Evaluating Wilderness Perception Mapping with the Addition of 3D Analysis: A Case Study in Pukaskwa National Park

Ryan Garnett

OUTD 9901

Dr. Harvey Lemelin

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Abstract

This research analyzed the wilderness area in Pukaskwa National Park with the use of the Wilderness Perception Mapping methodology. The research developed and employed a modified version of the Wilderness Perception Mapping methodology to provide wilderness perception mapping using the third dimension to analyze locations of visual impact. The locations identified with the traditional and modified Wilderness Perception Mapping methodologies were used as a basis for comparison between the two Wilderness Perception Mapping methodologies and with the established wilderness zone identified by Pukaskwa National Park. The methodology from the traditional Wilderness Perception Mapping was utilized in conjunction with 3D analysis techniques to spatially identify potential wilderness areas based on visual ability. When compared to the traditional Wilderness Perception Mapping methodology, viewshed analysis within a GIS generated spatial locations of potential wilderness which significantly increased wilderness areas. Further viewshed analysis was conducted to implement natural visual barriers from forested areas and compare the results to the previous two analyses, which resulted in increased potential wilderness areas within Pukaskwa National Park.

KEY WORDS: Wilderness, Wilderness Perception, Wilderness Perception Mapping, GIS, Visualization, Viewshed Analysis, 3D Analysis and Park Management.

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Glossary of Terms

2D

The term 2D refers to the second dimension, referring to the X and Y component in a spatial context.

3D

The term 3D refers to the third dimension, referring to the X, Y and Z component in a spatial context.

3D Analysis

The term 3D Analysis refers to conducting viewshed and line-of- sight analysis on geospatial data.

3D Model

“A representation of a three-dimensional, real-world object in a map or scene, with elevation values (z-values) stored within the feature's geometry. Besides geometry, 3D features may have attributes stored in a feature table” (ESRI, 2010, pg. 3).

DEM (Digital Elevation Model)

“The representation of continuous elevation values over a topographic surface by a regular array of z-values, referenced to a common datum. Digital Elevation Models are typically used to represent terrain relief” (ESRI, 2010, pg. D).

Geovisualization

"Short for Geographic Visualization, refers to a set of tools and techniques supporting geospatial data analysis through the use of interactive visualization" (Wikipedia, 2010, no page).

GIS

"Acronym for geographic information system. An integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes. A GIS provides a framework for gathering and organizing spatial data and related information so that it can be displayed and analyzed" (ESRI, 2010, pg. G).

Line

"On a map, a shape defined by a connected series of unique x, y coordinate pairs. A line may be straight or curved" (ESRI, 2010, pg. L).

Line-of- Sight

"A line drawn between two points, an origin and a target, that is compared against a surface to show whether the target is visible from the origin and, if it is not visible, where the view is obstructed" (ESRI, 2010, pg. L).

Point

"A geometric element defined by a pair of x, y coordinates" (ESRI, 2010, pg. P).

Polygon

“On a map, a closed shape defined by a connected sequence of x,y coordinate pairs, where the first and last coordinate pair are the same and all other pairs are unique” (ESRI, 2010, pg. P).

Shapefile

“A vector data storage format for storing the location, shape and attributes of geographic features. A shapefile is stored in a set of related files and contains one feature class” (ESRI, 2010, pg. S).

Viewshed

“The locations visible from one or more specified points or lines. Viewshed maps are useful for such applications as finding well-exposed places for communication towers, or hidden places for parking lots” (ESRI, 2010, pg. V).

Wilderness Perception Mapping

The method of applying an individual’s perspective on wilderness in a spatial context which can be mapped geospatially (Kliskey, 1994).

Chapter 1: Introduction

Introduction

The perception of a wilderness recreationalist can vary greatly depending on various internal and external factors. Influences to wilderness perceptions have been associated with human development, visual impact and social context (Kliskey, 1994, 1998; Stankey, 1972; Lutz et al., 1999 and Jones et al., 2004). A wide range of research on wilderness perceptions has been conducted. However, research related to the spatial distribution of an individual's wilderness perception has been exclusively conducted by Kliskey (1994) and Flanagan and Anderson (2008). Analysis of the spatial distribution of human developed features and activities in wilderness areas, provided insight into the potential wilderness areas present in wilderness managed areas. The analysis of wilderness from a 2D and 3D (see Glossary of Terms) perspective provided datasets for comparison, to evaluate perceived wilderness and wilderness management designated wilderness zones.

Pukaskwa National Park in Ontario was the primary location for data analysis. The Wilderness Perception Mapping methodology was conducted on geospatial data for Pukaskwa National Park and surrounding areas, in addition to a modified Wilderness Perception Mapping approach, which employed the use of 3D visualization. Wilderness Perception Mapping has been utilized to analyze regions in New Zealand and southern Colorado (Kliskey, 1994 and Flanagan and Anderson, 2008). A combination of freely available geospatial data, including vectors, satellite imagery and digital elevation models (see Glossary of Terms), in conjunction with GPS field surveyed data and geospatial data provided by Pukaskwa National Park, was utilized as a means for analysis.

The comparison between the traditional Wilderness Perception Mapping methodology (2D approach) and the modified Wilderness Perception Mapping methodology (3D approach) was a basis for understanding perceived wilderness areas within Pukaskwa National Park. Resulting data from the two approaches were compared to the established wilderness zone, identified in the presently available Pukaskwa National Park Management Plan, to distinguish any differences between the Pukaskwa National Park wilderness area and the social-oriented Wilderness Perception Mapping wilderness area. Prior to the comparison to the Pukaskwa National Park wilderness zones, the 3D visual wilderness regions were compared to 2D wilderness regions in order to understand the spatial differences between wilderness areas generated from the 2D and 3D Wilderness Perception Mapping methodology. The output spatial locations from the 2D and 3D Wilderness Perception Mapping methodology were compared to the wilderness zones in Pukaskwa National Park. In addition, the differences of wilderness locations between park management zoning and wilderness recreational perceptions generated from the 2D and 3D analysis were evaluated. The comparison provided an understanding of wilderness zoning from a park management perspective and of potential regions of wilderness perceived by wilderness recreationalists.

Wilderness Management in Canadian National Parks

The management of protected wilderness areas in Canada is conducted at the federal provincial, territorial and regional levels. Federally designated wilderness is defined and managed by Parks Canada under the National Parks Act.

The National Parks Act in Canada defines wilderness areas through management regulations or legislation (Government of Canada, 2010). “In these declared wilderness areas, the legislation only permits development and activities required for essential services and resource protection. Wilderness designation is one of a range of tools to ensure the preservation of wilderness values and will not change current visitor use of the area. Zoning and landscape management unit objectives will determine levels of use in declared wilderness areas" (Government of Canada, 2010, pg. 63).

On-site research location

Pukaskwa National Park provided the geospatial field survey locations for data accuracy modification and data collection. Data accuracy and collection were based on the availability of free geospatial data (see Appendix 2). Data accuracy enhancements and data collection consisted of the use of GPS units, in conjunction with freely available satellite and vector data. Frontcountry and backcountry areas, identified by the most current Pukaskwa National Park management plan, were addressed, as well as surrounding areas within eight kilometres of the park boundary. An eight kilometre buffer beyond the park boundary was selected as it is more than two times the greatest buffer distance identified by Kliskey (1994) in the Wilderness Perception Mapping methodology. The eight kilometre buffer provides additional distance for the viewshed analysis. A literature review did not provide insight on the spatial distance individuals can see and recognize. While that research would be extremely informative it is out of the scope of the current project.

Pukaskwa National Park

Pukaskwa National Park, located on the shores of Lake Superior in Northwestern Ontario, is the largest national park in Ontario (Canadian Heritage Parks Canada, 1995). Officially opened in 1983, Pukaskwa represents rugged landscape in the boreal forest that is home to woodland caribou, black bear and wolves (Canadian Heritage Parks Canada, 1995). The park is approximately 1,878 km^2 in size, located 300 km east of Thunder Bay and 400 km northwest of Sault Ste. Marie, Ontario (Canadian Heritage Parks Canada, 1995). Although national parks are managed through various zoning strategies, the wilderness zone in Pukaskwa National Park represents approximately 99% of the total area of the park, with the remaining four zones, Special Preservation, Natural Environment, Recreation and Park Services, occupying less than 2 km^2, or 1% of the total park area (Canadian Heritage Parks Canada, 1995). The visitation rate of Pukaskwa is one of the lowest within the Parks Canada system. According to the 2009-2010 visitation season statistics, Pukaskwa National Park received 6,289 visitors, making it the 13th least visited park in the Canadian National Park system and the 5th least visited of the southern parks located in the ten Canadian provinces (Brackley et al., 2011). Pukaskwa National Park is divided into two main zonal differences; front country and backcountry. The frontcountry region of Pukaskwa represents 1% or 2km ^{2} of the park. The frontcountry of Pukaskwa National Park is comprised of a campground for tents and campers, an administrative office, visitor centre and frontcountry walking trails. The Pukaskwa backcountry is primarily natural and untouched. Backcountry visitors to Pukaskwa National Park participate in activities along the Lake Superior coast on the Coastal Hiking Trail. The Coastal Hiking Trails is a 57 km backcountry trail containing 15 backcountry campsites. Pukaskwa National Park receives some of the lowest visitation rates in the national park system. Pukaskwa National Park received 6,289 visitors during the 2009-2010 season; the number of backcountry visitors is unknown, but expected to be very low. The combination of Pukaskwa National Park's physical environment, geographic location and low visitation rates makes Pukaskwa National Park an ideal research location to study the perception of wilderness recreationalists.

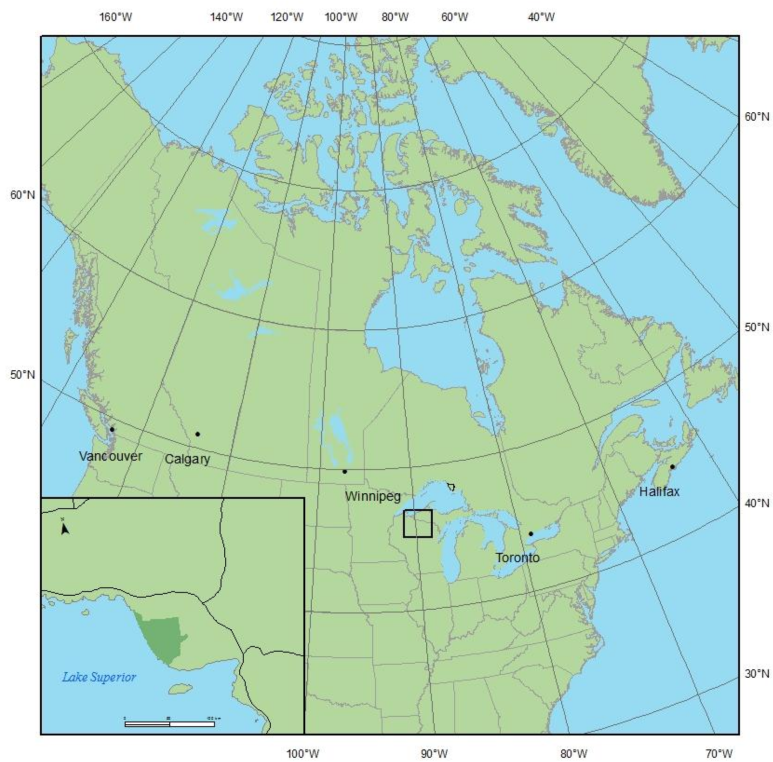

Figure 1: Pukaskwa National Park

Purpose

As stated earlier, research on wilderness perceptions and the development of an individual's wilderness perception, has shown a wide range of factors and influences that help formulate an individual's perception of wilderness. Researchers have emphasized the need to further understand the relationship between visitor attitudes and recreation impacts as an essential and often less examined, method of improving wilderness management (Jones et al., 2004). Attitudinal studies have shown that there are differences between particular approaches to protected area management and perceptions of wilderness by visitors. Better understanding of the variation in meaning of the term 'wilderness' by various users would increase the knowledge and expectations of wilderness visitors to protected areas. This would assist in the analysis of expectations and management strategies and could help reduce potential conflicts in wilderness areas.

