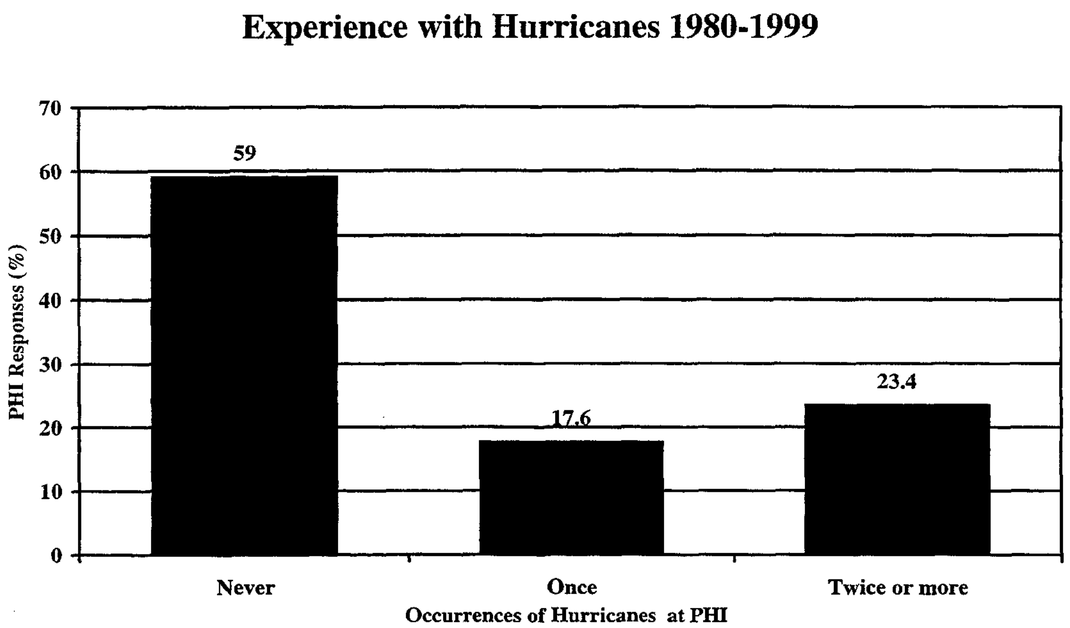
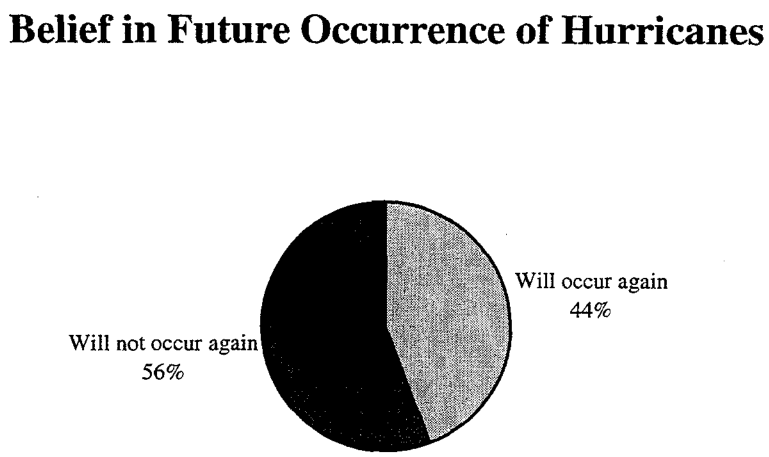


Figure 4.17 American PHI Belief in Future Occurrence of Hurricanes



Thunderstorms and their Products

A thunderstorm is the atmosphere's attempt to balance out the uneven energy between temperature and moisture (Frazier 1979). In simplified terms, warm, humid air rises (updrafts) from the ground and bumps into cooler, drier air aloft. As the air cools, the water vapor condenses and falls (downdrafts), often as rain (Williams 1992). Thunderstorms occur all over the world, the United States is no exception. Thunderstorms can form in isolated locations, along advancing cold and warm fronts and in bands as part of tropical storms and hurricanes (Williams 1992). Thunderstorms are frequent a substantial portion of the United States, with most days with thunderstorms occurs along the Gulf Coast and Florida, as well as in the intermountain regions of the central Rockies (Figure 4.18).

The concern with thunderstorms is their severity and duration. The fiercest of thunderstorms, called supercells, require special conditions to create their damaging hail,

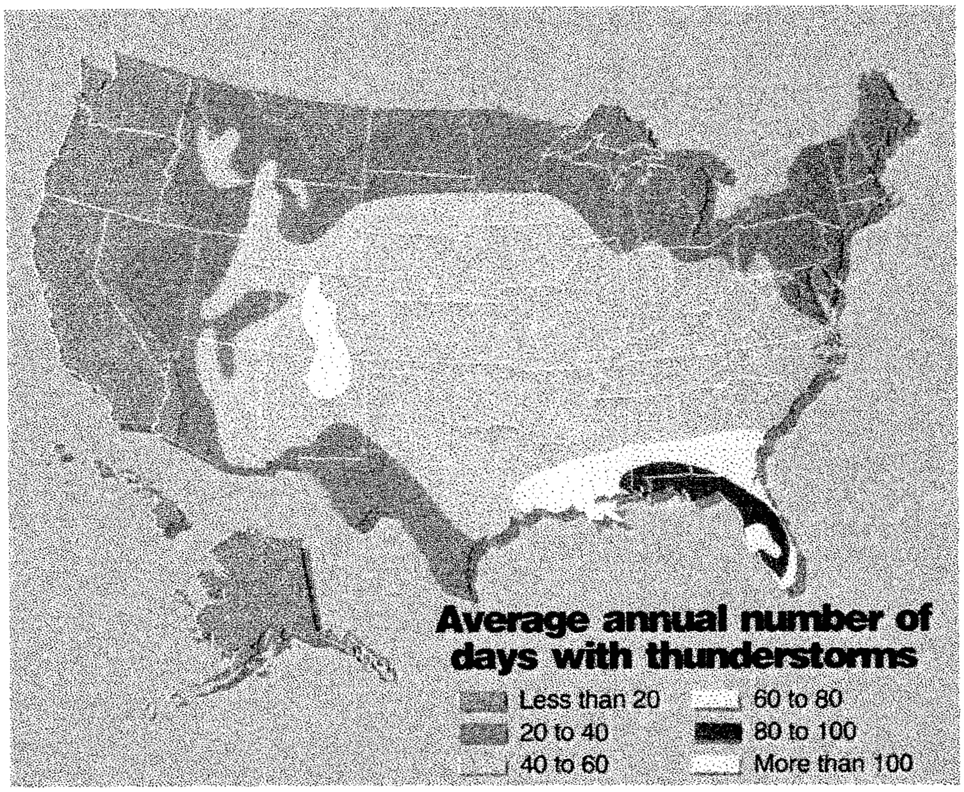


Figure 4.18 **Average Annual Number of Days with Thunderstorms in the United States**
(Source: Williams 1992: 115)

lightning, microburst winds and tornadoes. In the United States, these special conditions arise frequently, since warm moist air from the Gulf of Mexico can travel across relatively flat topography to clash with the cool, drier air traveling from the Rocky Mountains and Canada (Frazier 1979).

American public horticulture institutions are well experienced with thunderstorms. Only a few PHI (8.6%) have not experienced a severe thunderstorm during 1980-1999 (Figure 4.19). Nearly all gardens (91%) believe they will encounter severe thunderstorms in the future (Figure 4.20). Again, these data were obtained through responses from this study's survey instrument.

Figure 4.19 Experience with Severe Thunderstorms at American PHI

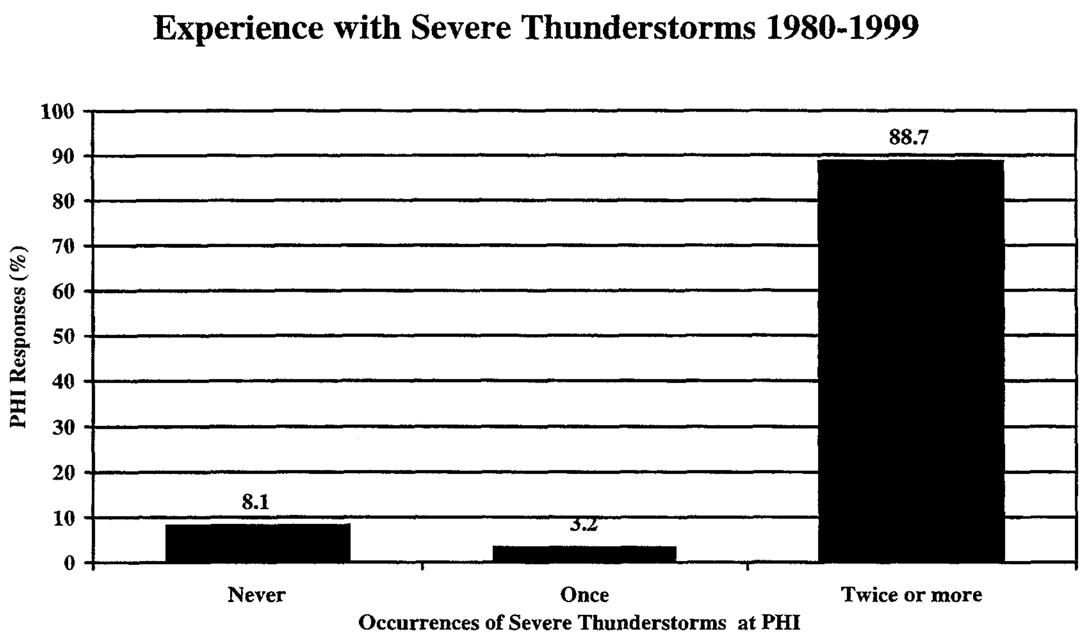
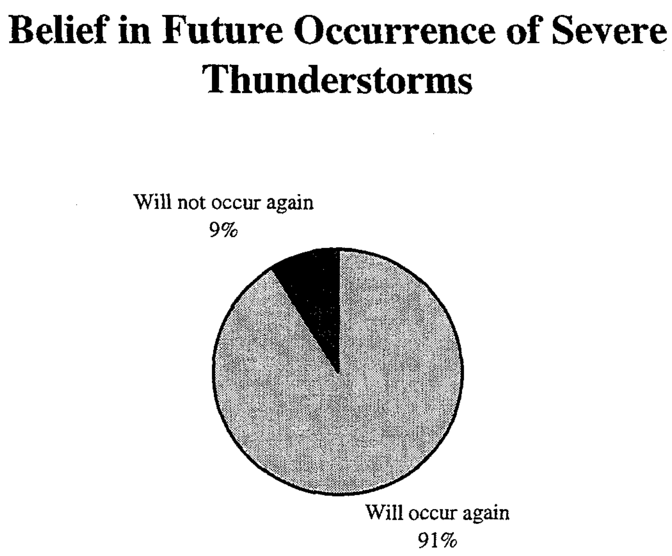


Figure 4.20 American PHI Belief in Future Occurrence of Severe Thunderstorms



Tornadoes

Tornadoes are the most violent inland windstorms on the planet. Scientists are aware of the conditions favorable for their development and although recent research has provided much insight into tornadoes, uncertainty remains as to what exactly causes them to form (Tobin and Montz 1997). Tornadoes can travel and speeds up to seventy m.p.h., with funnel wind speeds reaching several hundred miles per hour (Hoetmer 1991), as designated by the Fujita Scale (Table 4.4). Outside of the force of the tremendous winds of a tornado, the next most dangerous aspect associated with a tornado is wind-driven debris (Frazier 1979).

The temporal relationship of thunderstorms and their products, most notably tornadoes, is of interest when discussing regions of the United States most at risk.

Tornadoes have been recorded in all fifty states (Williams 1992); and more tornadoes occur in spring, the months of April through June (Tobin and Montz 1997), than at any other time of year. However, geographic location heavily affects the peak season of risk for thunderstorms:

> Tornadoes have a distinctive seasonal component in the United States. As winter gives way to spring…the jet stream migrates north, bringing with it severe weather systems that move along the boundary between cold and warm air masses. For southern states, thunderstorms begin early in the year (Figure 4.21) and their progression north can be tracked; by May or June, they have reached Minnesota. Along with these storms come lightning, hail and tornadoes (Tobin and Montz 1997).

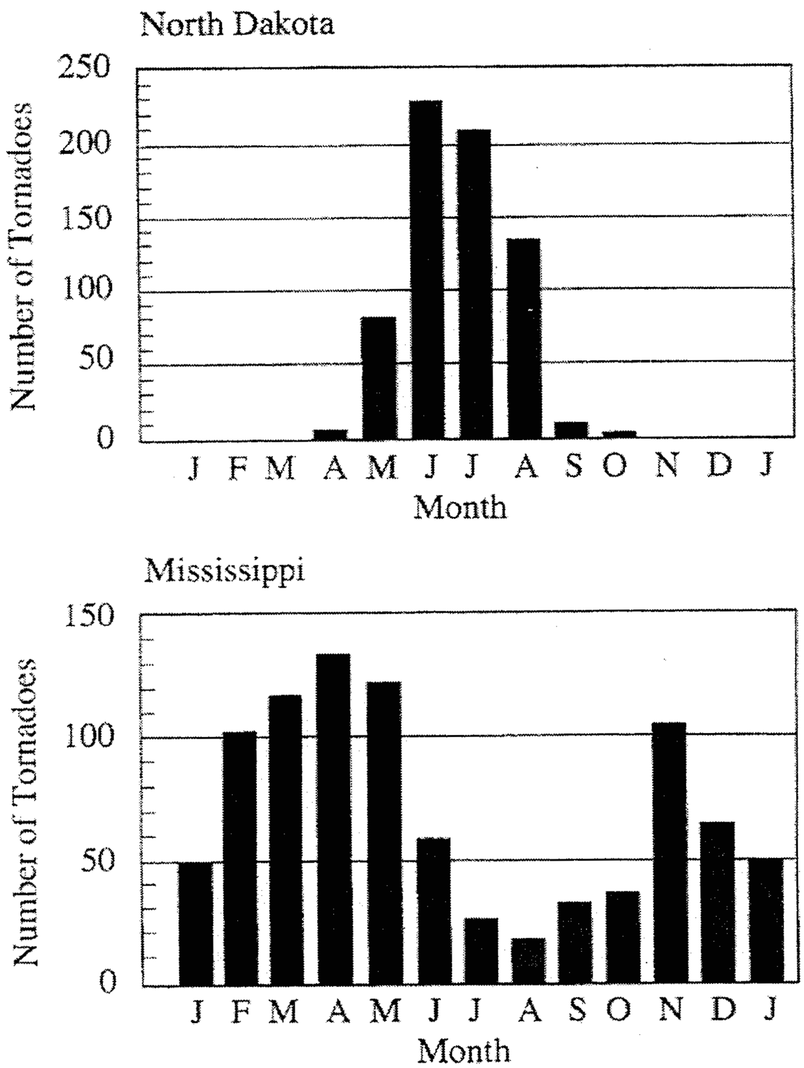
The incidence of tornadoes in the United States through records until 1991 reveals that severe thunderstorms and tornadoes occur most frequently between 2-7 p.m.; however, violent storms have been known to strike at all times of the day (Tobin and Montz 1997). Nearly 75% of all tornadoes in the United States are of F0 or F1 intensity (*The Fujita Scale* 1999).

Table 4.4 **The Fujita Scale**

(Source: <http://www.tornadoproject.com/fujitascale>)

F-Scale Number	Intensity Phrase	Wind Speed	Type of Damage Done
F0	**Gale tornado**	40-72 mph	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.
F1	**Moderate tornado**	73-112 mph	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
F2	**Significant tornado**	113-157 mph	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
F3	**Severe tornado**	158-206 mph	Roof and some walls torn off well constructed houses; trains overturned; most trees in forest uprooted
F4	**Devastating tornado**	207-260 mph	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
F5	**Incredible tornado**	261-318 mph	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 meters; trees debarked; steel re-inforced concrete structures badly damaged.
F6	**Inconceivable tornado**	319-379 mph	These winds are very unlikely. The small area of damage they might produce would probably not be recognizable along with the mess produced by F4 and F5 wind that would surround the F6 winds. Missiles, such as cars and refrigerators would do serious secondary damage that could not be directly identified as F6 damage. If this level is ever achieved, evidence for it might only be found in some manner of ground swirl pattern, for it may never be identifiable through engineering studies

Figure 4.21 **Comparison of Monthly Incidence of Tornadoes in a Northern and a Southern State** (Source: Tobin 1997: 112)



Tornadoes are commonly known to occur in the Eastern United States, particularly in the Great Plains (Figure 4.22), although there are increased risks noted in the South and other localized pockets.

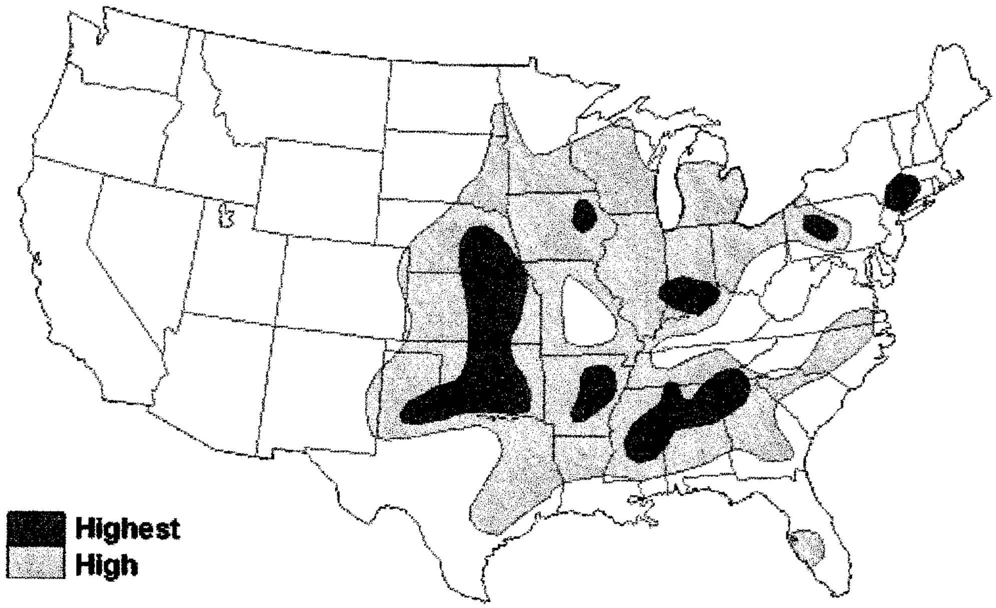


Figure 4.22 Tornado Risk Areas in the Contiguous United States (Source: U.S. Geological Survey)

Survey respondents shared that nearly three-quarters (72.5%) of American PHI did not experience tornadoes during the designated period (Figure 4.23). However, a sound majority (68.9%) of American public gardens do feel they are at risk of future tornado encounters (Figure 4.24).

Figure 4.23 Experience with Tornadoes at American PHI

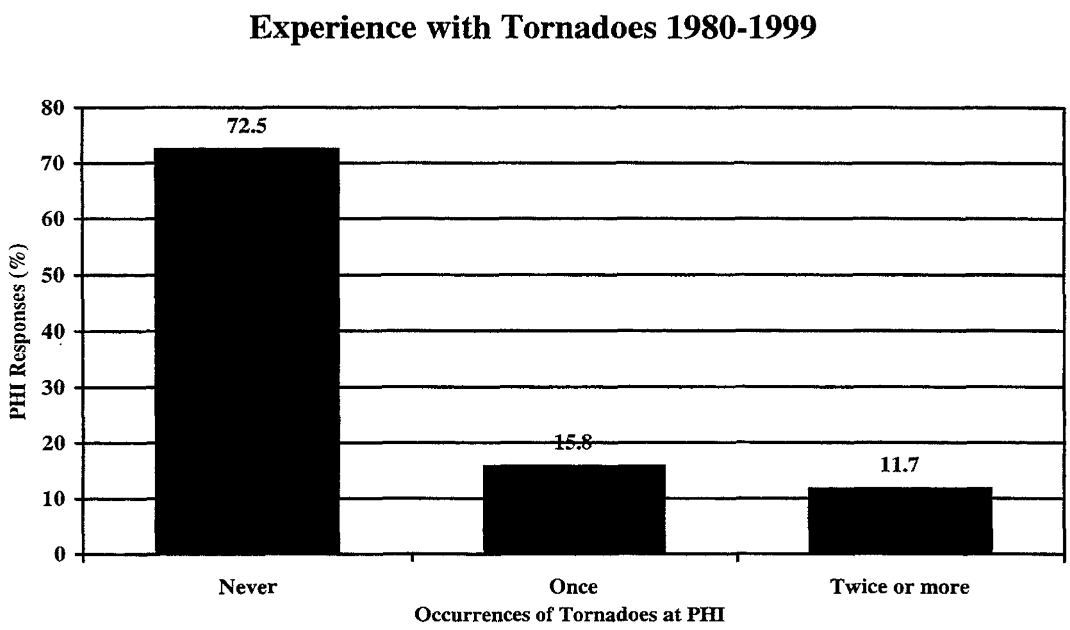
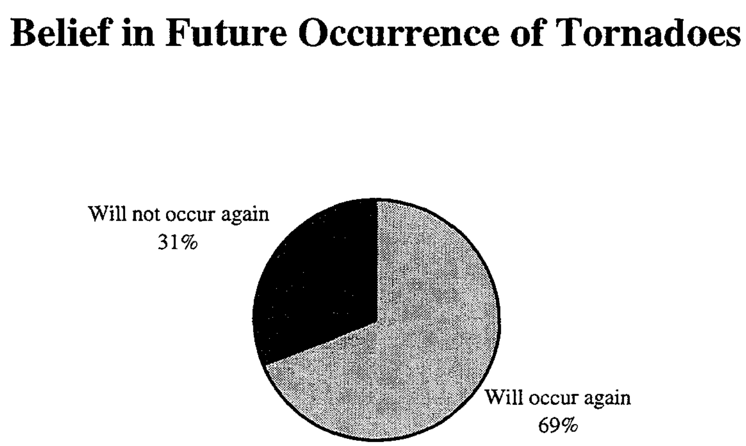


Figure 4.24 American PHI Belief in Future Occurrence of Tornadoes



Winds

Downbursts and severe windstorms are also a reality from severe thunderstorms. As air within a thunderstorm cools, it becomes heavier and plunges toward the earth. At times, these "microbursts" can produce straight-line winds of 150 m.p.h. or more (Williams 1992). A specific type of downburst, known as the "derecho", is most common from the Northern and Central Plains into the Ohio Valley, especially in late spring and summer. Derechos are thunderstorms that repeatedly produce downbursts (or straight line winds) as they move—the storm is characterized as having "winds of at least 58 m.p.h. and spread damage across an area at least 280 miles (Williams 1992)."

Not surprising is that wind need not attain hurricane strength to begin to inflict damage to plants, especially trees, as noted in the Beaufort Scale (Table 4.5). Damage to trees itself is a central part of the actual description used to help distinguish the levels on the scale. Wind may be the weather phenomenon most universally acknowledged as a risk maintenance reality for plant collections at botanic gardens.

In North America there is a wind phenomenon collectively dubbed Foehn winds. These regional winds can last for several hours, even days, producing winds approaching 100 m.p.h. Foehn winds are quite predictable and involve the movement of air across different land elevations. Perhaps Foehn winds are best recognized by their local names: the Chinook (Rocky Mountains), the Wasatch (Utah), The Columbia River Gorge winds (Washington) and the Santa Ana wind of California. The largest uncontrollable threat from these winds is their potential to promote fire conflagration, especially during dry season when vegetation is most flammable. The Chinook and Columbia River Gorge winds are most pronounced in

Table 4.5 **The Beaufort Wind Scale**
(Source: Truesdellto)

Code No.	Description	Wind Speed (miles per hour)	Observable Effects on the Environment
0	Calm	less than 1	Smoke will rise vertically.
1	Light Air	1-3	Rising smoke drifts, weather vane is inactive.
2	Light Breeze	4-7	Leaves rustle, can feel wind on your face, weather vane is inactive.
3	Gentle Breeze	8-12	Leaves and twigs move around. Light weight flags extend.
4	Moderate Breeze	13-18	Moves thin branches, raises dust and paper.
5	Fresh Breeze	19-24	Trees sway.
6	Strong Breeze	25-31	Large tree branches move, open wires (such as telegraph wires) begin to "whistle", umbrellas are difficult to keep under control.
7	Moderate Gale	32-38	Large trees begin to sway, noticeably difficult to walk.
8	Fresh Gale	39-46	Twigs and small branches are broken from trees, walking into the wind is very difficult.
9	Strong Gale	47-54	Slight damage occurs to buildings, shingles are blown off of roofs.
10	Whole Gale	55-63	Large trees are uprooted, building damage is considerable.
11	Storm	64-74	Extensive widespread damage. These typically occur only at sea, and rarely inland.
12	Hurricane	above 74	Extreme destruction.

winter, but the Wasatch and Santa Ana winds often occur in arid regions at the end of the dry season; in central California this coincides with November and December. In direct contrast to the fire hazards arising from Foehn winds, those winds that originate over the moist Pacific Ocean and travel up into the cooled western slopes of the Rockies, such as the Sierra Nevada, can cause heavy precipitation (*Regional Storm Exposures* 1996).

American PHI are familiar with wind hazards. Based on survey responses, a mere few (8.6%) stated that they did not experience any winds (Figure 4.25). Over ninety percent of PHI experience winds at least once from 1980-1999. Of all hazards investigated during this study, winds received the most responses (93.6%) with a belief in future occurrence (Figure 4.26).

Figure 4.25 Experience with Strong Winds at American PHI.

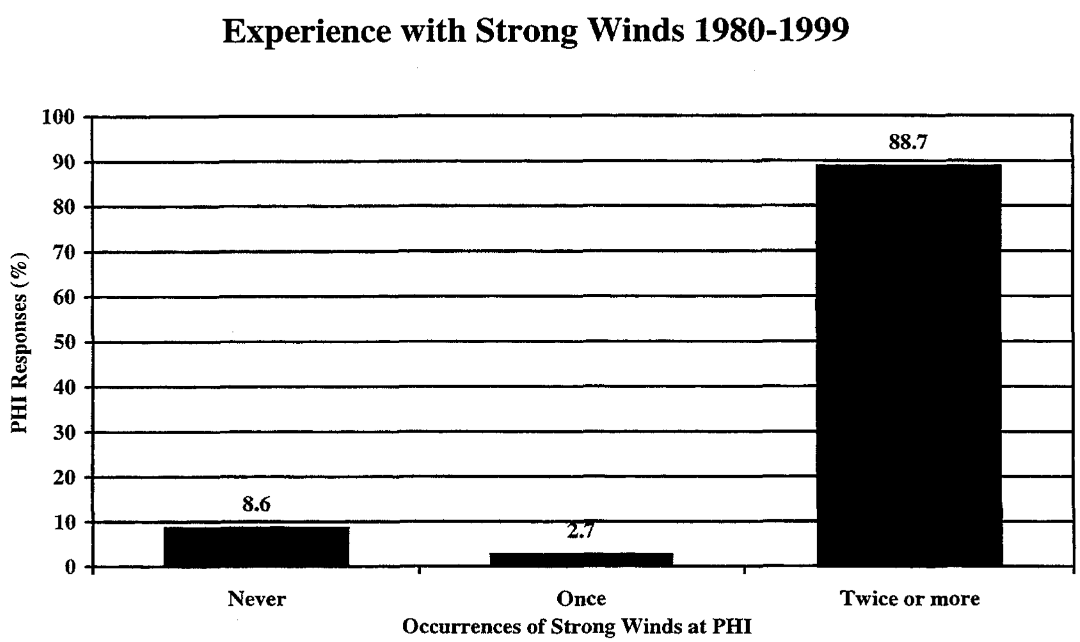
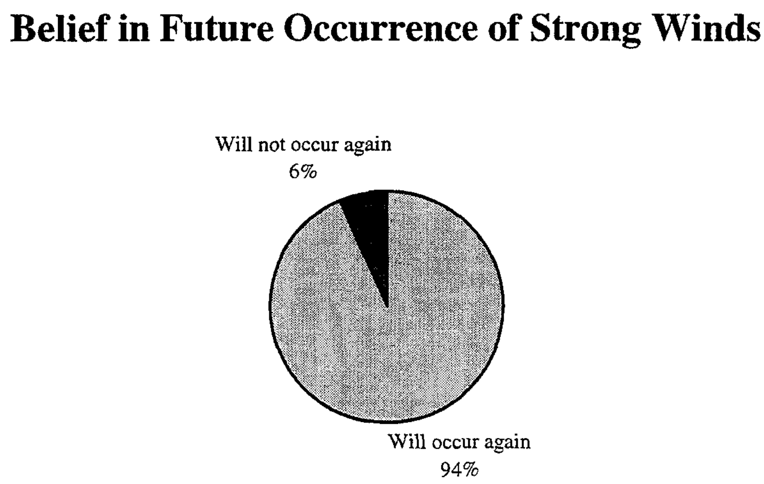


Figure 4.26 American PHI Belief in Future Occurrence of Strong Winds.



Hail

Hail are balls of ice that form as they travel in updrafts within thunderstorm clouds. The faster the updraft (the more energy in the thunderstorm), the larger the hailstone. The Midwest and Great Plains are at a consistent high risk for thunderstorms that produce hailstorms (Figure 4.27), especially during late spring (*Regional Storm Exposures* 1996). Agricultural crops are perennially affected, although major insurance companies reveal a significant amount of vehicular and building glass damages from hail, too (Williams 1992). Hail can often occur in bands upwards of one hundred miles long and about ten miles wide. "The largest of hailstones can fall at a rate of 90 m.p.h. (Williams 1992)."

About one quarter (26.1%) of PHI did not experience hail. Survey responses revealed that most (73.9%) PHI experienced hail at least once during 1980-1999 (Figure 4.28). Many (86%) believe hail will occur in the future (Figure 4.29).

