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## Chapter

# Landscape Hazards: Destructive Build Environment Zones and Safe Areas - An American Case Study

*Yoichi Kunii, Paige O'Keefe, Jon Burley, Luis Loures  
and Marifaye Regina Villanueva*

## Abstract

Planners, designers, governmental organizations, and citizens are interested in creating enduring safe buildable environments. Landscape hazards such as earthquakes, wildfires, hurricanes, tornados, flooding, volcanoes, radon, air pollution, sinkholes, avalanche, landslides, and blizzards create a complex set of destructive forces that form disturbances obliterating life and structures. In our study, we examined these forces across the lower 48 states of the United States of America. We applied geographic information system (GIS) technology to identify areas of extreme hazard and areas of low risk. Our investigation indicated that most of our study area (approximately 83%) was exposed to highly reoccurring destructive forces and that only relatively small patches (Upper Midwest-portions of Michigan, Wisconsin, and Minnesota) and thin stretches (Rocky Mountain Front Range—eastern Montana, Wyoming, and eastern Colorado) of land were relatively secure from these forces. This means that in the long term, much of the study area is not safe from disturbances that will destroy much of the built environment, challenging notions of sustainability for numerous metropolitan areas, United Nations Educational, Scientific, and Cultural Organization (UNESCO) Biosphere Reserves, UNESCO World Heritage Sites, National Parks, other noted historic sites.

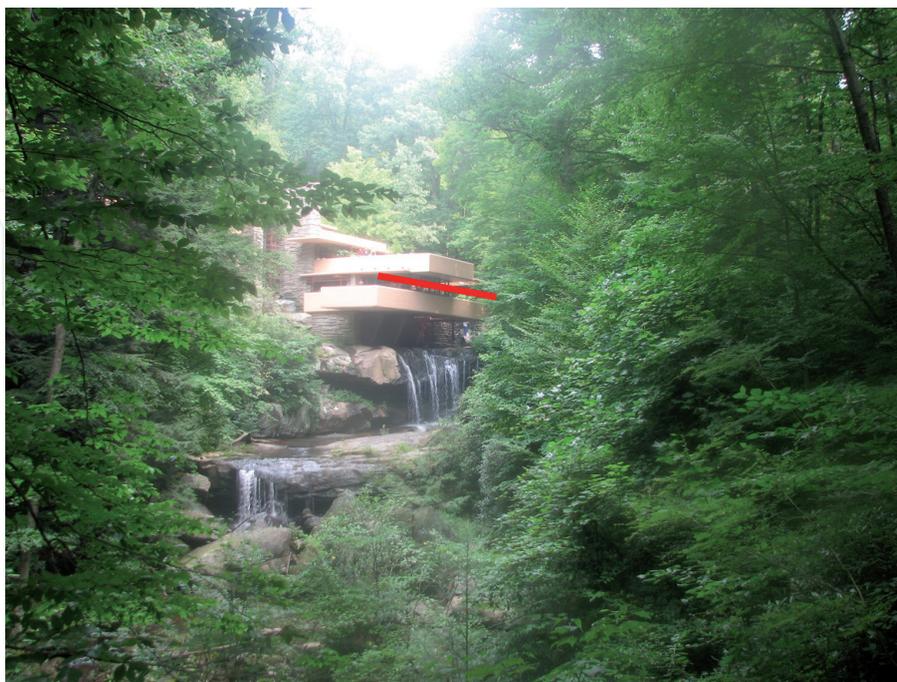
**Keywords:** environmental geology, environmental planning, landscape architecture, natural resources, physical geography

## 1. Introduction

Safe, enduring, sustainable built environments are of great interest to planners, designers, governmental organizations, and citizens. Yet yearly across the globe, built environments are destroyed by tsunamis, hurricanes, earthquakes, wildfires, tornadoes, volcanoes, flooding, landslides, avalanches, and other environmental hazards. The loss of life and damage to property is extensive. As each event occurs, scholars study the cause of the event, the extent of the damage, and impact upon the environment. For example, Foxworthy and Hill describe the cataclysmic event of the Mount St. Helens volcanic eruption of 1980—this event was only a relatively small volcanic eruption [1]. Ekey recounts the extent and damage of the 1988 Yellowstone fire; while Daniel and Ferguson edited a series of papers discussing the knowledge concerning wildfires and the urban interface [2, 3]. Stanley Changnon