Mapping wilderness perceptions has been successfully accomplished in mountainous protected area in New Zealand and Colorado. The examples of Wilderness Perception Mapping by Kliskey in 1994 and Flanagan and Anderson (2008) utilized 2D spatial analysis; the third dimension, visual impacts were omitted from these studies. According to Kliskey and Flanagan and Anderson (2008), wilderness perception of recreationalists can be dynamic and complex, consisting, at a minimum, of social background, recreational activities, recreational specialization and visual perception.

This study aimed to illustrate the spatial differences that 3D visualization can provide to the Wilderness Perception Mapping methodology. Previous research has examined the relationship between visual preference and perception of wilderness and how participants from different recreational activities have different attitudes and perceptions of wilderness. A review of the literature did not provide any research identifying the use of 3D analysis to spatially locate perceived wilderness areas. This project analysed Pukaskwa National Park with the use of the traditional 2D Wilderness Perception Mapping methodology as well as a modified Wilderness Perception Mapping methodology to include 3D visualization analysis.

Relevance of the Study

The analysis of managed wilderness areas with the use of Wilderness Perception Mapping has currently been conducted in mountainous regions in a 2D context outside of Canada. This study provided applied research of the mechanism to understand how the addition of 3D visualization alters the Wilderness Perception Mapping methodology, and to spatially identify wilderness locations. The research provided a tool for assessing wilderness perceptions at a different geographic topographical location, within a Canadian context. The potential close proximity of northern protected areas to industrial areas creates the possibility of conflict. Understanding the spatial location of wilderness and the visual extent of industrial infrastructure can be used by managers of both protected areas and industrial companies, to help minimize the potential conflict between the recreationalists using the northern protected areas and the established industry located in proximity to them.

Mount Revelstoke and Glacier National Park's 'visitor experience strategy' identifies five key areas for engagement and interaction (Government of Canada, 2010). Three of the five areas: "virtual travelers," "pass-through experience" and "beyond the edge and into wilderness" highlight the need to engage or increase visitor experiences with new media technology or through a wilderness experience (Government of Canada, 2010). The 'virtual travelers' initiative aims to provide experiences in the park and historic sites "anywhere in the world that technology or media can reach" (Government of Canada, 2010, pg. 23). The aim of the 'pass-through experience' is to "reach out to visitors in their vehicles and on-board the rail tour trains, using new media technologies and other innovative communications" (Government of Canada, 2010, pg. 23). The purpose of 'Beyond the edge and into the wilderness' is to provide a "sense of connection and stewardship that may come from a single backcountry trip or be the result of a lifetime of visits and an ever-deepening love of these places" (Government of Canada, 2010, pg. 23). Mount Revelstoke and Glacier National Park have clearly identified the use of new media technology and wilderness experiences as key elements within the park's "visitor experience management strategy."

By using a Modified Wilderness Perception Mapping approach with the addition of 3D analysis we identified the extent of wilderness areas in Pukaskwa National Park.

Research Objectives

The research objective was to analyze the potential areas of wilderness in Pukaskwa National Park based on the use of 2D and 3D analysis using the Wilderness Perception Mapping methodology. The results of the 2D and 3D Wilderness Perception Mapping were correlated to the wilderness zoning of Pukaskwa National Park to understand any potential differences in wilderness management. The research question was "Does the use of traditional and modified Wilderness Perception Mapping techniques provide different wilderness locations in Pukaskwa National Park?"

Chapter 2: Literature Review

This chapter is divided along a thematic analysis. The thematic grouping represents the major subject matter as it relates to the contribution to the research study. Each grouping is associated with case studies associated to previous wilderness research.

Backcountry Recreation

The field of recreation is quite broad and containing a number of sub-groups or disciplines within the overarching body. Fields include, but are not limited to; indoor recreation, leisure, sports, outdoor recreation, adventure recreation, backcountry recreation and wilderness recreation (Hall, 1989; Pigram and Jenkins, 1999; Plummer, 2005; Watson and Roggenbuck, 1991). Recreation is also comprised of numerous elements consisting of relationships, influences and factors that have been studied, researched and analyzed. As Hall (1989) explains, participation in outdoor recreational activities can be influenced by various factors, including supply, demand, perceptions and economic factors. Methods associated with classifying outdoor recreational resources and opportunities have been devised and implemented in management decision making processes. Various classification methods and models have been developed, including the Recreational Opportunity Spectrum (ROS), 'classification' by the Bureau of Outdoor Recreation (BOR) and 'suitability' by the Canadian Land Inventory (CLI) (Hal, 1989; Pigram and Jenkins, 1999; Plummer, 2005).

Demand, in recreational geography, has been defined in four distinct ways (Hall, 1989). A traditional means of defining demand is derived from the neoclassical economic definition; "a schedule of the quantities of some commodity that will be consumed at a various price" (Hall, 1989, p. 45). The neoclassical definition is purely an economic means of understanding demand. While economics may be a contributing factor to outdoor recreational demand, it is not considered the sole influence. The second definition is also based in economic theory and represented by consumption and commodity. This definition can be useful in numerous scenarios, however, it is deemed ineffective at defining demand in an outdoor recreational context (Plummer, 2005; Hall, 1989).

Latent demand, or unmet demand, is a measurement between the potential level of consumption and the potential level of unmet demand (Hall, 1989). Latent demand has been utilized to help understand the opportunity value of a recreational resource in a future tense (Hall, 1989). The final definition of demand can be used to forecast future consumption by evaluating transformations relating to change in the supply or accessibility, resulting in the identification of the latent demand; or the potential creation of demand (Hall, 1989).

Components of outdoor recreation consist of diverse elements, including physical, environment and social. Many predominant factors of outdoor recreation have been contributed to the physical environment (Plummer, 2005; Pigram and Jenkins, 1999). Plummer (2005) argues that outdoor recreation is primarily "a unique feature of human societies and a form of behavior" (Plummer, 2005, p. 97). Through social psychology leisure and human behavior are defined and managed in recreational settings. Various approaches suggest Plummer (2005) have been created to understand these interactions; some of the most prominent are discussed next. Maslow's Hierarchy of Needs has regularly been used to help understand outdoor recreational behavior, and has a fundamental concept of need fulfillment which identifies five human needs as the basis of the model; physiological, safety, love, esteem and self-actualization (Plummer, 2005). According to Maslow, each level of the model, starting at the base of the pyramid, must be partially fulfilled before an individual moves onward to a higher level within the pyramid structure (Plummer, 2005). Iso-Ahola's Levels of Causality of Leisure Behavior is a model specializing on the motives associated with leisure behavior (Plummer, 2005). The Levels of Causality of Leisure Behavior is represented by four levels ; leisure needs, perceived freedom and competence, need for optimal arousal and incongruity, and biological dispositions and early socialization experiences, within these levels, the upper ranks of the pyramid model are apparent (Plummer, 2005).

Additional theories and models have been developed that help to explain and understand outdoor recreational behavior, including the Expectancy Theory, Dimensions of Leisure Behavior, Hierarchies of Demand in Outdoor Recreation and Satisfaction in Outdoor Recreation (Plummer, 2005). These are explained next, Expectancy Theory is focused around an idea that "certain behaviors will yield certain rewards" (Plummer, 2005, p. 103). Expectancy Theory is comprised of two factors; that an individual has a perceived value of the reward an identified behavior will be provide; and individuals participates in a specific behavior to gain specific rewards (Plummer, 2005). The Dimensions of Leisure Behaviors, as stated by Iso-Aloha, suggests that an individual's motives for participating in leisure activities can be explained by both the potential for escape and the search for opportunities; representing psychological satisfactions pursued by individuals (Plummer, 2005). Behavioral approaches consider actions that are specifically identified and directed by "goals and/or expected outcomes" be the underlying theme for motivation associated with participating in leisure activities. These motivations are best expressed in Manning's Hierarchies of Demand in Outdoor Recreation (i.e.: activities, setting, motives and benefits) (Plummer, 2005). Many of the models associated with understanding outdoor recreational behavior focus on motives, while Manning suggests that satisfaction is a significant element. Manning also states in outdoor recreation that basis for satisfaction, is complex, particularly due to the diversity of influencing and changing factors and environmental conditions (Plummer, 2005). This complexity is conceptualized as a combination of situational variables and subjective evaluations (Plummer, 2005).

The concept of backcountry recreation has a variety of meanings and definitions; however, for this research project backcountry recreation will be defined as a non-mechanized activity involving one or more of the following three activities: hiking, backpacking and paddling. Backcountry recreation will not be limited to distance of travel or length of stay, because of the variation between the recreational activities that are being studied in this research project. Typically, backcountry paddling occurs over a period of time, extending from an overnight stay, to multiple weeks or months. Hiking and backpacking in a backcountry setting typically involve travelling long distances. Backcountry recreation will be defined as activities that are undertaken in more remote and less developed areas; defined as regions with minimal human development (ie: roads, buildings and electrical infrastructure). Finally, backcountry activities can be participated in a group, including a commercial setting, or individual context. These types of activities are described as follows.

Backcountry travel by foot is a popular recreational activity. Backpacking, which is the act of travelling by foot carrying gear and supplies, in a natural setting, is known by various other terms, such as hiking, bushwalking, trampling, trekking and walking (Buckley, 2006). Recreationalists participate in backpacking activities in various geographical conditions, different seasons and for various lengths of time (Buckley, 2006).

Backcountry paddling can consist of numerous modes of travel, differing by method of travel and the vessel used. While there are differences between the various types of travel, backcountry paddling can be characterized as propulsion of a floating vessel without the use of a mechanical device (Buckley, 2006). The mode of travel ranges for backcountry paddling including; canoeing, kayaking and rafting. Backcountry paddling can take place in flat water bodies, rivers or oceans (Buckley, 2006). The wide range of modes of paddling, as well as the environment in which they occur, will not be limited in the research study. All potential non-mechanized modes of paddling, in any environmental water body, will be considered as paddling throughout the research study.

