

# a past arrive<sup>yet to</sup>

"hindsights" from flood-resilient, culturally-significant built features  
for cultural landscape climate change practices in the National Park Service

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# *Approval*

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*To anyone who's had the courage to share their story:  
you never know how you might be helping someone else  
to write their own.*



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## Preface

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At the heart of this project is a curiosity about the processes that shape how we shape the environment. Cultural landscapes represent an interesting intersection between human and natural processes because they contain resources whose legibility, and therefore value, depends upon their own perpetuity. Unlike those historic and prehistoric objects that can be housed within museum collections, cultural landscapes comprise the interface between land and (often displaced) cultural processes, creating an inherent tension between the dynamic nature of "nature" and the cultural practices of preservation. As Harper Keeler pointed out at my presentation, this project is less of a set of proposals and more of a philosophical exploration of this inherent tension. Although an explicit, operational recommendation is made, I hope that the case studies and interventions ultimately serve as thought-provoking illustrations of the many ways that we can inhabit physical space and memory while coming to terms with change. In a way, this project illustrates the importance of keeping valuable cultural practices alive, rather than fighting to keep their material remnants alive, because only one of these is ultimately suited to withstand climate change.



## Abstract

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Planning for uncertain, future climates has become a dominant framework in resource management fields, and has recently expanded into cultural resource strategies within the National Park Service (NPS). However, because the NPS views material cultural resources, such as built features, as having no ability to change with the environment, *adaptive capacity* has been omitted from the cultural resource vulnerability assessment framework. Adaptive capacity contributes to a living system's ability to recover from and resist future impacts, thereby increasing its resilience. By omitting adaptive capacity, recent preliminary cultural landscape vulnerability assessments (VAs) excluded all resiliency considerations—an oversight that could undermine cultural landscape comprehension and adaptive planning. This project demonstrates that flood-resilient, culturally significant built features exist worldwide, and that they embody climate change management insights. Objectives included distilling resilience strategies from four case studies; applying these strategies to design intervention thought-experiments for Scotty's Castle, a flood-vulnerable NPS cultural landscape; and assessing each intervention's resiliency and cultural integrity trade-offs. Findings suggest that all realms of resiliency (ecological, social, organizational, and engineering) should be factored into cultural landscape VAs, and that truly adaptive planning requires tight coupling of management and resource subsystems. Additional adaptive management implications are discussed.

**opposite** The Guanyin Pavilion near Ezhou, China during the July 7, 2017 Yangtze River flood (image source: Rex Features.com).





# Part One

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*Our future is just a past yet to arrive,  
our past a future come and gone.*

- Natsuhiko Kyogoku



# 1 Introduction

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Preparing for climate change impacts has become a dominate discourse in resource management fields, including cultural resources. Concerns around conserving our nation's built heritage—historic buildings, structures, sites, and districts; and cultural landscapes—has generated new strategies within the National Park Service (NPS) that embrace **adaptive management**. This planning approach emphasizes embracing uncertainty through a willingness to respond, learn, and change management practices in the face of emerging climate trends and events. Adaptive planning, in turn, depends upon assessing the vulnerability of a resource, or entire cultural landscapes, to projected climate trends and events. However, current NPS conceptions of cultural resources limit the ability of the NPS, and its affiliates, to adequately assess entire cultural landscapes because they often encompass a complex overlap between cultural and natural resource features and systems.

The NPS's current cultural resource vulnerability assessment (VA) framework that was derived from natural resource literature which focuses on assessing ecological systems (Glick, Stein, and Edelson 2011). This framework defines vulnerability as a function of **exposure, sensitivity, and adaptive capacity** (see *The Vulnerability Assessment Framework* section later in this chapter). As

**opposite** a floating house in Iquitos, Peru (image source: Allen Sheffield, Flickr).

outlined in the NPS's *Cultural Resources Climate Change Strategy*, the vulnerability of a cultural resource is a function of its exposure and sensitivity only (Rockman et al. 2016). Although the NPS recognizes that adaptation is an important management quality, it assumes that the burden of adaptation falls solely on management: "a focus for climate change adaptation is our management of them" (2016). Thus, adaptive capacity was omitted at the expense of all possible forms of resiliency that may be intrinsic in a given cultural landscape. In response, this project broadly asks:

Do resilient cultural landscapes exist and, if so, how might they inform the NPS's cultural landscape climate change practices?

Before introducing the scope of the project, it's important to establish current conceptions of adaptive capacity and how they relate to the resiliency discourse, as well as how the NPS's practices fit within this larger discourse.

## Background Terminology

This project employs terminology that is either specific to the NPS context and/or is often interpreted across multiple fields, therefore obscuring definitions. For the sake of clarity, many

terms are defined (see Glossary in the appendix) and discussed as a means to establish this project's background.

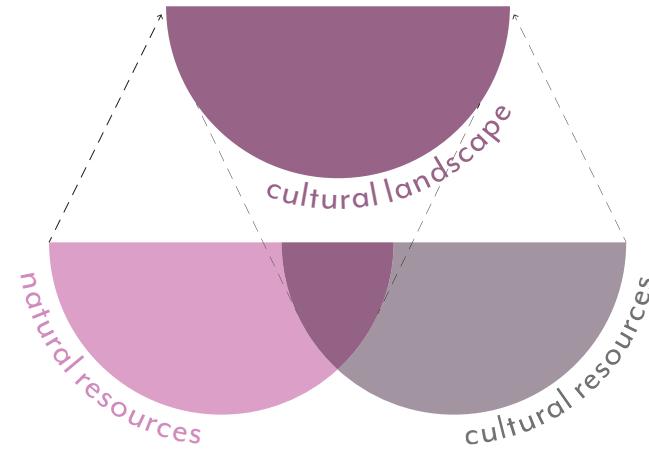
For the sake of clarity, this project uses terminology that is consistent with the service's conception of **resources**. The NPS was created by the Organic Act of 1916 to "...conserve the scenery and the natural and historic objects and the wild life therein..." (2017). "Natural and historic objects" refers to the two major resource categories used by the NPS: natural and cultural (Figure 1.2).

**Natural resources** include biological resources and processes, physical resources and processes (air, water, geology, etc.), ecosystems, and other highly valued, landscape-based features such as scenic views, or "scenery" ("Cultural Landscapes 101" 2018). **Cultural resources** include archaeological resources (sites, artifacts, documents, etc.), ethnographic resources, museum collections, cultural landscapes, and historic and prehistoric structures and sites. Additionally, cultural landscapes represent a complex system that will be discussed later in this chapter in the section titled *The Cultural Landscape Concept*.

This project uses the term **system** to refer to "a regularly interacting or interdependent group of items forming a unified whole" (Merriam-Webster 2018). Examples fall within three major categories that are pertinent to this project:

1) the social and organizational structures that comprise NPS management (*management systems*); 2) the living and non-living features and interactions that comprise natural resources (*natural resource systems*); 3) the living and non-living features that comprise cultural resources (*cultural resource systems*); as well as 4) generalized resources that don't differentiate between the two (resource systems). The term system is an especially appropriate concept for referring to these groupings because the omitted component that this project is responding to, **adaptive capacity**, is a potential quality of resilience that enables a system to permanently self-adjust to a specific stressor or threat. It was recognized in the 1970s that ecosystems can only be fully understood when framed as being inextricably connected to socio-cultural systems. This coupling is referred to as **social-ecological systems (SES)** (Figure 1.2) (Gunderson and Holling 2002). This new ecological paradigm gave rise to the concept of ecological resilience as we know it today.

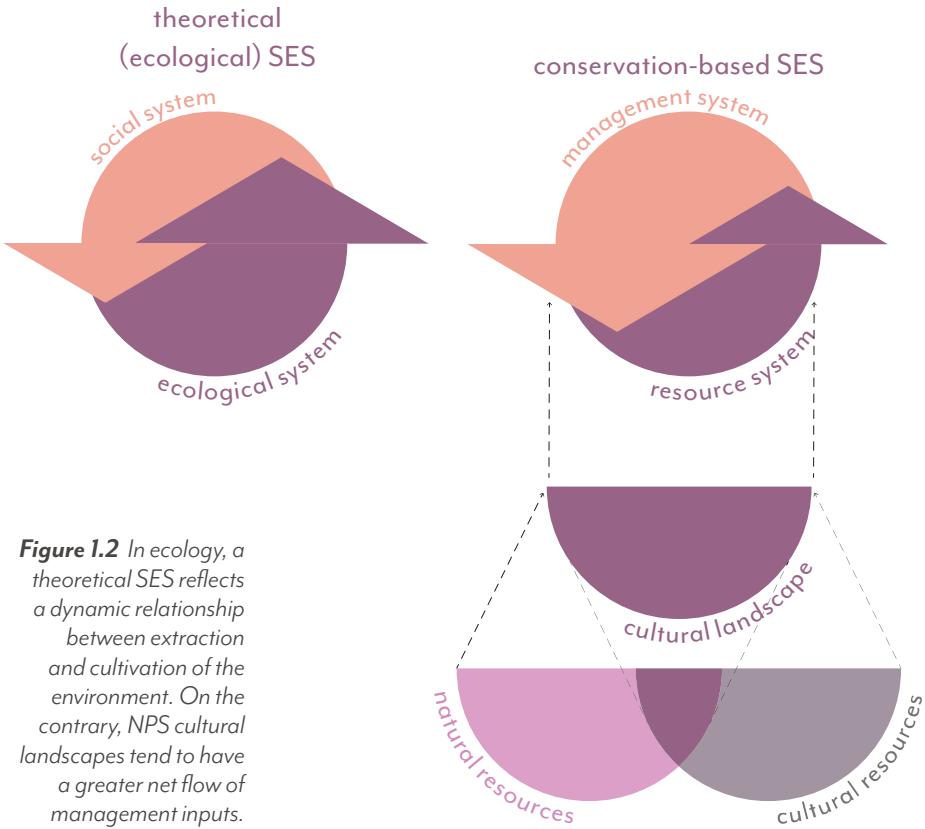
As mentioned above, the omission of **adaptive capacity** (AC) from the NPS's cultural landscape climate change VA framework is the impetus for this project. Like vulnerability, AC has been interpreted differently across many fields but is generally conceived as an ability to respond to disturbance by increasing resistance to future impacts through changes in internal



**Figure 1.1** The distinction between natural and cultural resources is sometimes difficult to discern, especially in the case of cultural landscapes.

organization, growth, or learning (Turner et al. 2003; Gallopín 2006; Smit and Wandel 2006; Folke 2006; Hosseini, Barker, and Ramirez-Marquez 2016). AC is important because it is nested within the concept of **resilience**—a generalized ability to withstand and recover from impacts. In the case of cultural landscapes, resilience is important to the understanding the dynamics of resource systems that comprise larger SES (Folke 2006; Gallopín 2006; IPCC 2014; Hosseini, Barker, and Ramirez-Marquez 2016). It is important to note that resilience is threat-dependent; in other words, a system's resilience is defined by its ability to adjust to the specific set of qualities that define stressor or impact (Hosseini et al. 2016).

AC is also important because it distinguishes **complex-adaptive systems**, or systems that are



**Figure 1.2** In ecology, a theoretical SES reflects a dynamic relationship between extraction and cultivation of the environment. On the contrary, NPS cultural landscapes tend to have a greater net flow of management inputs.

capable of self-organization and self-perpetuation (i.e. living, psychological, social, economic, etc.), from other system types (Folke 2006). This project accepts the general notion that AC is a subset of, or quality that contributes to, a system's overall resilience (Folke 2006; Gallopín 2006). Because cultural landscapes can contain complex-adaptive systems, adaptive capacity may be present in the living resources and ecosystems of cultural

landscapes in addition to the management systems.

In the case of the NPS's "Cultural Resource Climate Change Strategy", adaptive capacity is recognized as a quality that is intrinsic to resource management sub-systems of cultural landscapes and not the cultural landscapes themselves. Therefore, the NPS's strategies emphasize adaptive management, or management approaches that prioritize learning and change in anticipation of, and response to, climate change trends and events (Jarvis 2014; Rockman et al. 2016). Cultural landscapes represent a type of SES that encompasses both natural and cultural resource systems and features, which are often comprised of sub-systems that can be both complex-adaptive and non-adaptive. This complexity illustrates the over-simplification associated with designating cultural landscapes as cultural resources, thus risking major oversights when these terms are operationalized for climate change protocols. Furthermore, culturally significant "material components" in the form of built features such as buildings, bridges, and fences, have been documented as exhibiting resilience against environmental stressors, including climate-related hazards (Mathew 2005; Gruber and Herbig 2006; Arora and Gaur 2013; Gautam et al. 2016; Okubo 2016; Mitchell 2016). The features present at these sites and their contributing qualities contribute to

their landscape's overall resilience to a given set of environmental stressors. The other three domains are: organizational, social, and economic (Hosseini, Barker, and Ramirez-Marquez 2016). This project focuses on the **engineering** domain of resiliency in its response to the NPS's assumptions about material components of cultural landscapes. The NPS's focus on AC as a management quality falls under the organizational domain of resiliency.

## The Cultural Landscape Concept

Cultural landscapes are an important part of the NPS's stewardship mandate, which defines them as:

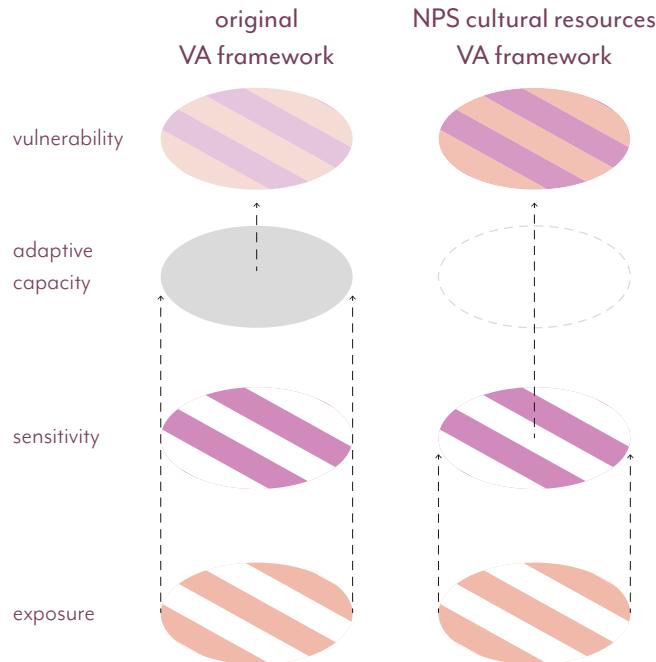
*"Geographic areas associated with a historic event, activity, or person; or that exhibits other cultural or aesthetic values (this category includes designed, vernacular, and ethnographic landscapes). Cultural landscapes encompass both cultural and natural resources as well as wildlife or domestic animals that have historic associations with the landscape" ("Cultural Landscapes 101").*

Cultural landscapes represent the built manifestations of historical relationships between our predecessors and their unbuilt, or

natural, world; a record of human responses to natural processes and changing environments. In this way, they are uniquely positioned to lend invaluable insights into how we might respond to environmental changes yet to come while also conveying a narrative about our collective past (Jarvis 2014; Mitchell 2016). These capacities are attributed to their inherent complexity which is comprised of a distinct intersection between resources, management, and landscape context that sets them apart from other cultural resources. Because their significance depends on their landscape context, they are also inherently dynamic and subject to varying rates of degradation when compared to other cultural resources. The promise of ever-advancing technologies also makes cultural landscapes potential vessels for yet-to-be uncovered historical insights. All of these qualities make managing them in the face of climate change especially challenging. For these reasons, the NPS places utmost importance on retaining the internal relationships that define their character, or **cultural integrity**.

The complexity and dynamism of cultural landscapes, though recognized widely by the NPS in the past 35 years, is not always reflected in its operational definitions and practices. As alluded to in the previous section, cultural landscapes are classified by the NPS as cultural resources

**Figure 1.3** Vulnerability is a function of a system's exposure, sensitivity, and adaptive capacity. The NPS's conception of vulnerability as it applies to cultural resources excludes adaptive capacity (right).



even though they contain both cultural and natural resource systems. What makes a cultural landscape significant is the ability of its historic patterns or processes to convey information about an historically significant event, period, person, or style (whether vernacular or designed). Generally speaking, cultural landscapes are managed to conserve the cultural integrity of the era of significance to which its features belong. The discrete features that comprise the cultural landscape are grouped into categories known as characteristics: natural systems and features, spatial organization, land use, circulation,

cultural traditions, topography, vegetation, cluster arrangement, buildings and structures, views and vistas, constructed water features, archaeological sites, and small-scale features. Those characteristics that are colored above can also be considered natural resources. An example of a cultural resource that is also a natural resource are the historic apple orchards at Buckner Homestead Historic District near Lake Chelan in Washington. Thus, defining cultural landscapes as cultural resources limits the extent to which cultural landscapes can be understood as complex systems comprised of overlapping natural and cultural resource systems (Figure 1.1).

This complex intersection between cultural and natural resources makes cultural landscapes inherently dynamic. Like all built and unbuilt environments, they are subject to cultural and natural forces that vary in intensity across spatial and temporal scales. These crossovers are further blurred within cultural landscapes that are still in use by their historically significant users or managed using historically significant practices. An example of this would be cultural landscapes where Native Americans are still actively stewarding the land (and whose traditional perspectives often do not differentiate between culture and nature). In this way, cultural landscapes represent a type of coupled SES in which management systems and resources systems are interrelated (Figure

1.2). This reinforces the importance of retaining a resilience-based component when assessing cultural landscape vulnerability to climate change. Although the successful management of resources for historic significance would suggest that the burden of adaptive capacity falls more heavily upon management systems, the variety of characteristics that make up a cultural landscape requires more careful considerations that can adjust accordingly to each feature's distinguishing qualities. To disregard any possibility of resilience within all features of a cultural landscape because one aspect of the cultural landscape's categorization does not fit an ecologically-based framework, is to severely limit the ability of management systems to capture a baseline understanding and risk inappropriate management adaptation. This is especially important when the unpredictability of climate change trends and events necessitates that responses and resource use are even more justifiable.

## The Vulnerability Assessment Framework

The NPS's original VA framework, which has been used for assessing natural resource system vulnerability to climate change, defines vulnerability as a function of exposure, sensitivity, and adaptive capacity (*Figure 1.3*) (Glick, Stein, and

Edelson 2011). This framework reflects a widely-accepted conceptualization of vulnerability as it pertains to natural resource management and social sciences (Smit and Wandel 2006; Bruno Soares, S. Gagnon, and M. Doherty 2012; National Park Service 2010; IPCC 2014). Since AC was omitted from the NPS's cultural resource VA framework based on the assumption that material-based cultural resources "can't change", cultural landscape vulnerability is currently defined as the sum of its exposure and sensitivity only. This truncated framework was reluctantly implemented for the first time by NPS affiliates during the recently completed preliminary VA report of three case study cultural landscapes within the NPS system. The case studies were: Buckner Homestead Historic District in Lake Chelan National Recreation Area, WA; Lyons' Ranches Historic District in Redwood National Park, CA; and Death Valley Scotty's Historic District in Death Valley National Park, CA (Melnick and Quiroz 2017). Death Valley Scotty's Historic District (DVSHD) has recently been impacted by flash floods and will be used in this project as a testing ground for experimental interventions.

To comprehend the potential loss of information that results from the omission of AC within cultural resource assessments, it's important to understand its role within natural resource vulnerability assessments. Adaptive



**Figure 1.4** The table coral *Acropora hyacinthus* demonstrates a heritable capacity to adapt to changing temperatures especially when allowed to acclimate prior to sudden changes.

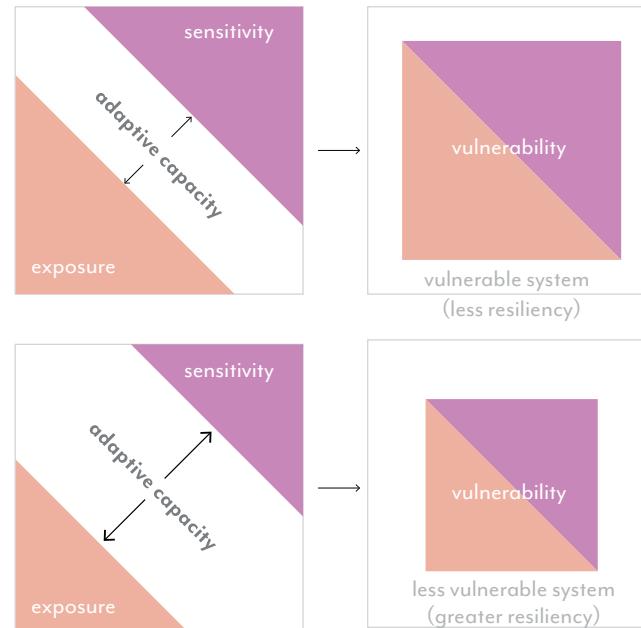
capacity contributes to the understanding of a resource system's baseline, or pre-disturbance, qualities (Gallopin 2006), and how that system might be impacted by projected climate trends and events. To do this, the degree to which the resource system might be in harm's way and the degree to which it is inclined to be impacted must be understood. These are captured by the exposure and sensitivity components of the VA framework, respectively. Exposure is assessed by analyzing the historical climate of a geographical location in comparison to projected trends and events (IPCC 2014). Sensitivity focuses on the qualities of the system that attribute to its propensity to

be impacted (Glick, Stein, and Edelson 2011). AC, on the other hand, represents an emergent ability for the resource system to initiate long-term and/or permanent change in response to exposure to climate trend stressors and impacts from events. AC is further differentiated from both components in that its presence can ameliorate the adversity that exposure and sensitivity engender (Smit and Wandel 2006). In this way, AC represents a crucial link between a resource system's exposure and sensitivity prior to the incorporation of adaptive management interventions.

An example of adaptive capacity at work can be seen in a species of table coral known as *Acropora hyacinthus* (Figure 1.4). Corals are known for their sensitivity to oceanic temperature changes—higher temperatures can cause the corals to jettison their symbiotic algae, a process known as bleaching—which often leads to the death of the coral. Corals generally require shallow, moderately warm water to survive due to their symbiont's' specific requirements. However, a 2014 study by Palumbi et al. revealed that *A. hyacinthus* can live in both cool and warm pools. When exposed to higher water temperatures, about half of the exposed cool pool corals bleached whereas only 20 percent of the warm pool corals suffered the same fate. Additionally, cool pool corals that spent one year in a warm pool prior to being tested demonstrated a higher resistance to increased

temperatures—only 32.5 percent of them bleached. This suggests that the corals have a capacity to withstand warmer temperatures when they can begin to acclimate ahead of time. Additional studies by the group revealed that this capacity for short-term acclimation is also heritable—the presence of over 100 genes that dictate heat resistance suggests that this capacity to cope can lead to the long-term adaptation of entire populations (Bay and Palumbi 2014). Therefore, populations of *A. hyacinthus* that live in heterogeneous environments demonstrate a high capacity for adaptation despite the species' high sensitivity and exposure to temperature increases.