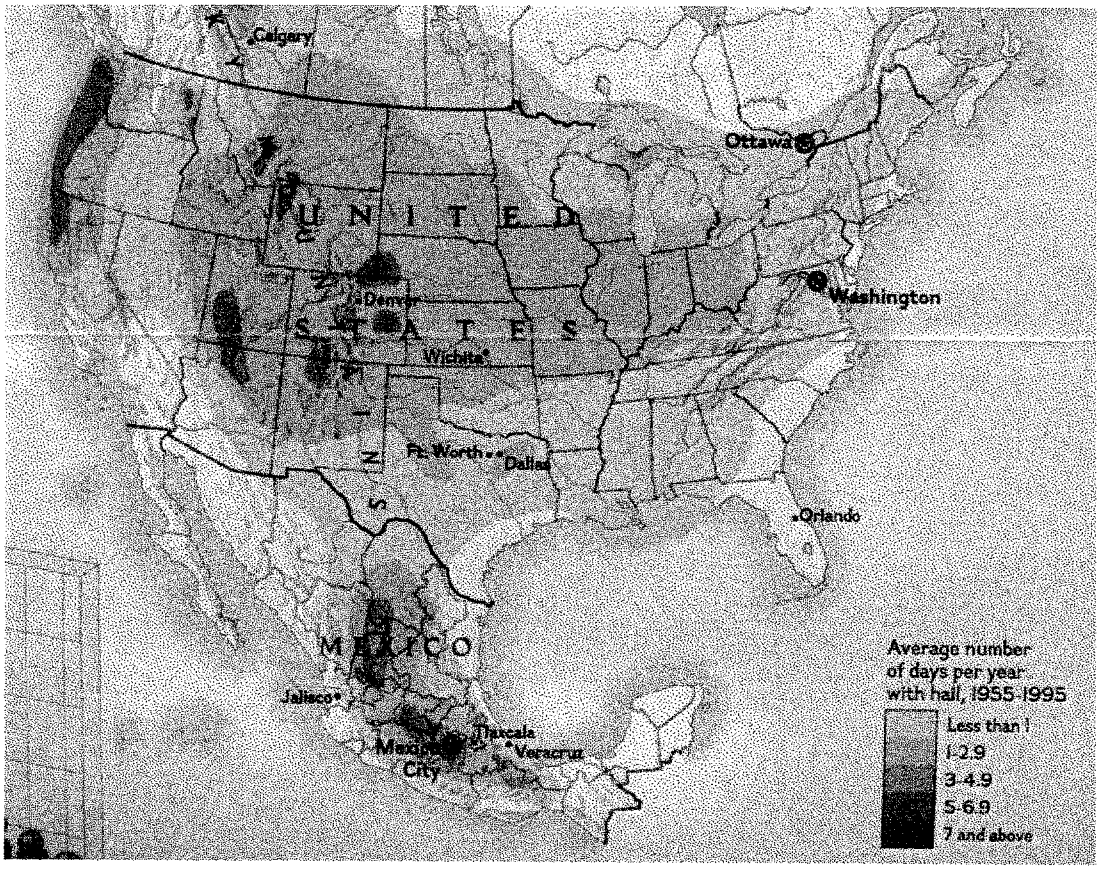


Figure 4.27 Average Number of Days with Hail Across Selected Areas of North America
(Source: National Geographic 1998)

Figure 4.28 Experience with Hail at American PHI.

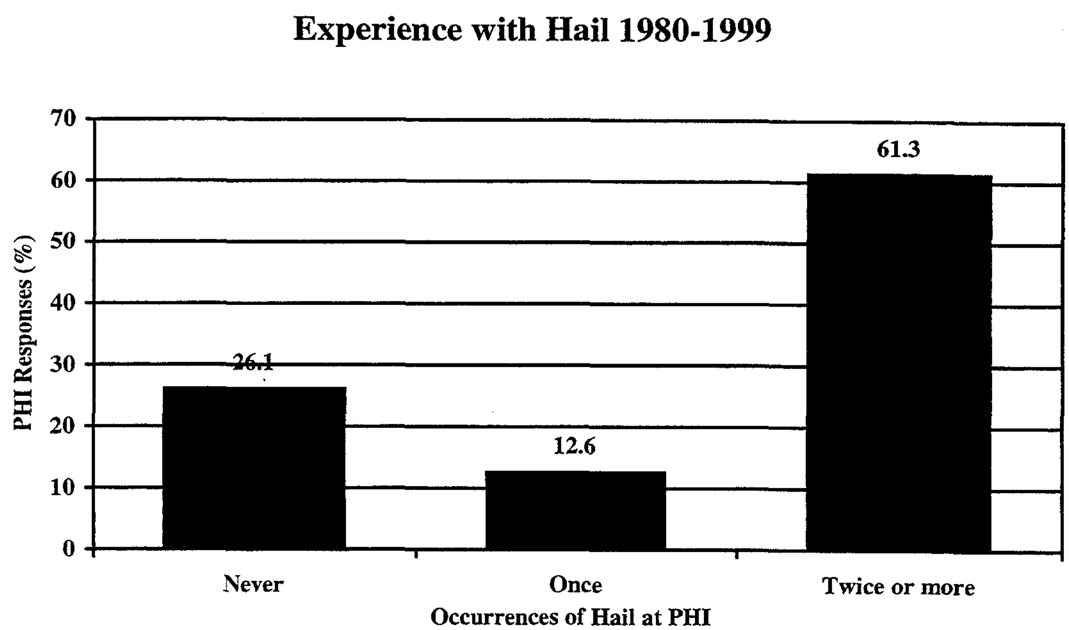
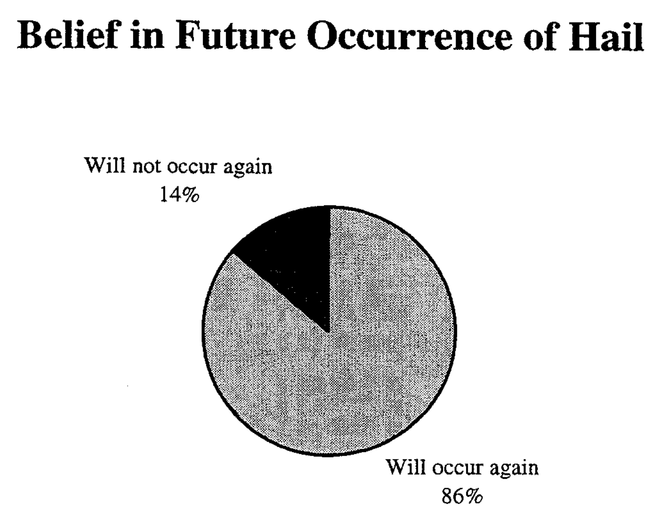


Figure 4.29 American PHI Belief in Future Occurrence of Hail.



Lightning

Lightning can affect plants, technologies and structures. Lightning strikes can obliterate a tree; strikes can also ignite vegetation. From a technological standpoint, lightning can damage buildings, especially chimneys and other highly positioned structures. Radio and television towers can be rendered unusable, and disruptions to power grids can result in outages in electricity, telephone and computer use. For these reasons, lightning can create business disruptions and direct losses (*Regional Storm Exposures* 1996). The effects of lightning can be mitigated in the forms of lightning arrestors; many public gardens invest this strategy in their most valuable trees for preservation and safety's sakes. As lightning is associated with thunderstorm activity, all areas of the U.S. are at varying risk of lightning. However, the seasonality and atmospheric requirements for thunderstorms makes Florida and the Gulf Coast especially accustomed to the phenomenon (see Figure 4.18, page 54).

The majority (77.1%) of American PHI experienced lightning during the period 1980-1999 (Figure 4.30). Survey responses also show that many (87.4%) believe lightning will occur again (Figure 4.31).

Winter Storms

Winter storms have varying characteristics; wind speed is the determinant for classifying as storm a blizzard (Frazier 1979). Other winter storms have their own distinguishing characteristics, such as Nor'easters and lake effect snowstorms. Regional differences exist regarding the annual expected snowfalls; mountainous and northern regions expect more snowfalls, as do the leeward areas of the Great Lakes.

In comparison to the tropical hurricane, which carries power in wind, water and ocean waves, the winter storm contains wind, snow and cold (Frazier 1979).

Figure 4.30 Experience with Lightning at American PHI.

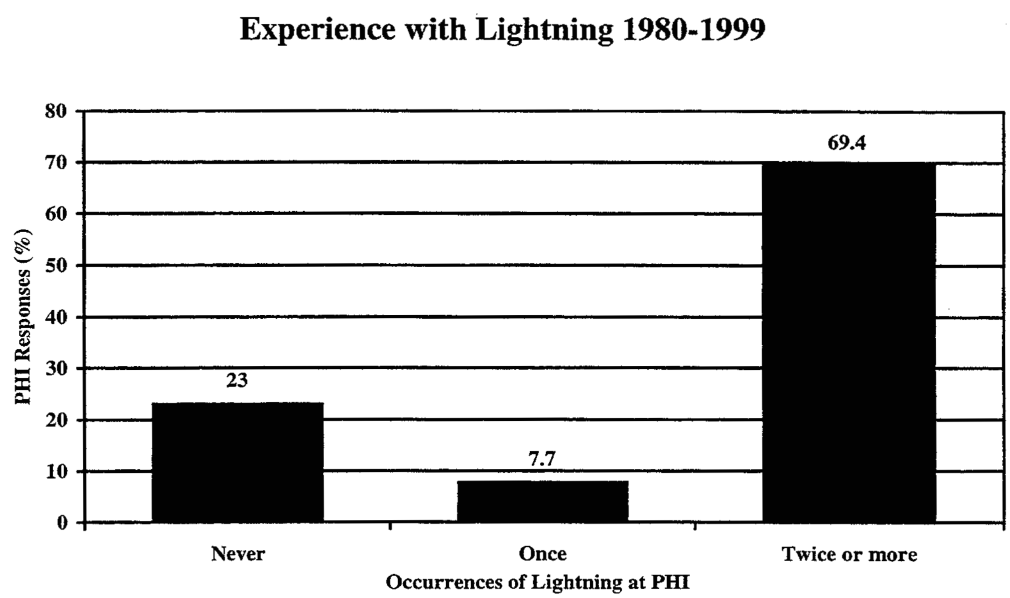
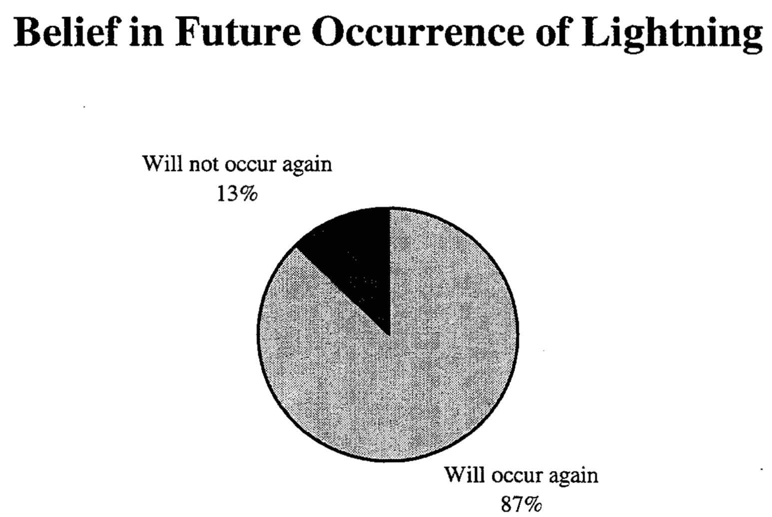


Figure 4.31 American PHI Belief in Future Occurrence of Lightning.



The storms of winter are a result of movements of extra-tropical cyclones—warm and cold air mixing low pressure centers. These storms need not bring only snow, but a variety of precipitation depending on local air temperatures. Ice, sleet, snow, freezing rain or even thunderstorms can be associated with the life of a winter storm as it travels across the United States. Figure 4.32 demonstrates the expected annual snowfall in the United States. Figure 4.33 reveals the regional ice accumulation load—the amount of ice that builds up on objects on average in the United States per annum.

Large winter storms typically have their origins in the Pacific and dump rain and snow on the western Rockies, as determined by temperatures at different elevations. As the storm passes onto Great Plains, they intensify as warm moist air is added from the Gulf of Mexico and cold air enters from the north. These storms can travel virtually anywhere across the eastern United States. Storms that take a track up the eastern seaboard are particularly dangerous and are known as Nor'easters. (Williams 1992).

Nor'easters are named for the sometimes hurricane force winds (+74 m.p.h.) blowing ashore from the northeast as the storm approaches. Nor'easters are known for providing strong winds, damaging surf, flooding rains and, if the cold air is in place, blizzard conditions (Schwartz 1999). As the storm can be physically large, great potential for disruption and damage are anticipated if conditions are perfect. Such was the case on the weekend of January 22-25, 2000, and March 12-15, 1993 when the winter storm caused an estimated 277 deaths and affected twenty-six states (and 50% of the nation's population) with hurricane force winds, storm surges, snowfall, even tornadoes and sub-freezing temperatures in Florida. If this storm were to be judged based on hurricane strength criteria, it would have achieved a category 3 status (Lott 1993). The "Superstorm of 1993":

> ...– one of the largest and most intense storms on record – began to grip the eastern third of the United States. The ensuing blizzard crippled much of the eastern third of the country, from Alabama to New England, with record cold, snow, and wind gusts well in excess of hurricane force. As the blizzard raced through up the eastern seaboard, it produced widespread whiteout conditions...States up and down the eastern seaboard declared disaster emergencies. All means of modern transportation were essentially paralyzed. Interstate highways from Atlanta northward were shut down. Secondary roads were completely impassable. For the first time, every single major airport on the East Coast had to close at one time or another because of the storm. An estimated 25 percent of the nation's airline flights were cancelled. The severe cold following the three-day storm preserved so much of the snow it prolonged the colossal travel nightmares, especially in the South where most roads could not be plowed. The combined effects of high winds and heavy wet snow downed thousands of miles of power lines leaving millions of customers in the dark for up to a week. The weight of the snow caused hundreds of roof collapses
> (Miller 1999).

Fallen snow and wind-driven snow are not the only possible components of a winter season storm. Although terms used for and condition for the formation of freezing precipitation varies, Americans are most familiar with the phenomena sleet, freezing rain, ice, and snow. The timing and location of the freezing of water in a storm determines the type of precipitation. Water droplets and vapor can freeze in the air, or may freeze upon contact with a cold object on the ground (Williams 1992).

"Ice accumulates when supercooled rain freezes on contact with surfaces, such as tree branches, that are at or below the freezing point (0°C). Periodically, other climatic events, including stationary, occluded, and cold fronts, also result in ice storms. (Hauer, et.al. 1994)." Icestorms (or glaze storms) are most likely in the Midwest and the East (Figure 4.33).

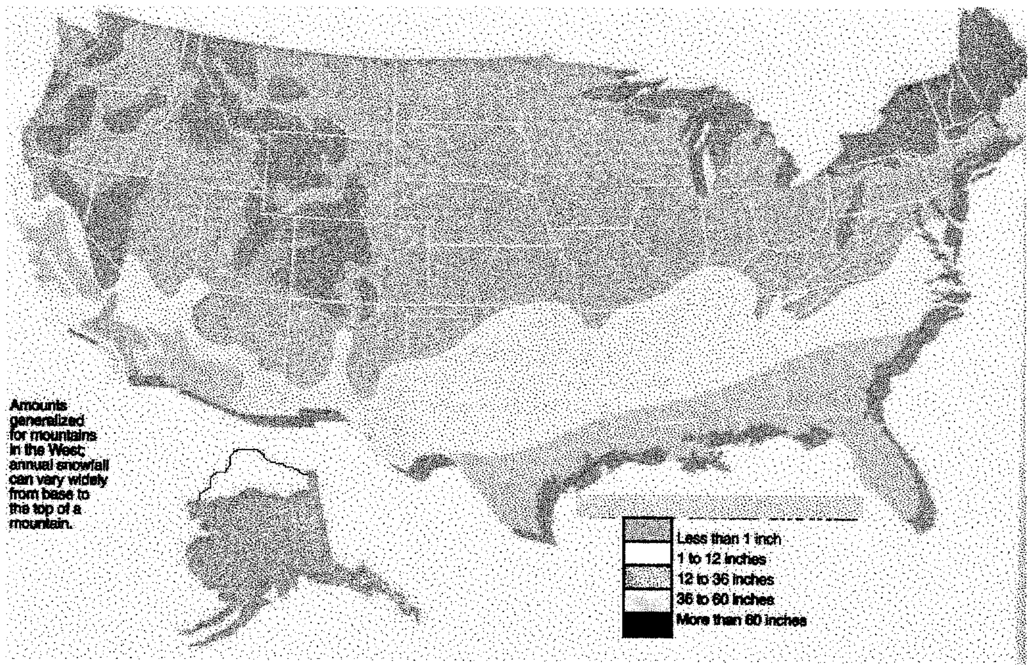


Figure 4.32 Average Annual Snowfall Amounts in the United States
(Adapted From: Williams 1992:96)

Whichever occurs, ice or snow, the fact remains that freezing precipitation causes safety hazards and can cause damage from weight accumulations on structures and plants alike. "Accumulations of ice can increase the branch weight of trees by thirty times or more. Strong winds substantially increase the potential for damage from ice (Hauer, et.al. 1994)." Ten inches of wet snow is equivalent to the volume and weight of one inch of rain; dry or powder snow is less dense as twenty to forty inches of snow will melt down to equal one inch of rain (Williams 1992).

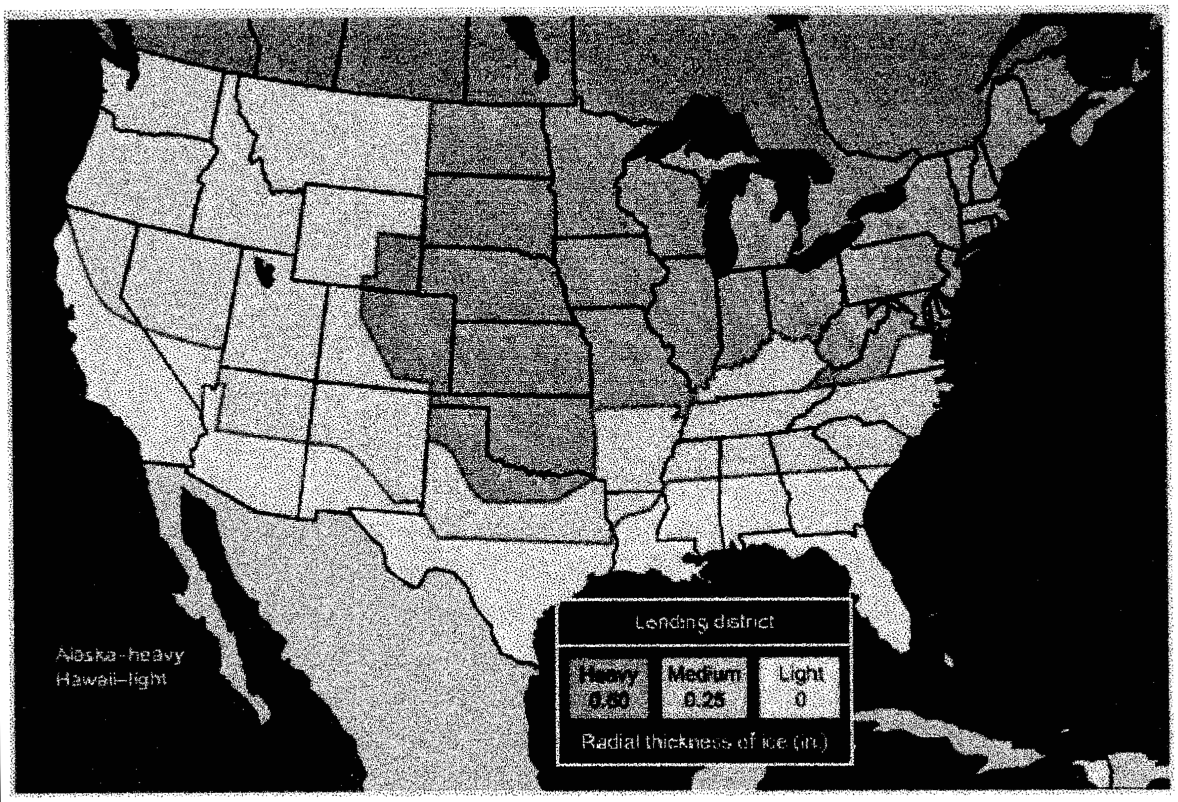


Figure 4.33 Regions of Ice Loading Districts in the United States
(Source: Hauer, et.al. 1994)

Survey responses to the collective "ice/snowstorm" hazard revealed that the majority (83%) of PHI experienced either of these winter storms at least once from 1980-1999 (Figure 4.34). Most (80.6%) PHI believe these storms will occur again (Figure 4.35).

Lastly, cold temperatures associated with winter can have damaging effects. The survey permitted write-in responses to types of natural hazards experienced, and "unseasonal cold" or "freeze" were among the responses noted. Failure of heating units or extremely frigid temperatures can cause cold to penetrate structural and ground insulation to freeze

Figure 4.34 Experience with Ice/Snowstorms at American PHI.

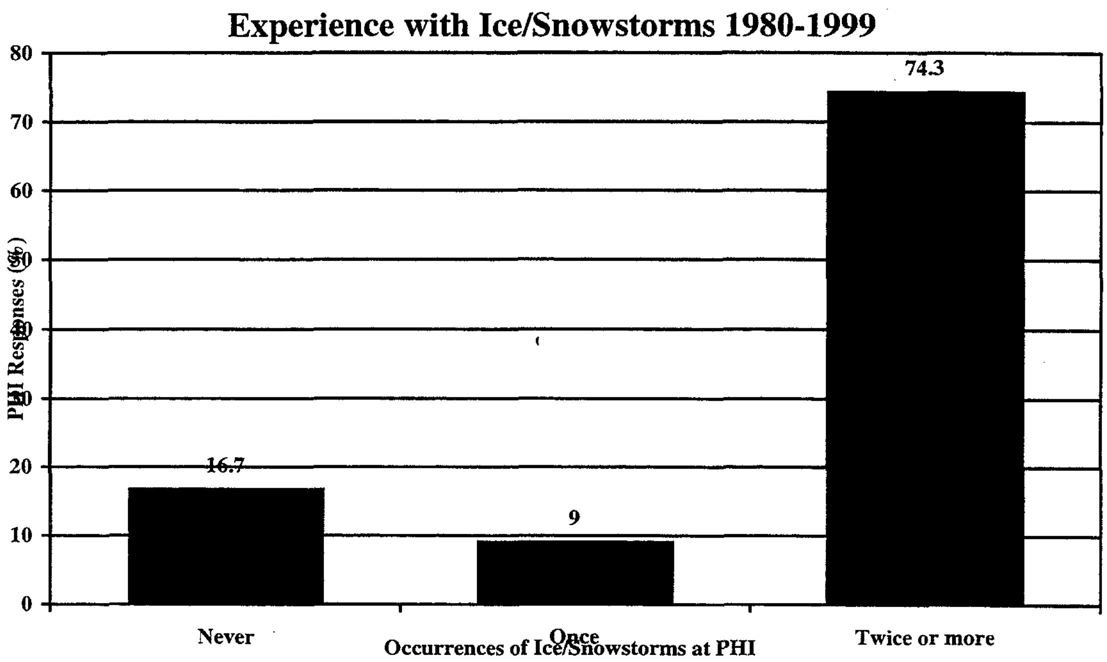
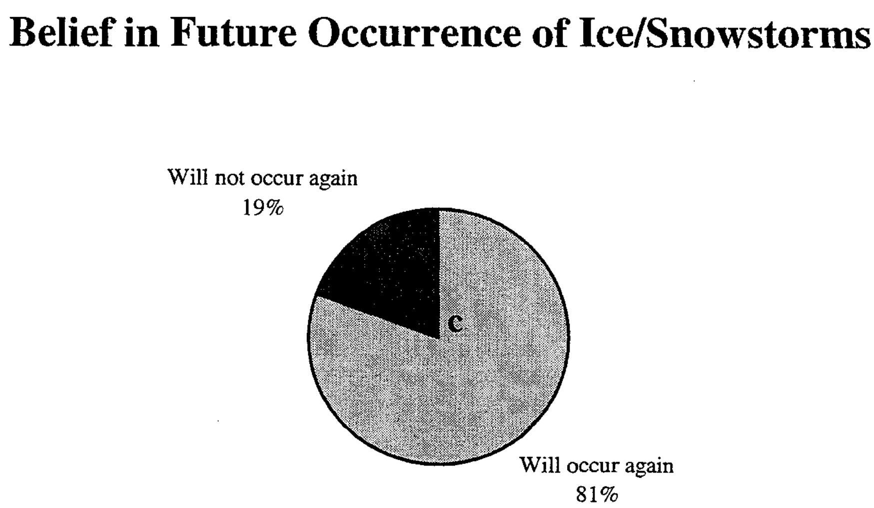


Figure 4.35 American PHI Belief in Future Occurrence of Ice/Snowstorms.



pipes and effect communication cables if condensation freezes. From a botanical standpoint, as "cold" is a relative term depending on usual seasonal temperatures, cold snaps can cause plant desiccation and lead to die back of shoots and leaves or completely kill a plant not physiologically equipped to handle the changes in temperature.

Understanding the spatial and temporal characteristics as well as potential strengths of natural hazards, the reader will have a heightened understanding and appreciation of the disaster experiences by public gardens in the next chapter. Moreover, an understanding of various natural hazards will assist public garden administrators determine any site-specific vulnerabilities to plants and facilities based on the respective threat to the natural hazard.

Chapter 5

DESCRIPTIONS AND DISCUSSION OF CASE STUDY SITES

This chapter will provide some basic background of each public garden and the corresponding natural hazard encountered. Each site's location, significant structures, and plant collections and components will be revealed followed by the litany of impacts incurred from the natural disaster with text and figures. Processes used in response and recovery efforts in the wake of the respective natural disasters completes each section for each site. This information will demonstrate the wide range of issues that must be addressed by PHI during disaster planning efforts and actual natural disaster experiences. Chapter Six will analyze and discuss the overall trends seen from the five case study sites' natural disaster experiences and subsequent recovery processes.

Fairchild Tropical Garden

Fairchild Tropical Garden (FTG) is located south of Miami in Coral Gables, Dade County, Florida. It is the largest tropical botanical garden in the continental United States. FTG was established in 1938 from a vision of amateur plant collector Robert H. Montgomery and American botanist Dr. David Fairchild. A naturalistic landscape design was created by William Lyman Phillips as characterized by informal flowing groupings of plants contrasted with broad, open meadows and eleven lakes across eighty-three acres. Several structures are located within FTG, including the administrative building, the educational

Corbin Building, an education Garden House, gift shop, maintenance sheds, café and an impressive interior collection of rare and tender tropical plants in a conservatory. The nearby Montgomery Center site is the location of additional research and office facilities, plant nurseries and greenhouses.

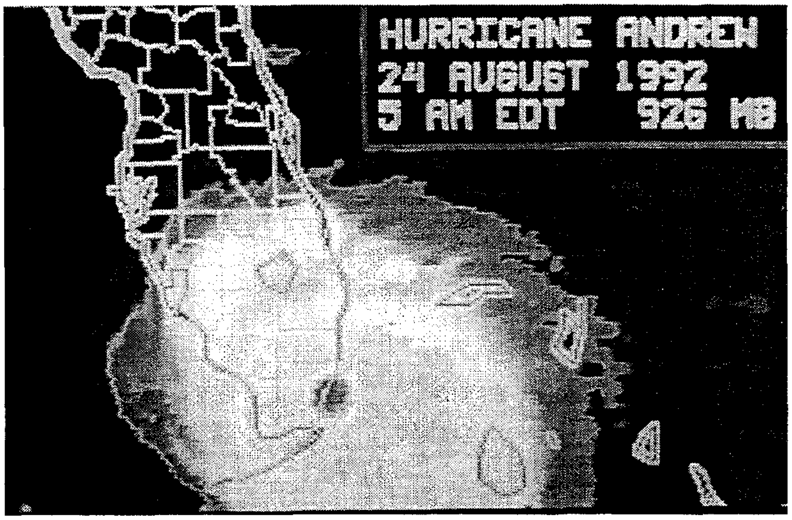
The gardens are home to a renowned collection of more than 700 species of palms from all over the world and 185 of the 200 known species of cycads. These and other tropical plants, numbering about 16,000 (some 3,000 species) are enjoyed by the public and used by scientists as a research laboratory. Fairchild fosters collaborations with medical research and educational institutions and also serves to preserve rare and endangered tropical plant species. FTG is governed as a non-profit organization and has an annual budget of just over $4 million.

Hurricane Andrew

On August 24, 1992 a category 4 hurricane named Andrew made landfall on the south Florida coast just south of FTG near Homestead and Florida City. Andrew's fury was compared to Hurricane Agnes from 1972. Agnes, however, was a much weaker category 1 storm that dumped disastrous amounts of rains on the Northeast. Hurricane Andrew was weaker in rainfall, but significantly more powerful in wind and storm surge.

After first crossing the island nation of the Bahamas on August 23 with 150 m.p.h. winds, Andrew continued to strengthen with winds steadily increasing. Andrew began its assault on Florida early in the morning of Sunday, August 24 with winds of 145 mph, with gusts up to 170 m.p.h. (Figure 5.1). Because of advance warning and advisories, south Florida had been evacuated and secured as much as could be enforced. Within five hours, Andrew had passed over the entire peninsula and continued to weaken, albeit slightly to a category 3 distinction, as it crossed the Gulf of Mexico.

Figure 5.1 Satellite Image of Hurricane Andrew Making Landfall in South Florida, August 24, 1992. (Photography courtesy Fairchild Tropical Gardens)



Then, on August 25, Andrew made final landfall in the United States in south-central Louisiana with winds of 120 m.p.h. and an eight foot storm surge. Dozens of tornadoes accompanied Andrew as it moved further inland and northeastward over Louisiana, Mississippi, Alabama and Georgia. Though Andrew quickly weakened to a tropical depression, Andrew's severe weather and torrential rains continued. Heavy rains fell in across the South, causing flash flooding in Louisiana and neighboring states (Sauer 1999). Andrew ranks as the costliest natural disaster in U.S. history, tallied at $25 billion in 1995 (Tobin and Montz 1997). Before Andrew, Hurricane Agnes held that distinction, having caused more than $3 billion in damage in 1972 (Sauer 1999).

