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A Tourism Impact Index for Water-Based Natural Attractions Field-Tested in Subarctic and Maritime Climates

Jason Fox
Western Kentucky University, jason.fox410@topper.wku.edu

A TOURISM IMPACT INDEX FOR WATER-BASED NATURAL ATTRACTIONS FIELD-TESTED IN SUBARCTIC AND MARITIME CLIMATES

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A TOURISM IMPACT INDEX FOR WATER-BASED NATURAL ATTRACTIONS
FIELD-TESTED IN SUBARCTIC AND MARITIME CLIMATES

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Leslie North, Director of Thesis

Jason Polk

David Keeling

Edward Huijbens

Dean, Graduate School 8/5/19
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Advised by: Dr. Leslie North, Dr. Jason Polk, Dr. David Keeling, Dr. Edward Huijbens

Department of Geography and Geology Western Kentucky University

Tourism in cold and cool-climate regions is largely characterized by recreational and sightseeing activities at water-based natural attractions such as beaches, coastal cliffs, and waterfalls. While the economic benefits of the tourism industry can contribute to a sustainable future for these regions, the environmental implications of a hastily-developed industry cannot be ignored given that cold-climate and cool-climate landscapes are at risk of rapid environmental change from a warming climate and other environmental concerns. This study consisted of the development of the Tourism Impact Index for Water-Based Natural Sites, the first of its kind, and its application and refinement in the field at various water-based natural tourism sites in Iceland and the Washington Olympic Peninsula. As no direct precedent for the index exists, the creation of the initial index draft was informed by other environmental indices available from the literature in related disciplines. The index contains 44 visually-assessed indicators, each scored on a scale of zero to three regarding potential severity of environmental impact. As the index was applied throughout the two study regions, improvements were incorporated into the design so as to create a well-validated product that may be shared with tourism managers and developers and with researchers to aid in the continued expansion of literature on tourism-environment interactions.

CHAPTER ONE: INTRODUCTION

Tourism in cold-climate and cool-climate regions has experienced a period of rapid growth within the most recent decades, especially throughout the Arctic and Subarctic (Jóhannesson et al. 2010; Stewart et al. 2005; Kaltenborn 2000). While this growth has become a reliable source of economic profit for some communities, thus prompting additional expansion of the industry, few studies have attempted to delineate the specific environmental implications of tourism activity in cold-climate and cool-climate regions. Tourism often implies rapid land-use change to accommodate high volumes of visitor traffic (Wang and Liu 2013), as well as increased demand for resources and spikes in carbon emissions from tourist activity (WTO 2008), all of which yield environmental impacts that are not yet fully understood.

In the context of the Arctic, Subarctic, and colder climates in general, the threats of climate change present additional challenges as communities must respond to and prepare for environmental change pertaining to glacial/permafrost melt, sea level rise, coastal degradation, and shifting availability of various resources as changing temperatures affect natural processes (IPCC 2007). In these vulnerable landscapes, research must address issues in sustainable tourism development by striving to increase awareness of tourism's environmental footprint and inform the implementation of management plans and regulations that could minimize the future impact of an expanding tourism industry. Despite this need, the available scientific literature on cold-climate tourism primarily focuses on general themes based in the social and economic sciences, such as changing demand, governance/regulation, and large-scale global change (Stewart et al. 2017), thus lacking the robust quantity of information needed to inform and support sustainable development, especially at the local scale. As a result, many pivotal connections between the tourism industry and the natural landscape remain understudied.

The growth of the tourism industry in cold and cool climates continues to bring record numbers of visitors to landscapes appreciated for their pristine wilderness quality, as these areas have yet to be transformed by highly-consumptive and environmentally impactful mass tourism. Forms of alternative tourism that promote environmental appreciation and awareness—namely ecotourism, wildlife tourism, and nature tourism—frequently lead the tourism scene in colder climate regions (see Hill and Gale 2009); however, as the tourism industry grows, the fragile cold-climate environments in the Arctic and elsewhere stand to face increased visitor volume, often resulting in site overcrowding and large-scale infrastructural development of the landscape to accommodate more visitors at a grander level of comfort. With these changes, some level of environmental degradation is inevitable as tourists interact with the landscape both directly through recreational activities and indirectly through the development and utilization of tourist services. The extent of this degradation is also understudied, and, with the addition of climate change threatening landforms such as glacial features and other popular natural attractions, a sustainable future for climate-vulnerable landscapes pressured by a dominating tourism industry can be difficult to achieve.

In order to link environmental change and tourism at the applied scale effectively, the connections between tourism activity, tourism development, and landscape change must be studied in greater depth. Limiting such advancement is the lack of readily-available and widely-applicable decision-making and evaluative tools to assist tourism development agencies, land and resource managers, and scientists in their efforts to protect natural tourism sites from their environmental vulnerabilities. Given the lack of data and supporting literature with which to reference tourism-driven changes to the localized landscape, especially in cool- and cold-climate environments, the development of an environmental index is an optimal method to establish baseline knowledge specific to a tourism site, as well as a means to expand general knowledge on tourism's environmental impacts at the broader scale. As the concept of "Last Chance Tourism" draws historic volumes of tourists to cold climates seeking experiences that are diminishing due to climate change (Lemelin et al. 2013; Eijgelaar et al. 2010), such research is imperative so as to gain the capacity to quantify the impacts of tourism activity and development for the purpose of ensuring that tourism can be sustained without irreversible environmental degradation.

The methodological base of this research is the creation of a new environmental index—the Tourism Impact Index for Water-Based Natural Sites (TII-WBNS, TII, or "the index")—to evaluate the severity of tourism industry impacts on water-based natural attractions. Indices are common research and management tools utilized throughout the environmental sciences to evaluate the many natural and anthropogenic forces and processes that shape a landscape as they vary across space and time (Ebert and Welsch 2004). No index is currently available to evaluate the environment as affected by various tourism-driven landscape changes in the same comprehensive capacity as the TII-WBNS.

1.1 Research Objectives and Questions

This research aimed to address the shortcomings of the current research on tourism and environmental change by linking tourism development and activity with the degradation of landscapes through the creation of an indexing tool tested across a variety of natural tourism sites. To address such a goal, this research operated under the premise that tourism development and activity creates disturbances of natural water-based features (e.g., waterfalls, beaches, etc.), yet the extent and variability of such disturbances remain unknown. Water-based sites are prevalent throughout the nature tourism sector, and such sites generally represent locations of high tourism influence in addition to active landscape change. Given this context, the following research questions were investigated:

- How can landscape degradation in cold and cool climates attributed to tourism development be measured with an environmental index?
    - What variables should be included in an environmental index in order to assess tourism-induced landscape change?
    - Through which design can an environmental index most efficiently and effectively evaluate tourism-driven landscape change?

Addressing these research questions may contribute to solving the challenges of continued tourism industry development amidst a warming climate by informing improved site management via regulation/policy and community action. The primary intended outcome of this research is the development of a validated form of the TII tested through extensive field application. The TII is necessary not only to bridge the literature gap in tourism-landscape interactions, but also to serve as a widely-applicable tool for tourism managers and researchers in a time when proper management and understanding of tourism’s environmental footprint are critically needed. The design of the index was informed by the review of other environmental indices used in related fields. Additional review of literature on tourism site management, tourism development and activity trends, and surface processes informed the variables included in the index as indicators. In order to verify the content and design of the index, a series of field applications was completed at 28 water-based natural tourism sites located throughout the study regions of Iceland and the Washington Olympic Peninsula. Improvements were incorporated into the index design during its application period and after analysis of the application results, providing a finely-tuned environmental index ready for continued use in cold and cool climates and for further testing in terms of expanded use by managers and researchers.

CHAPTER TWO: LITERATURE REVIEW

2.1 Tourism

Tourism is a massive worldwide industry that can be subdivided into many sectors that summarize the general intent or motivation of the tourist. Hill and Gale (2009) described the relationship between many of the specified sectors of tourism that have grown to prominence within the industry as a whole (Figure 2.1). Notably, mass tourism is practiced in large numbers and can be generally described as involving “comfortable” practices that do not necessarily introduce a tourist to unfamiliar, educational, or challenging experiences. In contrast, alternative tourism includes most any tourism sector that does not fall under the umbrella of mass tourism. While each of the sectors described in Figure 2.1 is practiced across all world regions to some extent, mass tourism is especially typical of warm-climate or tropical coastal regions where leisure and recreation dominate the purpose of travel. Forms of alternative tourism are typically more concentrated, yet ever growing throughout the worldwide tourism industry. Wildlife tourism, adventure tourism, and especially ecotourism can all be linked to some extent with sustainable tourism, and these forms of tourism often seek to contribute to local economies while minimizing environmental impact, promoting local conservation, and emphasizing tourist education about the region (Hill and Gale 2009).

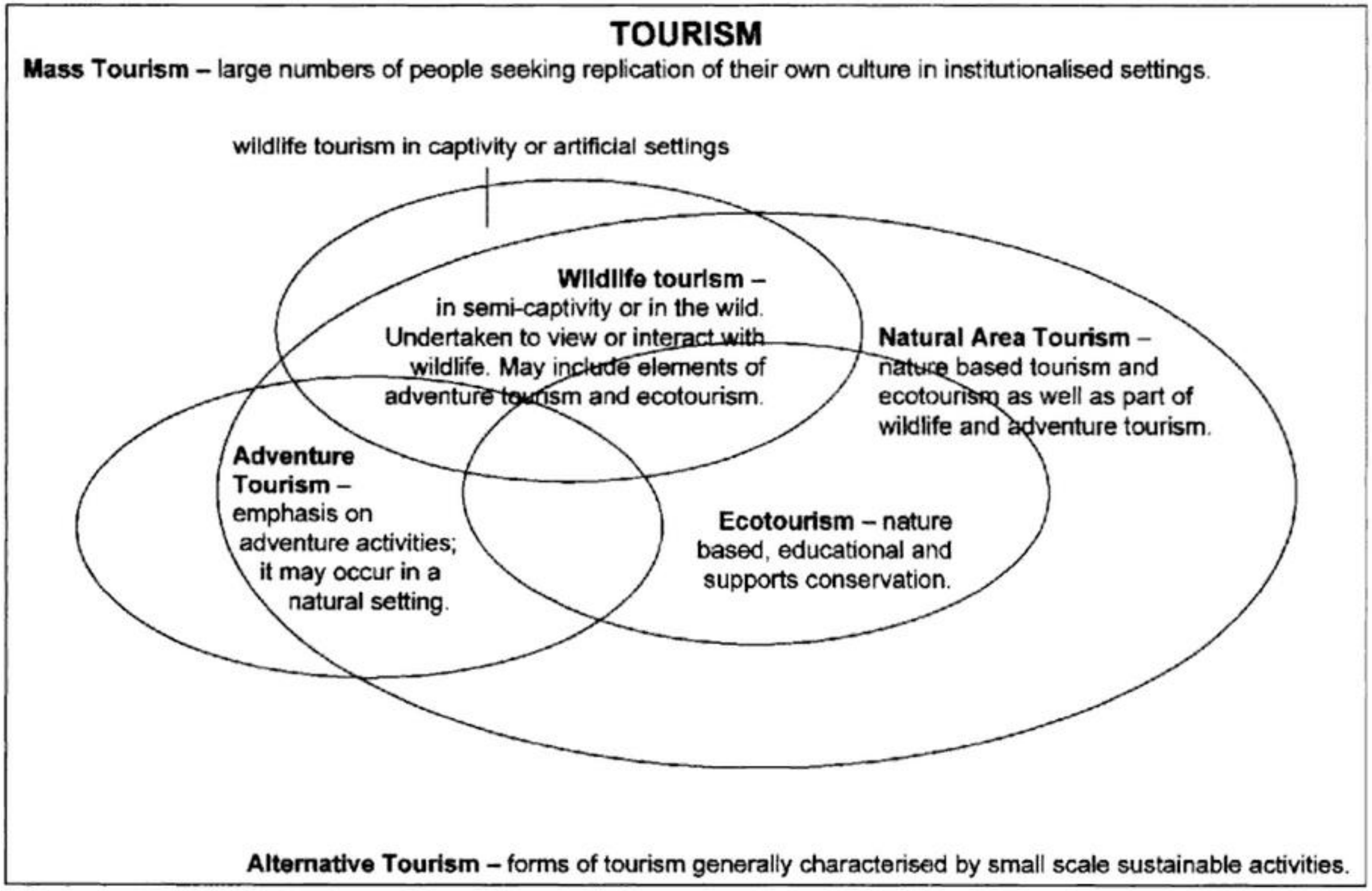

Figure 2.1. Relationships between various sectors of tourism. Source: Hill and Gale (2009, 5).

2.2 Tourism and the Environment

The field of research that examines the complex relationships between the tourism industry and the natural environment has gained much traction within recent decades, yet the body of research that can be applied directly to inform the sustainable management of natural sites remains limited and must be expanded to account for a growing worldwide nature-based tourism sector; this charge stems from the current knowledge of the environmental consequences of tourism activity and development as outlined by the available literature. The following review provides the scientific context from which the need is elevated for a comprehensive tourism impact evaluation tool for natural sites.

The environmental footprint of the tourism industry is well-acknowledged in the tourism literature, and, despite the occasional emphasis on environmental stewardship offered by alternative tourism, all forms of tourism contribute some degree of environmental impact on the locations in which they are practiced. Tourists are ultimately a foreign presence to a landscape who utilize the same resources and occupy the same spaces as endemic peoples, increasing the human capacity for which natural systems must accommodate. Tourists also enjoy a certain liberty in their ability to choose their destinations and, to a certain degree, how to interact with the landscape at their destinations. Tourist landscapes can therefore be considered as "commons," and the resources therein become common pool resources as described by Healy (1994). Healy drew from Hardin's (1968) foundational essay that coined the "Tragedy of the Commons," the notion that natural resources belonging all or many of the self-serving population are ultimately overused and, as a result, diminished or degraded. Healy (1994) elaborated that tourist landscapes as "commons" are not only subject to overuse, but they fail to foster the incentive for users to invest in such landscapes, as many tourists may enjoy the benefits offered by these landscapes at little to no need for personal investment in the landscapes' sustainability—as is their right to utilize common resources. The Tragedy of the Commons, therefore, forecasts that tourist landscapes are vulnerable to overuse and degradation, as well as a lack of general investment through which such concerns may be remediated.

The Tragedy of the Commons as applied to tourist landscapes is further compounded by questioning the sustainability of the nature-based tourism industry as a whole. Briassoulis (2002) discussed how tourist activities (e.g., sightseeing, travel, accommodation, entertainment, and services) must often operate alongside non-tourist activities (e.g., residential, agricultural, industrial, and commercial sectors) and also share infrastructure, facilities, natural resources, and other elements of the natural and human-constructed environment. Briassoulis (2002) highlighted the role of background tourism elements (BTEs) in sustaining tourist commons. In the case of nature-based tourism, BTEs include natural attractions like scenery, human inputs like cultural artifacts, and incorporations of both natural and human influence, such as national parks or nature preserves. Once background tourism elements are diminished, such as from overuse of common resources, a tourist landscape may begin to decline in appeal, and subsequently decline in visitation. To demonstrate this concept, Briassoulis (2002) pointed to the tourist area life cycle as delineated by Butler (1980).

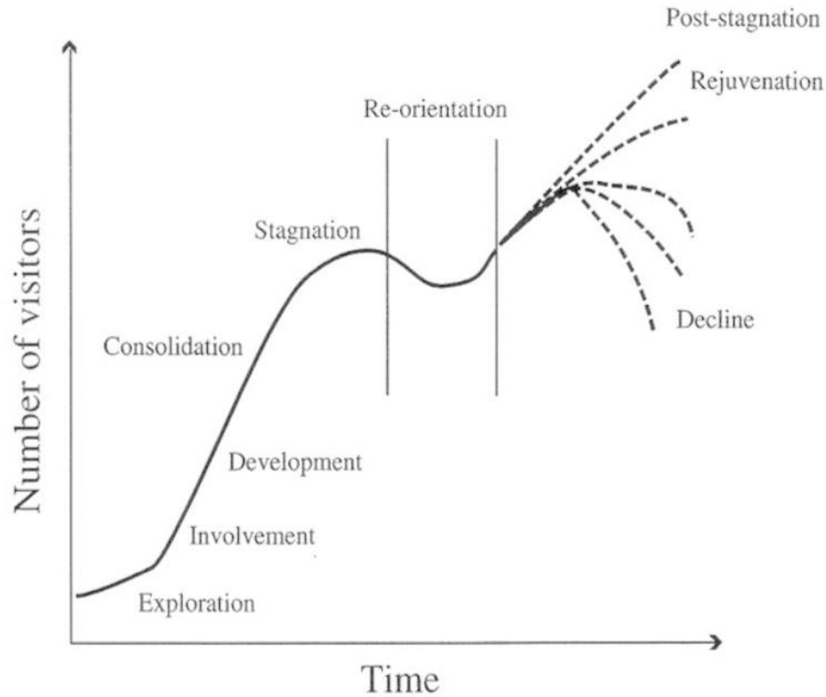

Figure 2.2. Modified Butler Tourist Cycle of Evolution. Source: Agarwal (2006, 215).

Modeled in Figure 2.2, Butler's cycle suggests that a tourist area first experiences an exploration stage with low visitation and a reliance on local facilities. In the subsequent involvement stage, some facilities may be constructed primarily for visitor use as visitation increases, and a tourist season emerges. The development stage represents substantial growth in visitation, marketing, and the development of sites. In the consolidation stage, the rate of growth in visitation will begin to slow, and tourism will play a large part in the regional economy. The stagnation stage is entered when peak visitation is reached, and carrying capacity, a concept discussed below, will likely be met or breached. From this point, a tourist area may experience decline as newer tourist markets outcompete, or rejuvenation of the area may later occur (Butler 1980). At the cycle's outset, alternative tourism will likely thrive, but as the cycle progresses, mass tourism will likely become more commonplace. Returning to the work of Briassoulis (2002), tourist commons face increased threat of overuse and degradation as the Butler cycle progresses. As the worldwide tourism industry has grown in recent years, environmental concerns regarding the depletion of tourist commons have gained heightened relevance as more natural areas serving as tourist sites are incorporated into the tourist area life cycle.

The environmental implications of increased tourism development and activity are not limited to the local scale. The tourism industry is inextricably intertwined with global climate change, not only as a contributing agent by means of carbon emissions and other impacts, but also as a highly-affected stakeholder in regional environmental change. Many studies have outlined the carbon footprint of the tourism industry from a variety of angles (e.g., Wu and Tian 2016; Amzath and Zhao 2014; Gössling et al. 2007). The World Tourism Organization (WTO 2008) estimated that 3.9-6.0% of the world's total CO_2 emissions can be attributed to tourism, a value that has likely increased within the last decade as the global tourism industry has expanded. As globalization continues to manifest in the worldwide tourism industry, tourism has shown to contribute to several other general global environmental issues, namely land use change, energy use, biotic exchange, exchange of disease, and changes in environmental perception and understanding from the public at large (Gössling 2002). These global environmental impacts of tourism are fed by local impacts, as largely induced by the Tragedy of the Commons, and they demonstrate that sustainability must be placed at the forefront of management, policy, and further development related to the tourism industry.

To more clearly address the ambiguities of environmental impact and sustainable tourism in natural areas, a quantitative basis may be useful, and an understanding of landscape processes, geomorphology, and human influence resurges into relevance. Jennings (2004) outlined the relationship of tourism development with landscape sensitivity through the exploration of lag time, environmental thresholds, and the concept of equilibrium. Jennings (2004) argued that the human influences of tourism development must be studied as processes that affect natural geomorphologic conditions and, therefore, alter landforms in nontraditional ways. Specifically, Jennings (2004, 275) described a threshold as "a value (or range of values) in one or more environmental variables…at which a change is induced, usually after a reaction time" (Figure 2.3). Intrinsic thresholds pertain to natural processes (such as long-term weathering changes), while extrinsic thresholds pertain to external forces "shocking the system" (Jennings 2004, 275). Tourism development, therefore, is an example of an extrinsic threshold.

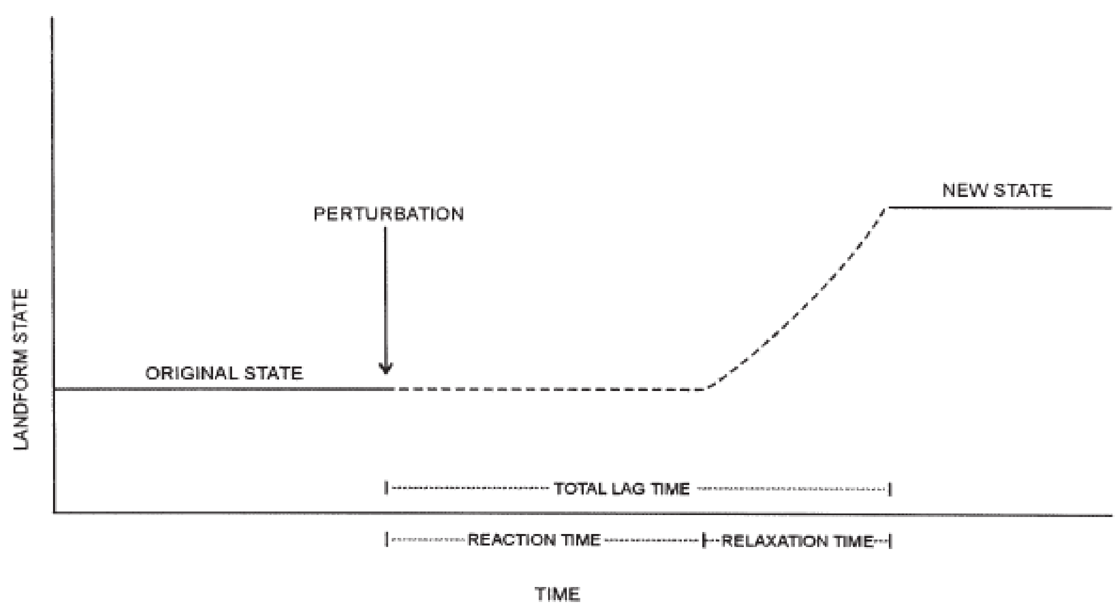

Figure 2.3. A simplified illustration of the landform change process. Tourism activity can serve as a perturbation, inducing a lag time before the landform achieves its new state. Source: Jennings (2004, 275).

Carrying capacity is another important consideration raised by Jennings (2004). Sousa et al. (2014, 545) defined tourism carrying capacity as "the level of human activity that an area can support without provoking deterioration of its physical and environmental characteristics." Using adapted mathematical equations, Sousa et al. (2014) found that tourism carrying capacity is easily breached, especially in settings of mass tourism, such as the beach tourism destinations of coastal Brazil. While carrying capacity is a key element of many tourism-environment studies, Jennings (2004) argued that defining environmental thresholds and lag time are more effective landscape sensitivity methodologies than simply defining carrying capacity, as the latter fails to consider feedback mechanisms between tourism and environmental systems.

The perceptions of tourists, tourism managers, and other stakeholders regarding the environment can serve as key factors to effectively design further research and policy in sustainable tourism. Interview and survey-based research is common in tourism studies as a means of summarizing the insights of tourism industry stakeholders, such as operators, residents, and tourists themselves. In order to understand tourist demographics, in addition to the activities and preferences of tourists, surveys and interviews are frequently conducted at regular intervals by organizations that represent a specific location or region. These studies may be completed by agencies themselves, such as the work of the Icelandic Tourist Board (ITB 2018) and the U.S. National Park Service (NPS 2019) (see Chapter Three), or the data collection process and reporting of results may be outsourced to private entities, such as the McDowell Group (2017) working for the Alaskan state government. Other studies utilize interview methods to better understand stakeholder values and to grasp the level of stakeholder comprehension of concepts such as vulnerability and resilience; for example, Espiner and Becken (2014) found through stakeholder interview analysis from New Zealand's glacier country that high levels of perceived vulnerability to environmental change do not equate a low degree of resilience to such change.

The relationships between tourism and the environment form the key research focus of this study; however, the field of scientific study linking the two subjects remains young. Despite the recent growth of tourism-environment research, few robust quantitative studies outside of CO_2 emission calculations, carrying capacity, and other well-established themes related to tourism-environment interactions that consider the environmental impacts of tourism have been published. Utilizing an approach that incorporates concepts in geomorphology, this research intends to address this literature gap by expanding knowledge on the linkages between tourism activity and development and the changes to the landscape such impacts induce.

2.2.1 Tourism and Landscape Degradation

Where natural sites serve as tourist attractions, tourists are directly interacting with the landscape and, therefore, are contributing to processes of landform evolution and degradation. Although the severity of land degradation may be most intense in the Earth's arid regions, land degradation is a global phenomenon accompanied by costly management implications. Gísladóttir and Stocking (2005) emphasized the importance of incorporating the other major elements of global environmental change, biodiversity and climate change, into land degradation research to address more comprehensively management issues at the global scale. Considering each of these elements in tandem is also necessary for research pertaining to tourist-landscape interactions.

A discussion of the biodiversity element of landscape degradation begins with a look at ecological sensitivity, a research focus where a great portion of the relevant literature is housed. Nature-based tourism activities commonly occur in protected areas or parklands that are considered ecologically sensitive (Schaller 2014), and these protected areas, therefore, face the challenges of tourism development that function in contradiction with the ideals of environmental conservation (Zhang et al. 2012). When frequent tourist activities such as hiking, off-road driving, or horseback riding are concentrated in confined areas, such as trails or areas of sensitive vegetation, extensive trampling may occur (Gatzouras 2015). The practice of measuring the extent of trampling and its consequences on soil compaction and plant cover upholds a longer research history than the emerging tourism-centered studies; Cole and Bayfield (1993) first defined a standard procedure for trampling assessment.

Within the past two decades, research has begun to explore tourism-based degradation specifically in colder climates. In Arctic, Subarctic, and alpine regions, both vegetation and soil cover can be considered highly vulnerable to erosion and degradation due to their susceptibility to both anthropogenic and natural pressures (Ólafsdóttir and Runnström 2009). Various studies have attempted to assess, measure, and respond to the level of degradation present in recreational trail areas of natural attractions in subarctic study sites such as Iceland. These studies are largely observational and, while many acknowledge the management implications of the findings, do not incorporate any level of landscape remediation into the methods. The work of Schaller (2014) in Iceland and

Hokkaido, Japan, provides an example of the connections between trail degradation and environmental sensitivity. Naturally, landscapes of fragile vegetation cover and of high erosion susceptibility are of substantial managerial concern when frequented by heavy tourist activity.

2.2.2 Methods in Tourism Management and Impact Evaluation

A variety of field methods have been developed across the literature to assess tourism-altered landscapes and to practice effective site management. Trail assessment is a common initial approach to site management; Schaller (2014) derived from the available literature three general categories of trail assessment methods: remote sensing, census-based methods, and point sampling methods; often a combination of the three are used in the same study. The remote sensing methodologies of trail degradation research allow for vast study regions to be considered comprehensively, and, when coupled with GIS capabilities, an entire study area can be assessed and mapped according to variables such as level of degradation present or general vulnerability to erosion or trampling. Examples include the work of Gatzouras (2015) in Iceland as well as the GIS modelling approaches of Tomczyk and Ewertowski (2011) in Poland and of Ólafsdóttir and Runnström (2009) in Iceland. Adopting a different approach, Hale (2018) published a mapping project of ecologically-sensitive areas that are potentially most threatened by tourism activity in which the author amassed the recorded location in geotagged photos posted to social media by tourists in the Icelandic Westfjords region. Similar studies may be used in the future to better understand spatial patterns in tourist activity as related to environmental concerns, especially in areas that are remote or otherwise sparsely monitored.

Point sampling and observational assessments remain in common practice for hiking trail assessment. For example, Ólafsdóttir and Runnström (2013) used field-based point sampling and condition class assessments in two specific trail sites to complete a more localized assessment study. Barros and Pickering (2017) considered degradation not only related to formal networks of hiking trails but also to informal trail networks and off-trail land plots that were still affected by human activity in their Andean study area. Informal trails (also called undesignated trails or visitor-created trails) are of substantial managerial concern where vegetation cover is limited or vulnerable to trampling and where other concerns such as erosion or pollution are of heightened concern. Marion and Leung (2011) diagnosed that informal trails are commonly at risk of trail widening, muddiness, soil loss, vegetation loss, and negative impacts to water quality. Some studies focus directly on mapping, monitoring, and comparing the severity of informal trails and formal trails in protected areas, such as national parks (e.g. Leung et al. 2011; Wimpey and Marion 2011). From a mitigation perspective, Schwartz et al. (2018) demonstrated that using physical barriers (e.g., fencing) combined with educational messaging about the importance of remaining on designated trails (e.g., educational signage) can work effectively to discourage further formation of informal trails.

Studies that exceed basic trail assessment or ecological sensitivity evaluations to provide a more comprehensive geomorphological analysis of tourism's development impacts are rare. For a full geomorphological assessment, a variety of assessment methods must be applied to the chosen study location. Mihai et al. (2009) attempted one such study in a mountainous tourist area in Romania by combining methods in remote sensing, pedological analysis, geomorphological and infrastructural mapping, and field surveying. Drawing from the precedent set by these previous studies discussed above, this research, through the use of an indexing tool, sought to provide a simplified method of wholesomely assessing a landscape, combining factors in geomorphology, tourism-related site degradation, and environmental management.

2.2.3 Coastal Tourism in Cold Climates

Coastal tourism has generally received much attention in the scientific literature, as coasts often serve as prime locations for large-scale tourism development. Therefore, the environmental influence of tourism is of undeniable relevance in coastal areas. Coastal areas remain, however, highly vulnerable to the effects of climate change, in addition to the various geomorphologic processes that continually alter the coastal landscape. When tourism is added to this mix, the coastal zone becomes even more dynamic, forcing researchers to consider the many complex relationships between both human and natural variables. Moreno and Amelung (2009) outlined the relationship of climate change with coastal and marine tourism, explaining that current studies focus heavily on destinations with little attention paid to the diversity of activities that fall under the umbrella of such tourism. Moreno and Amelung (2009) called for future research to develop vulnerability assessments and monitoring programs as well as raise awareness, promote adaptation and crisis management, and incorporate climate change into tourism policies. These areas of research fall in line with the future challenges poised for coastal tourism as outlined by the Intergovernmental Panel on Climate Change (IPCC

2007), which identified coastal and marine environments as highly vulnerable to climate change.

Coastal tourism is often reflected in land use change attributed to coastal development (Wang and Liu 2013). As the tourism industry grows, an increased area of land centered around attractions and hotspots of activity is converted into tourism infrastructure, such as hotels, businesses, developed attractions, and tourist transportation networks (highways, airstrips, harbors, etc.). Changes in land use may drastically shift the equilibrium of local environmental systems and processes, the extent of which is determined by the old land use that is newly converted (Wang and Liu 2013). Often, the converted lands include previously undisturbed forests or grasslands or former farmlands. When farmland is converted, the local balance of available resources may also be thwarted. When beaches and other landforms are developed, the ecological landscape is often fragmented, and natural vegetation may become scarce, leading to increased rates of coastal erosion (Wang and Liu 2013). As tourism often provides an economic boost to local regions, non-tourism urbanization may also become a source of land use change (Kara et al. 2013).