Thus, the presence of a heritable AC reduced the populations' overall vulnerability to temperature change by decreasing the populations' future sensitivity. It did not alleviate the coral's exposure to temperature changes since the species is already found in a variety of micro-climates and is immobile. An example of AC ameliorating exposure can be found in national park boreal conifer forest communities, which are shifting toward present-day tundras and away from warmer, southern climates (Gonzalez 2017). In these examples, AC ameliorates exposure and sensitivity (Figure 1.5), demonstrating its critical role in mobilizing scarce resources within a natural resource system in response to environmental stressors (Engle 2011). This highlights the



**Figure 1.5** Adaptive capacity has a modulating affect on the sensitivity and exposure of a system to potential impacts. When the system has a greater adaptive capacity, the system's overall vulnerability is decreased (adapted from "Adaptive Capacity and its Assessment" by Nathan L. Engle, 2011).

relationship between a resource system's vulnerability and its resilience, underscoring why resilience should necessarily be considered across all features of a resource system even if that system contains non-adaptive and/or material-based subsystems and/or features.

## Project Scope

Obtaining accurate baseline understandings of resource systems is the main impetus behind any VA framework that seeks to understand SES dynamics. This project assumes that for NPS cultural landscape managers to appropriately plan

for climate change, any potential for engineered resiliencies of material cultural resources as well as any potential resiliencies (including adaptive capacity) inherent to natural resource systems must be considered. By omitting AC from the cultural landscape VA framework, any inherent qualities that contribute to cultural landscape resiliency are consequently overlooked as well. This is problematic for the following reasons: 1) cultural landscapes are more complex than the NPS's generalized conceptualization of cultural resources suggests, 2) some natural resources are complex-adaptive systems which are defined by their capacity to change and grow, 3) some material-based, cultural resource systems (i.e. built features) have been documented to demonstrate resiliency against environmental change and/or hazards, and 4) the degree to which management can appropriately adapt depends on the accuracy of the assessed resource system's vulnerability baseline. To continue to overlook the potential existence of baseline resiliencies within cultural landscapes is to effectively nullify the progress that has been made towards understanding them as inherently dynamic systems. Without assessing the qualities that lend cultural landscapes their dynamism, management systems cannot fully discern the relationship between exposure and sensitivity at any scale, thereby potentially rendering adaptive management attempts ineffective. For coupled management-resource systems like cultural

landscapes to continue to retain their integrity into the future, having as complete of an assessment as possible is necessary when deciding how scarce resources should be mobilized in the face of unpredictable political and economic impacts from climate change.

These concerns are based on resiliency theory and established NPS cultural resource views and practices. Since the NPS conception of cultural resources is that they are often comprised of material components that cannot change with the environment, even though examples of culturally-significant, material-based features have been documented, this project will focus on the engineered resiliencies of culturally-significant built features in order to answer the following questions:

1. Do culturally significant landscapes with built features that demonstrate resilience to flood exist? If so, what are the qualities that contribute to the features' flood-resilience?

2. Are the flood-resilient qualities structurally discernible?

3. What role, if any, does extant cultural practices

play in supporting the engineered flood-resiliency?

4. What would flood resiliency interventions from each of the derived strategies look like? Do they significantly impact the cultural integrity of the site?

The goal of this project is to answer the questions raised above through two primary means: case studies and interventions. The case studies serve as precedents that demonstrate existing flood resiliencies. They are comprised of 4 globally distributed, culturally-significant landscapes which contain built features that have demonstrated on-going engineered resilience to flooding (*Figure 1.6*). These features' strategies will be interpreted and identified so that they can each inform a separate intervention. The second method, interventions, involves the projective design of 4 key interventions as a form of thought experimentation. Each of these interventions will be designed to maximize the flash-flood resiliency of the built features within a flood-vulnerable cultural landscape-- a complex known as Scotty's Castle within Death Valley Scotty's Historic District (DVSHD) in Death Valley National Park. In 2015, DVSHD was impacted by a major flash flood. The following year it was preliminarily assessed for climate change vulnerability using the NPS's

cultural resource VA framework (*Figure 1.3*) and "Climate Change and Cultural Landscapes: A Guide to Research, Planning, and Stewardship" (Melnick et al. 2017).

The interventions are intended to illustrate the inherent trade-offs between maximizing resiliency through retrofitting and retaining cultural integrity (*Figure 2.2*). Although all features, both natural and cultural, contribute to the cultural landscape system, the intervention experiments will focus on enhancing built feature resiliency since their representative strategies are 1) derived from built features, and 2) are intended to illustrate that if engineered resiliency can be added to a site, its pre-existence in any amount should be considered beforehand.



## 2 Methods

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This project is a response to the NPS's omission of adaptive capacity from its cultural resource climate change vulnerability assessment framework which is of special concern to cultural landscape management practices for reasons described in the Chapter 1. This project's research methods are two-fold: 1) case studies that inventory, interpret, and classify a variety of flood-resilient strategies implemented across four culturally significant sites; and 2) a set of projective intervention thought-experiments that apply each strategy to increase the resiliency of a flood-vulnerable NPS cultural landscape (Figure 2.1).

The project's theoretical approach is inherently subjectivist as it asks:

“How might the NPS conduct cultural landscape climate change vulnerability assessments and subsequent adaptive management planning differently?”

The interpretation method involves investigating case study cultural landscapes whose built features demonstrate resiliency to flood. Flood resiliency is determined by the presence of flood-prone landscapes that contain historic

**opposite** Chamunda Devi Temple in Rudraprayag, India, is located at the confluence of the Alaknanda and Mandakini rivers and has remained standing after losing secondary structures to flash-floods in 2013 (Arora and Gaur 2015).

Assumptions about Knowledge & the World	The Purpose of Knowing	Examples of Theoretical Perspective	Examples within Landscape Architecture	Typical Research Strategies	Typical Research Methods	Predominant Modes of Representation
Objectivism	<b>Instrumental/Predictive</b> <i>What, where &amp; how?</i>	[Post]positivist natural sciences	Landscape perception studies Landscape ecology.	Descriptive survey Modeling Experimentation & Quasi-experiments	Measurement and mapping Questionnaire surveys Statistical analysis Alternative futures	Mathematical symbols, with written interpretation
[Social] Construction	<b>Interpretive</b> <i>Who, when and why?</i>	Pragmatism Hermeneutics Symbolic Interaction Phenomenology	Design process Place studies Community studies Historical studies Project evaluations	Classification Ethnography Discourse Analysis Iconography Historiography Evaluation and Diagnosis	Close observation Interviews and focus groups Documentary analysis Life histories Post Occupancy Evaluation	Written narrative, with illustrative diagrams and photographs
Subjectivism	<b>Critical</b> <i>What are the consequences? How might things be done differently?</i>	Critical Inquiry Post-structuralism Feminist	'Expressivist' Theory 'Critical Visual Studies' Design scenarios	Action Research Projective Design Logical systems & argumentation	Deconstruction Reflection Creative Intervention	Diverse media -written -graphic -aural -performance

**Table 2.1** Theoretical orientation of this project based on the Foundations for Knowledge Claims from "Landscape Architectural Research: Inquiry, Strategy, Design" by Deming and Swaffield, 2011. This project uses social construction theory to interpret and classify case studies that are then applied in a subjectivist manner to inform multiple, experimental interventions.

and/or culturally significant built features. Each case study has a demonstrated history of local flooding and/or records of specific events that verify the built features' design intention and subsequent resiliency. Flood and seismic resiliencies are the most commonly documented strategies found across global cultural heritage sites, making flooding a highly appropriate stressor for the purposes of this project since it is climate related (Mitchell 2016). Each of the demonstrated strategies will be described and classified in accordance with existing engineering and ecological resiliency concepts where possible

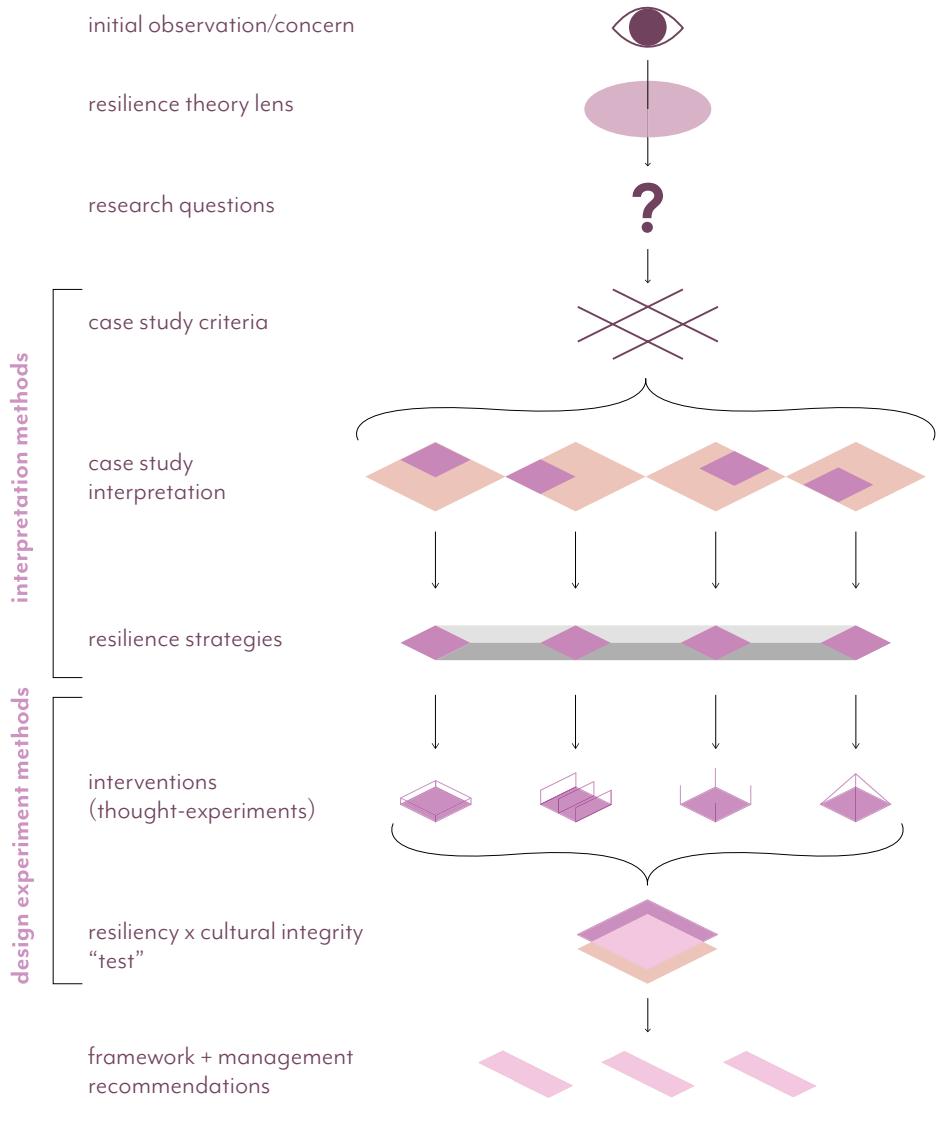
(Muller 2012; Francis and Bekera 2014; Hosseini, Barker, and Ramirez-Marquez 2016).

The set of experiments seek to apply the classified resilience strategies derived from the case studies to a single NPS cultural landscape and are referred as intervention experiments. These intervention experiments will be evaluated based on the following over-arching question:

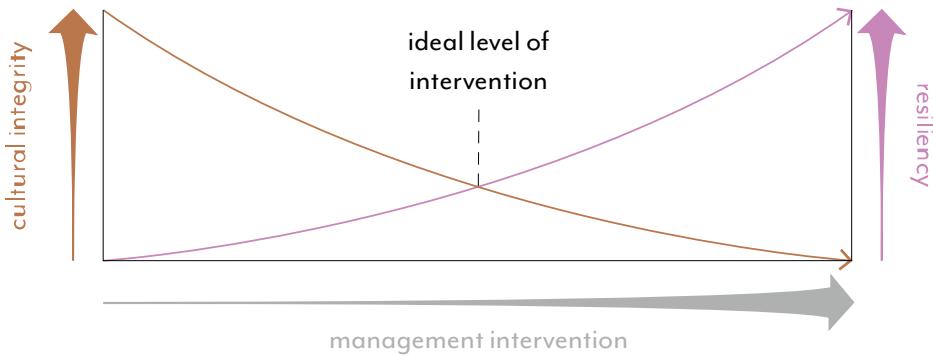
Is the cultural integrity of the site retained?

Retroactively adding engineered resiliency to a site will inevitably change its character, thus the trade-offs between adding resiliency and retaining cultural integrity were assessed and summarized in a table. Each intervention will aim to increase the engineered resiliency of the most vulnerable built features as much as its strategy prescribes. Since this project is focused around highlighting the potential for resiliencies within material components of cultural landscapes, it follows that the strategies, which are also derived from built features, should inform the treatment of vulnerable built features. Assessing these trade-offs addresses the potentially paradoxical goals of adapting practices to uncertain climate changes while maintaining the legibility of cultural significance; both of which fulfill the NPS's mandated goal as stewards of cultural resources (Figure 2.2).

To date, only three NPS cultural landscapes have been assessed for their exposure and sensitivity to climate change: Buckner Homestead Historic District in the Lake Chelan National Recreation Area; Death Valley Scotty's Historic District in Death Valley National Park; and Lyons' Ranches Historic District in Redwood National Park. The resulting report was the first attempt at applying the NPS cultural resources vulnerability framework to cultural landscapes, as mentioned in Chapter 1 (Melnick and Quiroz 2017). Of these three case studies, DVSHD was recently impacted



**Figure 2.1** research process with the two major methods grouped by brackets



**Figure 2.2** The conceptual relationship between maintaining maximum cultural integrity and maximizing resiliency where the ideal level of intervention represents a trade-off between extremes.

by flash flooding and was thus determined to be highly vulnerable to similar future events since sporadic, storm events are projected to occur more frequently within the park boundaries. DVSHD is located within Grapevine Canyon and is defined by a complex of built features collectively known as Scotty's Castle (Melnick et al. 2016). Some of these features were in the direct path of flood waters, including the historic Bonnie Clare Road, making them particularly vulnerable to flooding. Thus, the intervention experiments will focus on bolstering the resiliency of the district's built features to future flash flood events.

## Case Studies: Selection and Evaluation

Case studies were selected to serve as examples of global cultural landscapes that contain flood-resilient built features. The selection criteria are: 1) the site must be culturally significant,

2) there must be at least one extant, culturally significant built feature that is known to have withstood flooding at least once, and 3) the resilient qualities of those built features must be culturally significant and discernible. Cultural significance can be established by one of two ways: 1) UNESCO World Heritage site status or 2) local user groups who are connected to the original builders of the site consider the landscape and its features to be significant to their history, traditions, religion, and/or daily practices. The selected case studies are: the main street dyke of Santa Cruz de Mompox in Colombia; Katsura Detached Palace in Kyoto, Japan; the windmills of Kinderijk in The Netherlands; and the "living bridges" of the Khasi people in the Cherrapunjee valley of India. Additional considerations, such as geographic dispersal, cultural variety, and expected differentiation of resilience strategies, were made in order to maximize the representative range of the global case studies.

The framework for interpreting and classifying the flood resiliency strategy of each of the case studies encompasses three main criteria: structural qualities, environmental context, and cultural context (Figure 2.3). Since the resiliency of a system is threat-dependent, the framework is intended to consider all flood-related aspects, beginning with exposure, built features and their attributes, construction, and on-going maintenance

of the built features in question (Hosseini, Barker, and Ramirez-Marquez 2016). These criteria serve as a basis for interpreting the culturally significant, physical attributes that make each built feature inherently flood resilient; the environmental attributes that make the cultural landscape prone to flooding; and the cultural practices (extant or historical) that contribute to the feature's and/or landscape's on-going flood resiliency. Thus, each derived resiliency strategy is the result of a synthetic interpretation of the features' structural, environmental, and cultural flood-resilient attributes. The naming of these strategies uses existing resilience terminology where possible. Examples of widely-recognized resilience terms include adaptation, redundancy, robustness (as it pertains to resistance), and attenuation—all of which were used in the naming of the case study resilience strategies.

## Intervention Experiments

The interventions are intended to serve as thought experiments that "test" the feasibility of each resilience strategy. The test site is DVSHD and each strategy serves as the basis for a single design intervention. Each intervention is a projective design meant to interpret the cultural approach behind each resiliency strategy in an effort to increase the flood resiliency of DVSHD (see Chapter 4 for a summary of Scotty's Castle). These

experiments are intended to maximize DVSHD's resilience to flash floods, allowing for potential impacts on cultural integrity to be more easily discerned. Their efficacy as potential management actions will be evaluated based on how much the cultural integrity of the site is impacted.

It's predicted that no intervention that maximizes resiliency will also maximize cultural integrity. Most interventions are structural and, by their very nature, may interfere with the patterns of the landscape's significant features and characteristics. Cultural integrity is a nuanced notion that is based on the discernibility of these relationships and the condition of the significant features, so the "test" will involve a qualitative comparison of resiliency gains and cultural integrity losses based on the relative size and visual impact of the interventions. The trade-offs are summarized at the end of Chapter 4.



# Part **two**

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*The past is a foreign country;  
they do things differently there.*

- L.P. Hartley



## 3 Case Studies

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### Santa Cruz de Mompox, Colombia

Along the banks of the Magdalena River in the Caribbean plains of Colombia rests a UNESCO heritage city center that retains a striking resemblance to a Spanish colonial settlement. Santa Cruz de Mompox, named after the Depresión Momposina, was built parallel to the river along a dyke that serves as the main street of the center.

The Depresión Momposina is a marshy, tropical landscape that surrounds the confluence of the Cauca and Magdalena Rivers and is teeming with wildlife— aquatic birds, reptiles, and howler monkeys (*Figure 3.1*). Founded in 1539 in northern Colombia, Santa Cruz de Mompox played a major role in the Spanish conquest of Nueva Granada (the area known today as Colombia, Ecuador, Venezuela, and Panama) by securing river access into deeper territory and concurrently boosting commercial activity. Its preservation is also due in large part to the dynamics of the river. The economic decline that followed a 19<sup>th</sup> century shift in the river's main channel stagnated the center's economy, slowing potential developmental pressures, and allowing for many of the original buildings to persist largely untouched. After much of the city's

**opposite** a view of *Casa de Los Angeles* (foreground) and *La Iglesia de La Inmaculada Concepción* (background) from the River Magdalena (photo credit: Wikimedia Commons)



**Figure 3.1** (left)  
Mompox wetlands  
(photo credit: skyticlus,  
[dronestagr.am](http://dronestagr.am))

**Figure 3.2** (right) local  
cattle ranching (photo  
credit: Dan Rajter,  
[adventuresofadr.com](http://adventuresofadr.com))

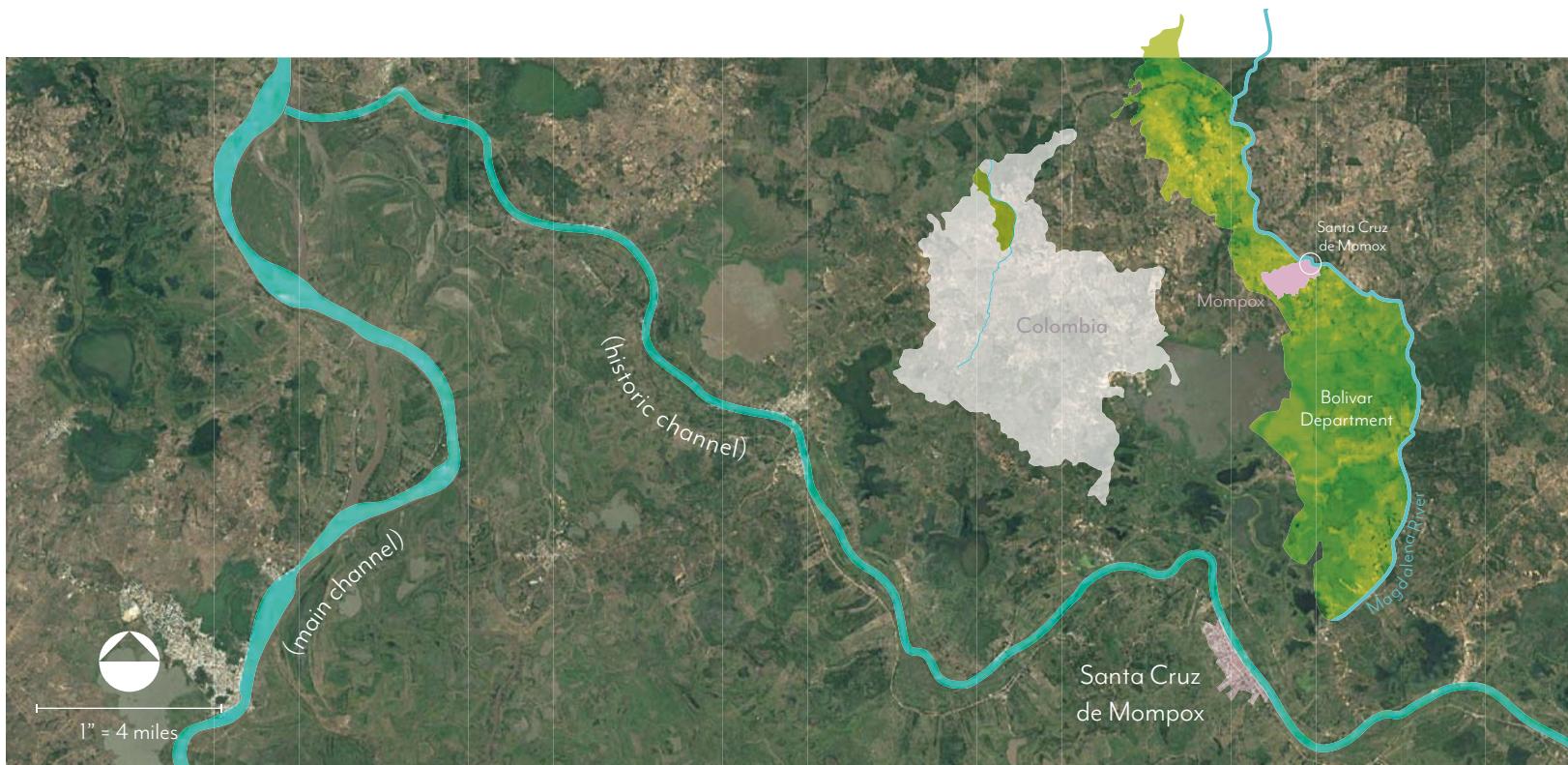
nobility left, the remaining artisans and farmers maintained the now localized economy, passing down their traditions which still define the center's culture to this day. These ongoing traditions have helped to further retain the center's built cultural integrity by perpetuating the buildings' historic programs. Since 1970, heritage-based building codes have been established in addition to the city's induction as a UNESCO World Heritage site, further serving to maintain the site's high degree of cultural integrity (Londoño 2012, <http://whc.unesco.org>).

Beyond the city boundaries, colonial life revolves around cattle grazing and farming (Figure 3.2). Severe floods in 2010 to 2012 heavily impacted the region's economy, resulting in on-going

economic stagnation. Today, the center's largest source of outside capital is tourism, which further supports the preservation of both the intangible and tangible heritage of the site (Londoño 2012, <http://whc.unesco.org>).