Impacts on FTG

Direct Impacts

As the hurricane made landfall, the plant collections and buildings were beaten by winds, salt spray, rain, and also wind driven land debris. Storm surge entered the peripheral lowlands area at FTG. Most major buildings weathered the storm well, will only minor problems such as window cracking or roof shaking. The concern with this type of damage was water leakage. Greenhouses and free-standing small storage sheds, however, did not withstand the forces of nature. The rare plant house roof collapsed and left fiberglass, metal and glass shards on top of rare and tender tropicals (Figures 5.2 and 5.3). Three of five greenhouses at the research center were destroyed, glass blown out and aluminum frames bent beyond repair (Figure 5.4).

Inventory, supplies and infrastructure was also affected from wind and water. Tools and growing media were lost if their protective structures were blown away. Exposure to moisture also rendered some fertilizers or growing media useless. Plants growing in pots were blown away. Plant labels across the property were often torn away from their respective plants. A vine pergola was severely damaged. Sprinklers mounted in the tree canopy were destroyed and across the area varying capacities of telephone, electricity and water utilities were lost. Fairchild lost all but one live phone line.

In general, plants sustained leaf tearing or complete defoliation; larger trees were uprooted, twisted or left leaning from the wind. Understory plants were crushed from fallen limbs and trees. Further structural damage to plants occurred from collisions with wind-driven debris. In total, one half of the large trees were lost, and over half of the tropical fruit

Figure 5.2 **The Rare Plant House Prior to Hurricane Andrew.**
(Photograph courtesy Fairchild Tropical Garden.)

Figure 5.3 **The Rare Plant House After Hurricane Andrew.**
(Photograph courtesy Fairchild Tropical Garden.)

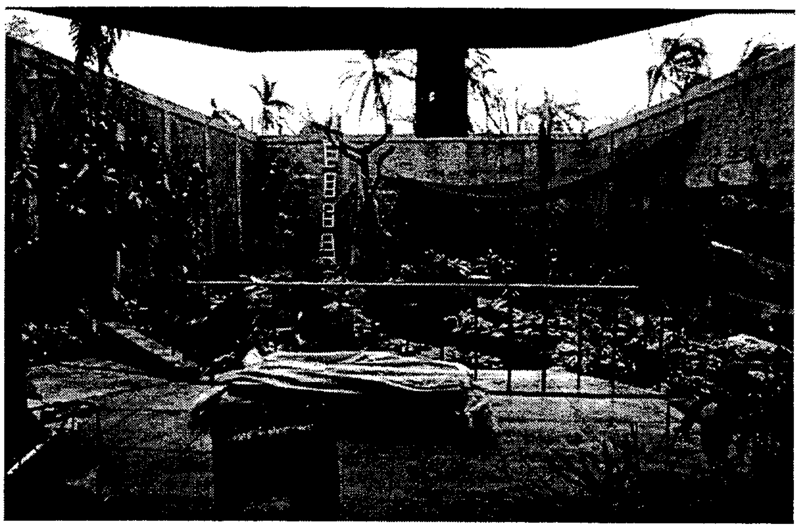
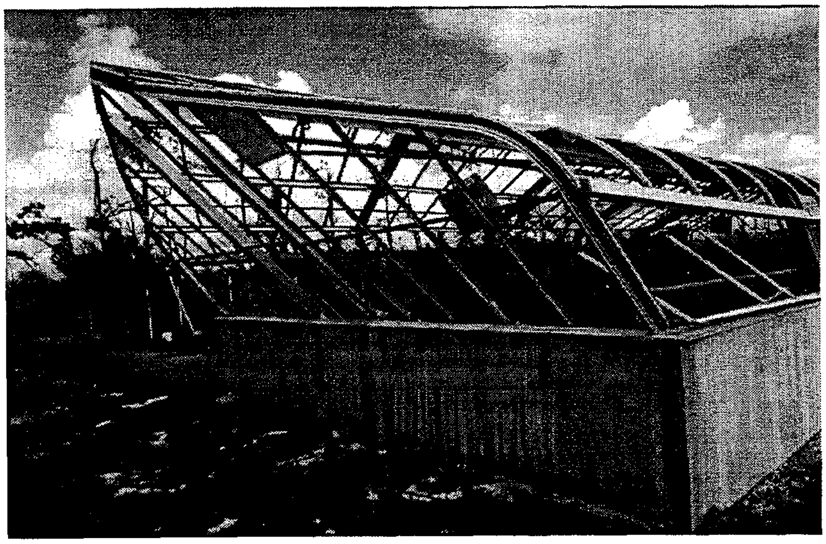


Figure 5.4 **Tilting of Aluminum Frame Greenhouse in Hurricane Andrew's Aftermath.** (Photograph courtesy Fairchild Tropical Garden.)



tree collection alone was destroyed. One half of all trees were completely defoliated. Approximately fifteen percent of the palm trees were lost. Roads and pathways within and outside of Fairchild were heavily littered with fallen leaves, limbs and entire trees (Figures 5.5 and 5.6). Overall, only five percent of all plant species were lost at Fairchild, mainly because of the redundancy in plantings across the property.

<u>Indirect Impacts</u>

As emergency response and recovery efforts commenced, further damage was sustained. Losses of the tall canopy trees left many tender, shade loving plants fully exposed to burning sunlight. Loss of water on the property affected the ability to clean and sustain any salvageable plants. In order to upright tipped trees, especially dicots, parts of the heavy

Figure 5.5 **A View of an Area of Fairchild Tropical Gardens with Lush Vegetative Understory and Tree Canopy Before Hurricane Andrew.** (Photograph courtesy Fairchild Tropical Garden.)

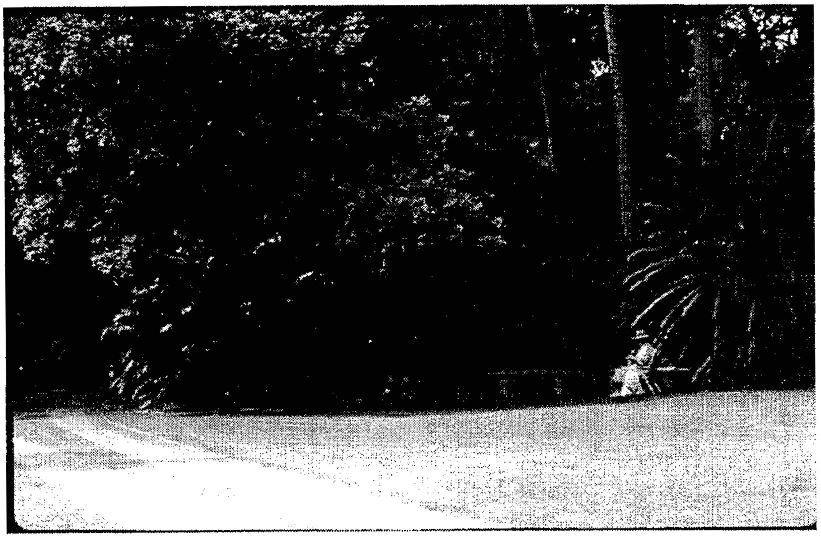


Figure 5.6 **A View of Same Area of Fairchild Tropical Gardens with Lush Vegetative Understory and Tree Canopy After Hurricane Andrew.** (Photograph courtesy Fairchild Tropical Garden.)

canopy had to be removed to facilitate the uprighting. The tremendous number of trees to be treated reduced the ability of recovery crews to expedite treatments to all needy plants. An additional indirect impact seen from Hurricane Andrew is an increase in weed plants due to the loss of canopy and increase in sunlight reaching the ground. Conversely, turf grass died or rotted in places where fallen vegetation debris had blanketed the lawn (Figure 5.7).

As crews began assessing and moving among the debris, inadvertent damage occurred to remaining plants and infrastructure. Leaf and limb breakage, trampling or unsupervised pruning or clearing resulted in further losses. Occasionally, salvaged plants were misplaced and carried away as debris. Use of heavy machinery also increased likelihood of further limb breakage or trampling as well as increasing soil compaction. Machinery could also easily destroy or tax remnant infrastructure such as walkways or paths, underground cables or conduits.

Figure 5.7 Debris Blanketed the Ground After the Hurricane
(Photograph courtesy Fairchild Tropical Garden.)

Further indirect impacts on Fairchild resulted because of the geographic area affected by Hurricane Andrew. Seven staff members lost their homes, and another eleven of employee homes incurred significant damage. Staff morale was affected; feelings of devastation and loss were common as staff were keenly aware of the garden's and personal losses and vulnerabilities. Roads were not easily passable by automobile. Supplies and labor were not always available or readily acquired because of community-wide demand. Lack of a consistent communication system slowed and impeded response. A governmental declaration of a curfew affected the timing of activities and military control made the open spaces of Fairchild vulnerable for confiscation as an emergency command post. Such circumstances contributed to the ultimate decision to close FTG for forty-one days to focus energies on clean up and recovery.

Although tropical plants have vigorous growth habits, further impacts from Hurricane Andrew included an overall change in the design integrity and aesthetic quality of the landscape. Fewer visitors came to the gardens, perceptions existed that little remained at the gardens or across South Florida. Tropical fruit production dropped off following the storm. The native pine stands survived the hurricane winds and were battered. Weakened from the storm and one of the few conifer species extant after Andrew, a regional pine bark beetle infestation destroyed the pines within six months. Still other plant types and species responded favorably to the increased light and decreased competition conditions that were prominent in the gardens after the storm.

A lengthy, laborious recovery process eventually resulting in the cancellation or rescheduling of Fairchild's fall continuing education classes. From a membership and public relations standpoint, it was evident that the experience with Andrew would need to be one "of renewal" at the gardens, rather than plant death and widespread destruction. Horticulturally, there was opportunity to re-evaluate the collections and reduce competition in planting beds; damaged trees that were old and poorly documented specimens could be removed and replaced with vigorous, scientifically documented new plant materials.

Response and Recovery

Initial visual assessment of plant collections and buildings occurred the same day as Hurricane Andrew hit. Staff able to walk or ride a bicycle down the road to the gardens made the first assessments. Certain buildings and areas of the property were inaccessible at this time due to debris and fallen trees.

The first full day after the storm, several staff reported for work and began tagging and identifying fallen trees as well as clearing important roads and paths. The director began the task of organizing the recovery procedures, which in his words were, "balance the need to bring order into the landscape and keep the spirits of the staff and volunteers up while moving to preserve the collection and decipher the information." Communication among staff to share progress reports and any needs would be best facilitated through a scheduled group meeting each day of the recovery. At the first meeting, staff was assigned the names of co-workers to learn of their post-hurricane statuses and needs, if any. Eighteen staff had their homes severely damaged or completely destroyed. A staff relief fund was established. Safety was stressed in all aspects of the impending clean up and salvaging efforts, and all staff would need to assist in sharing this message with all persons coming to the site. "Protection of the plant collection," stemming from the mission statement, was the foremost priority in the recovery effort.

The next step was the departmentalization of tasks. The director petitioned the board and local authorities for various emergency resources; contact was made with botanical garden professionals at a regional and national level. The grounds crew was in charge of clearing roads and initial tree clean up and maintenance issues (Figures 5.8 and 5.9), the volunteer coordinator to initiate a recruitment program for the recovery, the mechanic was given the equipment maintenance responsibility, which would be experiencing increased use and wear in the next few weeks. The financier was to set up financial controls for all emergency operations and dealing with the insurance company. The marketing

Figure 5.8 Massive Size of Certain Trees Demanded Stripping of Branches Prior to Overall Tree Removal.
(Photograph courtesy Fairchild Tropical Garden.)

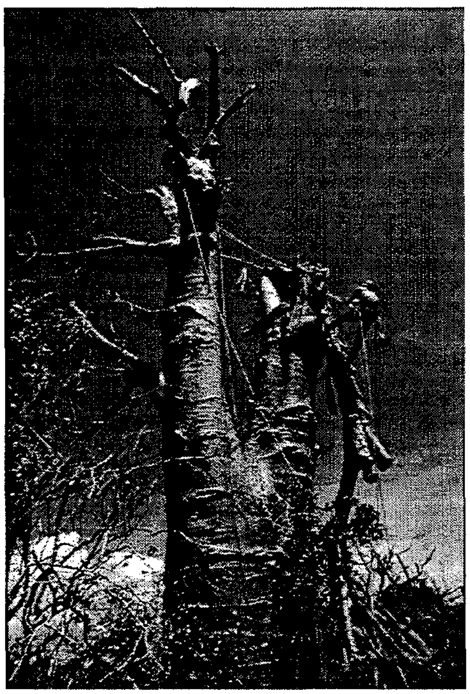


Figure 5.9 Palm Trees were Salvaged by Tipping Them Upright and Propping Them for Support While the Trees Reestablished Root Systems. (Photograph courtesy Fairchild Tropical Garden.)

coordinator was charged with handling off site communications, as her office phone was the only working unit on the property. She also then handled supply and logistics in anticipation of needing absolute control over organizing, locating, accepting and handling the timing of incoming recovery resources. Horticulturists began a "triage" operation of prioritizing and evaluating plants to be completely removed, removed but saved for research, uprighted or passed over until a later time. A simple coded color tagging system relayed the plant's fate. Curators acted as field marshals to ensure plants were appropriately tagged for salvage or removal. Plant debris would be moved to the lowland periphery of the gardens and laid in piles, to be chipped or composted at a later time (Figure 5.10).

The decision was made early on to establish a horticulture hotline to dispense information and address any questions by local citizens as they assess their own properties. Evening "Hurricane Sessions" were organized and were seminars open to the public to have experts discuss the implications and concerns associated with plant recovery. In addition, one planting section of the garden was earmarked to not be touched in the clean up, so that the natural processes of recovery could be watched and recorded and eventually interpreted to the public.

Publicity of the devastation was handled through a reporter from the *Miami Herald*, who lived in close proximity to FTG and had an established and favorable rapport with the institution. Additional contact was made by the director to national and international newspapers and magazines informing of the storm damage and requesting various research, plant, equipment and financial assistance. A media production company was contacted to produce a video documenting the recovery efforts at the gardens.

Incoming plant experts and researchers and specialized equipment operators were housed in one of the buildings on the property during their stays. Staff coordinated with local papers and radio stations the request for volunteer labor (Figure 5.11). Volunteers were assigned and directed to tasks that suited both the individual's desires and talents and the recovery priorities. The volunteers helped in clean up, record keeping, plant evaluation, plant identification, and plant labeling, among other tasks. A serendipitous find was volunteers with experience in food service, so the multitudes of staff, volunteers and visiting experts and labor could be fed and kept hydrated while working in the sun. Volunteers also needed

Figure 5.10 **Vegetative Debris was Hauled and Piled at a Location Within Fairchild Tropical Gardens.** (Photograph courtesy Fairchild Tropical Garden.)

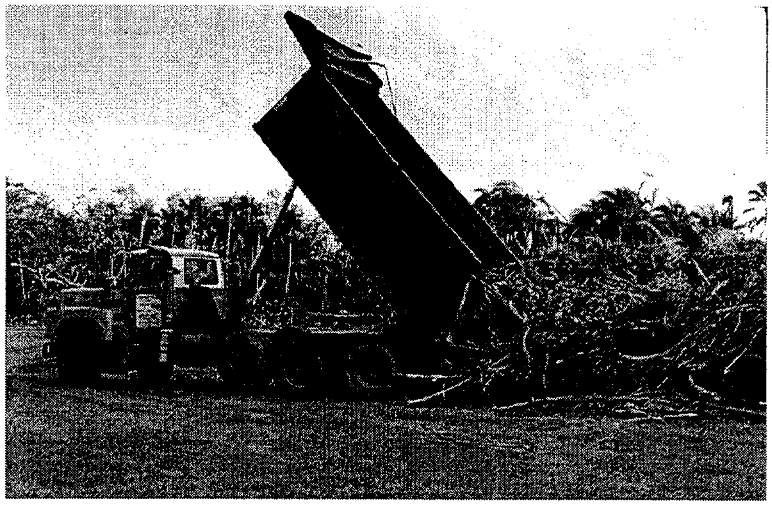


Figure 5.11 **Research, Education and Volunteerism were Prevalent During Fairchild's Recovery Efforts.** (Photograph courtesy Fairchild Tropical Garden.)

to be advised in advance of the need for hats, water, tools and gloves to help out in the recovery.

Recovery operations were underway seven days a week during every bit of daylight, as a curfew was imposed across the area daily from 7 p.m. to 7 a.m. Staff were wholeheartedly present on site for six to seven days a week during the initial clean-up and recovery efforts. Time was needed to downscale or stop the recovery operations in the late afternoon, conduct the staff meeting, determine the next day's priorities and plans of attack, and to dismiss local staff and volunteers in time for them to reach their homes before the curfew began.

Thanks to contacts made and random offerings by staff, garden members, and local citizens, off site resources were being located and brought to the site. Word of mouth and media coverage and advertisements across the nation led to resource location, too. One such resource was the gathering of wood collectors, who had an interest in the wood of several rare tropical trees. Evaluation and identification of trees and their cut logs was another project happening at Fairchild. This eventually led to the planning of a wood auction, which would help raise some funding for the recovery.

As staff and volunteers were sent to areas, verbal communications during and outside the daily staff meetings let the public relations station, with the telephone, disseminate the needs for equipment and other resources. The public relations station also could turn down and redirect donations and assistances not needed by FTG to other organizations in the community.

Calls made by staff and board members to their personal contacts, in Florida and across the country, had been fruitful and resulted in advisement on plant care, locating emergency grants, and acquiring specialized heavy equipment and supplies. Monetary grants were secured from the Fish and Wildlife Serve, the National Endowment for the Humanities, the MacArthur Foundation and the National Science Foundation.

As time permitted, a partnership with the Dade County Parks Department saw occasional county workers assisting FTG efforts; most notable was the use of a county water truck to hydrate surviving nursery plants and rootballs of salvaged plants at the gardens proper and at the Montgomery Center. The gardens also received an appropriation through the state legislature from a special state tax-supported trust fund created for the restoration of the region.

South Florida became a Presidentially declared disaster area and the Federal Emergency Management Agency (FEMA) and its resources were available to individuals, families, and businesses alike. As Fairchild soon learned the extent of their insurance coverage was not as extensive and encompassing as hoped, FEMA assistance proved to be an asset. FEMA guidelines, in 1992, were that trees were reimbursable at $100 each; FEMA funds could then only be used for debris removal and reconstruction of damaged structures. Fairchild was being classified as a "park," with no consideration for the research and conservation value of the plant collection. Under such a designation, FEMA would provide $100 replacement cost per tree, $150 per palm tree. Petitions were made to FEMA to prove that the gardens were a cultural institution with educational value. Fairchild was successful in proving this claim to FEMA officials, thanks in part to the testimony of the local and international community on personal and professional levels. Eventually, FEMA monies were used for the acquisition of replacement trees above the regular guidelines, which included the staff time and transportation costs associated with travel to tropical environments worldwide to collect specimens. An additional growing nursery was paid for and constructed off site and was used to nurture replacement seedling plants until they could finally be relocated permanently in the gardens.

Over the course of a year, and several meetings, FEMA also financed to rebuild damaged structures and identify mitigation projects at Fairchild. Repairs and rebuilding of greenhouses and shadehouses, tree replacement, stonework, hurricane shutter installation, irrigation replacement and other capitalized repairs totaled just under $2 million. Tree replacement in itself was approximately $900,000. The capitalized total of $2 million does not cover all hurricane related expenses, as Fairchild's internal bookkeeping procedures removed labor and travel expenses from this tally.

Eight years after Hurricane Andrew, Fairchild is fully recovered, although keen eyes can still see the effects of the storm on certain plants on the property. Nevertheless, a symbolic event designating a point of full recovery of Fairchild Tropical Gardens occurred in 1996 with the installation of the rare plant conservatory roof. The building has since begun a new era at the gardens housing the "Windows to the Tropics" exhibit.

The Hermitage

The Hermitage, the 700 acre historic property of the seventh President of the United States, Andrew Jackson, is situated twelve miles to the northeast of Nashville, Tennessee in Davidson County. An additional 400 acres of state owned land provides natural view sheds and buffers to the suburban growth areas immediately outside the Hermitage. Once an active plantation in the mid 19th century, the Hermitage today is open to the public to interpret the life of Andrew Jackson as well as to preserve and conserve the property's buildings and grounds and to perform scholarly research on Jackson, his family, farm workers and slaves. The Hermitage is governed by The Ladies Hermitage Association, a non-profit organization, with an annual operating budget of nearly $3 million. Ninety percent of the budget is supported by admission and museum store sales.

The Hermitage is a National Historic Landmark site. It is comprised of Jackson's restored mansion (The Hermitage), the Tulip Grove Mansion, Old Hermitage Church and Confederate Veteran's Cemetery, the original 1804 plantation cabins and outbuildings, an original slave cabin, garden, and Jackson's tomb and family cemetery. A visitor amenities center, administrative and curatorial offices, and operational storage and maintenance buildings are also located on the site.

The signature architectural features of the Hermitage property include the Greek Revival Hermitage (Figure 5.12) and Tulip Grove mansions, the Jackson Tomb (Figure 5.13) and the Hermitage Church and cemetery. The Hermitage mansion had just completed a $2.5 million restoration by 1998. Landscape features include a unique serpentine entrance drive lined with large cedars (planted by Jackson himself in 1838), and a one-acre garden designed by William Frost in 1819 still containing early 19th century heirloom shrubs and perennials as

Figure 5.12 **The Hermitage Mansion, with Allée of Cedar Tree Planted by Andrew Jackson in 1838.** (Photograph courtesy Ladies Hermitage Association.)

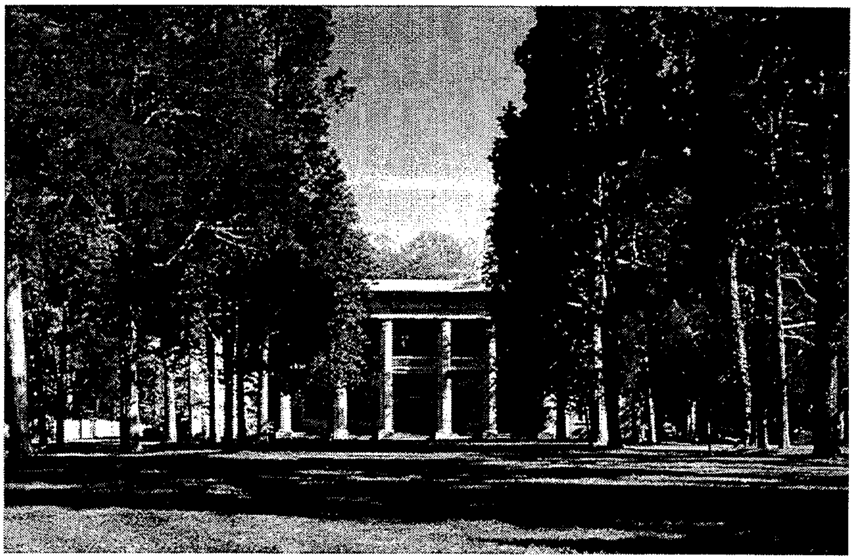


Figure 5.13 **The Jackson Tomb Cast in Shade from a Large Magnolia Tree.** (Photograph courtesy Ladies Hermitage Association.)

well as the Andrew and Rachel Jackson Greek Revival tomb monument. Woodlands and numerous sizable specimen trees dot the property, including several stately magnolias around the Jackson tomb and some state champion trees.

Tornado

On Thursday, April 16, 1998 severe thunderstorm cells developed and moved across western and central Tennessee. A series of tornadoes were spawned from these thunderstorms, including an F3 twister that struck downtown Nashville and two others (F4 and F5) in nearby counties. At approximately 3:45 pm, during business and visitation hours at the Hermitage, the F3 tornado raced across the property in a west to east swath. Staff and visitors alike were guided by an emergency plan and were secured in safe shelters across the property.

The tornado encountered by The Hermitage was borne mid-afternoon on the 16th and had a path length of nearly 15 miles and was over 1300 yards wide (Storm Data 1998). Estimates were that this tornado had winds in the proximity of 150 m.p.h., perhaps at times as high as 200 m.p.h. It is suspected that this was the same tornado (or a daughter tornado from the same cell) that had minutes before affected downtown Nashville and the suburb of East Nashville. Because of the tornado's history, The Hermitage had about fifteen minutes of preparation and warning.

In an uncanny comparison, the April 16 tornadoes in Nashville followed a path of destruction nearly identical to that of a string of tornadoes in 1923. The Hermitage then, as in 1998, was hit by a tornado and sustained losses to its landscape (Figures 5.14 and 5.15).

Figure 5.14 **Board Members of the Ladies Hermitage Association Pose with a Fallen Tree from the 1923 Tornado.** (Photo Courtesy Ladies Hermitage Association.)

Figure 5.15 **Board Members of the Ladies Hermitage Association Pose with a Fallen Tree from the 1998 Tornado.** (Photo Courtesy Ladies Hermitage Association.)

Impacts on The Hermitage

Direct Impacts

Over 2,000 trees were lost from the storm. The larger, older, and thus, more historic trees were easily toppled or were severely damaged with tears and dropped limbs. Most notable of landscape impacts was the loss of eighty-eight cedars in the guitar-shaped entrance allée (Figure 5.16), a magnolia at the tomb (Figure 5.17), and several 100+ foot tulip poplars near the Tulip Grove mansion. Both the cedars and magnolia were planted by Andrew Jackson in the 1830s. Across the property woodland tree stands and various non-historic specimen trees were toppled or harmed; many of the smaller trees were not harmed by the tornado.

Uprooted trees in the core historic area of the property exposed the root zone soil profiles to wind and water. Since the Hermitage was a working farm in the 1800s, it was possible that artifacts were unearthed amongst and around the tree roots. If care was not taken to investigate and document each root zone, historical insight and artifacts may be forgotten, lost or destroyed.

Although the tornado's path did not include direct hits on any structure, several building damages were incurred. Most damage sustained involved roofs. Windows were not blown out or cracked in general, but some glass pane cracking was evident in brick buildings. A fallen tree crushed one gable at the Old Hermitage Church (Figure 5.18), and another tree destroyed the smokehouse roof. The Hermitage mansion lost a chimney, gutters and a crack was found in the parapet wall. The Tulip Grove house also lost chimneys and sustained cornice damage. A slave cabin lost shingles and decking; the wood and wrought iron fences were crushed by fallen trees and limbs. Two grave monuments were toppled in the Jackson

Figure 5.16 **Tornadic Winds Snapped Trees Like Toothpicks in The Hermitage's Historic Cedar Allée.** (Photo Courtesy Ladies Hermitage Association.)

Figure 5.17 **The Jackson Tomb Monument Stands Exposed to the Sun After the Tornado.** (Photograph by author.)

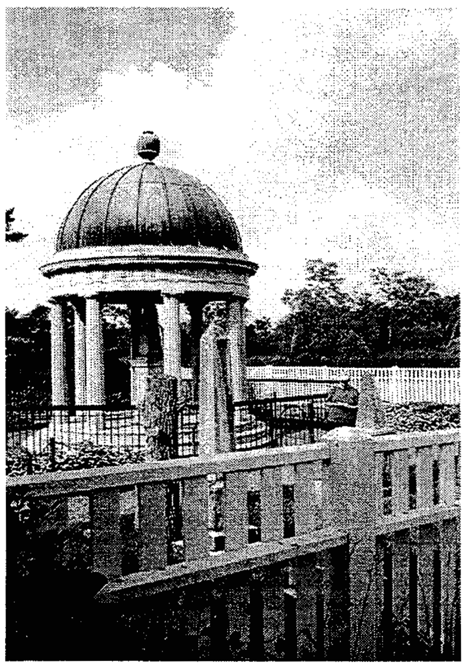


Figure 5.18 **The Old Hermitage Church Sustained Damage as the Result of a Wind-Toppled Tree.** (Photograph Courtesy Ladies Hermitage Association.)

family cemetery, but an additional fifty to one hundred monuments were fallen or broken in the Confederate Veteran's cemetery. The visitor center, administrative, and operational buildings were not harmed.

Indirect Impacts

Several hundred visitors, including two school groups, were at the Hermitage when the tornado struck. The advanced warning of the approach of the storm permitted the gathering of visitors and staff into shelters across the property. As a result, no one was hurt; however, the downing of trees across the property did halt vehicular access to and from the property.

The Hermitage was not the only property in the area hit by the tornadoes. The business areas of downtown Nashville and residential East Nashville secured emergency response resources and media coverage very quickly. Telephone lines were out, as was electricity for a week. Loss of electricity affected HVAC and other environmental controls needed for preservation of the interior collections in the mansions. Although the road was cleared within a few hours of the tornado to facilitate emergency and fire vehicles to the Hermitage, there were far too many unsafe areas. The Hermitage closed to the public for one month, losing admission, restaurant and gift shop receipts, equating to a loss of over $200,000 in earned revenues, which was recovered through business interruption insurance.

Clean up and recovery issues were now the foremost responsibility, but the usual duties of preventative maintenance and operations could not be abandoned. As the following months were quite rainy, the use of heavy machinery and equipment on the historic site would have been particularly damaging to soil profiles around archaeological sites and surrounding trees. Thus, much of the archaeological work around tipped trees involved hand work.

Employees were forced to deal with added stresses. Some staff sustained damage to their own homes from the storm. Feelings of devastation were internalized by staff as visual inspection of their work areas revealed loss of historic and landscape fabric and required a significant amount of time and labor to amend. This 'burn out' of staff led to the cancellation of several public relation events usually held at The Hermitage. Some staff left their positions after the clean up and initial recovery efforts from the tornado.

Horticultural losses and disruptions continued months after the tornado. Damaged trees, especially the tulip poplars and maples, continued to shed limbs as a result of internal fractures and/or subsequent diseases. The loss of canopy resulted in sunscalding of undergrowth plants in the gardens. Perennials looked tired or sickly and went dormant early, plant diseases such as anthracnose were more prevalent. Increased sunlight led to more rapid growth of the turfgrass. More staffhours were required for lawnmowing. Pits left by removed tree stumps, although filled with soil, were uneven and required care in navigating with the mowers.