Tourism industries in colder climates continue to grow rapidly as elsewhere, yet more sporadically. Colder regions attract high volumes of adventure tourists, wildlife tourists, and ecotourists seeking an alternative experience to tropical beach holidays. This growth in cold region tourism has become a source of great economic benefit for local regions, but the scientific literature has historically maintained its focus on tourism in warmer climates (Jóhannesson et al. 2010). An understanding of the geomorphologic processes pertaining to tropical or temperate climates must be appended with knowledge of cryogenic processes—the roles of glaciers, permafrost, and other features exclusive to cold regions—in order to progress the scientific literature of the entire cold climate coastal system. A similar approach should apply to tourism's environmental impact in cold region coastal zones; however, this leaves a considerable gap to be filled on the influence of land use change and other tourism influences on coastal erosion and other geomorphic processes.

Stewart et al. (2005) first outlined the available literature on tourism research specifically catered to the polar regions, identifying four general clusters of study: tourism patterns, tourism impacts, tourism policy and management issues, and tourism development. The authors, however, explicitly stated a great need for continued research in increasingly-applied settings. Stewart et al. (2017) revisited the same message over a decade later to review the progress that has been made, as well as the deficits yet to be addressed. Over the last decade, the key themes that have emerged from polar tourism research include development, management, technological advancements, and global change.

In considering the threats of climate change on both natural geomorphic processes and tourism activity in cold region coastal zones, a sense of temporal urgency falls upon the need to understand how tourism development impacts natural coastal processes. The concept of "Last Chance Tourism" has gained global relevance as visitors seek to witness glaciers and other landforms that are quickly diminishing, as well as wildlife endangered due to climatic change (Lemelin et al. 2013; Eijgelaar et al. 2010). If tourism-induced environmental thresholds continue to shift the equilibrium of cold region coasts at an unmanaged rate, Last Chance Tourism and tourist activity in its other 'sustainable' forms may contribute to the depletion of the very natural attractions that tourism seeks to conserve. Additionally, as even more small coastal communities begin to accept and embrace tourism as a source of economic vitality, local populations must gain an increased awareness of the consequences of tourist development in such a dynamic landscape.

Themes of environmental management remain important in the context of coastal zone tourism. Case studies abound that link location-specific tourism dynamics to sustainable tourism management and development in the face of continued climatic change. Some of the potential effects include responding to sea-level rise, altered shorelines, increased infrastructural demand to accommodate growing numbers of guests, and diminished water quality from pollution (Haller et al. 2011). Other studies on coastal tourism management are solution-oriented and seek to foster future development that can be considered sustainable with minimal environmental impact. Anctil and Le Blanc (2016) described their method for integrated coastal tourism development in developing countries, including suggestions for solid waste treatment, water management, taxing, and education campaigns.

Research has also addressed the geomorphologic consequences of human activities in the coastal zone, although studies are not always able to isolate the specific influence of tourism development from within general human activity. Xue et al. (2009) completed a case study in the northwest Bohai Sea (China) to delineate the extent of coastal erosion caused by human activity. Heavily relying on GIS analysis and mapping techniques, the authors discussed the many anthropogenic factors that affect coastal erosion, including fluvial sediment trapping, sand dredging, coastal engineering, and tourism. The authors stated that grain size at a case-study beach was larger in autumn than spring, attributing this to the direct transport of smaller sediment by intensive summer tourism activities (Xue et al. 2009).

Concepts and methods applied to general tourism can be specified to fit the context of coastal tourism. Moreno and Becken (2009) presented a climate change vulnerability assessment for coastal tourism in a five-step process, including analysis of the present tourism system (considering the economic, environmental, and social contexts) and the study area's climate characteristics; these steps are then integrated with identifiers of vulnerability to complete the assessment.

Both of the study regions chosen for this research, Iceland and the Washington Olympic Peninsula (see Chapter Three), contain many prominent tourism sites along the coast, and the characteristics of both regions are largely affected by their proximity to the coast. The considerations and concerns discussed above surrounding coastal tourism and cold-climate coastal tourism are therefore deeply relevant to the design and goals of this research. The "last chance" component of tourism in the study regions amplifies the imperativeness of the research to be completed and distributed to broader scientific audiences so as to better understand the exact ways tourism development impacts fragile environments.

2.3 Coastal Geomorphology

A majority of the sites at which the TII index was applied for this study are located on the coast or are affected by coastal processes; therefore, an examination coastal geomorphology and human impacts in coastal regions is appropriate. Generally, a coastal zone may be considered as offshore waters, the coastline, and adjacent shores (Sorensen 1997), although many definitions exist with varying degrees of specificity and purpose. By nature of this definition, a coast is a transitory zone with both oceanic and terrestrial processes at work, creating a dynamic geomorphic system. While a comprehensive review of coastal processes requires too extensive a focus in the context of this chapter, a general overview is provided.

Beatley et al. (2002) outlined the many processes that combine to form a dynamic equilibrium within a coastal zone, resulting in a variety of landforms and landscape characteristics. Often, the geomorphic potential of one process is dependent upon the presence and strength of others. To begin, wind serves as an important agent of light sediment transportation onshore and is attributed to the creation of dunes. Offshore, wind is responsible for wave formation and is a critical component of sea-originating storms (e.g., hurricanes). Waves may also form from seismic activity or tidal action and are also responsible for the transportation of sediment. Waves can either deposit more sediment than removed (constructive waves) or remove more than deposited (destructive waves) (Beatley et al. 2002).

Tides, which occur cyclically in correspondence with lunar patterns, can greatly affect coastal landscapes that are not influenced by strong waves, such as estuaries and lagoons (Viles and Spencer 1995). Tides dictate the areas of shoreline that will fall subject to wave processes as well as the duration of these interactions. Currents serve as another geomorphic agent by transporting sediment toward and away from shore, as well as from one area of shore to another (Beatley et al. 2002). Given each of these general processes, a great variety of coastal landforms are present across Earth's coastal zones, including barrier islands, beaches, estuaries, marshes, reefs, and rocky cliffs and bluffs. In addition to the natural processes outlined above, humans can also greatly impact coastal zones (Figure 2.4). While human influence will be discussed in greater detail below, it is important to note that both human and natural processes are critical in coastal morphology. As with any landscape, the processes that shape a coastal zone occur at varying timescales, ranging from seconds to millennia, as outlined in Table 2.1.

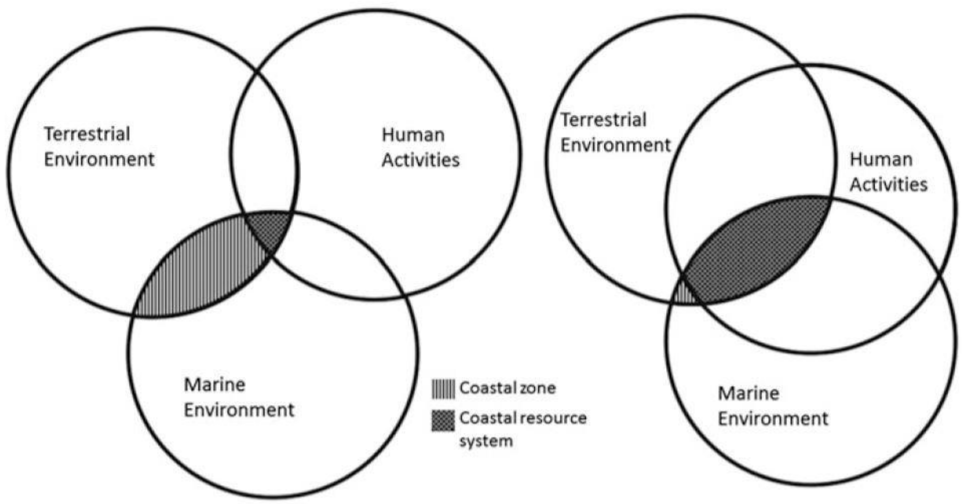

Figure 2.4. Relationship between human activities and the coastal zone. The left model represents the original conceptualization, and the model on the right represents a modern viewpoint. Source: Portman (2016, 5).

Table 2.1. Human and natural time scales of coastal change. Source: Adapted from Beatley et al. (2002).

Absolute Time Scale	Human Processes	Coastal Processes
Millenia		Response of sea level to cycles of glaciation and global warming
Centuries	Establishment of coastal settlement and industry patterns	Formation and erosion of primary capes; rotation of barrier islands
Decades	Impacts of rapid population growth and development; pollution	Formation and loss of habitats (e.g., marshes, dunes)
Years	Impacts of coastal engineering and management plans; pollution	Longshore drift; erosion and accretion of barrier beaches
Months	Impacts of tourism; pollution	Seasonal variation; shore profiles
Weeks	Impacts of tourism; emergency coastal protection works; pollution	Shore profiles; spring-neap tidal cycles
Days	Emergency flood protection works; pollution	Hurricane and coastal storm surge; inlet formation or closure
Hours	Sewage and other waste disposal; evacuation	Tidal cycles; hurricane and coastal storm surge and winds
Minutes	Litter	Waves and currents
Seconds		Sediment grain movement (wind and water)

Rocky coasts, several examples of which serve as index application sites for this research, are found throughout the world. These coasts are often characterized by cliffs, most of which are formed by marine erosion as the abrasive power of waves cuts away sediment from uplands within the coastal zone. Other cliffs are formed partially by land uplift along fault lines (e.g., in Malta) or by volcanic eruption (e.g., in Santorini, Greece) (Bird 2016). Scientific literature on rocky coasts continues to expand from both exploratory and applied research angles. As more is learned concerning the geology and formation of cliffs, recent studies have turned to research themes of management, assessing change over time, and responding to the threats of erosion and mass wasting events (see Kumar et al. 2009). As tourism industries continue to impact coastal areas, research that captures the extent of, and responds to, coastal changes can assist in informing proper tourism management practices.

2.3.1 Cold Region Coasts

While coastal geomorphology remains a widely-considered topic in scientific literature, the available knowledge diminishes when the scale is narrowed to Earth's colder climates. Byrne and Dionne (2002) defined cold region coasts as locations where frost and ice processes have a sufficient impact on the environment; therefore, many Subarctic regions may be included in this classification alongside the true polar regions. While many of the globally-relevant geomorphological processes introduced above are also indicative of cold region coasts, these colder coastal zones are distinguished by additional forces, namely permafrost, sea ice, snow cover, frost action, glacial activity, and isostasy (Figure 2.5) (Strzelecki 2011).

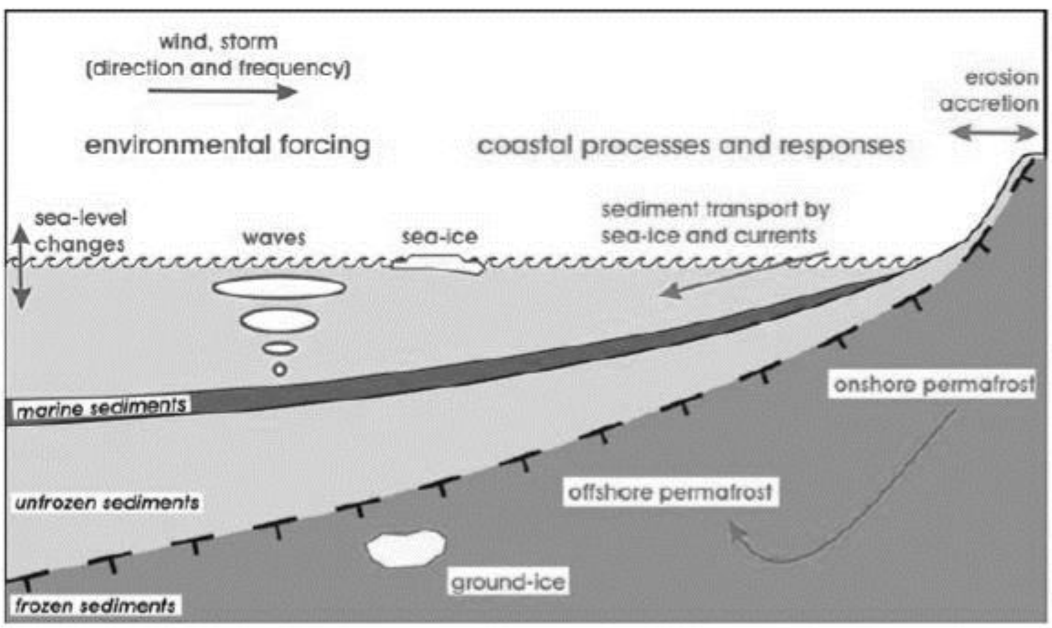

Figure 2.5. Cold-climate coastal processes. Source: Rachold et al. (2005, 64).

Modern studies of cold region coasts must address climate change and related warming trends, especially within greater proximity to the poles, as climatic changes may alter geomorphic processes, the rates and extents of which need to be calculated or estimated. Given the concerns of climate-driven sea-level rise and accelerated warming, Strzelecki (2011, 101) highlighted a need for more understanding of “the controls on High Arctic coastal geoecosystems.” For example, no formal model exists for coastal adjustment to glacial retreat in the High Arctic, but the complex relationships between geomorphic processes are conveyable through photographs of the region (Figure 2.6).

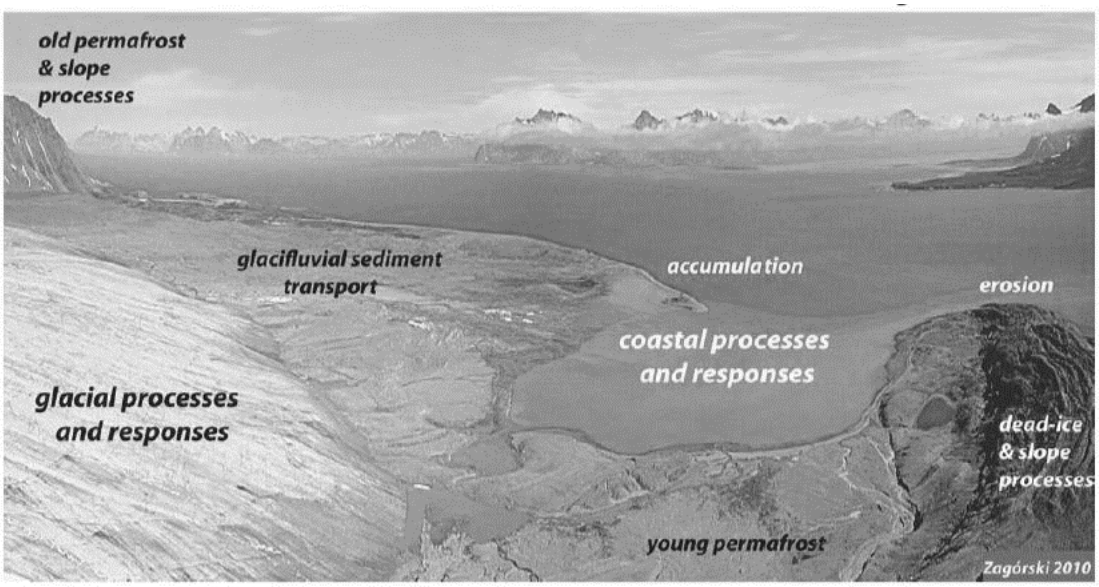

Figure 2.6. Processes active on High Arctic paraglacial coasts. Source: Photo by Zagórski (2010) as cited in Strzelecki (2011, 106).

Exploratory studies are beginning to fill in this knowledge gap in cold-climate coastal geomorphology. The International Arctic Science Committee sponsored the Arctic Coastal Dynamics project (ACD), a large-scale research initiative attempting to create and collect various data on Arctic coastal geomorphology. ACD research included developing an estimate of sediment and organic input from coastal erosion to inner shelves, assembling data on environmental forcing parameters, and expanding the capacity for Geographic Information Systems (GIS) to aid in research (Rachold et al.

2005). Nikiforov et al. (2005) adapted an approach from the ACD project to create a classification system for the Arctic coastal zone as a whole. This system attempted to broadly cover the types of landforms that may occur within cold region coasts and link them to the processes that shape them. While the classification admittedly maintained a generic scale, such a system can serve as a framework for more detailed classification studies in the future.

Other studies have addressed narrower research aims, often including a limited study area so as to keep results accurate and manageable. Gorokhovich and Leiserowiz (2012) documented the extent of coastal erosion of a study area in northwest Alaska using aerial photography to calculate mean erosion rates. Osborne and Forest (2016) combined observations with a review of literature to estimate sediment fluxes across the shelf region of the coastal zone in the Canadian Beaufort Sea.

The role of ice in cold region coasts is perhaps the largest differentiating factor from warmer coastal zones. Based on original observation-based studies, wave action has largely been considered the primary geomorphologic agent in the erosion of cliffs in cold temperate climates (areas further from the poles). Bernatchez and Dubois (2008) argued that cryogenic processes are highly underestimated in these cold temperate regions. Freeze-thaw cycles are emphasized as important erosional forces in the study area of coastal Québec. The frequency of freeze-thaw cycles is affected by snow cover and the direction of a cliff face; in effect, the exposure of a cliff face to increased heat from sunlight. Bernatchez and Dubois (2008) suggested that a feedback from a warming climate is less snow cover that will lead to intensified cryogenic processes. Given the cold-climate focus of this research, these climate-specific considerations should be incorporated into any tool designed to evaluate change in colder regions, including the index tool proposed herein.

2.3.2 Coastal Management

Perhaps the most immediate applications of coastal research in all forms fall under the function of coastal management. The conservation of coasts continues to gain the attention of researchers seeking to complete coastal research in applied settings. Such research often incorporates an implementation variable, a set of suggested steps of action, or a link to regulation, policy, and/or additional required studies. Management research can be applied at both large and small scales. At the most general scale, assessments of coastal vulnerability may be applied to an entire country's shoreline using aggregated data for shoreline erosion, coastal slope, sea-level rise, tidal considerations, etc. (Royo et al. 2016). The simplicity of such studies may hold severe limitations, but coastal vulnerability assessments can identify specific regions that require the most management and research attention. Other research approaches may survey the similar landforms of a coastal region, such as high-profile cliffs, and determine which particular locations are at greatest risk of collapse or major change from erosion, mass wasting, or tectonic forces (Kumar et al. 2009).

A qualitative perspective may also apply to coastal management, especially in the realm of conservation. May (2015) described the management potential for a coastal cliff world heritage site in the United Kingdom; the discussion included the management of visitor safety, site access, visitor education, and fossil collection. Affiliations with the United Nations Educational, Scientific and Cultural Organisation (UNESCO) or additional national conservational agencies and organizations are also important considerations in a coastal management scheme (May 2015). These management elements are important to ensure the sustainability of coastal sites with heavy human influence, and they may also be adapted to inland tourist sites. Crafting research findings that result in useful management knowledge is an important ambition of this study.

2.4 Indices in Tourism Research

Indices are created and applied commonly throughout the geoscience domain to classify and organize any system containing a variety of variables, or indicators, that are relevant to a landscape or process of interest. A successful environmental index will provide comparisons of the state of the environment as it varies across space and/or time (Ebert and Welsch 2004). A precedent for the use of indices in coastal or hydrological studies exists; coastal indices frequently target a central issue, such as vulnerability to sea level rise or, more generally, climate change. Index-based vulnerability research can be completed with various approaches dependent upon the types of variables used; examples include physical assessments (Özyurt and Ergin 2010), social/economic assessments (Boruff et al. 2005) and mixed-methods assessments or assessments that combine multiple indices together (Dolan and Walker 2004). Such vulnerability assessments can be applied to management techniques and contribute both physical and social data on environments for future research (Tibbetts and van Proosdij 2013).

The use of indices in tourism research provides applicable links of tourism to climate change and other environmental change. Vulnerability remains a key theme, as environmental change is often framed as the agent threatening the sustainability of the tourism industry of a region (e.g., Perch-Nelson 2010; de Freitas et al. 2008). In such studies, tourism's role as the change agent altering the environment is not substantially considered; however, these studies do suggest the fragility of the balance between human activity and the surrounding landscape.

Indices that link climate change and tourism have been released through the literature throughout the past two decades; often, researchers adapt an earlier index model to better serve its original function or to apply to a more specified purpose. For example, Mieczkowski (1985) released a popular early model of a general climate suitability index for tourism that has since been revised by de Freitas et al. (2008). Morgan et al. (2000) created an index for assessing optimal beach climate conditions for tourism. Other tourism index research has focused specifically on seasonality. Examples include the work of Li et al. (2018) on seasonal tourism demand in China, as well as the work of Yu et al. (2009) on the seasonality of weather patterns to inform tourism management in Alaska.

In each of the index-based studies noted above, climate or climatic change is defined as the active force, or source of change, that affects the success of the tourism industry. These indices are generally designed to support tourism development and management amidst a changing global or local climate. In total, this available index-based literature reflects a limited view of the complex environment-tourism dynamic that has been thoroughly explored in this chapter. While research has shown that climate change and general environmental conditions do in fact regulate the scope and scale of tourism that can be sustained, studies in landscape degradation and environmental management have also clearly shown the many detrimental effects to the environment and climate that a prominent tourism industry may yield in turn. The second half of this relationship can be ignored no longer if a truly environmentally sustainable global tourism industry is to emerge, especially in vulnerable, easily-altered environments such as the coastal zone, glacial landscapes, or other water-based sites. This study aims to create a new environmental index that is the first to define tourism development and activity as the change agents impacting the host landscape, thus not only providing a conservation tool to aid tourist site assessment and management but also to establish a precedent in the index-centered literature that sufficiently acknowledges and accounts for tourism's expanding environmental footprint.

2.5 Conclusions

This research incorporates elements from a wide variety of subfields in the environmental sciences, including tourism, geomorphology, environmental management, and land degradation science. In order for the Tourism Impact Index for Water-Based Natural Sites to be effective and widely applicable, especially within cold and cool climates as fits the focus of this study, the design of the index must exhibit a thorough understanding of each of these content areas. This literature review has demonstrated that, while each of these research disciplines acknowledges the consequences of an enlarging environmental footprint of the tourism industry and offers various methods and data that address and speak to the underlying issues, there exists a lack of comprehensive indexing tools that can specifically evaluate the environmental conditions at individual tourist sites to inform sustainable management.

As the world tourism industry has rapidly grown over the last century, the accompanying discipline of tourism studies has also expanded. Within the past two decades, tourism research has begun to acknowledge and quantify the level of influence tourism holds over the environment. As cold-climate and coastal landscapes throughout the world can be considered highly vulnerable to erosion, and often vegetation cover change in addition to other nuanced forms of degradation, an expanding tourism industry must exhibit caution in managing the size of its environmental footprint. Indices are gaining traction in tourism research as a means to combine multiple environmental variables together into evaluative tools to aid in tourism development; however, no index to date has attempted to combine tourism variables with geomorphological variables to evaluate the extent of tourism industry impacts at individual sites—a crucial gap this research addresses with the development and application of the Tourism Impact Index for Water-Based Natural Sites.

CHAPTER THREE: STUDY AREA

3.1 Study Region Selection

A core facet of this research is the application of the TII-WBNS in a variety of field settings in order to verify the index design, function, output, and applicability. As such, two distinct study regions were chosen as the backdrops for the field work necessary to apply the index robustly: Iceland and the Washington Olympic Peninsula in the United States. This chapter explains the rationale behind the use of these two study regions, outlines the specific site selection criteria used to choose specific index application sites, and provides geographic context for each study region. The final list of water-based natural tourism sites at which the index was applied is subsequently presented, and each site is briefly introduced.

Iceland and the Washington Olympic Peninsula were chosen in order to test the index in regions that represent high tourist volumes and a variety of water-based natural attractions within a manageable zone of travel. These qualifications ensured a wide pool of potential index application sites in both regions; however, there are also key differences between the two regions that are intended to speak to the robust applicability of the index. The study region choice of Iceland includes a Subarctic climate, minimal vegetation cover, and generally weak tourism management and regulation practices. The Washington Olympic Peninsula includes a maritime or oceanic climate, dense vegetation cover, and strong tourism management and regulation practices (by virtue of Olympic National Park and other agencies). Given the focus of this thesis on cold and cool climates, a sizable spectrum of different water-based natural tourism sites may be found within these two study regions.

3.2 Site Selection Criteria

This section outlines the developed criteria for site selection within the two study regions of Iceland and the Washington Olympic Peninsula to determine specific study area sites for index application. Through this set of criteria, selected sites share pivotal congruencies but also contain strategic differences from one another in order to test the index in multiple settings and capacities. The criteria outlined below were developed as guidelines to aid in the selection of the two study regions as well as the individual site selection process. The same criteria may also be utilized in choosing future locations at which the index may be suitable for use.

Table 3.1 lists the site selection criteria applicable to all chosen sites. These general criteria are defined so as to ensure that each selected site falls within the parameters of the study and properly aligns with the research objectives (see Chapter One); therefore, all chosen sites must contain a nature-based tourism setting, an annual tourism presence, and a water-based primary or secondary attraction. Each of these criteria is likely to be fulfilled differently, as sites may contrast greatly.

Table 3.1. Selection criteria applicable to all sites. Source: Created by author.

Criteria for All Sites	
Criterion	***Explanation***
Nature-Based Tourism Setting	Defined as: ▪ Tourists interact directly with the natural environment ▪ Features a primary or secondary attraction that is naturally occurring ▪ May include natural features, scenic areas, trails, etc. ▪ Site may also contain secondary non-natural attraction (e.g., visitor center, café, camping area, etc.)
Annual Tourist Presence	Quantity and regularity of tourist presence will vary
Primary Attraction or Prominent Secondary Attraction is Water-Based	Site should involve a hydrologically active landscape Examples include beaches, coastal cliffs, riversides, waterfalls, glacial landforms, lakeshores, etc.

Alongside the development of site selection criteria, a goal of at least 10 index application sites per study region was set for a total of at least 20 index applications. Of these ten sites per study region, parameters were defined to categorize the types of sites that were chosen. Table 3.2 lists the criteria specific to each of three different site types: upcoming sites, developing sites, and developed sites. These site types largely reflect the model of the Butler Tourist Area Life Cycle (Butler 1980). Four general criteria are considered: tourist presence, on-site infrastructure, one-site management, and mass tourism service. The first criteria, tourist presence, involves the volume of visitor traffic relative to other sites in the study region as well as the distribution of visitor volume over time. Some sites may experience a high degree of seasonality, while others may maintain a steady flow of visitors throughout the year.

Table 3.2. Selection criteria for sites by site type. Source: Created by author.

Criteria for Individual Sites				
Type of Site	Tourist Presence	On-Site Infrastructure	On-Site Management	Mass Tourism Service (e.g., tour buses, cruise liners)
I. Upcoming Site (1+ per Study Region)	Lowest visitor volume Intermittent presence	Little/no built infrastructure Some educational infrastructure	Minimal/no regular management	Not serviced by mass tourism
II. Developing Site (2+ per Study Region)	Medium volume Regular and steadily expanding presence	Some permanent built infrastructure Some educational infrastructure	Minimal regular management	Serviced by minimal/no mass tourism
III. Developed Site (2+ per Study Region)	Highest volume Regular presence, may be expanding	Major permanent built infrastructure Some educational infrastructure	Regular site management	Regularly serviced by mass tourism

On-site infrastructure can generally fall under one of two categories: built infrastructure or educational infrastructure. Built infrastructure refers to any physical construction that serves or assists tourists in their on-site activities. This may include buildings, pavilions, restroom facilities, or other structures and also accessibility features such as parking lots, service roads, constructed walkways, guide railings, fences, etc. Any constructed features containing informational material made available to visitors in a fixed location can be considered educational infrastructure; this may include signage, kiosks, or artistic installations.

On-site management refers to the level of human maintenance and monitoring in practice at the location. As a site's visitor volume and level of infrastructure increase, on-site management becomes an important consideration to ensure the site and its facilities remain safe to use and that environmental degradation is minimized (Newsome et al. 2013). Not all nature-based sites, however, may practice regular or otherwise sufficient management.

The final criterion is the presence of mass tourism services. As established in Chapter Two, mass tourism settings are typically highly consumptive of energy and resources and, in many cases, may attain to a business model valuing economic turnout over environmental stewardship. The presence of mass tourism services, such as charter bus tours or cruise liner service, raises new concerns regarding environmental degradation and general site sustainability, especially if proper management strategies are not in place.

Based upon the criteria defined in Table 3.2, an Upcoming Site (site Type I) represents a natural tourist attraction that sees few yearly visitor numbers in relation to other attractions in the study region, and the frequency of visitors may be intermittent depending on the season or various short-term considerations. Little to no built infrastructure should exist on the site, yet some basic educational infrastructure, such as interpretive signage, may be installed. The site should also be lacking in regular management, and no mass tourism should have regularly-scheduled tours or service to the site. The purpose behind the inclusion of upcoming sites in the index's field application process is to apply the index in locations where the environmental impacts of tourism have yet to be greatly felt. A preferable site chosen to represent this type category will be a candidate for future growth in tourism volume, perhaps rising to site Type II classification in future years should positive trends in overall tourism growth exist in its study region. At least one of the chosen sites per study region best fits the classification of an Upcoming Site.

A Developing Site (site Type II) experiences medium quantities of visitors in comparison to other sites in the study region. Some basic built infrastructure may be operational on site, and some educational infrastructure may also be installed. Additionally, some basic site management may be in practice. Mass tourism services on the site should be highly limited or nonexistent. Developing sites will preferably exhibit trends of growth in visitor volume and other criteria, placing them on a trajectory toward the qualities of a Type III site in future years should overall tourism growth trends exist in the study region. At least two of the chosen sites per study region best fit the classification of a Developing Site.

A Developed Site (site Type III) represents the most developed and matured natural tourist attractions. Compared with other sites in the study region, a Type III site will rank among the top regarding visitor volume. While the effects of seasonality may remain prominent, a Type III site will be more likely than the two lower classifications to maintain a visitor base outside of the high season. Prominent built infrastructure should be present, providing services and increased accessibility to visitors, and the presence of some educational infrastructure is also expected. Some form of regular management should exist, and a Type III site should be serviced by some form of regular mass tourism, such as regularly scheduled bus tours that include the site as a tour stop. At least two of the chosen sites per study region best fit the classification of a Developed Site.

3.3 Iceland

Iceland is an island country located in the North Atlantic Ocean. The island, approximately 103 km^2 in area, sits just south of the Arctic Circle, imbuing the country with characteristics of a subarctic climate. Iceland’s closest neighbors include Greenland (287 km away), Scotland (798 km away), and Norway (970 km away). Iceland is sparsely populated, with a January 2019 population of approximately 357,000 (Statistics Iceland 2019). Thereof, roughly two-thirds of the population are located within the region containing the country’s capital and largest city, Reykjavik. By contrast, Iceland’s largest municipality outside of the capital region, Akureyri, only has an approximate population of 18,000 people (Statistics Iceland 2016). The remainder of Iceland’s population is located in small town or rural settings. Most Icelanders live in or near the coastal lowlands, as the stark terrain of the country’s highland interior deems it largely uninhabitable.