## Building Along a River

What makes the city center unique as a Spanish colonial settlement is its pattern of development with respect to the Magdalena River (Figure 3.3). The main street of the center was built upon a dyke that defines the west bank of the river and the eastern edge of the center. Barricade walls, or *albarradas*, were built upon this dyke to provide additional protection from floods (Figure 3.4). The city center thus expanded linearly rather than



radially from a central plaza, which was the more common pattern for Spanish colonial settlements at the time. The center has three main plazas, all arranged in a line along the main dyke that serve as the center's major junctions. The fact that the nearly 500-year-old main street dyke and adjacent buildings are still in such an exemplary condition is a testament to the efficacy of the dyke's resistance to periodic inundation.

The architectural craftsmanship found in Nueva Granada combines imported techniques, *tapía pisada* (rammed earth and masonry), and local, indigenous techniques, *bajareque*. Imported techniques used brick, rounded and ashlar stones, or a mixture of the two in combination with modified mud and plaster (Figure 3.5) Bajareque, on the other hand, represents a conglomerate of pleated cane and liana vines that are plastered together with mud (Figure 3.6). Spanish colonists

**Figure 3.3** context map (upper right) with the location of Santa Cruz de Mompox in relation to the Magdalena River confluence (upper left)

**Figure 3.4** a view of Albarrada del Alba, one of the main streets with a visible barricade (image source: Wikimedia Commons)

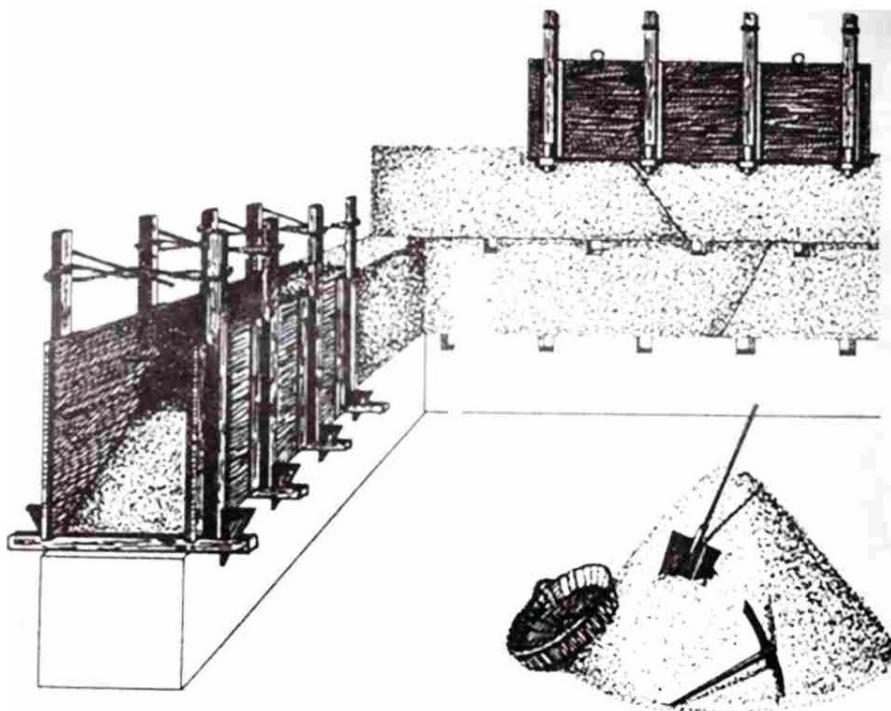


learned from local Indigenous people techniques for modifying local mud, selecting wood types, and identifying plants for construction purposes (Bustamante et al. 2014). As buildings became "more noble", the reliance on imported techniques grew (Bayón and Marx 1992). Since the original dyke and albaradas had to withstand constant and/or periodic inundation, they were most likely constructed using mixed *tapía pisada* methods while bajareque would have been more appropriate for siding applications. Today, the presence of historic and modern materials is interspersed throughout the river's edge. Some *albaradas* have been reinforced or replaced with concrete

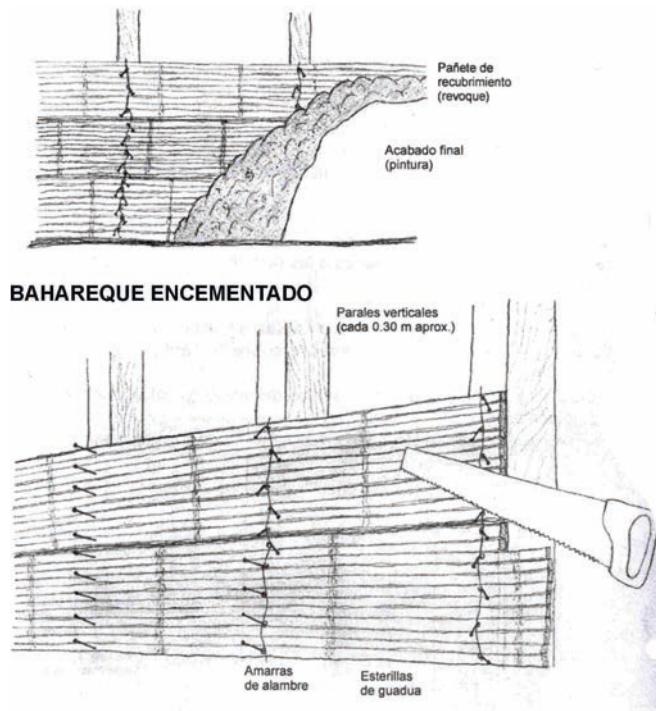
(Figure 3.4) while in other places the dyke shows a continued use of brick masonry right up to the water's edge (Figure 3.7).

## Contemporary Considerations

It's unclear how much of the dyke and albaradas have been reinforced or replaced with concrete but the notable lack of records that describe breaching floodwaters or dyke failure suggests that the center's main street dyke has been robust enough to resist serious flood impacts on the city center. It seems improbable that the river has never breached the dyke and albaradas



judging by the persisting integrity of the original structures. It should be noted, however, that flood breaches may still have occurred. The albarradas are physically discontinuous in order to provide direct access to the river which is especially common near plazas, suggesting that water levels could easily breach the dyke through the gaps. A study of the site in relation to its context reveals that although the city is built right on the water's edge, subsequent urban development remained rather dense (Figure 3.8). Judging by the proliferation of swamps and marshes immediately



**Figure 3.5** (left) diagram of wall construction using the tapía pisada technique atop a masonry foundation (source: Bustamante et al. 2014)

**Figure 3.6** (right) diagram of wall construction using the indigenous bajareque technique (source: Bustamante et al. 2014)



**Figure 3.7** a view of the Plaza del Mercado building as approached from the river shows brick masonry steps to the water's edge (image source: sergejf, Flickr)

environment.

The question about how the city center has resisted flood damage for nearly 500 years largely remains unanswered. It's not known whether local Indigenous peoples consulted with Spanish builders on the heights of flood waters, or if there were any recent indicators on nearby trees that could have informed how high to construct the dyke. However, judging by the flat expansiveness of the landscape, when the river breaches its eastern bank, it most likely spreads quickly and dissipates (Figure 3.8). Because the city's growth remained on the west side of a relatively straight and narrow stretch of the river, high water levels can easily spill over the east bank and spread out across the intact flood plain. Much of this land appears to be managed for grazing, which has kept it open and largely undeveloped. Although flooding has historically impacted the livelihood of local ranchers and farmers, such land uses have allowed for the continued deflection of rising water by the dyke, resulting in the ongoing preservation of Santa Cruz de Mompox. The center's concentrated, single-bank development has, in turn, helped to conserve the landscape's absorptive capacities at the regional scale, thereby allowing the city center's dyke and albaradas to be more effective.

## Resilience Strategies

In conclusion, the main resiliency strategy being deployed by the design and construction of Santa Cruz de Mompox can be summarized as robustness in the form of deflection and floodplain dissipation. It's important to note that the river is successfully deflected by the city's dyke as a result of the surrounding land's ability to spread the floods quickly, thereby dissipating their energy and volume across the floodplain. Although the dense development pattern of the city center may have been incidental, the inherent absorptive qualities of the surrounding wetland landscape play an important role in re-stabilizing the river after heavy rains. That being said, little is known about development changes upriver and how that might impact the city center in the future. Regardless of projections, the largely undeveloped adjacent floodplains in conjunction with a robust deflection strategy have immensely reduced any impacts that would have otherwise repeatedly damaged Santa Cruz de Mompox. Thus, the overall resilience strategy at work is robustness via flood deflection and landscape-scale dissipation, or as a conceptual, functional expression: **robustness = deflection + dissipation.**



**Figure 3.8** plan view of the city center in relation to the present-day city boundary and adjacent floodplains and wetlands



# The Windmill-Polder System at Kinderdijk-Elshout, Netherlands

Much of the Netherlands is a fluvial delta that sits just around a meter above sea level (Mulder 1991). In this land from which the term "landscape" itself was derived, the Dutch have been cultivating a delicate balance between land and water since before medieval times; draining enough water to ensure they stay above the surrounding rivers while channeling enough to ensure agricultural and seafaring prosperity. Since the early 14<sup>th</sup> century, windmills have played a pivotal part in this dance between land and water and were regarded as a national symbol through the 19<sup>th</sup> century when new energy sources began to slowly phase them out (Kaijser 2002; Roney 2009). However, one of the oldest intact drainage networks in Holland (and quite possibly the world), has remained operational to date— Kinderdijk-Elshout. Located in a delta in the "lowlands" south of Utrecht, the UNESCO World Heritage Site contains 19 drainage mills that function as a back-up to the modern-day electric pump houses (Figure 3.9) (Kaijser 2002; <http://whc.unesco.org>).

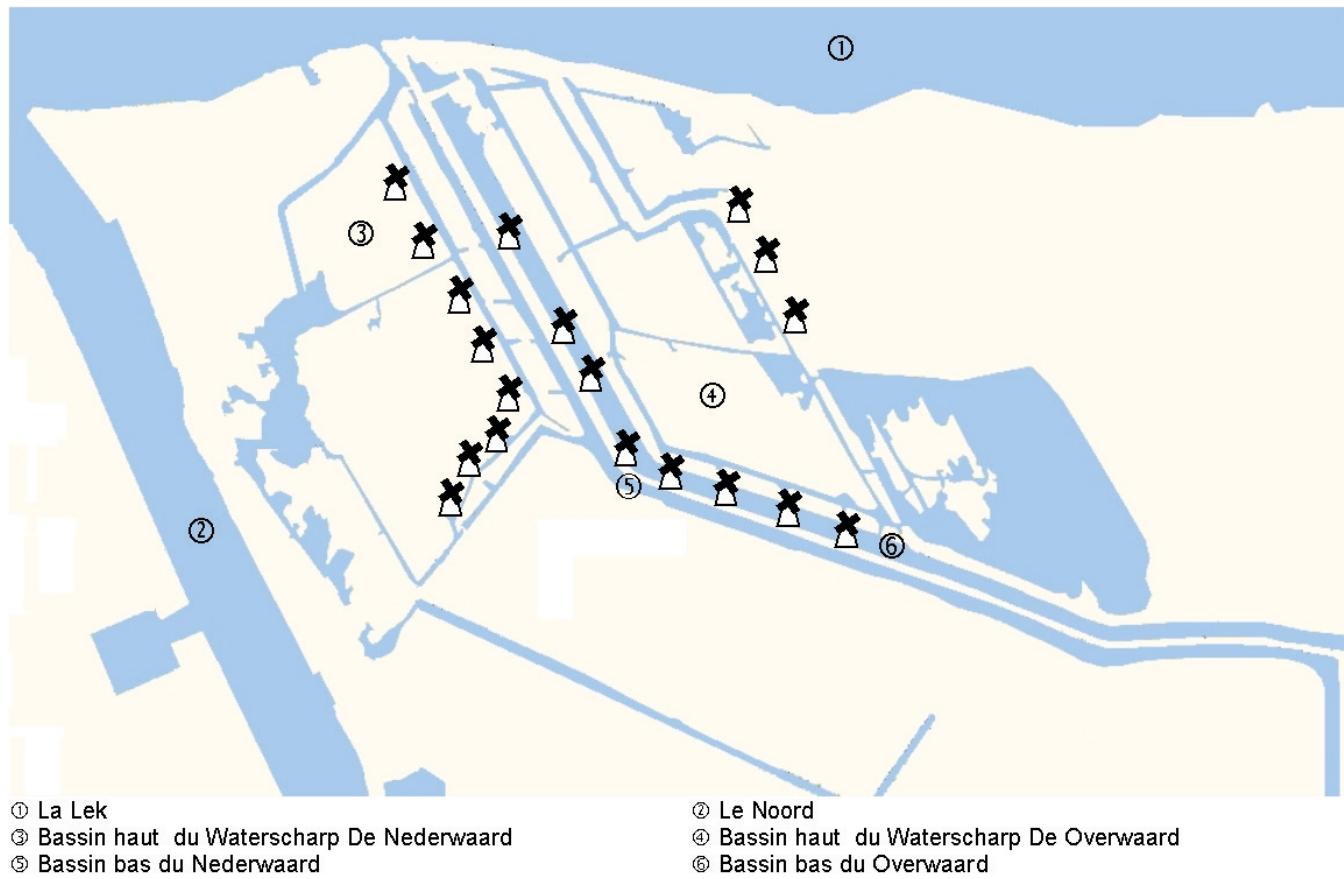
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**opposite** aerial view of Kinderdijk-Elshout looking west toward Rotterdam  
(photo credit: Wikimedia Commons)

The windmill complex at *Kinderdijk-Elshout* sits at the confluence of the Lek and Noord rivers and represents an historic version of the ongoing dance between the Dutch and their landscape. The worst flood in history at the time, the St. Elizabeth's Flood of 1421, claimed 100,000 lives and 73 villages were engulfed by the river. Legend has it that after the waters subsided, a baby cradle washed ashore with a cat perched on top. Both lives were saved, thus inspiring the naming of *Kinderdijk*; the child's dyke (Roney 2009). The Kinderdijk-Elshout complex consists of 19 drainage mills, 3 pumping stations, 2 discharge sluices, and 2 Water Board Assembly Houses. The mills fall into 3 categories: 8 round, brick ground-sailors; 10 thatched octagonal smock mills, and 1 hollow post mill.

## A History of Flood Management

The first polders that linked windmills to drainage systems (*boezems*) were built in 1447 and permanently impacted Dutch water management practices and the larger landscape (Kaijser 2002). They were adapted for drainage by replacing the grindstone with a scoop wheel, and again with the Archimedean screw in 1650 (which are still used today in modern facilities) (Roney 2009) (Figure 3.10). The requirements of drainage systems



**Figure 3.9** site map of Kinderdijk at the confluence of the Lek and Noord rivers (image source: Wikimedia commons)

increased as the drained lands, or polders, began subsiding faster and rivers began to overflow with excess drainage water (Mulder 1991). To alleviate this, storage ponds were constructed to regulate the flow between the boezem and adjacent canals or rivers. The first storage pond (*hoge boezem*) was built in 1490 to keep the River IJssel from flooding

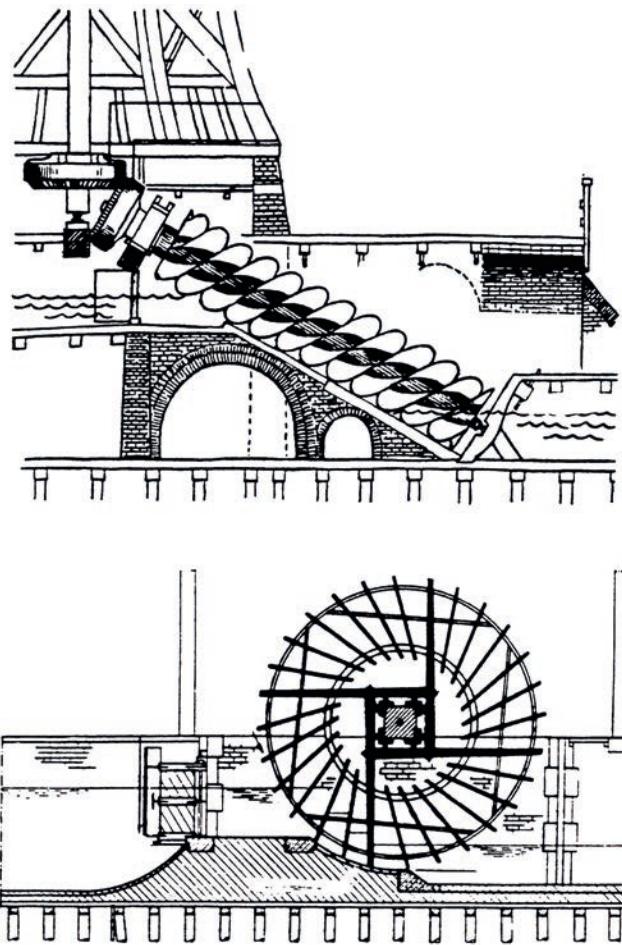
and covered 40 hectares. Five windmills in total were built along its dykes, setting the precedent for Kinderdijk (Kaijser 2002).

The windmill-polder system became the institutional norm and required a tandem social system to ensure its perpetuity (Kaijser 2002).

The construction of windmills alone required a skilled millwright that could design and build the structure and the mechanisms, ensure that they interlocked appropriately, and even carefully lift them into place. Polders had to be built in tandem with their conjoined windmills so that they matched the windmill's drainage capacity and that of their storage ponds. Additionally, millers were necessary for operating and maintaining the mills, often living inside the structures with their families. Millers were often skilled in sailing techniques which were needed for adjusting the sails on windmill blades whenever the wind changed direction. Millers still live in at least one of the mills at Kinderdijk to this day. Finally, a water board was needed to manage and organize the entire operation, from overseeing the maintenance of drainage networks and mills to collecting taxes from adjacent landowners (Kaijser 2002; <http://whc.unesco.org>). Thus, the construction of windmills and drainage networks required that extensive planning and management systems remain coupled with the built drainage structures and systems. All of these concerted efforts were aimed towards increasing the amount of drier land that could be cultivated and/or developed while responding to new issues that arose.

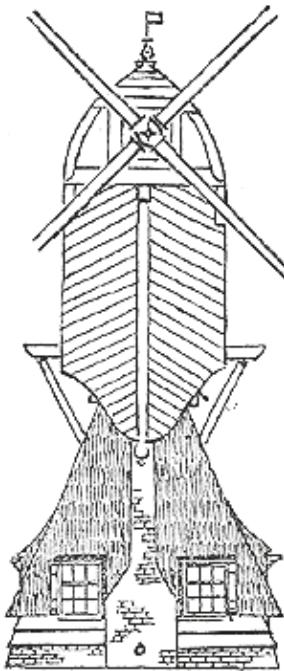
## Dutch Windmills

The windmills at Kinderdijk are

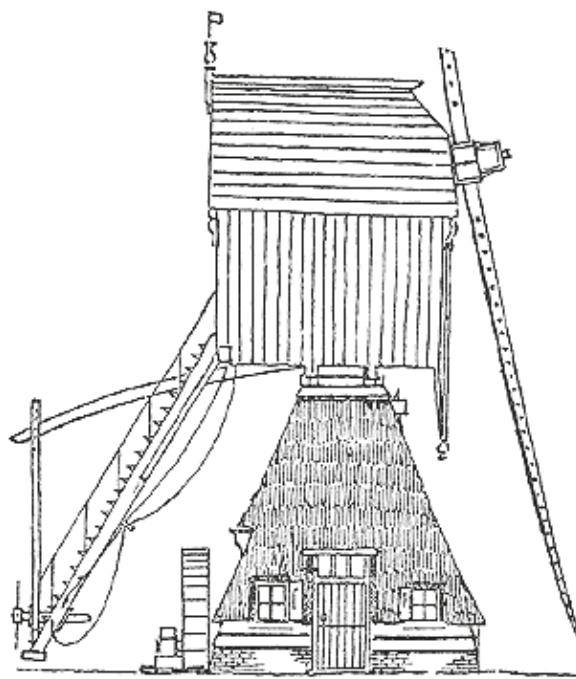


**Figure 3.10** the archimedean screw pump (top) which replaced the traditional paddle, or scoop, wheel (bottom) (image source: Stokhuyzen 1963).

representative of the most common styles found in South Holland. The hollow post mill, or *wip* mill, is one of the oldest drainage mill designs and was derived from the post mill (Figure 3.11). Made primarily of wood, the defining mechanisms consist of an upright shaft inside a hollow support

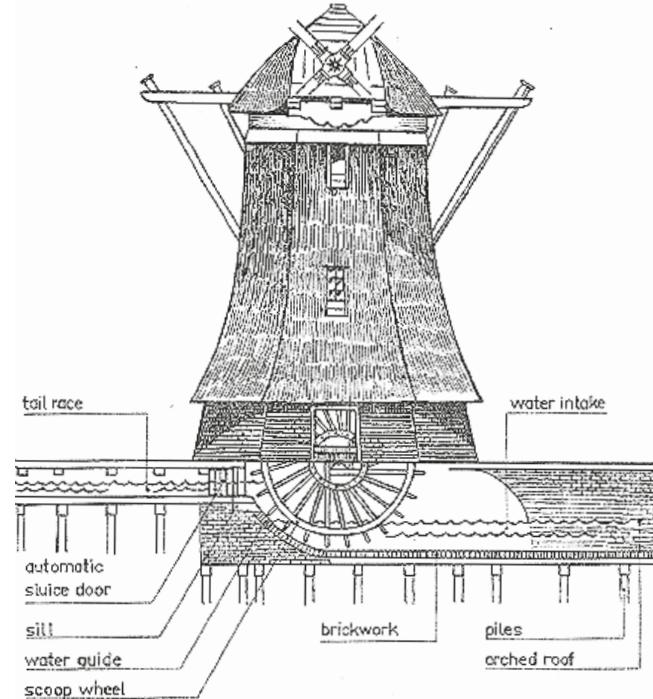


**Figure 3.11** (above) elevation side and front view of a wipmolen, or hollow-post mill (image source: Stokhuyzen 1963)



**Figure 3.12** (right) section elevation of an octagonal smock mill with a scoop wheel (image source: Stokhuyzen 1963)

post that connects the vertical pit and scoop wheel, which transfers the water from the polder to the sluice, with the wind shaft. This style is the smallest of Kinderdijk's and rarest in all of the Netherlands. Octagonal smock mills, or outside winders, on the other hand, are the larger, tapering, familiar style that is typical of South Holland (Figure 3.12). The bases are built of brick with thatched wooden-framed bodies. The octagonal frame is supported by heavy vertical and horizontal timbers that are incredibly sturdy and capable of withstanding high wind forces. The curved



exterior lines help to reduce the wind resistance of the descending blades of the sail. The last style represented at Kinderdijk are the brick ground-sailors, or grondzeiler (Figure 3.13). Because winds are stronger in the flat fields and polders, there is little need for elevated bases to lift the blades into the air. This style is derived from the stellingmolen, or tower mill, and where height isn't necessary, the towers were shorter and more commonly used as industrial mills or corn mills. However, at Kinderdijk, all of the mills are technically grondzeilers (with the exception of the hollow post

mill) because their blades nearly touch the ground. The only difference amongst the 18 large windmills is that the round grondzeilers are made of brick and the smock mills are thatch with brick foundations (Stokhuyzen 1963).