edited a document describing the extensive flooding event in the Mississippi River Basin of 1993 [4]. Numerous authors describe earthquake events ranging from events in relative wilderness to urban areas [5–9]. Margot Keam Cleary describes many more events of the twentieth century, noting avalanches, hurricanes/typhoons/cyclones, tornados, and tsunami/tidal waves [10]. In addition, authors have described catastrophic events such a meteorite collisions and atmospheric poisoning leading to changes in the composition and structure of the biosphere [11]. Each event would raise public awareness, but for many in the planning and design community, environmental hazards and the long term suitability of a building site were of minor importance when compared to issue of landscape conservation, design beauty, economics, and short term functionality [12, 13]. To illustrate this perspective, in the United States of America, Falling Water/Kaufman House, design by the acclaimed American architect of the twentieth century Frank Lloyd Wright in about 1935 is considered to be one of the great pieces of architecture for that century; yet in a 100 year flood, the waters of the seemingly serene creek rise to the mid-level of the living room (**Figure 1**) [11].

By the 1960s, planners and designers in the United States of America explored approaches to place built environment facilities in safe zones compatible with the structural ecology of the area, as illustrated by the barrier islands study of Ian McHarg and placing structures outside the path of avalanche zones at Snowbird, Utah by Dan Kiley [14, 15]. Landscape architects had expanded their work to encompass landscape planning studies, something that had not been widely practiced since efforts earlier in the twentieth century by Warren Manning [11]. For example, the complete land area and some aquatic habitats of the state of Hawaii have been completely planned and zoned with assistance of the professional design firm EDAW, led by Garrett Eckbo (the “E” in EDAW). The landscape is divided into areas for housing, recreation, grazing, crop production, forestry, armed services usage, conservation, and for use by the native Hawaiian people. The plan included considerations for mitigating the effects of three natural hazards: earthquakes,



**Figure 1.** *The red line approximates the level of the 100 year floodplain at the Falling Water House in Pennsylvania, USA (copyright © 2007 Jon Bryan Burley, all rights reserved, used by permission). In flooding conditions, the structure even acts as an obstruction to water flow, something that is often now prohibited for many areas of the United States.*

tsunamis, and volcanoes [16, 17]. This general approach was applied by Burley and Burley to a study site in Colorado, to determine safe building environments against wildlife, avalanche, rock fall, and flooding. They determined that in their study area, there was no safe site [18]. This interest extended to other areas in the world, as Feng et al. examined building site safety in the Wenchuan area of China and in the central Philippines in post-earthquake settings developing an index to assess and determine the resiliency of the setting to save lives [19]. But in many respects, response to landscape hazards in planning and design had been practiced by some in other parts of the world, long before Americans began to study such topics. For example, in Tokyo, Japan, the Kiyosumi Garden, developed in 1878–1885 was created as a safe-haven in post-earthquake events and together with a nearby public park, remains as a post-earthquake safe-haven and was used as a safe haven during the allied/American bombings of Tokyo in 1945, **Figure 2** [20]. Similar work concerning safe haven open space has been recently studied in the Chinese province of Fujian [21–23]. These examples illustrate that at times investigators, public officials, and concerned citizens have occasionally/sporadically addressed hazards in the built environment; however, interest in this topic has increased.

Community resilience is an increasingly addressed issue worldwide, as it encompasses a widespread usage of resources by community members that allows them to thrive in a constant state of change and unpredictability [24]. As climate change develops into an increasingly more harmful and destructive force, communities need to be able to withstand and recover from these devastating effects. Presented as an opportunity to face vulnerability with resilience, climate change is the quintessential factor which immediately is threatening both our natural and human systems. The need to establish, enhance and promote tools for the overall health and safety of communities is increasing; thus, Community Resilience Assessment (CRA) tools have continued to evolve over the course of the twenty-first century [25]. Resilience, a term consisting of varying definitions, is composed of the same underlying concept of a mix of natural and mechanical systems with the ability to adapt to extreme shocks and uncertainty [26]. When creating and planning a design, policy makers, developers, landscape architects, and other professionals involved in the process, all play a vital role in the implementation of community resilience. Although many are currently aware of the effects and future possibilities environmental change and landscape hazards, there are also many who are not thinking about the essential planning steps needed to be able to withstand these effects.