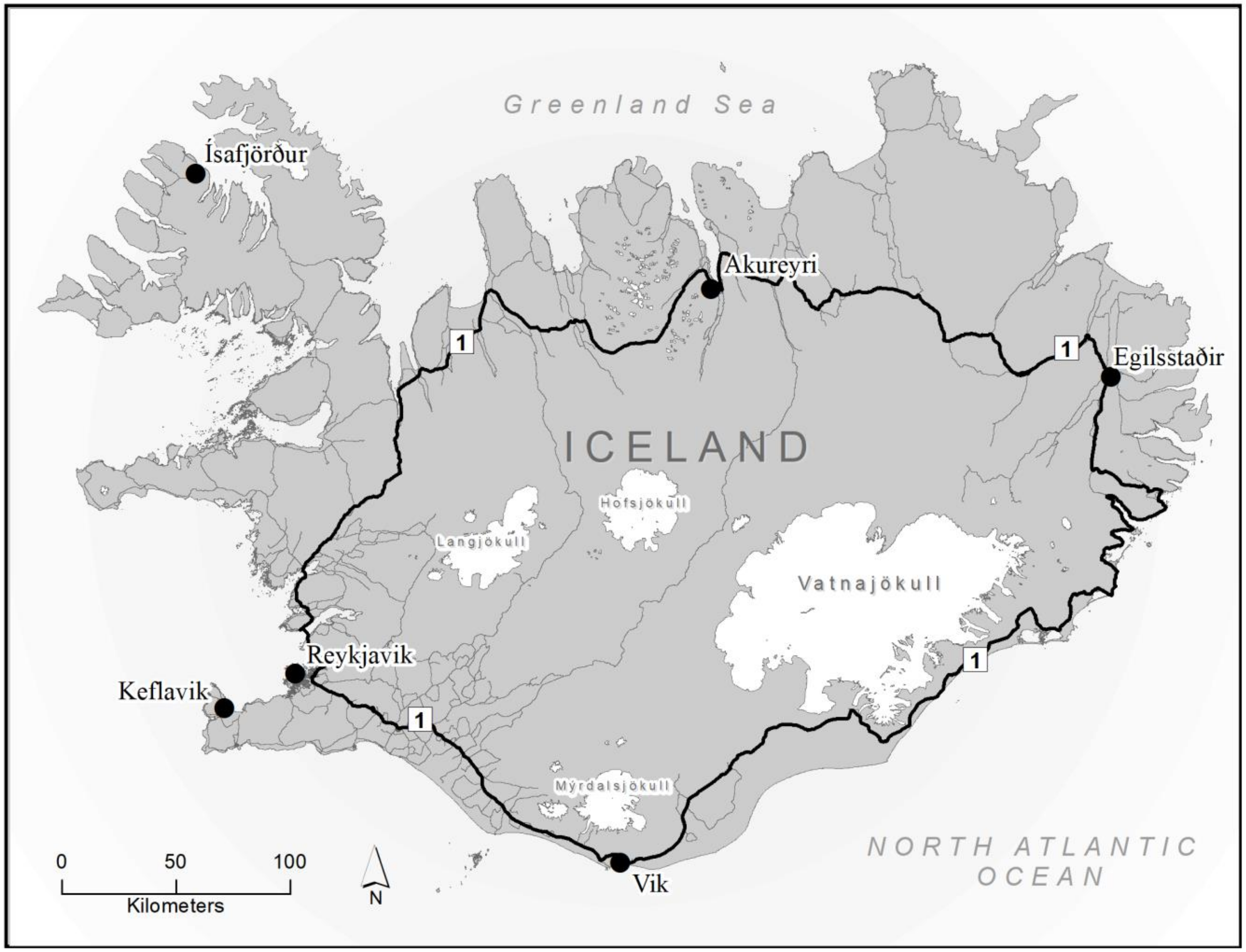

Figure 3.1. Map of Iceland. Includes major cities and major ice caps. Source: Created by author.

A unique geologic and geomorphic history has shaped Iceland's surface to include dynamic landforms and features that are highly attractive to the nature-based tourism industry. The landmass was created by volcanic processes due to its location on the Mid-Atlantic Ridge at the divergent boundary between the Eurasian and North American tectonic plates (Philander 2012). In addition to volcanic features, Iceland's subarctic climate is supportive of glacial activity. The many fjords found along Iceland's northern and eastern coasts were carved by once-existent glaciers descending to meet the ocean. The land ice that remains in Iceland today is limited to four distinct ice caps—Vatnajökull, Langjökull, Hofsjökull, and Mýrdalsjökull—and their glaciers, each located in Iceland's southern or central regions (Björnsson 2017).

Despite its northern latitude, Iceland experiences a maritime climate with cool summers and mild winters due to a moderating effect from a branch of the Gulf Stream that services the southern and western coasts of the country (IMO 2018). As a result, the southern portions of Iceland also receive greater amounts of rainfall than the north (IMO 2018). The southern coast experiences annual mean temperatures of 4-5° C. Precipitation varies greatly within short distances, but the southern coast of Iceland generally receives 1,000 to 1,600 mm of annual rainfall (Einarsson 1984).

3.3.1 Environmental Considerations in Iceland

The history of Iceland's natural environment is one of frequent and large-scale change. As a geologically-young and tectonically-active landmass, Iceland's soils contain volcanic parent material, and thus the majority of Icelandic soils are classified as Andosols (Arnalds et al. 2001). By their nature, Andosols are sensitive to erosion and other disturbances due to the absence of silicate-clay minerals (Arnalds et al. 2001). In addition to the frequent volcanic activity and enhanced erosion processes that continually alter Iceland's soils, human development is also an important consideration. Iceland was originally settled by the Norse in the 9th Century C.E., and the subsequent period was marked by the introduction of excessive grazing and deforestation (Dugmore et al. 2009). Since settlement of Iceland began, vegetation cover has continued to diminish; today approximately 28% of Iceland is vegetated, 1% of which remains wooded (Dugmore et al. 2009). The remainder of vegetation cover in Iceland is characterized by mosses and shrubs. Overall, Icelandic plant cover generally faces unfavorable growing conditions in regard to climate, especially in the rugged interior regions. Additional concerns stem from a warming climate, which has been shown to affect different tundra plant communities variably; short-term warming implications may also differ from long-term implications (Jónsdóttir et al. 2005).

Wind and water erosion are prevalent throughout Iceland, serving as key geomorphic agents to the landscape. Retreating glaciers in southern Iceland foster increased erosional activity as volcanic sands are transported and deposited via meltwater channels or through intensified aeolian processes from changing topographies at the glacial margin (Gísladóttir et al. 2005) (Figure 3.2). Rivers are present throughout Iceland and may be fed from glaciers, springs, lakes, or direct runoff. Of these river types, glacial-fed rivers boast the greatest discharge, length, and sediment load (Louvat et al. 2008). As a consequence of the annual glacial growth/melt cycle, glacial rivers typically begin to swell in June and may cause large flooding events throughout the summer

(Louvat et al. 2008); as a result of river swelling and other temperature-related seasonal variations, the intensity of erosional activity varies throughout the year.

Figure 3.2. Icelandic glacier and surrounding landscape. An outlet glacier of the Vatnajökull ice cap in southern Iceland drains into a swelled meltwater lake at its base carrying a high sediment load. Source: Photo by author.

The most present human influences on the environment within the Icelandic wilderness are the energy production and tourism industries. The abundance of Icelandic rivers descending in elevation from the ice caps in the highlands towards the lowlands brings high potential for hydropower development, which Iceland began to utilize at the large scale in the 1960s (Sæþórsdóttir and Saarinen 2015). Geothermal energy is common throughout Iceland as a means to heat water, and, since the opening of the first power plant in 1969, geothermal electricity is now generated in multiple locations across the lowlands. Together, hydropower and geothermal power account for 100% of the country's electricity generation (Sæþórsdóttir and Saarinen 2015). Many of the same hydrologic and geothermal features scattered throughout the Icelandic wilderness that are harnessed for energy also serve as tourist attractions.

3.3.2 Tourism in Iceland

Tourism is a dominant industry throughout Iceland with consistently-increasing yearly trends. Since 2010, the total number of yearly visitors to Iceland has more than quadrupled, reaching upwards of 2.2 million in 2017 (ITB 2018). The rate of growth in visitor numbers has also historically increased (Table 3.3). Over 98% of foreign visitors enter the country via Keflavik International Airport located on the Reykjanes Peninsula in the southwest. Other visitors enter the country via ferry service in Seyðisfjörður in the east (ITB 2018).

Table 3.3. Yearly change in number of visitors to Iceland, 2010-2017. Source: Adapted from ITB (2018).

Year	Number of Visitors	% Change from Previous Year
2010	488,600	N/A
2011	565,600	15.7%
2012	672,800	18.9%
2013	807,300	20.0%
2014	997,300	23.5%
2015	1,289,100	29.2%
2016	1,792,200	39.0%
2017	2,224,600	24.1%

Iceland's tourism industry experiences a large degree of seasonality, or differences in visitor volume and types of tourist activity between seasons, outside of the Reykjavik capital region. The vast majority of Icelandic tourists visit in the summer months, and thus the height of the tourism season begins in the latter half of May and extends through August. Even during the off-season winter months, a reliable yet much smaller pool of tourists will visit Iceland (ITB 2018). The availability of tourism services is largely reflective of the seasonal demand. Important in the environmental context, the tourist high season roughly corresponds with the period of the year in which glacial melt is most active; therefore, the natural landscape of Iceland can experience the highest levels of both human-induced and natural change during the summer months.

Iceland's unique landscape of volcanic and glacial features creates a variety of outdoor recreation and sightseeing opportunities that are popular with tourists; thus, many of Iceland's best-known tourist attractions are nature-based. Popular recreational activities include hiking, skiing, and horseback riding. Bathing in geothermal springs and whale watching are popular leisure-based options for tourists.

The high number of visitors to Iceland results in large-scale consequences for the country's economic, political, and natural landscapes. The Icelandic Tourist Board (ITB 2018) reported high profits from the tourism industry in the years since 2012, outperforming exports of both marine products and manufacturing products yearly since 2015. The Icelandic government has long recognized the importance of managing its influential tourism industry, providing regulatory support with the establishment of the Icelandic Tourist Board in 1964, an agency that crafts and updates new tourism development and management policies (Jóhannesson et al. 2010).

Most pivotal to this study are the implications of Iceland's tourism industry on the natural environment. A desire to experience Iceland's unique natural attractions is listed as the top factor influencing the decision of foreign visitors to travel to Iceland (ITB 2018; OECD 2017). Despite this popularity, tourism policy and management suffers from a lack of supportive research (Jóhannesson et al. 2010). Nevertheless, the strains of tourism on the Icelandic environment are well-acknowledged. Concerns of high erosion potential and lack of vegetation cover deem a large portion of Iceland's surface vulnerable to human activity. Many of Iceland's busiest natural attractions have already experienced a worrying degree of environmental degradation, namely sites located in the south and the southwest, the region containing the "Golden Circle" of prominent tourist destinations (OECD 2017).

In response to the harm tourists inflict on the natural environment, Iceland is emerging as a prominent focus of study for researchers to define more clearly and begin to renegotiate the complex tourist-environment relationship. Sæþórsdóttir (2014) grappled with the question of how tourism in wilderness areas in Iceland might be managed so as not to damage the pristine natural integrity of such locations. Sæþórsdóttir (2014) noted that in order for Icelandic policy that is designed to preserve wilderness to be implemented successfully, limits on tourist activity type and intensity of use must be comprehensively considered.

3.3.2.1 Geographic Patterns in Icelandic Tourism

Geographically, Iceland's tourism industry is commonly categorized in regions for statistical data collection and analysis. According to the Icelandic Tourist Board (ITB 2018), the Capital/Reykjanes Region supports the largest numbers of visitors year-round by recorded guest nights. This finding is sensible due to the inclusion of Reykjavik, Iceland's largest city, and Keflavik International Airport in this region. The region with the second-most number of year-round guest nights is the South, but this region experiences multiple times greater visitors in the summer than in the winter. The South region contains the majority of glacial features that serve as tourist attractions (Figure 3.3) in addition to many hydrological features (e.g., waterfalls), and popular beach sites. Often a variety of natural features are present within close proximity to one another, such as with the Jökulsárlón attraction, a popular glacial lagoon on the southeastern coast.

Figure 3.3. Tourists prepare for a glacier hike. Taken at Sólheimajökull, multiple guided tour groups commonly occupy the same stretch of glacier simultaneously. Source: Photo by author.

Cruise tourism is a growing sector of Iceland's tourism industry, with Reykjavik serving as the main port; 97% of cruise liners visiting Iceland are serviced through the Reykjavik port (ITB 2018). For cruise passengers and other short-term visitors without a rental car or other free-range transportation options, extensive bus tour services are available out of Reykjavik offering routes to and from Keflavik Airport, the Golden Circle, and other short-distance trips. The Golden Circle highlights several of Iceland's most visited attractions, namely Thingvellir National Park, Gullfoss, and Geysir. Over half of all Icelandic tourists visit these sites, and each of these locations is also most likely to be considered too crowded by tourists (ITB 2018).

In the north, Akureyri serves as a central hub of tourist activity, with day trips possible to natural attractions such as the Mývatn region or to popular small communities such as Húsavík and Siglufjörður. In recent years, cruise liner service to Akureyri has increased, thus bringing in an increased demographic of tourists with limited transportation freedom. As with Reykjavik-based tourism, bus tours across the region are widely available.

The remaining inhabited regions of Iceland with the fewest tourists, namely the Westfjords and Eastfjords, also reflect the same trends of yearly industry growth as the regions previously discussed (ITB 2018). For tourists in search of Icelandic wilderness experiences where overcrowded locations may fall short of satisfaction, the lesser-known regions of Iceland are gaining an increased interest.

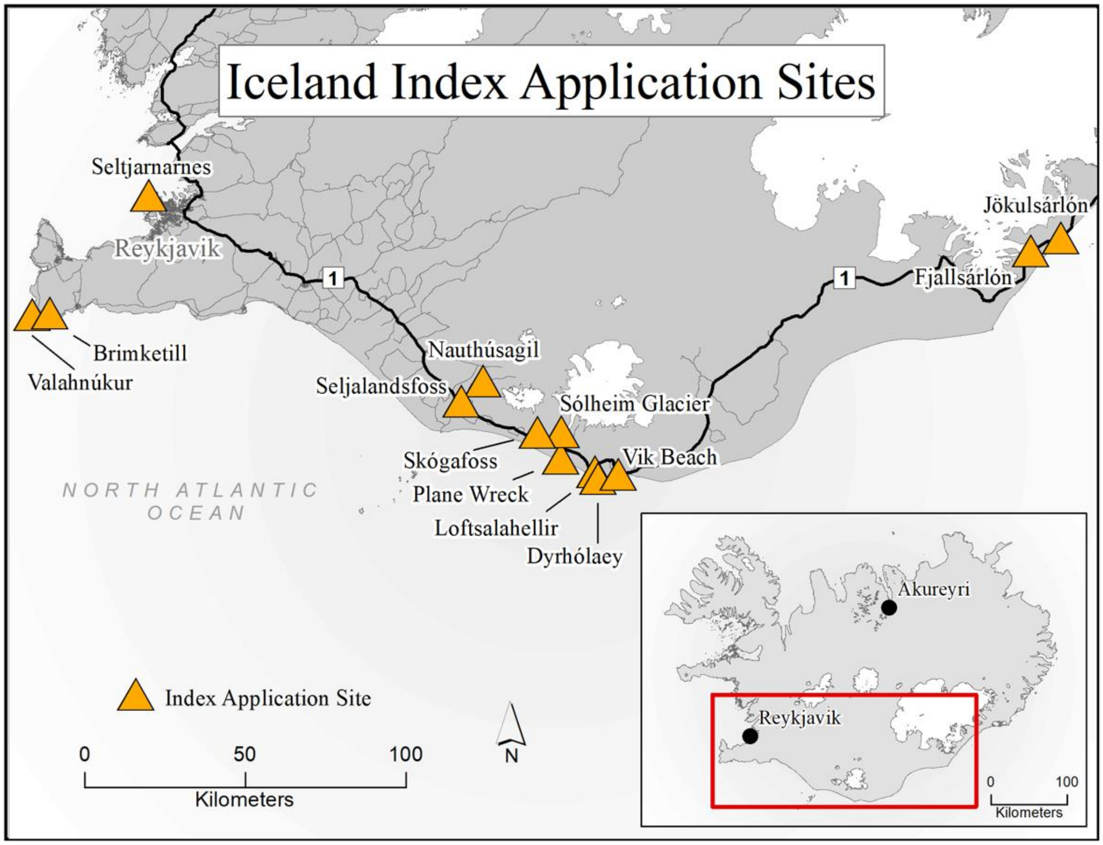

Figure 3.4. Map of the 13 index application sites in Iceland. Source: Created by author.

3.3.3 Selected Index Application Sites in Iceland

A total of 13 sites were chosen in Iceland for index application. Sites were carefully chosen that met the criteria set for all sites in Table 3.1, as well as to represent all three categories of site types in Table 3.2. Sites were also selected based on accessibility, familiarity, and accommodation of time constraints; therefore, some bias may be present in the selection of sites, yet the distribution of chosen sites was deemed to sufficiently support the goals of this research. All sites were located in the southwestern or southern regions of the island, representing the capital region and the South, the two most-visited regions of the country (ITB 2018). Figure 3.4 shows the location of all 13 index application sites, and Figure 3.5 provides a larger-scale look at the eight congregated sites along the central-southern coast.

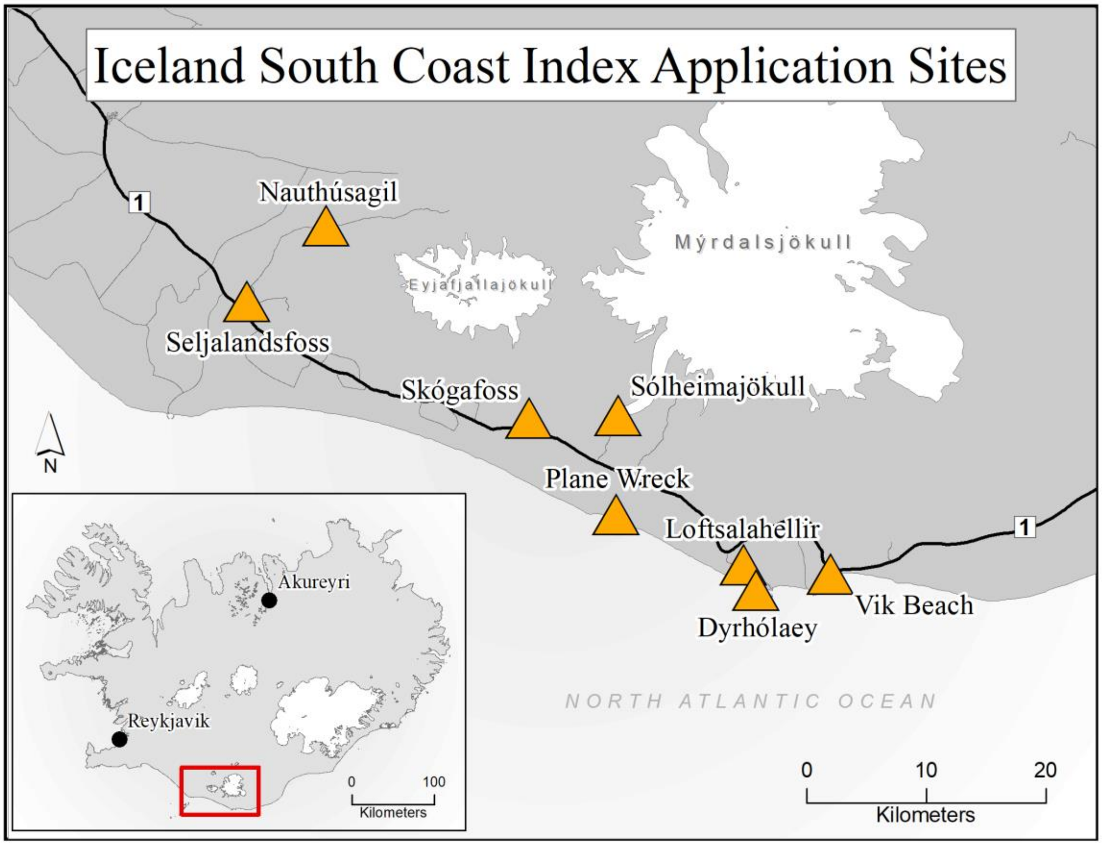

Figure 3.5. Eight index application sites in south-central Iceland. Source: Created by author.

Table 3.4 summarizes the characteristics of the 13 index application sites in Iceland. With some sites incorporated multiple times, the distribution of index applications includes four sandy beaches, two lakes/lagoons, three glacial features, three coastal cliffs, one cave, three waterfalls, and one site with a non-natural primary attraction. Five sites were classified as Developed (Type III) sites, six were classified as Developing (Type II) sites, and two were classified as Upcoming (Type I) sites. These various characteristics deem the chosen sites subject to the various geomorphologic and tourism-driven processes discussed in Chapter Two. Many of these sites are actively shaped by coastal processes (e.g., Valahnúkur Cliffs, Brimketill, and Dyrhólaey), as well as paraglacial processes (e.g., Jökulsárlón/Diamond Beach, Fjallsárlón, and Sólheimajökull). As discussed earlier, concerns of overcrowding, trampling of vulnerable vegetation, and erosion from tourist activity are prevalent throughout the Iceland study region, and these concerns apply to many of the selected sites, particularly at the sites designated as a Developed Site (Site Type III), such as Vik Beach, Skógafoss, and Seljalandsfoss. The selected sites, therefore, represent natural tourist areas where careful and focused research and environmental management is needed in order to ensure that the environmental footprint of tourism development and activity remains minimal in the face of continued climatic change and a growing tourism presence.

Table 3.4. Overview of index application sites in Iceland. Source: Created by author.

Site Name	Description	Site Type	Special Considerations
1. Valahnúkur Cliffs	Coastal Cliffs	II	
2. Brimketill	Coastal Cliffs	II	Lava rock pool
3. Seltjarnarnes	Beach	III	Urban park near Reykjavik suburb
4. Sólheimasandur	Beach	II	Airplane wreckage serves as non-natural primary attraction
5. Loftsalahellir	Cave, Estuary	I	Near Dyrhólaós Estuary
6. Dyrhólaey	Coastal Cliffs	II	Natural coastal arch
7. Jökulsárlón/ Diamond Beach	Glacial Lagoon, Beach	III	Calving icebergs
8. Fjallsárlón	Glacial Lagoon	II	Calving icebergs
9. Vik Beach	Beach	III	Urban park near Vik
10. Sólheimajökull	Glacier	II	
11. Skógafoss	Waterfall	III	
12. Nauthúsagil	Waterfall	I	Series of waterfalls in narrow canyon
13. Seljalandsfoss	Waterfall	III	

3.4 Washington Olympic Peninsula

The Olympic Peninsula is located in the northwest corner of Washington State and represents the northwesternmost corner of the coterminous United States. The area of the peninsula is 16,800 km^2, bounded by the Pacific Ocean to the west, the Strait of Juan de Fuca to the north (separating the landmass from Canadian Vancouver Island), and the Hood Canal (an extension of the Puget Sound) to the east (Figure 3.6). The region contains great variability in elevation, from sea level to 2,247 m at Mount Olympus. The Olympic Mountains cover the central portions of the peninsula (Halofsky et al. 2011); these mountains were created by tectonic uplift from the convergence of the Juan de Fuca Plate and the North American Plate, and the landscape has been further shaped by historic glacial activity (Harris et al. 2004).

Approximately one-third of the Olympic Peninsula is federally-owned land; the central, mountainous portion of the peninsula mostly falls within Olympic National Park (Olympic NP), and the park is surrounded on most all sides by Olympic National Forest (Olympic NF) (Halofsky et al. 2011). A thin stretch of the Pacific coastline also falls within Olympic NP. Portions of the peninsula are also tribally-owned. Clallam County, in the north of the peninsula, contains an estimated 2017 population of 75,474, and Jefferson County, in the south of the peninsula, contains an estimated 2017 population of 31,234 (U.S. Census Bureau 2017). Grays Harbor and Mason Counties also partially extend into the southern portion of the peninsula. Urban areas are sparse across the peninsula and include Port Angeles, Port Townsend, Sequim, and Forks.

Figure 3.6. Map of the Washington Olympic Peninsula. Includes major cities and federally-owned lands. Source: Created by author.

3.4.1 Environmental Considerations in the Olympic Peninsula

As the Olympic Peninsula is home to both mountainous and coastal systems, the environmental characteristics of the peninsula vary greatly across short distances. The Olympic Mountains affect precipitation greatly across the peninsula; moisture from the Pacific Ocean is intercepted by the mountains, and, while the crest of the mountain range represents the wettest place in the coterminous United States (>600 cm/year), the northeastern side of the peninsula experiencing the rain shadow effect from the mountains remains very dry at less than 40 cm/year in some locations (Peterson et al. 1997). Consequently, the western, windward portions of the peninsula experience a maritime climate, and the drier east is more akin to a continental climate. 80% of the peninsula's precipitation falls from October to March, and July and August are especially dry months by comparison; depending on elevation, this precipitation falls as either rain, snow, or both (Peterson et al. 1997).

Lower elevations of the peninsula (below 1500 m) contain dense coniferous forests (Figure 3.7). Tree species vary largely by elevation, and several distinct ecological zones are defined by elevation and precipitation (wet or dry side of the mountains); therefore, vegetation ranges from dense rainforest to alpine environments across the peninsula (Peterson et al. 1997). Of these various forested environments, Peterson et al. (1997) argued that low elevation forests and wetland areas within the peninsula are perhaps the most vulnerable to climate change due to alteration from human activity and a weaker level of protection as compared with higher elevation areas (which fall safely within the management of Olympic NP). Much of this disturbance to low-elevation forest takes the form of timber harvest. Within Olympic NF, timber harvesting has been commonplace since the 1920s, and, until the 1990s, forested lands were typically clear-cut, burned, and replanted. The 1994, Northwest Forest Plan changed the rationale of timber harvesting to incorporate more comprehensive ecosystem management, and a resource management plan for Olympic NF is reevaluated every decade. Some recent policy efforts within Olympic NF include adaptation and response to climate change (Halofsky et al. 2011).

Figure 3.7. Dense coniferous forest at the base of the Olympic Mountains. Located in Olympic National Park near Marymere Falls. Source: Photo by author.

The bordering Olympic NP, by mandate at its creation, upholds a stricter natural resource conservation policy, and much of the park remains in relatively pristine condition. Olympic NP is also beginning to incorporate new management policies that target climate change (Halofsky et al. 2011). As directed by the National Environmental Policy Act (NEPA), the Olympic National Park General Management Plan released in 2008 provides a highly-detailed analysis of natural resource management concerns and general potential environmental impact concerns present in all areas of the park, and the document also provides multiple suggestions and alternatives for managerial action to combat these concerns (NPS 2008).

During the most recent glacial maximum, the Olympic Peninsula was only partly covered by ice, but the Olympic Mountains nevertheless hold a long history of glacial expansion and retreat (Peterson et al. 1997). Many alpine glaciers still exist in the park today, but they are quickly diminishing due to warming climate trends; as of 2015, only four of these glaciers exceeded one square km in area (Riedel et al. 2015).

3.4.2 Tourism in the Olympic Peninsula

Olympic National Park dominates the tourism scene in the Olympic Peninsula as a whole. Olympic NP is over 3,730 km in size, 95% of which is congressionally-designated wilderness. Representing both the mountains and the coastal lands of the peninsula, the park contains 73 miles of wilderness coastline, over 3,000 miles of rivers and streams, and pristine temperate rainforest, all serving as tourism draws. The park offers a multitude of campgrounds, trails, accommodations, and other tourist features (Olympic NP 2019). Over 75% of total visitors to the Olympic Peninsula list visitation of Olympic NP as the primary reason for their travel, and the vast majority of visitors are from Washington or elsewhere in the United States (Ormer et al. 2001).

As shown in Table 3.5, visitation to Olympic National Park continually fluctuates. Within the last decade, visitation has remained relatively stable, but the number of visitors inconsistently increases or decreases from the previous year. 3,104,455 recreation visitors were logged for 2018, a decrease of approximately 300,000 visitors from the previous year (NPS 2019).

Table 3.5. Olympic National Park recreation visitor statistics, 2009-2018. Source: Adapted from NPS (2019).

Year	Recreation Visitors	Year	Recreation Visitors
2009	3,276,459	2014	3,243,872
2010	2,844,563	2015	3,263,761
2011	2,966,502	2016	3,390,221
2012	2,824,908	2017	3,401,996
2013	3,085,340	2018	3,104,455

Nature-based tourism activities are most commonly reported by tourists who visit the park; over 70% of visitors list the activities of scenic drives, hiking, and wildlife viewing (Ormer et al. 2001). Guests to Olympic NP highly utilize various park services, including ranger stations and visitor centers, interpretive programming, and park lodging. The most commonly-visited areas include Hurricane Ridge, Hoh Rain Forest, and Lake Crescent. Over 80% of visitor groups report to have gone hiking during their visit; the most common hiking locations include Hoh Rain Forest, Hurricane Ridge, Sol Duc, Quinault, Lake Crescent, and the many beaches along the Pacific Coast (Ormer et al. 2001). A decent variety of water-based sites are included within Olympic NP, such as waterfalls, scenic rivers, coastal cliffs, lakes, and beaches. Accessibility to many sites is limited to the warmer months, especially within the mountains where heavy snow is common in winter.

Outside of Olympic National Park, nature-based tourism opportunities exist in Olympic National Forest as well as several state or county-level parks. Some water-based tourism sites, such as Cape Flattery in the northwest corner of the peninsula, are located on tribal lands. Notably, there are several sites located along the Strait of Juan de Fuca, within close proximity to the cities of Port Angeles and Sequim, that are not owned by Olympic National Park.

3.4.3 Selected Index Application Sites in Washington

Fifteen index application sites were chosen in the Olympic Peninsula study area region. As with Iceland, sites were carefully chosen that met the criteria set for all sites in Table 3.1, as well as to represent all three categories of site types in Table 3.2. Sites were also selected based on accessibility, familiarity, and accommodation of time constraints; therefore, some bias may be present in the selection of sites, yet the distribution of chosen sites was deemed to sufficiently support the goals of this research. Eleven sites are located within Olympic National Park, three are located elsewhere on the Olympic Peninsula, and one extra site located to the east of Seattle, Snoqualmie Falls, was included to enhance the variety of the dataset (Figure 3.8).

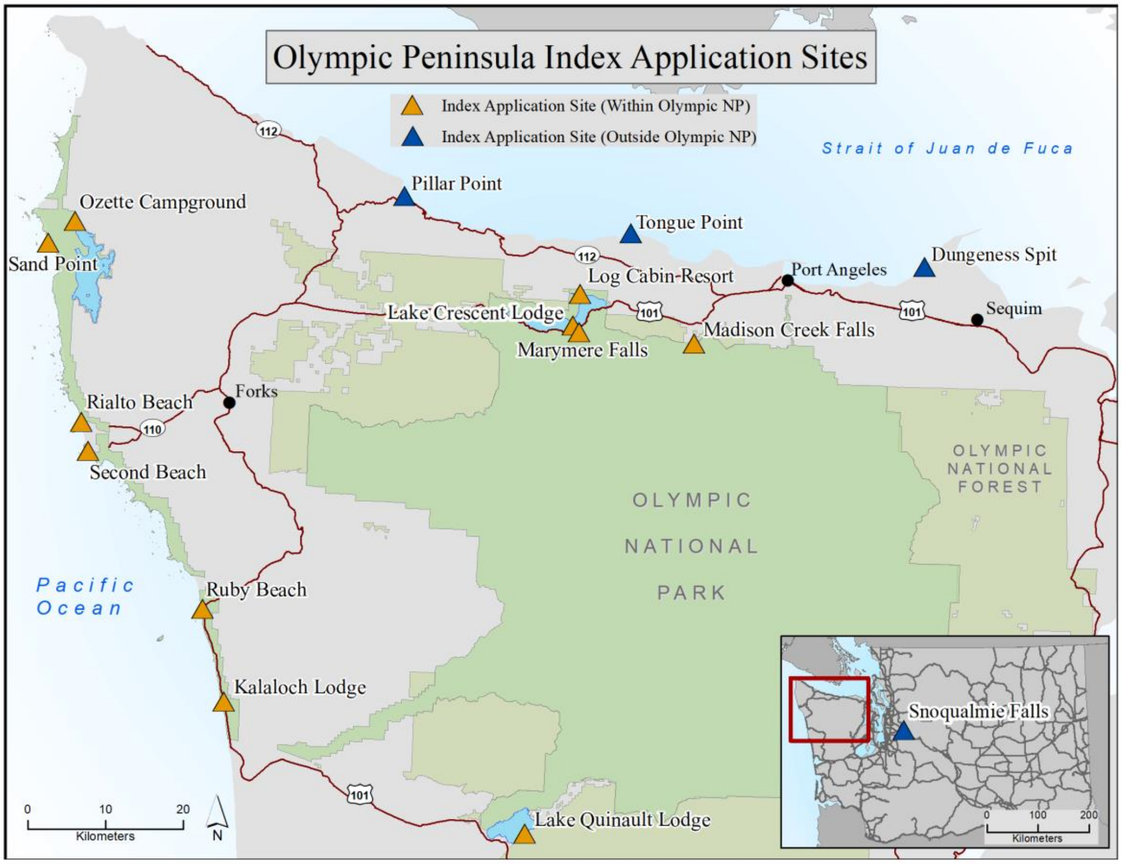

Figure 3.8. Map of the 15 index application sites in Washington. Snoqualmie Falls shown in the inset map. Source: Created by author.