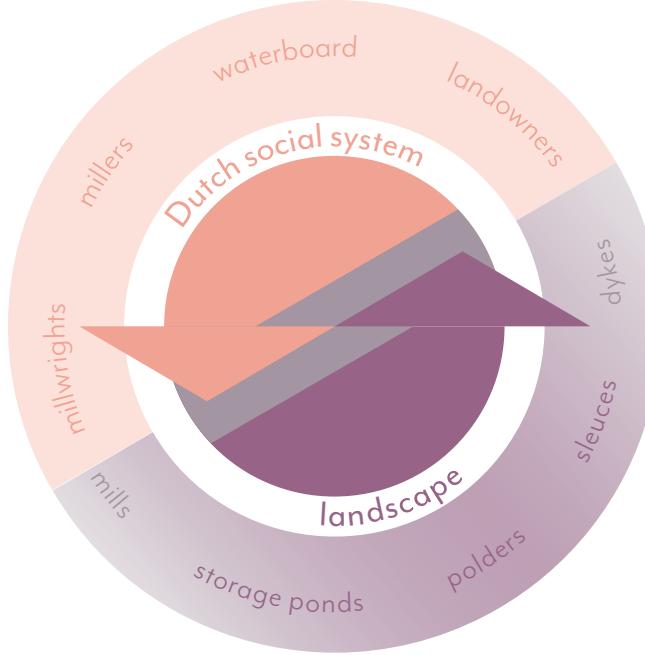
## The Windmill-Polder System

Although Kinderdijk relies on modern facilities to drain its polders, the complex still operates as a back-up drainage system in addition to providing visitor interpretation through a repurposed pumping station. Unlike many of the cultural landscapes found within U. S. National Park boundaries, Kinderdijk, like Santa Cruz de Mompox, is situated within the modern-day extension of its historic cultural context. In other words, because the Dutch today still rely on water management in much the same way that their ancestors did (if not more as a result of ground subsidence), the complex at Kinderdijk is not so much a relic of an historic land use but instead an example of present land use with historically maintained structures. This is particularly evident at the hollow post mill which is operated by a miller and his wife who live next door (this style of mill is too small to double as a dwelling) (Stokuyzen 1963). For these reasons, it's difficult to discuss the construction methods of the windmills as contributing to the structures' resilience without acknowledging that it is actually the landscape



**Figure 3.13** a brick grondzeiler, or ground-sailor, at Kinderdijk (image source: pixabay)

itself which is resilient as a result of the mills. Much of Kinderdijk's resilience stems from its ongoing, culturally-significant maintenance methods; the mills, polders, and the boezem simultaneously form the built features and the landscape of the site; they comprise a larger, reciprocal, ongoing process that is manifest in the physical windmill-polder system itself. The integrity of the cultural practices, land use patterns, and historic structures are so seamlessly integrated into each other that the conceptualization of the polder-mill-miller-millwright-boezem-river system as a social-ecological system can be much more clearly



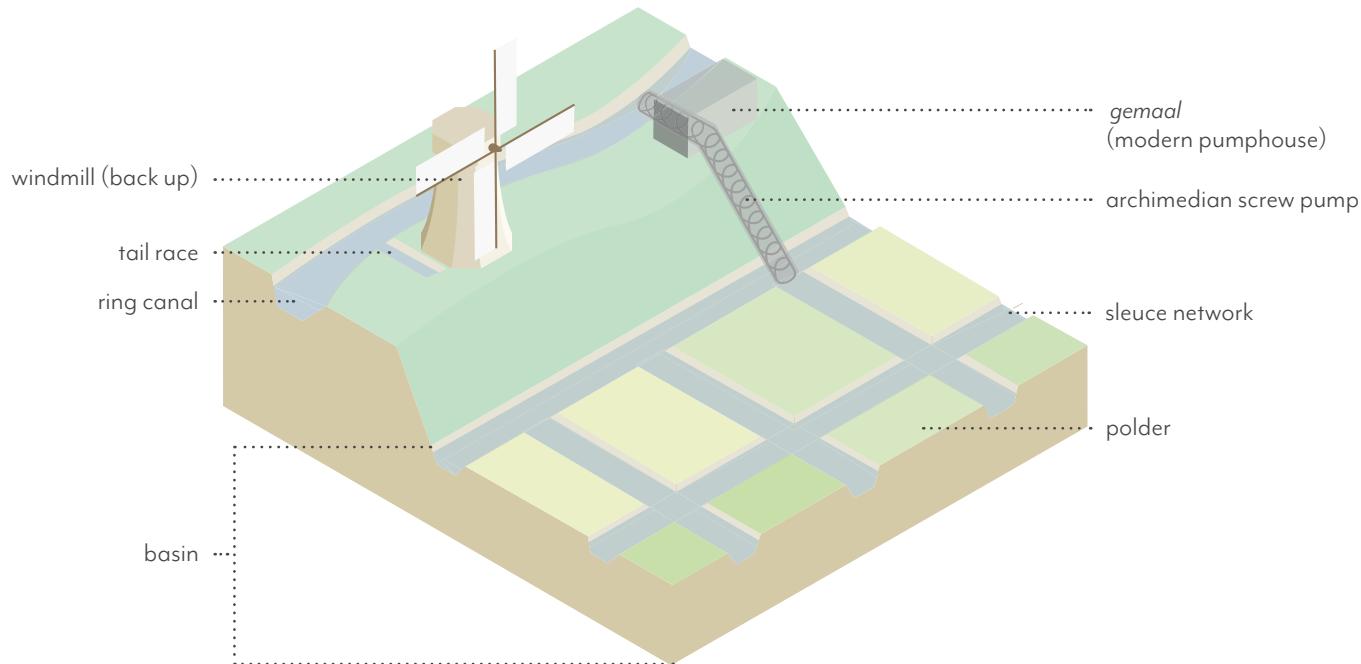
**Figure 3.14** conceptual SES diagram of the Dutch landscape as exemplified by Kinderdijk's windmill-polder system

supported (Figure 3.14). Thus, it is more accurate to describe the polders, rather than the mills, as being the resilient built features in this system since they are the impetus for, and recipient of, the flood-resilient properties that arise from the collective efforts of the mills, millwrights, millers, and boezem. If the polders are the flood-resilient, built features of the Kinderdijk landscape, then the rest of the coupled system comprises the resilience-contributing attributes. The landscape features, in this case, are also the resilience-contributing built attributes.

## Resilience Strategies

The resilience strategies employed at Kinderdijk are complex as a result of the tightly interleaved social and environmental components that are interconnected through intangible processes. As a result, Kinderdijk represents an SES with more closely interrelated sub-systems that experience more frequent feedback. This makes it difficult to provide an assessment of just the built features that define Kinderdijk. However, for the purposes of this project, the main engineered strategy appears to be redundancy. Because the windmill complex is maintained as a back-up to the electric pump houses, the mills themselves are a redundant system that can fulfill the role of the pump houses should the pump houses experience a power outage. The pump houses are not considered to be culturally significant in the same way that the mills are because they serve as current infrastructure that does not reflect historic traditions. That being said, the 19 historic mills are a part of the culturally significant historic system and provide a degree of redundancy within their own right because they are so numerous.

In addition to their redundancy, one of the most compelling qualities that make the windmill-polder complex resilient is its ability to capitalize on a plentiful, latent energy source- the wind- to continually drive the drainage of water. In this way,



**Figure 3.15** diagram of the windmill-polder system and its constituent landscape features as they remain today

the windmill-polder system demonstrates a degree of self-sufficiency by utilizing an available kinetic energy source. However, the mills would not be as effective if it weren't for the millers' constant vigilance in adjusting the sails on the blades to ensure maximum wind exposure. They, like the boezem, are still maintained using traditional knowledge and practices that, although potentially less common, are continuously revitalized through their ongoing use and application. This extant, culturally significant knowledge adds to the historic system's resiliency because it allows for the social subsystem to adaptively respond from

to unplanned events. That being said, the water management systems, both historic and current, are designed to prevent floods—it is not clear what role they play in resisting or withstanding flood. Through their very existence, they make the landscape and its coupled culture resilient to otherwise ever-present inundation.

In terms of built features, the polders are the truly flood-resilient features since the mills themselves are a means to an end. The polders display a degree of redundancy via their integration into a sequence of terraced water bodies (Figure

3.15). Each water body within the boezem, from the sluices to the canals to the reservoir and then the river, is higher in elevation than the body it is draining. This situates the polders at one end of a series of vertical steps which, in the case of a flood, offers multiple holding spaces for water to cascade through before it finally spills over into the polder. This sequencing nests redundant features into a series that also serves as a buffer; each subsequent water body essentially stalls the flooding process, allowing for increased response time.

In conclusion, the main engineering strategy at play at Kinderdijk is redundancy across various scales, including stacked water containment terraces that provide additional buffers through the utilization of an available, latent energy source. The latent energy source is plentiful and actively maintains the function of the built landscape while indirectly maintaining the condition of the site's materialistic, built features. For these reasons, the strategy is best summarized as redundancy via stacking and self-sufficiency via latent energy, or as a conceptual, functional expression: ***redundancy(stacking) + self-sufficiency(latent energy).***





## Katsura Imperial Villa, Japan

The Katsura Imperial Palace is a source of immense cultural pride as it represents the quintessential character of traditional Japanese architecture and landscape design. Its adjacency to the Katsura River allows for water to flow through the strolling garden, which is considered one of the finest gardens in Japan and once recognized for its high biodiversity (Yukihiro 2011). To compensate for this increased vulnerability to annual flooding, the palace was constructed on piers and is bordered by a living bamboo fence that was designed to attenuate incoming rising water (Yamashita et al. 2015; Okubo 2017).

The Katsura Imperial Palace was designed by and built under the supervision of Prince Hachijo no Miya Toshihito from 1620 to 1625 in the then-capital of Kyoto. It was intended to serve as a retreat for the prince, hence its epithet the Katsura Detached Palace. The site played host to a succession of villas that served the feudal Fujiwara clan prior to its reincarnation as the Detached Palace. The main building, or *shoin*, was built in the

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**opposite** a view of the main *shoin* looking southwest  
(photo credit: Christian Kaden, Flickr)

*shoin-zukuri* architecture style which came about during the Muromachi period (1336-1573) but was nonetheless typical of aristocratic architecture of the time. The structure is comprised of three sections: the old *shoin*, the middle *shoin*, and the new palace, which was added in 1642 by Prince Toshitada (Figures 3.16A-3.16B). Prince Toshihito consulted with Zen priests and a friend who introduced him to the poetry of Po Chu-I in order to maximize the palace and surrounding landscape's potential for various reflective activities (Ishimoto and Tange 1972).

### Down-to-Earth Aesthetic

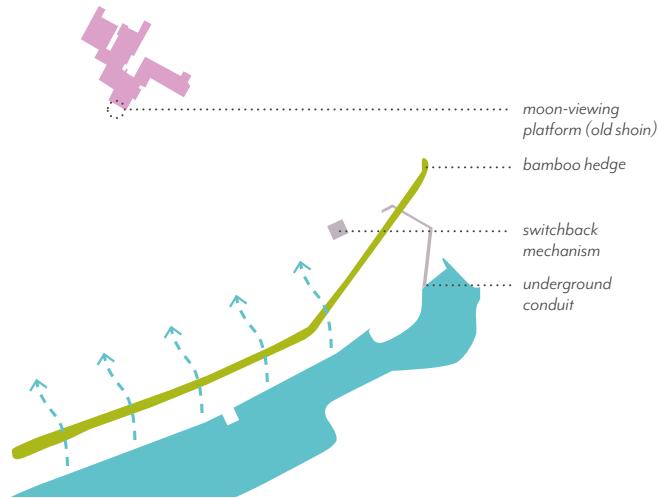
The *shoin-zukuri* style evolved from the original Japanese floor plan in which 2 partitions were created to separate indoor work from sleeping. Over time, more partitions with various heights, or ranking, were added as Japanese homes evolved along with accumulating wealth. The *shoin-zukuri* style is further characterized by wooden or paper covered doors along the exterior hallway, or *engawa*, a deep eave in front, and an elevated foundation (Ishimoto and Tange 1972). It was common for foundation footings, or piers, to be set upon carved or rough base stones, depending on the formality of the structure (Figure 3.17; Locher

## General Plan of Katsura Imperial Villa



**Figure 3.16A** site map of Katsura Imperial Villa with the features of interest highlighted in teal (adapted from: Ishimoto and Tange, 1972)

**Figure 3.16B** (opposite) diagram of site features and predicted river overflow



2010). In the case of sukiya homes, which were less formal, stones were often irregular in shape and reflected a more naturalistic connection with the earth; a style that was adapted for use with the main shoin at Katsura. This more rustic approach most likely stemmed from Prince Toshihito's desire for a more down-to-earth aesthetic (Okubo 2017). Sukiya homes and structures, like the small ceremonial teahouse within the garden, have main floors that are only slightly elevated. The main shoin, on the other hand, is elevated about 4-5 feet above the ground. The support piers are individually carved to fit their rough, asymmetrical base stone counterparts, another quality that is commonly found in sukiya-style homes. This, along with the weight of the finished structure, keeps the piers from slipping during floods while still allowing for flexibility in the case of earthquakes



(Locher 2010).

Additionally, some of the spaces between piers are plastered or lined with bamboo slats, forming continuous walls that more closely resemble a *renzoku-kiso*, or continuous footing foundation (Figure 3.18). The plastered foundational walls adjacent to the moon-viewing deck are exposed, which is surprising since plaster absorbs water and deteriorates over time. Those along the southern sides of the middle shoin and new palace are set

**Figure 3.17** examples of sukiya-style foundation piers showing variations in base stone shapes and sizes (image source: Locher 2010)



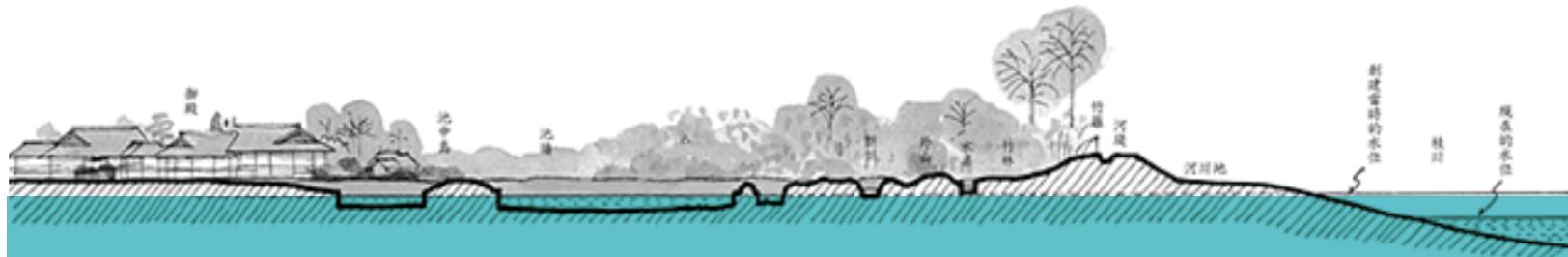
**Figure 3.18** (above)  
view of the middle  
shoin (right) and new  
palace (left) with  
foundation bamboo  
slats showing high water  
marks (image source:  
Wikimedia Commons)

back and away from the edge of the engawa. Why the difference exists is unknown though it was most likely an intentional decision. Despite their differences in exposure, the piers and bamboo slats show signs of past high water marks, a testament to the periodicity of flooding on the site (Yukihiro 2011). The overall execution of the main shoin demonstrates an awareness of the immediate environment through its elevated location within the floodplain, its visually seamless integration from within the structure, its use of stones and wood sourced from around Kyoto, and its stylistically humble connections to the site.

The design of the strolling garden was



**Figure 3.19** modern-  
day aerial view of the  
villa with dyke (white)  
and water intake along  
riverside (adapted from:  
Google Maps)



inspired by recollections of the Oguraike wetland system which existed within the Kyoto basin prior to settlement (Ikeda 2014). The series of designed ponds originally drew water from the Katsura River via a small inlet and meandered it throughout the complex, creating a series of wetlands that interplay with the site's built topography.

## Built Traditions

Mid-century maps of the site suggest that the river water is redirected via an underground conduit, as seen in the site map. The water was then passed through a series of channelized switchbacks to help attenuate the incoming flow, a feature that remains to this day. Recent Google imagery of the site shows that it is also elevated above the floodplain at approximately the same height as a dyke that extends northwest from the site and runs parallel to the river (Figure 3.19). It remains unclear whether the site's current elevation in relation to the river's bank illustrates approximately 400 years of channel incision or site

infill. However, it seems plausible that the site was filled prior to construction since the river's water would have needed a negative grade in order to flow freely into the site and through the switchbacks. This suggests that the topographical features were sculpted through the subtraction of infill so as to accommodate the water's inflow (Figure 3.20).

Another flood-resilient feature that is still present today is the historic bamboo hedge, or *katsura-gaki*, that wraps around the site's riverfront boundary (Figure 3.21). The hedge is made of living bamboo stalks that have been woven together to form a fence (Okubo 2017). This living fence serves as a filter for incoming flood debris, thereby preventing water from surging into the complex and damaging its features. The pliability of the bamboo hedge, in conjunction with its spreading, fibrous roots, allows for a high degree of flexibility without the risk of uprooting—a quality that can be easily observed during strong winds. This attenuation of floodwaters demonstrates a mentality of seeking harmony with nature through

**Figure 3.20**  
diagrammatic section  
showing the water table  
height (image source:  
unknown)



**Figure 3.21** the katsura-gaki, or bamboo hedge, as seen from the perimeter road (image source: culturejaponaise.info)

the construction of human systems that allow for adjusted inflows rather than resistance (Yamashita et al. 2015).

## Cultural Traditions

The complex is managed by the Imperial Household Agency, which employs gardeners and traditional builders to maintain the grounds using the same techniques that informed its original design and construction. Visitors are allowed in by appointment only to regulate the impact on the site. The landscape plants, including the katsura-

gaki, are regularly maintained by gardeners—a profession whose techniques has not changed much over the last centuries. Like Kinderdijk, much of the culture that created the site is still intact. However, the Katsura Imperial Palace is an aristocratic villa intended to provide respite from society as opposed to Kinderdijk which was, and still is, a part of the physical infrastructure that supports Dutch society.

## Resilience Strategies

The strategies that historically kept Katsura Imperial Palace from regularly flooding revolve around the attenuation, or amelioration of, flood impacts. The katsura-gaki provides the first line of defense against high water levels by filtering and slowing the flows. In this way, the hedge acts like a buffer that reduces the flood's overall impact. Once inside, the high waters push through, and perhaps over, the garden's topographical features and through or around the piers of the main shoin. Since the main shoin sits atop a flat lawn, the water can rise up a few feet before pushing into the building's main floors. The elevation of the main building expresses an allowance of disturbance rather than resistance. Although the materials of the hedge and main shoin demonstrate a degree of robustness by being anchored and immovable, the cultural attitude that informed the villa's design aligns the intentions of the site with the direction

of natural processes. However, more information is needed to fully understand the intention of the plastered foundation walls since their presence most likely inhibits flow and would be negatively impacted over time. Judging by the villa's built strategies, the width of the channel, and the broadness of the floodplain, the Katsura River most likely rose slowly and dissipated quickly during regular 17<sup>th</sup> century floods. It's likely that the site does not flood as frequently as it used to since the installation of the modern dyke. This is supported by a lack of records that confirm if the river breached its banks during a major flood caused by the Man-Yi typhoon in 2013 ([www.japantimes.co.jp](http://www.japantimes.co.jp)).

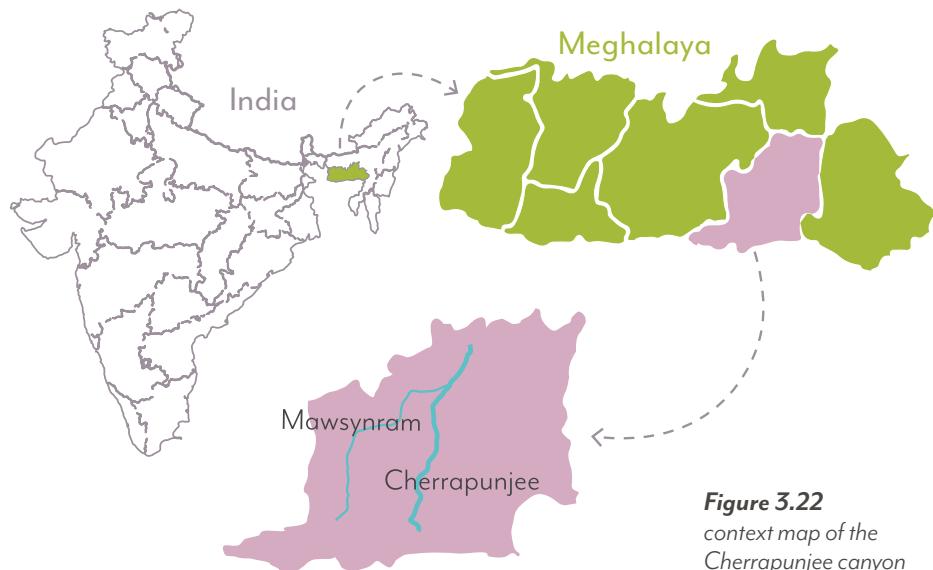
In summary, though it's not clear if the villa still experiences direct, seasonal flooding, the site's attitudes towards redirecting the Katsura River's water and attenuating incoming floodwaters communicates a strategy that focuses on diminishing impacts rather than preventing or resisting them. The material choices—bamboo and elevated piers—reinforce a sense of pliability and lack of engineered rigidity. For these reasons, the term **attenuation** most adequately summarizes both strategies.



## The Living Bridges of Cherrapunjee, India

Nestled within the densely forested subtropical state of Meghalaya in northeastern India lives an indigenous tribe known as the Khasi people. The Khasis have no written language but have passed down a bridge-building tradition that utilizes the aerial roots of a local banyan tree species; helping them to maintain access to food plots within a highly unpredictable environment.

Meghalaya, which is both a state and a plateau, means "abode of clouds" in Sanskrit and, not surprisingly, it contains the two wettest regions in the world in terms of rainfall: Mawsynram and Cherrapunjee (Murata et al. 2007; Shankar 2015). The Khasi people are native to one of these regions, Cherrapunjee, which is located within a deep canyon on the southern face of the Meghalaya plateau (Figure 3.22). For millennia, heavy rains and tectonic uplift have been carving this terrain into breathtaking yet unstable geologic features. The canyon's steep topography and heavy monsoonal rains make it prone to flash floods,



**Figure 3.22**  
context map of the  
Cherrapunjee canyon

landslides, and debris flows. This susceptibility is further exacerbated by the region's proximity to the tectonically active Himalayas just north of the plateau (Kale 2014). As a result, Khasis have cultivated many sustainable practices to help them adapt to their fragile and remote environment.