Wilderness Perception

Minimizing the impacts of recreation activities in wilderness areas requires monitoring and management strategies (Jones et al., 2004). In situations of multiple uses, this type of management can be exceptionally challenging and expensive. Attempts to understand wilderness perceptions of recreationalists have been conducted in various wilderness settings throughout the United States and Canada. Studies by Bultena and Taves (1961) collected data from interviews performed with over 428 campers and canoeists from 1956 to 1958 in the Superior National Forest, Minnesota, which provided some of the earliest understanding of visitor attitudes towards wilderness and forest management. Hendee et al. (1968) conducted their research in Glacier Peak Wilderness in Washington state, Three Sisters Wilderness in Oregon and Eagle Cap Wilderness in Oregon. This particular study focused on backpackers, day hikers and horseback riders in these protected areas; finding different wilderness perceptions between the recreational groups. Other early studies examining and measuring wilderness perceptions were conducted by Berger and Luckmann (1966). In this study they proposed that institutions, presumed to be experienced as concrete entities, are "actually social constructions in which the title of the institution…is often associated with attitudes towards its potential actions" (Jones, et al., 2004, pg. 51). Stankey (1972) examined the wilderness perceptions of 500 recreationalists (hikers, climbers, paddlers) visiting various wilderness areas throughout the US including: Bob Marshall in Montana, Bridger in Wyoming, High Uintas in Utah and the Boundary Waters Canoe Area in Minnesota. Many of these studies sought to understand the levels of wilderness purism in recreation. 'Wilderness purism' is a classification of various wilderness attributes consisting of infrastructures, solitude and remoteness (Bultena and Taves, 1961 and Hendee et al., 1968). The results of Bultena and Taves, Hendee et al., Young and Lucas suggested that visitors preferred "less than pure" wilderness experiences that are locations with human development and limited locations to experience solitude; while wilderness users preferred wilderness areas with less anthropogenic disturbances and more solitude.

More recent studies conducted by Lutz et al. (1999) and Jones et al. (2004) focusing on the social construct of wilderness recreationalists have also revealed various differences between rural and urban recreationists. The study involved 75 urban participants from Victoria, British Columbia and 75 rural participants from Telkwa, British Columbia. The results of the Lutz et al. (1999) study suggest that rural resident's perception of wilderness is less influenced by human interactions in natural settings, while urban residents are less tolerant to human related disturbances to natural environments. The study by Jones et al. (2004) during the summer of 2003 in Mt. Olympus Wilderness area in Utah noted differences in wilderness perceptions between rock climbers and non- rock climbers. Furthermore, Jones et al. discovered a significant difference in wilderness perception between sub groups of rock climbers.

Additional wilderness perception studies have been conducted that identified components of 'setting' related to wilderness, based on the recreationalist's perspective (Cole and Hall, 2009). The approach taken by Cole and Hall (2009) assessed the perceived sensitivity of experience associated with different setting attributes, which provided an empirical foundation for making decisions about the most significant indicators of wilderness settings. Cole and Hall (2009) concluded that elements impacting solitude, setting and human occurrence had the greatest influence associated with wilderness perception; in a positive and negative manner. The development of a recreationalist's perception of wilderness is dependent on individual experiences, social background and motivations associated to wilderness travel. As with other studies, solitude and human development had the greatest impact on the majority of recreationalists, regardless of the individual's social construct, level of wilderness experience or wilderness intensions (Cole and Hall, 2009; Higham et al., 2000a; Higham et al., 2000b)

An individual's wilderness perception can be based on various components, which may be physical, emotional or legislative (Higham et al., 2000b). Understanding the components that formulate an individual's wilderness perception can be associated with the level of involvement with the area, level of experience, social background and expectations (Kliskey, 1994; Higham et al., 2000a; Higham et al., 2000b; Stankey, 1973; Cole and Hall, 2009, Jones et al., 2004; Lutz et al., 1999). The perceptions of wilderness between backcountry users and non-wilderness users have similarities and striking differences, as noted by Higham et al. (2000b). These differences were categorized into four classes based on the Wilderness Purism Scale. The study concluded that the majority of the non-wilderness users were non-purists or neutralists, while the backcountry groups were identified as neutralists and moderate purists.

Social constructionists developed a theory that "perception of landscapes is often less objective because it is constantly being constructed differently among individuals according to their backgrounds and positions in the social environment" (Jones et al., 2004, p. 51). Participants defined as wilderness purists, preferred wilderness scenery to be pristine as a consequence of the learned values that they share for the institution of wilderness (Jones et al., 2004). In contrast, other individuals immersed within different social worlds prefer wilderness scenery as a function of a particular wilderness activity.

Wilderness Purism

Wilderness Purism Scaling (WPS) technique, developed by Stankey in 1973 is a system by which future researchers based their wilderness perception (Higham et al., 2000a). The wilderness purism scaling is based on four elements; artefactualism, naturalness, remoteness and solitude. The wilderness purism scale identified by Stankey (1972) classifies wilderness recreationalists into four classes; purist, moderate purist, neutralist and non- purist. The wilderness purism scale measures backcountry user's attitudes toward desired activities, infrastructure and settings defined as wilderness settings (Kliskey, 1994). Through sixteen items, participants identify the levels of wilderness desirability. The values from the sixteen questions are calculated to provide a score, which identifies the participant's wilderness purism level (see Table 1). The wilderness purism scores are calculated from a Wilderness Purism Mapping survey providing insight into the individual's wilderness perception. Higher scores from the survey implies a strong purist, while lower scores implies a non-purist.

Perception Level	Purism Class	Purism Score
1	Non-purist	16 – 45
2	Neutralist	46 – 55
3	Moderate Purist	56 – 65
4	Strong Purist	66 – 80

Table 1: Classification of perception levels based on purism scores
(Kliskey et al, 1994)

Wilderness perceptions have been consistently divided into groups associated with solitude, remoteness, human development and naturalness (Kliskey, 1994; Kliskey, 1998; Higham et al., 2000a; Higham et al., 2000b), and resulted in the creation the creation of the Wilderness Perception Scale (Stankey, 1972 and Stankey, 1973). Wilderness purism is influenced by physical facilities such as huts, tracks and bridges; as well as the attributes related to remoteness and solitude, such as mono-culture forests and mining adjacent to the wilderness areas. In a similar light, the Wilderness Purism Scale attempts to classify individuals into four classes, based on the perceived purism towards wilderness; strong purist, moderate purist, neutralist and non-purist (Stankey, 1972 and Stankey, 1973).

The Wilderness Purism Scale employs human development infrastructure such as trails, campsites, huts, bridges and roads, as well as elements of solitude and encounters with commercial recreational groups, as criteria to gage individuals' level of acceptance on a wilderness trip, to characterize them according to the Wilderness Purism Scale. Wilderness Purism Scale surveys were used to classify individual needs, tolerance to infrastructure and human development, and solitude. The Wilderness Purism Scale has been used in various wilderness research studies (Kliskey, 1994, 1995 and 1998; Higham et al. 2000a and 2000b). The following is a discussion of the four properties of Wilderness Perception Mapping.

Artefactualism is a property that describes any evidence of human activity in the recreational setting. Evidence of human activity may take the form of physical development, such as roads, trails, bridges, huts, toilets or campsites. Artefactualism can also consist of commercial activities such as logging, farming and mining. Tourist perceptions vary greatly across artefactualism (Higham et al., 2000a).

Naturalness, in the original research in New Zealand, was defined as an area with minimal ecological alterations. Elements of measuring naturalness according to the Wilderness Purism Scale include the following categories: minimum of two days to travel the area on foot and, stocking of non-native species, the existence of exotic trees and plants (Higham et al., 2000a). Within the case study in Pukaskwa National Park, the presence of forestry activities will serve as an indicatory of a none naturalness area.

The elements used to measure remoteness consist of areas free from motorized transportation, lack of road access to the area, and a great distance to urban developed areas (Higham et al., 2000a). Variables associated to remoteness have similar properties expressions as neutrality. Remoteness according to the levels of the purism scale is impacted by features associated to development (please see Appendix 1 for further details).

Solitude, as it is related to the Wilderness Purism Scale, is an intrinsic social element of a wilderness recreationalist. Solitude can be influenced by the number of participants to an area, and the presence (if any) of recreational activities as well as the density and/or encounters with individuals or groups. The idea of solitude is associated to individual experiences and constructs (Lutz et al., 1999).

Wilderness Perception Mapping

Solitude, remoteness and development have been long understood as elements that contribute to development of wilderness perception. Wilderness Perception Mapping, developed by Kliskey (1994), builds upon the research from the wilderness community to spatially map wilderness perceptions of wilderness recreationalists based on the Wilderness Purism Scale from Stankey (1972). Wilderness Perception Mapping employs Geographical Information Systems (GIS) to spatially identify geographic areas perceived as wilderness associated to the Wilderness Purism Scale. Wilderness Purism Scale is used with the Wilderness Perception Mapping methods to spatially classify geographic regions based on the four classes of wilderness purism.

Research conducted by Kliskey (1994, 1995 and 1998) focused on the North-West Nelson Ecological Region, comprised of the North-West Nelson Conservation Park and Kahurangi National Park on the south island of New Zealand. Backpackers and hikers completed the 16 question questionnaire in-order to illustrate their wilderness perceptions. The 16 questions provided a basis to generate a map of perceived wilderness areas for each of the four wilderness purism classes. The Wilderness Perception Mapping research by Kliskey in 1994 and 1995 was used to link to the Recreational Opportunity Spectrum (ROS) to generate a recreational opportunity map of the North-West Nelson Ecological Region based on the availability of backcountry recreational opportunities and wilderness perceptions (Kliskey, 1998).

The Wilderness Perception Mapping combined with the Recreational Opportunity Spectrum was also used in the San Juan National Forest and surrounding wilderness areas; Lizard Head Wilderness, Werninuche Wilderness and South San Juan Wilderness in south-western Colorado (Flanagan and Anderson, 2008). Flanagan and Anderson (2008) used four wilderness purism classes, strong purist, moderate purists, neutralists and non-purists as the classes for analysis, resulting in three purism classification areas. In this study, the strong purist, moderate purist and neutralist classes were represented, while the non-purist class was not distinctly different from the neutralist class.

Visual Perception of Wilderness

Visual perception studies provide additional information in the understanding of wilderness perceptions. For example Lutz et al. (1999) used a photo-based study and found significant differences between rural and urban participants of perceived anthropogenic activities. Lutz et al. (1999) concluded that rural visitors were more tolerant to anthropogenic disturbances than urban visitors (Lutz et al., 1999). Similar studies conducted by Hammitt and Patterson (1995) and Jones (1995) found that evidence of human impact (roads, buildings in surrounding towns) were scored significantly lower in visual preference than natural factors (Jones, 1995). This overview highlights the importance of visual landscapes to wilderness perceptions, while also recognizing individual differences. These various findings have resulted in differences in interpretations with some researchers arguing that visual preference is a social concept that is often highly subjective and personal, while others state that attitudes toward the natural landscape are dependent on its physical conditions and individual perceptions of the landscape (Jones et al. 2004).

Visual Perception

Visual impact assessment has been conducted through the help of images, photos and computer simulations (Palmer, 1979; Stevenson et al., 1979; Anderson, 1979; Paulson, 1979; Anderson et al., 1979; Kaplan, 1979; Hammitt, 1979; Hatfield et al., 1979; Blau et al., 1979; Angelo, 1979; Petrich, 1979 and Magill et al., 1979). Computer based visualization provides a method for simulating natural environment processes or changes to the environment. Computer based visualization provides a visual understanding of the natural environment at a variety of scales; site specific or landscape. Early technological limitations limited computer based visualization at the mid or large landscape level, confining computer based visualizations to site specific representations (Blau et al., 1979; Angelo, 1979 and Petrich, 1979). Site specific visualization, such as the study performed by Angelo (1979) who used computer graphics to visualize the proposed expansion of the Sunshine Ski Area in Banff National Park was limited by the available technology. The limitations during the Sunshine Ski Area expansion study reduced the visual area to a region 4,000' x 5,000' feet in size, which had to be plotted to paper maps for viewing. The availability of 3D rendering engines and graphics as the study by Angelo (1979) illustrates, limited the ability for real-time viewing.