When the Hermitage re-opened, the visitor experience was altered. Pedestrian access to the mansion and other attractions was altered. Although the media provided coverage on the Hermitage damage and an on-site interpretive exhibit shared information on the tornado, some visitors were unaware of the situation that caused the landscape maintenance lapses and the less-than-postcard vistas and approaches. Aesthetically, the property was heavily wounded. Shaded lawns were gone, the signature cedar allée diminished (Figures 5.19, 5.20, 5.21), the gardens very open and naked, and the loss of trees on the periphery now revealed views to nearby highways and strip malls (Figure 5.22).

Response and Recovery

A disaster plan, which followed American Association of Museum and other professional guidelines, was already extant and tested at The Hermitage prior to 1998. The document included policies and procedures for a chain of command, emergency job descriptions and responsibilities, communication tree and location of supplies. This plan guided staff in safety procedures regarding the movement of all staff and visitors into appropriate shelters as the tornado approached. It also proved to expedite immediate response after the tornado and start key procedures in the recovery process.

Within minutes of the passing of the tornado, staff immediately began their specific emergency duties. The curatorial and building departments first acted to protect any damaged buildings from further wind and water damage, and to provide a quick verbal

Figure 5.19 **Before Shot of the Gate Entrance to the Historic Guitar-shaped Drive Leading to The Hermitage Mansion.** (Photograph courtesy Ladies Hermitage Association.)

Figure 5.20 **Post-Tornado Shot of the Same Gate Entrance in Figure 5.19.** (Photograph courtesy Ladies Hermitage Association.)

Figure 5.21 **The Loss of Eighty-eight Cedar Trees Drastically Changed the Landscape Aesthetic and Integrity of the Historic Guitar-shaped Entrance Drive.** (Photograph by author.)

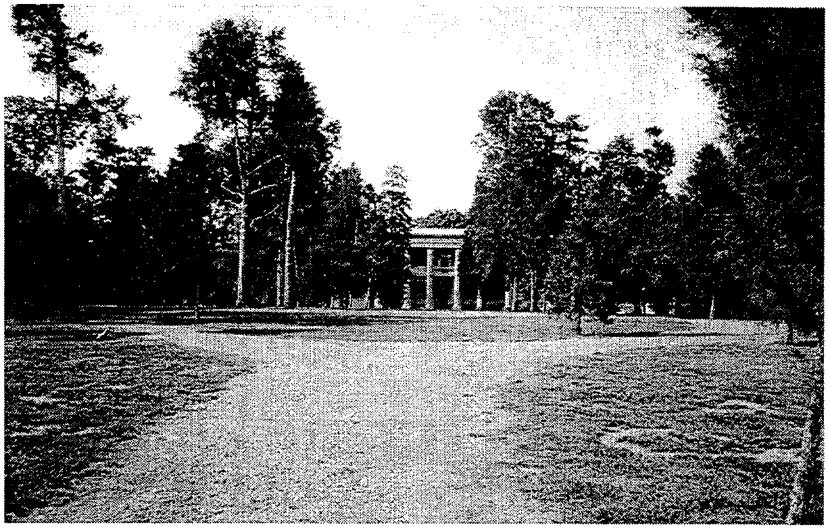
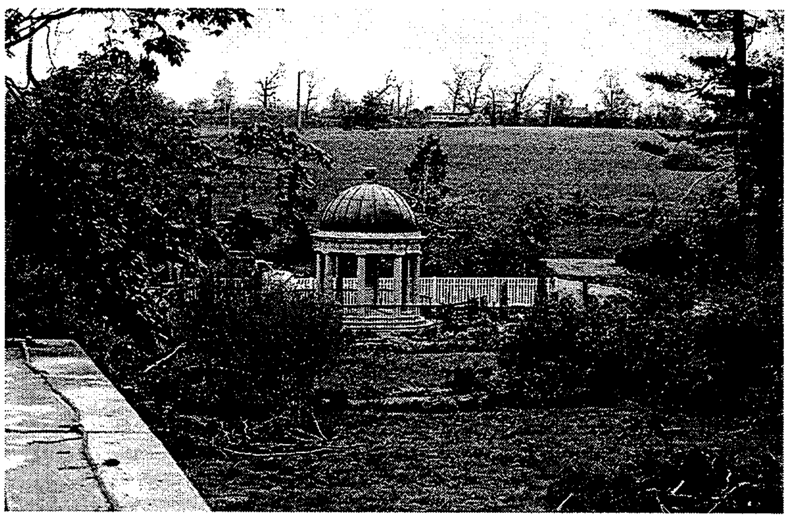


Figure 5.22 **Loss of Trees Across the Property Opened Up Once Woodland and Pastoral Viewsheds and Exposed Surrounding Suburban Sprawl and Highway Traffic.** (Photograph courtesy Ladies Hermitage Association.)



assessment report. Security and grounds crews concentrated efforts on clearing the exit roads and vital internal access routes so that visitors could leave the property and public emergency vehicles could reach core areas of The Hermitage. Visitor Services dealt directly with the concerns and needs of the on-site visitors while telephone and electric service was out. The first few hours after the tornado saw staff executing their appropriate emergency tasks without one central staff meeting.

The decision was made in the next few days to establish a priority to the preservation of historical and archaeological elements on the property over issues of recovery costs and duration. This guiding principle was one that other historic sites that had been affected by natural disasters had recommended to The Hermitage when staff contacted professionals in the aftermath of the tornado. Contact made with other sites with disaster experience was valuable, as it provided The Hermitage with information and advise on a variety of recovery issues. These disaster mentors, if you will, shared insight on how to organize staff, how to work with recovery agencies, and to anticipate issues that The Hermitage may encounter during the clean up and recovery. Mentors also steered The Hermitage toward various service providers that would best meet the needs of a historic estate and grounds. Some of these mentoring sites provided experts and workers to assist in evaluating damage to the landscape materials and help with clean up.

With the preservation priority firmly established, and duties outlined in the disaster plan, staff began to pursue recovery issues. Individuals were given responsibilities that needed to be addressed on top of their usual daily operational tasks. Written descriptions as well as photo and video documentation of the losses to structures and plants were made. A more thorough investigation of damages occurred at this time, so that clean up efforts could be guided by horticulture or preservation caveats on recovery procedures. A staff member was designated as liaison in anticipation of dealing with the insurance company, the government and FEMA, building contractors, and landscape contractors. Once staff evaluated the property and had assessed the safety of the damaged areas, volunteers were accepted and contributed to the clean up activities.

Within the first weeks of the disaster, The Hermitage quickly created a financial recovery plan, and modified it accordingly as the recovery period progressed. The recovery plan already had a sound starting basis, as The Hermitage had a sizable operating reserve fund and a comprehensive insurance package. Insurance coverage included a property and casualty policy as well as one for business interruption. A positive relationship with the local and national insurance companies proved very beneficial in first developing a disaster plan and ultimately in communicating losses and understanding the full extend of policy coverages. With all parties familiar with the specific needs of The Hermitage's recovery, claims and payments were completed within a reasonable timeframe.

Davidson County was declared a disaster area by the President, and within days of the tornado, the executive and finance directors of The Hermitage were conversing with FEMA and Tennessee Emergency Management Agency (TEMA) officers. As FEMA funds would only cover non-insurable losses, dialog acted to determine the extent of funding and other assistance The Hermitage could utilize. One notable regulation of FEMA that affected the recovery at The Hermitage was the restriction on use of FEMA contracted services on materials destined for sale or improvement. Thus, any tree earmarked for sale as lumber could not be benefited through the use of FEMA sponsored and financed equipment. Realizing this stipulation, however, The Hermitage still utilized the monies to negotiate a contract with a preferred contractor. This facilitated the continued removal of plant debris to a dumping area on the property, and other debris to landfills or other appropriate sites.

The Hermitage also worked to establish several partnerships with private and public organizations during the recovery. To begin, the National Park Service was contracted to create a computerized database of the landscape. Through this global positioning system (GPS) database, all lost and surviving trees were inventoried as to location and size. The Tennessee Department of Forestry provided an identification process for downed trees that may have lumbering potential. Through their advice, logs were registered with the SmartWood Program, an international organization which certifies lumber is ethically harvested. This registration also would permit The Hermitage to track the wood from its sale to the creation of wood products. The Gibson Guitar Company used the wood from fallen hickory and tulip poplars to create a limited line of collector guitars, with proceeds from the sales to go back to The Hermitage. Local woodcrafters who also used the wood had made similar arrangements regarding the sale of items in the museum store.

The unfortunate situation arising from the tornado was also seen as an opportunity to strengthen and improve the Hermitage. Through strategic thinking and foresight, extra time and funds could be secured for additional repairs and improvements to buildings and equipment during the recovery. The landscape could be better restored to the Andrew Jackson era with reconstructed designs and replaced plantings.

Included in the recovery plan being created as the recovery effort unfolded was the evolution of a public relations, marketing and development plan. With the surrounding community also being affected by the same storm, The Hermitage did not want to start a public appeal when individuals and families were also facing damages and losses. Thus, the membership was called upon and informed of the situation and need for help. Secondly, The Hermitage needed to communicate to the world that the site was temporarily closed, had sustained minor damage and would soon reopen. Staff also anticipated that tourism to the site would be down regardless, so they prepared for a 10% drop in the operating budget and geared marketing strategies to help compensate for the loss. National press releases were drafted and used and a proactive approach to informing and handling the local media was formed. In addition, the re-opening of the site was promoted through a series of national media events, including using Tennessee's country music star role call and Vice-President Gore. The release of the newly designed $20 bill also created an opportunity to promote the survival and vitality of The Hermitage after the tornado. The extensive marketing campaign helped diminish the anticipated attendance decline, as visitor numbers and site revenue were higher than expected immediately following reopening.

The Hermitage recognized that the tornado is part of its historical legacy and continuum. With a tornado hitting the site in 1923, and again in 1998, interpretive materials were collected and presented. An exhibit, complete with historical and recent photographs and commentary on the 1998 tornado was centrally displayed in the visitor center. A softcover photo and commentary book on the site's tornado experience was also printed and sold in the museum shop.

Three years after the tornado, The Hermitage's building restorations have been completed and business operations have recovered. The landscape and gardens, however, have not, as replacement plantings are just being scheduled or commenced. Over $2 million has been used in the response and recovery at The Hermitage, yet both years found the site operating within its budget. Unfortunately, some trees remain on the decline from the injuries sustained from the winds and airborne debris. The landscape is drastically changed, and will take years to reach the same aesthetic quality as that before the tornado.

Linnaeus Arboretum

The Linnaeus Arboretum (LA) is part of the campus of Gustavus Adolphus College (Gustavus) in Saint Peter, Minnesota. Located in Nicollet County in the south-central part of the state, sixty miles southwest of Minneapolis-Saint Paul, the college is the home to 2400 liberal arts students. The campus is situated on the western hills atop the Minnesota River Valley, and the adjacent historical city of Saint Peter, with a population of 10,000, rests in the valley. The college dates to 1862 and is affiliated with the Evangelical Lutheran Church of America. It is part of a consortium of small private colleges in the Upper Midwest and has nearly 20,000 living alumni.

The LA exists at Gustavus to "provide and enriching environment to educate the mind, revive the spirit and delight in Minnesota's natural history and Swedish heritage." Begun in 1973 through the efforts of Dr. Charles Mason, a Gustavus biology professor, LA is fifty-five acres comprised of formal gardens and three natural ecosystems: northern coniferous forest, deciduous forest, and prairie. Two structures are part of the arboretum, the Melva Lind Interpretive Center, which hosts both arboretum and college events, and an authentic 1860s Swedish log cabin and pioneer garden (Figure 5.23).

Although not officially designated part of the LA, the landscaping of the greater Gustavus campus is locally considered "arboretum" with its hundreds of specimen trees, seasonal planting beds, numerous outdoor bronze sculptures created by an in-residence sculptor and picturesque vistas into the valley and St. Peter (Figure 5.24). The campus is made up of fifty-nine educational, operational and administrative buildings, including the regional landmark, Christ Chapel. Gustavus is governed as a private, non-profit university establishment with an operating annual budget of $60 million. LA is governed under this

Figure 5.23 **The Authentic 1860s Björnsen Swedish Cabin is One of the Core Landmark Structures Within the Linnaeus Arboretum.** (Photograph by author.)

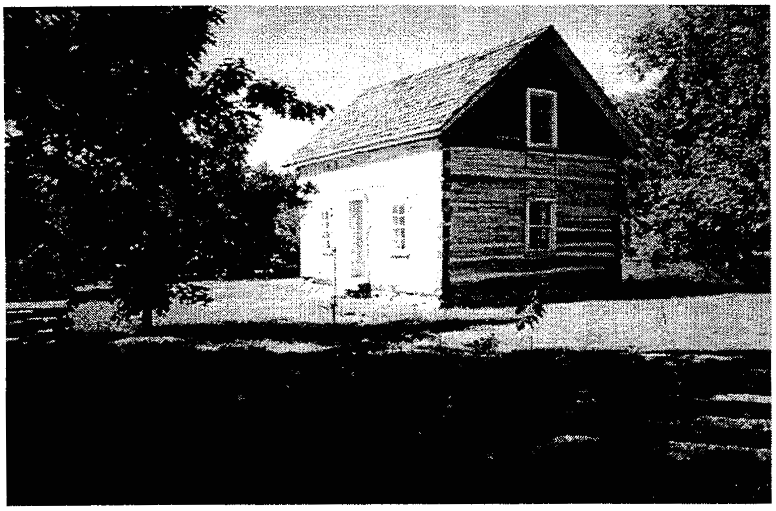
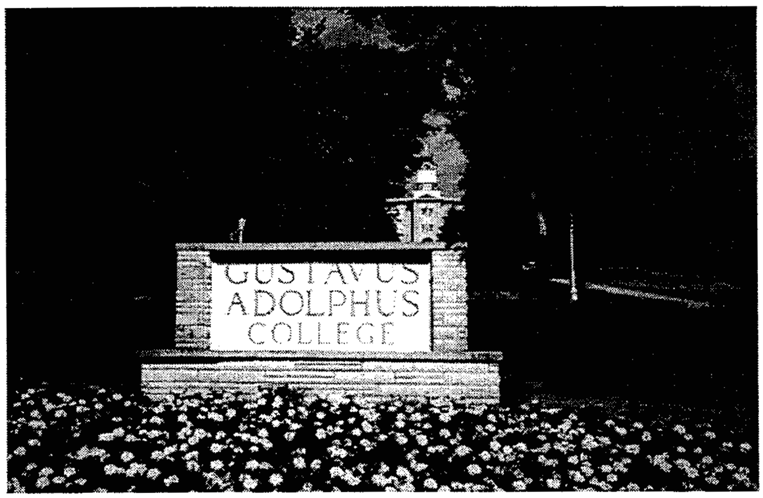


Figure 5.24 **The Campus of Gustavus Adolphus College is Recognized for its Shaded Walks and Vistas and Landscaped Grounds and Arboretum.** (Photograph by author.)



non-profit, education institutional umbrella and is apportioned a $250,000 budget. For this case site, the overall campus was included along with LA in the discussion of the natural disaster because of the joint governing authority.

Tornado

Just days after the beginning of spring semester break at Gustavus, on Sunday, March 29, 1998, severe thunderstorms wreaked havoc across southern Minnesota. In an area not known for early spring tornadoes, a series of small tornadoes began advancing across the southern tier of counties in the mid-afternoon. As the thunderstorm line strengthened, an F3 tornado was formed and touched down some sixty-seven miles from St. Peter. This tornado, or series of subsequent tornadoes, traveled at an estimated speed of sixty m.p.h. and created a path 2200 yards wide. By 5 p.m. this tornado had just devastated a small village center and continued on a trek towards St. Peter; just prior to hitting Gustavus, the tornado attained an F4 rating and maintained a path width of a mile and a half (Storm Data 1998).

Because of the consistent visual tracking and radar projection of the tornadoes, St. Peter received upwards of a half hour warning of the approaching twister. The campus was virtually vacant as it was a weekend and only a handful of students remained in the dormitories during the semester break. At approximately 5:30 p.m. the tornado, actually a family of five to seven tornadoes under the masquerade of one debris cloud, crossed the center of the Linnaeus Arboretum and the campus of Gustavus Adolphus College. The tornadoes continued down into the valley and invaded the city of St. Peter. Estimates placed the strength of the tornado at the cusp of F3 to F4.

Impacts on LA and Gustavus

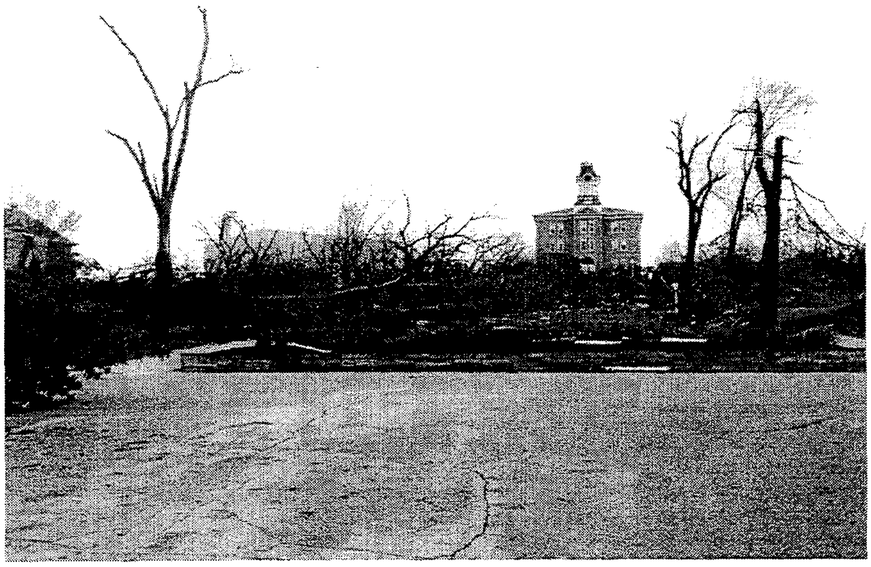
Direct Impacts

The tornadoes brought with them winds upwards of 200 m.p.h. as well as airborne debris. All fifty-nine buildings on the campus were affected to varying degrees: eight major buildings sustained significant structural damage and seven major campus buildings were unusable for five months during repairs. One apartment complex, eight college-owned homes and one residence hall were destroyed. Eighty percent of all windows on campus were broken. Roof damage was widespread, and 85% of all roofs required replacement. HVAC equipment located on rooftops was severely damaged or lost. The only building on the campus on the National Register of Historic Buildings sustained roof damage and its clock tower was operationally disrupted. The one hundred fifty foot chapel shire, a symbol landmark of the campus and city, was twisted over. Ninety percent of all campus trees (numbering approximately two thousand) were lost (Figure 5.25).

Within LA, ninety percent of all trees within the formal gardens were lost, compared to only ten percent of the trees in the natural ecosystem plantings. The Interpretive Center roof was lifted and interior furniture cast airborne. The historic Swedish cabin was obliterated. The roof of the outdoor pavilion and the arbor were flattened. Plant labels were ripped from the ground or trees and lost, nearby parked cars were lifted and replaced within the arboretum.

As the winter frosts had already left the ground, a great number of evergreen trees toppled over in the winds. Deciduous trees had not yet sprouted their leaves. Most deciduous large trees nonetheless were twisted and toppled, although it varied across the campus. Tree trunks were snapped off, entire trees uprooted with many broken and thrown

Figure 5.25 Over 2,000 Trees Across the Campus and Arboretum Were Destroyed and All Campus Buildings Were Affected to Varying Degrees. (Photograph courtesy Gustavus Adolphus College.)



limbs scattered across the site. Those trees still standing were noticeably left leaning from the winds and many had wind driven debris wedged into the bark and covering the branches. Other small trees and shrubs, although not commonly toppled, were filled with debris and sustained massive branch and twig tears and breaks. Lawns and sports turf across the campus were inundated with glass shards and other small building debris fragments.

Debris of all kinds littered the streets and walkways of the campus as well as the surrounding community. In total, over six hundred tons of debris was collected from the campus and carried to the landfill. This tonnage did not include items restricted from landfills, such as plant material and recyclables, although such items inevitably were sometimes included during a large scale clean up event.

Indirect Impacts

With damage to roofs and windows blown out, leaking rainwater and wind threatened to further harm or remove interior objects. The library was most susceptible structure exposed to this threat. Depending on building and academic department, various artwork, supplies, equipment or paper records were damaged, destroyed, or lost in the wind. The loss of electricity disrupted daily operations and clean up activities. Because telephone wires were located underground, phone service was not lost. Emergency generators allowed the use of the telephone system, the large number of incoming calls seeking information and offering help jammed lines. Other means of communications also were not readily usable: computer systems were down, voice mail unavailable; office relocations and busy workloads reduced opportunities for person-to-person contact.

Other utilities, however, such as gas and electricity were out. Loss of HVAC in certain buildings—the weather after the tornadoes turned drastically colder with snow flurries—impeded visual damage assessments and scheduling of clean-up crews. The campus was not safe and needed intense repairs. The campus closed and suspended all classes and regularly scheduled activities for three weeks.

The influx of various contractors and volunteers in the attempt to clean up and help the campus reopen unfortunately led to some further losses, most notably to the landscape. Soil compaction occurred from heavy machinery use and the storage of building and construction materials on the ground. Sidewalks buckled under the weight of the machines. Inadvertent breakage of plants resulted from the heavy machinery bulk and movements; lack of supervision led to varying degrees of evaluation on the health and salvage-potential for plants across the expanse of the campus. The removal of damaged sidewalks potentially affected surviving tree's root systems. Buildings, equipment and supplies may have been sacrificed as well with many tasks being assessed differently by individuals and groups of varying expertise helping in the clean up.

The tornadoes' destruction across the greater community led to further impacts. State and local authorities restricted access to the town and campus. Several employees lost or sustained damage to their homes. Huge sections of the town also called for some of the same clean up and recovery resources needed by Gustavus. Although the campus was well insured, individual citizens were not finding their insurance experiences working out as well. It became a demoralizing time for many persons affected by tornado damage across the area. Interaction and dialog between the town of St. Peter and the campus sought cooperation and expedition of response and recovery. In addition, campus staff would have an additional workload trying to deal with recovery while also resuming their usual work duties in order to complete the current academic year.

Since the college was in the academic year, students would need to be informed and the education operations assessed and continued, if possible. There was a strong need to reopen the campus and maintain the educational integrity of the college. There was concern Gustavus would potentially experience a drop in enrollment and relating incomes needed for campus operations. The three week closure of the campus equated to a cumulative tuition loss, as termed 'refund to enrolled students', at nearly $7 million and was covered by insurance.

The public needed to realize that the campus was harmed but not destroyed. Strategies were needed to retain current students and attract new students in order to continue the college's educational endeavors.

The uprighting and cabling of trees across the campus utilized time and resources, as the summer progressed, many of these trees did not survive the stress. More trees were lost as time passed. Wounds from flying debris made plants more susceptible to various diseases and stresses. Because lawns were filled with shrapnel, intense raking or complete sod replacing was needed. Increased watering was needed to nurture the weakened plantings previously affected from the tornadoes. Some plantings were not aesthetically pleasing during the initial growing season after the storm; flowers were not abundant, tree canopies lop-sided, the campus landscape barren. The viewsheds to and from the campus into the valley and St. Peter were drastically changed: buildings once masked in trees were now exposed.

A 100 m.p.h. windstorm the following summer took more landscape casualties. Many of the cabled and uprighted trees could not handle an additional physical strain and were toppled. Widespread and numerous replanting efforts continued through the summer and into the fall. The stresses associated with transplanting may render some trees and shrubs less healthy as they enter the winter months without first establishing. The need for the campus to have a beautiful landscape to recruit and retain students demanded replanting even though the timing of planting or the selection of plants was not optimal.

Response and Recovery

There was no loss of life to students or staff on the Gustavus campus, likely attributable to the forewarning of the approach of the tornadoes and the timing of the disaster on a weekend during Spring Break. Within minutes of the passing of the tornado, people emerged from their shelters in both the city of St. Peter and on campus and began instinctually searching for human injury and promoting safety. Visual assessments of losses were made as well. The State Highway Patrol and the National Guard were present following the storm, and access into the city was restricted. Gustavus employees traveling into St. Peter were approved for access as they entered the city to get to campus to report for work.

The tornado struck less than one hour before the fall of darkness on a Sunday night; the first night was spent immobilizing equipment, developing some basic strategies for recovery and making initial contacts with authorities and insurance and service providers. A news conference was held the first day after the storm. The media, from local radio and newspapers to regional and national television stations, picked up the story of the disaster. However, the media initially solicited commentary from a wide variety of people, and was free to interpret and use such commentary as fact or fiction. Many interviewees were not necessarily qualified to provide concrete information, but certainly could provide much emotional commentary.

Gustavus was already in a good position leading into disaster recovery, as it already had an emergency manual and response plan that would guide the initial activities. The college had fostered sound professional ties to businesses in the region and in the state, most notably with insurance providers, contractors and sister colleges. Moreover, each department within the college was well aware of the special needs and services required for clean up and recovery in their areas. Individual employees had also a keen sense of locating local and regional suppliers and service providers that would be able to assist in the recovery. Several college staff had varying levels of training in crisis situations and communications and/or had conducted research on crisis planning.

Despite the adversity facing the campus, the theme for the recovery effort was "Building a Greater Gustavus." With a goal to expedite the return of students to a safe campus and resume the educational mission, the campus did officially close, however, for twenty-one days to fully concentrate on recovery. Since electricity and windows across the campus were lost, emergency generators were used for supporting operations in two recovery stations. College Relations, Telecommunications and Admissions relocated into one area; Safety and Security, Physical Plant and Student Affairs worked out of another site

Gustavus' relationship and rapport with a regional insurance provider assisted in the recovery. The college held several policies which broadened the scope of coverage, including property/casualty, business interruption, and automobile insurance, for example. The insurance company, well aware of the operational needs and mission of the campus, understood the extent of policy coverages and the building and landscape components of the Gustavus campus. The insurance company immediately contracted a disaster recovery service on behalf of the college to provide expertise, specialized equipment and guidance. The college's preferred and reputable contractor worked with the disaster recovery service and the college administrators and planners. Contractors that had previously dealt with the college or were referred were utilized as well. College physical plant staff focused their efforts on buildings on the campus periphery or those not first addressed by the disaster recovery organization and contractors. Appropriate college finance officers consistently communicated with the insurers through all aspects of the claim adjustments. With no official photographer for the campus, photo documentation of damage was fortunately obtained through the borrowed use of personal picture collections from students, staff and St. Peter residents.

The college president, board and other key people were aware that the devastation to the entire community would have an impact on locating and accepting recovery resources.

As Gustavus enjoyed positive relationships with its insurance provider and many contractors, some offers of help could be best used if redirected to the recovery efforts in St. Peter. A joint partnership between city leaders and the campus aimed to collectively assist both entities to recover. The city utilities worked to restore electricity to the campus and assist in the restoration and later upgrade of service. Negotiations with the county landfill resulted in a reduced bulk rate charge for the dumping of debris during recovery. Scrap metal from the damaged buildings was recycled and tree debris was hauled to a city site for chipping and reuse by residents and the campus alike. City church leaders opened their safe, less damaged facilities to others to use as meeting places and information sharing centers. The College thanked community groups and individuals for their offers of help, but urged them to first place their efforts in the city of St. Peter, as the campus recovery was already moving forward. The Red Cross provided food for workers at the campus during the first weeks after the storm.

Campus officials also anticipated that governmental assistance, from FEMA or other bodies, would likely not be appropriate or available for use by a private organization. FEMA officials did visit Gustavus, and were impressed that the college, along with its insurance provider and contractors, had already taken proactive measures to recover. FEMA's involvement, providing funding for the clean up and debris of non-insured property, was significantly diminished at Gustavus. FEMA did provide funding for the replacement of sports turf on the athletic fields, which would not be covered by the campus insurance coverage. FEMA also authorized the immediate acquisition and movement of trailers to Gustavus for primary use of classroom space, although insurance actually paid for the trailers. Monies for the replacement of trees and other landscaping would not be provided by

FEMA. It was planned that a separate collegiate alumni and public campaign would be undertaken to re-landscape the campus.

The creation of a communications plan was central to the recovery and the theme of "Building a Greater Gustavus." Public relations and development staff worked to facilitate the effective communication of the recovery and to solicit and rally financial and other philanthropic help from both the concerned media and public. Creating objectives and identifying the target audience was important. The challenge was to relay information to staff and the public without the use of computers, email, voice mail, offices or a full staff during the most intense aspect of a recovery period.

The communication strategy listed objectives that would support the recovery theme and maximize time and energy. Staff recognized that the audiences to be reached included the general public, 20,000 alumni, current students, parents, employees, prospective students, fellow organizations and agencies, departmental membership groups, and donors. The strategy (Table 5.1) would be implemented in a team approach, calling upon the efforts of several campus offices and using an outside consultant (who happened to be an alumnus), a volunteer versed in newsletter production and information system staff to create and update a web site. Three college officials were designated official media spokespersons, and were the only people disseminating information to ensure the conveyance of a consistent, factual recovery message. In addition to using traditional media, letters and reports were mailed to alumni, a video was produced documenting the damages and process of recovery, and a special internal, on-site newsletter was circulated to campus staff.

As the media was covering the recovery efforts, rather than solely the devastation,

Table 5.1 Communication Objectives of Gustavus Adolphus College Following the March 29, 1998 Tornadoes.

Communication Objectives of Gustavus Adolphus College Following the March 29, 1998 Tornadoes
• To convey the message that the campus was damaged but NOT devastated and that Gustavus would reopen soon; • To convey these messages of recovery and hope to all of the Colleges' constituencies through various communications, including mainstream media outlets; • To accommodate all media requests (national and local, mainstream and specialty) as quickly as possible, despite having a small staff and working without the usual communication tools; • To allow media access to campus while also ensuring their safety and allowing for ongoing cleanup and repair efforts; • To gather information and communicate with various internal and external audience in a expedient manner; • To monitor the information being disseminated and control or combat any misinformation or rumors spread via the media, Internet or work of mouth.

many public events were organized to provide a tangible element to the "Building a Greater Gustavus" theme and spirit. Some events occurring were: tree planting ceremonies, an outdoor worship service, a fundraising party for campus trees, benefit concerts for the city of St. Peter, and Gustavus staff and students participating in clean up projects in the city once the academic year resumed. A sense of community responsibility and caring literally and figuratively advanced the region's recovery from the tornado.