Table 3.6 provides an overview of each index application site. Overall, a wide variety of water-based features are represented, including seven beaches, three waterfalls, four lakeshores, and two sites with accessible coastal cliffs. All three levels of site development are also represented. Some sites fit loosely within two classifications and are either labeled as such or are represented as compared to other sites in the area. The index was applied at these 15 sites in mid-March; during this time of year, some of the mountainous regions of the Olympic Peninsula with heavy snowfall typically remain closed; therefore, Sol Duc Falls, originally intended to be used as an index application site, was inaccessible. The Park’s glaciers were also inaccessible during this period.

As with Iceland, coastal processes, as discussed in Chapter Two, actively shape many of the Washington index application sites (e.g., Tongue Point, Sand Point, and Rialto Beach). The selected sites were intently chosen to contrast with Iceland sites in terms of climate, vulnerability of the landscape, and level of environmental management/protection, as the distribution of Washington sites represents primarily forested areas located within federally or locally-protected lands.

Table 3.6. Overview of index application sites in Washington. Source: Created by author.

Site Name	Description	Site Type	Special Considerations
1. Dungeness Park	Coastal Cliffs	II	Adjacent to Dungeness Wildlife Refuge
2. Tongue Point	Coastal Cliffs, Beach	III	Recreation Area
3. Madison Creek Falls	Waterfall, Riverside	II	Within Olympic NP; Elwha River access
4. Lake Crescent Lodge Area	Lakeshore	III	Within Olympic NP
5. Marymere Falls	Waterfall	II/III	Within Olympic NP
6. Log Cabin Resort	Lakeshore	II/III	Within Olympic NP; Sits along Lake Crescent
7. Pillar Point	Beach	I	Recreation Area
8. Sand Point	Beach	I	Within Olympic NP; Shared facilities with Ozette Lake, 3-mile hike to beach
9. Ozette Campground	Lakeshore	II	Within Olympic NP; Sits along Ozette Lake
10. Rialto Beach	Beach	III	Within Olympic NP
11. Second Beach	Beach	I/II	Within Olympic NP
12. Ruby Beach	Beach	II	Within Olympic NP
13. Kalaloch Lodge Area	Beach	III	Within Olympic NP
14. Lake Quinault Lodge Area	Lakeshore	III	Borders Olympic National Forest
15. Snoqualmie Falls	Waterfall, Riverside	III	Site managed by Puget Sound Energy; Active hydropower site; Located east of Seattle

CHAPTER FOUR: METHODS

4.1 Overview of Methods

The intersections of tourism studies and geomorphological science are not thoroughly understood; yet, as demonstrated by the literature reviewed in Chapter Two, both tourism and natural processes serve as major agents of rapid landscape change, especially within the context of a changing climate in environmentally-sensitive regions. Cold-climate coastal research acknowledges the presence and impact of tourist activity in the coastal zone, yet methods often do not consider or directly account for tourism variables. This study seeks to construct a new path in tourism-environmental science by intentionally and pointedly addressing tourism development impacts specifically with the backdrop of environmental change in cool and cold-climate landscapes. The central methodological framework of this research is the development of the Tourism Impact Index for Water-Based Natural Sites (TII-WBNS)—an index functionalized to assess the level of tourism-induced environmental degradation of individual nature tourism sites; the successful creation of a refined, widely-applicable index constitutes the central goal of the research.

As discussed in Chapter Two, indices are highly utilized throughout the geosciences to evaluate many environmental factors of interest collectively through the use of a variety of scored variables named indicators (Ebert and Welsch 2004). The development of an index to address the goals of this research is an appropriate central method for multiple reasons; first, current indices that link tourism with environmental themes only consider the environment's impacts on the tourism industry rather than the impacts of tourism development on the environment. The TII is the first index to flip the roles and thus view tourism as an agent of environmental change. The literature clearly recognizes tourism's contributions to environmental degradation and related landscape change, but an index has yet to be developed that provides a tool to comprehensively assess the severity of tourism's environmental impacts at individual natural attractions/sites. The second reason for the development of the TII is the necessity of its use as tourism industries across cold/cool climates and elsewhere continue to expand amidst rapid climatic and environmental change. Site managers can benefit greatly from the TII as a tool to assess the severity of tourism-related environmental impacts at their natural sites and subsequently develop informed plans of remediation and future management. Through the widespread utilization of the TII, the growing tourism presence in fragile environments may begin to shrink its detrimental environmental footprint, an important step toward sustainability.

This chapter outlines the methods used to both create, test, and improve the TII. Other environmental indices were analyzed to inform the initial draft of the TII, and the index was then applied in 28 water-based natural sites in the two study regions of Iceland and the Washington Olympic Peninsula (see Chapter Three). During and after these field applications, improvements were made to the mechanics of the index in order to release a field-verified index product alongside the publication of this study.

4.2 Index Creation

The initial phase of the research consisted of the creation of a first draft of the TII. A complete, well-drafted version of the index was necessary before the index was taken into the field to be applied in order to keep adjustments minimal between applications and to properly capitalize on the minimal time available in the field. The first draft of the TII was carefully crafted in order to match its use with its purpose: to evaluate the severity of tourism impacts at individual water-based natural sites. Table 4.1 outlines the design parameters and goals the index was designed to fulfill. The index was designed to be broadly applicable across any type of water-based natural site, and it is intended to serve as a highly-accessible and easy-to-use tool for any tourism manager, environmental manager, or researcher.

Table 4.1. Goals and parameters for the TII-WBNS. Source: Created by author.

Tourism Impact Index for Water-Based Natural Sites	
Goals	***Parameters***
Simple to Use	▪ Index can be easily applied, even at a site previously unfamiliar to the index user ▪ Index design is easy to interpret, and minimal background knowledge in geomorphology or tourism is necessary ▪ No field equipment, special tools, or samples are required to complete the index ▪ Indicator scores can be directly traced to features or evidence found at the site
Quick to Use	▪ An application of the index can be completed quickly, preferably within a work day
Applicable to Any Water-Based Natural Tourism Site	▪ The index remains easy and quick to use at any qualified site, no matter its characteristics o This study specifically verifies that the index is suitable for use in Subarctic and Maritime climates, but the index design caters to all climates
Outputs/Results are Simple to Understand	▪ Index results can be interpreted easily, with simplified mathematical operations ▪ Index scores are comparable between multiple sites, even if the sites themselves are unalike

Guided by a review of literature on tourism's environmental impacts concerning water-based landforms and landscapes (see Chapter Two), indicators for the index were chosen seeking to represent comprehensively the most important factors related to tourism development and activity and their potential alterations of a natural site. Also considered as indicators were factors in baseline landscape vulnerability as well as managerial and educational practices that can serve to mitigate or discourage tourism behaviors that are linked with landscape degradation.

The design of the index was informed by review of other relevant environmental indices published in the literature. Indicators are typically ranked or scored to allow for direct considerations and comparisons between qualitative/observational variables as well as quantitative variables with different units of measure. The indicators that make up an index are commonly displayed in tabular format. Ranking systems vary by index, but the approach is nevertheless consistent across many indices. Özyurt and Ergin (2010) utilized a ranking system of 1-5 to assign values to various sea-level rise parameters serving as index indicators, using a mix of both qualitative and quantitatively-designed indicators (Table 4.2). The design of the TII most heavily borrowed from the Karst Disturbance Index (KDI), first released by van Beynen and Townsend (2005). The KDI has since been reevaluated, refined, and expanded through various field applications, such as the work of Porter et al. (2016). Indicators in the KDI are ranked on a scale of 0 to 3, with 0 representing a negligible or inapplicable impact and 3 representing the most severe impacts. A total index score is calculated by summing the individual indicator scores and dividing by the total possible score, receiving a single value between 0 and 1. Scores closer to 1 represent highly-disturbed karst settings, and scores closer to 0 represent pristine or minimally-disturbed karst settings (van Beynen and Townsend 2005). The design of the TII mimics this scoring rationale.

Table 4.2. Ranges of vulnerability applied to physical parameters of sea-level rise. Source: Özyurt and Ergin (2010, 267).

		Range				
		Very low	**Low**	**Moderate**	**High**	**Very High**
Parameters		**1**	**2**	**3**	**4**	**5**
Rate of SLR	mm/yr	<1	1-2	2-5	5-7	7-9 and over
Geomorphology		Rocky cliffed coasts Fiords	Medium cliffs Indented coasts	Low cliffs Glacial drift Alluvial plains	Cobble beaches Estuary Lagoon	Barrier beach Sand beach Salt marsh Mudflats Deltas Mangrove Coral reefs
Coastal Slope		>1/10	1/10-1/20	1/20-1/30	1/30-1/50	1/50-1/100
Significant Wave Height	m	<0.5	0.50-3.0	3.0-6.0	6.0-8.0	>8.0
Sediment Budget		More than 50% of the shoreline is in accretion	Between 10-30% of the shoreline is in accretion	Less than 10% of the shoreline is in erosion or in accretion	Between 10-30% of the shoreline is in erosion	More than 50% of the shoreline is in erosion
Tidal range	m	>6.0	4.0-6.0	2.0-4.0	0.5-2.0	<0.5
Proximity to Coast	m	>1000	700-1000	400-700	100-400	<100
Type of Aquifer		leaky confined		confined		unconfined
Hydraulic Conductivity	m/day	0-12	12-28	28-41	41-81	>81
Depth to groundwater level above sea	m	>2.00	1.25-2.0	0.75-1.25	0.0-0.75	≤0.00
River Discharge	m^3/s	>500	250-500	150-250	50-150	0-50
Water Depth at down stream	m	≤1	2	3	4-5	>5

A 0 to 3 indicator scoring system was chosen due to its relative simplicity. Depending on observations made at the site of index application, index users must choose between four levels of impact for each indicator. In order to define these levels of impact, careful attention was focused on the scales at which tourism development and landscape degradation occur. As the TII was scheduled to be applied in two cold/cool-climate study regions, the factors affecting water-based natural sites in these climates were specially considered. Levels of impact were also defined in order to fulfill the goals and parameters set for the index in Table 4.1; therefore, each indicator is designed so as to be scorable without use of any field equipment, without the need for field sampling, and to be otherwise easy to score through visual observations alone. Consequently, the TII can be considered a visual assessment, which contributes to the fulfillment of the first two index goals: simplicity and speed of use. Visually-assessed indicators help to minimize cost and time necessary for index application as compared to other standard methods of water-based site assessment that involve use of instruments such as GPS, turbidimeters, flow meters, and sampling equipment.

The first index design was constructed to serve as a general template for assessing each application site. As conditions and the relevance of indicators vary between sites, flexibility was built into the index design in such a way to allow for the differences between sites to be incorporated into the scoring system while the general index structure remains consistent. Users of the index, therefore, are granted some level of discretion as to which indicators are emphasized based on the application site’s characteristics.

Indicators in the TII were categorized by content. Some sets of indicators contain a geomorphologic focus, while others contain a larger focus on tourism development or a blend of both human and natural variables. A complete version of the original index draft is presented and discussed in Chapter Five.

4.3 Index Application and Refinement

Once a draft of the TII was completed, the field application period began. The testing of the index across varying tourism scenarios is a critical component of this research, as many indices are not field-tested upon initial publication/release and are therefore unverified. The application and refinement of the TII are therefore useful as measures of quality control. As described in Chapter Three, two study regions were chosen for index application: Iceland and the Washington Olympic Peninsula. Index applications in Iceland were completed in October 2018, and index applications in Washington were completed in March 2019. The index was applied at 13 sites in Iceland and 15 sites in Washington, completed in the order as listed in Table 3.4 and Table 3.6 in Chapter Three. The order of index applications was chosen by location, estimated time required at each application site, and proximity of sites to one another.

At all sites, the index was completed by both the principal investigator (PI) and a field assistant. The field assistant completed the index independently of the PI and submitted the index application results to the PI after visiting each site. The inclusion of a field assistant serves as a key contribution to strengthening the design of the index by highlighting discrepancies in scoring between the PI and the field assistant. Any discrepancies were subsequently considered by the PI in adjusting the wording and general design of the index. Ultimately, the field assistant helped to ensure that the index will return a consistent score for a site no matter the user. As the PI was also the creator of the index, holding an unavoidable creator's bias, the field assistant helped to identify confusing or unclear aspects of the index that the PI may not have previously noted. In both Iceland and Washington, the field assistants who accompanied the PI had not played any role in the creation of the TII, and the field assistants were first shown the index only shortly prior to visiting the first application site. Neither field assistant had an extensive background in tourism or environmental science, instead holding academic backgrounds in visual art (Iceland field assistant) and ecology and music (Washington field assistant). Ideally, future users of the index should have familiarity with the characteristics of the site(s) at which they apply the index as well as a general background in tourism or environmental management. The use of field assistants from outside this field of study demonstrates the relative ease of the index's use, especially in its updated, refined form that addresses the discrepancies and confusions in scoring of the original index versions.

4.3.1 Index Field Application Procedure

A standard procedure was followed at each site to complete the index. Upon arrival at a site, the PI and the field assistant thoroughly examined all attractions, facilities, trails, and other relevant features. An unfilled paper copy of the most recent index version was held at all times for reference, and some indicators were scored at the same time relevant observations were made. Exploration of each site involved investigation of any water-based features, other features of interest, trails, structures, facilities, and available services. The individual sites varied greatly, featuring great diversity in natural features, such as waterfalls, beaches, coastal cliffs, glacial features, etc., but the tourism influence present at each site was also highly varied. Neither study region was visited during the peak visitation summer months, yet tourists were nevertheless present at almost all sites. Tourist activity was monitored whenever possible, and evidence of past tourism activity or potential tourism activity was also noted. Photographs were taken at each site of the water-based features as well as of any significant tourism-related features.

The PI and field assistant did not participate in any guided tours or interpretive programs, although the availability of such opportunities, if present at all, was noted. Some sites were too large to cover every trail in the time available; in such cases, only the main trails were followed by the PI and research assistant. In all cases, each site was considered to be thoroughly explored by the researcher in order for the index to be applied holistically as a reflection of the entire site. In the event of significant precipitation during an application, photographs and critical notes were taken while exploring the site, and the index itself was filled out immediately following site exploration in the shelter of the researchers' vehicle or a nearby structure.

Some sites that were originally planned to serve as index application sites were deemed completely or partially inaccessible during the time of visit or attempted visit. The index was not completed at two sites originally intended as application sites. At Glymur waterfall in western Iceland, intense rainy and windy conditions made the mountainous trail to the falls too difficult to traverse and effectively evaluate for the index. The road to Sol Duc Falls in Olympic National Park had yet to be cleared of snow, deeming the site inaccessible altogether. These two sites, consequently, are omitted from any official results.

4.3.2 Calculation of Results and Index Refinement

After site applications were completed, the indicator scores for each site, as completed by both the PI and the field assistant, were reviewed. Discrepancies in scoring between the two index users were marked. Next, index scores were calculated for each site using the results collected by the PI. As the index design is divided into three sections (see Chapter Five), each site received three sectional scores as well as an overall index score. To achieve this, all scores were summated and then divided by the total possible score, either in each section or in the index as a whole. This provides scores with a range of 0 to 1; 0 represents no tourism impact at a site, and 1 represents the highest possible tourism impact. Each score was then multiplied by 100 to return a finalized score on a range of 0 to 100; this form is intended to be easier to interpret, highlighting the difference in severity between high and low scores.

At times, important tourism impact-related observations were made at index application sites that were not reflected in the indicators. These observations, as well as discrepancies in scoring between the PI and the research assistant, were considered as areas in which to improve the wording or design of the index. After the application period in Iceland was completed, changes were applied to the index that were then included in the version that was used in the next application period in Washington. Similarly, more changes were incorporated to the index after completion of all Washington index applications. With these changes intact, the current version of the index represents a product thoroughly-tested for Iceland and the Washington Olympic Peninsula as well as, by extension, Subarctic and Maritime climates. The methods that contributed to the current version of the index also ensure that the index design meets its four goals; the index has been designed and tested to be easy to use, quick to use, widely-applicable to any water-based tourism site, and simple to interpret its results.

CHAPTER FIVE: RESULTS AND DISCUSSION

5.1 Original Index Draft

As discussed in Chapter Four, the Tourism Impact Index for Water-Based Natural Sites was originally drafted with reference to the Karst Disturbance Index (van Beynen and Townsend 2005), as well as other published environmental indices. The form of the index as first tested in Iceland, provided in full in Table 5.1, was named the Index for Cold-Climate Hydrologically-Active Tourism Sites. The index contained a total of 44 indicators, each ranked on a scale of 0 (no/negligible impact to the site) to 3 (extreme impact to the site). All indicators were designed to be visually-assessed, although some indicators require some knowledge of the tourism scene in the region and the state of the site year-round. Therefore, general familiarity of tourism and environmental conditions in the region can be considered a prerequisite for index use. Indicators were grouped into three sections: Baseline Landscape Vulnerability, Physical Development and Infrastructure, and Activity-Based Inputs. Within each section, indicators were also grouped by similar content into indicator categories.

Baseline Landscape Vulnerability (BLV) reflects the various geomorphologic mechanisms, whether natural or anthropogenic, that may leave a landscape vulnerable, excluding any effects of tourism development or activity. This is an important first step for a wholesome look at tourism impact at sites, as sites that are already vulnerable to landscape change will be placed at even higher risk upon the introduction of tourism. Indicators in this section include erosion potential/capacity, seasonal considerations, vegetation, and non-tourism human activities, such as resource extraction, agriculture, and development within a relevant area of the site.

Table 5.1. First version of the TII-WBNS. Source: Created by author.

Section One: Baseline Landscape Vulnerability					
Indicator Category	**Indicator**	**3**	**2**	**1**	**0**
Erosion Capacity	1.1 Wind Erosion	Highly-exposed to the open coast or to other sources of intense wind action	Intermittent periods of intense wind influence	Site is highly-sheltered from wind (forested, shielded by valley, etc.)	Caves or other sites with minimal wind influence
	1.2 Water Erosion/Sediment Load	Waters are glacially-fed or show other evidence of high sediment load; may also be coastal	Coastal sites only; wave activity as prime water erosion factor	Little visual evidence of sediment transportation and deposition beyond dissolved solids	Minimal turbidity
	1.3 Ice Activity	Surface highly characterized by freeze-thaw, permafrost, or glacial activity	Some impact from ice activity	Little impact from ice activity	No ice activity
	1.4 Seasonal Variability	High degree of seasonality; intensity of erosion consistently changing through the year	Medium degree of seasonality; a clear difference in erosion intensity between seasons	Low degree of seasonality; little change in erosion intensity between seasons	No variation in erosional intensity by season
Vegetation/Ecological Sensitivity	1.5 Plant Cover	No/minimal plant cover	Sparse plant cover	Some key erosional areas with no plant cover	Total plant cover
	1.6 Species Sensitivity	Moss heath	Grassland	Wetland, Forest	Glacier and other areas of no plant cover
Non-Tourism Human Impacts	1.7 Agriculture	Active large-scale agriculture within 1 km	Active small-scale agriculture within 1 km	Site sits on converted agricultural lands, or remnants of agricultural disturbances within 1 km	No agriculture or agricultural history
	1.8 Development	Commercial and/or residential development within 1 km	Minimal commercial and/or residential development within 1 km	Minimal residential development within 1 km	No development within 1 km

Table 5.1 (contd.)

	1.9 Water Pollution	Point-source water pollution detected/waters regularly subject to boat pollution, severe agricultural runoff, construction runoff, etc.	Event-based point-source pollution inputs	Untraced non-point source pollution potential only	Waters contain no clear pollutant inputs
	1.10 Resource Extraction	Permanent/long-term operations on site (e.g. logging, fishing, mining, or energy)	Permanent/long-term operations within relevant vicinity	Short-term operations or remnants of past operations on site or within relevant vicinity	Site is protected from resource extraction
Section Two: Physical Development & Infrastructure					
Indicator Category	**Indicator**	**3**	**2**	**1**	**0**
Access and Accessibility	2.1 Road Type: Water Infiltration and Runoff	Paved roads and parking; highly-obstructed natural stormwater infiltration	Gravel roads and parking; some obstruction to natural stormwater infiltration	Dirt roads and parking; no obstruction to natural stormwater infiltration	Not accessible by road
	2.2 Road Type: Erosion	Dirt roads and parking	Gravel roads and parking	Paved roads and parking	Not accessible by road
	2.3 Distance from Parking to Attraction	Parking options are within meters of attraction(s)	Parking options are within 100 m of attraction(s) and uphill of attraction(s)	Parking options are within 100 m of attraction(s) and downhill/roughly same elevation of attraction(s)	Parking options are farther than 100 m from attraction(s)
	2.4 Parking Capacity	>30 cars	15-30 cars	<15 cars	No parking on site
	2.5 Tour Bus or Boat Accessibility	Site is bus/boat-accessible, parking for more than 4 buses available	Site is bus/boat-accessible; parking for 2-4 buses available	Site is bus/boat-accessible; parking supports maximum of one bus at a time	No tour bus/boat accessibility
Construction	2.6 Presence of Construction Zones	Large-scale construction on site w/ substantial landscape alteration	Small-scale construction on site w/ minimal landscape alteration	Nearby construction within 300 m of site	No construction zones within 300 m
Structures: Facilities	2.7 Toilet Facilities	No toilet access	Sanitary toilets	Portable toilets, high toilet demand	Portable toilets, low toilet demand

Table 5.1 (contd.)

	2.8 Camping Facilities	Large designated camping area	Small designated camping area	Makeshift camping present	No camping on site
Structures: Services and Attractions	2.9 Services (Dining, Shopping, etc.)	Multiple permanent structures/complexes providing services	One primary permanent structure/complex providing services	Temporary structures providing services	No structures providing services
	2.10 Lodging	Multiple hotels/hostels/other large-scale accommodation on site or within 500 m; may include camping	One large-scale accommodation on site or within 500 m; may include camping	Camping only	No lodging available on site
	2.11 Attraction-Functioned Structure	Permanent structure/complex serves as a main attraction (e.g. museum) rivaling natural attraction	Permanent structure/complex serves as a secondary attraction, not as highly-visited as natural attraction	Other permanent or temporary structure on site, yet does not serve as an attraction or provide services	No other structures unaccounted for in Services category
Seasonal Variations	2.12 Seasonality of Services	Services are open year-round w/ steady visitor traffic	Services are closed in the winter	Services only open during peak tourism season	No services on site
Trail Infrastructure	2.13 Trail/Path Type	Dirt, sand, and other uncovered paths only	Gravel, mulch, and other non-paved path types	Paved paths	No trails/paths
	2.14 Land Alterations for Trail Installation	Severe alterations: cutting into bedrock, steepening gradient, etc.	Moderate alterations	Minimal alterations	No alterations
	2.15 Erosion Controls	No erosion controls incorporated into trail design/construction	Minor erosion controls	Major erosion controls	Erosion control is not needed or is stringently and actively managed
	2.16 Barriers (excluding restrictive signage)	No fences or other barriers barring visitors from straying off trails	Some fences or other barriers but may be easily and often violated	Major fences and other barriers that are difficult to violate	Barriers are completely restrictive, or visitors have no opportunities to stray from trails

Table 5.1 (contd.)

	2.17 Other Structures	Site contains 3 or more major trailside structures (e.g. pavilions, gazebos, platforms, docks, outposts)	Site contains 1-2 major trailside structures	Site only contains minor trailside structures (e.g. art installations, lamp posts, various utility items)	Site contains no trailside structures
	2.18 Channel Alteration	Streams and other water features are highly channelized or otherwise severely altered	A few major alterations	A few minor alterations	No alterations
Signage	2.19 Educational Signage	No educational signage	Signage solely used for navigation purposes	Some educational signage	Guests can adequately learn about the site from signage alone
	2.20 Cautionary Signage	No signage present to caution visitors of danger or discouraged behavior	Inadequate cautionary signage present	Cautionary signage present, but not well-displayed or adequately legible in appropriate language(s)	Adequate cautionary signage, or no signage needed to ensure safety of environment and of visitors
Section Three: Activity-Based Inputs					
Indicator Category	**Indicator**	**3**	**2**	**1**	**0**
Traffic	3.1 Annual Visitor Count	Site is visited by >75% of tourists to the region	Site is visited by 51-75% of tourists to the region	Site is visited by 25-50% of tourists to the region	Site is visited by <25% of tourists to the region
	3.2 Average Group Size	Largest typical group size equal to multiple busloads	Largest typical group size equal to one busload	Largest typical group size of 5-15 people	Largest typical group size of 5 people
Trail Use	3.3 Informal/ Undesignated Trails	Extensive network of well-defined informal trails	Some short, well-defined informal trails	Only a few poorly-defined, short informal trails	No informal trails
	3.4 Trampling: Vegetation	Vegetation near trails or areas of activity is severely trampled	Some concentrated areas of moderate trampling	Minimal trampling	No trampling
	3.5 Trampling: Erosion	Trails or areas of activity exhibit severe evidence of erosion	Some concentrated areas of moderate erosion	Minimal erosion	No visible erosion

Table 5.1 (contd.)

Activity Type	3.6 Off-Road Vehicle Use	Frequent/regular use of ORVs with severe erosional damage or potential for erosion	Irregular use of ORVs in areas of moderate erosional potential	Rare use of ORVs in areas of no erosional concern	Use of ORVs prohibited
	3.7 Water Use/Contact	Waters are regularly used for swimming and other primary-contact activities	Waters are regularly used for secondary-contact activities only (e.g. fishing, boating, etc.)	Visitors contact with waters is rare	Visitor contact with water is prohibited or impossible
	3.8 Water Pollution Potential	Tourists regularly engage in activities resulting in direct pollution	Tourists irregularly engage in activities resulting in direct pollution	Pollution activities limited to littering	No evidence of any activity-based pollution
Concentration of Activity	3.9 Seasonality (Temporal)	Extreme activity/traffic year-round	Extreme activity/traffic during peak season(s), very little activity/traffic during off-season(s)	Some seasonal variation in visitor traffic and activity type w/ some periods of high traffic	Little seasonal variation in visitor traffic and activity type w/ low traffic year-round
	3.10 Area of Greatest Activity (Spatial)	High tourist volumes in a small physical space; frequently causes overcrowding	High tourist volumes in a large physical space; occasional overcrowding	Tourist volume rarely exceeds spatial capacity	Tourist volume never exceeds spatial capacity
Management	3.11 Active Site Management	No site management	Occasional upkeep of site, no evaluative management	Some active management evaluating environmental conditions	Regular site management, actively addressing environmental issues
	3.12 Site Staff and Management Presence	No guides, rangers, or managers on site	Irregular presence of volunteer or untrained staff	Regular presence of untrained staff in peak season(s)	Trained staff present full-time and year-round
	3.13 Site Regulation	No regulation	A few weak or unenforced regulations	A few in-tact regulations; some enforcement	Fully-protected
Education	3.14 Non-Signage-Based Education	No education	Education only available off-site	Basic tours or educational efforts available on site	Expansive educational efforts on site

Section Two, Physical Development and Infrastructure (PDI), considers any permanent or otherwise long-term alterations or additions to the landscape as initiated by tourism development at a site. This involves any constructed facilities, such as restrooms, lodging, camping facilities, and human-made attractions (museums, visitor centers, etc.) as well as alterations to the landscape designed for increased accessibility to attractions or services, such as parking lots and trails, as well as any sort of stormwater drainage system, channel alterations, erosion controls, etc., that were installed alongside these features. Trail or trailside infrastructure, restrictive barriers, and signage are also included as indicators.

The third index section, Activity-Based Inputs (ABI), represents any changes or potential changes to the landscape caused by the actions of tourists themselves as they interact with the trails, attractions, and other features at a site. The section also includes any managerial activities and regulations that may help to preserve a site. Examples of indicators in this section include informal trails, visitor count, contact with/use of water-based features, crowding, and presence of managers, rangers, or other staff on site.

5.2 Iceland Index Application Results

The index as presented above was taken to Iceland to undergo an initial round of field applications in October 2018. As discussed in Chapter Three, the index was applied at 13 water-based natural tourism sites located in the south and southwest of the country, where the landscape is constantly under reform from coastal, glacial, fluvial, and aeolian processes. Table 5.2 details the overall index results, as well as the three sectional results, from index application at each site as completed by the principal investigator. Potential scores range from 0 to 100; high scores represent large environmental impact from tourism, and low scores represent small environmental impact. Full Iceland scores completed by the principal investigator are provided in Appendix B.

Table 5.2. Iceland index application scores. Highest scores are shown in bold, and lowest scores are italicized. Source: Created by author.

Site Name	**Total Score**	**Section One Score** (BLV)	**Section Two Score** (PDI)	**Section Three Score** (ABI)
1. Valahnúkur Cliffs	56.1	50	50	69
2. Brimketill	*42.4*	40	*35*	54.8
3. Seltjarnarnes	*42.4*	53.3	36.7	*42.8*
4. Sólheimasandur	53	40	53.3	61.9
5. Loftsalahellir	45.5	*36.7*	46.7	50
6. Dyrhólaey	*42.4*	43.3	38.3	47.6
7. Jökulsárlón/ Diamond Beach	56.1	53.3	58.3	54.8
8. Fjallsárlón	48.5	50	45	52.4
9. Vik Beach	**63.6**	66.7	**66.7**	57.1
10. Sólheimajökull	51.5	46.7	46.7	61.9
11. Skógafoss	**63.6**	**70**	56.7	69
12. Nauthúsagil	47.7	46.7	41.7	57.1
13. Seljalandsfoss	53.8	43.3	46.7	**71.4**
Site Average	51.4	49.2	47.8	57.7

Iceland site total scores ranged from 42.4 (Brimketill, Seltjarnarnes, and Dyrhólaey) to 63.6 (Vik Beach and Skógafoss). Section One (BLV) scores ranged from 36.7 (Loftsalahellir) to 70 (Skógafoss). Section Two (PDI) scores ranged from 35 (Brimketill) to 66.7 (Vik Beach). Finally, Section Three (ABI) scores ranged from 42.8 (Seltjarnarnes) to 71.4 (Seljalandsfoss). The average total score as compared with the average sectional scores shows that Section Three (ABI) tended to higher scores as compared to Sections One and Two, raising the total average score.