One such practice, known locally as *jing kieng jri*, capitalizes on the adaptive qualities of *Ficus elastica*, a native species of fig tree that can be found throughout the evergreen broadleaf forests of Meghalaya. Khasis have been intertwining and

**opposite** a mature, double-decker living root bridge near Nongriat village (photo credit: Arshiya Urveeja Bose, Flickr)

Location [India]	Span [feet]	Growth stage	Safety level [5 is safest]
Riawai	75	Mature	5
Wahryngkoh	15	Mid life	3
Mawkyrnot	250	Early life	1
Mawkyrnot	150	Early life	1
Mawkyrnot	250	Mid life	3
Nongthymmai	60	Mid life	3
Nongthymmai	80	Early life	1
Nongthymmai	20	Mature	5
Nongriat	40	Mature	5
Nongriat	50	Mature	5
Nongriat	60	Mid life	3

**Table 3.1** characteristics of living root bridges as of 2015 (image source: Shankar 2015)

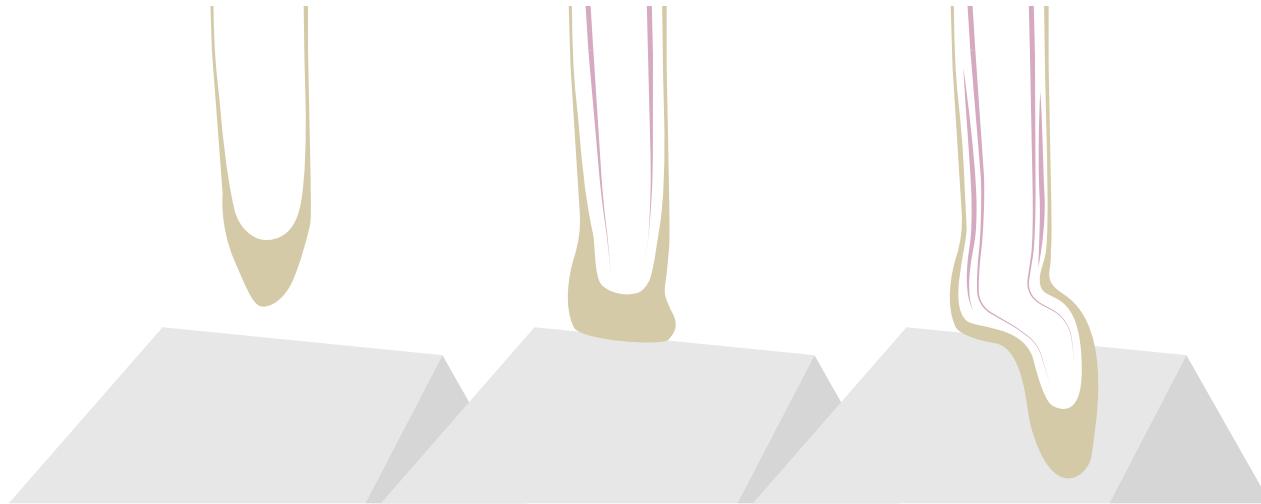
guiding the aerial roots of these species into living bridges for generations, passing down the tradition through oral and demonstrative means.

The bridges range from 15 to 250 feet in length and can support 20-35 people at a time. The age at which the bridges reach maturity ranges

from 15 to 30 years after construction commences. Unlike steel suspension bridges used elsewhere in Meghalaya, the living root bridges capitalize on local materials that are well-adapted for the environment and grow stronger with time, making it possible for generations of Khasis to go about their daily activities uninterrupted by flash floods (Shankar 2015). It's believed that a single living bridge can last up to 600 years (Mathew 2005). To date, eleven living root bridges of varying lengths and ages have been documented throughout the Cherrapunjee valley (Table 3.1).

## Built-In Flexibility

The key to the success of the living root bridges lies within the adaptive capacity of the *Ficus elastica* tree, also commonly known as a banyan tree. Like most evergreen fig species, *F. elastica* begins its life cycle as an epiphyte—a plant that grows on another plant, or in this case, another tree. Young *F. elastica* saplings send aerial roots down from the canopy and to the forest floor where they wrap firmly around boulders and infiltrate cracks along the river bank (Mathew 2005). The process of attaching and anchoring triggers the growth of gelatinous fibers within the roots, making them able to withstand the dynamic stresses of rushing water or the weight of human movement (Figure 3.23). When building a new bridge, the Khasis use bamboo as scaffolding and

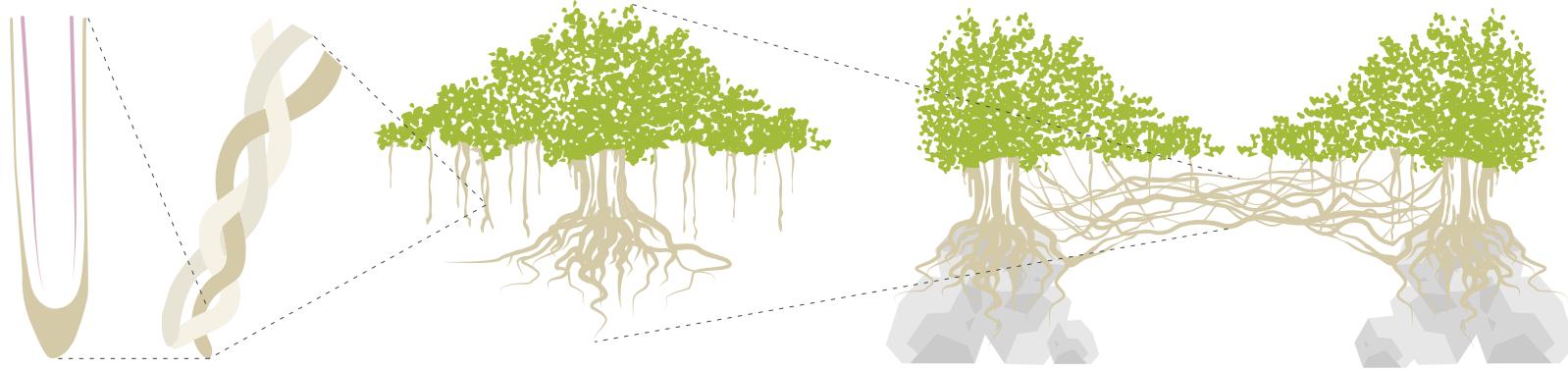


**Figure 3.23** time lapse diagram of gelatinous fiber growth within anchoring aerial roots

guide intertwined, young *F. elastica* aerial roots across streams and ravines through the hollow trunks of the *Areca catechu* palm. The *A. catechu* trunks also provide the roots with nutrition and protection from the weather. Once the roots reach the other side, they are allowed to attach and anchor into the riverbank. This process is repeated for several years as aerial roots are joined midspan for reinforcement. As the roots thicken, the *A. catechu* trunks and bamboo scaffolding are removed. Stones, soil, and timber planks are used to fill the gaps in what will become the floor of the bridge. Rain and daily use compact the paving materials while growing roots expand and fix the stones and planks in place (Shankar 2015).

## Bridge Benefits and Limitations

The living root bridges encompass multiple benefits when compared to steel suspension bridges, a conventional substitute used in similar applications. The stiffness and elasticity varies throughout each bridge since they are built over the course of several years. This improves each bridge's capacity to withstand, or resist, dynamic water loads. The variety of roots from different points of origin also create redundancy, which in the case of extreme stress, diffuses the water load throughout the structure. This redundancy occurs at a range of scales, from the tissue level to the structural level (Figure 3.24). Furthermore, the load bearing capacity of each bridge increases over time as the roots grow in diameter and robustness (Figure 3.25).



**Figure 3.24** diagram of the many levels of redundancy found within each living root bridge

This physical robustness is also reflected at the genetic and tissue levels since no fungus, disease, or pests have been observed attacking the bridges. Finally, no mechanical failure has been observed to date, which serves to further demonstrate the bridges' immense engineered resiliency (Shankar 2015).

In addition to their robustness and redundancy, the bridges exemplify ecological resilience, too. As described above, the trees have an adaptive capacity to respond to tensile stresses by increasing the elasticity of their roots. The bridges also minimally impact the quality of the surrounding environment since they are completely integrated into the local ecology. Furthermore, their materials can be sourced in the immediate vicinity and require no outside knowledge, thereby minimizing the demand on the local community (Shankar 2015). Because the

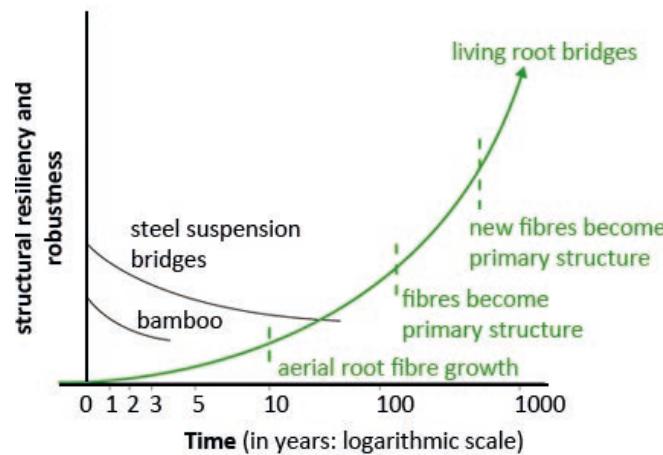
Khasi people have no written language, the passing down of oral traditions is especially important to their ability to persist in such a remote region, thus the need to maintain the bridges reinforces communal resilience via communication and collaboration.

The bridges may be a culturally and regionally appropriate solution, however they do incur some limitations. One of these is the long growing phase. Without continual addition of aerial roots, the bridges cannot grow strong enough to resist daily loads and seasonal floods. For this reason, the bridges are unsafe for use during the first 15 or so years of construction. Furthermore, the trees must be properly located. Although rather robust as a species, the aerial roots and foliage of *F. elastica* need proper soil, light, and water conditions. Lastly, without ongoing community involvement, the bridges would eventually cease

to exist. Judging by the different stages of growth found in the bridges today, it's been concluded that the Khasis are still actively cultivating living bridges as of 2015 even though a few steel suspension bridges have been constructed within the region (Shankar 2015).

## Resilience Strategies

In conclusion, the living root bridges are a unique example of culturally significant built features that demonstrate immense adaptive capacity for withstanding the tensile stresses of flash floods and dynamic loads. Unlike most built features, the bridges are inherently adaptive, and therefore dynamic, since they continue to live after construction and are built using trees that are uniquely suited for the conditions in Cherrapunjee. In terms of engineered resiliency, the living bridges demonstrate robustness by growing denser over time, thereby increasing their ability to resist dynamic weight loads (Figure 3.25). They also demonstrate redundancy at various levels of organization, from the tissue level to the bridge level—numerous elastic fibers form within each anchored root, numerous roots emerge from numerous locations on each tree, numerous roots are intertwined at numerous locations to construct each bridge, and at least two trees which are rooted at numerous places, are used to construct each bridge. Furthermore, the



cultural practices that sustain them have been in effect for generations though the exact number is difficult to determine since their stewards have no written records. Thus, the overall strategy can be summarized as robustness that's achieved through adaptation and redundancy, or, as a conceptually functional expression: **robustness = adaptation + redundancy**.

**Figure 3.25** graph depicting increasing robustness and subsequent resiliency of maturing root bridges (source: Shankar 2015)



## 4 Intervention Thought-Experiments

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### Scotty's Castle, Death Valley National Park, California

According to the National Park Service's cultural landscape inventory, Scotty's Castle, a complex located within the Death Valley Scotty Historic District in Death Valley National Park, is historically significant at the regional and local scale for its 20th century architecture, folklore, archeology, art, and invention. Designed and built in the 1920s by Albert Johnson for his paramour Walter Scott, aka 'Death Valley Scotty,' an eccentric mineral baron, Scotty's Castle is a Spanish-style ranch that illustrates the material wealth and values of frontier mineral extraction during the turn of the 20th century. As of 2011, the landscape's characteristics and associated features have retained an overall state of "good condition" based on the National Register of Historic Places' seven aspects of cultural integrity: location, design, materials, workmanship, setting, feeling, and association through the retention of the relevant landscape characteristics (2011). A summary and map of the site's culturally significant, or character-defining, features can be found in *Table 4.1* and *Figure 4.1* on the following pages.

**opposite** view of the castle  
and annex looking northwest  
(photo credit: Noah Kerr,  
2016)

## Scotty's Castle Site Map



## Scotty's Castle Historic Significance Summary

Death Valley Scotty Historic District, Death Valley National Park, California, USA

### Period of Significance: 1907 - 1954

"The Scotty's Castle complex serves as a reminder of the excesses of mining promotion during the early 20th century, the frontier romanticism connected with it, and the conspicuous consumption practiced by the wealthy during the 1920s."

### National Register Significance: B (association with an historic figure)

"The district as a whole is most closely associated with one of the best known and most colorful figures produced by the American mining frontier—Death Valley Scotty (Walter Scott)."

### National Register Significance: C (association with an historic style or tradition)

Scotty's Castle is significant under Criterion C for its unusual and extravagant use of Spanish-styled architecture built in a remote desert location, and for the use of experimental building techniques and materials by its owner, Albert Johnson.

### Character Defining Features (see adjacent map)

buildings and structures	annex, hacienda guest house, power house and pavilion, chimes tower, Scotty's cabin, gas house, stable, motel unit/garage, entrance gate, lower grapevine ranch fe, wash house, upper tie storage area, tunnels, swimming pool, solar heater, Scotty's grave, cook house, gravel separator, powder storage, Scotty's Castle, retaining walls
circulation	entrance road, Scotty's Castle building road, Tie Canyon access roads, water catchment, tile courtyard, stone walkways, concrete driveway, watercourse
constructed water features	watercourse
topography	terraces
vegetation	picnic area (cottonwood, willow, mesquite, palms), cottonwood corner (cottonwood, willow, mesquite, palms), building complex: palms, cholla cacti, and compatible Joshua tree and creosote bush

**Figure 4.1** (opposite) map of character-defining features at Scotty's Castle complex. Non-significant features are italicized and those addressed in the interventions are **lilac**.

**Table 4.1** a summary of Scotty's Castle's historic status and significant features from the NPS's 2011 cultural landscape inventory

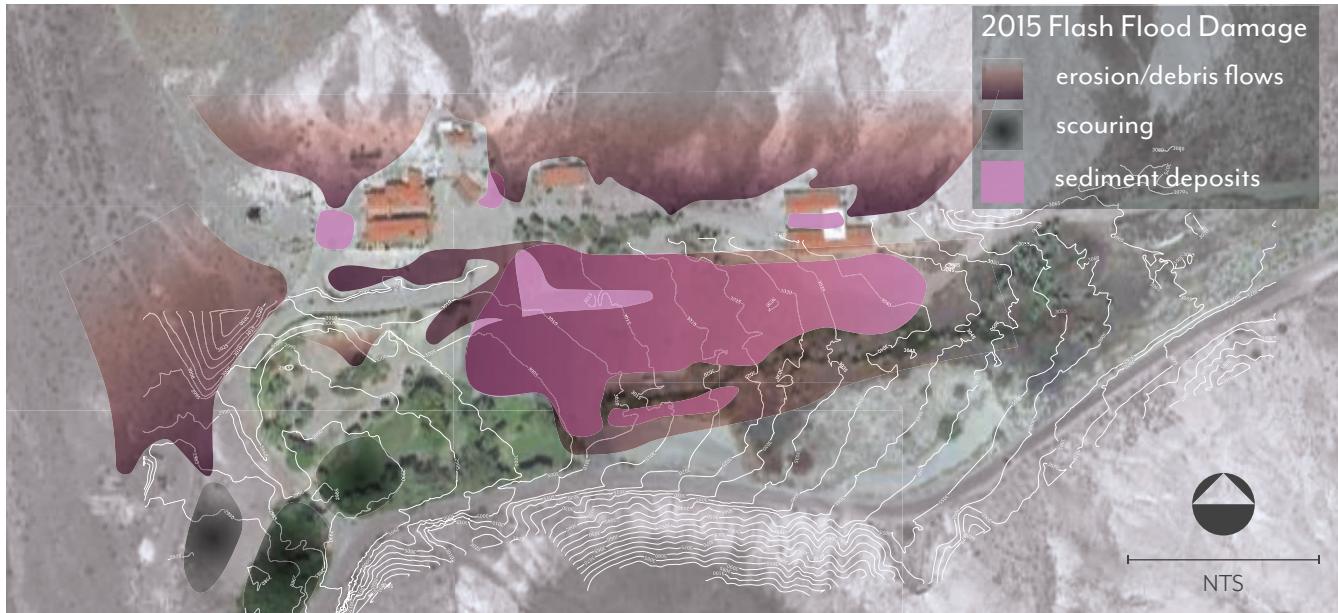
**Figure 4.2** (adapted from post-flood assessments by Louis Berger for the NPS)



## Recent Flood Impacts

In October 2015, this cultural landscape was impacted by a 1000-year flash-flood event (Figure 4.2). The motel unit/garage was directly impacted by flows, depositing sediment throughout the structure while erosional flows from the northern slopes abraded the exterior of the stables. Additionally, the basement of the guest house has been impacted by erosion and/or debris flows in the past although it's unclear what the extent of the damage was most recently. Damage to other features includes missing vegetation within the riparian corridor and designed watercourse, altered topography and scouring within the spring channel, and sediment deposition within the underground

tunnel system and swimming pool (Figure 4.3). Impacts to park service infrastructure include missing fences and parking lot damage. Beyond the site's boundaries, infrastructural damage includes the historic Bonnie Clare Road (and prehistoric Timbisha Shoshone tribe travel corridor) and parallel power lines. These features were completely washed away at various locations, rendering the site inaccessible and incapable of providing year-round caretaker housing and visitor interpretive services (Figures 4.4A-4.4B) ("Bonnie Clare Road Reconstruction" 2018).



**Figure 4.3** (adapted from the NPS's cultural landscape preliminary damage assessment, October 30, 2015)

## Site Selection and Current Conditions

To summarize the previous chapter's findings, the four flood-resiliency strategies derived from the case studies are: **robustness = deflection + dissipation; redundancy(stacking) + self-sufficiency(latent energy); attenuation; and robustness = adaptation + redundancy.** Scotty's Castle was selected as the site for these strategies for three reasons: 1) it is the only one of three cultural landscapes to be assessed using the current NPS VA framework, 2) it was determined to be vulnerable to climate change-related flash-flood events, and 3) its flash-flood vulnerability has been observed and documented as recent as 2015 (Melnick et al. 2016; Melnick and Quiroz 2017).

Although the site's intrinsic resiliencies were not formally assessed, the recent flood event demonstrated that the site is vulnerable to flash-flows and associated erosion. Furthermore, according to IPCC's 2013 report, the frequency and intensity of such events will likely double over the next century, suggesting that the 2015 flood event is likely to occur as frequently as a 500-year flood, or 0.2% in any given year (Melnick et al. 2016). The site's current vulnerability is a product of its location at the foot of the southward canyon walls near a broad, spreading section of the canyon's wash. The chimes tower, power house, solar heater, castle, annex, cook house, gas house, and hacienda were built atop terraces constructed from cut-and-fill operations. This grading was most likely



**Figure 4.4A** (right) portion of historic Bonnie Clare Road after the 2015 flash flood

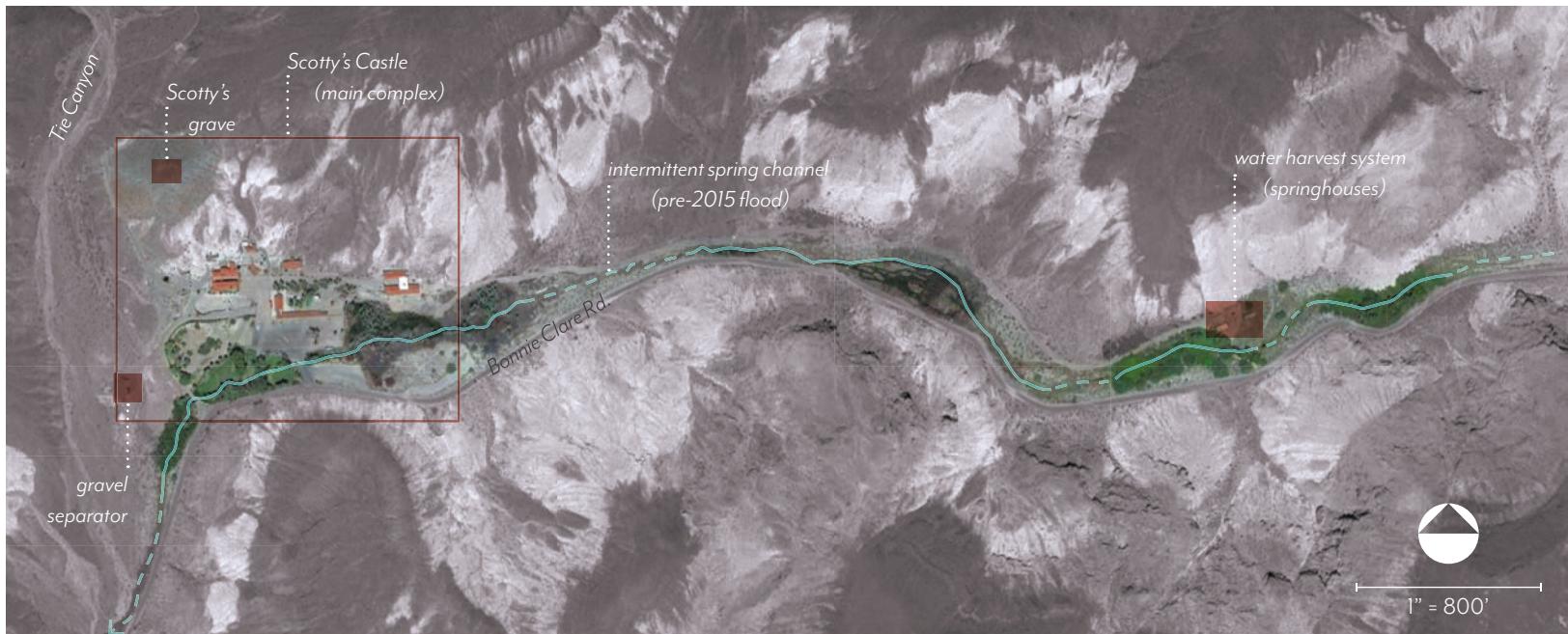
**Figure 4.4B** (below) flood damage to powerline poles (photo credit: Osceola Refetoff)



a prerequisite for constructing the complex's buildings, so it's unclear whether Albert Johnson was also planning for flash-floods. The terraces might have also played a role in achieving desirable views rather than avoiding flash-flood events.

The complex was sited near a natural spring that surfaces further up Grapevine Canyon where it is tapped (*Figure 4.5*). The built features that were not constructed on terraces (the motel unit, garage, and water course) were in the direct path of the recent flash-flood. The stables, which are located adjacent to the riparian area and on the first terrace, were impacted by sedimentation and erosive flows also associated with the recent flash-flood event.

On the other hand, the spring, which is tapped further up the canyon, may have been one of the largest factors for siting the complex since the site's remoteness and extreme climate may have made year-round occupation otherwise impossible. The site also capitalizes on its solar exposure to passively heat the diverted spring water. This continual flow has made it possible for the site to sustain year-round use prior to the 2015 flood when it was rendered inaccessible. The spring is only partially diverted and continues to flow relatively channelized—occasionally surfacing where the underlying bedrock is shallowest. At these junctures, the water supports wash-adapted, riparian vegetation that contributes to the historic character of the site's landscape (while also providing invaluable desert habitat). Regardless of projected precipitation changes, the Grapevine Canyon spring is expected to persist indefinitely since its source is connected to underground remnants from the last ice age rather than



precipitation (Bedinger and Harrill 2012).