In an attempt to depict a dynamic system responding to hazards and change that is not necessarily in balance, Graham A. Tobin cohesively created a conceptual framework for analysis of sustainability and resilience that consists of three separate



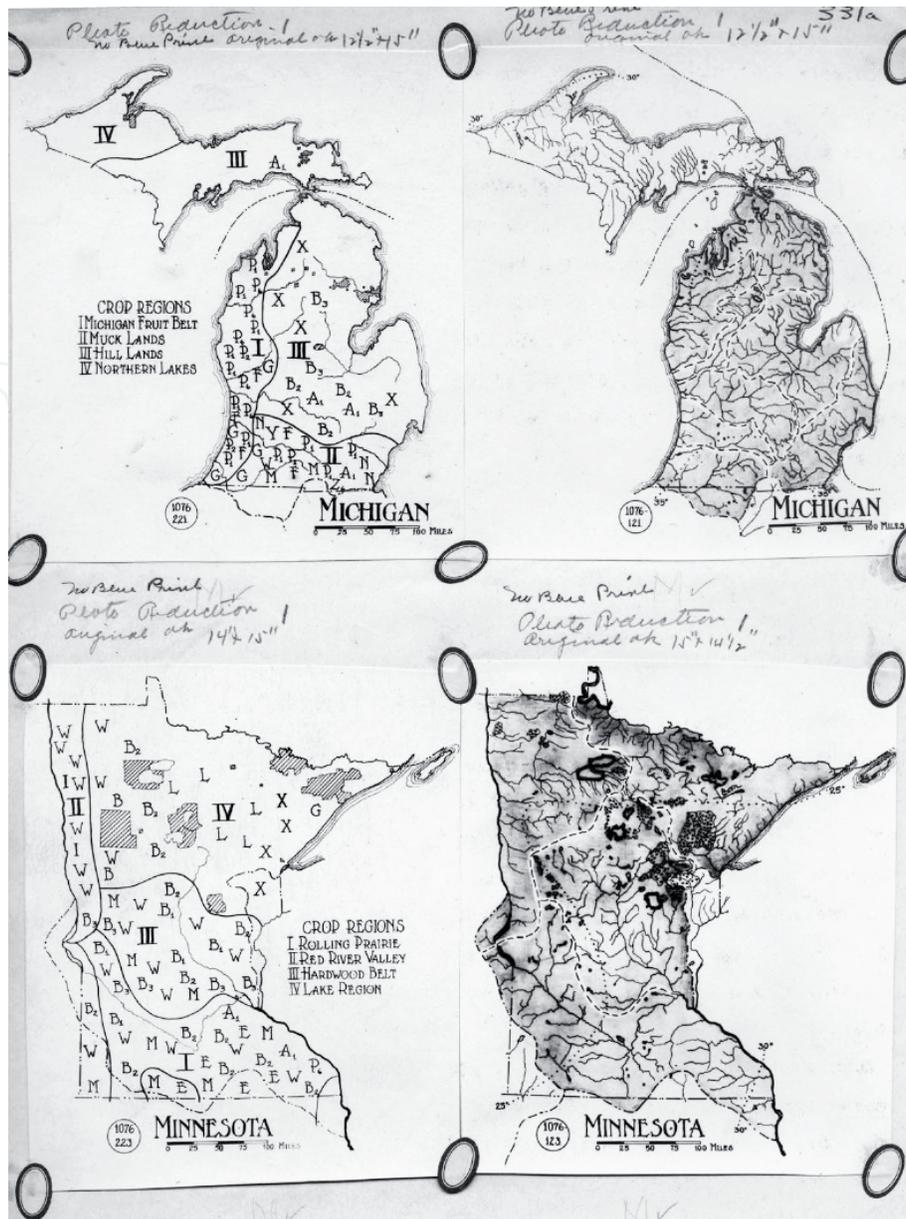
**Figure 2.**  
*A view of the Kiyosumi Garden in Tokyo, Japan is an open space that remains as a refuge for post-earthquake events (copyright © 2019 Jon Bryan Burley, all rights reserved, used by permission).*