5.2.1 Iceland Index Scores Analysis

The field application period in Iceland represented the first opportunity to test the index for effectiveness of its intended use. Each of the 13 application sites are not discussed fully below, but data that support trends and suggest important caveats of the index performance are discussed instead in order to address the research goals of this study. In order to ensure that the TII fulfills its purpose, analysis of the Iceland data demonstrates how index results reflect the actual observed conditions at a site. Ideally, the observed conditions at each site, no matter its type of attraction, its level of tourism influence, or its baseline landscape vulnerability, can be correctly interpreted through analysis of the index scores at that site. This can be tested with the logic that sites with higher observed tourism impact should receive higher index scores.

The three different index sections each contain a different number of indicators: Section One contains 10, Section Two contains 20, and Section Three contains 14. This means that the Section Two score weighs more heavily on the total index score than the other two sections, and Section Three weighs more heavily on total index score than Section One. Table 5.3 presents the 13 Iceland sites in ranked order by total score, also showing the highest sectional score for each site. Section Three, Activity-Based Inputs, was commonly found as the highest sectional score at nine of the sites, suggesting that indicators in this section were typically scored high across the study region. A look at the individual indicator scores shows that high scores in Section Three are influenced by the general lack of active management on site, lack of regulatory protection over the site, lack of non-signage-based education, large group size, high visitation, and strong observed evidence of erosion and harm to vegetation through trampling, informal trails, etc. The site with the lowest Section Three score, Seltjarnarnes, is a well-maintained park outside a suburb of Reykjavik where group size, visitation, erosional concern, and trampling concern were all observed as relatively low.

Table 5.3. Ranked total scores and highest sectional scores of Iceland sites. Source: Created by author.

Site Name	Site Type	Total Score	Highest Sectional Score
Dyrhólaey	II	42.4	47.6 (ABI)
Brimketill	II	42.4	54.8 (ABI)
Seltjarnarnes	III	42.4	53.3 (BLV)
Loftsalahellir	I	45.5	50 (ABI)
Nauthúsagil	I	47.7	57.1 (ABI)
Fjallsárlón	II	48.5	52.4 (ABI)
Sólheimajökull	II	51.5	61.9 (ABI)
Sólheimasandur	II	53	61.9 (ABI)
Seljalandsfoss	III	53.8	71.4 (ABI)
Valahnúkur Cliffs	II	56.1	69 (ABI)
Jökulsárlón/Diamond Beach	III	56.1	58.3 (PDI)
Vik Beach	III	63.6	66.7 (BLV, PDI)
Skógafoss	III	63.6	70 (BLV)

Using these Section Three results as an example, levels of higher observed tourism impact and higher observed baseline landscape vulnerability generally matched index results with higher index scores. Four of the top five total index scores represent sites classified as Developed Sites (Site Type III), showing that sites with higher observed levels of tourism development tend to return higher index scores; however, these results are not necessarily so straightforward to predict. A special look at a few select sites shows how the index responded to sites with high observed tourist impact and low baseline landscape vulnerability, and vice versa. Seljalandsfoss, a Type III site, has an undeniably-large tourism presence. Easily accessible and located directly off the main ring road, Seljalandsfoss is a tall waterfall that is one of the most frequently-visited water-based sites in the south of Iceland. The site has a large parking lot, is a frequent stop for tour buses, and contains several small shops, as well as restrooms. Many tourists frequently crowd a small area, as the walk to the falls area is minimal. Seljalandsfoss received the highest ABI sectional score of all Iceland sites as well as the highest sectional score out of any sections for any site at 71.4. Despite this high value, the Section One and Two scores are lower in comparison to several other Iceland sites. As a result, the total score for Seljalandsfoss was moderated to 53.3. Conversely, Seltjarnarnes received its highest sectional score for BLV at 53.3, but its lower PDI and ABI scores lowered the site's total index score to 43.2. These examples demonstrate how the averaging effect used to calculate the total score can be potentially misleading. For a more specific look at which specific environmental or tourism-related conditions are of most pressing managerial concern, sectional scores and individual indicator scores are therefore more meaningful than total index scores. Users of the index should keep in mind that, while the total index score is useful as a general look at the severity of tourism impact at a site, much more in-depth information pointing to specific areas of concern can be found with an analysis of index sub-scores.

The distribution of scores for the 13 Iceland sites does not appear to suggest that the type of water-based attraction (waterfall, coastal cliffs, glacial feature, etc.) has much bearing on total index score. The principal investigator and research assistant in Iceland observed each site to be highly unique, and index results show that even similar types of water-based attractions can yield highly-different total scores as well as sectional scores. For example, Nauthúsagil, Seljalandsfoss, and Skógafoss are each waterfall sites that share the common water source of the Eyjafjallajökull minor ice cap; as such, these three sites are also located in relative proximity to one another (Figure 5.1). Despite this, Nauthúsagil, a Type I site, scored lower than Seljalandsfoss, a Type III site, both of which in turn scored lower than Skógafoss, a Type III site. As observed, the level of tourism development and activity, as well as the baseline landscape vulnerability at each of these three waterfalls varied greatly from one another, and index scores reflect these differences.

Figure 5.1. Three Icelandic waterfall sites. Nauthúsagil (left) scored lower than Seljalandsfoss (bottom), both of which scored lower than Skógafoss (top). Source: Photos by author.

5.2.2 Iceland High Scores Analysis

A key intended function of the index is for scores to reflect the different levels of tourism development and activity present among a variety of sites. Logically, a well-functioning index should capture the range of tourism impact, with low observed impact sites receiving low scores and high observed impact sites receiving high scores. To demonstrate the extent to which the TII-WBNS reflects levels of impact into its scoring, an analysis of the conditions at high-scoring and low-scoring sites is appropriate. The intricate characteristics of the sites discussed below were reflected in their corresponding total index and sectional scores.

The two Iceland index application sites that shared the highest total index score were Skógafoss and Vik Beach. As both of these sites were observed to contain an impactful tourism scene as well as high baseline landscape vulnerability, the index scores captured the status of the sites with relative accuracy, the details of which are discussed below. Skógafoss returned a BLV score of 70, a PDI score of 56.7, an ABI score of 69, and a total index score of 63.6. The high BLV was attributed to sheep farming on site, commercial and residential development near the site, agricultural runoff potential, and the glacially-fed water source with high seasonal variability in terms of erosion. The site was also largely developed for tourist use, containing a large parking lot commonly utilized by tour buses, multiple shopping and lodging options within walking distance, and uncovered trails that cut deep into the hillside parallel to the main falls. The ABI score was also high, reflecting high visitation, large group size, an expanded network of informal trails that fragmented natural vegetation severely, and overcrowding in several areas. Some in-progress management was observed on the site, as the extended uphill section of the site, accessible from the lookout area at the top of the falls, was completely closed until further notice for remediation of the damaged landscape from tourist trampling (Figure 5.2). The area, also used as a sheep pasture, was frequently traversed by tourists who continued to trek up the mountainside past the main falls area. Well-defined informal trails were also marked with signs instructing to keep away, an important management step for preventing further damage to the hillside next to the falls. These informal trails that allowed for additional viewing of the falls were also a safety concern, as they led directly up to the exposed cliffside where tourists could extend themselves too far near the cliff edge to take photographs of the falls.

Figure 5.2. Well-marked restrictive signage at Skógafoss. The sign also explained ongoing management efforts on site. Source: Photo by author.

Vik Beach, the black-sand area just south of the town of Vik in southern Iceland, returned a BLV score of 66.7, a PDI score of 66.7, an ABI score of 57.1, and a total index score of 63.6. Vik Beach is in some ways an atypical site as compared to several others at which the index was applied in Iceland in that the ABI score was the lowest of the three sectional scores. Due to high erosional capacity, no plant cover, and proximity to major development, the BLV score was relatively high. Additionally, the river channel emptying into the ocean was highly altered, and trails were unpaved and involved extensive alteration of the landscape for installation. Facilities in town within a short walking distance from the site were considered as site facilities, raising the PDI score. Overall, the Vik Beach functions as an urban park, but, as compared with Seltjarnarnes, which also serves as an urban coastal park, the development of Vik Beach leaves the site much more vulnerable to tourism impact.

5.2.3 Iceland Low Scores Analysis

The lowest total scores from the Iceland study region were recorded for Dyrhólaey, Brimketill, and Seltjarnarnes. As Seltjarnarnes has already been discussed, the former two of the three will be analyzed further. Dyrhólaey is a picturesque sea arch located along a set of coastal cliffs near the town of Vik in southern Iceland. The arch itself is currently inaccessible, but it may be viewed by tourists from an upraised region that hosts a small lighthouse, higher in elevation than the arch itself. Dyrhólaey generally received low sectional scores: BLV at 43.3, PDI at 38.3, and ABI at 47.6. The site's greatest natural vulnerabilities include its extreme windiness (wind erosion capacity) and moss heath vegetation cover, but BLV is otherwise low. The site is not developed in terms of facilities and services, and, other than a lack of toilets, erosional controls built into trail design, and educational signage, there are few physical development concerns. Newly-installed barriers eliminate the once-sizable safety concerns for tourists wandering too close to the unstable ledges. While the site is popular, it is not easily accessible by tour bus due to the steep and tight-turned drive necessary to reach the site, and tourist activities are limited to walking around the enclosed areas.

Brimketill is another coastal cliff site and is located on the southern coast of the Reykjanes Peninsula. It features a lava rock pool (hence the “kettle” or “cauldron” nomenclature in Icelandic) that is constantly overfilled by the crashing sea waves against the cliffside. Brimketill is a young tourist site, but its popularity is noticeably increasing to those familiar with Iceland’s tourism scene. As such, visitation has grown in recent years, but the site itself remains a relatively-small attraction. The site received a BLV score of 40, a PDI score of 35, and an ABI score of 43.2. The PDI score is particularly low, reflecting the lack of any facilities, a small parking capacity, and a lack of extensive trails that may become management concerns. Merely a few years ago, there was no designated path to the lava rock pool, and the coastal cliffs themselves had to be traversed, introducing safety concerns to the site. A new enclosed observation deck has been recently constructed, limiting the potential for tourists to wander along the unstable cliffs and making the site overall much more confined (personal observation 2016; 2018) (Figure 5.3). Because of these recent site changes and its growth in popularity, Brimketill was classified as a Type II site, but the index application results at Brimketill reflect that tourism impacts to the site remain minimal, especially as compared to other sites within the study region.

Figure 5.3. Ocean waves crash into Brimketill. Observed from the newly-constructed enclosed viewing deck, effectively limiting tourist movement along the dangerous cliffs. Source: Photo by author.

5.3 Washington Index Application Results

Given the analysis of results from the Iceland field application period discussed above, the TII-WBNS in its first tested form was deemed to work sufficiently well. A select few changes in the wording of indicators were implemented, but the organization of indicators, as well as the indicators themselves, were not changed between the field application period in Iceland and the first applications in the Washington Olympic Peninsula. The changes that were implemented reflected consistent confusions as voiced by the Iceland research assistant or discrepancies in scoring between the research assistant and the principal investigator that might be addressed by changing the wording or focus of indicators. The differences between levels of scoring (0-3) were also altered for a select few indicators (all index changes are specifically outlined later in this chapter).

Table 5.4. Washington index application scores. Highest scores are shown in bold, and lowest scores are italicized. Source: Created by author.

Site Name	Total Score	Section One Score (BLV)	Section Two Score (PDI)	Section Three Score (ABI)
1. Dungeness Park	31.1	30	38.3	21.4
2. Tongue Point	40.9	33.3	46.7	38.1
3. Madison Creek Falls	31.8	30	28.3	38.1
4. Lake Crescent Lodge Area	37.1	*16.7*	53.3	28.6
5. Marymere Falls	28.8	*16.7*	38.3	23.8
6. Log Cabin Resort	44.7	23.3	**60**	38.1
7. Pillar Point	42.4	**43.3**	41.7	42.9
8. Sand Point	*25*	30	*26.7*	*19*
9. Ozette Campground	30.3	20	40	23.8
10. Rialto Beach	33.1	26.7	38.3	28.6
11. Second Beach	34.1	30	31.7	40.5
12. Ruby Beach	34.8	26.7	33.3	42.9
13. Kalaloch Lodge Area	43.2	33.3	55	33.3
14. Lake Quinault Lodge Area	43.9	26.7	58.3	35.7
15. Snoqualmie Falls	**52.3**	40	55	**54.8**
Site Average	36.9	28.4	43	34

As discussed in Chapter Three, the index was applied in 15 water-based tourism sites in Washington, 14 of which were located within the Olympic Peninsula, and 11 of which were located within Olympic National Park. Table 5.4 provides the total score and the three sectional scores for each of the 15 Washington index application sites as completed by the principal investigator. As with the Iceland results, potential scores range from 0 to 100; low scores represent smaller impacts, and high scores represent greater impacts. Full Washington PI index results are provided in Appendix D.

Total scores across all Washington sites ranged from 25 to 52.3. Section One (BLV) scores ranged from 16.7 to 43.3. Section Two (PDI) scores ranged from 26.7 to 60, and Section Three (ABI) scores ranged from 19 to 54.8. Out of the three sections, PDI scores tended to be higher than the other two sections, also serving to raise the total score of many sites. The average total score was 36.9.

5.3.1 Washington Index Scores Analysis

As was presented with the Iceland data, Table 5.5 presents the order of Washington index application sites ranked by total score, and the table also shows the highest sectional score for each site as well as the site type as defined by the site selection criteria in Chapter Three. Of the 15 Washington sites, Sand Point received the lowest total score (25), and it also boasts the lowest position when the comparing the highest sectional score at each site. Snoqualmie Falls received the highest total score at 52.3. Given that Snoqualmie Falls was specially chosen to represent a high-impact tourist site outside of the Olympic Peninsula for comparative purposes, the highest-scoring site within the peninsula should also be considered, which falls to the Log Cabin Resort with a total score of 44.7.

Table 5.5. Ranked total scores and highest sectional scores of Washington sites. Source: Created by author.

Site Name	Site Type	Total Score	Highest Sectional Score
Sand Point	I	25	30 (BLV)
Marymere Falls	II/III	28.8	38.3 (PDI)
Ozette Campground	II	30.3	40 (PDI)
Dungeness Park	II	31.1	38.3 (PDI)
Madison Creek Falls	II	31.8	38.1 (ABI)
Rialto Beach	III	33.1	38.3 (PDI)
Second Beach	I/II	34.1	40.5 (ABI)
Ruby Beach	II	34.8	42.9 (ABI)
Lake Crescent Lodge Area	III	37.1	53.3 (PDI)
Tongue Point	III	40.9	46.7 (PDI)
Pillar Point	I	42.4	43.3 (BLV)
Kalaloch Lodge Area	III	43.2	55 (PDI)
Lake Quinault Lodge Area	III	43.9	58.3 (PDI)
Log Cabin Resort	II/III	44.7	60 (PDI)
Snoqualmie Falls	III	52.3	55 (PDI)

Consistent with the Iceland results, as total score increases, the highest sectional score also tends to increase, with a few exceptions. Developed sites (Site Type III) also tend to have higher total scores than upcoming and developing sites (Site Types I and II), with a few exceptions. Notably, Pillar Point, designated an upcoming site at the start of this study, returned a total index score that is more consistent with Type III sites in the region; this is partially explained by the high sectional score for BLV at Pillar Point, which helped to raise the total score. As with the Iceland data, these trends help to verify the overall design of the index, as more developed sites with larger observed tourism impacts tend toward higher scores.

Table 5.5 also shows that a majority of Washington sites had the highest sectional scores in Physical Development and Infrastructure (a change from Iceland, where the trend leaned toward highest sectional scores in Activity-Based Inputs). High PDI scores raise the total index score due to the larger number of indicators in that section compared to the other two, but these high scores also speak to the general characteristics of water-based tourism sites in Washington and the Olympic Peninsula more specifically—these sites throughout the study region tend to be highly-developed.

The role of Olympic National Park, in which 11 of the Washington index application sites were located, is a crucial consideration in these results. As discussed in Chapter Three, tourist sites within the park are stringently managed with the goal of preserving nature in its most pristine state for present and future generations to enjoy. Managerial efforts throughout the park are consistently contributing to the conservation of natural sites despite a continued tourism influence. At Olympic NP locations, trails are clearly marked, restrictive and educational signage is almost always present, and sites showed clear evidence of managerial efforts in terms of trail maintenance and environmental condition assessment. The high PDI section scores can also be partly attributed to the devotion of Olympic NP to provide adequate services to park visitors. Three of the sites at which the index was applied are designated as "lodge areas," and two more serve as large designated camping areas (including the ambiguously-named Log Cabin Resort). In each of these Olympic NP locations, the principal investigator and Washington research assistant observed extensive lodging infrastructure often accompanied by a variety of other facilities and structures, such as boat rental, docks, ranger stations, sanitary restrooms, etc.

High PDI section scores were not limited to Olympic NP. The four sites outside of the park were managed/owned by various other entities, but all four were observed to contain extensively built-up tourism infrastructure, and PDI scores reflect these considerable levels of development.

Overall, BLV section scores were low throughout the study region. Many of these sites were heavily forested or otherwise featured adequate vegetation cover, minimizing wind erosion potential. As the Olympic Peninsula experiences a moderated maritime climate, compared to colder climates, seasonal variability and ice activity are minimized. Given the protected status of the Olympic NP sites, development, agriculture, and resource extraction were frequently not observed within the relevant proximity of many sites. Each of these factors help to lower BLV scores.

Several sets of sites were noted by the principal investigator to contain key similarities to one another, and these sets of sites were typically grouped together spatially. For example, Rialto Beach, Second Beach, and Ruby Beach are all located along the Pacific Coast within a relatively short distance from one another. They all feature sandy beaches, often with small cliffy islands a short distance into the ocean, featuring more resistant bedrock than that which eroded away around it (Figure 5.4). Although the level of development differed at each of these three beach sites, they still returned similar total index scores, ranging from 33.1 to 34.8. The Kalaloch Lodge Area is also located along this stretch of coast, but it returned a higher PDI score and total index score than the less-developed beach sites to the north due to the extensive service and lodging facilities on site. Spatial proximity of sites is reflected elsewhere in the data. Marymere Falls and the Lake Crescent Lodge Area, for example, returned the exact same low BLV score of 16.7; these two sites are within very close distance to one another (Marymere Falls includes the entirety of the hike to the falls which begins close to the

Lake Crescent Lodge Area), and both sites therefore represent very similar environmental conditions; however, the total index scores for the two sites are quite different, with the Lake Crescent Lodge Area returning a much higher PDI score than Marymere Falls due to its many facilities along the lakeshore serving as a hub for tourist activity in the Lake Crescent area of the park.

Figure 5.4. Second Beach in Olympic National Park. Many miles of Pacific shoreline within the park feature similar vistas, and these sites returned similar scores. Source: Photo by author.

5.3.2 Washington High Scores Analysis

As with the Iceland sites previously discussed, the observed conditions of high or low tourism impacts were largely reflected in the Washington index scores. To demonstrate the extent to which these ranges in tourism impact were captured by the index, an analysis of high-scoring and low-scoring sites from Washington is appropriate. Snoqualmie Falls returned the highest total score (52.3) in the study region, as well as some of the highest sectional scores. The site received a BLV score of 40, a PDI score of 55, and an ABI score of 54.8. Snoqualmie Falls, located near the city of Snoqualmie to the east of Seattle, is a large, active hydropower facility that redirects water from the Snoqualmie River at the top of the tall waterfall through a power station before the water is released back into the river downstream of the base of the falls. Because energy generation of itself is not a feature of tourism, the index places energy generation under the indicator for resource extraction within the BLV section. Snoqualmie Falls, however, is uniquely managed as a tourism destination by Puget Sound Energy, the company that runs the hydropower operation. The falls itself draws tourists, but visitors to the site may also witness the hydropower process in action. Surrounding the falls, a large park has been developed providing a large number of facilities to visitors, and the site is widely-visited. These considerations lead to the highest ABI score out of the Washington sites as well as one of the highest PDI scores.

Log Cabin Resort, located on the shores of Lake Crescent in Olympic National Park, received the second highest total score of the 15 Washington sites as well as the highest PDI score. The “resort” contains both a large designated camping area as well as several log cabins and a small lodge. These accommodations as well as the various structures that surround them for tourists to use (e.g. boat rentals) largely contributed to the high PDI score and high total index score.

5.3.3 Washington Low Scores Analysis

Sand Point, located in the northern section of the stretch of Pacific Coast owned by Olympic National Park, received low index scores across the board. The site received a total index score of 25, a BLV score of 30, a PDI score of 26.7, and an ABI score of 19. Sand Point is a spatially-expansive site; parking, restroom facilities, and some educational signage are located at the site of the Ozette Lake Ranger Station. To reach the actual Sand Point, tourists must hike a 3-mile trail through the Olympic Wilderness (pristine forest), eventually arriving at the beach. Tourists hiking in the vicinity may also choose to take a trail of similar length to Cape Alava, also using Ozette Lake as a starting point. Sand Point, Cape Alava, and the northwest corner of Ozette Lake may be linked to form a triangular hiking route over 9 miles in distance. Because of time constraints, the principal investigator and Washington research assistant chose to travel to Sand Point, but an index application for Cape Alava would likely return similar results.

Because of the exclusivity of Sand Point, it is not as highly-visited as other sites within the national park. The forested trail to the beach was noted to be impeccably maintained and designed so as to minimize impact on the surrounding officially-designated wilderness. Much of the trail surface was a partially-elevated wooden walkway, the design of which minimizes fragmentation of vegetation. Water flow was also carefully considered in trail construction, as channels to allow more natural drainage across the trail were built in areas that were not wooden walkways, often installed every few meters (Figure 5.5). As one negative aspect of the site, the beach site itself contains a steep, grassy hill that was observed to be partially eroded from tourists climbing to the top. Overall, these considerations, especially the impressive level of management invested into the site, contributed to very low index scores for PDI and ABI, as well as a very low total index score.

Figure 5.5. Drainage control trail infrastructure. Installed in frequent intervals along the Sand Point trail. Source: Photo by author.

5.4 Study Region Comparisons

Two distinct study regions, each within the realm of cold and cool climates, were purposefully chosen for index application in order to test the flexibility of the index to work effectively across a wide variety of natural water-based tourism settings. By comparing trends in the results between Iceland and Washington sites, the design of the index can be further scrutinized to ensure its accuracy and therefore to meet the objectives of this study. From a management or a research perspective, using the same indexing tool across Iceland and Washington allows for data-based comparisons of tourism sites between the two regions despite their unique environmental conditions.

Overall, total index scores as well as sectional scores tended to be higher in Iceland than in Washington. The strategic categorization of the index's indicators offers insights to explain this trend. To begin, Iceland sites consistently returned higher BLV scores than Washington counterparts; Iceland BLV scores ranged from 36.7 to 70 (the lowest score representing Loftsalahellir, a cave) while Washington BLV scores ranged from 16.7 to 43.3. The index therefore suggests that the Icelandic landscape is overall much more vulnerable to environmental change than Washington, a conclusion that is heavily supported by the literature and the observations of the principal investigator.

Iceland is sparsely vegetated, and the majority of vegetation cover is moss heath, which is highly vulnerable to trampling and irreparable damage. With a lack of trees, Iceland sites are generally very windy, and the glacial landscape along the south coast is constantly under reform, carrying and distributing sediment collected by glaciers via complex networks of meltwater channels. While resource extraction is not of great concern in Iceland as compared to logging-related concerns in Washington, many sites in Iceland were in close proximity to livestock agriculture. Even despite the threats of logging in Washington, most index sites were located in Olympic National Park, where forests are carefully preserved. Many sites in Washington were heavily forested, and even sites that included a beach or coastal cliffs boasted dense forest and vegetative cover leading from the parking areas to the coastal margin. These considerations explain the lower BLV trends in Washington as compared with Iceland.

PDI scores in Iceland ranged from 36.7 to 66.7, and PDI scores in Washington ranged from 26.7 to 60. Although Washington sites generally returned slightly lower PDI scores, the two study regions are rather comparable for this index section. PDI does not necessarily reflect the characteristics of an attraction or natural site itself, but it rather shows the extent to which a site has been developed and altered in order to support tourist activity. In both study regions, index application sites were chosen utilizing site selection criteria that represented a wide variety of site development, and each study region contained multiple Type I, II, and III sites. It is therefore sensible that both study regions showed a wide variety of PDI scores. Despite differences in BLV, similarities between Iceland and Washington sites may easily be drawn in terms of PDI. For example, Skógafoss (PDI=56.7) and Snoqualmie Falls (PDI=55), are both highly-visited waterfall sites that contain extensive parking options (including tour bus parking), lodging, and several stores and other service facilities. Both were also categorized as Type III (Developed) sites.

As with BLV, ABI scores were generally higher in Iceland than in Washington; Iceland ABI scores ranged from 45.2 to 71.4, and Washington ABI scores ranged from 19 to 54.8. A look at several key indicators explains this regional difference. Site management and regulatory protection were generally strongly present throughout Washington, especially in Olympic National Park, while these safeguards over sites were often missing or only weakly present at Iceland sites. Trampling, involving erosion and harm to vegetation, was overall much more frequently observed in Iceland given the region's higher baseline vulnerability in these regards. These forms of trampling were also apparent throughout Iceland as evidenced by networks of informal trails. In

Washington, informal trails were far more rarely observed, and site management efforts, such as well-defined formal trails, as well as natural barriers (impassable forest) likely encourage tourists to adhere to formal trails more successfully than in Iceland. Finally, the area of greatest activity, a measure of crowdedness, was highly-scored across several Icelandic sites, whereas crowdedness or potential for crowdedness was not typically noted as a concern in most Washington sites. Where tour buses in Iceland bring large group sizes to sites with limited room for exploration (e.g., Seljalandsfoss, a site with only a few short main trails around the falls area), the "Concentration of Activity" indicator category within the ABI section of the index reflected these conditions appropriately.

Given that BLV scores and ABI scores tended to be higher in Iceland than in Washington, the trend of higher total index scores in Iceland is explained. These scoring trends that match the conditions observed at the sites function as important indications that the index design is effectively capturing the differences between the two study regions and reflecting those differences in the scoring mechanisms. To further support the success of the index design, scores from sites within the same study region also show decent variety, indicating that the index not only captures the differences between two geographically-distant and highly-contrasting regions such as Iceland and Washington, but the differences between sites within close spatial proximity to one another are also reflected in scoring.

5.5 Index User Scoring Discrepancies

A key facet of the methodological design of this study was the simultaneous application of the index at all sites by two independent researchers: the principal investigator as well as a research assistant. Through this practice, the consistency of the index was tested across users. While the principal investigator's scores are used and discussed in this chapter as the official record, the principal investigator also reviewed the research assistants' index results and marked the discrepancies between the two interpretations of the same site. The patterns of discrepancies can speak to areas in which the index design and wording could have been improved at the time of application (an older version of the index was used in Iceland, but only a few minor changes were applied before Washington field applications). These results ultimately influenced the most current index updates as well as the information provided in subsequent sections concerning index use.

Discrepancies between the principal investigator and the research assistants were common, although more common in the Iceland applications than in Washington. Of the 44 indicators, only six indicators returned no discrepancies from all 12 of the Iceland sites in which both researchers applied the index (the research assistant did not apply the index at Site 13, Seljalandsfoss, due to unforeseen circumstances). 12 additional indicators had one or two discrepancies across the 12 Iceland sites, leaving 26 indicators with three or more discrepancies in Iceland sites. Table 5.6 provides the number of discrepancies recorded for each indicator across all 12 Iceland sites.

Table 5.6. Scoring discrepancies from 12 of the 13 Iceland sites. Source: Created by author.

Scoring Discrepancies: 12 Iceland Sites					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	#Discrep.	Indicator	#Discrep.	Indicator	#Discrep.
1.1	2	2.1	1	3.1	0
1.2	0	2.2	1	3.2	5
1.3	6	2.3	4	3.3	4
1.4	5	2.4	7	3.4	7
1.5	5	2.5	4	3.5	6
1.6	4	2.6	1	3.6	6
1.7	2	2.7	1	3.7	5
1.8	2	2.8	0	3.8	1
1.9	7	2.9	3	3.9	4
1.10	0	2.10	1	3.10	7
		2.11	4	3.11	8
		2.12	2	3.12	1
		2.13	3	3.13	5
		2.14	5	3.14	0
		2.15	3		
		2.16	4		
		2.17	7		
		2.18	2		
		2.19	0		
		2.20	5		

Although the index was applied by both users at three more sites in Washington than in Iceland, there were far fewer discrepancies in scoring at the Washington sites. From the 15 site applications in Washington, eight of the indicators held no discrepancies, 18 indicators had one or two discrepancies, and 18 indicators had three or more discrepancies. Table 5.7 provides the number of discrepancies recorded for each indicator across all 15 Washington sites.

Table 5.7. Scoring discrepancies from the 15 Washington sites. Source: Created by author.

Scoring Discrepancies: 15 Washington Sites					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	#Discrep.	Indicator	#Discrep.	Indicator	#Discrep.
1.1	0	2.1	0	3.1	0
1.2	1	2.2	0	3.2	1
1.3	8	2.3	2	3.3	2
1.4	7	2.4	2	3.4	4
1.5	7	2.5	5	3.5	2
1.6	2	2.6	0	3.6	0
1.7	0	2.7	0	3.7	3
1.8	2	2.8	3	3.8	1
1.9	6	2.9	2	3.9	5
1.10	1	2.10	1	3.10	2
		2.11	1	3.11	4
		2.12	4	3.12	2
		2.13	4	3.13	4
		2.14	3	3.14	6
		2.15	5		
		2.16	2		
		2.17	5		
		2.18	1		
		2.19	7		
		2.20	2		

As the TII-WBNS is a visual assessment, correct index results depend upon accurate visual observations. However, the qualitative wording of many indicators also leaves some room for interpretation when choosing how to score many of the 44 indicators. These differences in interpretation as well as incomplete or even different, yet accurate observations can largely explain discrepancies. By highlighting these discrepancies, changes to the index design as well as the instructional material that might be distributed alongside the index may be specifically catered to minimize the potential for inaccuracies in future index applications. The following discussion analyzes some of the most inconsistently-scored indicators between the principal investigator and both research assistants.

Indicator 1.3, Ice Activity, had six discrepancies in Iceland and eight in Washington. Disagreements occurred frequently between a score of 0, "no ice activity," and 1, "little impact from ice activity." Ice activity describes such influences as freeze-thaw processes, permafrost, and glacial activity. To score this indicator accurately, index users must employ knowledge of a site's conditions year-round, not just in the height of the tourism season where warmer temperatures often discourage substantial ice activity. Relatedly, Indicator 1.4, Seasonal Variability, also had a high number of discrepancies in both study regions and requires knowledge of how seasonal changes affect the site. Similarly, knowledge of visitation trends and tourism conditions at a site throughout the year is required for several indicators, such as Indicator 2.12, Seasonality of Services, and many of the activity-based indicators, such as Indicator 3.9, Seasonality (Temporal), and Indicator 3.10, Area of Greatest Activity (Spatial). If users of the index are not familiar with the conditions of the site during both the off season and the peak season, these indicators might not be scored accurately. While the principal investigator had some background knowledge of crowdedness and seasonality at many of the sites, especially in Iceland, the research assistants typically were unfamiliar with the sites before visiting them to apply the index, and their scores largely reflected the site conditions at the time of visit. Neither field application periods in Iceland or Washington occurred during the peak visitation summer months, and sites were generally uncrowded at the time of visit.