Early computer based visualization of landscape level environments analyzed spatial data to generate 2D representations of landscape level viewsheds (Paulson, 1979, Hatfield et al., 1979 and Anderson, 1979). Hatfield et al. (1979) utilized computer aided visualization to determine the viewshed and line-of-sight of a proposed surface mine within the proximity of a national park in southern Colorado. Geographic data was utilized to gage the topographic composition of the region for line-of-sight analysis from the surface mine to all regions of the national park. The limitations of the technology required the data to be represented as a 2D colourized raster file (Hatfield et al., 1979).

Utilization of visualization and visual assistance for the understanding of visual impact and individuals' wilderness perception has recently adopted the use of photo based surveys to assist with social science analysis. Development of perceptions associated to wilderness and the natural environment are engrained with numerous factors, including a visual component (Jones et al., 2004, Lutz et al., 1999, Dorwart et al., 2010, Tahvanainen et al., 2001 and Buijs, 2009). The visual component provides a different developmental process in the development of a perception than verbal description (Tahvanainen et al., 2001). The visual component has a significant difference in the development of an individual's perception compared to verbal description (Tahvanainen et al., 2001). Visual perception studies also identify the importance of various visual components on an individual's wilderness perception (Jones et al., 2004; Jones et al., 2000 and Lutz et al., 1999).

Photography based visual perception studies have been used to assist with the understanding of management practices and the impact on individual's recreation and wilderness experience. Jones et al. (2004) employed photographs to understand the impact that rock climbing fixed anchors has on the rock climber's and hiker's wilderness perception. The visual survey provided a means to quantify the role and impact the visual component has on an individual's wilderness perception. Similar studies have been conducted elsewhere, including the comparison of visual perception of wilderness between urban and rural residents by Lutz et al. (1999). Implementing visual analysis and landscape aesthetics is somewhat subjective (Kroh and Gimblett, 1992). Especially since landscape locations can vary in scenic beauty and cultural significance. Furthermore, the variation inherent in a landscape location is compounded by the number and range of user experiencing the landscape; resulting in difficulties classifying the perceived visual value of the area.

Spatial Context of Wilderness

Wilderness as a concept and a location has numerous meanings and values depending on the individual assessing the location. Wilderness has been categorized using the following terms of reference; remoteness, solitude and minimal human development (Kliskey, 1994; Kliskey et al., 1994; Kliskey, 1995; Lucas, 1980, Jones et al. 2004). The classification of wilderness from a spatial perspective has typically been conducted from an ecological view at the landscape scale. However as discussed earlier, spatial understanding of wilderness has also been explored with a social approach by Kliskey (1994, 1995 and 1998) and Flanagan and Anderson (2008). Social approaches are used in the Wilderness Perception Mapping technique to provide a spatial context to wilderness. However, such approaches have been over-shadowed by the ecological landscape level spatial understanding of wilderness.

The classification and evaluation of wilderness has been tied to the naturalness of the area and the natural processes which are present within the wilderness area (White et al., 2000). Ecological processes have been used as the basis to evaluate wilderness in numerous wilderness research projects. White et al. (2000) discuss the use of species and gene flow characteristics on the ecological landscape as a means to understand and evaluate wilderness characteristics. The natural processes and make-up of the environment is discussed as the means to assess and evaluate the wilderness health. White et al. (2000) expanded these discussions by incorporating certain ecological processes such as forest density and forest composition as elements of wilderness. The ecological processes are the primary agents in the understanding of the wilderness environment. The ecological approach to wilderness management and wilderness understanding is reflected in the work by Gray and Davidson (2000). The approach proposed by Gray and Davidson (2000) is based on a landscape definition similar to White et al. (2000). Aplet et al. (1999) refer to the following explanation of wilderness from the ecologist David Cole:

> …"that wilderness is expected to be both untrammeled, or uncontrolled and free, and pristine, or what would have existed in the absence of post-aboriginal humans". Cole concludes that these two goals provide conflicting direction for managers, as manipulation is often needed to repair damage caused by overuse, exotic species invasions, fire exclusion, and other processes that have altered ecosystems away from natural conditions. Cole argues that these goals are to some extent mutually exclusive and proposes a system of wilderness zoning that emphasizes different goals on different tracts (Aplet et al., 1999, pg. 2).

While Cole touches on factors that are associated with social elements of wilderness, the basis for Cole's explanation is from an ecological viewpoint. Aplet et al. (1999) argued that naturalness and freedom are the basis for signifying wilderness and are features that can be used to provide spatial context to wilderness. Naturalness, as defined by Aplet et al. (1999) utilizes an ordinal range from artificial to pristine; whereas freedom is based on an ordinal range from controlled to self-willed (Aplet et al., 1999). Within naturalness and freedom, solitude, remoteness, uncontrolled processes, natural composition, unaltered structure and pollution or lack thereof have been identified as indicators of wilderness. These six indicators combined by Aplet et al. (1999), were used with spatial data within a GIS to spatially identify wilderness areas at the landscape level within the United States.

Spatial context has been used to identify areas of wilderness based on both ecological and social connotation using established indicators, rather than on the wilderness values of the individual; literature related to spatial context and wilderness is lacking research in the geographic understanding of wilderness from the perception of the individual.

Chapter 3: Methods

Wilderness perceptions have been studied in many capacities from various geographical locations. Earlier wilderness perception research was conducted to help understand the motives and attitudes of the wilderness recreationalist. Advancements in computer technology and geographical information systems (GIS) have assisted with creating correlations between wilderness perceptions and geographical locations. Hickey and Lawson (2005) state that spatial science and critical human geography have core values that are connected by open inquiry, continuing questioning and reflexivity. Hickey and Lawson (2005) argue that reflexivity is vastly important because the "principle of open inquiry ultimately rests on constant interrogation of our questions and evidence. Reflexivity is defined as the interdependence of what is observed and the observer(s)" (Hickey and Lawson, 2005, p. 100). The practice of reflexive research requires researchers to probe questions of "what is the connection between the scientist and the science and what impact does that connection have?" (Hickley and Lawson, 2005, p. 100).

Insight into the researcher's previous life experiences will be provided to assist with the understanding of how the researcher acquired the information and desire to undertake a graduate level research project. Following the information related to the researcher's world perspective, detailed information related to the research methodology will be provided.

Researcher's World Perspective

My wilderness perception has been developed through personal and social experiences over a period of ten years. I grew up in a small, rural town on the eastern shore of Nova Scotia in a single-parent family. Upon completing high school, I enrolled in the

Geography program at Saint Mary's University in Halifax, Nova Scotia, before transferring to Lakehead University in Thunder Bay, Ontario and earning an Honours degree in Outdoor Recreation, Parks and Tourism with a bachelor's degree in Geography. After graduating from Lakehead University, I completed an Advanced Diploma in Remote Sensing at the Center of Geographic Science in Lawrencetown, Nova Scotia. My perceptions of wilderness were influenced while attending my undergraduate studies at Lakehead University. During the summer months between university studies, I worked for Parks Canada in Jasper National Park in Alberta and Mount Revelstoke/Glacier National Park in British Columbia. The experiences as I traveled increased my understanding of wilderness. My perceptions and attitudes of wilderness continued to expand. My professional experiences acquired from working in the geovisualization industry provided a different view of wilderness perception, specifically the visual-spatial distribution of wilderness.

Research Methodology

Kliskey's research on Wilderness Perception Mapping was grounded in the Behavioral Geography Theory. An approach aimed at understanding how dimensional analysis can be implemented into planning and management decision frameworks related to the definition of wilderness areas. The research conducted by Kliskey (1994), and Flanagan and Anderson (2008), utilized spatial analysis approaches specifically related to two dimensional analysis. This research provided analysis as to how the use of the third dimension can assist with wilderness perception mapping within the context of Pukaskwa National Park.

Traditionally, planning and management decisions have utilized GIS and spatial analysis in the context of 2D analysis (Llobera, 2001). Omitting the third dimension (3D) undermines the importance of, and factors related to, visual impact. The theory of visual representation and perception identifies the importance individuals place on visual information within the decision making process (Lurie and Mason, 2007; Langdon and Coltheart, 2001). Visual representation makes use of "the uniquely human ability to recognize meaningful patterns" (Laurie and Mason, 2007, p. 161). Visual representation consists of numerous exemplifications including virtual reality; computer displays and simulations in a three dimensional interactive visual environment (Laurie and Mason, 2007). Visual representations, such as 3D virtual reality have been demonstrated to change the relationship between visual information and decision making abilities (Laurie and Mason, 2007).

Further research related to visual impacts and visual importance associated with wilderness perception has been conducted illustrating the level of importance individuals place on the visual element (Lutz et al, 1999; Jones et al., 2004).

> "To date, the use of GIS to explore human space, i.e. as encountered by an individual, has been very limited. This is partly due to the fact that most GIS operations are based on a traditional geographical view of space which is essentially two-dimensional with a fixed and external frame of reference. The absence of GIS procedures that consider terrain and built environment representations together is a clear indication, among others, of these limitations. Hence, traditional GIS operations are inadequate for developing models of human–space interaction, particularly human perception, whenever a mobile frame of reference is considered. Though some attempts exist to relate GIS with cognition and perception, these have mostly concentrated on landscape preference. Ultimately, the design of new GIS routines, and/or the development of new spatial tools that will

accommodate human and other factors, will become necessary if cognitive and perceptual factors are to be linked with spatial information. In the meantime, existing GIS can be used to illustrate the necessity and potential of these types of analyses." (Llobera, 2001, p. 25).

This research aimed to take the fundamentals of visual perception and apply these to the existing Wilderness Perception Mapping methodology to help increase how understanding how adding the third dimension impacts affects perceptions or definitions of within the context of Pukaskwa National Park.

The Wilderness Perception Mapping analysis was conducted with the use of freely available geospatial data. The geospatial data used in the original research conducted by Kliskey (1994) was vector data collected at a 1:250,000 scale. The geospatial data utilized for the author's research project consisted of a combination of freely available vector data collected at a 1:50,000 scale, Landsat ETM+ satellite imagery, field collected GPS data and digitally transcribed paper maps. Geospatial data from Pukaskwa National Park had limited impact on the research as a consequence of the lack of available data during the analysis portion of the study. The geospatial data was analyzed with the use of ESRI ArcGIS version 10, with the assistance of the 3D Analysis extension.

The Wilderness Perception Mapping performed by Kliskey in the mid 1990's utilized 2D mapping techniques. Mapping technologies in the 1990's were restricted to 2D analysis because of software and hardware limitations of the time. This study modified the techniques used by Kliskey by incorporating 3D visualization techniques, in addition to 2D mapping. The 3D Analysis performed utilized 3D viewshed analysis with bare earth digital elevation models (DEMs). Anthropogenic features were analyzed using 3D analysis to understand the visual impacts of human developed infrastructures. Anthropogenic features identified by Kliskey were used in the 2D and 3D visual analysis (see Appendix 1 for a list of the features). The mapping methods, 2D mapping and 3D viewshed analysis, were performed in Pukaskwa National Park to identify potential locations of conflict. Modifying the original methods employed by Kliskey by the addition of visual analysis improved the analysis of Wilderness Perception Mapping beyond static feature distance mapping. The addition of visual analysis identified the ability of backcountry recreationalists to observe backcountry infrastructure based on spatial location. This enabled an understanding of the visual extent of backcountry infrastructure, which could further assist managerial comprehension of the visual impact of infrastructure on backcountry recreationalists' wilderness experiences.