Eager to help, alumni, current and prospective students, neighboring colleges and the general public supplied thousands of man hours of volunteer work during the recovery. On the first weekend after the tornadoes, nearly 2000 volunteers descended on the campus to help with the clean up. As staff and contracted workers already had special projects to supervise and work on, individual and group volunteers were sent to various areas to help clean the landscape of plant debris, glass and insulation fragments. Realizing the surrounding communities desired to help out, some organizing was needed to ensure volunteers would be located in safe areas for their work, had appropriate equipment, and would be fed and watered. Campus staff requesting volunteer help communicated the need for gloves and rakes, sack lunches, and water. In some circumstances, these items were provided through donations, or brought by the volunteers themselves. As the roads into St. Peter were closed off, additional planning and services were required to facilitate the passage of vehicles transporting hundreds of volunteers into the city and then to and from the campus.

Opportunities unfolded that would permit the college to begin construction of planned site improvements because of the clean up and recovery. The loss of some buildings and landscaping provided a unique chance to not only repair buildings, but relocate, construct new ones and re-think the selection and placement of trees and landscaping as the campus and arboretum is replanted. Major damages to the dining service building and some residence halls dictated an accelerated construction schedule for a long-envisioned and planned campus center and new student housing. More energy efficient windows were used in replacements, additional rooms and facilities were built, new walkways installed. Upgrades to campus electricity systems were made. An intensive capital campaign was launched as part of the "Building a Greater Gustavus" efforts.

A special appropriation by the state legislature was made to the college with the understanding that the monies were to fund planning and improvements to the campus. The state government had acknowledged Gustavus's economic impact on the region and wanted to guarantee the future viability of the organization. As the campus recovered and expanded simultaneously, addition employment opportunities were being created. Through thoughtful planning, strategic fundraising and implementation of new structures and improvements to the campus following the tornado, the Moody's bond business rating for Gustavus Adolphus College improved.

The Linnaeus Arboretum and the greater campus landscaping were reevaluated. Monoculture plantings were avoided, and the arboretum's landscape plan was revised. Again, opportunities for improvements and additions were incorporated into the recovery process. Although the replacement costs for the landscaping across Gustavus was valued at approximately $2 million, insurance provided $75,000 for debris removal. Through symbolic donations from a regional nursery, tree plantings ceremonies occurred as areas of the campus were completed being cleaned and repaired. Donations from a local nursery of mature-sized trees, destined for removal anyway, helped to add variety and depth to the new plantings on the campus. An individual provided funding for the installation of an irrigation system in two areas on campus that would help the campus re-beautification strategies be met.

Money and manpower were being made available to advance the recovery efforts in the Linnaeus Arboretum. Previously acquired funds earmarked for the creation of an arboretum endowment assisted in acquiring other plantings for both the campus and the LA. Additional fundraising was undertaken to collect the estimated $2 million for fresh landscaping. The borrowed expertise and manpower of an arborist crew from the University of Minnesota's Landscape Arboretum helped to evaluate and treat the wounds of damaged trees. A local's referral to a carpenter experienced with historic Swedish cabin building methods and materials permitted the reconstruction of the log cabin. Student workers conducted research, finished inventory and labeling projects, and helped water and care for new replacement trees to help the LA return to and improve over the conditions extant before the tornadoes (Figure 5.26).

Property/casualty insurance covered the costs of repairs to the Interpretive Center roof, windows and replacement of furniture. As part of the "Building a Greater Gustavus" crusade, a wing was added to the center and would become the offices for the Arboretum Director and the Environmental Studies department. Insurance also would cover the costs associated with the reconstruction and labor on the 1860s Swedish Cabin. The cabin location was reconsidered as well. Taking into account the historic context of the structure and the layout of the arboretum, the cabin and its pioneer garden were relocated from the deciduous forest to the naturalized prairie area of the arboretum.

With the new landscape plan, focus, and horticultural vigor for LA, additional projects were set for the arboretum. The creation of a wetlands pond to collect rainwater and reduce the effects of water runoff into the valley, underplantings in the naturalized forest areas, and eventual repair and upgrade to the wood chip paths across the arboretum, are three such projects. Gustavus also acquired additional adjacent land, and will need to be managed as either buffer land or as an extension of the arboretum.

Students returned to the college three weeks after the tornado. Classes resumed, and temporary buildings and as well as cleaned and repaired campus facilities were used for classrooms and student amenity areas. Use of the arboretum as an educational setting for many academic departments at the college continues to grow; new and surviving plantings offer current students the opportunity to conduct research, gain experience with and enjoy

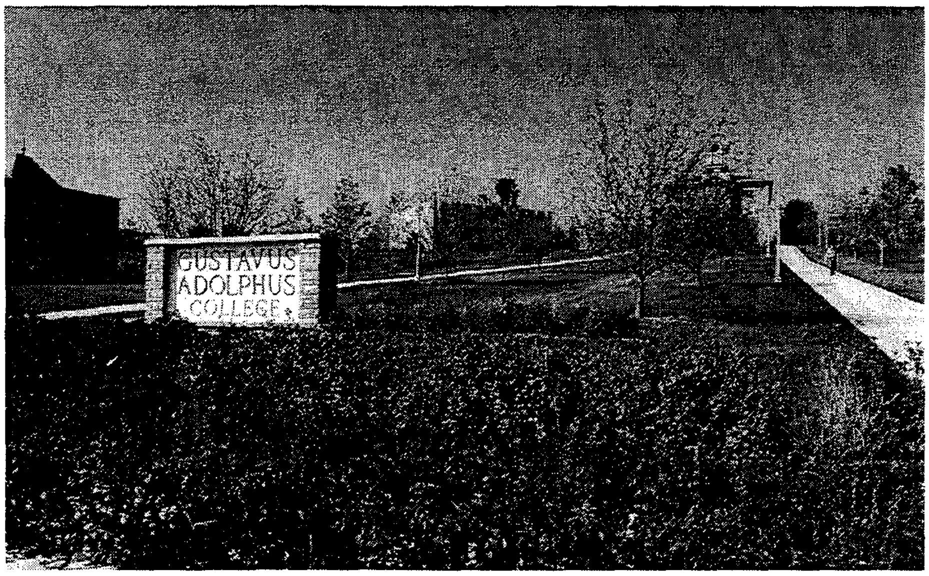


Figure 5.26 The Main Approach to the College was Among the First Areas Replanted to Relay the Reality of Recovery and Accomplishment to the Community (Photograph courtesy Gustavus Adolphus College)

the plant resources found on campus. The senior class completed degree requirements and graduated on schedule that May. The following fall saw the entrance of the largest freshmen class ever enrolled at the college, and upperclass student retention remained in the ninety percentile range. The symbolic completion of the recovery from the March tornadoes was during the following October, as the regional landmark Christ Chapel received the final repairs to its 150 foot spire.

Two years after the tornadoes, planting of trees and improvement and additions to the landscape continues. As funds are secured, additional planting will be phased in, both in the LA and across the campus. Gustavus Adolphus College and its Linnaeus Arboretum have recovered, but the aesthetic and plant diversity qualities of the site will take several more years to reach a point equal to that which existed before the 1998 storm.

Longwood Gardens

Longwood Gardens, Inc., is located twenty five miles to the southwest of Philadelphia, Pennsylvania near Kennett Square, in Chester County. The estate of the late Pierre S. du Pont, Longwood Gardens today is comprised of 1050 acres of formal gardens, fountains, conservatories and greenhouses and managed perimeter lands. The original historic farmhouse, educational and operational buildings and administrative offices, as well as a visitor center, plant nursery and research facility are located within the property. In addition, several houses on the site are used by employees, interns, and students as residences.

The heritage of the site first finds its beginnings with the Peirce family, who developed an arboretum on the land in the late 18th century, with several of the original plantings still extant. The Peirce-du Pont House is a conglomerate of several house additions, first dating to the mid-1700s. A substantial portion of the constructed areas of Longwood is historic, dating to the time of and constructed from specifications made by du Pont in the early 20th century. These fountains, walkways and conservatories are accompanied by a large number of landscape plants and designs that are key components of the du Pont legacy. Longwood is considered one of the world's most outstanding examples of a display and heritage garden. It is a non-profit organization with an annual operating budget of about $30 million, of which nearly half is gained through visitor admission, programming and restaurant receipts, etc.

Winter Storms

Natural events of March 12-15, 1993 and January 1994 proved damaging and disruptive to Longwood Gardens. Each involved freezing precipitation; each event varied in its effect on the structures, plants, and daily operations on the property.

The "Superstorm of 1993" affected the entire eastern seaboard of the United States, and in Pennsylvania, dropped a heavy wet snow in accumulations from ten to thirty-six inches. The moisture content of this snow was documented to be nearly 4:1 (Lott 1993), meaning four inches of snow was equivalent in water and weight as one inch of rain. The standard ratio considered for a 'heavy wet snow' is 10:1. This storm also brought strong winds and bitterly cold temperatures, with recorded wind gusts to 52 m.p.h. and lows to 8°F.

Longwood's extensive production and display greenhouses are constructed using thousands of glass and fiberglass panels. With interior planting beds filled with seasonal plants, Longwood attracts visitors daily through the winter months. The Superstorm of 1993 began on a Friday and peaked through the weekend, a time when visitation is often higher. March also is seen as a time to anticipate the onset of outdoor spring interests and visitation to Longwood begins to increase.

During the winter season, in January 1994, Longwood Gardens again faced disruptions to operations and threats to interior and outdoor plants. A series of events, ranging from rain and snowfalls to ice storms, battered southeastern Pennsylvania repeatedly over the course of three weeks. The month's events were: ice and snow on January 4; windy, rain changing to ice on January 6-7; ice on January 8-9; heavy rain January 12-13; bitter cold from January 15-16; snow, sleet, rain with bitter cold throughout January 17-20; heavy snow on January 26; heavy rain on January. The result of the repeated events was an approximate six inch blanket of ice on all outdoor surfaces, including roofs, paths, and roadways, and a thick glazing of ice on trees and shrubs.

Impacts on Longwood Gardens

Direct Impacts: March 1993

The Superstorm of 1993 damaged structures and plants alike. The most memorable damage occurred to the greenhouses. The usual preventative measure of increasing the greenhouses' temperatures to melt the roof snow was ineffective against the wind, cold temperatures and fast rate of snowfall. The excessive weight of the wet snow subsequently caused panes of glass in the Main Conservatory complex and some of the adjacent greenhouses to break or crack (Figure 5.27). In the Exhibition Hall and Orangery, these glass panes were located roughly seventy feet above the display beds and public walkways (Figure 5.28). Additional glass panels broke on smaller greenhouses, particularly in areas where snow

Figure 5.27 Plastic Sheets Temporarily Replace the Glass Panels that Cracked and Fell Out As a Result of the Fast Accumulation of Heavy Snow
(Photograph courtesy Longwood Gardens, Inc.)

from adjacent gabled roofs would slide down onto smaller greenhouses (Figure 5.29).

Glass breaks and cracks affected 248 roof panes. Shards of glass were impeded in the planting beds, or lay shattered across walkways and benches. No interior plants were lost. The loss of glass also caused the temperatures of the greenhouses to drop; an increased need for heat from the boilers resulted in an additional use of 7300 gallons of fuel oil.

Outdoors, the rate of accumulation and the weight of the snow pulled down tree branches. The topiary garden, with its evergreen tree forms, was particularly affected as the formally trained branches were being pulled down from their trained habits. Other trees

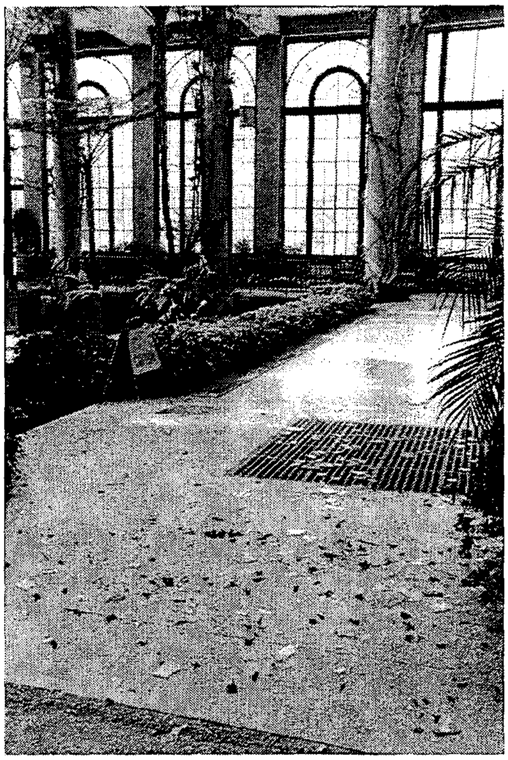


Figure 5.28 **Shattered Roof Glass Plummeted to the Conservatory Walkways and Planting Beds** (Photograph courtesy Longwood Gardens, Inc.)

Figure 5.29 Snow Slid Off of Adjacent Greenhouse Gables Onto Lower Greenhouse Roofs Resulting in More Damage (Photograph courtesy Longwood Gardens, Inc.)

encountered weighted branches as well, but evergreen shrubs and trees were most vulnerable. The high winds accompanying the storm acted to shake the snow from branches and alleviate the weight loads.

Indirect Impacts: March 1993

This winter storm also threatened safety to both staff and the visiting public. Citing apparent safety concerns with the snow accumulating on the greenhouse roofs, administrators closed Longwood Gardens for the first extended time period in its recorded history. The property closed midday on Saturday, March 13th and reopened on Tuesday, the 16th. The conservatories, perhaps the primary draw for visitors during the late winter, remained closed until the 18th to allow for necessary glass repairs and cleaning of interior walkways and planting beds. Employees were forbidden to walk in the greenhouses with broken glass, and those with clearance in these areas were required to exercise caution and wear appropriate safety gear as they worked. The employee mid-winter party, scheduled for March 13th, was postponed.

Further disruptions and inconveniences were a result of the storm. Slippery areas were widespread in the nursery and access was restricted. Some exterior doors to garages, greenhouses and sheds across the property would not close completely because of snow-drifts, ice, and the melting-refreezing process.

More losses (expenditures) were incurred during the response and recovery to the storm. The use of the boilers to maintain a favorable ambient temperature in the greenhouse led to a higher fuel oil bill. Additional labor for the installation of replacement glass and for extra monitoring of the greenhouse plant collections, beyond regularly approved overtime, was over 250 hours. Approved overtime duties included cleaning up glass, supply runs and snow removal, which were in addition to the normal daily operational duties at the gardens that could not be neglected.

Closing Longwood to the public halted business income sources. Admission, garden shop and restaurant sales were lost for two and a half days, March 13-15. The restaurant and garden shop opened again from March 16, but since the greenhouses were closed during clean up and recovery, admission fee was waived as visitors could only see Longwood's outdoor gardens.

Direct Impacts: January 1994

Repeated winter storms during the month of January caused structural and horticultural losses. Fiberglass bubble panels on the East Conservatory roof were harmed as ice sheets would break free from the top of the roof and slide down and shear lower bubble panels. The windows of other greenhouse areas were unharmed as preventative heating schedules dissipated any snow or ice accumulations, unlike in March 1993. Some office and operations buildings suffered slight damages to gutters. The extreme cold froze a pipe in a maintenance area of the Main Conservatory. Outdoors, trees and shrubs and paths were glazed in layers of snow and ice (Figure 5.30). Cold temperatures were placing a strain on the boilers and their pipes, as certain greenhouses were not maintaining the necessary temperatures. Weight strains on large trees, especially evergreens, were widespread across the property (Figure 5.31). Branches and entire trees came down both in the formal garden areas as well as in the woodlands. Other trees remained standing, but their trunks had cracked from the weight of snow coupled with twisting winds.

Adverse weather conditions hindered expedient and effective snow and ice removal and made tree repair more time consuming and treacherous. The timing of repeated rain, ice or snowfalls found workers best served focusing efforts on main traffic areas rather than trying to keep every road and path cleared. Safety was a primary concern, as sanding and salting of walkways and steps did not guarantee sound traction for people or vehicles. Over the month, four employees and two visitors filed official accident reports.

Disruptions were widespread across staff daily schedules and tasks. Shifts for winter snow removal and safety crews were pushed forward to provide enough time to effectively

Figure 5.30 Reflected Sunlight Reveals the Layers of Ice on Pathways and in Trees (Photograph courtesy Longwood Gardens, Inc.)

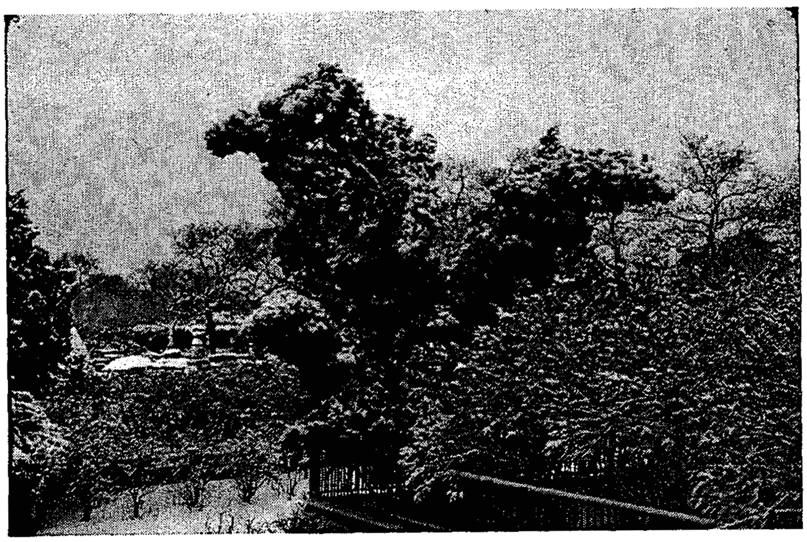


Figure 5.31 The Added Weight of Snow and Ice Caused Many Trees to Lose Form and Sustain Internal Fractures (Photograph courtesy Longwood Gardens, Inc.)

sand and clean roads, lots and main pathways for visitors by official opening times. As snow and ice finally begin to melt from buildings and paths, evening temperatures re-froze the water onto previously ice-free areas. Water from melting snow and ice also seeped into door jambs and into locks, preventing normal monitoring or work routines in greenhouses and storage sheds. Electric gates froze in various positions. On bitterly cold nights, the regular boiler system was not adequately keeping certain greenhouse temperatures at a safe level. Extra monitoring was needed with the use of numerous portable propane heaters. A power outage on one weekend day coupled with a heightened danger for falling tree limbs called for the closing of the property.

Indirect Impacts: January 1994

The treacherous road conditions across southeastern Pennsylvania impaired travel to and from Longwood. Many local roads were closed and access to local hospitals, food sources, and equipment stores was made extremely difficult and uncertain. Although spare bubble panels are kept on hand, the extent and number of panels destroyed on the East Conservatory roof exceeded the in-house supply. The rush order for the custom panels still had a turnaround time of 3-4 weeks.

Snow and ice removal in itself resulted in varying inadvertent damages. Chains on heavy machinery caused scraping and wear on brick and paved paths and roadways. Lower branches of adjacent trees were snapped as ice and snow was cleared from roads and away from buildings. Plant label stakes were buried from view and accidentally bent or removed as snow was plowed and removed.

Additional impacts from the bad winter weather that January were noted. Wear on the carpeting in the visitor center resulted from the increased tracking of salt and sand.

Regular maintenance on buildings and trees was placed on hold as priority was given to safety and the removal of hazards. The frozen pipe in the Main Conservatory led to minor flooding near the telephone switchboard and in staff restrooms. Certain spring bulbs did not sprout in areas in the property, perhaps due to the thick layer of ice depleting soil oxygen or lowering soil temperatures; woody shrubs and perennials required later pruning to offset random twig breakage to improve aesthetics. Internal stress fractures potentially led to plant loss or death as the growing season began and diseases infected or water uptake was disrupted in tree branches and trunks.

Response and Recovery

Preparations were made in anticipation of the winter storms in both March 1993 and January 1994. Longwood had taken several measures based on their previous experiences: from being in a northern climate, having ample financial and equipment resources, staff know-how and planning. Policies existed to maintain and promote an organizational goal of fiscal responsibility; no governmental assistance would be called upon in the event of disaster, and other external resources would be called upon in only the severest and most rare of circumstances. Safety of employees and visitors was paramount. Comprehensive insurance policies were held. Snow melting materials were stockpiled, equipment conditioned, and contingency heaters and generators available. Increases in the greenhouse temperatures would help offset the accumulation of freezing precipitation on the glass panels. Regardless of the precautions taken, unanticipated issues arose during the response and recovery from damages and disruptions connected to these winter storms.

In March 1993, the storm characteristics rendered many greenhouse roofs vulnerable, even with preventative heating. Departmental and section leaders closely monitored the exterior conditions on the property as well as the threat of damage to the greenhouses. Through active communication and dialog, the executive call was made to close the property as safety was quickly diminishing. There was anticipation that extra care and monitoring would be required of staff as the storm progressed and daylight ended. The proximity of various staff housing on the property alleviated concerns of inability to get to work, or for workers stranded at the gardens finding shelter for the evening.

Within hours of site closure, the first panels of greenhouse glass cracked and fell to the interior floors and planting beds. Further safety concerns were communicated and there was restricted access to the greenhouses. Emergency measures dictated the use of cardboard and light plywood to block any reachable roof holes. With access to larger conservatory roofs very unsafe during the storm, extra loads were put on the boilers to compensate for loss of heat through the glass openings.

As more panels gave way, the in-house stock of replacement panels would not be adequate, so orders were placed with businesses in nearby Kennett Square. Poor weather conditions and the damage to the conservatories led the daily reevaluation and continuation of the site closure through the remainder of the weekend. The drop in temperatures following the storm resulted in snowdrifts to contain ice: negotiating and moving the snow was difficult and extremely hazardous, especially on the conservatory roofs. Workers needed to strategically remove snow from the greenhouse roofs in phases in order to minimize further damage to glass from snow slides.

Again, with the process being treacherous, more time was required to begin the cleanup and recovery on the greenhouses. Snow removal on the ground was tedious as well, as ice also required removal from drains and any overhanging tree branches. The level of safety was high enough on the grounds to permit the resumption of regular operations on Monday morning, the 15th. The visitor center, garden shop, and restaurant re-opened to the public; admission was waived as the conservatories remained closed during the repairs.

Priority was placed in repairing the glass panes in the greenhouses. Extra staffhours were clocked and continued restrictions on greenhouse access disrupted normal maintenance regimes of the horticultural staff. Further localized disruptions also needed attention, such as clearing doorjambs, de-icing locks and fixing frozen electronic gates. Across the property, a week was set aside primarily for the clearing of snow and repair of damages.

The cost associated with the disruptions and damages was tallied at just under $60,000, and would be absorbed by the institution's regular budget. Insurance claims were made for business interruption and loss of revenue during the site closure. The finance office communicated with the adjustors and kept track of all requests for overtime and extra expenses associated with the recovery.

In January 1994, repeated storms increased the difficulty of snow and ice clean up and resuming normal business and operational schedules. The tried and proven snow removal procedures and safety and maintenance concerns normally associated with a winter storm were repeatedly tested over a short period of time. The compounded effects of different winter precipitation and fluctuating temperatures were the primary source for disruptions and plant damage. The ongoing occurrence of the storms led itself to be addressed as an added tax on staff workloads and the annual budget. Reserves of sand and salt eventually were used up from the repeated storms; these materials were in short supply in the entire region. Emergency contact with the local government led to a supplemental supply for use at Longwood.

Increased amounts of clean up work, with the need for sanding, clearing roads and walkways and removing hazardous trees and branches forced staff to efficiently communicate and work together. Outdoor horticulturists needed to assess the condition of roads and pathways in their work zones. These gardeners also needed to assess plant damages and report concerns to the arborist crew. Evaluation forms were drafted and included a sliding priority scale. Very severe damage to trees or safety risks were given the highest priority for treatment; trees damaged in remote or inaccessible natural areas of the gardens were given the lowest priority. The added workload on the arborist crews meant that the usual winter tree maintenance duties were placed on hiatus.

Damage to the fiberglass "bubble" panels on the East Conservatory roof was repaired by the in-house maintenance staff. The scale of damage to bubbles quickly depleted in stock replacement panels. No local businesses carried the unique fiberglass bubble panels, and a special order with a distant manufacturer was needed. A rush delivery request was placed as well. Improvisation saw temporary wood and cardboard panels being used until the replacement parts arrived, about three weeks later. Since 1994, the manufacturer discontinued the production of these fiberglass panels, so future replacements would not be as easily facilitated.

Indoor horticulturists and maintenance staff encountered increased responsibilities as well. Cold temperatures and the ephemeral characteristics of snow and ice rendered electric gates useless, walkways dangerous, heating pipes less conductive, water pipes frozen, and greenhouse temperatures less stable. Added time, patience and communication were needed to monitor and correct problems arising from the weather changes. Many staff daily schedules were reduced to essential regular activities and the rest of the time dealing with minor problems, clean up and repairs.

As the result of one storm in January, the electricity was knocked out at Longwood. The gardens closed for the balance of that day. Public roads in the area were closed and visitors, emergency vehicles and some staff had great difficulty moving to and from the property and required special on site assistance. Again, added disruptions to daily activities were widespread. Staff accidents led to an increase in workers compensation and health benefits, also personal leave. Taking added safety precautions when traveling the grounds resulted in drops in worker efficiency rates, and snow removal and arborist equipment needed more maintenance scheduling.

The recovery period for Longwood Gardens was no more than one month for both of the winter storms investigated. The use of extensive internal financial, staff and equipment resources diminished the severity of these winter hazards' effects. However, the experiences of March 1993 and January 1994 were later addressed in Longwood's planning and policy strategies. Mitigation was undertaken during expansions and restoration projects that would likely be encountered again from winter storms. Metal wire cages were placed over greenhouse panels on lower houses that were underneath angled roofs. These cages prevent snow slides from crashing through lower greenhouse roofs. Major restoration on the Main Conservatory saw the use of a laminate glass panel and the disregard for tempered or regular glass panes in the roof. An emergency generator facility was built and scheduled preventative pruning occurs on a vast majority of trees. Considerations of safety, material strength, and fiscal responsibility guided implementation of these mitigation strategies.

Mercer Arboretum and Botanic Garden

The Mercer Arboretum and Botanic Garden (MABG) covers over 250 acres of East Texas pine woods along Cypress Creek, about twenty miles north of Houston in Humble, Texas. MABG is part of a system of twenty-six parks in Precinct Four of Harris County. The site was originally the homestead of Thelma and Charles Mercer and through purchases by the county government in 1974 and 1983, the site today includes the Mercer family buildings as well as large stands of river woodlands and constructed gardens. A visitor center, administrative buildings, maintenance and plant nursery facilities are located on the property, as is a non-affiliated county library.

MABG is considered as the Houston area's largest display of native and cultivated plants. The site seeks to establish and maintain a versatile botanical facility to serve the public, the horticulture industry and the scientific research community. Formal display and instructional gardens have holdings of temperate and tropical plants and natural gardens demonstrate native bog, pond and woodland ecosystems. In addition, the Center for Plant Conservation (CPC) has an established program and planting at the gardens for the study and cultivation of Delta Region endangered plants.

MABG lies in the drainage basin of and along the meandering course of Cypress Creek. Harris County and adjacent counties around Houston are part of one of the largest and fastest growing coastal areas in the United States. During the past thirty years, high levels of development have occurred from population and economy growth (Eckels 1999). The Harris County Office of Emergency Management has been proactive in their attempts to reduce the impacts of flooding in the region. One such strategy is the use of river flow monitors across the waterways in the county. Two monitors are in the proximity of MABG on Cypress Creek; the monitor located one half mile upstream (Sensor 1119) has been used to assist in preparation and mitigation at MABG when the creek approaches flood stage. Flood stage is at the 85 feet level at the gardens.

The Mercer Arboretum and Botanic Garden has experienced flood events from Cypress Creek a few times in the recent past. In 1989 and 1994, flooding resulted from rainfall events and consequential urban drainage runoff. The 1989 event was the biggest flood on record, when waters in Cypress Creek spilled into land surveyed in the "100 year flood event" topography. Since then, the administrative offices have been relocated into a building situated on eight-foot pylons (Figure 5.32), placing vital records and facilities above the height of the expected high level mark for a 500 year flooding event. Most recently, in 1998, heavy rainfalls in both October (the result of a degrading tropical storm) and November caused significant flooding in MABG.

Riverine Flooding

The movement of the remnants of Hurricane Madeline northward into South Texas resulted in as many as fifteen rivers across the region to exceed their previously recorded peak water flows. On October 17, 1998 localized flash floods occurred from San Antonio eastward to Houston. Parts of South Texas received as much as twenty inches of rain during the three-day rainfall event. By October 18, major 'countywide' flooding was reported in at least eight counties. In Harris County, steady rainfall was occasionally accompanied by F0 tornadoes resulting in minor roof damages and blown down trees.

According to Cypress Creek flood sensors nearest to MABG, the creek first reached flood stage (eighty-five feet) on Sunday, October 18, and remained at or above flood stage

Figure 5.32 Past Flooding Experiences Led to Construction of an Administrative Office Set Upon Eight-Foot Pylons
(Photograph by author)

for three days, until October 21. Less than one month later, a localized rainfall event in the northern suburbs of Houston caused Cypress Creek to again flood, first reaching flood stage on a Friday. It remained above flood stage at MABG from November 13-15, 1998 (Figures 5.33 and 5.34).