Indicator 1.5, Plant Cover, was often scored differently. Here, the frequent discrepancies were between a score of 1, "some key erosional areas with no plant cover," and 2, "sparse plant cover." This indicator must be scored carefully after careful judgement of the plant cover conditions at the site of application, as each site will differ greatly in terms of acceptable plant cover.

Indictor 1.9, Water Pollution, was highly disagreed upon concerning a score of 0, “waters contain no clear pollutant inputs,” and 1, “untraced non-point source pollution only.” The principal investigator commonly recognized that most sites, especially those within close proximity to highways or development, are likely subject to nonpoint source pollution. Only sites where water quality remains exceptionally pristine and unthreatened were intended to receive a score of 0, which was more commonly assigned by the research assistants.

Trends between the principal investigator and the two research assistants for Section 2 (PDI) were more sporadic. For Iceland sites, common discrepancies existed considering the definition of a trailside structure (Indicator 2.17), and for Washington sites, common discrepancies existed considering the adequacy of educational signage (Indicator 2.19). This shows that users may score certain indicators consistently across various sites yet return different scores compared to other users. In order to avoid this type of discrepancy regarding simple differences in interpretation of wording, it is highly suggested that for future applications of the index, multiple users should work together to complete the index. When differences in interpretation arise, the users should discuss the scoring choice as pertains to the particular site conditions in question and subsequently form a consensus. If multiple users work together to apply the index, the potential for missed or faulty observations is also decreased, and a more robust assessment of a site is possible.

Indicators in Section 3 (ABI) are largely designed to utilize qualitative scales of measure, such as "severe, moderate, and minimal," "major and minor," and "frequent, irregular, and rare." These scales, again, are subject to differences in interpretation, and discrepancies in scoring were common across many indicators that utilized these scales in Section 3 for both Iceland and Washington sites. Once again, future users of the index should carefully consider and jointly decide how the conditions at their sites best match certain scores.

The indicators containing a high number of discrepancies were each reviewed, and the wording of many of these indicators was subsequently updated to add a greater degree of specificity and clarity between scoring options. These changes to the index are incorporated in the final version of the index provided below. For some indicators, updates to the wording of scoring options were not deemed sufficient to address the potential for inconsistencies in scoring. To further address the high number of discrepancies, an Instructional Guide for index use has been developed, found in total in Appendix A. The Instructional Guide is designed to walk users of the index through the proper procedure for applying the index at a site, calculating scores, and interpreting scores. A brief description of how to score each indicator is also provided. Ultimately, this review of discrepancies played a strong role in crafting an index product that minimizes opportunity for bias and inconsistencies as the index is further applied.

5.6 Final Index Product and Usage

After the conclusion of the field application period in Washington, more changes were applied to the index. Observations by the principal investigator and the Washington research assistant brought about new tourism-related considerations that were not explicitly covered in the index. Therefore, the wording and focus of some indicators were updated. The name of the index was also changed to the Tourism Impact Index for Water-Based Natural Sites (TII-WBNS). This change in name is meant to reflect the intention that the index may be applicable to water-based sites across all climates and should not be limited to cold regions. The Washington study region, although many index application sites commonly experience snow and some fringe effects of glacial melt from the higher elevations of the Olympic Mountains, tested the warmer boundary of what may be considered a "cold climate," and the index appears to have functioned in this warmer region as effectively as in Iceland. Were the index to be applied in any tropical or subtropical regions in the future, indicator 1.3, Ice Activity, should be omitted, and calculations should be adjusted accordingly to reflect 43 total indicators and only 9 indicators in the BLV section. Additional adjustments, particularly to the BLV section, may be necessary for the TII to work as effectively in warmer climates as in the Subarctic and Maritime climate study regions in which the index has currently been tested. Additional field applications are therefore recommended at water-based tourism sites in warmer climates prior to any expansive use of the index in such regions.

Table 5.8 summarizes each of the changes and updates applied to the index in order to reach its current form, starting from the original version of the index as it was first used in Iceland. While the overall design of the index remained largely the same, wording was frequently tweaked in order to make the descriptions of each score easier to understand, to include environmental or tourism-based considerations that were not originally accounted for, and to address common scoring discrepancies between the principal investigator and the research assistants. These index updates are intended to minimize room for error as the index is ultimately distributed to new users who might apply the index across a variety of water-based sites in new world regions.

Table 5.8. Summary of index changes and updates. Source: Created by author.

Indicator Affected	Description of Change	Time of Update
1.5 Plant Cover	Score of 3: “No/minimal plant cover” to “no plant cover”	Iceland application period
1.7 Agriculture	Score of 1: “within relevant vicinity” to “within 1 km”	Iceland application period
1.8 Development	All scores: “within relevant vicinity” to “within 1 km”	Iceland application period
1.9 Water Pollution	Score of 2: omitted words “boat pollution or other”	Iceland application period
2.1 Road Type: Water Infiltration and Runoff	Score of 3: added “highly-obstructed natural stormwater infiltration” Score of 2: added “some obstruction to natural stormwater infiltration” Score of 1: added “no obstruction to natural stormwater infiltration”	Iceland application period
2.7 Toilet Facilities	Score of 3 and 2: omitted “high toilet demand”	Iceland application period
3.7 Water Use/Contact	Score of 2: added “e.g. fishing, boating, etc.”	Iceland application period
1.7 Agriculture	Score of 3: added “includes crops, livestock, and relevant animal activity”	WA application period
1.10 Resource Extraction	Score of 0: reworded to “site is protected or otherwise excluded…”	WA application period
2.7 Toilet Facilities	Score of 1 and 0: added “or pit toilets”	WA application period
2.11 Attraction-Functioned Structures/ Secondary Attractions	Indicator name updated; changed from “Attraction-Functioned Structures”	WA application period
2.12 Seasonality of Services	Score of 3: omitted “w/ steady visitor traffic”	WA application period
2.13 Trail/Path Type	Score of 1: added “or boardwalks”	WA application period
2.17 Other Structures	Score of 3: omitted “outposts” Score of 1: added “picnic tables”	WA application period
2.18 Channel Alteration/Culverts	Indicator name updated; changed from “Channel Alteration”	WA application period
2.20 Cautionary/ Restrictive Signage	Indicator name updated; changed from “Cautionary Signage”	WA application period
3.6 Off-Road Vehicle Use	Score of 0: added “or otherwise excluded from use”	WA application period
3.12 Site Staff and Management Presence	Score of 1: changed “untrained” to “untrained/trained”	WA application period
1.6 Species Sensitivity	Score of 3: added “or other highly-vulnerable plant cover”	Post-application
2.12 Seasonality of Services	Score of 2: added “or portions of the off-season”	Post-application

Table 5.8 (contd.)

3.2 Average Group Size	Reworded Scores of 3, 2, and 1 to "Group size commonly reaches…" Score of 0: changed to "5 or fewer"	Post-application
3.6 Off-Road Vehicle/ Transport Animal Use	Indicator name updated; changed from "Off-Road Vehicle Use" All scores: added "horses, etc."	Post-application
3.4 Trampling: Vegetation	Score of 0: added "or no plant cover"	Post-application
1.3 Ice Activity	Specifics added to all scores	Review of discrepancies
1.4 Seasonal Variability	Specifics added to score of 0	Review of discrepancies
1.5 Plant Cover	Specifics added to all scores	Review of discrepancies
1.9 Water Pollution	Specifics added to score of 0	Review of discrepancies
2.19 Educational Signage	Specifics added to scores of 1 and 0	Review of discrepancies
3.4 Trampling: Vegetation	Specifics added to scores of 2 and 1	Review of discrepancies
3.5 Trampling: Erosion	Specifics added to score of 3	Review of discrepancies
All Indicators	Instructional Guide created for use as a companion to the index	Review of discrepancies

It should be noted again that the TII-WBNS is a visual assessment; therefore, an accurate assessment of tourism impact at a site through the index is ultimately a function of the user correctly translating observations of the site into the constraints of the index. The index may be more straightforward to use at some sites as compared to others, and the user may at times have to make judgements calls. Before applying the index, a user should maintain at least basic familiarity of the site, its environmental conditions, and the tourism influences that are present. The user should also clearly define the boundaries of the site, realizing that some facilities or areas of a site may also be shared with one or several other sites. If multiple scores seem applicable to a site (for example, a site contains some sections of paved trail but also some sections of unpaved trail), the user should choose the score that reflects the largest impact, unless technicalities of the site qualify as an exception.

Index users should also note that the index scores for a site may change over time. As natural sites are continually altered by both natural and human processes, the physical characteristics as well as the scale at which tourism influence occurs may change greatly, and these site alterations will undeniably affect the corresponding index scores. An application of the index should therefore be considered as a snapshot in time of the tourism impact at a site. Managers may consider reapplying the index to sites at regular time intervals or after any substantial natural or anthropogenic changes to the site have occurred. The index application results presented in this study should also be considered as snapshots of the conditions of the 28 included sites at the time the index was applied (October 2018 in Iceland and March 2019 in Washington). As such, the index results may not necessarily reflect conditions of the 28 sites during other times of the year or the conditions of the sites in future years. In Iceland especially, tourism is rapidly expanding, and environmental impacts from tourism at the 13 Icelandic application sites as well as elsewhere in Iceland will likely increase as sites become more crowded and developed and as warming climate trends accelerate the rate of glacial melt and other environmental changes in the region. Given these predictions, the index scores for Iceland should also reflect these more intense impacts and rise accordingly.

Table 5.9 provides the most current version of the index, with all changes summarized in Table 5.8 intact. This version of the TII has been thoroughly field-tested in Subarctic and Maritime climate zones and may be considered as ready for further use throughout these climates.

Table 5.9. Final version of the TII-WBNS. Source: Created by author.

Section One: Baseline Landscape Vulnerability					
Indicator Category	**Indicator**	**3**	**2**	**1**	**0**
Erosion Capacity	1.1 Wind Erosion	Highly-exposed to the open coast or to other sources of intense wind action	Intermittent periods of intense wind influence	Site is highly-sheltered from wind (forested, shielded by valley, etc.)	Caves or other sites with minimal wind influence
	1.2 Water Erosion/Sediment Load	Waters are glacially-fed or show other evidence of high sediment load; may also be coastal	Coastal sites only; wave activity as prime water erosion factor	Little visual evidence of sediment transportation and deposition beyond dissolved solids	Minimal turbidity
	1.3 Ice Activity	Surface highly characterized by freeze-thaw, permafrost, glacial activity, or extensive snowpack	Some impact from ice activity: freeze-thaw, permafrost, glacial activity, or extensive snowpack	Little impact from ice activity; surface may spend extended periods under heavy snow	No ice activity; snow never accumulates for extended periods
	1.4 Seasonal Variability	High degree of seasonality; intensity of erosion consistently changing through the year	Medium degree of seasonality; a clear difference in erosion intensity between seasons	Low degree of seasonality; little change in erosion intensity between seasons	No variation in erosional intensity by season; reserved for sites without clear differences between seasons
Vegetation/Ecological Sensitivity	1.5 Plant Cover	No/minimal plant cover; soils or bedrock are thoroughly-exposed throughout the site	Sparse plant cover; some areas with exposed soils or bedrock	A few key erosional areas with no plant cover and exposed soils or bedrock	Total plant cover
	1.6 Species Sensitivity	Moss heath or other highly- vulnerable plant cover	Grassland	Wetland, Forest	Glacier and other areas of no plant cover
Non-Tourism Human Impacts	1.7 Agriculture	Active large-scale agriculture within 1 km; includes crops, livestock, and relevant animal activity	Active small-scale agriculture within 1 km	Site sits on converted agricultural lands, or remnants of agricultural disturbances within 1 km	No agriculture or agricultural history

Table 5.9 (contd.)

Non-Tourism Human Impacts (contd.)	1.8 Development	Commercial and/or residential development within 1 km	Minimal commercial and/or residential development within 1 km	Minimal residential development within 1 km	No development within 1 km
	1.9 Water Pollution	Point-source water pollution detected/waters regularly subject to boat pollution, severe agricultural runoff, construction runoff, etc.	Event-based point-source pollution inputs	Untraced non-point source pollution potential only	Waters contain no clear pollutant inputs (no development or activity upstream or within relevant watershed)
	1.10 Resource Extraction	Permanent/long-term operations on site (e.g. logging, fishing, mining, or energy)	Permanent/long-term operations within relevant vicinity	Short-term operations or remnants of past operations on site or within relevant vicinity	Site is protected or otherwise excluded from resource extraction
Section Two: Physical Development & Infrastructure					
Indicator Category	**Indicator**	**3**	**2**	**1**	**0**
Access and Accessibility	2.1 Road Type: Water Infiltration and Runoff[1]	Paved roads and parking; highly-obstructed natural stormwater infiltration	Gravel roads and parking; some obstruction to natural stormwater infiltration	Dirt roads and parking; no obstruction to natural stormwater infiltration	Not accessible by road
	2.2 Road Type: Erosion[1]	Dirt roads and parking	Gravel roads and parking	Paved roads and parking	Not accessible by road
	2.3 Distance from Parking to Attraction	Parking options are within meters of attraction(s)	Parking options are within 100 m of attraction(s) and uphill of attraction(s)	Parking options are within 100 m of attraction(s) and downhill/roughly same elevation of attraction(s)	Parking options are farther than 100 m from attraction(s)
	2.4 Parking Capacity	>30 cars	15-30 cars	<15 cars	No parking on site
	2.5 Tour Bus or Boat Accessibility and Parking	Site is bus/boat-accessible, parking for more than 4 buses available	Site is bus/boat-accessible; parking for 2-4 buses available	Site is bus/boat-accessible; parking supports maximum of one bus at a time	No tour bus/boat accessibility

Table 5.9 (contd.)

Construction	2.6 Presence of Construction Zones	Large-scale construction on site w/ substantial landscape alteration	Small-scale construction on site w/ minimal landscape alteration	Nearby construction within 300 m of site	No construction zones within 300 m
Structures: Facilities	2.7 Toilet Facilities	No toilet access	Sanitary toilets	Portable toilets or pit toilets, high toilet demand	Portable toilets or pit toilets, low toilet demand
	2.8 Camping Facilities	Large designated camping area	Small designated camping area	Makeshift camping present	No camping on site
Structures: Services and Attractions	2.9 Services (Dining, Shopping, etc.)	Multiple permanent structures/complexes providing services	One primary permanent structure/complex providing services	Temporary structures providing services	No structures providing services
	2.10 Lodging	Multiple hotels/hostels/other large-scale accommodation on site or within 500 m; may include camping	One large-scale accommodation on site or within 500 m; may include camping	Camping only	No lodging available on site
	2.11 Attraction-Functioned Structures/ Secondary Attractions	Permanent structure/complex serves as a main attraction (e.g. museum) rivaling natural attraction	Permanent structure/complex serves as a secondary attraction, not as highly-visited as natural attraction	Other permanent or temporary structure on site, yet does not serve as an attraction or provide services	No other structures unaccounted for in Services category
Seasonal Variations	2.12 Seasonality of Services	Services are open year-round	Services are closed in the winter or portions of the off-season	Services only open during peak tourism season	No services on site
Trail Infrastructure	2.13 Trail/Path Type[1]	Dirt, sand, and other uncovered paths only	Gravel, mulch, and other non-paved path types	Paved paths or boardwalks	No trails/paths
	2.14 Land Alterations for Trail Installation	Severe alterations: cutting into bedrock, steepening gradient, etc.	Moderate alterations	Minimal alterations	No alterations
	2.15 Erosion Controls	No erosion controls incorporated into trail design/construction	Minor erosion controls	Major erosion controls	Erosion control is not needed or is stringently and actively managed

Table 5.9 (contd.)

Trail Infrastructure (contd.)	2.16 Barriers (excluding restrictive signage)	No fences or other barriers barring visitors from straying off trails	Some fences or other barriers but may be easily and often violated	Major fences and other barriers that are difficult to violate	Barriers are completely restrictive, or visitors have no opportunities to stray from trails
	2.17 Other Structures	Site contains 3 or more major trailside structures (e.g. pavilions, gazebos, platforms, docks)	Site contains 1-2 major trailside structures	Site only contains minor trailside structures (e.g. art installations, lamp posts, picnic tables, various utility items)	Site contains no trailside structures
	2.18 Channel Alteration/Culverts	Streams and other water features are highly channelized or otherwise severely altered	A few major alterations	A few minor alterations	No alterations
Signage	2.19 Educational Signage	No educational signage	Signage solely used for navigation purposes	Some educational signage; may not be well-displayed or appropriate for interpretation by general audiences	Guests can adequately learn about the site from signage alone; signage should be well-displayed and simple to interpret for general audiences
	2.20 Cautionary/ Restrictive Signage	No signage present to caution visitors of danger or discouraged behavior	Inadequate cautionary signage present	Cautionary signage present, but not well-displayed or adequately legible in appropriate language(s)	Adequate cautionary signage, or no signage needed to ensure safety of environment and of visitors
Section Three: Activity-Based Inputs					
Indicator Category	**Indicator**	**3**	**2**	**1**	**0**
Traffic	3.1 Annual Visitor Count	Site is visited by >75% of tourists to the region	Site is visited by 51-75% of tourists to the region	Site is visited by 25-50% of tourists to the region	Site is visited by <25% of tourists to the region
	3.2 Average Group Size	Group size commonly reaches multiple busloads	Group size commonly reaches one busload	Group size commonly reaches 5-15 people	Largest typical group size of 5 or fewer people

Table 5.9 (contd.)

Trail Use	3.3 Informal Trails[2]	Extensive network of well-defined informal trails	Some short, well-defined informal trails	Only a few poorly-defined, short informal trails	No informal trails
	3.4 Trampling: Vegetation	Vegetation near trails or areas of activity is severely trampled to an irreparable extent	Some concentrated areas of moderate trampling with great damage	Minimal trampling; vegetation appears to not be greatly damaged	No trampling, or no plant cover
	3.5 Trampling: Erosion	Trails or areas of activity exhibit severe evidence of erosion; may involve trail widening, steepening of gradient, displacement of dirt/gravel, etc., mass wasting, etc.	Some concentrated areas of moderate erosion	Minimal erosion	No visible erosion
Activity Type	3.6 Off-Road Vehicle/ Transport Animal Use	Frequent/regular use of ORVs/horses, etc. with severe erosional damage or potential for erosion	Irregular use of ORVs/horses, etc. in areas of moderate erosional potential	Rare use of ORVs/horses, etc. in areas of no erosional concern	Use of ORVs/horses, etc. prohibited or otherwise excluded from use
	3.7 Water Use/Contact	Waters are regularly used for swimming and other primary-contact activities	Waters are regularly used for secondary-contact activities only (e.g. fishing, boating, etc.)	Visitors contact with waters is rare	Visitor contact with water is prohibited or impossible
	3.8 Water Pollution Potential	Tourists regularly engage in activities resulting in direct pollution	Tourists irregularly engage in activities resulting in direct pollution	Pollution activities limited to littering	No evidence of any activity-based pollution
Concentration of Activity	3.9 Seasonality (Temporal)	Extreme activity/traffic year-round	Extreme activity/traffic during peak season(s), very little activity/traffic during off-season(s)	Some seasonal variation in visitor traffic and activity type w/ some periods of high traffic	Little seasonal variation in visitor traffic and activity type w/ low traffic year-round

Table 5.9 (contd.)

Concentration of Activity (contd.)	3.10 Area of Greatest Activity (Spatial)	High tourist volumes in a small physical space; frequently causes overcrowding	High tourist volumes in a large physical space; occasional overcrowding	Tourist volume rarely exceeds spatial capacity	Tourist volume never exceeds spatial capacity
Management	3.11 Active Site Management	No site management	Occasional upkeep of site, no evaluative management	Some active management evaluating environmental conditions	Regular site management, actively addressing environmental issues
	3.12 Site Staff and Management Presence	No guides, rangers, or managers on site	Irregular presence of volunteer or untrained staff	Regular presence of untrained/trained staff in peak season(s)	Trained staff present full-time and year-round
	3.13 Site Regulation	No regulation	A few weak or unenforced regulations	A few in-tact regulations; some enforcement	Fully-protected
Education	3.14 Non-Signage-Based Education	No education	Education only available off-site	Basic tours or educational efforts available on site	Expansive educational efforts on site

[1] If a site contains paths, trails, or roads of multiple types at substantial length, choose the indicator score of higher impact.
[2] Alternatively referred to as desire paths or user-defined trails.

The index has many extended uses beyond mere assessment of the severity of tourism impact on the landscape at a water-based natural site. At individual sites, managers should seriously consider sectional scores as well as the scores of individual indicators as guidance for areas of managerial concern. High scores should be addressed to remediate the threat of the impact on the site. BLV may not be simple to address, but managers should reference the indicator scores from this section to remain aware of the key vulnerabilities of their site(s).

The Instructional Guide (Appendix A) provides some suggested guidelines for interpreting index results. With the information provided in Table 5.10, index users can classify the total and sectional index scores on a general scale regarding level of tourism impact. The boundaries between severe, moderate, and minimal tourism impacts were drawn based on the results from field application in Iceland and Washington. The highest total scores from the field application period were calculated at 63.6 for Skógafoss and Vik Beach, and the lowest total score was calculated at 25 for Sand Point. Most sites included in this research fall under the Moderate Tourism Impact category regarding total score. The distribution of sectional scores contained more variety than total scores; sectional scores ranged from 16.7 (Lake Crescent Lodge Area and Marymere Falls, BLV) to 71.4 (Seljalandsfoss, ABI). The same boundaries between severe, moderate, and minimal impact have been defined for sectional scores as for total index score in Table 5.10. Index users should remember that the classifications in Table 5.10 are meant to serve as broad, general interpretations of index scores that can assist in facilitating strategies for site management that properly align with index results.

Table 5.10. Suggested interpretations of TII-WBNS scores. Source: Created by author.

Score Range	**Interpretation**
Total Index Score	
60 - 100	**Severe** Tourism Impact
30 – 59.9	**Moderate** Tourism Impact
0 – 29.9	**Minimal** Tourism Impact
Sectional Scores	
60 - 100	**Severe** Impact
30 – 59.9	**Moderate** Impact
0 – 29.9	**Minimal** Impact
Individual Indicator Scores	
3	**Substantial** Impact
2	**Modest** Impact
1	**Minimal** Impact
0	**Negligible** Impact

Table 5.11, also included in the index's Instructional Guide, may assist index users to apply the classification of index results from Table 5.10 into remediation and general management strategies. Depending on the level of tourism impact indicated by total and sectional scores, site managers may need to heavily consider remediating environmental damage from tourism development and activity either immediately or sometime in the near future as the site is continually developed and utilized for tourism purposes. The suggestions provided in Table 5.11 are drawn from the specific indicators that are included in each section. Site managers and other invested stakeholders of a water-based natural site should not rely solely on the suggestions in Table 5.11, as these are again meant to provide general interpretations of index results. Environmental impacts of tourism at specific sites should be addressed on an individual basis though extensive research and careful planning. To this end, index results can serve as a reference or a starting point to remediating the environmental impacts of tourism.

Table 5.11. Suggested actions for site management based on index scores. Source: Created by author.

Level of Impact (Score Range)	Suggested Actions for Remediation
Total Index Score	
Severe: 60 – 100	▪ Consider upgrading managerial efforts ▪ Complete quantitative assessments of environmental degradation (e.g., trail assessments for erosion) to better inform remediation strategies ▪ Consider limiting traffic or intensive activity in highly-degraded areas ▪ Apply index over time to monitor changes ▪ See sectional scores
Moderate: 30 – 59.9	▪ Consider upgrading managerial efforts ▪ Apply index over time to monitor changes ▪ See sectional scores
Minimal: 0 – 29.9	▪ See sectional scores
Section 1: Baseline Landscape Vulnerability	
Severe: 60 – 100	▪ Consider heightened protective status ▪ Identify and regularly monitor areas of erosional risk ▪ Protect plant cover ▪ Discourage further development in agriculture, resource extraction, and commercial/residential activity
Moderate: 30 – 59.9	▪ Identify areas of erosional risk ▪ Protect plant cover ▪ Discourage further development in agriculture, resource extraction, and commercial/residential activity
Minimal: 0 – 29.9	▪ No immediate remediation suggested
Section 2: Physical Development and Infrastructure	
Severe: 60 – 100	▪ Limit/avoid any future construction on site ▪ Complete an environmental assessment for future updates to site infrastructure ▪ Improve drainage infrastructure in parking and trail areas ▪ Upgrade facilities utilizing sustainable designs, systems, and materials ▪ Consider renovating trail design to minimize ecological disturbance, erosion (e.g. boardwalks, encouraging natural vegetation growth) ▪ Add restrictive, cautionary, and educational signage
Moderate: 30 – 59.9	▪ Upgrade facilities utilizing sustainable designs, systems, and materials ▪ Consider renovating trail design to minimize ecological disturbance, erosion ▪ Add restrictive, cautionary, and educational signage
Minimal: 0 – 29.9	▪ Add cautionary and educational signage

Table 5.11 (contd.)

Section 3: Activity-Based Inputs	
Severe: 60 – 100	▪ Consider heightened protective status ▪ Limit traffic in congested areas during peak visitation ▪ Limit visitor contact with water-based features ▪ Limit traffic in areas of erosional concern ▪ Prohibit access to areas subject to trampling ▪ Monitor eroded and trampled areas ▪ Monitor tourist activity and enforce posted rules ▪ Increase on-site management presence
Moderate: 30 – 59.9	▪ Limit traffic in congested areas during peak visitation ▪ Limit visitor contact with water-based features ▪ Limit traffic in areas of erosional concern ▪ Monitor eroded and trampled areas
Minimal: 0 – 29.9	▪ No immediate remediation suggested

The index may also be used as a reporting tool and a comparative tool. Managers may use the index and indicator scores, which are designed to be simple to interpret (all utilizing a 0 to 3 or a 0 to 100 range), to report on conditions at their sites to the public, agencies, or other pertinent stakeholders. Index scores can also be used to draw data-based comparisons between multiple sites to help make management decisions where funding and resources are limited. Most importantly, total index scores are designed to reflect comprehensively the total tourism impact at a site by strategically evaluating and combining all of the major variables that affect the environmental conditions at a water-based tourism site. Returning to the review of the literature in Chapter Two, no other indexing tool in individual site management offers this product; the TII is the first of its kind and is intended to serve a valuable purpose in furthering research and tourism management in environmentally-vulnerable locations with an expanding tourist presence.

CHAPTER SIX: CONCLUSIONS

This study presented the Tourism Impact Index for Water-Based Natural Sites, the first environmental index designed to holistically evaluate tourism impact on environmentally-vulnerable water-based natural sites. The previous lack of such a tool was compounded by a lack of focused literature that intently connects studies in tourism with studies of landscape development and environmental management. As these factions of science continue to meld together, the TII-WBNS offers a tool to assess, analyze, and share quantitative information that represents the various tourism-related factors that influence the health of a water-based natural tourist site.

As many indices are published without extensive testing to first verify their design and use, this study aimed to test, refine, and release a fully-verified product so that the index may be immediately used properly to fulfill its purpose. This study involved the testing of the index across 28 water-based natural tourism sites located in Iceland and the Washington Olympic Peninsula. Alongside these applications, the index was continually reviewed and updated to account for misinterpretations, inconsistencies between users, and unaddressed variables affecting the tourism-influenced landscapes. Across the two study regions, the index was applied at a wide variety of water-based sites, representing a full spectrum of tourism development as well as different water-based attractions, including waterfalls, beaches, coastal cliffs, lakes, and glacial features. As a result of these field applications, the index has been verified for use at any water-based natural site located in Subarctic or Maritime climates.

The 28 field applications also serve as case studies where the TII was used to evaluate the conditions at each site. Analysis of the field applications showed that observed environmental and tourism-related conditions were well-reflected in the index data. The organization of the index allows a user to calculate a total index score as well as three sectional scores that divide the index by content. These sectional scores, as well as the individual indicator scores themselves, are particularly useful to managers and researchers in identifying areas of great concern, areas of low concern, and areas where managerial efforts should be applied in order to ensure the sustainability of a site amidst continued tourism activity and influence. As the world tourism industry continues to grow, well-informed managerial efforts will be crucial to the preservation of natural sites in the face of climate change and other environmental concerns.

The index design is not without room for error and misuse, and this study found that two users who apply the index simultaneously at the same site can score many indicators differently based on previous knowledge of the site, differences in scoring interpretation, and the thoroughness of their observations of the site. To minimize inaccuracies, managers should work together when applying the index at sites that are already well-known by the users. If multiple sites are to be compared, the same user or team of users should apply the index at each of the compared sites for consistency.

The index was designed with several goals in mind to ultimately support its applicability; the final index product has shown to fulfill each of these goals, as it is simple, inexpensive, and quick to use, applicable to any water-based natural tourism site as tested in Subarctic and Maritime climates, and the outputs were designed to be easily interpreted. The index is a visual assessment, meaning that no special equipment, sampling, or resource extraction is necessary to complete the index. Given that the index is designed in part to implement the ideals of sustainable tourism, the use of the index itself fittingly requires minimal interactions with the landscape, but the results still provide robust and holistic data. This reliance on observational data collection ensures that the footprint of this research was minimal, and the index may be widely applied to even the most vulnerable sites without worrying about contributing a negative environmental footprint.

Upon returning to the original research questions this study aimed to address, the study has provided a verified index design to assess tourism-induced landscape change. The indicators included in the index have shown to capture the complexities and variety of environmental and tourism-related factors that contribute to landscape change at tourist sites. Ultimately, this study demonstrated that an environmental index can serve as a suitable tool used to evaluate individual sites, and the field-tested TII-WBNS is the product of this research process.

This research and the TII-WBNS as a functional product of this research elicit various implications for public policy regarding nature-based tourism in environmentally-vulnerable locations. The index can help to promote responsible tourist behavior at sites, as the index results may prompt managers to improve educational and restrictive signage, expand interpretive programming, and advocate for enhanced regulatory protection of water-based features and other natural resources. Guided by index results, site managers may seek to limit or regulate the flow of traffic to reduce overcrowding and erosion. Updated barriers, trail design, and educational efforts can discourage tourists from engaging in harmful or prohibited activities, trampling vulnerable plant cover, and defining informal trails. Tourists who visit well-managed sites with expansive interpretive opportunities will ultimately become more informed about the environmental concerns a site faces, and they may gain a more conscious recognition of their own environmental footprint as tourists. These implications that may spawn from managerial responses to index applications at a site may therefore ultimately encourage a more sustainable form of tourism. At the broader scale, the TII-WBNS provides a tool for site-specific data-collection and interpretation that can inform science-backed policy regarding wilderness preservation, site regulation and protection, natural resource management, natural area development, and tourist activity management.

6.1 Future Work

The results of this study prompt several paths of extensive future work. From an environmental management perspective, the index may be applied to any water-based natural site where managers face environmental concerns from a current or anticipated tourist influence. If used across multiple sites, the index may function as a method to understand more fully the scale of tourism impact at vulnerable natural sites, and it may also suggest important trends concerning baseline landscape vulnerability, tourism development, and activity-based inputs across tourism regions. If used strategically, multiple index applications at a site over time can capture how the landscape is specifically changing and indicate the rate at which change is occurring. The index itself provides a historical snapshot of conditions at a site, so present index applications can serve as historical references in the years ahead.