heuristic normative theories (meaning based upon expert opinion): a mitigation model, recovery model, and structural-cognitive model [27]. Collectively, these provide an in-depth look at the realities of implementing a sustainable and resilient framework that demonstrates the difficulties such as local context, social and political activities, and economic concerns. Tobin's ideas have been adapted from the works of Waugh and Mazmanian and Sabatier [28, 29]. In order to prevent high levels of exposure and risk, acts of prevention are critical to a community's success in the complete cycle hazard recovery and resilience. An example given are the mitigation policies that ensure specific conditions are met when implementing design standards of flood embankments and levee systems. Thus, a physical action is being taken towards the overall community resilience instead of the issue remaining theoretical which does not provide any measurable outcome. These conditions were then condensed into six major priorities for successful implementation: (1) sound theory with causal linkages to assure reasonable goals; (2) tasks and programs must be assigned to sympathetic agencies with adequate resources; (3) leaders must have managerial and political skills; (4) clear policy objectives with long term commitments; (5) organized constituency support; (6) no undermining of the policy over time [27]. Overall, these conditions and goals must be clearly articulated in order to provide safety, resilience, and resources over time to a wide variety of communities.

The state-of-the art concerning landscape hazards suggests that there is a wider concern across the public and professional ability and interest in assessing and implementing plans and design related to this issue. Still, the effort is case by case, city by city, and region by region. Rarely has there been an examination of a broad set of hazards for a substantially large area. Reporting of hazard events is often in the national and international news cycle. As this article is being completed, the wildfires of Australia are in the news [30]. In some respects there is no comprehensive study because no governmental agency is fully/completely



**Figure 3.** A page from Warren Manning's National Plan, with a reorganization of the American states based upon physical/watershed boundaries (copyright © expired, obtained from the Iowa State University Library Special Collections and University Archives) [31].



**Figure 4.** A page from Warren Manning's National Plan, illustrating how the new states of Michigan and Minnesota are divided into management regions for agriculture, forestry, and conservation (copyright © expired, obtained from the Iowa State University Library Special Collections and University Archives) [31].

responsible to address planning and design for all types of hazards (the most comprehensive agency responds to hazards in the United States, the Federal Emergency Management Agency (FEMA) advising the public concern advanced preparation for some types of hazards such as earthquakes, wildfires, tornados, and hurricanes). Unfortunately no investigatory team has been funded to examine this issue in the same manner as Warren Manning, who lived from 1860 to 1838, who prepared a national comprehensive conservation management plan for the United States (**Figures 3 and 4**) [31]. He did not examine landscape hazards. But if he was living today, maybe it would be an issue that he might address.

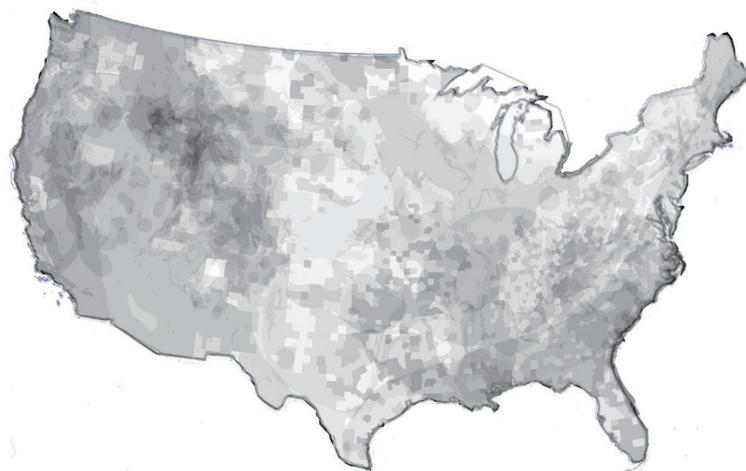
We wondered if it was possible to address the lower 48 states concerning a multiplicity of landscape hazards to gain a more comprehensive understanding of the issues facing the built environment and long-term sustainability of building sites? In our investigation we were curious about: are there only small areas that merit hazard planning and design?; are there numerous and extensive areas that are relatively safe zones?; and what is the situation in the lower 48 states?