The mapping of wilderness perception performed by Kliskey consisted of buffering spatial objects at an identified distance. Integrating 3D analysis and 3D visualization introduced another dimension of perception. Geospatial 3D analysis requires the use of a digital elevation model (DEM), which is a raster file representing the above sea level height of the area as a digital number. A DEM is a matrix of pixels that have a spatial resolution in the X and Y axis and an elevation as a digital number representing the height above sea level (Llobera, 2003). The spatial resolution of the DEM can vary from fine to coarse. The effect of a DEM creates a stair-step visual representation. Standard 3D analysis, such as line-of-sight analysis, uses a bare earth model (Llobera, 2003). Geospatial GIS vector data was used to locate features, land usage and management strategies that impact wilderness recreationalists based on the wilderness purism scale. The Wilderness Perception Mapping methodology has classified four properties of wilderness; artefactualism, remoteness, naturalness and solitude. The wilderness properties have associated features, land usage and management strategies that are identified in the GIS vector data for the mapping of wilderness perception (see Appendix1).

The implementation of 3D analysis utilized the Viewshed algorithm within the 3D Analyst extension of ESRI ArcGIS version 10. The viewshed algorithm computes the area of visibility for each pixel within a digital elevation model according to an input of observer points that represent an X, Y location. Geospatial data, identified in Appendix 1, was utilized for input as observer points. Polygon and polyline data was converted to point data at a point density of 30 metres, which coincided with the pixel resolution of the input digital elevation model. The inputted observer point data was analyzed within the ESRI Viewshed algorithm providing a raster file of areas within view, and out of view of the observer points. The locations of “out of view” were classified as potential areas of wilderness, as the areas were not within viewscape in the 3D analysis areas (see Appendix 3).

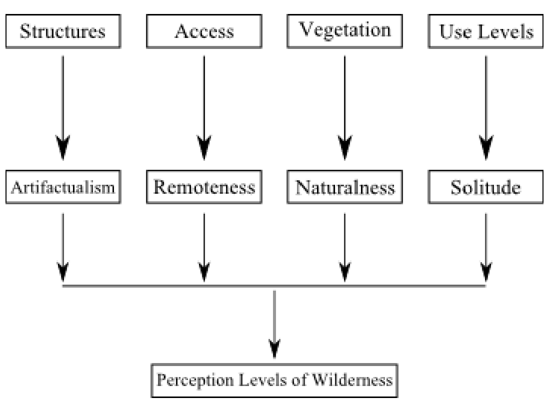

Figure 2: Wilderness Perception Schema
(Kliskey, 1994)

Research Design

The analysis of Wilderness Perception Mapping employed the methodology designed by Kliskey (1994) with modifications to accommodate 3D analysis and adaptations to the human development features based on the geographical differences between this research project and the original. While the studies by Kliskey (1994) and Flanagan and Anderson (2008) were conducted in areas without active railway lines or areas of motorized travel, the potential negative effect from motorized travel and/or railway lines on wilderness perceptions were however, recognized. Since Pukaskwa National Park is located south of the Canadian National railway line and on the eastern shores of Lake Superior, a large body of water that experiences various methods of motorized boat travel; commercial and personalized travel, these features were added to this particular study. The buffer distances of roads in the original study conducted by Kliskey (1994), which closely resemble railway lines and motorized water travel, were used as the buffer distances of railway lines and motorized water travel in this study.

Traditional Wilderness Perception Mapping techniques were conducted to identify potential regions of wilderness in Pukaskwa National Park, and the resulting analysis was used to identify areas to perform 3D analysis. In addition, regions of participant recreational activities were used, in conjunction with areas identified by the traditional Wilderness Perception Mapping analysis, to identify regions for 3D analysis

Limitations

Spatial analysis, 2D or 3D, is dependent on the availability and accuracy of geospatial data. Freely available data, which is provided by Natural Resources Canada, has inherent data inaccuracy, which the researcher attempted to eliminate through the acquisition of more accurate datasets and field surveys. Wilderness recreationalists represent a wide range of individuals who have a great array of expectations for their associated wilderness experience. The differences between wilderness recreationalists presented difficulties in clearly identifying recreational users within each of the four wilderness purism classes. Future research into understanding the differences and similarities between the recreational users within the four wilderness purism classes will provide better insight to wilderness recreationalists and the spatial locations of wilderness perceptions.

Chapter 4: Results

Data Analysis

Wilderness Perception Mapping in Pukaskwa National was performed using the traditional 2D approach and the modified 3D approach. As stated earlier, the data utilized included; freely available geospatial datasets, transcribed information and data collected from image classification. The data consisted of Canadian National Topographic System (NTS) 1:50,000 topographic vector data and digital elevation models (DEMs) and Landsat ETM+ multispectral satellite imagery. The transcribed data was collected digitally from the 1:100,000 Pukaskwa National Park map, which identified locations of warden cabins, lighthouse and backcountry campsites, as well as the Coastal Hiking Trail. Landsat ETM+ satellite imagery, scenes p022r026, p022r027, p023r026 and p023r027, were used with Feature Analyst, an object-oriented feature extraction tool, to identify locations of forestry activity. Standard image analysis feature extraction techniques were utilized to extract areas which have experienced forest extraction activities. The layers from each of the available datasets were used as input layers for the traditional Wilderness Perception Mapping and the modified Wilderness Perception Mapping techniques.

Traditional Wilderness Perception Mapping

The process of analyzing the data with the traditional Wilderness Perception Mapping techniques followed the established buffer distances identified by Kliskey (1995). The two features which did not have established buffer values (railway and area of mechanized travel) inherited the buffer values from the established distances of sealed/paved roads (see Appendix 1). Traditional Wilderness Perception Mapping analysis was performed in ArcGIS

10 with the use of an ArcInfo license. The resulting analysis generated four distinct Wilderness Perception Mapping classes; non-purist, neutral purist, moderate purist and strong purist. The spatial locations identified by the traditional Wilderness Perception Mapping techniques were calculated to distinguish the area, in square kilometres and hectares, of each identified polygon. XTools Pro version 8.0.0, an ArcGIS plugin, was used to perform the area calculation of the identified wilderness polygons.

Modified Wilderness Perception Mapping

The modified Wilderness Perception Mapping consisted of conducting 3D analysis of regions in Pukaskwa National Park. Each region was identified from results of the traditional Wilderness Perception Mapping analysis. Regions deemed "non-wilderness" by the traditional Wilderness Perception Mapping analysis that overlapped with regions where visitors participate in backcountry recreational activities, qualified for modified Wilderness Perception Mapping analysis. The areas identified for analysis were the regions around the backcountry campsites and the Coastal Hiking Trail, which coincide with the only locations where backcountry visitors are able to participate in backcountry activities within Pukaskwa National Park.

The analysis of the identified regions was divided into two separate analyses; backcountry trail locations and backcountry campsite locations. The division of the regions was based upon the established maximum buffer distance identified by Kliskey (1995). The established maximum buffer distance is 1 kilometre for backcountry trails and 2 kilometres for backcountry campsites. The difference in maximum buffer distance between the two feature types suggested a difference in wilderness perceptions, which warranted individual analysis of each feature type.

The backcountry trail was subdivided into 57 sections, each section representing a length of 1 kilometre, which is the maximum buffer distance identified by Kliskey (1995) for trails. The 57 backcountry trail sections were surrounded by an area of 1 square kilometre, according to the maximum buffer distance of a trail, for 3D analysis (see Figure 8 on page 56). This process resulted in the least amount of potential 3D analysis overlapping, while maintaining equal 3D analysis areas for statistical purposes.

The backcountry campsite locations were converted into an orthogonal 4 square kilometre (2 kilometres X 2 kilometres) polygon for 3D analysis. The 4 square kilometre polygons are consistent with the maximum buffer distance of 2 kilometres identified by Kliskey (1995). The generation of 4 square kilometre 3D analysis areas resulted in 15 individual backcountry campsite locations (see Figure 21 on page 69).

The modified Wilderness Perception Mapping analysis was performed in ArcGIS 10, with the 3D Analysis extension and an ArcInfo license. The analysis utilized ESRI's Viewshed function to conduct 3D visual analysis for each zone in the backcountry trail and backcountry campsite analysis. The 2D features required to perform the traditional Wilderness Perception Mapping analysis were utilized in the 3D analysis. Each of the 2D features was converted to a point feature class, which served as points of visual obstruction. Line and polygon 2D features were converted to points at a distance of 30 metres; the spatial pixel resolution of the input DEM. The converted 2D features provided locations of visual obstruction for the 3D analysis. A 30 metre DEM, a 1:50,000 NTS DEM, was used as the input raster dataset for analysis. The resulting 3D analysis generated a raster output consisting of "areas in view" and "areas not in view". The output 3D analysis raster was converted from a raster file to a polygon file for analysis. The areas identified as not in view were classified as perceived wilderness areas. Area calculation was performed on the identified wilderness areas and calculated with the use of XTools version 8.0.0.

3D Visualization Processing Requirements

The processing of the modified Wilderness Perception Mapping areas was achieved with the use of three computers. The computers ranged in computing specifications. The first computer had a Dual Core 2.3 GHz processor with 4 GB of RAM and a NVIDIA 512 MB graphics card running on Windows XP 32-bit operating system. The second system had a Quad Core 2.3 GHz i5 processor with 4 GB of RAM with a Radon 1,696 MB graphics card running on Windows 7 64-bit operating system. The final computer was a Quad Core 2.8 GHz i5 processor with 8 GB of RAM with an ATI Radeon HD 5570 1024 MB graphics card running on Windows 7 64-bit operating system. The processing of the two location areas, backcountry trails and backcountry campsites, took a week and a half of constant computing with the use of the three stated computers.

Traditional Wilderness Perception Mapping

The four purism classes identified by the traditional Wilderness Perception Mapping analysis also identified spatial locations of perceived wilderness within Pukaskwa National Park. The areas identified by the analysis ranged in size from less than a hectare to over 1,700 km^2 of perceived wilderness. The analysis of the traditional Wilderness Perception Mapping techniques revealed that perceived wilderness area declined as the level of wilderness purism class increased; from 1,708.33 km^2 in the non-purism class to 1,249.47 km^2 in the strong purism class. The analysis of the traditional Wilderness Perception Mapping techniques also revealed an increase in *potential* wilderness locations as the level of purism classes and wilderness desirability increases, so does the chance for greater wilderness fragmentation.

	Non-Purist	Neutral Purist	Moderate Purist	Strong Purist
Wilderness Areas	3	5	4	4
Areas >2,000 Ha	1	2	1	1
Total Area (km^2)	1,708.33	1,639.44	1,443,35	1,249.47
Minimum Area (km^2)	0.10	0.10	0.03	0.03
Maximum Area (km^2)	1,706.68	1,426.33	1,291.51	1,158.74
Mean Area (km^2)	569.44	327.89	360.84	312.37
Standard Deviation	985.74	620.88	622.81	565.54

Table 2: Pukaskwa National Park 2D Wilderness Perception Mapping Zones

Non-purism class

The result of the traditional Wilderness Perception Mapping analysis identified three areas of perceived wilderness (see Figure 3 and Table 2). Wilderness, as defined in the 1995 Pukaskwa National Park management plan, is an area of at least 2,000 hectares (Canadian Heritage Parks Canada, 1995). According to this definition the traditional Wilderness Perception Mapping analysis for the non-purism class has one area of perceived wilderness, which occupies an area of 170,768 hectares.