The second path of future work beyond this study involves further refinement and testing of the index in new scenarios. This study confirmed the use of the index for Subarctic and Maritime climates, but water-based natural tourism is a worldwide phenomenon. In order to ensure that the index in its current state is suitable for all regions, especially in warmer climates, further testing is needed; such work may be completed by applying the index in a variety of sites in additional study regions with the same approach observed by this study in Iceland and the Washington Olympic Peninsula.

Future research involving the TII-WBNS can extend even further through additional refinement of the index design and content. In order for the index to be truly suitable for all water-based natural tourism sites in all climates, especially given future environmental change and tourism industry growth, the index should be considered an organic document whose structure may remain under revision so that it may be applied in new capacities more effectively. Future research with the index can explore the intricacies of the scores as related to the observed phenomena they represent, and improvements may be implemented accordingly. This line of work may be completed in hand with the mission to test and verify the index for use in warmer climates. Further testing and improvement of the index can ultimately allow environmental managers to reap more benefits from its use, enjoying greater accuracy and depth in the interpretation of results.

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APPENDIX A: INSTRUCTIONAL GUIDE FOR INDEX USE AND INTERPRETATION

Tourism Impact Index for Water-Based Natural Sites Instructional Guide

Jason Fox
Western Kentucky University Center for Human GeoEnvironmental Studies (WKU CHNGES)

I. Overview and Conditions of Use

The Tourism Impact Index for Water-Based Natural Sites (TII-WBNS or "the index") is designed to evaluate the level of disturbance and degradation by which a natural site has been affected by tourism development and activity. The index specifically caters to sites with primary or secondary hydrologic attractions; the use of the index is therefore suitable for, but not excluded to, the following settings: beaches, coastal cliffs, waterfalls, glaciers, lakeshores, and riversides. The index references the conditions of a site at its time of application and does not reflect how a site might change over time. Site managers and researchers may use the index as a tool to assess the footprint of tourism at water-based natural sites and to pinpoint specific areas of managerial concern.

The current version of the TII-WBNS has been field-tested across a variety of water-based natural settings in Subarctic and Maritime climates. While the index is designed to be applicable to water-based natural tourism sites in any climate, the current version of the index has yet to be verified for use in warmer regions. In order to return accurate results, index users should maintain a basic familiarity with the characteristics of the climate and environmental conditions of an application site. Users should also have general knowledge concerning the year-round conditions of an application site, particularly in regard to tourist activity.

II. Instructions for Use

The TII-WBNS contains a total of 44 individual indicators categorized by content into three sections: Baseline Landscape Vulnerability, Physical Development and Infrastructure, and Activity-Based Inputs. Each indicator contains four levels of scoring: 0-3. A score of 0 reflects a nonexistent or negligible impact, a score of 1 represents a minimal impact, a score of 2 represents a modest impact, and a score of 3 represents a substantial impact. Each indicator is designed to be accurately assessed through visual/observational means.

1. To minimize observational bias, it is highly recommended that the index be applied by a team of **two or more users** at a site, although the index may be completed individually if the user is highly familiar with the site prior to index application.
2. When applying the index to a site, users should thoroughly explore the premises, taking notes and photographs as appropriate for documentation purposes.
3. After thorough assessment of the site, users should review each indicator and jointly decide and record which score best fits the observed conditions of the site.
4. After scoring is complete, total and sectional scores may be calculated.

For Sectional Scores:

1. Calculate the sum of all indicator scores from within a section.
2. Divide the sums by the total possible sectional sums:
   - Section One: Baseline Landscape Vulnerability: **/30**
   - Section Two: Physical Development and Infrastructure: **/60**
   - Section Three: Activity-Based Inputs: **/42**
3. Multiply each sectional score by 100.

*If one or more indicators is added to or omitted from an index application, update the sectional sums accordingly to reflect the new number of indicators.

For Total Index Score:

1. Calculate the sum of all 44 indicators.
2. Divide the sum by the **132**, the total possible sum.
3. Multiply the score by 100.

*If one or more indicators is added to or omitted from an index application, update the total possible sum accordingly to reflect the new number of indicators.

To Interpret Scores:

Index sectional scores and total scores range from 0 to 100. A score of 0 represents no tourism disturbance to a site with no baseline vulnerability concerns, and a score of 100 represents the most severe tourism disturbance to a site with very high baseline vulnerability. Given the averaging effect built into the scoring system, extreme low or high scores are uncommon. Below are some general considerations for interpreting the various index scores:

- The **total index score** should be used to compare multiple sites at which the index has been applied. These comparisons can provide a look at natural sites that are scoring higher or lower than the typical scores for a region of interest.
- **Sectional scores** and **individual indicator scores** provide information on the specific factors that contribute to the total score, especially if scores are higher or lower in comparison to others in a region of interest. When considering management practices or remediation at individual natural sites, sectional scores and specific indicator scores should be carefully considered.
- Use the table provided below as a guide to interpret index scores. Note that each natural site is unique, and index scores should be utilized in tandem with visual observations and other relevant data (e.g., quantitative measurements) when addressing management concerns.

Suggested Scoring Interpretation	
Score Range	**Interpretation**
Total Index Score	
60 - 100	**Severe** Tourism Impact
30 – 59.9	**Moderate** Tourism Impact
0 – 29.9	**Minimal** Tourism Impact
Sectional Scores	
60 - 100	**Severe** Impact
30 – 59.9	**Moderate** Impact
0 – 29.9	**Minimal** Impact
Individual Indicator Scores	
3	**Substantial** Impact
2	**Modest** Impact
1	**Minimal** Impact
0	**Negligible** Impact

Level of Impact (Score Range)	Suggested Actions for Remediation
Total Index Score	
Severe: 60 – 100	▪ Consider upgrading managerial efforts ▪ Complete quantitative assessments of environmental degradation (e.g., trail assessments for erosion) to better inform remediation strategies ▪ Consider limiting traffic or intensive activity in highly-degraded areas ▪ Apply index over time to monitor changes ▪ See sectional scores
Moderate: 30 – 59.9	▪ Consider upgrading managerial efforts ▪ Apply index over time to monitor changes ▪ See sectional scores
Minimal: 0 – 29.9	▪ See sectional scores
Section 1: Baseline Landscape Vulnerability	
Severe: 60 – 100	▪ Consider heightened protective status ▪ Identify and regularly monitor areas of erosional risk ▪ Protect plant cover ▪ Discourage further development in agriculture, resource extraction, and commercial/residential activity
Moderate: 30 – 59.9	▪ Identify areas of erosional risk ▪ Protect plant cover ▪ Discourage further development in agriculture, resource extraction, and commercial/residential activity
Minimal: 0 – 29.9	▪ No immediate remediation suggested
Section 2: Physical Development and Infrastructure	
Severe: 60 – 100	▪ Limit/avoid any future construction on site ▪ Complete an environmental assessment for future updates to site infrastructure

	▪ Improve drainage infrastructure in parking and trail areas ▪ Upgrade facilities utilizing sustainable designs, systems, and materials ▪ Consider renovating trail design to minimize ecological disturbance, erosion (e.g. boardwalks, encouraging natural vegetation growth) ▪ Add restrictive, cautionary, and educational signage
Moderate: 30 – 59.9	▪ Upgrade facilities utilizing sustainable designs, systems, and materials ▪ Consider renovating trail design to minimize ecological disturbance, erosion ▪ Add restrictive, cautionary, and educational signage
Minimal: 0 – 29.9	▪ Add cautionary and educational signage
Section 3: Activity-Based Inputs	
Severe: 60 – 100	▪ Consider heightened protective status ▪ Limit traffic in congested areas during peak visitation ▪ Limit visitor contact with water-based features ▪ Limit traffic in areas of erosional concern ▪ Prohibit access to areas subject to trampling ▪ Monitor eroded and trampled areas ▪ Monitor tourist activity and enforce posted rules ▪ Increase on-site management presence
Moderate: 30 – 59.9	▪ Limit traffic in congested areas during peak visitation ▪ Limit visitor contact with water-based features ▪ Limit traffic in areas of erosional concern ▪ Monitor eroded and trampled areas
Minimal: 0 – 29.9	▪ No immediate remediation suggested

III. Indicator Scoring Guide

Reference the content below when making indicator scoring decisions. Indicators marked with an (*) indicate that background knowledge of year-round site conditions is required for accurate scoring decisions.

Section 1: Baseline Landscape Vulnerability (BLV)

Indicators in this section assess the factors that may leave a natural site vulnerable, excluding all tourism-based influences on that site.

1.1 Wind Erosion. Reflects the potential capacity of the landscape to be altered by wind activity. Look for evidence that indicates wind-induced landscape change, such as potholes, fine-grained deposited sediment, or exposure to the open coast or large plains with little natural shelter. Also look for evidence that protects a landscape from wind-induced change, such as forested or well-vegetated cover, valley walls, or cave conditions. Note that a landscape may be subject to wind influence even if windy conditions are not present at the time of index application.

1.2 Water Erosion/Sediment Load.* Reflects the turbidity of relevant water-based features at a site and the potential capacity of the landscape to be altered by water activity. A score of 0 should be applied only if water erosion is negligibly applicable to an application site. Note that glacially-fed waters in particular will carry more sediment during periods of heightened discharge.

1.3 Ice Activity.* Reflects the erosion capacity of various ice- and snow-based mechanisms. This indicator should be scored with consideration of year-round conditions at an application site, especially the height of winter conditions when ice activity may be most prominent. Consider activities such as freeze-thaw, permafrost, glacial activity, and long-term snowpack or snow cover. Assign scores based on severity of one or many of the aforementioned mechanisms.

1.4 Seasonal Variability.* Reflects how sites change throughout the year regarding erosional capacity of any kind. This indicator requires index users to consider the year-round conditions of the site: is there a clear change in erosional capacity between seasons? Examples of high scores may include glacial landscapes with a clear change between warmer melt seasons and colder seasons of glacial accretion. Temperate climates will likely score low for this indicator unless specific site conditions imply otherwise.

1.5 Plant Cover. Reflects total vegetative cover across site premises. When bedrock or loose soils are exposed, erosion capacity increases, and the site becomes more vulnerable. A score of 0 is reserved for sites with total plant cover throughout (e.g., forested sites with heavy underbrush, or grasslands). Carefully examine areas with no plant cover to determine whether non-vegetated areas are common throughout the site (score=2) or if only a few isolated areas of the site are of concern (score=1). A score of 3 is reserved for sites with very little vegetative cover throughout.

1.6 Species Sensitivity. Reflects the most common form of vegetation found at a site. In colder climates, mosses are highly vulnerable to trampling and other damaging events, and take long periods to grow back once damaged. Wetlands and forests exhibit greater diversity and resilience.

1.7 Agriculture. Reflects the presence of agricultural activity on or near a site. Large-scale operations include permanent use of the land for intensive crop production, animal husbandry, or the housing of other animals. Small-scale operations may be impermanent or otherwise deemed to bear little impact on the site.

1.8 Development. Reflects non-tourism related human development on or near the site. This indicator includes both commercial and residential development. Industrial activity and other land uses outside of residential development should be counted as commercial development for the purposes of this indicator. Scores of 3 are reserved for sites with high levels of development in close proximity to a site. A score of 2 reflects less development of a smaller impact to a site. A score of 1 reflects only minimal residential activity nearby.

1.9 Water Pollution.* Reflects evidence of active sources of pollution to relevant waters of a site. Point sources can be tied to a specific location of pollutant discharge (e.g., sewer pipes), whereas nonpoint sources cannot be tied to a specific location. While nonpoint sources may be difficult to observe, consider any development or other activity upstream or within the watershed of a site and any pollutants that may enter the relevant waters of a site as a result of nearby activity. A score of 3 reflects regular or continuous point source pollution, such as discharge from nearby industry. A score of 2 reflects event-based point source pollution inputs, such as occasional dumping of garbage.

*1.10 Resource Extraction**. Reflects the presence of any operations on or near a site that involve the extraction of natural resources (e.g., logging, fishing, mining, or energy). Long-term operations may be evidenced by the presence of permanent facilities (e.g., warehouses or power plants). If any operation affects the environmental conditions of a site, it should be considered to fall within the relevant vicinity of the site, even if farther than 1 km.

Section 2: Physical Development & Infrastructure (PDI)

Indicators in this section assess long-term physical alterations and additions to a site that are utilized by tourists or for tourism-related purposes.

2.1 Road Type: Water Infiltration and Runoff. Reflects the capacity of roads and parking areas to properly drain stormwater. Paved surfaces obstruct the natural infiltration process of precipitation. If a site contains multiple types of road and parking surfaces of substantial length, choose the corresponding indicator score of higher impact.

2.2 Road Type: Erosion. Reflects the erosion capacity of roads and parking areas. Dirt surfaces are more susceptible to erosion than gravel and paved surfaces. If a site contains multiple types of road and parking surfaces of substantial length, choose the corresponding indicator score of higher impact.

2.3 Distance from Parking to Attraction. When parking options are close to water-based attractions, pollution concerns from automobile activity may be heightened, in addition to other concerns. Therefore, the elevation change between parking options and water-based attractions is also relevant, as pollution will travel downhill, especially if it is fed into drainage pathways. At sites where parking options are of substantial distance from water-based attractions, these concerns are minimized.

2.4 Parking Capacity. Reflects the number of standard-sized vehicles that may be accommodated simultaneously at a site. This indicator should exclude tour bus considerations.

2.5 Tour Bus or Boat Accessibility and Parking. If a site is accessible to and utilized by tour buses, school buses, or other forms of transportation with large passenger capacity, such as cruise liners, mass tourism is encouraged. Larger vehicles are also of greater pollution concern than standard-sized vehicles. This indicator reflects the presence of designated parking spaces or areas for these vehicles. Even without designated parking options, tour buses may still regularly visit a site, and this should be incorporated into scoring decisions accordingly.

2.6 Presence of Construction Zones. Construction zones subject a site to various forms of pollution, sedimentation, and runoff. If areas of a site are under construction, consider the size of the project and the degree to which the surrounding landscape is being altered to accommodate the new installment or renovation. A large-scale project may include construction of a hotel, visitor center, restaurant, other lodging/camping facilities, etc. Small-scale projects may include construction of shelters, restroom facilities, small expansions to existing buildings, landscaping projects, or the installation of power lines or other utilities.

2.7 Toilet Facilities. Tourists require access to basic toilet facilities, but the type of facilities present may indicate different levels of environmental impact. Sanitary toilets involve installation of sewage treatment infrastructure. Waste collected by portable toilet facilities is typically removed from the site. When no toilet facilities are accessible, tourists may be forced to directly pollute a site with their waste. Judge relative toilet demand based on the number of tourists who visit a site, as well as distance from other nearby facilities (e.g., service stations).

2.8 Camping Facilities. Designated camping areas are denoted by the presence of clearly-defined lots for RV/camping vehicle parking or tents, as well as infrastructure such as picnic tables, fire pits, and showering/restroom facilities. A large designated camping area is evidenced by greater than roughly 15 camping lots or a large amount of camping infrastructure. Small designated camping areas should contain fewer than 15 camping lots accompanied by minimal infrastructure. Makeshift camping includes backcountry camping or the otherwise impermanent use of an area for camping purposes.

2.9 Services (Dining, Shopping, etc.). Reflects the presence of permanent or temporary structures or buildings that provide services or goods directly to site visitors. Permanent structures may include indoor restaurants and gift shops. Temporary structures may include food stalls, food trucks, or gift stands.

2.10 Lodging. Reflects the availability of large-scale accommodation for tourists on or within walking distance to a site. Examples may include hotels, hostels, or sets of cabins. Camping may be included, but when camping is the only option present, a score of 1 should be applied. Small-scale lodging that accommodates a maximum of 5-6 people, such as bed-and-breakfast services or other privately-owned homes, should not be counted for this indicator and should be reflected in Indicator 1.8 (Development).

2.11 Attraction-Functioned Structures/Secondary Attractions. Reflects any structure or complex that serves as a primary or secondary attraction within the same premises as a natural site. Examples may include a museum, lighthouse, historic structure, etc. This indicator also accounts for any other significant building or structure on a site that has not been accounted for in the previous indicators. Does not include small trailside infrastructure (e.g. gazebos or utility items—see Indicator 2.17: Other Structures).

2.12 Seasonality of Services.* Reflects whether services on a site as noted by Indicators 2.9, 2.10, and 2.11 are open year-round or only for portions of the year. Note that a site may remain open and accessible to tourists even if on-site services are temporarily or periodically closed.

2.13 Trail/Path Type. Reflects the erosion potential of trails or significant paths on site. Uncovered trails of loose material are more susceptible to erosion. If a site contains multiple types of trail or path surfaces of substantial length, choose the corresponding indicator score of higher impact.

2.14 Land Alterations for Trail Installation. Reflects any direct alterations to the landscape for the installation of trails or paths. Examples may include steepening of gradient, cutting steps or rampways out of hillsides, clearing of large boulders, drilling into bedrock, or other large-scale digging projects. A score of 3 is reserved for evidence of a drastically-altered landscape for trail installation. A score of 2 reflects some general displacement of soil or rock with little effect on drainage or erosion potential. A score of 1 reflects only minor alterations (e.g. cutting steps out of a hillside).

2.15 Erosion Controls. Effective erosion controls built into trails can help counteract negative erosional effects of land alterations for trail installation observed in Indicator 2.14. Examples may include planting a steep hillside with cover crops to hold soil in place, installing drainage pathways into a trail to mimic natural drainage patterns, or installing a protective wall to strengthen a hillside vulnerable to collapse. Carefully consider a score of 0 before assigning a score of 3, 2, or 1. If there is evidence of stringent erosion management, or if there is no need for erosion control given the topography and environmental conditions of a site, a score of 0 may be appropriate.

2.16 Barriers (excluding restrictive signage). Barriers limit tourist movement and activity to designated areas, protecting landscapes that might be vulnerable to trampling, erosion, or other concerns. Visitors should be discouraged, therefore, from straying off trails by use of barriers. Carefully consider whether fencing or other barriers can be easily ignored or violated (e.g. low rope fencing vs. tall steel or wooden fencing).

2.17 Other Structures. Accounts for any trailside structures present at a site. Major trailside structures include pavilions, gazebos, platforms, docks, etc. Minor trailside structures include art installations, lamp posts, picnic tables, and utility items. Carefully classify the trailside structures present.

2.18 Channel Alteration/Culverts. Search for evidence of alterations to the natural pathways of streams, rivers, or even channels of stormwater runoff. Culverts and other simple drainage infrastructure should be considered as minor alterations (score=1). Major alterations may include widening a stream bank, rerouting a stream bank, dam installation, etc. (score=3 or 2).

2.19 Educational Signage. Accounts for the presence and adequacy of educational signage providing information to tourists about the environmental or geological characteristics of a site, or about any other important aspects or features pertaining to a site. A score of 0 is reserved for sites containing extensive educational signage that can be easily read and interpreted by general visitors of adult age. This should include the display of legible information in appropriate languages to serve the regional tourist demographics.

2.20 Cautionary/Restrictive Signage. Accounts for signage erected with the purpose of ensuring or encouraging visitor safety or the protection of the natural environment. This may include danger/warning signs, signs indicating restricted behavior, and signs indicating areas that are not accessible to visitors. A score of 0 is reserved for sites with signage that thoroughly informs tourists of restrictions and potential dangers. This signage should be legible and available in appropriate languages to serve the regional tourist demographics.

Section 3: Activity-Based Inputs (ABI)

Indicators in this section assess patterns in tourist behavior and activity, as well as active management and remediation efforts at a site.

*3.1 Annual Visitor Count**. Reflects the rough percentage of total yearly visitors to a region who also visit the specific site of index application.

*3.2 Average Group Size** Reflects the largest size of a typical group, or the number of people who jointly visit a site. Consider the frequency of tour bus arrivals or other mass transit service. A score of 3 is reserved for sites where multiple busloads of people are commonly visiting the site simultaneously. Sites with no bus service should be limited to scores of 1 or 0. Also consider visitation trends during the peak of the tourism high season when scoring this indicator.

3.3 Informal Trails. An informal trail, also referred to as a user-defined trail or desire path, indicates the lack of adherence to official trails and paths. These trails are often created by tourists trampling vegetation or wearing down erosion-prone soils. When informal trails are present, consider the length, width, and frequency of these trails across a site. Some informal trails will be well-defined, and they may appear to be used just as frequently as official trails.

3.4 Trampling: Vegetation. Even if informal trails are not present, vegetation may still be damaged from tourist trampling. Examine if vegetation near trails or in high traffic areas appears to be flattened, dying, or in worse health than surrounding vegetation. Also consider the vulnerability and rarity of the type of vegetation that is damaged (refer to Indicator 1.5). Examine the spatial frequency of trampled vegetation to differentiate between scores of 3 and 2. A score of 0 is reserved for sites with either no plant cover or no evidence that tourists regularly stray from trails.

3.5 Trampling: Erosion. Reflects evidence of eroded trails or other high-traffic areas. Evidence of highly-eroded trails include widening, steepening, displacement of dirt/gravel, mass wasting, etc. A score of 3 is reserved for highly-eroded trails and high-traffic areas that would require extensive remediation efforts to address. A score of 2 represents some areas of high erosion, but not as consistently-observed throughout the site as a score of 3 would indicate. A score of 0 is reserved for sites where erosion is stringently managed, or where trails are not erodible (i.e., paved trails).

*3.6 Off-Road Vehicle/Transport Animal Use**. Reflects the usage of other means of transportation around a site aside from foot traffic. A score of 3 is reserved for sites where off-road vehicles, all-terrain vehicles, or transport animals, such as horses or mules, are used regularly or on a daily basis by tourists as part of typical site activities. If such means are irregularly used in areas where erosion may occur, a score of 2 is appropriate.

*3.7 Water Use/Contact**. Reflects the degree to which tourists interact with relevant waters of a site. Primary contact activities denote tourists physically immersing in water or otherwise experiencing maximal contact (e.g., swimming). Secondary contact includes indirect contact with water (e.g., fishing, boating, etc.). Consider the regularity of primary and secondary contact of tourists with site waters, and also consider how these activities might change throughout the year as temperature and other conditions affect the spectrum of water-based activities that are plausible.

*3.8 Water Pollution Potential**. Reflects the potential pollution of relevant waters of a site from the direct activities of tourists. Consider the sources of water use/contact from Indicator 3.7, as well as any other tourist activities that may result in direct or indirect pollution, and note the frequency or regularity of these activities. Also note the availability of proper waste disposal utilities. Finally, consider how pollution potential might change throughout the year as tourist activity varies.

*3.9 Seasonality (Temporal)**. Reflects the temporal aspect of crowdedness and use of a site's facilities. Consider year-round visitation patterns of an application site and determine the periods of a year during which the site is most visited, if ever. Carefully match visitation trends with the best-fitting indicator score.

*3.10 Area of Greatest Activity (Spatial)**. Reflects the spatial aspect of crowdedness and use of a site's facilities. Examine the size of areas where tourists generally congregate (e.g., to view a water-based feature, to line up/wait for services, etc.), and consider the frequency of which these areas are filled with visitors at or near relative capacity. Make sure to incorporate knowledge of year-round site conditions, especially considering the peak of the high season.

*3.11 Active Site Management**. Reflects any efforts to manage environmental conditions at a site, such as trail management, vegetation control, clearing debris, etc. Do not rely solely on evidence of management found at a site at the time the index is applied, but also consider how the site is maintained throughout the year. Also consider differences between typical upkeep activities (e.g. mowing grass, trimming foliage) and strategically addressing environmental concerns (e.g. remediating eroded paths). These factors will help distinguish a score of 2 (general upkeep) from a score of 1 or 0 (environmental evaluation and remediation).

*3.12 Site Staff and Management Presence**. Reflects the presence and availability of staff and/or environmental managers on site premises. Staff can help inform tourists about a site as well as monitor a site's resources. Note whether staff are trained to be able to answer questions and specifically address site-specific issues, and also note whether staff are present throughout the year or only during periods of the year.

3.13 Site Regulation. Reflects the level of regulatory protection of a site. Consider whether a site is protected by national park status, provincial/state/local park status, jurisdiction under another land management agency, or otherwise protected or partially protected by laws or various policies. Also consider the strength and level of enforcement of these protections and whether they translate into active monitoring, protection, conservation, or management of resources and significant features within a site. A score of 0 is reserved for sites whose resources are fully-protected by laws or regulations, such as areas managed by the United States National Park Service. If a site is managed by a particular agency or other entity, consider the mission, mandate, and goals of these entity in regard to environmental protection. Some sites may be protected in theory but not in practice.

*3.14 Non-Signage-Based Education**. Reflects the availability of tours, interpretive programming, interpretation staff, or other means of educating tourists about a site excluding the use of signage. Some sites may have information available off-site, such as at a nearby visitor center. This indicator does not include websites, other internet media, or publicly-dispersed brochures/pamphlets/etc., barring circumstantial exceptions. A score of 0 is reserved for sites whose on-site interpretive programs are thorough, providing tourists with a complete educational experience in the form of an extensive interpretive tour, talk, museum or media experience, etc. A score of 1 indicates that, while some interpretive programming is available on site, it is not necessarily used by all visitors, and/or it does not thoroughly educate tourists about the features of interest contained about a site. If on-site interpretive programming is only available for less than half of the year, a score of 1 should be assigned.

APPENDIX B: ICELAND PRINCIPAL INVESTIGATOR FULL INDEX DATA

The following sets of data include the full index application data for the 13 Iceland sites as completed by the principal investigator. These scores correspond with the version of the TII-WBNS as presented in Table 5.1 (Chapter Five).

Site 1: Valahnúkur Cliffs					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	2
1.2	2	2.2	2	3.2	3
1.3	1	2.3	3	3.3	1
1.4	1	2.4	2	3.4	2
1.5	3	2.5	3	3.5	2
1.6	0	2.6	0	3.6	1
1.7	0	2.7	3	3.7	0
1.8	1	2.8	0	3.8	1
1.9	2	2.9	0	3.9	3
1.10	2	2.10	0	3.10	3
		2.11	2	3.11	2
		2.12	0	3.12	3
		2.13	3	3.13	3
		2.14	1	3.14	3
		2.15	3		
		2.16	2		
		2.17	1		
		2.18	0		
		2.19	1		
		2.20	2		

Site 2: Brimketill					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	2
1.2	2	2.2	2	3.2	0
1.3	1	2.3	1	3.3	0
1.4	1	2.4	2	3.4	1
1.5	2	2.5	1	3.5	1
1.6	2	2.6	0	3.6	0
1.7	0	2.7	3	3.7	1
1.8	0	2.8	0	3.8	1
1.9	1	2.9	0	3.9	3
1.10	0	2.10	0	3.10	3
		2.11	0	3.11	2
		2.12	0	3.12	3
		2.13	1	3.13	3
		2.14	2	3.14	3
		2.15	3		
		2.16	1		
		2.17	0		
		2.18	0		
		2.19	1		
		2.20	2		

Site 3: Seltjarnarnes					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	3	3.1	0
1.2	2	2.2	1	3.2	0
1.3	1	2.3	3	3.3	1
1.4	1	2.4	2	3.4	1
1.5	2	2.5	1	3.5	1
1.6	2	2.6	0	3.6	2
1.7	0	2.7	2	3.7	2
1.8	3	2.8	0	3.8	1
1.9	2	2.9	0	3.9	1
1.10	0	2.10	0	3.10	0
		2.11	2	3.11	2
		2.12	0	3.12	3
		2.13	1	3.13	1
		2.14	1	3.14	3
		2.15	1		
		2.16	2		
		2.17	2		
		2.18	0		
		2.19	1		
		2.20	0		

Site 4: Sólheimasandur					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	2
1.2	3	2.2	2	3.2	0
1.3	1	2.3	0	3.3	2
1.4	2	2.4	3	3.4	2
1.5	3	2.5	2	3.5	2
1.6	0	2.6	0	3.6	1
1.7	0	2.7	3	3.7	1
1.8	0	2.8	0	3.8	1
1.9	0	2.9	0	3.9	3
1.10	0	2.10	0	3.10	0
		2.11	3	3.11	3
		2.12	0	3.12	3
		2.13	3	3.13	3
		2.14	2	3.14	3
		2.15	3		
		2.16	3		
		2.17	0		
		2.18	0		
		2.19	3		
		2.20	3		

Site 5: Loftsalahellir Cave					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	2	2.1	2	3.1	0
1.2	1	2.2	2	3.2	0
1.3	1	2.3	1	3.3	1
1.4	1	2.4	1	3.4	2
1.5	1	2.5	1	3.5	2
1.6	2	2.6	0	3.6	1
1.7	1	2.7	3	3.7	1
1.8	1	2.8	0	3.8	1
1.9	1	2.9	0	3.9	0
1.10	0	2.10	0	3.10	1
		2.11	0	3.11	3
		2.12	0	3.12	3
		2.13	3	3.13	3
		2.14	2	3.14	3
		2.15	3		
		2.16	3		
		2.17	2		
		2.18	1		
		2.19	1		
		2.20	3		

Site 6: Dyrhólaey					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	2
1.2	2	2.2	2	3.2	0
1.3	1	2.3	1	3.3	0
1.4	1	2.4	2	3.4	0
1.5	2	2.5	2	3.5	1
1.6	3	2.6	0	3.6	0
1.7	0	2.7	3	3.7	0
1.8	0	2.8	0	3.8	1
1.9	1	2.9	0	3.9	3
1.10	0	2.10	0	3.10	2
		2.11	1	3.11	2
		2.12	0	3.12	3
		2.13	2	3.13	3
		2.14	1	3.14	3
		2.15	3		
		2.16	0		
		2.17	1		
		2.18	0		
		2.19	3		
		2.20	0		

Site 7: Jökulsárlón/Diamond Beach					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	3
1.2	3	2.2	2	3.2	3
1.3	2	2.3	3	3.3	2
1.4	2	2.4	3	3.4	0
1.5	3	2.5	3	3.5	2
1.6	0	2.6	0	3.6	3
1.7	0	2.7	2	3.7	2
1.8	0	2.8	0	3.8	1
1.9	3	2.9	3	3.9	3
1.10	0	2.10	0	3.10	2
		2.11	0	3.11	1
		2.12	3	3.12	0
		2.13	2	3.13	0
		2.14	2	3.14	1
		2.15	3		
		2.16	3		
		2.17	1		
		2.18	1		
		2.19	1		
		2.20	1		

Site 8: Fjallsárlón					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	2	2.1	2	3.1	1
1.2	3	2.2	2	3.2	2
1.3	2	2.3	0	3.3	1
1.4	2	2.4	3	3.4	1
1.5	2	2.5	2	3.5	1
1.6	3	2.6	0	3.6	1
1.7	0	2.7	2	3.7	1
1.8	0	2.8	0	3.8	1
1.9	1	2.9	2	3.9	1
1.10	0	2.10	0	3.10	1
		2.11	1	3.11	2
		2.12	3	3.12	3
		2.13	2	3.13	3
		2.14	1	3.14	3
		2.15	2		
		2.16	2		
		2.17	0		
		2.18	0		
		2.19	1		
		2.20	2		

Site 9: Vik Beach					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	3	3.1	1
1.2	3	2.2	1	3.2	2
1.3	1	2.3	1	3.3	2
1.4	1	2.4	3	3.4	2
1.5	3	2.5	3	3.5	2
1.6	0	2.6	0	3.6	1
1.7	3	2.7	2	3.7	1
1.8	3	2.8	0	3.8	1
1.9	3	2.9	3	3.9	1
1.10	0	2.10	0	3.10	1
		2.11	2	3.11	1
		2.12	3	3.12	3
		2.13	3	3.13	3
		2.14	2	3.14	3
		2.15	3		
		2.16	3		
		2.17	3		
		2.18	3		
		2.19	1		
		2.20	1		

Site 10: Sólheimajökull					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	2	3.1	3
1.2	3	2.2	2	3.2	2
1.3	3	2.3	0	3.3	3
1.4	3	2.4	3	3.4	0
1.5	3	2.5	3	3.5	2
1.6	0	2.6	0	3.6	2
1.7	0	2.7	2	3.7	3
1.8	0	2.8	0	3.8	1
1.9	1	2.9	2	3.9	1
1.10	0	2.10	0	3.10	2
		2.11	0	3.11	2
		2.12	3	3.12	1
		2.13	3	3.13	3
		2.14	0	3.14	1
		2.15	3		
		2.16	3		
		2.17	0		
		2.18	0		
		2.19	1		
		2.20	1		

Site 11: Skógafoss					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	2	2.1	2	3.1	3
1.2	3	2.2	2	3.2	3
1.3	1	2.3	1	3.3	3
1.4	3	2.4	3	3.4	3
1.5	1	2.5	3	3.5	1
1.6	2	2.6	0	3.6	1
1.7	3	2.7	2	3.7	1
1.8	3	2.8	2	3.8	1
1.9	3	2.9	3	3.9	3
1.10	0	2.10	3	3.10	3
		2.11	0	3.11	1
		2.12	3	3.12	2
		2.13	3	3.13	1
		2.14	2	3.14	3
		2.15	1		
		2.16	2		
		2.17	1		
		2.18	0		
		2.19	1		
		2.20	0		

Site 12: Nauthúsagil					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	2	3.1	0
1.2	3	2.2	2	3.2	0
1.3	1	2.3	1	3.3	3
1.4	2	2.4	1	3.4	3
1.5	1	2.5	1	3.5	2
1.6	2	2.6	0	3.6	0
1.7	3	2.7	3	3.7	3
1.8	0	2.8	0	3.8	1
1.9	1	2.9	0	3.9	0
1.10	0	2.10	0	3.10	1
		2.11	0	3.11	2
		2.12	0	3.12	3
		2.13	3	3.13	3
		2.14	0	3.14	3
		2.15	3		
		2.16	3		
		2.17	0		
		2.18	1		
		2.19	1		
		2.20	3		

Site 13: Seljalandsfoss					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	2	2.1	2	3.1	3
1.2	3	2.2	2	3.2	3
1.3	1	2.3	1	3.3	1
1.4	2	2.4	3	3.4	1
1.5	0	2.5	3	3.5	1
1.6	2	2.6	0	3.6	0
1.7	2	2.7	2	3.7	3
1.8	0	2.8	0	3.8	1
1.9	1	2.9	1	3.9	3
1.10	0	2.10	0	3.10	3
		2.11	0	3.11	2
		2.12	3	3.12	3
		2.13	1	3.13	3
		2.14	1	3.14	3
		2.15	3		
		2.16	2		
		2.17	1		
		2.18	1		
		2.19	1		
		2.20	1		

APPENDIX C: ICELAND RESEARCH ASSISTANT FULL INDEX DATA

The following sets of data include the full index application data for the 13 Iceland sites as completed by the research assistant. These scores correspond with the version of the TII-WBNS as presented in Table 5.1 (Chapter Five).