Impacts on Mercer Arboretum and Botanic Gardens

Direct Impacts

In the natural areas adjacent to Cypress Creek, floodwaters were as deep as five feet. In the formal planting areas of MABG, water depth was typically no more than a few inches,

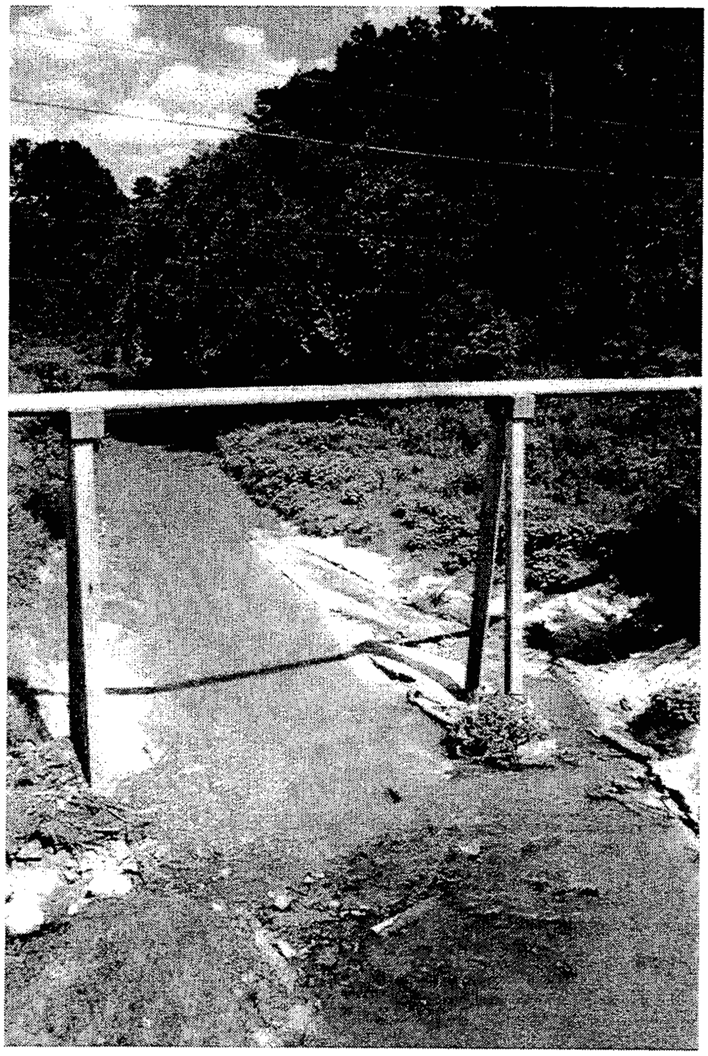


Figure 5.33 Cypress Creek's Typical Water Flow (Photograph by author)

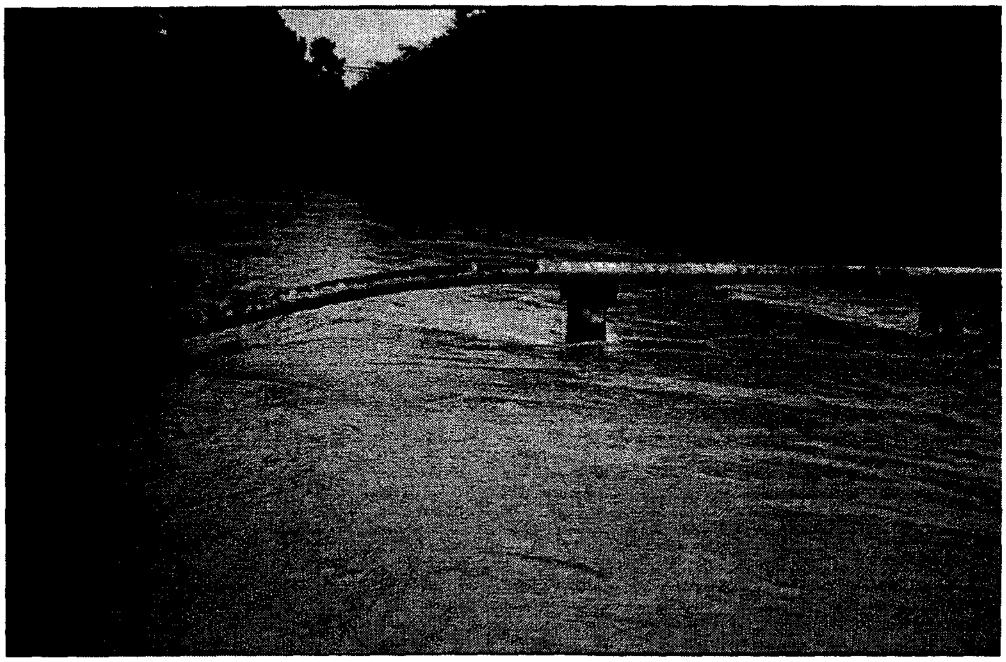


Figure 5.34 Cypress Creek's Water Flow Following a Significant Rainfall Event (Photograph courtesy Mercer Arboretum)

although local topography dictated precisely which gardens were flooded. Continued development in the metropolitan area increases impermeable surface areas in the creek's drainage basin. Physical effects are the widening of Cypress Creek's banks and the increased expansiveness of floodwaters onto adjacent lands. The most damaging aspect at MABG was the exposure and inundation of plants to floodwaters for an extended period of time. When the waters receded days later, the plant losses were tallied and infrastructure was evaluated for damage from each flood.

Parts of the property flooded were littered with debris ranging from garbage to re-deposited plant and refuse materials and silt. Silt and river muck blanketed bricked walkways, earthen paths and planting beds in any depth from one half inch to as deep as eight inches. In the arboretum trail system, nearest the river, silt and sand were as deep as two to four feet on paths and footbridges.

Infrastructure was impacted as well. One small office building had approximately three inches of water covering its floor; carpeting was saturated and lower paneling boards were also damaged from direct exposure to water. Footbridges in the arboretum trail system acted as a catch for any floating driftwood; some bridges were structurally affected. Water fountainheads and basins filled with silt and muck. Well casings cracked and the site's drinking water supply was compromised. Drains normally draining water into the creek now acted as a means for rising floodwaters to enter the gardens and planting beds.

Inventory losses were apparent, even though many preventative measures were taken. Before the flooding, nursery stock, pots, equipment and growing media and other items were stored on a raised level or relocated to keep them dry (Figure 5.35). Any unsecured buoyant items from the nursery or gardens were carried away, including plant labels. Growth media bags were exposed to floodwater. Powdered fertilizer and chemical bags hardened from the increased ambient humidity or became dampened through capillary action (Figure 3.36). Mulch, sand, and compost piles exposed to high waters were washed downstream.

Because of a lengthened exposure to flood waters, many plants were affected, but not all immediately. Nearly 100% of all annual plantings and about 15% of all woody and herbaceous plants were likely lost per flood event across MABG. Annual flowers, the foundation of an autumn display planting in southern Texas, were quickly killed. Endangered and arid plants in the garden also did not tolerate the direct contact with water.

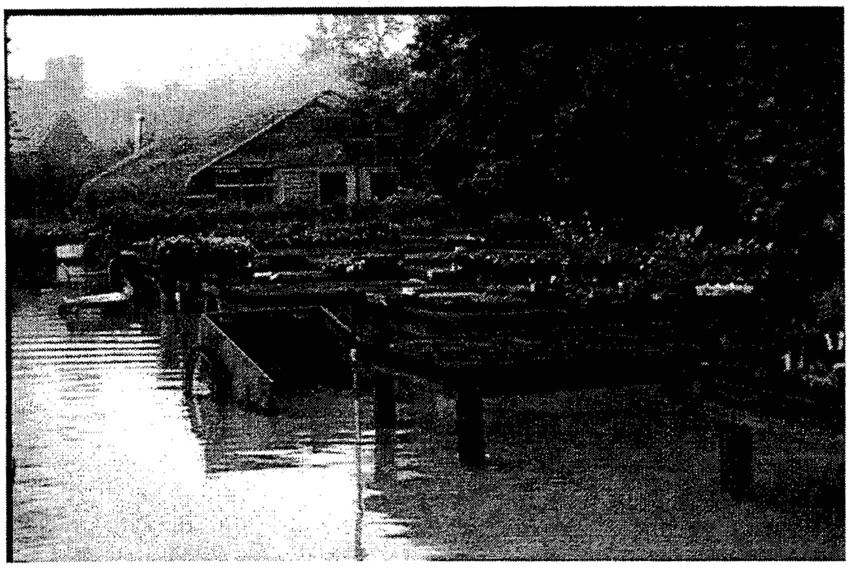


Figure 5.35 With Advanced Warning, Plants Were Placed Atop Tallest Benches to Avoid Contact with Floodwaters (Photograph courtesy Mercer Arboretum)

Figure 5.36 Buoyant Supplies Were Readily Affected and/or Moved by Invading Floodwaters (Photograph courtesy Mercer Arboretum)

Some plants were washed away in the varying flood currents while other plants were concurrently deposited on the property, including desirable ornamental as well as invasive aquatic weed plants or seeds. Native trees and perennials, in general, handled the floods much better than exotic ornamental plants. The timing of the floods in late fall was advantageous for the preservation of many tender tropical plants in the gardens, since they had already been pulled in anticipation of a killing frost prior to the floods.

Local fauna fled to higher ground as the woodlands along the creek flooded. Snakes, such as water moccasins and copperheads, fled to the perceived safety of the garden's sheds and buildings. Rats, snapping turtles and armadillos also relocated to areas of the garden. Fire ants sought refuge on any floating or dry item in the flood plain.

Indirect Impacts

The Mercer Arboretum and Botanic Garden was not the only site in Harris County affected by floods. Numerous residential and business areas were also flooded, and these areas typically received emergency response and media coverage first. Not all staff was physically able to get to MABG in an expedient manner. High water blocked various thoroughfares and bridges leading to the site. Although MABG is part of the county governing authority, it was not the only public park impacted by the flood. Certain resources would need to be shared and apportioned across the county.

Safety concerns, including the reality of hazardous animals taking refuge in debris and in buildings across the property, prevented immediate damage assessment and clean up. The general public, whether a visitor or as a volunteer, could not be permitted on site. The property closed its gates to the public for at least a week for each event; more heavily damaged areas of the gardens remained off limits once the central display gardens were cleaned and reopened to visitors.

As the floodwaters subsided, drains were now clogged with silt and debris. Irrigation PVC pipes cracked from the settling of soil as saturated soils dried. Plants remaining were covered in silt and needed washing immediately. Still other plants fell victim to root and stem rot, and diseases and pathogens were more easily affecting plants weakened by the flood. A soil fungus, *Phytophora sp.*, spread in the favorably warm, soggy soils in the wake of the flooding. It is believed to have detrimentally affected many plants, including mature ornamental trees. The timing of the floods in late fall caught many plants at the beginning of their annual winter dormancy--effects on these plants were not apparent until the next spring.

The overall health and vigor of a variety of perennials and woody plants was declined, and plant losses continued several months after the floods had passed. Visitors to the gardens were not necessarily aware that recent flooding events had caused the negative impact on aesthetics. Louisiana iris, a native of the marshlands, easily survived the floods, but the following year's flowers were not as numerous or prolific. Although Mercer did not cancel a special event centered upon the Louisiana iris flowering, the diminished display may have negatively impacted the public's perceptions of MABG and its collections.

Clean up and recovery efforts associated with the floods disrupted about one year's worth of regular operations. The typical daily and seasonal routines for maintenance, plant care and anticipated garden enhancements were delayed or indefinitely postponed. There was a notable increase in weeds in planting beds, believed to have sprouted from seeds and plant parts deposited by the floodwaters. The clean up itself was not hassle free. For example, there were occurrences of equipment getting stuck in the soggy post-flood soils in the woodlands and there was inadvertent breaking of branches and trampling of various plants as machinery and people cleaned off paths and worked in planting beds.

Response and Recovery

The parental Harris County Precinct Four District, with internal connections to the Harris County Office of Emergency Management, reduced MABG's burdens for response and recovery. With governmental research, planning and departments, the system was prepared and experienced in the general procedures for response and recovery from riverine flooding events. The county departments collectively approached the task of recovery across the county on a case-by-case basis at all of its facilities. Debris removal was facilitated through county waste removal contractors, construction materials and supplies acquisitions would be handled by the usual county vendors. Equipment would be purchased by the county or existing equipment would be relocated to the respective county sites.

The role for MABG was to communicate its needs to county officials. Appropriate county engineers and departments would be dispatched to MABG to evaluate the integrity of infrastructure, assess damages and organize necessary repairs. These repairs would be paid for with funds already in the county budget, or from emergency appropriations. Specialized labor for repairs and clean up would be supplied by county contractors. General manual labor for clean up was supplied by correctional inmates already in the county detention system.

The property closed its gates to the public for one week after each flooding event. The clean up efforts were prioritized and located first in the formal gardens and administrative areas of MABG (Figure 5.37). Upon the reopening of these core garden areas, more effort could be placed on the recovery efforts in the peripheral garden areas, such as ecosystem gardens and nature trails closer to Cypress Creek.

Presidential declaration of disaster in Harris County after the October flooding event released various FEMA resources to the county. The county, in turn, had the task of dispersing these resources throughout its own properties based on its own assessments. Consequently, many FEMA funding stipulations placed on individuals and private firms, for example, were not relevant within the parks system. Disaster monies could be dispersed for plant collection replacements, which were, in 1998, no longer allowed in private sector recoveries funded by FEMA.

Figure 5.37 Ironically, Water is the Primary Clean Up Tool in the Wake of a Flood to Remove Deposited Silt and Sand (Photograph courtesy Mercer Arboretum)

The second flood event, a month later in November, was not a federally declared disaster. The close proximity of the second flood to the first, however, found the county with resource reserves and could receive any appropriate state or local assistance to continue the overall recovery from flooding. Simply, all costs associated with another flood recovery process would be absorbed by the county government's budget.

As MABG was a unique property in the county park system, horticultural expertise came from the MABG staff, not from the larger county governmental body. Moreover, professional contacts of staff were also called upon as needed to help evaluate and/or complete horticultural tasks during the response and recovery. Based on experience and standard procedure, it was MABG's responsibility to conduct initial visual damage assessments in the arboretum and gardens and to then inform and summon the county offices.

By utilizing plant records, MABG began the process of locating replacement plants for use in recovery. County plant production contractors and regional botanical gardens and conservation centers were called upon to replenish the display and endangered plants lost in the flood events. Staff had liberty to select plant specimens and species according to MABG's needs; desired plant size and cultivars could be acquired as deemed available or appropriate for the site. Purchase ordering and approval procedures extant in the county government system guided plant replacement processes. Plants with delayed physical signs of deterioration from the floods and subsequent diseases were removed and replaced using these same procedures.

Additional support was potentially available to the Mercer during the recovery. The non-profit support group was undergoing organizational changes and was not best situated to take on a strong recovery role. Volunteer help, although restricted access to the gardens because of safety hazards, were eventually permitted to unite with staff in cleanup and the resumption of maintenance tasks. A majority of these volunteers were affiliated with this non-profit group. Since the flooding was widespread in the area in both October and November, the media did not find relative importance in reporting the damages and needs of MABG. Some phone calls did come in to staff, but random acceptance of replacement plants or volunteer labor was not seen as a good strategy. Visitors to the gardens after the flooding events were aware of the devastation only if verbal communication was made with staff, or the visitor was already aware of MABG's location in the Cypress Creek floodplain.

Less than six months after the floods, MABG had a majority of the clean up completed; the more highly visible formal garden areas completed and replanted first. The onset of spring found the renewal of surviving plants and the replacement of annuals and woody plants across the property. By the first summer, a near full recovery from the floods was evident. Only a few pathways in the natural trail system needed cleaning. The need to refocus efforts on recovery from the floods, in general, found MABG behind in its regularly planned maintenance and improvements to the gardens.

Dialog continues across various levels in Harris County management and departments, including MABG, to locate funding and ideas to lessen the future impact of flooding and other disasters in the Houston area. Flood attenuation projects are ongoing, preparedness studies being conducted, development covenances in place, and land acquisition of flood prone private properties are among the mitigation strategies being advanced by the county government. Some of these mitigative projects are being funded by state and federal tax dollars, including FEMA's 'Project Impact.'

Chapter 6

ANALYSIS OF EXPERIENCES AT CASE STUDY SITES

This chapter has been organized to discuss the reactive trends and opportunities facing each case study site as presented in Chapter Five. These trends will provide insight to assist public gardens to determine their site-specific vulnerabilities to natural hazards based on the experiences of the five case study sites. The trends will also help PHI employees familiarize themselves with issues and impacts likely from a natural disaster so that they might draft appropriate planning and preparedness strategies.

Interviews with the directors and staff at the five case study sites revealed some common overall trends in response and recovery processes, not all of these trends are necessarily negative in nature. The natural disaster experience raised issues on a variety of levels that needed to be addressed or capitalized on by each organization, based on its unique circumstances. Four of the five case study sites, Fairchild Tropical Garden (Fairchild), The Hermitage, Linnaeus Arboretum (Linnaeus) and Longwood Gardens (Longwood), are private non-profit organizations. Only the Mercer Arboretum and Botanic Gardens (Mercer) is a governmental institution. All five sites had the goal to fully recover from the natural disaster, that is, return the site to a condition identical or similar to that which existed before the natural disaster.

Figure 6.1 summarizes the issues that were observed from the case study qualitative interview portion of this study. Each of the bulleted issues will be discussed in depth in the balance of this chapter. Explanations and caliber of these issues (or trends) will enlighten PHI as to the issues that must be taken under advisement and consideration in the processes of conducting a site vulnerability to natural hazard analysis, creating a disaster and recovery plan and ultimately, anticipating site needs and realities if and when a natural disaster occurs in the future.

Reactive Trends	Opportunities
• Extent of community devastation • Accessibility and availability • Human resources • Leadership and guidance • Prioritization • Implementation of recovery • Communication • In-kind assistance • Indirect impacts • Site disruptions • Acquisition of recovery resources	• Horticultural integrity • Public relations • Organizational integrity and learning • Project implementation

Figure 6.1 Summation of Natural Disaster Experience Issues Observed From Qualitative Case Site Interviews

Reactive Trends

The destructive nature of a natural disaster was evident at all case study sites—whether they were of a physical, emotional or organizational nature. These "reactive" trends gleaned from the interviews conducted at the case sites may be categorized into the following areas: extent of community devastation, accessibility and availability, human resources, leadership and guidance, recovery implementation, prioritization, communication, in-kind assistances, indirect impacts, site disruptions, and recovery resource acquisitions.

Extent of Community Devastation

The public horticulture institution was not the only entity in the community to be physically affected from the natural hazard. This had several implications. First, this affected the allocation and timing of response and recovery resources. Four of the case study sites had to commence response and recovery efforts along with other households and businesses in their immediate and regional communities. Machinery, expertise and in-kind donations (from volunteer labor to money) were shared and scheduled amongst the disaster victims. Fairchild Tropical Garden and the Linnaeus Arboretum took proactive roles to utilize resources they needed while also redirecting some resources to other organizations and households to advance the community's recovery. The Hermitage officials made a conscious decision to suspend an immediate blanket campaign for public donations of money and volunteer help. Based on the greater needs of the community, The Hermitage believed that solicitation of money from the public would be poorly timed while private households and businesses were also being cleaned and personal recoveries were beginning. A capital campaign for tree replacement commenced well after community-wide clean up efforts ended and rebuilding was underway. Mercer Arboretum and Botanic Gardens, although managed under the larger county government system, set priorities regarding machinery, supplies and labor on the basis of total county response and recovery needs, and then within the county parks system.

Finally, four of five case sites were keenly aware of the issue of debris removal—both building and vegetative debris. Depending on local governmental planning or decisions made in the wake of the disaster, vegetative debris was collected at a site, chipped and then recycled as landscape mulch and provided to any interested party. This occurred at the Linnaeus Arboretum, and debris at Mercer was carried away according to government procedures and contracted service providers. Other sites, Fairchild, The Hermitage, and Longwood were able to locate debris piles and some recycling strategies on site, as peripheral land layouts permitted. Debris removal itself was facilitated through the use of already owned equipment, or through contractors. Some sites' insurance policies covered this added expense if external equipment, transport or dumping charges were imposed from disaster clean up activities. Various restrictions were imposed at landfills and other rendering sites regarding hazardous, biodegradable or other forms of debris would be accepted for dumping.

Accessibility and Availability

Another trend implication stemming from the extent of devastation is the availability and accessibility of recovery resources. In some cases, the destruction of businesses or impassability of roads to business areas hampered recovery. Then contingency plans were needed to locate and secure machinery, supplies and even foodstuffs. The Linnaeus Arboretum found its rural community heavily damaged, including many of its service providers and suppliers. New contacts were made in surrounding communities for services and supplies, and issues of timing and organizing transportation runs of these goods and services needed to St. Peter arose. Fairchild Tropical Garden saw an entire three county metropolitan area heavily damaged from a hurricane. Although not every business was destroyed, many roads were impassible to the gardens for several days and recovery resources such as bottled water, food, gloves, rakes, etc. needed to be located at businesses much farther away than usual. Moreover, there was competition for these same resources from a large population affected by the hurricane. Demand was high and supplies and services were often hard to readily come by.

The ability of staff, other labor and professional expertise to access the site after the disaster is an additional issue that must be considered. Martial law, safety and security checkpoints, curfews, and impassable roads could impede or slow the movement of human resources to and from the site. Fairchild, The Hermitage, Linnaeus, and Mercer dealt with human resource availability and accessibility to their sites, based on their site's specific and unique disaster circumstances. Longwood reduced the impact of the winter storms on staff availability by having many staff housed directly on the property. In addition, personal property losses experienced by staff may alter the availability and comfort levels of staff to report to work. Four of five case study sites experienced staff personal property losses from the natural hazard; concessions and planning were undertaken to balance the personal needs and professional obligations of the affected staff. Safety and liability issues also had an impact on the type of personnel permitted in response and recovery projects. Volunteers were precluded from involvement at the Mercer and The Hermitage initially; and Linnaeus and Fairchild instructed volunteers to recovery tasks based on site safety and varying priorities.

Human Resources

The physical losses to PHI and the operational disruptions had an affect on staff. Sense of overwhelm and devastation, emotional shock, low morale and the losses of personal property and increased domestic pressures could be found at all five case study sites in varying degrees following the natural hazards.

Leadership and Guidance

Upper managerial or departmental leadership assisted the organization undertake response and recovery from the natural disaster. Whether the organizational leader undertook a public visionary approach or an "in the trenches" motivational approach, the leader(s) helped to organize the overall recovery efforts. Leadership in the form of a previously written disaster plan or strategy helped the response and recovery efforts. The Hermitage, Linnaeus, and Longwood all had written plans of varying scopes that nonetheless helped organize and begin the necessary tasks involved in response and recovery. The Mercer, although it did not have a written plan, took advantage of the mental plan that was common among staff, since the site had experienced flooding previously and was aware of the needs and processes involved with recovery on the site and within the county parks system. Consequently, the natural disaster experiences at all five sites led to the later creation of or modifications and re-evaluations to written and mental disaster plans.

Implementation of Recovery

Each recovery process was approached and advanced by a division of staff labor and duties across the organization's departments. Organizations with and without a written plan came to this strategy, through deductive reasoning or through advise solicited from other organizations that had natural disaster recovery experience. The process was team-oriented on a variety of levels: upper management worked cooperatively to deal with governmental and business matters, departments worked to achieve damage assessment and clean-up tasks, and volunteers, when used, acted to assist staff and upper management reach recovery goals.

Among the case sites the recovery process itself was approached differently, based on site needs, protocols and procedures. Fairchild and The Hermitage created partnerships with external organizations, individual staff and external professionals to help the recovery. Grants and FEMA assistance were sought and secured. The Hermitage utilized comprehensive insurance claims, unlike Fairchild. The Linnaeus used a disaster recovery company, as directed and contracted by its insurance provider, along with its proven college contractors, staff resources, and tremendous amounts of volunteer labor. Longwood organized the recovery internally with extant staff labor, expertise and equipment. Mercer acted locally and then reported its damages and needs to the parental government officials who in turn organized equipment, specialized assessors, labor and supplies on Mercer's behalf.

Prioritization

In effect, each PHI had to address and manage its response and recovery needs. Disaster response was logically prioritized (either via a written plan or by verbal communications among people) to first address human safety and health concerns, followed by clean up and the start of recovery. Recovery efforts were guided and evaluated uniquely by each PHI. Fairchild's recovery was guided by its mission statement--evaluation of damage and plant "triage" operations were prioritized based on plant rarity and health. At The Hermitage, priority again was directed by the mission statement and the very nature of the site. Historical structure evaluation and treatments were given initial priority, but there was sympathy given to soil structures and history associated with fallen trees. At Linnaeus, being part of a college campus, priority was first placed on evaluating and protecting the academic resources; but plants were also included in the overall approach to clean up and recovery. Longwood placed human safety first in its winter storm dilemmas, including not placing staff at risk during clean up and recovery. Priority was also given to mitigation so that future conservatory glass breakage would be avoided in a similar winter storm. Mercer prioritized its clean up and recovery first in any buildings and in the more highly visited areas near the site entrance and in endangered species planting beds.

Communications

Communication was noted as being the most necessary component of the recovery process. All four of the non-profit sites recognized the need to communicate internally among staff, and this was effectively facilitated through scheduled meetings. Not all sites were able to communicate through the use of modern technologies, such as email, radios or telephones, so in-person contact remained a key part of any communication plan for a disaster response and recovery. The Hermitage took a proactive approach to communicating its needs to outside contractors and professionals. In order to preserve the historic site's integrity, extra time was required to share the reasoning and importance of following rules to outsiders. The Hermitage and Linnaeus implemented specific communication strategies after the disaster, most importantly with the media. All communication was positive, accurate and recovery oriented only after a proactive and controlled approach to dealing with outside individuals, special interest groups, and the media.

Off-site information dissemination was altered when a larger region was affected by the natural hazard. For one reason, telephone and computer lines could be lost for a time, as was the situation at Fairchild, The Hermitage, and Linnaeus. Another reason is that local authorities and media may not be privy to or aware of the situation at one site when several sites are damaged. Entire counties were devastated in South Florida, not just Fairchild; downtown Nashville and a residential suburb were hit before The Hermitage sustained damage. The tornadoes passing through Linnaeus had history in several other counties and communities. Longwood happened to one site across the Eastern Seaboard that had to deal with the effects of a large scale winter storm. Residential flooding was widespread and was in the broader public interest in Houston, effects on a secluded county park was not as dire as those affecting human life.

In-kind Assistance

Fairchild and Linnaeus were two sites that relied heavily upon volunteer labor and in-kind donations. Each site recognized the need to permit community citizens, professionals and businesses to satisfy their desires to help out. Both of these PHI realized that both volunteer labor and donations must be managed. At Fairchild, volunteers were tracked and sent to areas with an appropriate work and safety level, and with supervision (when possible). Volunteer help and in-kind donations of money or materials were taken only if Fairchild could use them. Donations that were not specific to the recovery needs at the site were declined or redirected to other sites. Staff or visiting research professionals that voiced a need for volunteers or who were comfortable managing them were given volunteer workers. At the Linnaeus, college alumni, students and many volunteer church and community groups made pilgrimmages to St. Peter to contribute. Transportation, parking, food services and tools would need to be organized prior to 2,000 volunteers coming to the campus. Safety was a concern, and not all volunteers were truly qualified or physically fit for all recovery activities. Organization of volunteers was needed as they entered the campus and then appropriate information and supplies had to be disseminated to all group and project leaders. In the other case study sites, volunteers were not called upon because of safety concerns, lack of an organizing staff liaison or simply because of established liability concerns and/or policies.

Interestingly, all five case sites would not accept in-kind plant donations from the public. This was based upon organizational policy at Longwood, but the other sites realized the difficulty in managing quality and type of donations and the added time and expense associated with staff having to travel to another site to prepare, dig and transport live plant materials. Exceptions were made on a case-by-case basis, depending on plant rarity or the donator's affiliation to the PHI. Again, individual site needs and circumstances dictated the acceptance or decline of in-kind donations of plants, materials or other goods.

Indirect Impacts

Indirect impacts from the natural hazard were noted at all five case study sites. Using the broadened term 'impacts,' such examples included site closure and loss of earned income, changes in daily work responsibilities during the recovery period, changed health and aesthetic quality of the landscape, and changes in site safety during clean up, just to name a few. Impacts beyond the direct force of the natural hazard were seen over a prolonged period of time. At Fairchild, staff workloads and schedules and plant losses were being affected at least six months after the hurricane, likely even longer as plant replacement and building repairs were then just getting underway. At The Hermitage, tree limbs continued to drop on damaged trees over a year later, the view sheds from the mansion remain drastically changed, and changes in the plant growing environment affects the types of plants to be grown in the gardens. The Linnaeus also saw continued decay of surviving plant materials, soil compaction, and gutting of woodchip pathways occurred throughout the recovery phase. The campus is once again filled with flowers and trees but it remains a less shaded and wind-protected site. Longwood endured disruptions to staff duties and rotations for a month after each winter storm; damaged trees and shrubs needed extra pruning and care the following growing season. Mercer had parts of its natural trail system closed for several months and visitors to the site after the flooding could see a "tired" look on many plants.

Site Disruptions

Disaster response and recovery efforts disrupted the usual operational and maintenance regimes of all PHI. Certain organizations dealt with these disruptions better. For one, The Hermitage, Linnaeus, and Longwood had insurance resources available to them when their sites closed to the public; Mercer's costs were absorbed by the county budget. Fairchild, however, did not have the comprehensive insurance coverage that it thought it had. Immediate and delayed plant losses from the natural hazard were given foremost priority for removal or simply incorporated into the regular operational tasks of the PHI. Some sites had large numbers of staff or volunteers available that would reduce the impact on usual operations.

Disruptions did not only affect the physical maintenance issues, but also site income and public perceptions. Site closure affected income and the economic feasibility of future projects and funding campaigns. Changes in the site aesthetics also placed pressure on staff to decide whether or not to cancel special events and classes. Fairchild cancelled a portion of its fall continuing education offerings after Andrew; The Hermitage cancelled several large scale events as late as 18 months after the tornado as recovery continued.

All sites did not have all the necessary equipment or supplies for clean up and recovery efforts. This varied site to site, depending on in-house equipment and supplies, and extent of the damages. In some cases, replacement parts were not readily available from suppliers and manufacturers and in other cases, machinery so specialized was located and used by professionals that many people interviewed said, "I never knew such equipment existed." Response and recovery was also disrupted as equipment needed to be first located and then brought to the site.