## Intervention Approach

Each intervention represents a built, conceptual application of each strategy and thus serves as a thought experiment that highlights cultural integrity impacts and the degree of social adjustment needed to increase flood-resiliency. In this way, the interventions are intended to convey the degree of effort required to retroactively add resiliency to historic built features and land-use patterns—features and patterns that are intended to be read the same into the future, regardless of surrounding changes or the degree of inherent

resiliencies. For these reasons, the interventions are not intended to be built, but rather are intended to expose the tension between cultural landscape adaptation and preservation. Furthermore, because the interventions are intended to illustrate abstract strategies, they contain assumptions about the hydrology and engineered capacities of the site. These considerations are discussed at the end of the chapter.

Since resiliency evaluations depend on the threat being assessed, it was necessary that this project's case study interpretations focused on a single stressor or hazard type. To reiterate, this project focuses on flood-resiliency alone because

**Figure 4.5** Grapevine Canyon context map with Scotty's Castle complex, spring channel, and spring house's location

it is one of the most-documented environmental stressors that have elicited historic built responses worldwide and is a growing, climate change-related concern. The project and interventions do not address increasing temperatures and its side effects because these changes tend to be much more gradual and are therefore more difficult to interpret in built responses. Furthermore, hazard response interpretations of built forms are generally scarce, regardless of hazard or stressor.

Because built forms are the physical manifestation of cultural responses to environmental change, the feedback between cultural processes and the built environment can sometimes be so tightly interlinked that are functionally inseparable. This tight coupling has been observed at Kinderdijk-elshout, and the Dutch landscape at large. In this way, the embodied responsiveness of the built features to flooding, or any other recurring environmental stressor, acts as an indicator of how closely the social/cultural and environmental/ecological systems are linked. In this case, "closeness" is determined by the relative speed by which the social/cultural systems learn from environmental impacts. Thus, just like SESs represent a type of coupled system, engineered and social systems represent another type of coupled system in which the built features, or engineered system, specifically represents a crucial link between the two. In other words, the built environment is one major, interactive link between social/cultural and environmental/ecological systems. For this reason, the case studies consist of interpretations of both materialistic and cultural qualities. This approach proved especially

useful once it was determined that the resilience strategies at work at each site were the product of the ongoing management between the social and built systems. This supports the conceptualization of resiliency as an emergent property of engineered systems (Park et al. 2013).

The overall approach for this project's experimental interventions can be summarized as a form of *ethnomimicry*. In the social sciences, this term describes the adaptive, behavioral responses of a minority individual or group who perceives a need to blend-in with the dominant culture. This behavior is sometimes referred to as *code-switching* or *self-ethnicization* (Römhild 2017). For the sake of avoiding the re-definition of existing terms, this project's design process will be referred to as **faciomimicry**— from the Latin 'facio,' which means "to make" and is the root of the word "façade". Faciomimicry is the process of mimicking responsive, built forms from another cultural group and/or time to inform functionally similar designs within a new cultural and/or environmental context. When used to address projected environmental impacts, this design approach represents a culturally or socially adaptive process that borrows built forms and coupled traditions to inform design solutions and management practices. In this way, this design process mirrors biomimicry; both processes involve the translation of forms and patterns from different system domains (i.e. ecological, different cultures) to achieve functionally similar designs.





**Figure 4.6** plan view  
of two proposed barrier  
walls and reggraded flood  
"fan"

## robustness = deflection + dissipation

This intervention draws from the robustness strategy achieved by the deflecting *albarradas* and the dissipating floodplain at Santa Cruz de Mompox. It contains one of the simplest forms of flood deflection—a barrier wall—that works in conjunction with the adjacent broad bend in the wash. At Santa Cruz de Mompox, the strategy takes the form of a dyke, acting as the foundation for the city's spine. At Scotty's Castle, two angled walls are proposed for the eastern edge of the complex—one that deflects flows from the stables and the other from the low-lying structures within the complex (Figure 4.6). Like the *albarradas*, they are discontinuous; lessening the visual impact and amount of materials needed. This intervention also closely resembles the NPS's current proposed flood management plan (Figure 4.7).

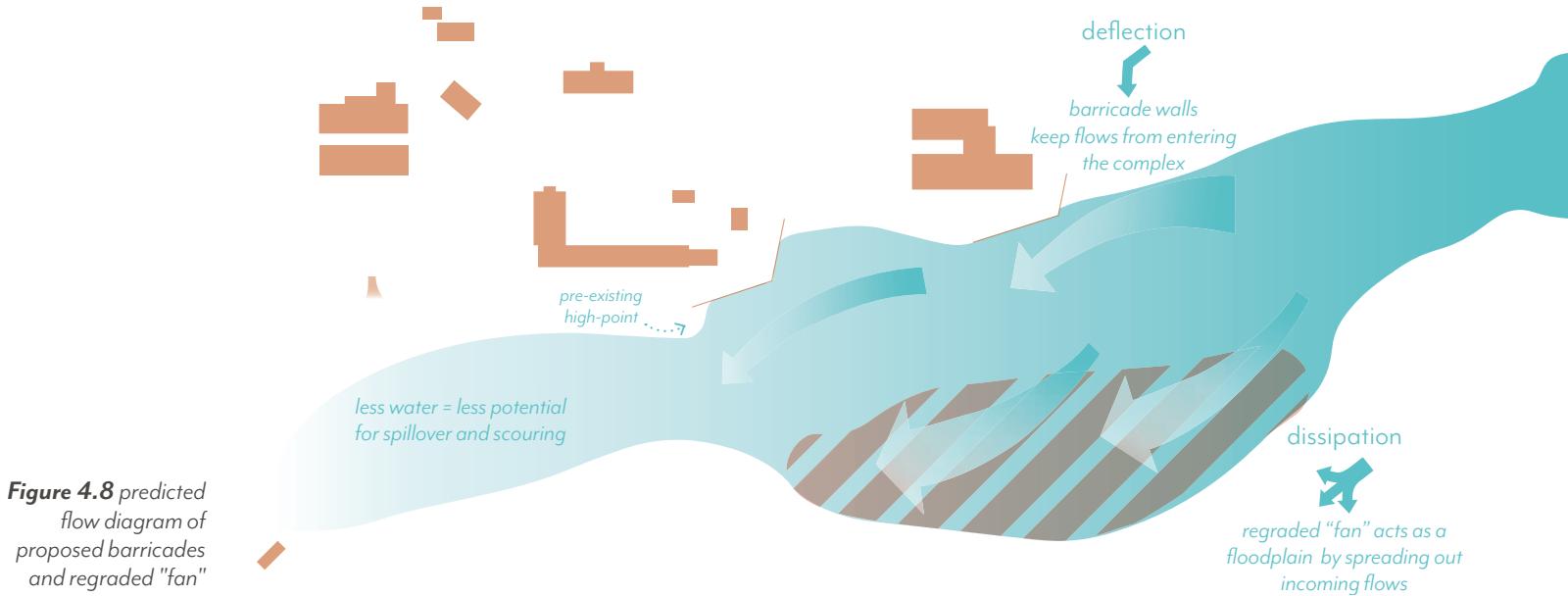
The second part of the strategy, dissipation, is derived from Santa Cruz de Mompox's surrounding floodplains and wetlands. At Scotty's Castle, the wash fans out south of the stables before narrowing again through the picnic area. This broad area is currently at a higher elevation than its surroundings and did not experience any inundation during the 2015 flood. This intervention proposes that the "fan" is regraded so that it is flatter and lower than the wash just south of the



**Figure 4.7** the NPS's post-2015 flood diversion strategy for Scotty's Castle

stables, drawing incoming flows away from the complex and across the bend (Figure 4.8). This pseudo-floodplain reduces the direct impact on the second wall and causes suspended loads, such as coarse debris and silt, to deposit across the fan rather than scouring the channel east of the bridge. Slowing and spreading also allows for infiltration, although more geologic analysis is needed to understand whether or not infiltration is possible at this portion of the wash.

The lower wall's location capitalizes on an existing high point south of the unit/garage, keeping any flows which eddy around it from pushing beyond the parking lot. In summary,



**Figure 4.8** predicted flow diagram of proposed barricades and regraded "fan"



**Figure 4.9** perspective view of the two barrier walls on the eastern edge of the complex and reggraded "fan"

this strategy entails barricade walls that work in tandem with the regraded "fan" to push and spread water away from the stables, motel unit/garage, and pool.

## Trade-Offs

This intervention's cultural integrity trade-offs are relatively minimal.. The walls can be built with materials that blend-in with the site's existing aesthetic, thereby minimizing visual impacts to the character (*Figure 4.9*). The walls also would not incur major changes in the wash's existing naturalistic and planted vegetation. On the other hand, the walls may very well block visibility of the built features and their relationship to the rest of the site especially from the east looking in. Like the rest of the interventions, the capacity for flash-flows to incur the most damage was the biggest design consideration. Furthermore, the strategy's source site does not include discernible strategies for secondary issues, such as erosion, and were therefore not employed in conjunction with the overarching deflection strategy. As a result, hillslope erosion from the northern edge of the complex is not addressed by this intervention. See *Table 4.2A-B* at the end of this chapter for a full summary of this interventions resiliency/cultural integrity trade-offs.

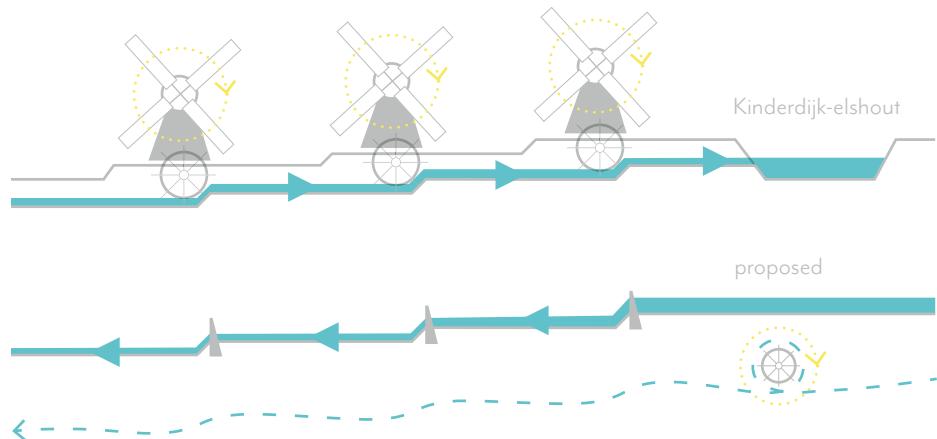


## redundancy(stacking) + self-sufficiency(latent energy)

This intervention draws from the redundancy and self-sufficiency achieved by the stacking of wind-powered, drainage basins at Kinderdijk-elshout. The nested, water-retaining terraces lift water in stages from the bottom to the top using an abundant and readily available energy source (Figure 4.9). The proposed intervention inverts this stacked system to produce a series of check dams that interface with retrofitted, existing infrastructure to generate an emergency electricity supply.

The first design aspect takes the form of a series of stacked dams that hold and delay flash flows, thereby catching coarse debris and allowing overflow to occur in stages. Repeating dams create a redundant system that should be capable of ameliorating flash flows across most sizes and intensities. A major flood event would be forced through four dams with V-notched checks (or check weirs) before finally reaching the complex (see section at the bottom of Figure 4.10).

**Figure 4.10** (opposite) plan and section elevation of proposed dams with diagram of proposed micro hydro-electric spring harvesting system



The first dam in the series is connected to the existing spring harvesting system via a diversion pipe. Non-diverted spring water is allowed to flow through below-ground perforations in the dams, surfacing intermittently as it presently does. These points of surface flow correlate with shallow places in the bedrock which could provide an ideal footing for each dam. The dams are secured into the bedrock, ensuring structural integrity and complete flood retention.

The second aspect of this intervention draws from the intangible aspect of the windmill-polder system—the harnessing of latent energy that contributes to the site's flood resiliency (Figure 4.9). At Kinderdijk-elshout, wind is plentiful enough

**Figure 4.9** comparative functional diagram of the stacked infrastructural systems with built-in energy harvesting

to be harnessed for the continual pumping of water. However, in Death Valley the flood threats are not continual enough to warrant an ongoing use of energy, thus the focus of the latent-energy component was shifted to improve the site's overall resiliency in addition to directly protecting the cultural integrity of its features. The spring provides a small, continual source of water that is harvested and stored by a spring house and holding tanks. With the simple addition of a micro-hydro turbine, the existing spring infrastructure can double as an energy generating system (see diagram at the top of *Figure 4.10*). The volume of water held in the existing tanks could create some head pressure needed to generate electricity while water is simultaneously diverted to the complex. This energy can be stored for emergency use within batteries in the spring house or it can be used directly at the complex. This modification could increase the infrastructural resilience of the complex by using the spring to generate energy with minimal infrastructural additions. The micro-hydro turbine indirectly couples the electricity system with an existing, culturally significant, passive-energy system that is still on site—the solar heater (see site map at beginning of chapter).

By making the site's water and electricity systems more secure, the ability for park staff to be sustained during and after flood events is greatly

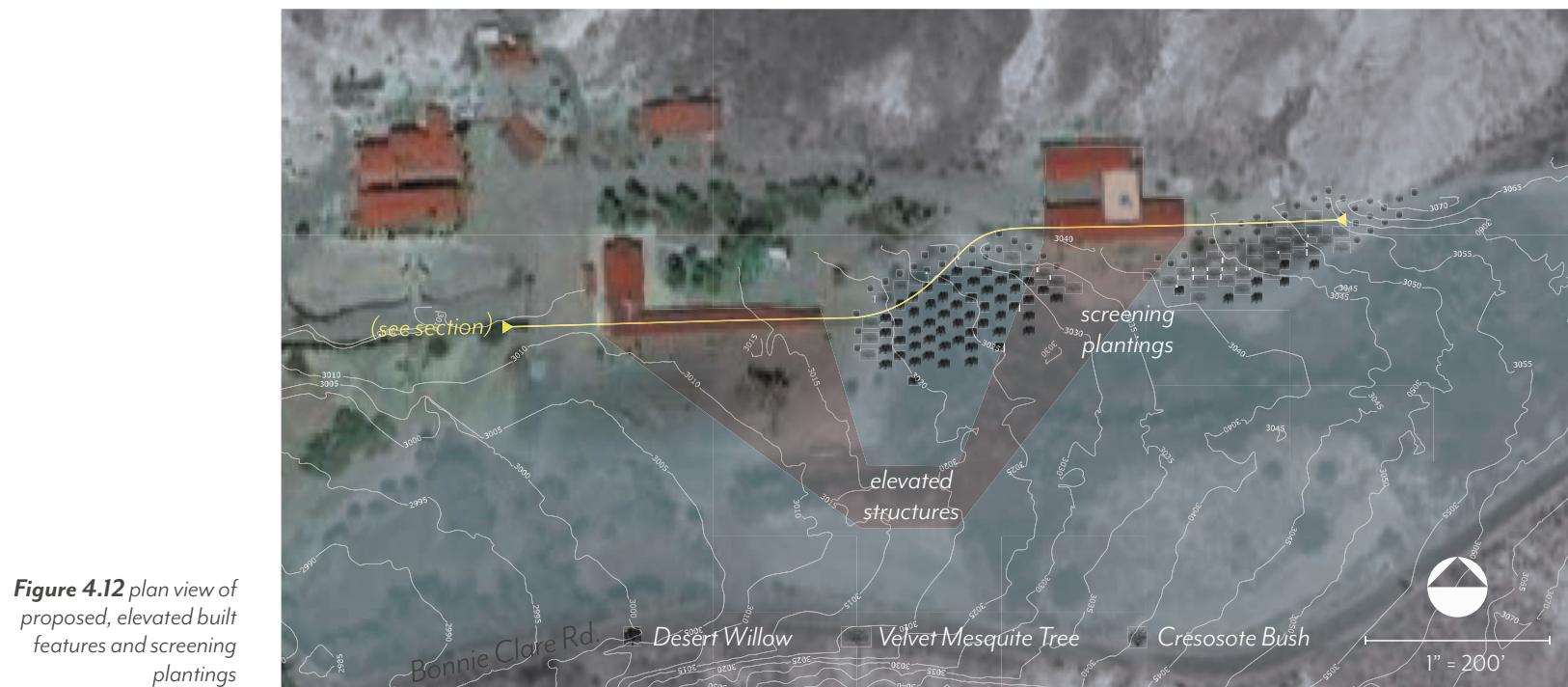
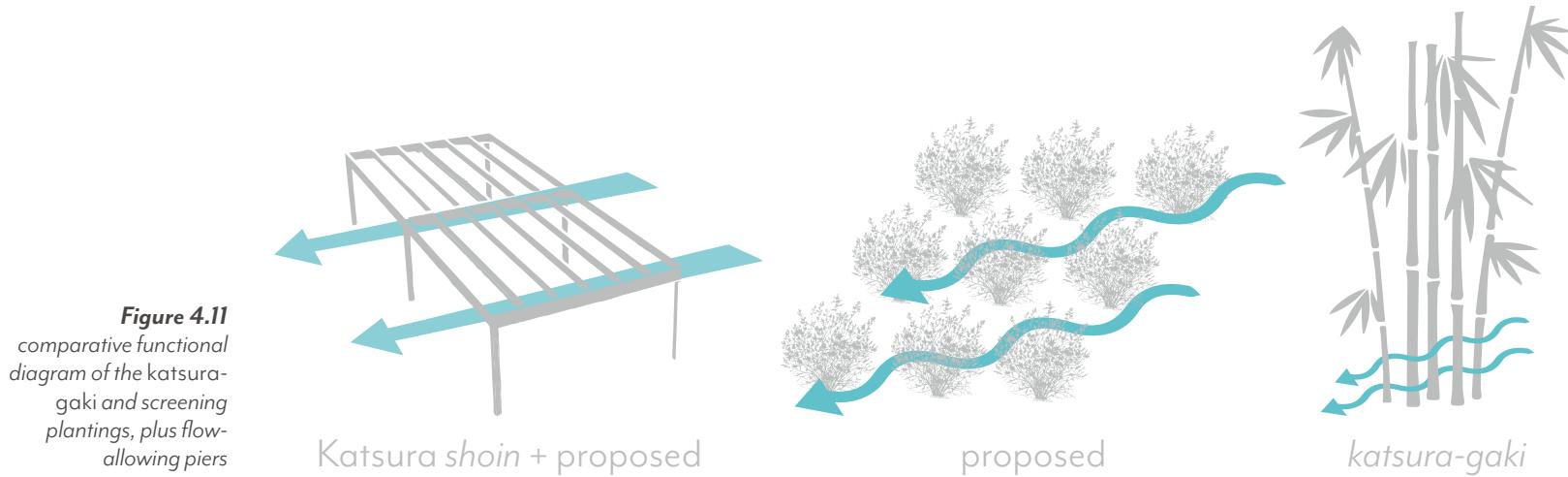
enhanced. This improves response and recovery rates, thereby greatly contributing to the site's infrastructural and social resiliency in addition to its engineered resiliency.

## Trade-Offs

This intervention has minimal impacts on the cultural integrity of the site since it is situated beyond the complex. Its biggest limitations are centered around the degree of technical knowledge needed to adequately size the dams and execute an effective latent-energy harvesting system. The contrary nature of the site's flood-related issues makes continual input unnecessary, thus making it difficult to design a functionally similar use of latent energy that is suited to Scotty's Castle. This intervention assumes that year-round occupation of the site will be re-established so that the proposed infrastructural changes can be maintained and supervised. This continual exchange between social input and electricity output is a key quality of the resiliency strategy at Kinderdijk-elshout.

Like the other interventions, this intervention does not account for impacts from hillslope erosion since the source site's strategy does not address erosion or debris flows in a discernible way. This and other discussed trade-offs are summarized in Tables 4.2 A-B at the end of the chapter.





## attenuation

The third intervention for Scotty's Castle draws from the attenuating bamboo hedge and *shoin* stilts at Katsura Imperial Villa (Figure 4.10). In this proposal, the stables and motel/garage unit are elevated on piers and lattice-patterned screens of hardy riparian trees and shrubs are planted upstream (Figure 4.11). This intervention, like those before it, consists of two design aspects that work together to reduce the overall impact of flash flows.

The first line of flood-defense consists of a latticed field of bank-stabilizing, riparian plantings that functionally mimic the *katsura-gaki* at a larger scale. The selected trees are well-adapted to local wash conditions and deploy robust and regenerative adaptive strategies, rather than pliability, to withstand the physical stresses of desert washes (i.e. wind, water flows, and fire). The plantings are situated in offset, alternating rows that create overlap and redundancy in much the same way that a bamboo hedge does. The tree lattice is intended to attenuate the incoming flows by trapping coarse debris (i.e. uprooted trees and plants) and generating friction. Passing flows impact the piers of the elevated structures with less force. The stabilizing qualities of these trees, which are described in the next intervention, helps

them to withstand incoming flows and thereby accumulate suspended debris.

The second aspect of the intervention consists of elevating the stables and the motel unit/garage, which are the most exposed, culturally significant, built features on the site (Figure 4.12). The stables would only need to be slightly elevated since they were built upon a terrace and were minimally directly impacted by flash flows. The motel unit/garage, on the other hand, was directly impacted by flows and received a large amount of sediment which significantly damaged the gift shop and garage exhibits inside. The proposed intervention uses plastered foundation piers, much like those at Katsura, to greatly reduce the visual impact of the structural modification. However, unlike the main *shoin*, these walls would be designed to break-away under heavy impacts so that the flows (which have been coarsely filtered by the screening plantings) can pass through without damaging the overall structural integrity of the feature.