## 2. Methodology

To conduct the study, the team examined the same basic setting as Warren Manning [31]. The investigatory team gathered public data concerning a set of landscape hazards across the lower 48 of the United States, including: earthquakes, wildfires, hurricanes, tornados, flooding, volcanoes, radon, air pollution, avalanche, landslides, sinkholes, and blizzards [32–40]. The maps were drawn in layers with three values: high risk (medium gray with a 10–200 year time frame), moderate risk (light gray 500 year time frame), and low risk (white great than 500 year time frame), similar to Burley and Burley [18] and McHarg [14]. The model to compile the maps in a series of overlays was similar to Johnson and Burley, where the most hazardous value (a medium gray) across the overlays determined the hazard risk for a location [41]. Only locations with no high (medium gray) or moderate hazard rating (light gray) would receive a low (near white) hazard rating [41]. Locations with no value in the hazardous rating and with a maximum of a moderate rating would appear in the results map a moderate rating. For example, a site with a moderate earthquake score and all other scores being low, would be rated as a moderate (light gray) hazardous area. No effort was made to derive weighted maps or maps with linear combinations. As of yet, no investigator has demonstrated that the hazard layers should be combine in some latent dimension or equation. Although in the future, investigators might explore statistical relationships amongst the variables, as other investigators had done in visual quality and soil reclamation studies [42, 43]. The late Phil Lewis did discover that wetlands, slopes that require protection, and recreational lands covaried forming corridors, suggesting a latent dimension in environmental conservation and recreation to for greenways [44]. But so far, no such work has been accomplished with hazard data. In this hazard study the resulting map in this investigation may appear with many levels of gray (darker indicate many hazards and white indicating no hazards).

## 3. Results

The resultant map (**Figure 5**) contained approximately 83% of the study area with high and moderate hazard ratings. The locations with a fair expanse of low ratings occurred in the rain shadow (east) of the Rocky Mountains on the western



**Figure 5.**

*A map of the hazard areas in the lower 48 of the United States when all the hazard maps are combined together (copyright © 2018 Yoichi Kunii and Jon Bryan Burley, all rights reserved, used by permission).*

edge of the Northern Great Plains from west Texas to Montana and a smaller swath of land in the upper Midwest (Michigan, Wisconsin, northern Minnesota). A patchwork of lighter gray also occurs on the west side of the Appalachian Mountain in the Tennessee and Ohio River valleys north towards Pennsylvania and New York. However, there is no truly completely safe site. Smaller, county sized patches of relatively low hazard areas occur in the mountain west.