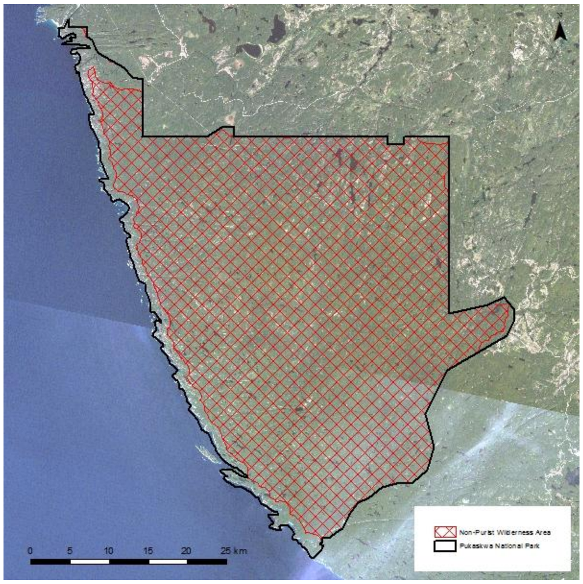

Figure 3: Pukaskwa National Park Non-Purism 2D WPM

Neutral purism class

The result of the traditional Wilderness Perception Mapping analysis for each category identified five areas of perceived wilderness (see Figure 4 and Table 2). According to the definition of wilderness identified by Pukaskwa National Park, the traditional Wilderness Perception Mapping analysis for the neutral purism class has two areas of perceived wilderness, occupying areas of 21,232 and 142,633 hectares.

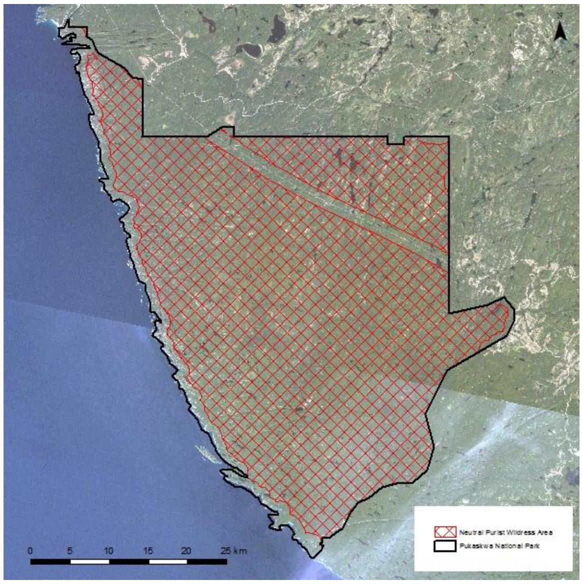

Figure 4: Pukaskwa National Park Neutral Purism 2D WPM

Moderate purism class

The result of the traditional Wilderness Perception Mapping analysis identified four areas of perceived wilderness (see Figure 5 and Table 2). According to the definition of wilderness identified by Pukaskwa National Park, the traditional Wilderness Perception Mapping analysis for the moderate purism class has three areas of perceived wilderness, consisting of areas of 2,610, 12,571 and 129,151 hectares.

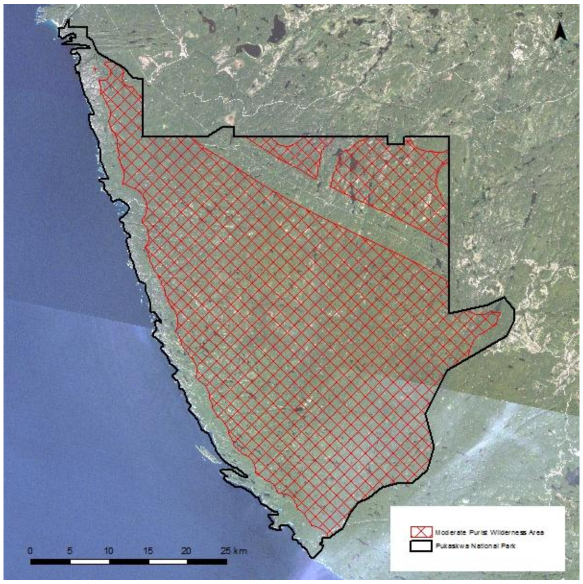

Figure 5: Pukaskwa National Park Moderate Purism 2D WPM

Strong purism class

The result of the traditional Wilderness Perception Mapping analysis identified five areas of perceived wilderness (see Figure 6 and Table 2). According to the definition of wilderness identified by Pukaskwa National Park, the traditional Wilderness Perception Mapping analysis for the strong purism class has two areas of perceived wilderness, consisting of areas of 8,415 and 115,873 hectares.

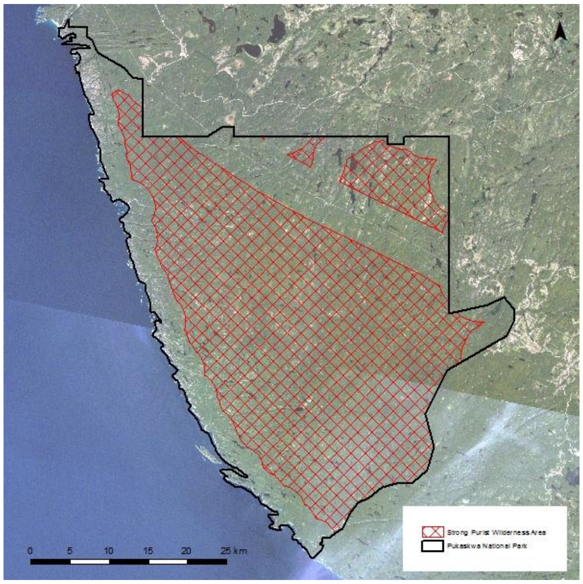

Figure 6: Pukaskwa National Park Strong Purism 2D WPM

Analysis of the total area of perceived wilderness as identified by the traditional Wilderness Perception Mapping analysis results in a loss of wilderness area across wilderness purism classes. The transition from non-purism to strong purism registers a loss of perceived wilderness area (see Figure 7). The cumulative loss in perceived wilderness is 45,886 between the non-purism and strong purism class.

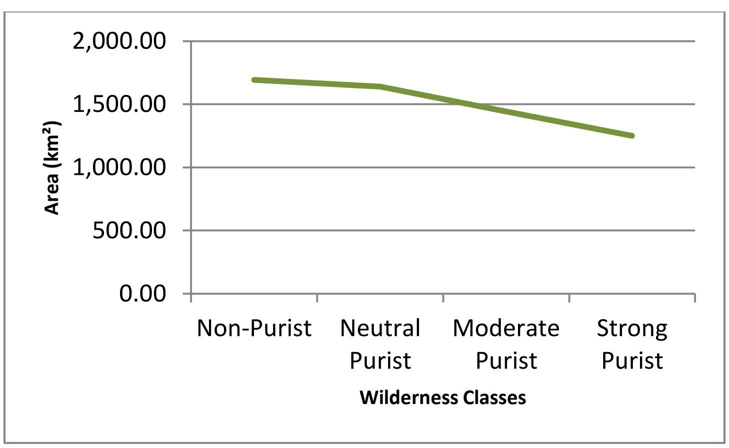

Figure 7: Pukaskwa National Park Wilderness Perception Mapping Zones Trends

Modified Wilderness Perception Mapping

The modified Wilderness Perception Mapping analysis consisted of two different analyses; the backcountry trail area and the backcountry campsite locations. The analysis of the backcountry trails consisted of 57 1km² areas, which ranged in size from 0 to 1km² for each of the 57 backcountry trail area locations. The backcountry campsite locations include 15 locations ranging from 0 to 4 km². Comparative analysis of the modified Wilderness Perception Mapping areas and the traditional Wilderness Perception Mapping results was conducted for each of the four wilderness purism classes to understand the impact visual analysis has on the spatial location of perceived wilderness. Analysis of the modified Wilderness Perception Mapping technique compared to the traditional Wilderness Perception Mapping technique revealed a significant increase in potential wilderness area in each of the four purism classes.

Non-purist backcountry trail locations

Viewshed analysis was conducted on each of the 57 km² backcountry trail locations using the established impacting features identified by the Wilderness Perception Mapping methodology (see Appendix 1). The backcountry trail areas are located along the east coast of Lake Superior, starting in the northwestern portion of the park, continuing south (see Figure 8). Viewshed analysis was conducted on each of the 57 locations to generate area information, which was compared to the area identified by the traditional Wilderness Perception Mapping techniques.

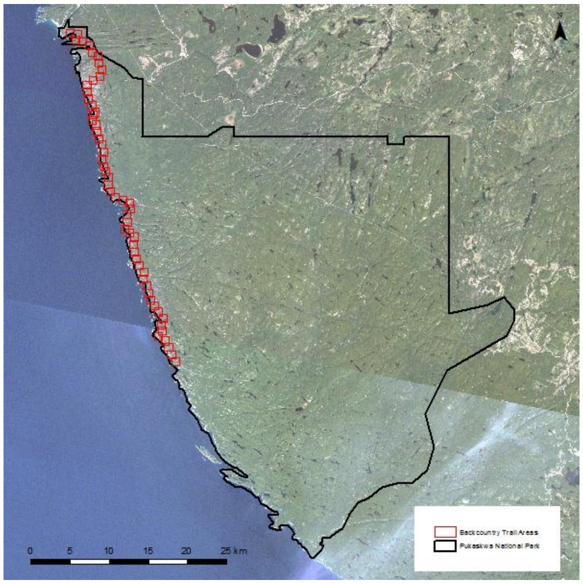

Figure 8: Pukaskwa National Park Backcountry Trail 3D Analysis

The resulting analysis generated clusters of perceived wilderness based on the ability to visually locate features identified as undesirable by non-purists. The clusters of perceived wilderness ranged in area from 0 km² to 1 km² (see Figure 9 and Figure 10). The area of the 57 backcountry trail locations were summed together to provide an understanding of the total area of perceived wilderness in the non-purist class based on visual impact. The perceived wilderness of the 57 backcountry trail locations for the non-purist class totaled 17.81 km² of the potential 57 km²; representing 31.25% of the total analyzed area. The area of perceived wilderness calculated from the traditional Wilderness Perception Mapping technique represented 4.18 km² of the potential 57 km²; which is 7.33% of the total analyzed area. The difference in area between the modified and traditional Wilderness Perception Mapping techniques was 13.63 km².