## Trade-Offs

Trade-offs that are inherent to this intervention exist in both approaches. The first entails adapting the function of the elevated built

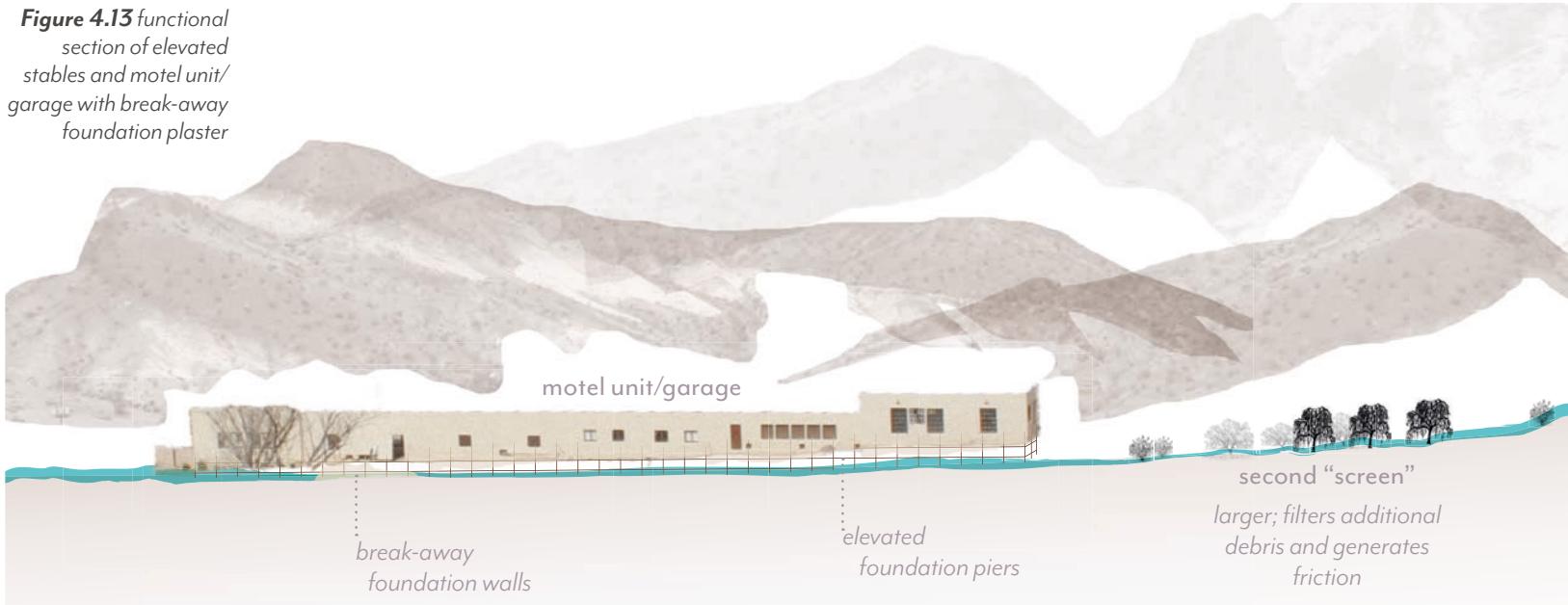
features to match their newly elevated states. Access ramps and interpretive panels would be needed to make the features accessible while differentiating the climate change adaptations from the site's historic character. In this way, these built, climate change responses would become a new part of the site's historical narrative, contextualizing it as a part of the larger framing of built heritage sites as cultural responses to dynamic environments. Furthermore, although elevating the stables would most likely alleviate some of the impacts from hillslope erosion, these impacts on other built features still remain. Once again, the source case study site does not contain discernible insights into addressing erosion or debris flows that are separate

from the main floodwaters and are therefore left unaddressed.

Although the fire cache and public restrooms are highly exposed to flash flows, they are not considered to be culturally significant since they were added by the NPS after the era of significance. For the sake of the thought-experiment, these additional structures are not directly addressed even though they would most likely be included in a real-world application of this flood-resilience strategy.

Limitations related to the plantings entail

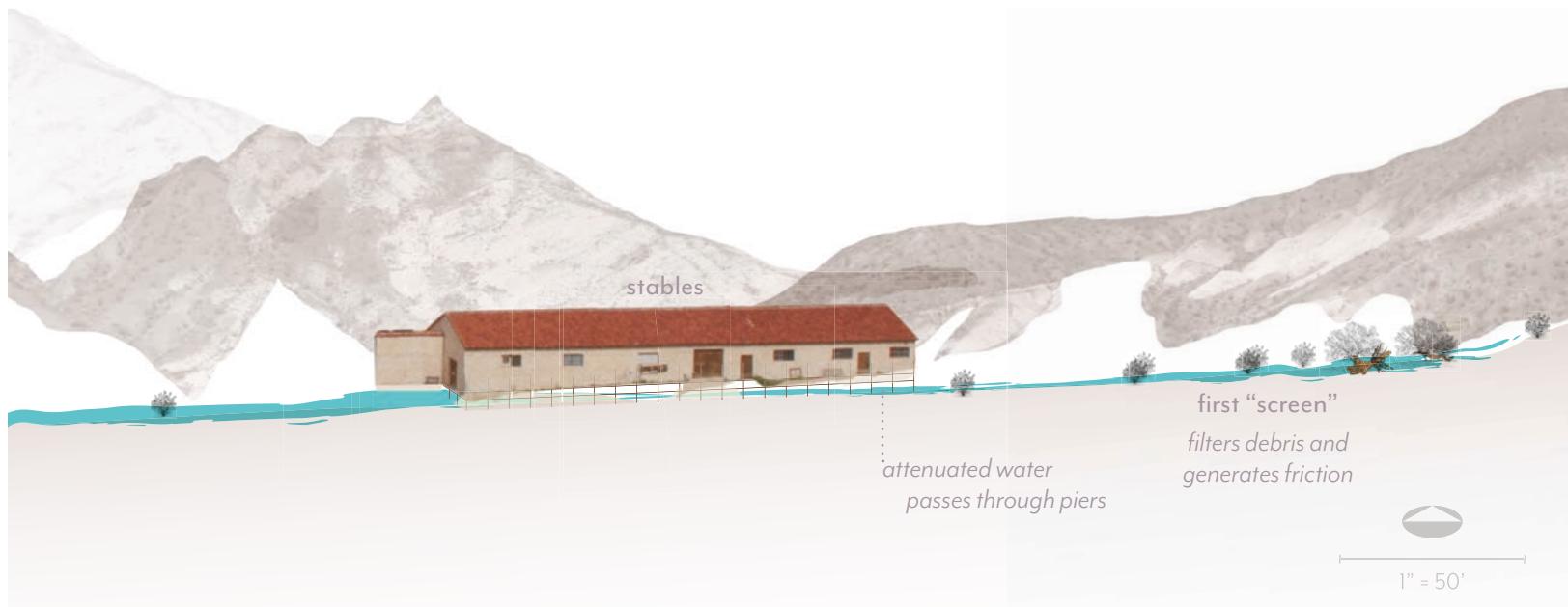
**Figure 4.13** functional section of elevated stables and motel unit/garage with break-away foundation plaster



the need for a long-term adaptive management plan that would prescribe proper establishment care and on-going cultivation. The function of the plantings requires that year-round occupation is reestablished, that spring water be diverted for irrigation during the establishment phase, and that on-going pruning and/or training is provided. Although these plants were selected for their inherent flood resilience, proper root training and pruning would greatly enhance their ability to permanently anchor into the bedrock and surrounding soil as well as resist breakage while under flood stress. Furthermore, ongoing care is needed to phase-out and replace declining

or severely damaged trees. The strength of the bamboo hedge is in its redundancy; trees that are not replaced over time add flood stress to the remaining trees. Such a degree of cultivation is consistent with this distilled strategy since cultural practices, like gardening, ensure the perpetuity of the built character that defines Katsura Imperial Villa. These, and other trade-offs are summarized in Tables 4.2A-B at the end of this chapter.

*.... contextualizing it as a part of the larger framing of built heritage sites as cultural responses to dynamic environments.*



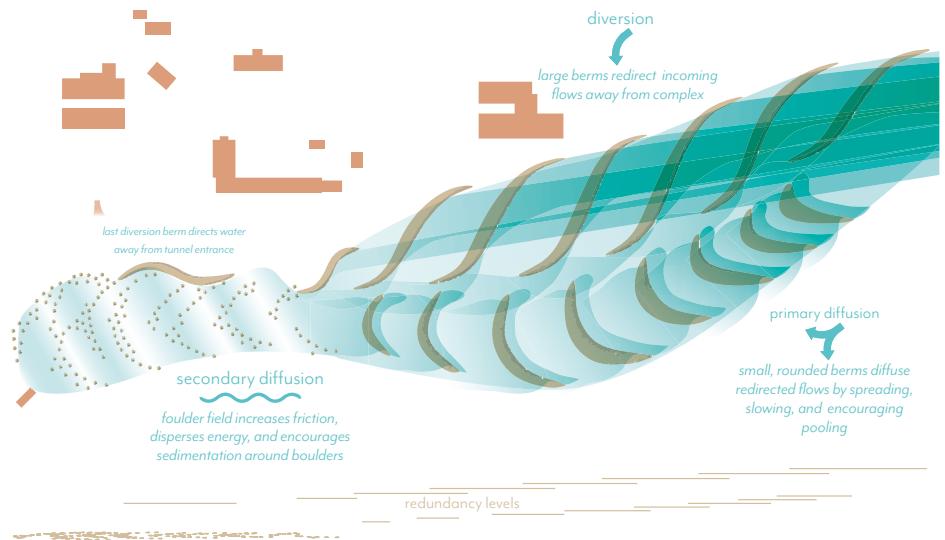


## robustness = adaptation + redundancy

The final intervention draws upon the living root bridges and their robustness, which is a product of the fig trees exhibiting redundancy at multiple scales and adaptive capacity—the resiliency attribute that spurred this project. When translated from a sub-tropical montane region to Death Valley, this strategy takes the form of a series of redundant earth forms that vary in shape, size, and subsequent functions (Figure 4.13). They serve as the scaffolding for, and are stabilized by, wash-adapted, desert shrubs and trees.

*Ficus elastica* trees are so well adapted to the stresses and conditions caused by frequent monsoonal flooding. When physically combined to form a bridge, they provide a unique example of engineered resilience. Most built features found throughout the world are comprised of non-living materials which are subject to eventual weathering, decay, or both, making them incapable of adaptation in the ecological sense (even though they may exhibit varying degrees of other types of resiliency). The Khasis' living bridges, on the other

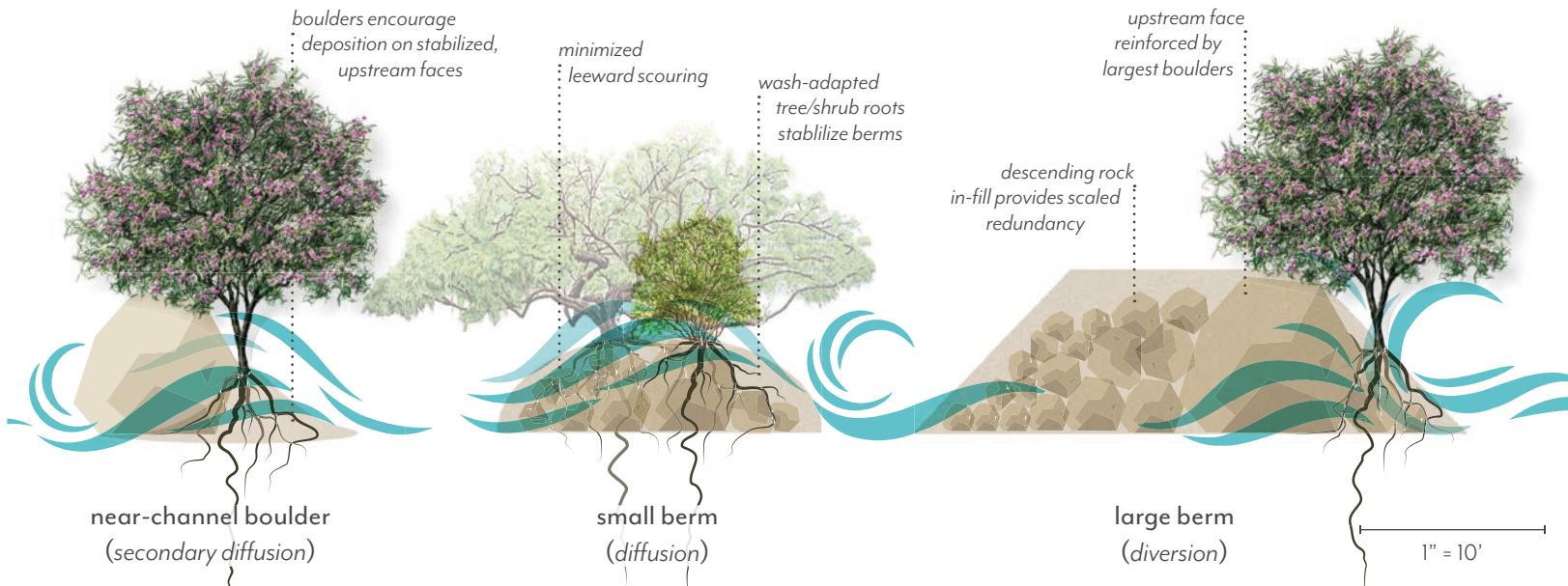
**Figure 4.14** (opposite)  
plan of proposed earth  
forms and associated  
plantings



hand, are intended to remain alive throughout the life of the structure, capitalizing on the increasing returns generated by the trees' growth processes. In other words, the trees' ability to respond to physical stimuli through adjustments to internal growth processes allows them to grow stronger and more flexible, and therefore more robust, as they mature.

The proposed earth forms vary by type (size and shape) and provide 2 major functions: diversion and diffusion (Figure 4.14). They are designed to intercept, redirect, and "process" incoming flows in stages so that floodwaters move more slowly

**Figure 4.15** functional diagram of scaled redundancy across earth forms



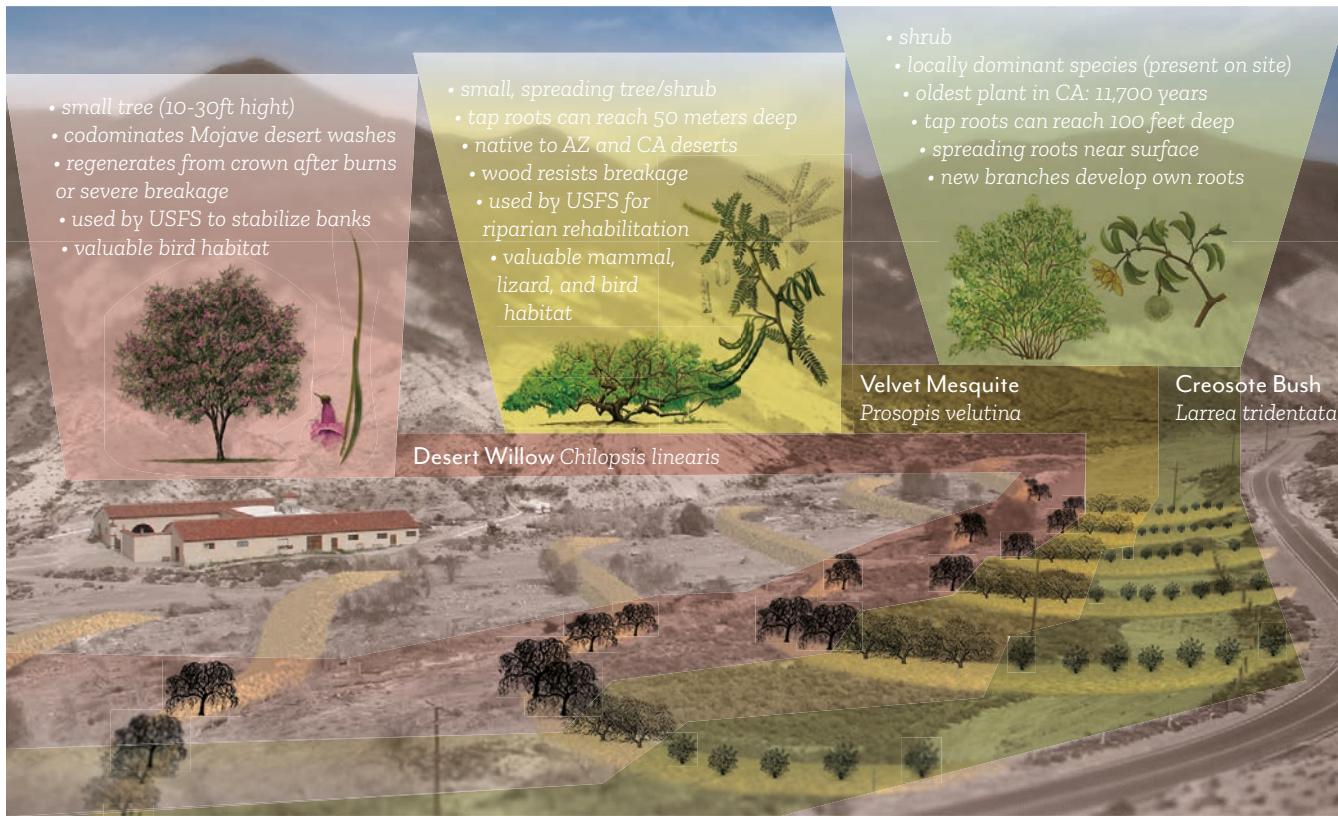
**Figure 4.16** section elevation of the earth forms showing scaled redundancy within each

and smoothly through the wash. This is done by diverting the stream away from the complex and directing it over cupped forms that spread and diffuse it, allowing for it to pool and drop its suspended loads. Coarse debris are skimmed off as the water is forced to spill over the broadest parts of each form. The flows then pass through a braided field of boulders that comb the water of finer sediments and further diffuse its energy to reduce scouring as it leaves the complex.

The proposed intervention area spans the broadest stretch of the wash and will need to be regraded so that it is relatively flat with a slight

slope south and west of the complex. The cut from this operation can be used to fill the gaps between the coarse materials of the proposed earth forms (Figure 4.15).

The earth forms demonstrate redundancy at multiple scales. They encompass three different form types with overlapping and yet distinct functions (Figure 4.14). Each functionally different zone (i.e. diversion, diffusion, secondary diffusion) within the intervention area is comprised of multiple identical earth forms. Furthermore, each form type is comprised of scaled, repeating elements that work in tandem to reinforce the



**Figure 4.16** perspective looking upstream with the stables in the background with adaptive plantings information

form's overall robustness, mirroring the layers of redundancy found within the living root bridges (Figures 4.15). These elements consist of stabilizing plantings on the upstream side of the form, followed by large boulders designed to bear the brunt of the impact, interlocking smaller boulders and rocks, and gravel in-fill from regrading. The smallest forms represent the simplest unit of the structural binary—a plant and a boulder.

The selected trees and shrub species are phreatophytes, meaning that they have adapted to water scarcity by growing deep roots that tap into the water table. They are all southwest desert wash natives and have varying adaptations that make them particularly suited for their roles as stabilizers within and along the main channel (Figure 4.16). Over time, the spreading roots of the proposed plantings will increasingly stabilize the

internal structure of each form while the largest boulders support their bases by catching sediments on the upstream side (*Figure 4.15*). Scouring along the downstream edges of each form is a non-issue and will instead add to the overall friction process that is intended to slow the flash-flows. If the plants are maintained, the forms will maintain themselves through deposition on the upstream side and erosion on the downstream side with each passing flood.

## Trade-Offs

The trade-offs for this intervention stem from the degree of care that the plantings require. The living root bridges are continuously reinforced for 15-30 years before they're ready for heavy use, and even then, they require occasional repairs. Likewise, the optimum stability for each earth form would most likely occur when its plantings have reached full maturity, which, for desert plants, can take much longer. However, assuming that spring water can be diverted for irrigation during the establishment phase and that pruning and training is provided during the formative years, the maturation phase might be less than that found in wild individuals. Additionally, specialized watering techniques may be necessary to encourage appropriate tap-rooting while also encouraging surface stabilization. Once again, this design depends on a continual partnership with skilled

caregivers and therefore assumes that year-round occupation will be reestablished.

For similar reasons as the other interventions, hillslope erosion was also not addressed by this design. A summary of this intervention's trade-offs can be found at the end of this chapter in *Tables 4.2A-B*.

## Additional Considerations

Some additional considerations arose during the intervention design and evaluation process. These are worth mentioning since they might influence the efficacy of their conceptual implementation, the interpretation of their resiliency/integrity trade-offs, or both.

A major assumption made by each intervention is that all of the site's culturally significant, built features were equally important. Of the exposed features that were directly addressed, no decisions were made regarding their importance to the overarching historic narrative. By focusing on built features, three of the four interventions inadvertently relegated the wash, and its constituent natural systems and features, to stage the interventions. The result may have been the same even if features were prioritized, but

it should be noted that management assumptions can be made about feature importance even when the goal is equal prioritization. Even so, 2 of the interventions enhance the functionality of the wash by boosting the presence of the spring, existing plant species, and overall riparian habitat quality, as well as potentially increasing the adaptive capacity of management through tighter system coupling.

There are a few limitations relating to the noticeable environmental differences between the case studies and Death Valley Scotty Historic District that are worth mentioning. For one, applying strategies derived from humid environments to an arid environment could raise questions regarding the defensibility of the final forms of each intervention. However, the *faciomimicry* design approach is not intended to mimic forms but instead emphasizes the mimicry of the cultural values embodied by the built forms. Thus, the strategies are intended to be more open to interpretation and therefore more flexible—a point that was inadvertently supported by their application to a desert, cultural landscape. An unexpected outcome was that the harsher environmental conditions at Scotty's Castle served to highlight the adaptive importance of the proposed, closely-coupled management and resource systems in increasing the social/organizational resiliency of the site in addition

to its engineered resiliency. The interventions' need for close management may have been less apparent had the intervention site been more environmentally similar to the case study sites. This demonstration is important because "tighter coupling" will become increasingly important as climate-related events become more frequent and the resources needed to prepare become more scarce. Another potential limitation related to environmental differences could be the overall lack of consideration for hillslope erosion amongst the interventions. The structural impacts caused by hillslope erosion at Scotty's Castle did not arise directly from flash flows, and were thus considered to be secondary impacts since they were caused by rainfall and run-off rather than the flood in the wash. Thus, any built responses to hillslope erosion that may have been present in the case studies were not considered addressable by flood-resiliency analysis and were therefore non-discernible.

A noteworthy pattern seen across three of the interventions was the demonstrated need for greater cultural intervention. This could be interpreted as a reflection of the lack of extant cultural programming at Scotty's Castle, which, if it were present, might actually decrease the site's overall resiliency. There is an inherent tension present at a site whose cultural significance stems from its demonstration of material excess in an environment defined by scarcity. This tension

## Engineered Resiliency Enhancements

	Robustness via Deflection and Dissipation	Redundancy and Self-Sufficiency via Stacking and Latent Energy	Attenuation	Robustness via Adaptation and Redundancy
<i>built features have increased resilience to flooding</i>	✓	✓	✓	✓
<i>existing riparian vegetation, built and unbuilt, has increased resilience to flooding</i>		✓		✓
<i>features have increased resilience to hillslope erosion</i>				
<i>intervention enhances physical resiliency beyond cultural integrity (i.e. infrastructurally, ecologically)</i>		✓	✓	✓
<i>intervention enhances intangible resiliency beyond cultural integrity (i.e. organizationally, socially/culturally)</i>		✓		✓

**Tables 4.2 A & B**  
summary of trade-offs  
between engineered  
resiliency and cultural  
integrity across  
intervention experiments

highlights the importance of reintroducing or bolstering a site's source traditions, practices, and/or land uses if they increase the engineered, social, and ecological resiliency of the site. Thus, the values embodied by the built features should also call to question how "cultural significance" is determined when the contrast between it and its environmental and contemporary cultural context is extremely high. How will the significance of cultural landscapes that are already at extreme

odds with their containing systems be determined in a world where climate change is sure to further polarize those extremes?