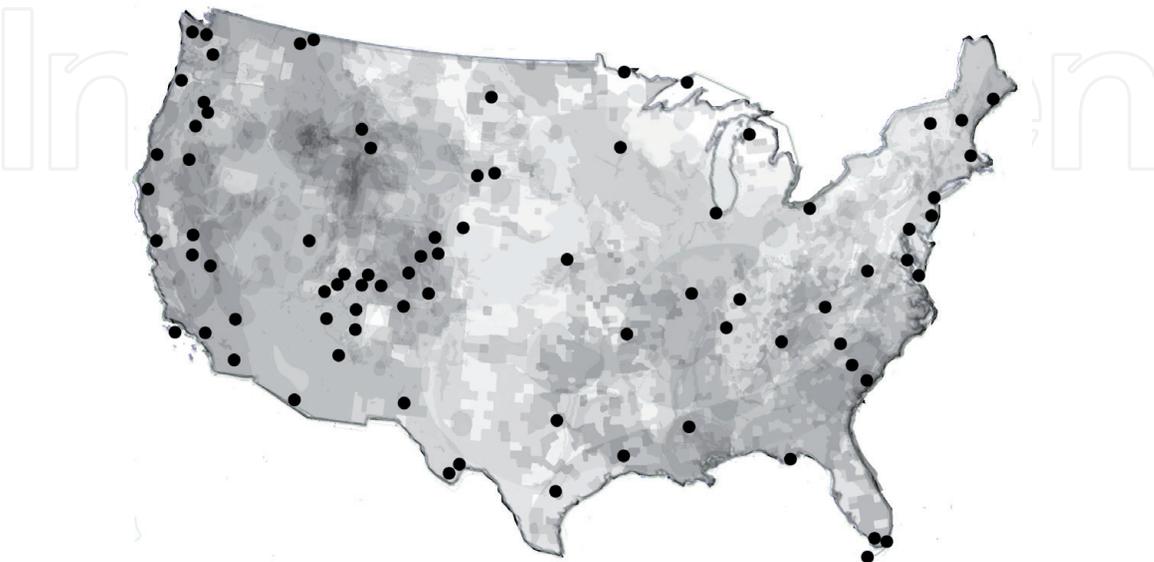
#### 4. Discussion

When the environmental hazards are combined together, it become clear that much of the landscape will encounter some sort of hazard that may affect the built environment. The map suggests that over a 200 year period (10 generations), most sites will encounter some sort of hazard. While for any one generation, a group of individuals or community may experience no hazard event, in the higher hazard areas, events may be frequent across generations. The map in **Figure 5** indicates that much of the country will face repeated events and that there are relatively few refuges. This may be a surprise to some citizens and public officials who may expect their environments to remain stable and safe long term. The map suggests that building sites may be disturbed, even destroyed at a frequent rate, meaning within 10 generations. The disturbance probability is much greater than for just some unlucky locations such as in the San Francisco area, the gulf coast in the south east, or in and near Yellowstone National Park.

What does this mean for the built environment? For long term sustainability, care and thought may have to be given to mitigating the expected forthcoming event. Building codes and site design may have to reflect minimizing damage and sustaining life.

**Figure 6** presents a map containing United Nations Educational, Scientific and Cultural Organization (UNESCO) Biosphere and Cultural Heritage areas, plus National Parks, and other historic landscape architectural sites described by Newton, Tobey, and Burley and Machemer [11–13].

The map illustrated in **Figure 6** suggests that many valued natural environments, cultural sites and other valued landscapes are in zones that will be exposed



**Figure 6.**  
*A map illustrating the locations of valued landscapes across the landscape hazards composite map are combined together (copyright © 2019 Yoichi Kunii and Jon Bryan Burley, all rights reserved, used by permission).*

to disturbance. Only a few sites on the Great Plains or in northern Michigan and Minnesota may be in areas with little change from hazards. Change is coming. Often individuals may assume that these sites may remain undisturbed and unaffected for many centuries. But the truth may be that many of these sites will encounter events much sooner than expected. Very few sites may have the longevity that the Pyramids of Giza in Egypt have endured. After all, the other six wonders of the world are in ruins [11]. Even places like central Michigan exposed to few events, over the last 12,000 years endured mile high glaciers, large fluctuations in the level of the Great Lakes, the extinctions of mammoths (*Mammuthus primigenius* (Blumenbach, 1799 [originally *Elephas*])) and mastodons (*Mammut americanum* Kerr 1792), the migration of vegetation from the south, the clearing for forests, the coming of urbanization, the automobile, and the invasion of exotic species [11].

In this study, there are more variables that could be included, such as water or soil pollution, or the impacts of various climate change scenarios. In addition, it could be debated about how the variables were classified and combined, or possibly a different base map for a certain variable could be used. Other investigators could generate variations on the results. This study is not definitive.

The environmental dangers to building sites are real and extend to nations around the world (**Figure 7**). The recent eruption of the Taal volcano in the Philippines illustrates the dangers to the built environment as it is an earthquake zone and volcano hazard area [45]. This is the same area that was hit by Typhoon Phanfone (Ursula) in late December 2019 [46].



**Figure 7.** An image of the Taal Volcano erupting in January 2020 as seen from Los Baños, Philippines. The volcano is erupting tens of kilometers away, beyond the mountain/hills in the back of the image (copyright © 2020 Marifaye Regina Villanueva, all rights reserved, used by permission).

## 5. Conclusion

Planners and designers are engaging issues related to examining larger landscapes. This engagement facilitates understanding factors, forces, and influences upon the built environment. In this investigation, it was discovered that much of the study area will experience hazards events that will perturb the built environment, sooner than some might expect. To be sustainable or resilient may mean that these disturbances may require thoughtful adjustment by citizens, government officials, the construction industry, and planning/design professionals. Landscape architecture has become a profession engaged in examining broader environmental concerns beyond site planning and detailed design.

### Conflict of interest

The authors declare no conflict of interest.

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