Acquisition of Recovery Resources

Finally, interviews at four of the five case sites revealed that many staff and directors did not expect recovery resources from external people or organizations to be offered to the PHI during its time of adversity. Many people were unaware that some special interest groups, materials or funding opportunities existed. Varying awareness of available resources by staff and leadership potentially slowed down initial organization and contact with resource providers. As word of the disaster spread, and people involved in the recovery efforts contacted friends and associates, an unanticipated network of recovery planning and resource solicitation was created. At all five sites, individual staff, garden members, board members, alumni, volunteers and networked industry professionals were among the people actively searching and locating potential resources for use in the recovery efforts.

Local and state governmental officials were not excluded in their involvement in acquiring resources. The interest of public officials in disaster recovery was often piqued through the efforts of staff and factions of the anxious public contacting the local governmental offices and representatives and voicing concerns to officials. Gardens that already had an established relationship with the local government system and/or officials enjoyed expedited assistance; however, a garden could have an amiable, distant connection with a government through a staff member or other contact and still gain assistance, but at the expense of time.

Opportunities

The destructive nature of a natural disaster also carries opportunity. Throughout the interviews conducted as part of this study, the researcher noted that all interviewees shared the opportunities for change and improvements as a result of the destructive and emotionally painful disaster. For efficiency, these opportunistic trends stemming from a natural disaster may be categorized and discussed in these four areas: horticultural integrity, public relations, organizational integrity and learning, and project implementation. Potential for disaster mitigation can be noted in all five categories.

Horticultural Integrity

It cannot be denied that vast damage to and/or outright loss of plant collections occurred either directly or indirectly as a result of a natural hazard at all five case study sites. However, each site gained insight into the health, quality and value of its collections as a result of the disaster. At Fairchild, the loss of many larger or redundant trees in the collection provided an opportunity for a re-evaluation of species content of planting beds. Outdoor areas of the garden that had become very thickly vegetated were now cleaned and "thinned out" to provide better growing and display situations for plants in the collection. At Linnaeus, the tendency of the tornadic winds to drastically affect certain evergreen species led to discussion on increasing the biodiversity of replacement plantings during recovery.

Loss of plant labels resulted in a renewed interest in documenting and inventorying trees remaining and to be added to the arboretum grounds. The Hermitage benefited from the GIS tree mapping project; this was the first inventoried database of the outdoor collections the property ever had. The Hermitage also reconsidered the placement of large growing trees in proximity to historic structures. The historic design integrity and accuracy of plants dating to the Jackson era were preserved and insured the same plant species would be utilized in very historic areas. Longwood and Mercer documented its plant losses and replacements according to usual plant accession procedures. These sites used their plant records to locate sources and other information on plants to be used during recovery.

Public Relations

The PHI public relations may be discussed on two levels: the community and the professional network. The community (the physical neighborhoods surrounding the PHI) relations at Fairchild, The Hermitage, and Linnaeus were particularly challenged as a result of the disaster. Factual information and requests needed to be disseminated to the public in a variety of ways. Whether or not a specific communications plan or strategy was developed or written is not the issue. What is important in the discussion of community relations is that each of three sites made a concerted effort to reach specific audiences during the recovery period. Each site commented that the reaction of the community to the recovery concerns of the PHI revealed that the PHI had "value in the community." Both people familiar with and new to the PHI became interested and involved in the recovery process through donations, volunteering and networking. This phenomenon was seen as an opportunity to quantify the community's perceived value in the PHI as well as providing an opportunity for the PHI to expand its constituency base. As one interviewee stated, "the disaster was a way for us to realize our place and sense of value across the community. We came out very well, but going through a tornado was a painful means to realize that your community believes in and values you."

The professional networks of the PHI were also broadened and often strengthened as a result of the natural disaster. Sister public gardens, scientific and recovery experts, governmental officials, and specialized tradesmen were brought together during the process of recovery. Four of five case sites noted that additional professionals were contacted and utilized during the recovery. Many of these professionals brought with them or sent specific and specialized equipment; financial, legal or logistical advise; and emotional support for the damaged site's staff, volunteers and community.

Organizational Integrity and Learning

All five case site interview respondents stated that the natural disaster experience was valuable for their organization. Although few sites perhaps gained financially from the disaster experience, all sites' interviewees felt that they learned so much by doing that they are better prepared to face a disaster in the future. Organizational leaders gained management and leadership training through a "baptism by fire." Staff became more aware of risks, organization and collection vulnerabilities, policies, procedures and insurance coverages. Safety, emergency response and other planning documents were re-evaluated and often modified or simply created. The effects of the natural disaster and recovery emotionally and physically on staff and volunteers could be evaluated and plans and strategies created to avoid these identified problems in the future. PHI also gained insight into the specific resources (equipment, grants, government programs, workers, etc.) that would be required for use with their collections and structures.

Mitigative strategies were employed at all five sites, although in varying, voluntary capacities. Mitigation ranged from installing hurricane shutters to upgrading the quality of glass in conservatories to selecting more structurally stronger tree species for planting. The Mercer demonstrated the most pronounced mitigative strategy—lifting office out of the flood plain by relocating the building on pylons. These decisions were fueled by a change in perspectives caused by the damaging, disruptive and pricey effects and safety concerns raised from the natural hazard encountered.

The clean up and removal of debris from their sites provided an opportunity to refresh the physical landscape and improve the staff's outlook for growth and renewal. The conditions of the plant collections and structures located within each site led to the prioritization of recovery efforts. The mission statement and master plan could guide the reconstruction and repair. An increased sensitivity to the mission statement would act to streamline the efforts of the PHI and help focus the organization during recovery and growth. Linnaeus completely re-evaluated its mission statement prior to commencing recovery. The overall change in the landscape provided a timely opportunity to start the planning and implementation of new strategies for the arboretum.

Finally, the PHI shared their experiences and insights on disaster risks, response and recovery. Professional papers were written and submitted to industry journals and newsletters. Lectures, special programs, exhibits and interpretive materials were made both on site and in the greater community sharing experiences and "how tos" of the natural disaster experience. This information sharing acted to inform policy at other organizations; hopefully to avoid similar future damages and disruptions from a natural hazard.

Project Implementation

Closely related to advancements in organizational integrity and learning is the opportunity afforded for project implementation. Even though replacement and reconstruction projects may have been immediately undertaken after the natural disaster, several longer term projects were commenced as well. The Hermitage conducted restoration projects on damaged historical buildings and addressed historic tree replacements. Linnaeus and its parent, Gustavus Adolphus College, began facility expansions and new landscape planning projects, including plant mapping and labeling and arboretum collection accessions. Not all projects, however, were proactively selected for implementation. The damage from the disaster itself warranted a reactionary project implementation that perhaps was not eagerly anticipated. The Hermitage, for example, was forced to address the issue of replacing the historic cedars on the entrance drive. In this dilemma, dialog continues on whether to save remaining historic trees, or replant the drive with all new plant material in order to preserve the landscape design integrity.

Project implementation was facilitated by site master plans. Building code upgrades were facilitated during the reconstruction phases of recovery. New structures were built; annexes and extensions were constructed, and poor landscape plantings and designs were altered based on organizational needs and goals presented in the master plan.

In summation, Chapter Six lists both reactive trends and opportunities that arose from natural disaster experiences from a group of five public gardens. These trends may or may not apply to every PHI, as based on each specific site's plant collections, facilities, financial situation, staffing, or location, among others. However, the experiences of these five PHI can assist other public gardens anticipate impacts and needs if a natural disaster occurs in the future. The experiences can inform and help create and implement disaster policy.

Chapter Seven will look at the results from this study's survey instrument in order to test the research hypotheses. Results from the survey, which encompasses data from over 220 PHI across the United States, may also provide insights into understanding the response and recovery experiences faced by the five case study sites.

Chapter 7

NATIONAL SURVEY RESULTS AND DISCUSSION

Chapter Seven reveals the results of the national quantitative survey distributed to the institutional members of the American Association of Arboreta and Botanical Gardens (AABGA). The survey acted (1) to provide broadened data to be statistically tested to either prove or disprove the researcher's hypotheses, and (2) to select institutions for case study site interviewing. Criteria used for each of these actions may be found in chapter one; a copy of the survey instrument may be found in Appendix A.

Location of these survey results after the presentation and discussion of the case studies was intentional. Such a format attempts to first familiarize the reader with specific PHI disaster experiences and to introduce the trends and issues observed from these experiences. The survey results not only will prove or disprove testable hypotheses, but will also act to assist in the explanation of the overall disaster planning situation of the broader scope of American PHI.

Three conceptual hypotheses were addressed in this study, as listed in the introduction in Chapter One. First, losses sustained at PHI are similar. Secondly, public gardens are better prepared to handle the process of disaster recovery as a result of previous natural disaster or hazard experiences. "Better prepared" is qualified as including increased risk perceptions and having disaster response and recovery plans. Finally, public gardens do not have the resources within themselves, that is, not found internally within the site's governing organization to recover from a natural disaster. For statistical analysis, each conceptual hypothesis was tested through the use of one or more empirical research hypotheses. These research hypotheses will be presented in this chapter.

Hypothesis One

The conceptual hypothesis presumes that losses sustained at PHI are similar. In order to test this hypothesis a research hypothesis was drafted and applied to four loss typologies: losses to plant collections, losses to historically significant plant collections, losses to facilities and systems, and losses to historically significant facilities and systems.

Are there differences between governmental and non-governmental PHI that result in different patterns of losses?

H_0 **There are no differences.**

H_1 **There are differences.**

Table 7.1 displays the chi-square and significance values for the plant loss typology. Concerning losses to plant collections, there is no observed relationship found between governmental and non-governmental PHI (x=.02, df=1, sig.= .86). The null hypothesis was accepted. Thus, based on this study's survey of PHI since 1980, these data suggest that there are no differences between governmental and non-governmental PHI that results in different patterns of losses to plant collections from a natural disaster. Similar patterns of plant losses sustained from natural disasters at American PHI are apparent.

Table 7.1 The Impact of PHI Governance on Different Patterns of Losses on Plant Collections from a Natural Disaster (n=221)

	Governmental PHI	Non-Governmental PHI
Yes, plants lost	86.5%	87.5%
No plants lost	13.5%	12.5%

Chi Square = .02 df = 1 Significance =n.s. (.86)

The second loss typology, historically significant plant collections, is displayed in Table 7.2. There is no observed relationship found between governmental and non-governmental PHI (x=.33, df=1, sig.= .56). The null hypothesis was accepted. Similar patterns of historically significant plant losses sustained from natural disasters at American PHI are apparent.

Table 7.2 The Impact of PHI Governance on Different Patterns of Losses on Historically Significant Plant Collections from a Natural Disaster (n=196)

	Governmental PHI	Non-Governmental PHI
Yes, historical plants lost	46.9%	47.5%
No historical plants lost	53.1%	52.4%

Chi Square = .33 df = 1 Significance = n.s. (.56)

Test results on losses to facilities and systems, the third loss typology, is revealed in Table 7.3. Again, there is no observed relationship found between the two different PHI governances regarding different patterns of losses from a natural disaster (x=.08, df=1, sig.=

.77). Again, the null hypothesis was accepted. Similar patterns of losses to facilities and systems sustained from natural disasters at American PHI are apparent.

Table 7.3 The Impact of PHI Governance on Different Patterns of Losses on Facilities and Systems from a Natural Disaster (n=219)

	Governmental PHI	Non-Governmental PHI
Yes, facilities and systems lost	58.3%	55.8%
No facilities and systems lost	41.6%	44.2%

Chi Square = .08 df = 1 Significance = n.s. (.77)

The final typology, losses to historically significant facilities and systems, was analyzed and results posted in Table 7.4. No observed relationship was found between the two different PHI governances regarding different patterns of losses from a natural disaster (x=1.37, df=1, sig.= .24). The null hypothesis was accepted. Similar loss patterns to historically significant facilities and systems at American PHI are apparent.

Table 7.4 The Impact of PHI Governance on Different Patterns of Losses on Historically Significant Facilities and Systems from a Natural Disaster (n=145)

	Governmental PHI	Non-Governmental PHI
Yes, historical facilities and systems lost	39.1%	27.0%
No historical facilities and systems lost	60.9%	73.0%

Chi Square = 1.37 df = 1 Significance = n.s. (.24)

Although the case study sites investigated in this research were all comprised of different plant collections and structures, it was obvious that all five sites were subjected to losses. Regardless of governing body, each of these sites had direct or indirect impacts relating to plant collections and facilities and systems. Site specific values on historically significant plants and facilities was the only inconsistency noted in types of losses across the case study sites.

Hypothesis Two

In order to gain insight into conceptual hypothesis regarding preparedness of public gardens as a result of natural disaster experience, past occurrences and current risk perceptions of natural hazards were examined. One outcome from the survey is an inventory of past experiences of natural hazards at PHI and beliefs in future occurrences of these hazards (Table 7.5). The results of this inventory were previously displayed as part of Chapter Four: Natural Hazards and Risk Perceptions.

Across the United States, natural hazards that have been most commonly experienced at least one time since 1980 by public gardens include: severe thunderstorms (91.9%), winds (91.4%), ice/snowstorms (83.3%), drought (79.3%), lightning (77.1%), and hail (73.9%). Flooding has been experienced by just less than one-half (45.5%)of all American PHI. Hazards experienced at least once in the past twenty years by much less than half of all public gardens include landslides (6.3%), wildfire (9.1%), earthquakes (19%), and tornadoes (27.5%).

Results also show that, across the United States, public gardens perceptions of risk is highest for wind (93% belief in future occurrence) followed by severe thunderstorm (91%), lightning (87.4%), hail (86%), drought (84.7%), ice/snowstorm (80.6%) and tornado

(68.9%). These seven hazards are located in the top one-third percentile range. Hazards with perceived levels of risk in a middle-third percentile again only includes flooding (57.2 % belief in future occurrence). The lowest one-third percentile of risk perceptions finds earthquake (31.2% belief in future occurrence), wildfire (30.3%) and landslide (12.2%).

Table 7.5 **American Public Horticulture Institutions' Experiences with a Natural Hazard and Belief about Future Possibilities of Occurrence**

Type of Hazard	Past Occurrence			Belief in Future Occurrence
	Never	Once	Twice or more	
Winds	8.6%	2.7%	88.7%	93.6%
Severe Thunderstorm	8.1%	3.2%	88.7%	91.0%
Lightning	23.0%	7.7%	69.4%	87.4%
Hail	26.1%	12.6%	61.3%	86.0%
Drought	20.7%	18.9%	60.4%	84.7%
Ice/Snowstorm	16.7%	9.0%	74.3%	80.6%
Tornado	72.5%	15.8%	11.7%	68.9%
Flooding	54.5%	13.1%	32.4%	57.2%
Hurricane	59.0%	17.6%	23.4%	44.1%
Earthquake	81.0%	7.7%	11.3%	31.2%
Wildfire	91.0%	5.0%	4.1%	30.3%
Landslide	93.7%	4.1%	2.3%	12.2%

Using the data from Table 7.5, the researched began to investigate the degree of preparedness as determined through increased risk perceptions from past experiences. The following research hypothesis was stated, and was used for all natural hazards listed in Table 7.5:

Is there a relationship between perceptions of risk of a natural hazard with past experiences with that same hazard?

H_0 There is no relationship.

H_1 There is a relationship.

Table 7.6 reveals the statistical significance associated with each natural hazard type experience and the perceptions of encountering them again. For this test, cross-tabulations were conducted on actual hazard experiences versus hazard perceptions. All hazard types reveal significance at the <.001 level. Thus, for all natural hazards, the null hypothesis was rejected, and the alternate hypothesis accepted: there is a relationship between perception and past experience.

Proportional reduction of error (PRE) readings reveal positive relationships between experiencing an event and then believing it will occur again. In addition, all the gamma readings are strong (range of .771 to .974). This suggests that the hazard experience is highly responsible for the correlating hazard's risk perception—the closer a gamma reading is to "1", the stronger the relationship that a change in one variable (experience) will result in a change in the other variable (risk perception). It is interesting to note that of all the hazards' relationship strengths, it is lightning (.771) that is the lowest. Although this gamma reading still shows a relationship between experience and perception, it is markedly lower than the gamma readings for other natural hazards. This suggests that experience with lightning does not necessarily always equate to an increased risk perception at American PHI, when compared to other natural hazards. The author believes may be rooted in a cultural myth—"Lightning does not strike the same place twice."

Table 7.6 **Relationships Between Events that have Occurred and Perceptions that they can Occur Again at American Public Horticulture Institutions**

Hazard Type	Chi-Square value (x^2)	Significance (alpha)	P.R.E. (gamma)
Drought	91.62	<.001	.944
Earthquake	63.23	<.001	.886
Flooding	108.88	<.001	.954
Hail	84.90	<.001	.952
Hurricane	135.26	<.001	.962
Ice/Snowstorm	136.37	<.001	.962
Landslide	77.15	<.001	.974
Lightning	36.48	<.001	.771
Severe Thunderstorm	95.58	<.001	.936
Tornado	30.57	<.001	.910
Wildfire	37.85	<.001	.931
Winds	93.61	<.001	.962

An additional measure of disaster preparedness is determining which factors affect public gardens' risk perceptions, disaster planning and use of recovery resources. Six composite variables were formed using responses from the survey based on twenty years of public gardens' experiences:

- **Total Risk Perception (RP)**—respondents were grouped based upon the total number of natural hazards they believed they are currently at risk of encountering.
- **Total Natural Disaster Experience (NDE)**—respondents were grouped based upon the total cumulative number of natural disasters and hazards experienced.

- **Total Impacts on Plants and Structures (PS)**—respondents were grouped based upon whether their site was impacted with losses to plants and/or structures from a natural disaster.
- **Total Impacts on Historical Plants and Structures (HPS)**—respondents were grouped based upon whether their site was impacted with losses to historically significant plants and/or structures from a natural disaster.
- **Total Amount of Disaster Recovery Assistance Used (DRA)**—respondents were grouped based upon the total, cumulative amount of governmental and non-governmental resources used after a natural disaster.
- **Total Planning (P)**—respondents were grouped based upon their site's current level of disaster planning (disaster response plan and disaster recovery plan).

Table 7.7 provides insight into the distribution of PHI responses in each composite variable. Total Risk Perception was comprised of a possible fourteen natural hazards, and the most that any one PHI stated as being at risk for is eleven natural hazards. The average number of natural hazards PHI representatives believed they were at risk of encountering was 7.5, and nine risks was the most numerous.

Total Natural Disaster Experience was likewise comprised of a possible fourteen natural hazard events, and eleven was the most reported by any one PHI. The average total natural disaster experience by an American PHI is 6.4 and seven natural disasters was the most common response by all PHI in this survey.

Table 7.7 Distribution Matrix of Composite Variables

	Possible Range of Responses	Actual Range Observed from Respondents	Mean	Mode
Total Risk Perception	0-14	0-11	7.5	9
Total Natural Disaster Experience	0-14	0-11	6.4	7
Total Impacts on Plants and Structures	0-2	0-2	1.4	2
Total Impacts on Historical Plants and Structures	0-2	0-2	0.6	0
Total Amount of Disaster Recovery Assistance Used	0-17	0-7	1.5	1
Total Planning	0-2	0-2	0.5	0

Total Impacts on Plants and Structures was comprised of three possible responses: no impacts (0), impact on either plants or structures (1), and impact on both plants and structures (2). The average total impact was 1.4, with most PHI responding that they had experienced both impacts to plants and structures--the mode of two.

Total Impacts on Historical Plants and Structures (HPS) takes into account all entities that may have historical significance, and thus distinguishes itself from the previous Total Impacts on Plants and Structures (PS). However, both the HPS and PS were comprised of the same response structure: 0-2. The average HPS was 0.6, with most PHI responding that they had not sustained any losses to historical plants and structures.

Total Amount of Disaster Recovery Assistance Used was comprised of a possible seventeen resources, both governmental and private in nature. The actual range noted from respondents was that PHI used between 0-7 resources over a twenty year period. PHI on average used 1.5 resources for natural disaster recovery since 1980. Most public gardens had used only one disaster resource in the past twenty years.

Finally, Total Planning was comprised of three possible responses: no plan whatsoever (0), presence of a disaster response plan (1), and presence of a response plan with a recovery plan (2). The possible and observed range of responses was 0-2. The average amount of total planning was 0.5, and most PHI did not have any type of disaster plan extant.

Composite Variable Cross Tabulation Results

The first cross tabulation of composite variables involved the dependent variable 'Total Risk Perceptions" and was governed by this research hypothesis:

Is there a relationship between an experience-related composite variable with the composite variable "Total Risk Perceptions"?

H_0 There is no relationship.

H_1 There is a relationship

Table 7.8 presents that all the results were statistically significant: "Total Disaster Experiences" and "Total Impacts on Plants and Structures" at the <.001 level, "Total

Impacts on Historical Plants and Structures" at the <.05 level, and "Total Amount of Disaster Recovery Resources Used" at the <.01 level. All four independent variables were found to have positive relationships with "Total Risk Perceptions," as seen in correlation values. "Total Natural Disaster Experiences" has a strong relationship (.68) with "Total Risk Perceptions." The null hypothesis was rejected for all cross tabulations in this test, and the alternate hypothesis accepted--there is a relationship between. Again, this lends support for the earlier findings that natural hazard experiences, whether they be of impacts on historical or non-historical entities, affects perceptions of natural hazard risks at public gardens (as presented in Table 7.6). This results also suggests that the past use of disaster recovery resources may contribute to increasing natural hazard risk perceptions.

Table 7.8 Relationships Among Composite Variables that Determine "Total Risk Perceptions" at American Public Horticulture Institutions.

Composite Variable	Correlation Value (Pearson's R)	Level of Significance (alpha)
Total Natural Disaster Experiences	.68	<.001
Total Impacts on Plants and Structures	.28	<.001
Total Impacts on Historical Plants and Structures	.15	<.05
Total Amount of Disaster Recovery Resources Used	.19	<.01

To determine which composite variables affect disaster planning at public gardens, the researcher conducted three related cross tabulations. The first of these tests was governed by the following research hypothesis:

Is there a relationship between other specified composite variables with the composite variable "Total Planning"?

H_0 There is no relationship.

H_1 There is a relationship.

The null hypothesis was accepted for three of the five composite variables (Table 7.9). No relationship exists between "Total Planning" and: "Total Risk Perceptions" (s=.18), "Total Natural Disaster Experience" (s=.21) or "Total Amount of Disaster Recovery Resources Used" (s=.08). Only the results concerning the two remaining independent variables were found to be statistically significant, "Total Impact on Plants and Structures" and "Total Impacts on Historical Plants and Structures"--both at the <.01 level.

Risk perceptions and past experiences (with natural hazard events and the actual use of recovery resources) does not consistently or readily result in drafting of policy at American PHI. What does affect total planning is total impacts, that is, physical damage resulting from a natural disaster. These results suggest that American public gardens undertake disaster planning because of previous impacts, regardless if impacts are to plants and buildings of a historical or non-historical nature. These results also show that total risk perceptions to natural hazard events has no effect on disaster planning. Moreover, not even past hazard experience seems to have propelled PHI to undertake disaster planning.

Table 7.9 **Relationships Among Composite Variables that Determine "Total Planning" (Response + Recovery Plans) at American Public Horticulture Institutions.**

Composite Variable	Correlation Value (Pearson's R)	Level of Significance (alpha)
Total Risk Perception	.09	n.s. (.18)
Total Natural Disaster Experience	.08	n.s. (.21)
Total Impacts on Plants and Structures	.18	<.01
Total Impacts on Historical Plants and Structures	.18482	<.01
Total Amount of Disaster Recovery Resources Used	.11669	n.s. (.08)

Next, each of individual plans that comprised the composite variable "Total Planning" was cross tabulated against the same list of independent variables. It was hoped that this would provide insight to learn of any discrepancies between the factors affecting the presence of a disaster response plan and the recovery plan. These tests were governed by this research hypothesis:

Is there a relationship between other specified composite variables with the individual variable "Response Plan Present/Recovery Plan Present"?

H_0 There is no relationship.

H_1 There is a relationship.

Further investigation reveals, through Table 7.10, that only "Total Impacts on Historical Plants and Structures", with a <.01 level of significance, had a relationship with the presence of a disaster response plan at American PHI. No relationships were found with the other composite variables.

Preliminary background research on disaster planning at cultural institutions across the United States revealed an interesting insight to the researcher. In comparison to public gardens, much more published planning and had taken place at heritage sites, whether as a required for museum accreditation or assumed museum management practices. From this knowledge, it is possible to surmise that a historical plant or building management responsibility may be what is propelling some PHI to undertake disaster response planning.

Case study institutions provide some support to this finding. Most notably, The Hermitage had an extant response plan at the time of the tornado. However, other non-historic sites also had taken the initiative to draft response plans: Gustavus Adolphus College (Linnaeus Arboretum) and Longwood Gardens, and the Harris County Emergency Management (Mercer Arboretum and Botanic Gardens). Fairchild Tropical Garden did not have a plan at the time of Hurricane Andrew. One cannot completely explain why certain PHI did or did not have a response plan at the time of their disaster based on the case study sites. There may have been other factors that led to the drafting of response plans, such as a human liability issues at a residential college, insurance auditing, or simply sound management practices. These factors were not researched in the course of this thesis.

Table 7.10 **Relationships Among Composite Variables that Determine Presence of the Disaster Response Plan at American Public Horticulture Institutions.**

Composite Variable	Correlation Value (Pearson's R)	Level of Significance (alpha)
Total Risk Perceptions	.09	n.s. (.20)
Total Natural Disaster Experiences	.08	n.s. (.21)
Total Impacts on Plants and Structures	.12	n.s. (.08)
Total Impacts on Historical Plants and Structures	.17	<.01
Total Amount of Disaster Recovery Resources Used	.06	n.s. (.37)

Similar cross tabulations were conducted using the singular disaster recovery plan against composite variables (Table 7.11). Statistical significance is noted only with variable "Total Impacts on Plants and Structures" at the <.01 level. Here, the null hypothesis was rejected and the alternate hypothesis accepted. No other composite variable revealed relationships and thus null hypotheses were accepted based on alpha values.

Unlike that noted for the response plan (see Table 7.10), "Total Impacts on Historical Plants and Structures" did not reveal any relationship with the presence of a recovery plan at American public gardens. Simply put, it is direct losses to plants and structures that enticed PHI to create a disaster recovery plan. Only one case study site actually drafted a recovery plan from its experience.

Surprising is the fact that perceptions or past experiences with hazards did not, in themselves, warrant creation of a recovery plan at PHI, as some literature would suggest.

PHI that had disaster recovery plans also had disaster response plans in this study. These PHI also likely created their plans based on past impacts to historical fabric at their site. The researcher is uncertain to the exact factor that caused a PHI to create a response plan, but stop short of then also creating a recovery plan, since these findings suggest that recovery planning is promoted after further losses to plants and structures. Commentary from case study interviewees suggests that PHI may not view a recovery plan for each hazard worth all the intricate time and investigation needed for its creation. Perhaps these PHI are not completely familiar with the intent of a recovery plan, and perceive that such a plan must specifically lay out every resource to use after a disaster. Or, as in the case of one case site, recovery planning was facilitated by an outside service provider under the insurance contract—thus, there was little need for the site to carry the sole responsibility of planning all aspects of recovery.

Table 7.11 Relationships Among Composite Variables That Determine Presence of the Disaster Recovery Plan at American Public Horticulture Institutions.

Composite Variable	**Correlation Value** (Pearson's R)	**Level of Significance** (alpha)
Total Risk Perception	.01	n.s. (.91)
Total Natural Disaster Experiences	.01	n.s. (.95)
Total Impacts on Plants and Structures	.18	<.01
Total Impacts on Historical Plants and Structures	.13	n.s. (.06)
Total Amount of Disaster Recovery Resources Used	.13	n.s. (.07)

Finally, the composite variables that concerned actual disaster experiences or losses were cross tabulated with the independent variable "Total Amount of Disaster Recovery Resources Used". This test provided information on the factors that would cause American PHI to use recovery resources from many sources. The research hypothesis was:

Is there a relationship between other specified composite variables with the individual variable "Total Amount of Disaster Recovery Resources Used"?

H_0 There is no relationship.

H_1 There is a relationship.

All independent variables were statistically significant at the <.001 level (Table 7.12). All null hypotheses were rejected and alternate hypotheses accepted. Each also demonstrated a positive relationship with "Total Amount of Disaster Recovery Resources Used". Such results suggest to the researcher that PHI will likely utilize recovery resources as the situation warrants: experiences and impacts affects the need (total amount) of resources. More experience with locating and using a recovery resource will likely assist the PHI in knowing who and what to solicit in a time of future need from a disaster. However, the researcher believes there likely are other factors extant that may better indicate what affects recovery resource solicitation and ultimate usage. Case study sites were either familiar with people to contact from past disaster experiences (or networking), or the scope of damage prompted staff to search outside of the organization for specific resources,

Table 7.12 **Relationships Among Composite Variables that Affect Total Recovery Resource Assistance Used at American Public Horticulture Institutions.**

Composite Variable	**Correlation Value** (Pearson's R)	**Level of Significance** (alpha)
Total Natural Disaster Experiences	.26	<.001
Total Impacts on Plants and Structures	.31	<.001
Total Impacts on Historical Plants and Structures	.22	<.001

Hypothesis Three

To determine if public gardens were utilizing recovery resources within their respective governing organizations, composite variables were again created from the survey data. Using secondary data sources, each respondent PHI was placed into either the "governmental" or "non-governmental" governance category. Universities and colleges were omitted from this grouping due to lack of specific information differentiating between those that are state-funded or private-funded.

The distribution matrix of these recovery resource composite variables are shown in Table 7.13 for the reader's information. Through question 9 of the survey (Appendix A), PHI collectively responded with a range of 0-9 different governmental and non-governmental resources used between 1980-1999 for recovery. On average, PHI used either governmental or non-governmental resources less than one time during this time period. Most PHI responded that they had not used any resources.

Table 7.13 **Distribution Matrix of Recovery Resource Composite Variables**

	Possible Range of Responses	Actual Range Observed from Respondents	Mean	Mode
Use of Governmental Recovery Resources	0-9	0-3	.5	0
Use of Non-Governmental Recovery Resrouces	0-9	0-6	.9	0

To begin to test the third hypothesis, Table 7.14 reveals the compared usage of various recovery resources by governmental and non-governmental PHI during the survey period 1980-1999. Non-governmental PHI were much more dependant upon securing help from both governmental and non-governmental sources when compared to governmental PHI.