Last of all, it's worth noting that although most of the interventions require greater cultural intervention, the long-term maintenance needed by them suggests that they are permanent interventions. This may seem contradictory to adaptive management implications since

## Cultural Integrity Impacts

	Robustness via Deflection and Dissipation	Redundancy and Self-Sufficiency via Stacking and Latent Energy	Attenuation	Robustness via Adaptation and Redundancy
<i>does NOT visibly obscure features</i>		✓	✓	✓
<i>is NOT stylistically inconsistent with site's character</i>	✓	✓		
<i>does NOT interrupt relationships between site's features</i>	✓	✓		
<i>does NOT require permanent, adaptive change to social/organizational practices</i>	✓			
<i>does NOT impact visual, material integrity of site</i>	✓	✓	✓	✓

willingness to change approaches is a key feature of climate change responses. That being said, the permanence of the interventions is a direct result of their case study sources, which were responses cultivated over generations of environmental adaptation. Even at Santa Cruz de Mompox, which was built by recently-arrived settlers, the building techniques implemented were adapted from local indigenous peoples suggesting the possibility of exchange of environmental information beyond just

construction plant knowledge.



# Part **three**

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*Trae el pasado sólo si vas a construir.*

*(Carry the past only if you are going to build from it.)*

- Doménico Cieri Estrada

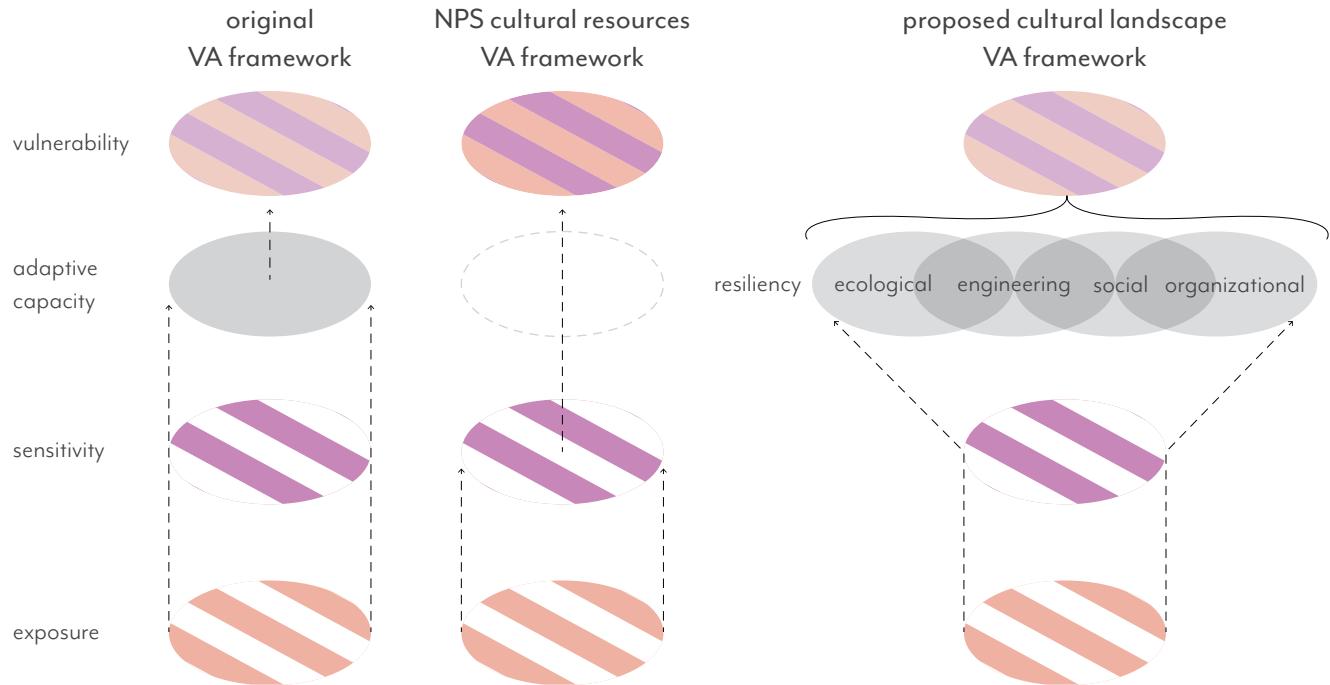


## 5 Discussion

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This project was spurred by concerns raised by the NPS's exclusion of adaptive capacity, and subsequently resiliency, from vulnerability assessments of cultural landscapes, based on an understanding of material cultural resources as being non-adaptive. As discussed in Chapter 1, this decision reveals problematic assumptions that undermine current conceptions of cultural landscapes and thereby challenge the efficacy of adaptive planning within the National Park Service. In response, this project interpreted the flood-resilient strategies found in culturally significant, built features from around the world to illustrate how material components can be resilient, even if not adaptive. Narrowing the focus to engineered resilience alone proved difficult since the resiliencies of the case studies' closely associated social systems were demonstrated by proxy, thus making it virtually impossible to separately assess one without folding in the other. In other words, the cultural practices and traditions that gave rise to resilient built features were often still present in varying degrees, and are responsible for the persistence of engineered resiliencies within the extant built features. This close coupling of social/cultural and built systems was echoed by the interventions since three of them required considerable social and/or organizational adaptation on behalf of management systems to ensure their proper establishment and continued efficacy.

**opposite** The swamp community of Atchafalaya in Louisiana as seen from a railroad bridge circa 1930. (image credit: Thomas Bernard)



**Figure 5.1** proposed cultural landscape VA framework as compared to the current VA framework

In short, the findings suggest that cultural landscapes can, and do, demonstrate resiliency. Recall that adaptive capacity is just one of many possible qualities that can contribute to a system's resilience, but other forms of resilience, such as engineered robustness, redundancy, and even adaptation, can be, and are, built-in to the material components of cultural landscapes all over the world. Resiliency as a site precondition was demonstrated by the case studies, and resiliency as a form of historic rehabilitation was demonstrated by the intervention experiments.

Since resiliency is defined according to a given threat or stressor, this project focused on flooding; a stressor that is climate-related and well documented. Each of the four culturally significant case studies were selected with variety in mind: global distribution, cultural representation, architectural traditions, and established cultural significance. Each case study contains built features that are flood-resilient and/or contribute to the cultural landscape's overall flood-resiliency, making such features the focus of each site's analysis. This project anticipated the need for

analyzing cultural contributions in addition to the discrete physical qualities of the resilient built features, but the degree to which extant cultural practices are still linked at some of the sites was unexpected. This inextricable linkage made each site's analysis more complex (a summary of the findings are summarized at the end of Chapter 3). The resulting interpretations of the features' functions with regards to their environment, construction, cultural traditions, an on-going maintenance provided adequate insight to inform transferable strategies. The resulting thought-experiment interventions designed for the same Scotty's Castle demonstrated that resiliency can be achieved without significant impact on key built features but with varying degrees of impact on the appearance, and therefore character, of the cultural landscape as a whole.

## Vulnerability Assessments: A Tool for Cultural Landscape Adaptation

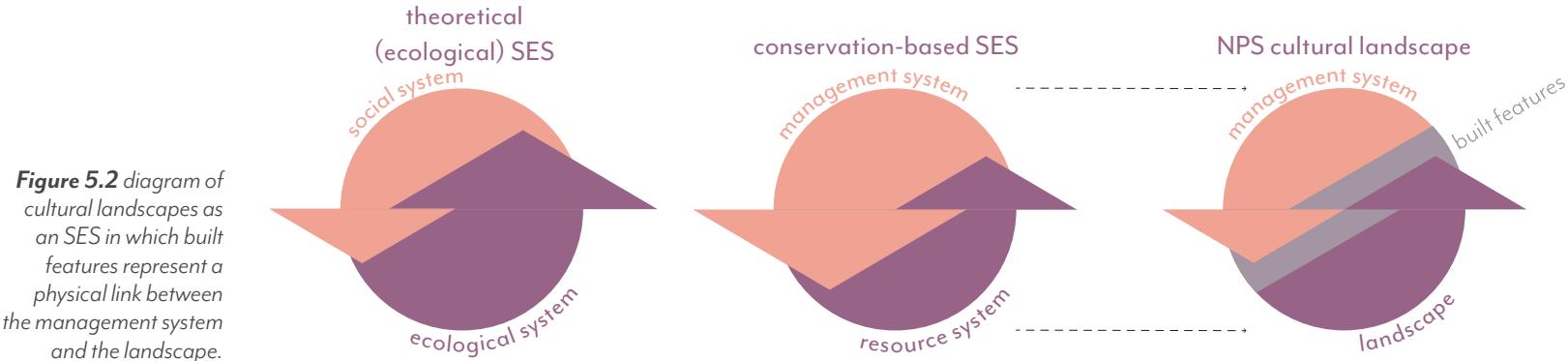
The main lesson learned from the case studies and the intervention experiments is: resiliency, which includes adaptive capacity, should be incorporated into the cultural landscape framework so that vulnerability is expressed as a function of exposure, sensitivity, and resiliency (Figure 5.1). Furthermore, the findings suggest that **all** domains of resiliency (social/cultural, organizational [NPS], engineered, and ecological) should be formally

assessed by cultural landscape VAs. This differs from the original framework that considers AC in that it expands resiliency considerations beyond that of complex adaptive systems. In natural resource literature, adaptive capacity captures the ameliorative qualities of the species, communities, populations, and/or ecosystems in question.

*All domains of resiliency should be formally assessed by cultural landscape vulnerability assessments.*

In cultural landscapes, the implications of an expanded framework that captures all ameliorative qualities includes assessing the resilience of non-adaptive resource systems in addition to the adaptive capacity of complex-adaptive resource systems, regardless of their "cultural" or "natural" designation. This holistic approach would more likely ensure that all resource systems and their resiliency propensities are projected into adaptive planning and management, thereby informing appropriately adaptive responses through management interventions and responses.

The findings also support the conceptualization of cultural landscapes as a type



**Figure 5.2** diagram of cultural landscapes as an SES in which built features represent a physical link between the management system and the landscape.

*For management systems to be truly adaptive, they must be tightly coupled with their resource systems.*

of SES since the case studies exhibit engineered and social resiliencies in addition to ecological adaptation. Current NPS practices do recognize the potential for adaptation within cultural landscapes, but only in their natural systems and features. An example of this can be seen at Rapidan Camp in Shenandoah National Park where the woolly adelgid is devastating the native hemlock forests. NPS management has responded by phasing-in tulip poplar trees (*Liriodendron tulipifera*), a heat-tolerant tree, in an effort to restore the site's historic overstory character.

Since a cultural landscape can be

conceptualized as a type of SES, its built features, including climate change interventions and culturally significant plantings and land-use patterns, represent a physically manifested link between management and the landscape in the same way that lived-in built environments link a community, city, region, or society to its ecological context (Figure 5.2). In fact, the very labeling of culturally significant sites, as "culturally significant" (regardless of their official status), carries connotations of historic, particularly within the NPS. Such a description suggests that the source culture is no longer present, thereby separating the site's historic cultural values from its present-day cultural values. Even at historic case study sites, such as Katsura Imperial Villa and Kinderdijk, this preconceived separation proved to be misleading. When applied to the NPS model, this blurring of historic and contemporary cultural values supports the notion that cultural landscape



management systems should be framed as the landscape's newest "occupants" and therefore, the SES's contemporary social sub-system. In other words, cultural landscapes are reflections of their current occupants' cultural values, which, in addition to natural processes, continuously shape them. It follows then that for management systems to be truly adaptive, they must be tightly coupled with their resource systems, meaning that they are continuously engaged with the cultural landscape, highly susceptible to learning from trends and events, and willing to adjust their approaches accordingly, essentially making them predisposed to social/organizational evolution. This supports current cultural resource philosophies within the NPS that embrace rehabilitation as a means of integrating resilience practices into cultural

landscape management through repurposing (Beagan and Dolan 2015). Repurposing can also inform interpretation of management actions as the newest layer of cultural activity, which will be discussed more in the following section, *A Case for Re-Interpretation*. In extreme cases, this same logic supports relinquishing resistance-based, engineered approaches for the sake of embracing landscape processes and "landscape hospice" (Melnick 2015). **Landscape hospice** is the act of non-intervention in which the most vulnerable or impacted features are allowed to erode while the process is documented, and as suggested in this project, interpreted for visitors to witness.

## Programming Social Adaptation

The reciprocal feedbacks that give rise

**Figure 5.3** the outer shrine at Ise Jingu, Geku, is one of several buildings that are completely rebuilt every 20 years (image source: Yusuke Okada, [www.jnto.go.jp](http://www.jnto.go.jp))

**Figure 5.4** a Japanese bowl demonstrating the kintsugi philosophy. This art form, known as kintsukuroi, uses gold lacquer to repair broken ceramics. (image source: Wikimedia Commons)



to resilience within adaptive systems suggests that VAs can also become the first step towards the site's programming. Three of this project's interventions required greater initial and ongoing interaction between management systems and proposed infrastructure than what was previously programmed on site. Of these, two require intensive cultivation during the first several years. Although these interventions were derived from outside sources where long-term engagement was key, they might not represent appropriate adaptations for Scotty's Castle, meaning that the next major flash flood event could trigger a learning

process, and ideally, a new or revised intervention. This level of feedback depends upon tightly linked adaptive management systems, thereby mirroring the cultural-linking pattern found across the case studies. In Cherrapunjee, for example, the bridge-building knowledge, and therefore the bridges themselves, are sustained through the act of continual augmentation and repairs. This practice of maintaining built heritage resilience through active cultural practice can also be seen at Ise Grand Shrine in Japan (Figure 5.3). Every 20 years, the shrine is completely disassembled and then reassembled adjacent to its prior location. This living practice has simultaneously made this ancient shrine one of the oldest and youngest buildings in all of Japan.

### A Case for Re-Interpretation

If adaptive planning is to be feasible, it must prioritize which vulnerable features are most important to the site's narrative, both culturally significant and increasingly prominent. The interventions in this project did not consider feasibility since they were intended to be thought experiments. However, VAs that assess resiliency should be able to provide a greater degree of vulnerability resolution, thus making the prioritization of features, characteristics, and landscapes more feasible. Features that are determined to be too vulnerable or too resource intensive become appropriate candidates for

*Seizing environmental impacts as an interpretive opportunity makes today's lessons available for future generations to reflect on.*

landscape hospice, thereby allowing them to convey a new narrative of climate change and resource management. This approach is compatible with resilience practices in that it encourages appropriate allocation of resources during scarce and uncertain times.

Climate change impacts are an important part of a landscape's narrative and, in managed landscapes, it's imperative that we embrace the limitations of stewardship policies in the face of accelerating natural processes. This approach mirrors *kintsugi*, the Japanese philosophy that an object's scars should be viewed as an important part of its present condition. Kintsugi is the conscious choice to celebrate, rather than hide, the honest history of a place, even if it does not reflect the place's culturally significant, or designated, character. In this way, seizing environmental impacts as an interpretive opportunity supports the NPS's dual mandate by making today's lessons available for future generations to reflect on. Even in hypothetical cases in which all significant features are retained but the interventions would have too much of an impact on the site's character, this approach can still be used to embrace the landscape's newest layer of cultural history—park management's built response to accelerating impacts. Approaching cultural integrity impacts as an interpretive opportunity emphasizes that landscape history is an ongoing process as rather

than a stage for fixed objects. Both extremes of the intervention spectrum offer the chance to interpret the processes of change rather than fixating on objects that will inevitably disappear. In a world that is rapidly, and sometimes unpredictably, changing, not even our heritage preservation values can afford to remain maladaptive.

## Embracing Landscape Change

As James Mitchell identifies in *Celebrating Hazard Cultures: A Missed World Heritage Opportunity?*, 47 UNESCO world heritage sites provide "excellent examples of the conditional nature of how humans choose to engage with environmental uncertainties" (2016). Mitchell argues that these sites contain "valuable lessons about our capacity for adaptation in the face of uncertain future risks", such as climate change (2016). Such an interpretation of heritage sites as offering a physical, historic record that can inform future climate change adaptations summarizes this project's motivation and value. It confirms that many recognized sites exist that demonstrate both intangible and structural environmental resiliencies. This also simultaneously suggests that more examples exist beyond the scope of official recognition. This implication is reflected by two of the case study sites in this project: Katsura Imperial Villa and the Cherrapunjee valley.

Of the 47 resilient UNESCO sites, engineering

approaches that seek to control or redirect natural processes dominate whereas a minority of them demonstrate non-structural approaches that seek to accommodate, rather than control, extreme natural processes. The latter strategies include: selection

suggests that the human recipients understand themselves as playing little to no part in making natural processes disastrous when in reality, as anthropogenic climate change has demonstrated, human activities create the vulnerabilities that natural risks exploit by placing settlements and/or land uses in exposed areas or by exacerbating natural processes through environmental modification (Mitchell 2016). In the era of climate change, this nature/culture divide has weakened, but such an awareness cannot reverse the surfacing and still-yet-to-be-seen ramifications of our nation's extensive infrastructural networks and historic landmarks — built landscape features that cannot be rebuilt without seriously impacting their historic function or the systems that rely on them.

*The very act of adding resiliency retroactively means constraining the available methods to those that control and redirect.*

of risk-minimizing construction sites; warning and evacuation systems; and "relocation to safer places" (Mitchell 2016). Like Mitchell points out, responses that apply "technological fixes" to control or redirect hazards dominate in the west. This generalization holds true for the case studies—the eastern approaches reflect an accommodating attitude that allows extreme natural processes to occur. These differences in cultural preferences are, at their basic level, perceptual reflections of the natural environment, highlighting the possibility that my implementation of the eastern strategies may also reflect inherently western values. Built "solutions" that problematize extreme processes via corrective means reflect both a "characterization of nature as separate from humanity, and of disasters as outcomes that are inflicted" (Mitchell 2016). This

This project demonstrates that cultural landscapes cannot be truly retrofitted for resilience if they weren't originally designed to be so. The UNESCO sites that are still capable of conveying natural disaster lessons do so because their inherent resiliencies were built-in from the start. The very act of adding resiliency retroactively means constraining the available methods to those that control and redirect, which may very well exacerbate already intensifying or emerging extreme natural processes. This offers a possible explanation as to why the implementation of the living root bridge strategy at Scotty's Castle still

takes the form of redirection and flow control. If some of today's culturally significant sites were not built in accordance with their contextual natural processes, let alone their historic extremes, then they most likely cannot account for events beyond such extremes, such as those projected for changing climates. This means that holding ground will likely emphasize engineering approaches that control and redirect. This severely limits the options that cultural resource managers can choose from and thereby limits how much their concomitant cultural values and adaptive practices can evolve. This seemingly inevitable perpetuation of maladaptive values becomes a greater concern when already scarce resources, such as person-power and funding, may become more scarce as increasing disaster rates stretch available resources further.

The implications of retroactive resilience-building provide a deeper basis for embracing landscape hospice as an opportunity to interpret climate events as landscape history in the making, thereby emphasizing narratives about coupled landscape and humanity processes rather than perpetuating discredited narratives of disappearing, fixed objects. This will ultimately require a cultural shift within the NPS so that such adaptive management can be possible. This shift may have already occurred within certain sectors of the service, as demonstrated by the recognition



**Figure 5.5** the "Brown House" at Rapidan Camp, Shenandoah National Park (image source: WhiskeyBristles, atlasobscura.com)

*Adaptation **should** be emphasized as a function of management systems, but not at the expense of considering other resiliencies.*

of ecological resilience within cultural landscapes. This management approach is reflected at Rapidan Camp in Shenandoah National Park where managers are actively replacing disappearing hemlock forests with heat-resistant tulip poplars to reestablish the forest character of the site (Figure 5.4). As this project points out, these philosophies have yet to be expanded to include material and/or cultural resources, as is reflected by the NPS's formalized processes. Surprisingly, this project's findings support the NPS's *Cultural Resource*

*Climate Change Strategy* in that adaptation should be emphasized as a function of management systems, but not at the expense of considering ecological, engineering, and, if it applies, social resiliencies that are inherent to the resource systems. If the larger SES is to be truly resilient, then the adaptive capacity of the management sub-system depends upon the resiliency of the built sub-system, and vice versa. This further supports the need for vulnerability assessments to provide a baseline of all forms of resiliency that are expressed within a coupled management/resource system since resilience is an emergent property, rather than an attribute of, tightly coupled systems (Park et al. 2013). A resilience-oriented VA framework sets the stage for coupling the systems more tightly, thereby making them more resilient by decreasing lag-time between reciprocal feedbacks. It's worth noting that this also makes management philosophies more difficult to conceptualize and communicate to the public.

## Future Work

The goal of this project was to demonstrate that material components of cultural landscapes can exhibit resiliency, even if it's not specifically adaptive capacity. It was illustrated that, by extension, cultural landscapes are capable of demonstrating all domains of resiliency. This project offers the operational recommendation of substituting the VA term "adaptive capacity" with

"resiliency". Future work could entail applying the proposed framework to one of the three preliminarily assessed cultural landscapes and comparing the thoroughness of each. How these assessments inform resource prioritization, which is crucial to adaptive planning, is yet another venue that could be explored after clarifying the proposed framework.

## Writing Our Autobiography

As Pierce Lewis famously said in *Axioms for Reading the Landscape: Some Guides to the American Scene*, "our human landscape is our unwitting autobiography, reflecting our tastes, our values, our aspirations, and even our fears, in tangible, visible form" (1979). In the age of climate change, recognizing the entire landscape as a cultural landscape is ever more accurate since no part of it has been left untouched by human action. We are continuously shaping its record through the layers that we build and even intentionally erase. For the NPS to value the contribution of today's narratives to future understandings of our climate change responses, it must adapt.

This project has demonstrated that the success of cultural landscape adaptation depends upon the adaptation of its management system, which in turn depends on its organizational adaptation in the form of a cultural shift. This is not as distant as it seems since the NPS's dual

mandate is a cultural product of 1916 and its interpretation is also subject to cultural, if not legal, changes. Thus, a cultural shift may mean reinterpreting our obligation to future narratives as recognizing inherent resiliencies in cultural resources; embracing rehabilitation and landscape hospice; and interpreting landscape processes as a way of embracing landscape change rather than fixating on temporary features. Luckily, our global landscape is embedded with instructions for how to do this, if only we know how to read it.



# Appendix

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# Glossary

## **adaptive capacity**

1. a system's ability to permanently self-adjust in response to a specific external stressor, i.e. *flood*
2. a quality that contributes to a system's overall resilience and is unique to complex adaptive systems

## **adaptive management**

1. a management approach that plans for uncertainty by providing instruction for how to anticipate, respond to, and quickly recover from projected climate change trends and events
2. a form of planning that emphasizes learning and self-adjustment as a means of organizational adaptation

## **complex-adaptive system**

a self-perpetuating system that is capable of self-organization and adaptation, i.e. *organisms, ecosystems, economies, social networks, human communities*

## **cultural integrity**

1. the degree to which historically significant landscape characteristics are still present

2. the extent to which the general character of the historically significant era is still present

## **exposure**

the presence of a resource or resource system in an area that may be impacted by projected climate change trends or events

## **landscape hospice**

the act of allowing a resource or resource system to deteriorate without intervention while care is taken to document and interpret the process

## **sensitivity**

the inherent propensity of a resource or resource system to be negatively impacted by projected climate change trends or events

## **resilience**

a system's ability to withstand and recover from a specific external stressor; four realms: *ecological, social, organization, engineering*

## **resource**

in the case of the National Park Service, an entity or system that is considered valuable because of its contribution to our national heritage

**social-ecological system (SES)**

a complex adaptive system that consists of human systems and their activities coupled with ecological systems and processes

**system**

a set of parts that are connected by function and/or association

**vulnerability**

the susceptibility of a resource system to be impacted by a given stressor





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