Site 1: Valahnúkur Cliffs					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	2
1.2	2	2.2	2	3.2	3
1.3	0	2.3	3	3.3	1
1.4	1	2.4	1	3.4	2
1.5	3	2.5	3	3.5	1
1.6	3	2.6	1	3.6	1
1.7	0	2.7	3	3.7	1
1.8	0	2.8	0	3.8	1
1.9	0	2.9	0	3.9	3
1.10	2	2.10	0	3.10	3
		2.11	2	3.11	3
		2.12	3	3.12	3
		2.13	3	3.13	3
		2.14	1	3.14	3
		2.15	3		
		2.16	2		
		2.17	1		
		2.18	0		
		2.19	1		
		2.20	3		

Site 2: Brimketill					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	2
1.2	2	2.2	2	3.2	0
1.3	0	2.3	1	3.3	0
1.4	1	2.4	1	3.4	1
1.5	1	2.5	1	3.5	1
1.6	2	2.6	0	3.6	0
1.7	0	2.7	3	3.7	0
1.8	0	2.8	0	3.8	1
1.9	0	2.9	0	3.9	3
1.10	0	2.10	0	3.10	3
		2.11	0	3.11	3
		2.12	0	3.12	3
		2.13	3	3.13	2
		2.14	2	3.14	3
		2.15	3		
		2.16	2		
		2.17	2		
		2.18	0		
		2.19	1		
		2.20	0		

Site 3: Seltjarnarnes					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	3	3.1	0
1.2	2	2.2	1	3.2	0
1.3	0	2.3	1	3.3	1
1.4	1	2.4	1	3.4	1
1.5	1	2.5	1	3.5	0
1.6	2	2.6	0	3.6	2
1.7	0	2.7	2	3.7	1
1.8	3	2.8	0	3.8	0
1.9	0	2.9	0	3.9	1
1.10	0	2.10	0	3.10	0
		2.11	1	3.11	3
		2.12	0	3.12	3
		2.13	1	3.13	1
		2.14	2	3.14	3
		2.15	0		
		2.16	3		
		2.17	1		
		2.18	0		
		2.19	1		
		2.20	0		

Site 4: Sólheimasandur					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	2
1.2	3	2.2	2	3.2	0
1.3	1	2.3	0	3.3	1
1.4	2	2.4	3	3.4	0
1.5	3	2.5	2	3.5	2
1.6	0	2.6	0	3.6	2
1.7	0	2.7	3	3.7	1
1.8	0	2.8	0	3.8	1
1.9	0	2.9	0	3.9	1
1.10	0	2.10	0	3.10	0
		2.11	0	3.11	3
		2.12	0	3.12	3
		2.13	3	3.13	3
		2.14	1	3.14	3
		2.15	3		
		2.16	3		
		2.17	0		
		2.18	0		
		2.19	3		
		2.20	3		

Site 5: Loftsalahellir Cave					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	2	2.1	2	3.1	0
1.2	1	2.2	2	3.2	0
1.3	1	2.3	1	3.3	1
1.4	2	2.4	1	3.4	1
1.5	1	2.5	1	3.5	1
1.6	2	2.6	0	3.6	0
1.7	1	2.7	3	3.7	1
1.8	0	2.8	0	3.8	1
1.9	0	2.9	0	3.9	0
1.10	0	2.10	0	3.10	0
		2.11	0	3.11	3
		2.12	0	3.12	3
		2.13	3	3.13	3
		2.14	2	3.14	3
		2.15	3		
		2.16	3		
		2.17	0		
		2.18	1		
		2.19	1		
		2.20	3		

Site 6: Dyrhólaey					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	2
1.2	3	2.2	2	3.2	1
1.3	1	2.3	1	3.3	0
1.4	2	2.4	1	3.4	0
1.5	1	2.5	1	3.5	1
1.6	3	2.6	0	3.6	0
1.7	0	2.7	3	3.7	0
1.8	0	2.8	0	3.8	1
1.9	0	2.9	0	3.9	1
1.10	0	2.10	0	3.10	1
		2.11	2	3.11	2
		2.12	0	3.12	3
		2.13	2	3.13	3
		2.14	1	3.14	3
		2.15	3		
		2.16	0		
		2.17	2		
		2.18	0		
		2.19	3		
		2.20	0		

Site 7: Jökulsárlón/Diamond Beach					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	3
1.2	3	2.2	2	3.2	2
1.3	3	2.3	2	3.3	1
1.4	2	2.4	3	3.4	0
1.5	3	2.5	3	3.5	2
1.6	0	2.6	0	3.6	3
1.7	0	2.7	2	3.7	1
1.8	0	2.8	0	3.8	1
1.9	3	2.9	2	3.9	2
1.10	0	2.10	0	3.10	0
		2.11	0	3.11	1
		2.12	3	3.12	0
		2.13	3	3.13	0
		2.14	2	3.14	1
		2.15	3		
		2.16	2		
		2.17	0		
		2.18	0		
		2.19	1		
		2.20	0		

Site 8: Fjallsárlón					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	2	3.1	1
1.2	3	2.2	2	3.2	1
1.3	3	2.3	0	3.3	2
1.4	2	2.4	2	3.4	0
1.5	1	2.5	2	3.5	2
1.6	3	2.6	0	3.6	0
1.7	0	2.7	2	3.7	1
1.8	0	2.8	0	3.8	1
1.9	3	2.9	2	3.9	1
1.10	0	2.10	0	3.10	0
		2.11	0	3.11	1
		2.12	3	3.12	3
		2.13	2	3.13.	0
		2.14	2	3.14	3
		2.15	2		
		2.16	2		
		2.17	0		
		2.18	0		
		2.19	1		
		2.20	2		

Site 9: Vik Beach					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	1
1.2	3	2.2	2	3.2	1
1.3	1	2.3	2	3.3	2
1.4	2	2.4	2	3.4	3
1.5	1	2.5	2	3.5	1
1.6	2	2.6	0	3.6	0
1.7	0	2.7	3	3.7	1
1.8	3	2.8	0	3.8	1
1.9	0	2.9	0	3.9	1
1.10	0	2.10	0	3.10	0
		2.11	2	3.11	3
		2.12	0	3.12	3
		2.13	3	3.13.	2
		2.14	2	3.14	3
		2.15	1		
		2.16	3		
		2.17	1		
		2.18	3		
		2.19	1		
		2.20	1		

Site 10: Sólheimajökull					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	2	3.1	3
1.2	3	2.2	2	3.2	1
1.3	3	2.3	0	3.3	1
1.4	3	2.4	3	3.4	1
1.5	3	2.5	3	3.5	1
1.6	0	2.6	0	3.6	0
1.7	0	2.7	2	3.7	2
1.8	0	2.8	0	3.8	1
1.9	1	2.9	2	3.9	1
1.10	0	2.10	0	3.10	1
		2.11	0	3.11	1
		2.12	3	3.12	1
		2.13	3	3.13.	2
		2.14	3	3.14	1
		2.15	3		
		2.16	3		
		2.17	0		
		2.18	0		
		2.19	1		
		2.20	2		

Site 11: Skógafoss					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	2	2.1	2	3.1	3
1.2	3	2.2	2	3.2	1
1.3	0	2.3	1	3.3	3
1.4	1	2.4	2	3.4	2
1.5	1	2.5	2	3.5	1
1.6	3	2.6	0	3.6	0
1.7	3	2.7	2	3.7	1
1.8	3	2.8	2	3.8	1
1.9	3	2.9	3	3.9	1
1.10	0	2.10	1	3.10	1
		2.11	0	3.11	0
		2.12	3	3.12	0
		2.13	2	3.13.	0
		2.14	3	3.14	3
		2.15	2		
		2.16	1		
		2.17	0		
		2.18	0		
		2.19	1		
		2.20	0		

Site 12: Nauthúsagil					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	0	2.1	2	3.1	0
1.2	3	2.2	2	3.2	0
1.3	1	2.3	0	3.3	2
1.4	1	2.4	1	3.4	2
1.5	1	2.5	0	3.5	1
1.6	3	2.6	0	3.6	0
1.7	2	2.7	3	3.7	1
1.8	0	2.8	0	3.8	1
1.9	0	2.9	0	3.9	1
1.10	0	2.10	0	3.10	0
		2.11	0	3.11	3
		2.12	0	3.12	3
		2.13	3	3.13.	3
		2.14	0	3.14	3
		2.15	3		
		2.16	3		
		2.17	0		
		2.18	0		
		2.19	1		
		2.20	2		

The Iceland research assistant did not complete the index at Site 13, Seljalandsfoss, due to unforeseen circumstances.

APPENDIX D: WASHINGTON PRINCIPAL INVESTIGATOR FULL INDEX DATA

The following sets of data include the full index application data for the 15 Washington sites as completed by the principal investigator. These scores correspond with the version of the TII-WBNS as presented in Table 5.1, with updates instated from the Iceland application period described in Table 5.8 (Chapter Five).

Site 1: Dungeness Park					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	3	3.1	0
1.2	2	2.2	1	3.2	0
1.3	0	2.3	0	3.3	1
1.4	1	2.4	3	3.4	1
1.5	0	2.5	2	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	1
1.8	1	2.8	3	3.8	1
1.9	1	2.9	0	3.9	1
1.10	0	2.10	0	3.10	1
		2.11	0	3.11	0
		2.12	0	3.12	1
		2.13	3	3.13	0
		2.14	1	3.14	1
		2.15	2		
		2.16	1		
		2.17	1		
		2.18	0		
		2.19	1		
		2.20	0		

Site 2: Tongue Point					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	3	3.1	0
1.2	2	2.2	1	3.2	0
1.3	1	2.3	2	3.3	1
1.4	1	2.4	3	3.4	1
1.5	1	2.5	2	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	3
1.8	0	2.8	3	3.8	1
1.9	1	2.9	0	3.9	1
1.10	0	2.10	1	3.10	1
		2.11	2	3.11	1
		2.12	0	3.12	2
		2.13	1	3.13	1
		2.14	1	3.14	3
		2.15	1		
		2.16	2		
		2.17	3		
		2.18	0		
		2.19	1		
		2.20	0		

Site 3: Madison Creek Falls					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	3	3.1	1
1.2	1	2.2	1	3.2	0
1.3	1	2.3	0	3.3	0
1.4	1	2.4	2	3.4	1
1.5	1	2.5	0	3.5	1
1.6	1	2.6	0	3.6	0
1.7	2	2.7	0	3.7	1
1.8	0	2.8	0	3.8	1
1.9	1	2.9	0	3.9	2
1.10	0	2.10	0	3.10	3
		2.11	0	3.11	1
		2.12	0	3.12	2
		2.13	1	3.13	0
		2.14	1	3.14	3
		2.15	3		
		2.16	2		
		2.17	0		
		2.18	0		
		2.19	1		
		2.20	3		

Site 4: Lake Crescent Lodge Area					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	3	3.1	3
1.2	0	2.2	1	3.2	1
1.3	1	2.3	2	3.3	0
1.4	1	2.4	3	3.4	1
1.5	0	2.5	1	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	2
1.8	0	2.8	0	3.8	1
1.9	1	2.9	2	3.9	2
1.10	0	2.10	3	3.10	1
		2.11	2	3.11	0
		2.12	2	3.12	0
		2.13	3	3.13	0
		2.14	1	3.14	0
		2.15	3		
		2.16	3		
		2.17	0		
		2.18	0		
		2.19	0		
		2.20	1		

Site 5: Marymere Falls					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	3	3.1	2
1.2	1	2.2	1	3.2	0
1.3	1	2.3	0	3.3	0
1.4	1	2.4	3	3.4	1
1.5	0	2.5	1	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	0
1.8	0	2.8	0	3.8	1
1.9	0	2.9	0	3.9	2
1.10	0	2.10	0	3.10	1
		2.11	1	3.11	1
		2.12	0	3.12	0
		2.13	3	3.13	0
		2.14	1	3.14	1
		2.15	2		
		2.16	2		
		2.17	0		
		2.18	0		
		2.19	2		
		2.20	2		

Site 6: Log Cabin Resort					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	3	3.1	1
1.2	0	2.2	1	3.2	1
1.3	1	2.3	2	3.3	1
1.4	1	2.4	3	3.4	1
1.5	1	2.5	2	3.5	1
1.6	1	2.6	0	3.6	1
1.7	0	2.7	2	3.7	2
1.8	1	2.8	3	3.8	1
1.9	1	2.9	2	3.9	2
1.10	0	2.10	3	3.10	1
		2.11	0	3.11	1
		2.12	2	3.12	1
		2.13	1	3.13	0
		2.14	1	3.14	2
		2.15	3		
		2.16	3		
		2.17	3		
		2.18	0		
		2.19	1		
		2.20	1		

Site 7: Pillar Point					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	3	3.1	0
1.2	2	2.2	1	3.2	0
1.3	1	2.3	3	3.3	1
1.4	1	2.4	2	3.4	1
1.5	1	2.5	1	3.5	2
1.6	1	2.6	0	3.6	0
1.7	0	2.7	0	3.7	2
1.8	0	2.8	0	3.8	2
1.9	1	2.9	0	3.9	1
1.10	3	2.10	0	3.10	1
		2.11	0	3.11	1
		2.12	0	3.12	3
		2.13	1	3.13	1
		2.14	2	3.14	3
		2.15	2		
		2.16	3		
		2.17	1		
		2.18	2		
		2.19	3		
		2.20	1		

Site 8: Sand Point					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	1
1.2	2	2.2	2	3.2	0
1.3	1	2.3	0	3.3	1
1.4	1	2.4	1	3.4	1
1.5	1	2.5	1	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	1
1.8	0	2.8	1	3.8	1
1.9	0	2.9	0	3.9	1
1.10	0	2.10	0	3.10	0
		2.11	0	3.11	0
		2.12	0	3.12	0
		2.13	1	3.13	0
		2.14	1	3.14	1
		2.15	0		
		2.16	0		
		2.17	2		
		2.18	1		
		2.19	1		
		2.20	1		

Site 9: Ozette Campground					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	2	3.1	1
1.2	1	2.2	2	3.2	0
1.3	1	2.3	1	3.3	1
1.4	1	2.4	2	3.4	1
1.5	0	2.5	0	3.5	1
1.6	1	2.6	0	3.6	1
1.7	0	2.7	2	3.7	1
1.8	0	2.8	2	3.8	1
1.9	1	2.9	0	3.9	1
1.10	0	2.10	1	3.10	1
		2.11	0	3.11	0
		2.12	0	3.12	0
		2.13	2	3.13	0
		2.14	0	3.14	1
		2.15	0		
		2.16	3		
		2.17	1		
		2.18	0		
		2.19	3		
		2.20	3		

Site 10: Rialto Beach					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	3	3.1	2
1.2	2	2.2	1	3.2	1
1.3	0	2.3	2	3.3	1
1.4	1	2.4	3	3.4	1
1.5	2	2.5	2	3.5	1
1.6	0	2.6	0	3.6	0
1.7	0	2.7	2	3.7	1
1.8	0	2.8	0	3.8	1
1.9	0	2.9	0	3.9	1
1.10	0	2.10	0	3.10	1
		2.11	0	3.11	0
		2.12	0	3.12	0
		2.13	1	3.13	0
		2.14	1	3.14	2
		2.15	3		
		2.16	3		
		2.17	1		
		2.18	0		
		2.19	1		
		2.20	0		

Site 11: Second Beach					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	1
1.2	2	2.2	2	3.2	0
1.3	0	2.3	0	3.3	1
1.4	0	2.4	1	3.4	1
1.5	1	2.5	0	3.5	1
1.6	0	2.6	0	3.6	0
1.7	0	2.7	0	3.7	3
1.8	2	2.8	1	3.8	1
1.9	1	2.9	0	3.9	2
1.10	0	2.10	0	3.10	1
		2.11	1	3.11	1
		2.12	0	3.12	3
		2.13	3	3.13	0
		2.14	1	3.14	2
		2.15	1		
		2.16	3		
		2.17	0		
		2.18	1		
		2.19	1		
		2.20	2		

Site 12: Ruby Beach					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	3
1.2	2	2.2	2	3.2	0
1.3	0	2.3	0	3.3	1
1.4	0	2.4	3	3.4	1
1.5	1	2.5	1	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	1	3.7	3
1.8	0	2.8	0	3.8	1
1.9	1	2.9	0	3.9	2
1.10	0	2.10	0	3.10	2
		2.11	0	3.11	1
		2.12	0	3.12	1
		2.13	3	3.13	0
		2.14	2	3.14	2
		2.15	3		
		2.16	3		
		2.17	0		
		2.18	0		
		2.19	0		
		2.20	0		

Site 13: Kalaloch Lodge Area					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	3	3.1	3
1.2	2	2.2	1	3.2	0
1.3	0	2.3	2	3.3	1
1.4	1	2.4	3	3.4	1
1.5	2	2.5	3	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	3
1.8	0	2.8	0	3.8	1
1.9	1	2.9	2	3.9	2
1.10	0	2.10	3	3.10	1
		2.11	0	3.11	1
		2.12	3	3.12	0
		2.13	1	3.13	0
		2.14	2	3.14	0
		2.15	2		
		2.16	2		
		2.17	2		
		2.18	0		
		2.19	1		
		2.20	1		

Site 14: Lake Quinault Lodge Area					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	3	3.1	3
1.2	0	2.2	1	3.2	1
1.3	1	2.3	0	3.3	2
1.4	0	2.4	3	3.4	2
1.5	1	2.5	2	3.5	2
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	1
1.8	3	2.8	0	3.8	1
1.9	1	2.9	3	3.9	1
1.10	0	2.10	3	3.10	1
		2.11	3	3.11	1
		2.12	3	3.12	0
		2.13	1	3.13	0
		2.14	2	3.14	0
		2.15	2		
		2.16	3		
		2.17	2		
		2.18	1		
		2.19	1		
		2.20	0		

Site 15: Snoqualmie Falls					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	3	3.1	3
1.2	1	2.2	1	3.2	1
1.3	1	2.3	0	3.3	1
1.4	1	2.4	3	3.4	1
1.5	1	2.5	2	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	2
1.8	2	2.8	0	3.8	1
1.9	1	2.9	3	3.9	3
1.10	3	2.10	2	3.10	2
		2.11	2	3.11	0
		2.12	3	3.12	3
		2.13	2	3.13	2
		2.14	2	3.14	3
		2.15	2		
		2.16	0		
		2.17	3		
		2.18	3		
		2.19	0		
		2.20	0		

APPENDIX E: WASHINGTON RESEARCH ASSISTANT FULL INDEX DATA

The following sets of data include the full index application data for the 15 Washington sites as completed by the research assistant. These scores correspond with the version of the TII-WBNS as presented in Table 5.1, with updates instated from the Iceland application period described in Table 5.8 (Chapter Five).

Site 1: Dungeness Park					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	3	3.1	0
1.2	2	2.2	1	3.2	0
1.3	0	2.3	0	3.3	1
1.4	0	2.4	3	3.4	0
1.5	0	2.5	2	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	1
1.8	1	2.8	2	3.8	1
1.9	1	2.9	0	3.9	1
1.10	0	2.10	1	3.10	1
		2.11	0	3.11	0
		2.12	3	3.12	1
		2.13	3	3.13	0
		2.14	1	3.14	1
		2.15	2		
		2.16	0		
		2.17	3		
		2.18	0		
		2.19	0		
		2.20	0		

Site 2: Tongue Point					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	3	3.1	0
1.2	2	2.2	1	3.2	0
1.3	0	2.3	2	3.3	1
1.4	1	2.4	3	3.4	1
1.5	0	2.5	2	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	3
1.8	0	2.8	3	3.8	1
1.9	1	2.9	0	3.9	1
1.10	0	2.10	1	3.10	1
		2.11	2	3.11	1
		2.12	3	3.12	2
		2.13	1	3.13	1
		2.14	1	3.14	3
		2.15	2		
		2.16	2		
		2.17	3		
		2.18	0		
		2.19	0		
		2.20	0		

Site 3: Madison Creek Falls					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	3	3.1	1
1.2	1	2.2	1	3.2	0
1.3	1	2.3	0	3.3	0
1.4	1	2.4	2	3.4	1
1.5	1	2.5	0	3.5	1
1.6	1	2.6	0	3.6	0
1.7	2	2.7	0	3.7	1
1.8	0	2.8	0	3.8	1
1.9	0	2.9	0	3.9	1
1.10	0	2.10	0	3.10	3
		2.11	0	3.11	2
		2.12	0	3.12	2
		2.13	1	3.13	2
		2.14	1	3.14	3
		2.15	3		
		2.16	2		
		2.17	0		
		2.18	0		
		2.19	1		
		2.20	3		

Site 4: Lake Crescent Lodge Area					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	3	3.1	3
1.2	0	2.2	1	3.2	1
1.3	0	2.3	2	3.3	0
1.4	0	2.4	3	3.4	0
1.5	0	2.5	1	3.5	0
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	2
1.8	0	2.8	0	3.8	1
1.9	0	2.9	2	3.9	2
1.10	0	2.10	3	3.10	1
		2.11	2	3.11	0
		2.12	3	3.12	0
		2.13	3	3.13	0
		2.14	1	3.14	0
		2.15	3		
		2.16	3		
		2.17	0		
		2.18	0		
		2.19	0		
		2.20	1		

Site 5: Marymere Falls					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	3	3.1	2
1.2	1	2.2	1	3.2	0
1.3	1	2.3	0	3.3	0
1.4	1	2.4	3	3.4	1
1.5	0	2.5	2	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	0
1.8	0	2.8	0	3.8	1
1.9	0	2.9	0	3.9	1
1.10	0	2.10	0	3.10	1
		2.11	0	3.11	1
		2.12	3	3.12	0
		2.13	3	3.13	0
		2.14	1	3.14	1
		2.15	2		
		2.16	2		
		2.17	0		
		2.18	0		
		2.19	2		
		2.20	2		

Site 6: Log Cabin Resort					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	3	3.1	1
1.2	0	2.2	1	3.2	1
1.3	0	2.3	2	3.3	1
1.4	0	2.4	3	3.4	1
1.5	1	2.5	3	3.5	1
1.6	1	2.6	0	3.6	1
1.7	0	2.7	2	3.7	2
1.8	1	2.8	3	3.8	1
1.9	0	2.9	2	3.9	1
1.10	0	2.10	3	3.10	1
		2.11	0	3.11	1
		2.12	2	3.12	1
		2.13	1	3.13	1
		2.14	1	3.14	1
		2.15	3		
		2.16	3		
		2.17	3		
		2.18	0		
		2.19	1		
		2.20	1		

Site 7: Pillar Point					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	3	3.1	0
1.2	2	2.2	1	3.2	0
1.3	0	2.3	2	3.3	0
1.4	1	2.4	2	3.4	1
1.5	1	2.5	1	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	0	3.7	3
1.8	0	2.8	0	3.8	1
1.9	1	2.9	0	3.9	1
1.10	3	2.10	0	3.10	1
		2.11	0	3.11	2
		2.12	0	3.12	3
		2.13	0	3.13	2
		2.14	0	3.14	3
		2.15	3		
		2.16	2		
		2.17	0		
		2.18	2		
		2.19	0		
		2.20	1		

Site 8: Sand Point					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	1
1.2	2	2.2	2	3.2	0
1.3	0	2.3	0	3.3	0
1.4	0	2.4	2	3.4	0
1.5	0	2.5	1	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	1
1.8	0	2.8	0	3.8	1
1.9	1	2.9	0	3.9	1
1.10	0	2.10	0	3.10	1
		2.11	0	3.11	0
		2.12	0	3.12	0
		2.13	3	3.13	0
		2.14	1	3.14	2
		2.15	1		
		2.16	0		
		2.17	0		
		2.18	0		
		2.19	2		
		2.20	0		

Site 9: Ozette Campground					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	2	3.1	1
1.2	0	2.2	2	3.2	0
1.3	0	2.3	2	3.3	1
1.4	0	2.4	1	3.4	1
1.5	1	2.5	0	3.5	1
1.6	1	2.6	0	3.6	1
1.7	0	2.7	2	3.7	1
1.8	0	2.8	2	3.8	1
1.9	0	2.9	0	3.9	1
1.10	0	2.10	1	3.10	1
		2.11	0	3.11	1
		2.12	0	3.12	0
		2.13	2	3.13	0
		2.14	1	3.14	2
		2.15	3		
		2.16	3		
		2.17	1		
		2.18	0		
		2.19	3		
		2.20	3		

Site 10: Rialto Beach					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	3	3.1	2
1.2	2	2.2	1	3.2	0
1.3	0	2.3	2	3.3	1
1.4	0	2.4	3	3.4	0
1.5	0	2.5	3	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	3
1.8	0	2.8	0	3.8	1
1.9	1	2.9	0	3.9	1
1.10	0	2.10	0	3.10	1
		2.11	0	3.11	1
		2.12	0	3.12	2
		2.13	3	3.13	0
		2.14	0	3.14	2
		2.15	0		
		2.16	3		
		2.17	0		
		2.18	0		
		2.19	0		
		2.20	0		

Site 11: Second Beach					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	1
1.2	2	2.2	2	3.2	0
1.3	0	2.3	0	3.3	1
1.4	0	2.4	1	3.4	1
1.5	0	2.5	0	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	0	3.7	3
1.8	0	2.8	0	3.8	1
1.9	1	2.9	0	3.9	1
1.10	0	2.10	0	3.10	1
		2.11	1	3.11	1
		2.12	0	3.12	3
		2.13	3	3.13	0
		2.14	1	3.14	2
		2.15	1		
		2.16	3		
		2.17	0		
		2.18	1		
		2.19	0		
		2.20	0		

Site 12: Ruby Beach					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	2	3.1	3
1.2	2	2.2	2	3.2	0
1.3	0	2.3	0	3.3	1
1.4	0	2.4	3	3.4	1
1.5	0	2.5	0	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	1	3.7	3
1.8	0	2.8	0	3.8	1
1.9	1	2.9	0	3.9	2
1.10	0	2.10	0	3.10	2
		2.11	0	3.11	1
		2.12	0	3.12	1
		2.13	3	3.13	0
		2.14	2	3.14	1
		2.15	3		
		2.16	3		
		2.17	0		
		2.18	0		
		2.19	0		
		2.20	0		

Site 13: Kalaloch Lodge Area					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	3	2.1	3	3.1	3
1.2	2	2.2	1	3.2	0
1.3	0	2.3	2	3.3	1
1.4	1	2.4	3	3.4	1
1.5	1	2.5	3	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	3
1.8	0	2.8	0	3.8	1
1.9	1	2.9	1	3.9	2
1.10	0	2.10	3	3.10	1
		2.11	0	3.11	1
		2.12	3	3.12	0
		2.13	1	3.13	0
		2.14	2	3.14	1
		2.15	2		
		2.16	2		
		2.17	2		
		2.18	0		
		2.19	0		
		2.20	1		

Site 14: Lake Quinault Lodge Area					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	3	3.1	3
1.2	0	2.2	1	3.2	1
1.3	0	2.3	0	3.3	2
1.4	0	2.4	3	3.4	2
1.5	1	2.5	2	3.5	2
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	1
1.8	3	2.8	0	3.8	1
1.9	1	2.9	3	3.9	1
1.10	0	2.10	3	3.10	1
		2.11	3	3.11	1
		2.12	3	3.12	0
		2.13	1	3.13	0
		2.14	2	3.14	0
		2.15	2		
		2.16	3		
		2.17	2		
		2.18	1		
		2.19	1		
		2.20	0		

Site 15: Snoqualmie Falls					
Section 1: BLV		*Section 2: PDI*		*Section 3: ABI*	
Indicator	Score	Indicator	Score	Indicator	Score
1.1	1	2.1	3	3.1	3
1.2	1	2.2	1	3.2	1
1.3	0	2.3	0	3.3	1
1.4	0	2.4	3	3.4	1
1.5	1	2.5	3	3.5	1
1.6	1	2.6	0	3.6	0
1.7	0	2.7	2	3.7	3
1.8	0	2.8	0	3.8	1
1.9	0	2.9	3	3.9	1
1.10	0	2.10	2	3.10	3
		2.11	2	3.11	0
		2.12	3	3.12	0
		2.13	1	3.13	0
		2.14	2	3.14	0
		2.15	2		
		2.16	0		
		2.17	0		
		2.18	3		
		2.19	0		
		2.20	0		