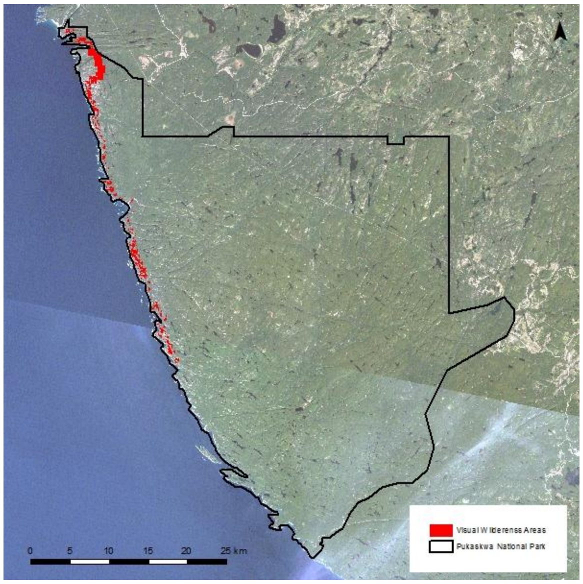

Figure 9: Pukaskwa National Park Backcountry Trails Non-Purism 3D WPM

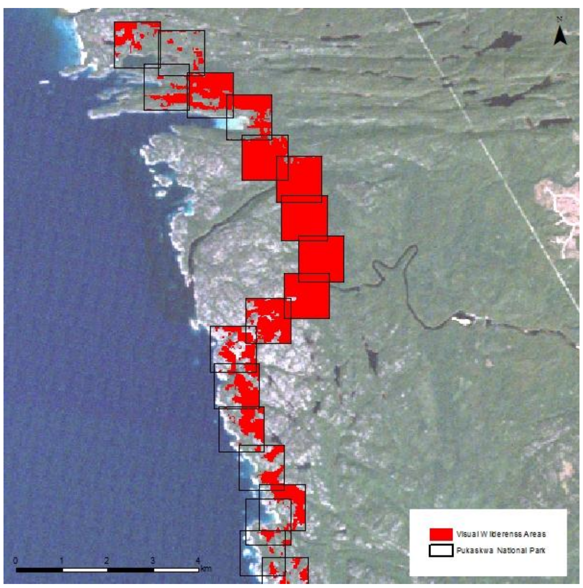

Figure 10: Pukaskwa National Park Backcountry Trails Non-Purism 3D WPM

Statistical analysis was conducted on the area difference between the modified and traditional Wilderness Perception Mapping analysis in-order to understand the affect visual perception has on the spatial distribution of wilderness perception. The mean area was calculated for each of the 57 backcountry trail locations from both the modified and traditional Wilderness Perception Mapping analysis, and revealed a mean area of 0.31 km^2

for the modified Wilderness Perception Mapping analysis and a mean area of 0.07 km² for the traditional Wilderness Perception Mapping analysis (see Table 3).

	3D WPM Area km²	2D WPM Area km²	Difference	x-mean	(x-mean) ²
Sum	17.81	4.18	13.63	0.00	1.55
Count (n)	57	57	57	57	57
Mean	0.31	0.07	0.24	0.00	
Variance (x^2)					0.03
Std Dev.					0.17

Table 3: Pukaskwa National Park Backcountry Trails Non-Purism 3D Analysis Results

A leaf and stem analysis, which is a technique for displaying quantitative data in a graphical format, was conducted on the modified and traditional Wilderness Perception Mapping analysis to understand the distribution of the data and provide information on which form of variance and standard deviation was most appropriate. The modified Wilderness Perception Mapping analysis was represented as positive values, while the traditional Wilderness Perception Mapping analysis was represented as negative values on the leaf and stem plot. The ranges in the leaf and stem analysis were 0, 0.25, 0.50, 0.75 and 1.0 for the modified Wilderness Perception Mapping analysis and 0, -0.25, -0.50, -0.75 and -1.0 for the traditional Wilderness Perception Mapping analysis. The result of the leaf and stem analysis identified a Chi Squared data distribution (see Figure 11), which means the variance and standard deviation to be conducted is consistent with the statistical analysis performed on a normal distribution of data (Milton and Arnold, 2003). Variance and standard deviation statistics were conducted to understand the statistical significance between the modified and traditional Wilderness Perception Mapping analysis. The variance of the analysis was 0.03, resulting in a standard deviation of 0.17 in the area difference between the modified and traditional Wilderness Perception Mapping analysis.

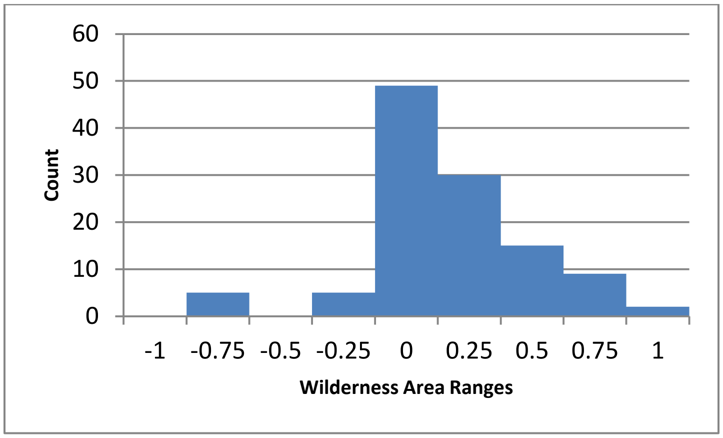

Figure 11: Pukaskwa National Park Backcountry Trails Non-Purism 3D Analysis Chart

Neutral purist backcountry trail locations

The resulting viewshed analysis generated clusters of perceived wilderness based on the ability to visually locate features identified as undesirable by neutral purists. The clusters of perceived wilderness ranged in area from 0 km² to 1 km² (see Figure 12 and Figure 13). The area of the 57 backcountry trail locations were summed together to provide an understanding of the total area of perceived wilderness in the neutral purist class based on visual impact. The perceived wilderness of the 57 backcountry trail locations for the neutral purist class totaled 17.81 km² of the potential 57 km²; representing 31.25% of the total analyzed area.

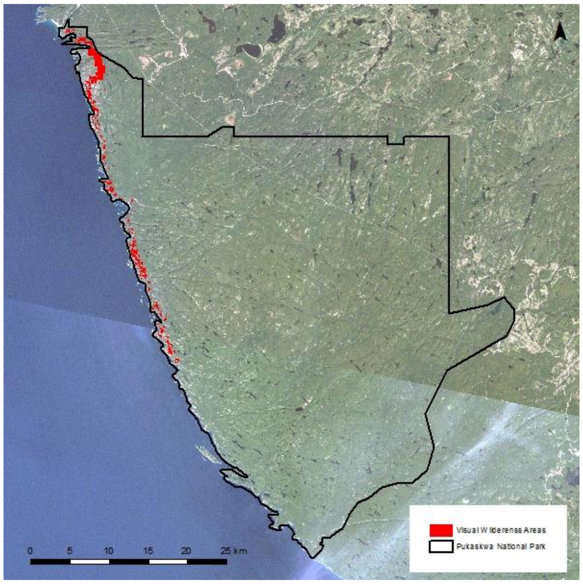

Figure 12: Pukaskwa National Park Backcountry Trails Neutral Purism 3D WPM

The area of perceived wilderness calculated from the traditional Wilderness Perception Mapping technique represented 4.22 km² of the potential 57 km²; which is 7.40% of the total analyzed area. The difference in area between the modified and traditional Wilderness Perception Mapping techniques was 13.59 km².

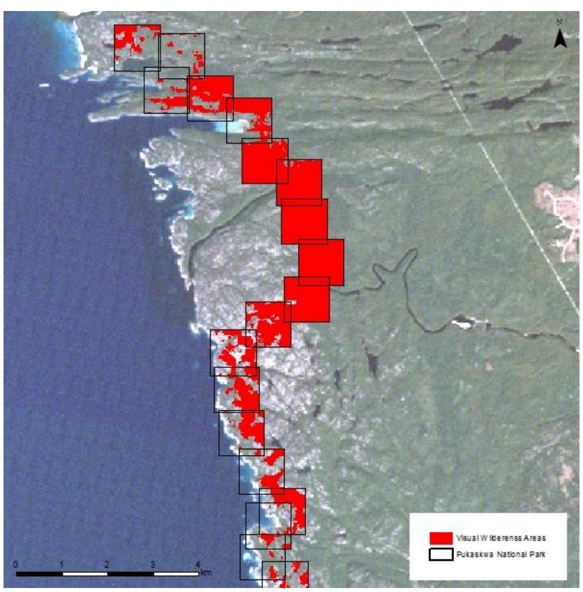

Figure 13: Pukaskwa National Park Backcountry Trails Neutral Purism 3D WPM

Statistical analysis was conducted on the area difference between the modified and traditional Wilderness Perception Mapping analysis to understand the affect visual perception has on the spatial distribution of wilderness perception. The mean area was calculated for each of the 57 backcountry trail locations from both the modified and traditional Wilderness Perception Mapping analysis, and revealed a mean area of 0.31 km² for the modified Wilderness Perception Mapping analysis and a mean area of 0.07 km² for the traditional Wilderness Perception Mapping analysis (see Table 4).

	WPM3D Area km²	WPM2D Area km²	WPM Difference	x-mean	(x-mean)²
Sum	17.81	4.22	13.59	0.00	1.53
Count (n)	57	57	57	57	57
Mean	0.31	0.07	0.24	0.00	
Variance (x²)					0.03
Std Dev.					0.17

Table 4: Pukaskwa National Park Backcountry Trails Neutral Purism 3D Analysis Results

A leaf and stem analysis was conducted on the modified and traditional Wilderness Perception Mapping analysis to understand the distribution of the data and provide information on which form of variance and standard deviation was most appropriate. The modified Wilderness Perception Mapping analysis was represented as positive values, while the traditional Wilderness Perception Mapping analysis was represented as negative values on the leaf and stem plot. The ranges in the leaf and stem analysis were 0, 0.25, 0.50, 0.75 and 1.0 for the modified Wilderness Perception Mapping analysis and 0, -0.25, -0.50, -0.75 and -1.0 for the traditional Wilderness Perception Mapping analysis. The result of the leaf and stem analysis identified a Chi Squared data distribution (see Figure 14), which means the variance and standard deviation to be conducted is consistent with the statistical analysis performed on a normal distribution of data (Milton and Arnold, 2003). Variance and standard deviation statistics were conducted to understand the statistical significance between the modified and traditional Wilderness Perception Mapping analysis. The variance of the analysis was 0.03, resulting in a standard deviation of 0.17 in the area difference between the modified and traditional Wilderness Perception Mapping analysis.

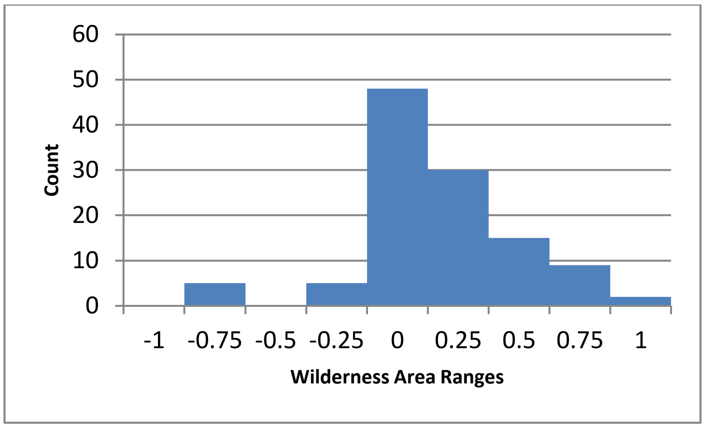

Figure 14: Pukaskwa National Park Backcountry Trails Neutral Purism 3D Analysis Chart

Moderate purist backcountry trail locations

The resulting viewshed analysis generated clusters of perceived wilderness based on the ability to visually locate features identified as undesirable by moderate purists. The clusters of perceived wilderness ranged in area from 0 km² to 0.92 km² (see Figure 15 and Figure 16). The area of the 57 backcountry trail locations were summed together to provide an understanding of the total area of perceived wilderness in the moderate purist class based on visual impact. The perceived wilderness of the 57 backcountry trail locations for the moderate purist class totaled 16.83 km² of the potential 57 km²; representing 29.53% of the total analyzed area.