Table 7.14 **Percentage of American PHI that Utilized Different Types of Recovery Resources During the Survey Period 1980-1999.**

	Governmental Resources	Non-Governmental (Private) Resources
Governmental PHI	23.7%	16.5%
Non-Governmental (Private PHI)	76.3%	83.5%

Recovery resources were grouped into composite "governmental" or "non-governmental" categories, as presented in the survey, based on participating public gardens' twenty year experiences. Once these composite variables were created, they were cross tabulated to determine if statistically-based relationships existed between the amount of resources used by the two PHI governances. The research hypothesis stated:

Is there a relationship between the amount of governmental or non-governmental recovery resources with PHI goverances?

H_0 There is no relationship.

H_1 There is a relationship.

Statistical significance (Table 7.15) was found with the use of governmental recovery resources (df= 1, s=<.001). The null hypothesis was rejected and the research hypothesis accepted. There is a relationship between the amount of governmental recovery resources used by the PHI governances.

Conversely, the null hypothesis was accepted (df=1, s=.24) regarding the amount of non-governmental recovery resources used by the two PHI governances. This suggests that at American PHI, there was no relationship between the amount of private resources used and whether or not the affected PHI was a governmental or private garden.

Table 7.15 **Relationships Between Composite Variables That Reveal Use of Recovery Resources Across Governing Bodies at American Public Horticulture Institutions.**

	Correlation Value (Pearson's R)	Chi-square Value	Significance (alpha)
Governmental Recovery Resources	.39	26.46	<.001
Non-Governmental Recovery Resources	-.05	7.94	n.s. (.24)

The data presented in Tables 7.14 and 7.15 was also interpreted by the researcher to suggest that governmental PHI did not attempt to secure or utilize recovery resources as much as private PHI. This study did not investigate factors that would affect the acceptance of resources, however, this data tends to reveal a trend that governmental public gardens have more resources within themselves (within their governing organization) to recover from a natural disaster. Governmental PHI and non-governmental PHI are utilizing governmental recovery resources. The difference lies in that the private PHI are requesting outside public resources for their recoveries and the publicly funded governmental PHI are acquiring these same resources from with the public sector.

SUMMARY

Hypothesis One

There are no statistically based differences between governmental and non-governmental PHI losses sustained due to a natural disaster during the period 1980-1999 in the United States. Both PHI governances experienced losses to plant collections, facilities and systems, historically significant plant collections and historically significant facilities and systems.

Hypothesis Two

All natural hazards investigated by the survey instrument revealed a strong relationship between experience and a subsequent change in risk perception. In addition, relationships also were noted between 'Total Risk Perceptions' and each of the composite variables 'Total Disaster Experience', 'Total Impacts on Plants and Structures', 'Total Impacts on Historical Plants and Structures' and 'Total Amounts of Disaster Recovery Resources Used'.

However, these observed increases in natural hazard risk perceptions were not found to have any affect on the creation of disaster response or recovery plans at PHI. What the research did find was that 'Total Impacts on Historical Plants and Structures' had an effect on the existence of a disaster response plan. 'Total Impacts on Plants and Structures' was found to be only variable that had an effect on the presence of a disaster recovery plan.

Hypothesis Three

Although both governmental and non-governmental (private) PHI were found to have utilized both governmental and non-governmental (private) recovery resources, the statistical analysis revealed that only governmental recovery resources were being used by both governance sectors of American PHI. This hints that governmental PHI are using governmental recovery resources (within the governing authority) whereas private PHI were using governmental recovery resources (outside of the governing authority). Thus, this leads this researcher to believe that governmental PHI, in general, will have more resources within themselves to recover from a natural disaster. Again, this research did not investigate the factors that affect the actual acceptance and use of different types of recovery resources.

Chapter 8

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This research utilized qualitative case studies interviews and a quantitative national survey involving 224 American Public Horticulture Institutions to examine natural hazard perceptions, natural disaster experiences and recovery. A discussion on natural hazard and American PHI perceptions of risk first educated and prepared the reader to become familiar with actual public garden natural disaster experiences. This discussion also provided a foundation to begin to understand how American PHI, on the whole, have been addressing issues relating to natural disaster management.

Five case study sites, all of which experienced a natural disaster, led the researcher to develop **a list of common trends observed that PHI should be aware of regarding natural disaster impacts, response and recovery**. Although specific management responsibilities and circumstances may vary from one public garden to the next, these issues should be considered when a public garden commences a disaster planning process. **These issues, as listed in Chapter Six (Figure 6.1, page 154), were found to be both of a reactive nature and filled with opportunities.**

Public gardens must be aware of the negative repercussions of a natural disaster experience. These negative effects go well beyond the obvious destruction to plants or buildings from the forces of nature. Reactive challenges include issues such as: the extent of devastation across the greater community, availability of workers and accessibility to and from the garden, effects on staff morale and welfare, need for leadership and guidance of response and recovery strategies, how to implement these strategies, prioritizing the response and recovery efforts, creating effective communication lines, managing in-kind assistance during the recovery, managing the barrage of indirect impacts and site disruptions that follow the direct hazard hit, and managing the process of acquiring and using recovery resources.

The apparent detrimental effects of a natural disaster experience may be offset if public gardens anticipate and plan for maximizing opportunities during recovery. The reality of losses to plant collections or facilities cannot be diminished; however, the public garden can grow and be strengthened as an organization if opportunities are identified during the response and recovery period. Opportunities arise in changes and improvements to the site's: horticultural integrity, public relations and perceived community value, internal organizational processes and policies, and ability and chance to implement construction projects. One cannot fail to realize the potential of public garden staff and advocates to liaise, cooperate and think creatively to meet the challenge of recovering from a natural disaster and learning from the experience.

Regarding the collective experiences of American PHI, results from this study's survey showed **that a vast majority of PHI have no disaster plan whatsoever** (Table 2.1, page 14). It is quite likely that PHI, like other businesses, simply do not place disaster planning at the forefront of their efforts (Table 2.2, page 15). **There are, however, PHI that have taken steps to plan**. **This study did not attempt to investigate all factors**

that were propelling disaster planning at PHI, but it seems that past disaster experience is certainly one factor.

In Chapter Seven, research hypotheses were statistically tested to support or disprove three conceptual hypotheses first presented in Chapter One. The first of these conceptual hypotheses, that losses to PHI from natural hazards are similar, was tested. Tables 7.1-7.4 (pages 173-174) indicate that **there are statistically no differences between governmental and non-governmental PHI regarding losses sustained from natural disasters during 1980-1999. The researcher anticipates this similarity in losses across PHI to continue without prejudice**.

The second conceptual hypothesis, which stated the idea that PHI are better prepared to handle the process of disaster recovery as a result of a previous disaster experience, was also tested. Table 7.5 (page 176) shows that past experiences do have a direct effect on increased perceptions of risk. However, Tables 7.9-7.11 (pages 184, 186-187) reveal that **perceptions did not result in disaster planning**—one step that would help PHI better handle disaster recovery. Furthermore, it was found that the **creation of a disaster response plan was fueled only by past impacts on historically significant plants and facilities. The creation of a disaster recovery plan was only made after sustaining losses to plants and facilities from a natural disaster**. In both these cases, planning was indeed affected from a past disaster experience, and lends some, but not overwhelming support to the hypothesis that PHI are better prepared to handle disasters and disaster recovery processes as a result of past experiences. The fact that PHI total perceptions, total natural disaster experiences and total amount of disaster recovery assistances used did not result in the similar end of creation disaster plans tends to diminish an argument that all experiences indeed result in better preparedness.

Thus, this researcher is not fully convinced that PHI in general are better prepared to deal with a disaster or recovery. The fact that 61% of PHI do not have disaster plans shows that public gardens are not bridging the gap between having a belief in future occurrences of a natural hazard and actually planning to offset the hazard's potential impacts. Also, when commentary from case study interviews is combined with these data, the researcher is not certain that all experiences are truly being documented and internalized within PHI organizations leading to creation or modification to disaster plan documents. It is more likely that individuals at a PHI are internalizing their experiences and becoming more prepared. Unfortunately, as these staff leave the PHI, their perceptions, experiences and recovery resources contacts and savvy are likely not to fully remain at the PHI.

The last conceptual hypothesis claims that public gardens do not have the resources within themselves to recover from a natural disaster. Survey responses and statistics results, as shown in Tables 7.14 and 7.15 (pages 190 and 192) show that **governmental and non-governmental PHI are using both governmental and non-governmental (private) recovery resources. However, statistical analysis reveals that governmental recovery resources are being called upon more consistently than non-governmental resources**. For this reason, governmental PHI are using resources within themselves (within their governing authority) to recover from natural disasters. Non-governmental PHI are utilizing both governmental and private resources, and thus cannot be seen as having the resources within themselves.

Recommendations

In order to advance natural disaster planning and dialog among American PHI, the researcher suggests that several actions be taken. **<u>The first action is further research</u>**. As this was the first known investigation into natural disasters specific to public gardens, there remains a wealth of opportunity to learn about factors that may affect or control PHI natural hazard perceptions and disaster planning policies. Further study could be done regarding:

- Compare disaster perceptions, preparedness and experiences among different PHI across the ten FEMA regions of the US.
- Interview PHI to learn what factors motivate the physical creation and implementation of written disaster response and recovery plans.
- Learn the parameters and scope of insurance coverages purchased by PHI.
- Total disaster impacts, as quantifiable in dollars, of natural hazards at American PHI during the 1990s.
- Programs and resources available within American society that have effectively led PHI to become more disaster prepared or resilient.
- Investigate natural disaster experiences between governmental and non-governmental PHI based on similar mission statements, organization types, age, financial statement, and perceived public values, among others.
- Investigate the relevancy of this study's reactive trends and opportunities to difference governances of PHI that have experienced a natural disaster.
- Compare American PHI natural disaster experiences and recovery issues with PHI experiences in Canada, and also in other countries.

Secondly, with a network of PHI already extant with the AABGA, this researcher feels that **<u>a national standard for measuring and comparing impacts and a database for sharing information on natural disasters at public gardens can be created</u>**. Public gardens are at a particular risk to natural hazards, as the management requirements of plant collections constantly come in direct contact with natural forces. *The Impacts of Natural Disasters* (1999) has already presented thoughts and recommendations on creating a consistent measure for natural disaster impacts; American PHI can be one area where such a measurement could be drafted, tested and evaluated. Besides insurance and governmental emergency assistance payouts, there is also much hyperbole and dramatic descriptions being used to inventory and compare disaster impacts at public gardens. There is an opportunity to create an industry benchmark for comparing and discussing natural disaster impacts at public gardens. Such components of this benchmark could include insurance payouts as well as the raw number of plants lost, length of business closure, hours of labor required for response and recovery, and duration of time in which indirect impacts of the natural disaster manifest themselves on plants. **The AABGA membership should also draft a standard template for a disaster response and recovery plan relevant for use by public horticulture institutions**.

Certainly, public gardens cannot be expected to abandon their current endeavors to intensively and exclusively plan for a potential future natural disaster experience. **Public gardens,** *at a minimum*, **need to investigate and become aware of their plant collections' and overall organizations' vulnerabilities to natural hazards and act accordingly. They also can identify mitigation strategies that will make their sites more resistant to the powers of natural hazards and their impacts**. As stewards of living plant collections and as societal leaders in the maintenance, conservation and enjoyment of the plant world and horticultural landscapes, public gardens must take actions to ensure the viability and perpetuity of these natural and cultural resources for generations to come.

"An organization without a disaster planning and recovery strategy is abdicating its responsibilities to its people, its customers and other constituencies, its investors and other stakeholders, and to its community (Levitt 1997)."

APPENDIX A

QUANTITATIVE MAIL SURVEY INSTRUMENT

Natural Disaster Experience and Disaster Recovery at Public Horticulture Institutions in the USA

Longwood Graduate Program
University of Delaware
153 Townsend Hall
Newark, DE 19717-1303
(302) 831-2517

This questionnaire is being distributed to all Institutional Members of the AABGA in the United States. The Longwood Graduate Program is funding this project at the University of Delaware. The study focuses on perceptions of natural threats, disaster experiences and disaster recovery resources. This study only focuses on natural hazards caused by geological, atmospheric or hydrological processes. Please take a few moments to respond to the questions presented in this document.

As required by regulations and ethics governing the conduct of survey research, your responses will be kept confidential. The following code identifies you only for data analysis and a survey response inventory:

____

When you have completed the survey, please return it in the enclosed pre-paid envelope. Thank you for taking part in this study.

1. Which of the following natural hazards do you think could occur in your area and affect your institution's facilities and plant collections?

[PLEASE CIRCLE ONE ANSWER FOR EACH HAZARD LISTED]

EARTHQUAKE/SHAKING	YES	NO
LANDSLIDE	YES	NO
FLOODING	YES	NO
HURRICANE	YES	NO
SEVERE THUNDERSTORM	YES	NO
TORNADO	YES	NO
HAIL	YES	NO
HIGH WIND/GALES	YES	NO
ICE/SNOWSTORM	YES	NO
LIGHTNING	YES	NO
WILDFIRE	YES	NO
PROLONGED DROUGHT	YES	NO
OTHER (specify, if any)		
______________________	YES	NO

[PLEASE CONTINUE TO THE NEXT PAGE]

2. Which of the following natural hazard events have occurred at your institution in the past twenty years?

	NEVER	*ONCE*	*TWO OR MORE TIMES*
EARTHQUAKE/SHAKING	❐	❐	❐
LANDSLIDE	❐	❐	❐
FLOODING	❐	❐	❐
HURRICANE	❐	❐	❐
SEVERE THUNDERSTORM	❐	❐	❐
TORNADO	❐	❐	❐
HAIL	❐	❐	❐
HIGH WIND/GALES	❐	❐	❐
ICE/SNOWSTORM	❐	❐	❐
LIGHTNING	❐	❐	❐
WILDFIRE	❐	❐	❐
PROLONGED DROUGHT	❐	❐	❐
OTHER (as specified in Question 1) ______________________	❐	❐	❐

[IF ALL BOXES CHECKED ABOVE ARE "NEVER," PLEASE SKIP TO QUESTION 10]

3. Did your institution experience physical losses and damages to ***plant collections*** as a direct result of any of the experiences indicated in Question 2?

❐YES
❐NO **[GO TO QUESTION 5]**

4. Were any of these plant collections of historical significance?

❐YES
❐NO

5. Did your institution experience physical losses or damages to ***facilities and operational systems*** as a direct result of any of the experiences indicated in Question 2?

   ❐ YES
   ❐ NO [**GO TO QUESTION 7**]

6. Were any of these facilities and systems (and their non-plant components) of historical significance?

   ❐ YES
   ❐ NO

7. Referring to Question 2, please indicate the natural disaster that has resulted in the **greatest damage or disruption** to your institution in the past twenty years.

   The phrase **"damage or disruption"** includes physical damage as well as disruption of operations and ability to fulfill your mission statement.

   Type of Natural Hazard ____________________________

   Event Name (if appropriate)____________________________

   Year It Happened ________________

8. Briefly, list the damage and disruption that this event caused at your institution:

   [YOU MAY WANT TO INCLUDE ANY REFERENCES TO AMOUNT OF COLLECTIONS LOST, SEVERITY OF DAMAGE TO FACILITIES, AMOUNT OF TIME YOUR INSTITUTION MAY HAVE CLOSED, LOST REVENUES, RECOVERY OR REPLACEMENT COSTS, ETC.]

9. Which of the following resources (if any) did your institution use to assist in the recovery efforts after any disaster events checked in Question 2? **[CHECK ALL THAT MAY HAVE BEEN USED IN THE PAST TWENTY YEARS.]**

Governmental Resources

- ☐ Federal Emergency Management Agency (FEMA)
- ☐ US Dept of Agriculture (USDA)
- ☐ IRS (loss of income credit)
- ☐ Small Business Administration (SBA)
- ☐ State funds
- ☐ County funds
- ☐ City funds
- ☐ Other resource (specify)
- ☐ Other resource (specify)

Non-Governmental Resources

- ☐ Private Sector Monetary Loan
- ☐ "Friends" group [501 (c)3 status]
- ☐ Individual gifts and donations
- ☐ Own contingency funds
- ☐ Own endowment
- ☐ Insurance claims (specify types)
- ☐ Corporate assistance (specify)
- ☐ Professional and other Botanical Garden/Museum assistance (specify assistance)
- ☐ Other resource (specify)

[PLEASE CONTINUE TO THE NEXT PAGE]

Now let's turn to efforts your institution may have initiated regarding natural hazards and disasters.

10. Does your institution have a <u>disaster response plan</u>?

    ☐ YES . . . . . . Year of adoption ________________
    ☐ NO . . . . . . **[GO TO QUESTION 12]**

11. Does your disaster response plan have sections (or annexes) for different types of disasters?

    ☐ YES
    ☐ NO

12. Does your institution have a <u>disaster recovery plan</u>?

    ☐ YES . . . . . . Year of adoption ________________
    ☐ NO . . . . . . **[GO TO QUESTION 14]**

13. What was the stimulus for the development of your disaster recovery plan?

14. On a scale of "1 to 10" ("1" being extremely low and "10" being extremely high), how would you rate your institution's level of planning for and securing resources in anticipation of a natural disaster? **[CIRCLE THE NUMBER ON THE SCALE]**

    1 2 3 4 5 6 7 8 9 10

    ← Low priority High priority →

15. Would your institution be willing to participate as a future case study site on disaster reduction and recovery planning?

    ☐ YES
    ☐ NO

Thank you for taking the time to complete this survey. Your input is valuable and will assist us in understanding the issues that Public Horticulture Institutions must face from natural disasters.

Please place completed survey in the return (postage-paid) envelope and mail as soon as possible.

APPENDIX B

HUMAN SUBJECTS EXEMPTION FOR SURVEY PORTION OF RESEARCH

UNIVERSITY OF DELAWARE

OFFICE OF THE VICE PROVOST FOR RESEARCH

210 Hullihen Hall
University of Delaware
Newark, Delaware 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

17 March 1999

Mr. James Burghardt
Longwood Graduate Program
Campus

Dear Mr. Burghardt:

Subject: Human subjects approval for "Natural perils and disaster recovery at public horticultural institutions"--survey portion only

The above-referenced proposal, which you submitted for human subjects approval, will qualify as research exempt from full Human Subjects Review Board review under the following category:

> Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless (1) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects, and (2) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

This exemption is for the survey portion of this project only. Separate review and approval of the proposed case studies will be required. Please submit information describing the case-study portion of the research before enlisting the three to five participants in the study.

Under university and federal policy, all research, even if exempt, shall be conducted in accordance with the Belmont Report, copies of which are available from this office. Please notify the Human Subjects Review Board if you plan any changes in this project.

Sincerely,

Costel Denson

Costel D. Denson
Vice Provost for Research
Chair, Human Subjects Review Board

cc: James Swasey

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APPENDIX C

SEMI-STRUCTURED CASE STUDY INTERVIEW SCHEDULE

Semi-Structured Interview Schedule

I. Characteristics of the Natural Disaster That Occurred

Tell me about the characteristics of the natural disaster event(s).

- *What was the date of this event(s)?*
  Does this event have an accepted name/ title? Specify.
- *What are some of the measured strengths of this particular event? How large of a geographic area was affected by this event(s)?*
- *Was this event a federally declared disaster? A state declared disaster?*
- *Were there any human casualties from this event?*

II. Losses Sustained from this Event

What loss (as quantified in dollars, if available) occurred to your

- *Plant Collections?*
- *Buildings?*
- *Infrastructure (paths, roads, fencing, etc.)?*
- *Records and Documents?*
- *Equipment and supplies/ inventory?*
- *Libraries?*
- *Others (i.e. ornamentation, artworks, furniture, etc.)?*
- *Business Income (a result of business interruption)*

What damage, if any, occurred as a result of 'clean-up' activities after the natural hazard event?

III. Disruptions to Organization in the Recovery Process

Did the site encounter any disruptions of the following (that affected your ability to function during the recovery period?):

- *Electricity?*
- *Telephone?*
- *Water?*
- *Physical Access:*

- *From off site to the site?*
- *To areas within the site?*
- *To organizational data/records?*

- *HVAC?*
- *Facility relocations:*
    - *Of production areas (nursery, greenhouses)*
    - *Visitor amenities (visitor center, restaurant, parking, entrance, etc.)*
    - *Business (administrative) offices*
    - *Operational/Maintenance facilities*
- *Employee (worker) Availability?*
- *Site Income?*

How long was the property (or parts of the property) closed?

IV. Process Used to Evaluate and Inventory Losses (includes organizational expertise AND external consultants/assessors)

Plant Collections:

- *Whose task was it to document, evaluate and assess the losses?*
- *What method was used?*
- *How long did the process take?*

Buildings:

- *Whose task was it to document, evaluate and assess the losses?*
- *What method was used?*
- *How long did the process take?*

Infrastructure (paths, roads, fencing, etc.):

- *Whose task was it to document, evaluate and assess the losses?*
- *What method was used?*
- *How long did the process take?*

Records and Documents:

- *Whose task was it to document, evaluate and assess the losses?*

- *What method was used?*
- *How long did the process take?*

Equipment and supplies/inventory:

- *Whose task was it to document, evaluate and assess the losses?*
- *What method was used?*
- *How long did the process take?*

Libraries:

- *Whose task was it to document, evaluate and assess the losses?*
- *What method was used?*
- *How long did the process take?*

Others (i.e. ornamentation, artworks, furniture, etc.):

- *Whose task was it to document, evaluate and assess the losses?*
- *What method was used?*
- *How long did the process take?*

Business Income (a result of business interruption):

- *Whose task was it to document, evaluate and assess the losses?*
- *What method was used?*
- *How long did the process take?*

V. Processes and Factors in Selection, Locating and Securing Recovery Resources

- *What strategies did have in place at the time of the event that would cover (or help compensate for) any losses from a natural hazard?*
- *In this circumstance, was your goal to fully recover from the disaster, partially recover, or undertake no recovery efforts whatsoever?*
- *What resources within the organization did you have and were utilized in the recovery effort?*
- *What was the greater community's reaction to learning of damage to your site?*
- *What type of media coverage did you receive after the disaster?*
- *What was your relationship with the media immediately after the natural disaster?*
- *What was your relationship with the media during the recovery process?*

- *What information-sharing occurred with returning or visiting people to your site after the disaster and during recovery?*
- *How was debris moved and disposed from your site?*
- *Were there any issues regarding volunteers and/or donations/in-kind assistance offered?*
- *Who was involved in selecting, locating, and securing recovery resources?*
- *How did you learn of resources?*
- *When did you learn of these resources?*
- *When did you accept/use these resources?*
- *Overall, how much time elapsed from you identifying a recovery need to locating it to finally utilizing on site?*
- *Was there any assistance offered to you that you refused? Why?*
- *If you had a recovery plan at the time, did the plan help or hinder your recovery efforts and process?*

VI. Recovery Resources Utilized

- *Which resources (financial, material, horticultural, consultative, personnel, etc.) did you actually use for your recovery*? [be specific for areas mentioned in **QIII.**]
- *What percentage of these utilized resources came from within your organization?*
- *Were there any resources you wish you could have located that you needed?*
- *What delays or unexpected problems did you encounter in getting the assistance you expected?*

VII. Opportunities for Mitigation

- *During the recovery process, were any additional strategies or plans identified that might prevent this type of damage from occurring in the future? Were any of these implemented in the reconstruction/rehabilitation efforts?*
- *Were there any local/state ordinances that directed or mandated your preventative strategies and plans for the future?*

VIII. Length of the Recovery Period

- *Have you recovered from this event yet? (Explain)*
- *If so, how much time expired before the "recovery process" was completed?*

- *Is your organization's overall health/status better off, worse off or about the same as a result of the natural disaster?*

IX. Institutional Learning

- *What have you learned from your natural disaster experience?*
- *Has this natural disaster experience changed your site's:*
    - *Disaster response plan?*
    - *Disaster recovery plan?*
    - *Risk Management strategies?*
    - *Insurance coverage?*
- *Did you get disaster recovery assistance from the sources you expected?*
- *Was this assistance more or less than what you had expected before the disaster?*
- *On a scale of 1-100 (1 meaning not even remotely prepared, and 100 meaning extremely prepared), how prepared were you to deal with disaster recovery in the immediate aftermath of the natural disaster?*
- *And now, using the same scale, how prepared are you to recover from a natural disaster?*
- *Consider your organization's <u>overall health</u> (personnel, finances, productivity, etc.) prior to the disaster. Today, now that you have gone through a disaster, would you say your organization's health is worse off, better off, or about the same as it was before the disaster?*
- *May I have a copy of your disaster response plan?*
- *May I have a copy of your disaster recovery plan?*
- *How often are these plans revised and/or updated?*

X. Organizational Background Information

- Brief history of the site, botanical collection and other support groups.
- What is your annual operating budget?
- What is your acreage?
- How many staff (PT, FT, volunteer)?
- Have you any slides or other visuals documenting the peril, the response and recovery?

APPENDIX D

HUMAN SUBJECTS APPROVAL FOR CASE STUDY PORTION OF RESEARCH

HUMAN SUBJECTS REVIEW BOARD ACTION

University of Delaware
Newark, DE 19716

Protocol title: **Natural disaster experience and recovery at public horticulture institutions**

Principal investigator(s): **James Burghardt and James Swasey**

HSRB number: **HS 99-219**

Type of review: ☒ Expedited ☐ Full Board

The Human Subjects Review Board has reviewed the above-referenced protocol with respect to (1) the rights and welfare of the subjects; (2) the appropriateness of the methods to be used to secure informed consent; and (3) the risks and potential benefits of the investigation, and has taken the following action:

☐ Approved without reservation

☒ Approved as revised

☐ Disapproved for reasons noted below

Approval date: **23 July 1999**

Approval period: **1 year**

Expiration date: **22 July 2000**

Submittal date for
continuing review: **22 June 2000**

Changes in this protocol must be approved in advance by the HSRB.

Comments:

Costel D. Denson

Date July 23, 1999

Dr. Costel D. Denson
Vice Provost for Research
Chairman, Human Subjects Review Board
210 Hullihen Hall
302-831-4007, 302-831-2828 fax
cddenson@udel.edu

APPENDIX E

RESEARCH CONSENT FORM

RESEARCH CONSENT FORM

"Natural Disaster Experience and Recovery at Public Horticulture Institutions"

Researcher: James Burghardt, Longwood Graduate Fellow
Address: 153 Townsend Hall, University of Delaware, Newark, Delaware 19717-1303
Phone: (302) 831-2517

Thank you for agreeing to participate in this research study which will take place at your institution on January 1 and 2, 2000. This form outlines the purposes of the study and provides a description of your involvement and rights as a participant.

Purpose of this Research

The purposes of this research study are to identify issues relating to Public Horticulture Institution recovery efforts as a result of a natural disaster and to help inform policy on issues relating to a recovery process. Moreover, this research will fulfill the requirement necessary to receive a MS in Public Horticulture at the University of Delaware.

Your institution was selected as a case study subject based on the following criteria (Your institution met all of these criteria based on responses to an initial survey completed in April 1999):

- Management of a living plant collection
- Current AABGA institutional membership
- Location in the Eastern United States
- Sustained losses from a natural disaster since January 1, 1990
- This natural disaster was weather or flood based (not seismic)

As a participant in this study, the institutional director is requested for an in-depth interview. The case study visit shall be no more than two business days. The researcher will come to your institution. During this period, general background information on the institution will be asked, as well as inquiry into the disaster event and the subsequent recovery process. If you grant permission for audio taping, no audio tapes will be used for any purpose other than to complete this study. These audio tapes will be accessible and identifiable only to the researcher above named in a secure location. The tapes will be transcribed (used in qualitative analysis) and will be returned to you upon your request, or destroyed upon acceptance of the researcher's thesis. From the information collected from this site visit, a case report will be written and included in a published thesis. You will receive a copy of the final case report for approval prior to thesis publication.

In addition to your institution, there are four other public horticulture institutions earmarked for participation in this research.

Conditions of Subject Participation

Your participation in this research study is entirely voluntary, and there will be no consequences to you or your institution in the event that you wish to terminate participation in the study. Confidentiality of the institutional director and any subsequent naming of individuals in the course of the interviews will be guaranteed. The participant, after the site interview, will have the sole decision as to whether the institution's name will remain concealed or become public for subsequent reporting of study data. In the event you wish to retain your institution's name, a pseudonym will be created and used in all published documents.

Your participation in this study may be terminated by the researcher in the event it is learned that, through the course of the interview, the institution has not met the above listed five case study selection criteria.

Risks and Benefits

Benefits to your institution rising from your participation may include a comprehensive evaluation of past natural disaster recovery processes, and potential to inform policy at other public gardens at risk for natural disasters.

Overall, there are no foreseeable risks to you through your participation in this research. Interview questions concerning decisions on recovery and mitigation strategies may have potential to impact future employability. For this reason, the researcher will exercise caution in order to maintain confidentiality of the participant, responses, and any other names given during the interview(s). The researcher shall not release any participant's (and/or referred individual's) name in the interview transcripts, nor in any account (written or verbal)of the institution's disaster experience.

Note: It may be out of the researcher's control to protect the institutional name in the event that your institution's natural disaster experience can be publicly identifiable. The participant's identity and comments will be protected by the researcher even when the institution name may be publicly known.

Financial Considerations

Your institution is under no financial obligation to participate in or facilitate this research study. The Longwood Graduate Program shall cover all travel, room and board costs for the researcher.

Contacts

You are encouraged to ask questions at any time about the nature of this study and the methods that I am using. Your suggestions and concerns are important; please contact me at any time at the address/phone listed above. Alternatively, you may also contact the University of Delaware's Human Subjects Review Board chairman, Dr. Costel Denson, at (302) 831-4007 for questions concerning research subject's rights, the research project and/or research-related injury.

Subject's Assurances

Your participation in this research study is entirely voluntary; you have the right to withdraw at any point in the study, for any reason, and without any prejudice, and the information collected and records and reports written will be turned over to you.

Consent Signatures

I agree to these terms:

Participant____Date________________

I agree to these terms:

Researcher____Date________________

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