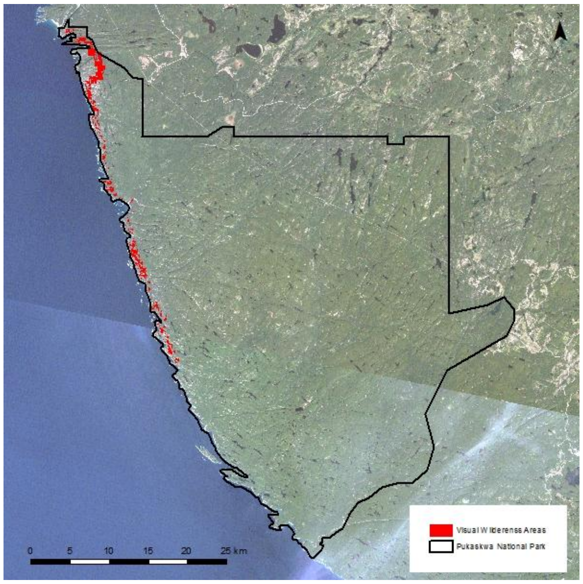

Figure 15: Pukaskwa National Park Backcountry Trails Moderate Purism 3D WPM

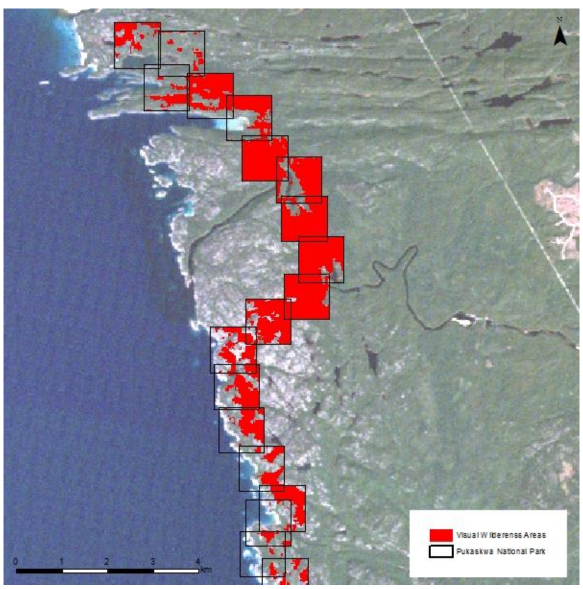

Figure 16: Pukaskwa National Park Backcountry Trails Moderate Purism 3D WPM

The area of perceived wilderness calculated from the traditional Wilderness Perception Mapping technique represented 0 km² of the potential 57 km²; which is 0% of the total analyzed area. The difference in area between the modified and traditional Wilderness Perception Mapping techniques was 16.83 km².

Statistical analysis was conducted on the area difference between the modified and traditional Wilderness Perception Mapping analysis to understand the affect visual perception has on the spatial distribution of wilderness perception. The mean area was calculated for each of the 57 backcountry trail locations from both the modified and traditional Wilderness Perception Mapping and revealed a mean area of 0.30 km² for the modified Wilderness Perception Mapping analysis and a mean area of 0.00 km² for the traditional Wilderness Perception Mapping analysis (see Table 5).

	WPM3D Area km²	WPM2D Area km²	WPM Difference	x-mean	(x-mean)²
Sum	16.83	0.00	16.83	0.00	3.40
Count (n)	57	57	57	57	57
Mean	0.30	0.00	0.30	0.00	
Variance (x^2)					0.06
Std Dev.					0.25

Table 5: Pukaskwa National Park Backcountry Trails Moderate Purism 3D Analysis Results

A leaf and stem analysis was conducted on the modified and traditional Wilderness Perception Mapping analysis to understand the distribution of the data and provide information on which form of variance and standard deviation was most appropriate. The modified Wilderness Perception Mapping analysis was represented as positive values, while the traditional Wilderness Perception Mapping analysis was represented as negative values on the leaf and stem plot. The ranges in the leaf and stem analysis were 0, 0.25, 0.50, 0.75 and 1.0 for the modified Wilderness Perception Mapping analysis and 0, -0.25, -0.50, -0.75 and -1.0 for the traditional Wilderness Perception Mapping analysis. The result of the leaf and stem analysis identified a Chi Squared data distribution (see Figure 17), which means the variance and standard deviation to be conducted is consistent with the statistical analysis performed on a normal distribution of data (Milton and Arnold, 2003). Variance and standard deviation statistics were conducted to understand the statistical significance between the modified and traditional Wilderness Perception Mapping analysis. The variance of the analysis was 0.06, resulting in a standard deviation of 0.25 in the area difference between the modified and traditional Wilderness Perception Mapping analysis.

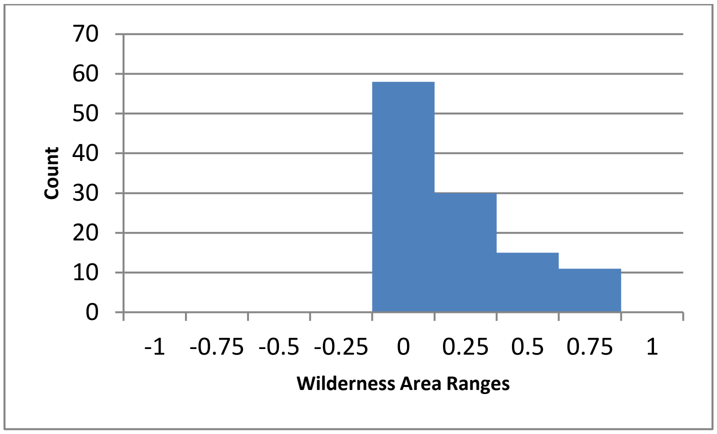

Figure 17: Pukaskwa National Park Backcountry Trails Moderate Purism 3D Analysis Chart

Strong purist backcountry trail locations

The resulting viewshed analysis generated clusters of perceived wilderness based on the ability to visually locate features identified as undesirable by strong purists. The clusters of perceived wilderness ranged in area from 0 km² to 0.92 km² (see Figure 18 and Figure 19). The area of the 57 backcountry trail locations were summed together to provide an understanding of the total area of perceived wilderness in the strong purist class based on visual impact. The perceived wilderness of the 57 backcountry trail locations for the strong purist class totaled 16.83 km² of the potential 57 km²; representing 29.53% of the total analyzed area.

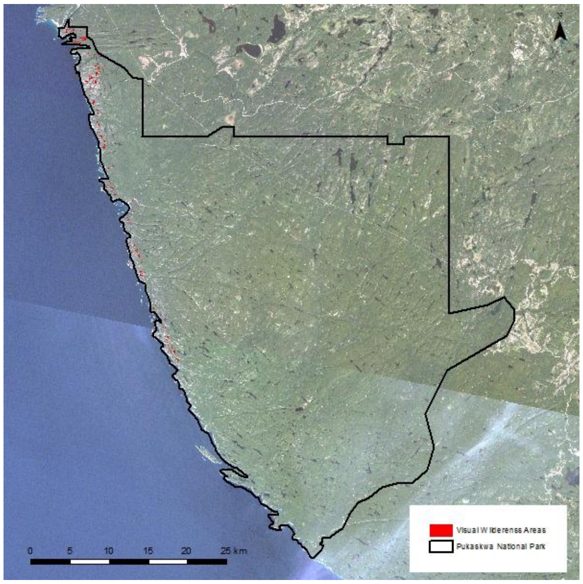

Figure 18: Pukaskwa National Park Backcountry Trails Strong Purism 3D WPM

The area of perceived wilderness calculated from the traditional Wilderness Perception Mapping technique represented 0 km² of the potential 57 km²; which is 0% of the total analyzed area.

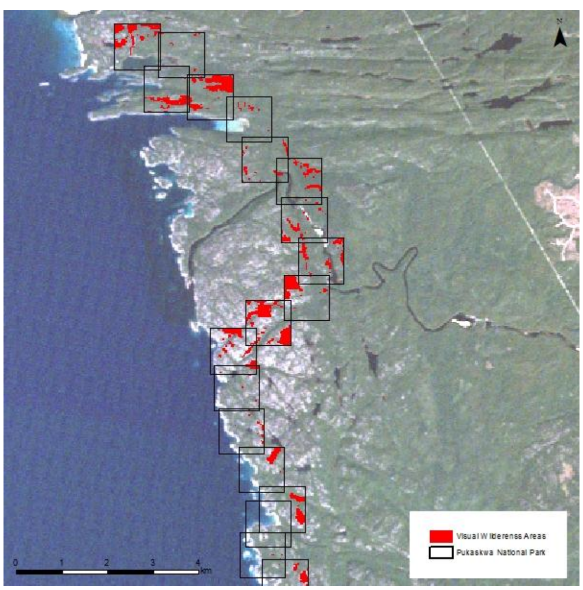

Figure 19: Pukaskwa National Park Backcountry Trails Strong Purism 3D WPM

The difference in area between the modified and traditional Wilderness Perception Mapping techniques was 16.83 km².

Statistical analysis was conducted on the area difference between the modified and traditional Wilderness Perception Mapping analysis to understand the affect visual perception has on the spatial distribution of wilderness perception. The mean area was calculated for each of the 57 backcountry trail locations from both the modified and traditional Wilderness Perception Mapping analysis and revealed a mean area of 0.30 km² for the modified Wilderness Perception Mapping analysis and a mean area of 0.00 km² for the traditional Wilderness Perception Mapping analysis (see Table 6).

	WPM3D Area km²	WPM2D Area km²	WPM Difference	x-mean	(x-mean)²
Sum	16.83	0.00	16.83	0.00	3.40
Count (n)	57	57	57	57	57
Mean	0.30	0.00	0.30	0.00	
Variance (x^2)					0.06
Std Dev.					0.25

Table 6: Pukaskwa National Park Backcountry Trails Strong Purism 3D Analysis Results

A leaf and stem analysis was conducted on the modified and traditional Wilderness Perception Mapping analysis to understand the distribution of the data and provide information on which form of variance and standard deviation was most appropriate. The modified Wilderness Perception Mapping analysis was represented as positive values, while the traditional Wilderness Perception Mapping analysis was represented as negative values on the leaf and stem plot. The ranges in the leaf and stem analysis were 0, 0.25, 0.50, 0.75 and 1.0 for the modified Wilderness Perception Mapping analysis and 0, -0.25, -0.50, -0.75 and -1.0 for the traditional Wilderness Perception Mapping analysis. The result of the leaf and stem analysis identified a Chi Squared data distribution (see Figure 20), which means the variance and standard deviation to be conducted is consistent with the statistical analysis performed on a normal distribution of data (Milton and Arnold, 2003). Variance and standard deviation statistics were conducted to understand the statistical significance between the modified and traditional Wilderness Perception Mapping analysis. The variance of the analysis was 0.06, resulting in a standard deviation of 0.25 in the area difference between the modified and traditional Wilderness Perception Mapping analysis.

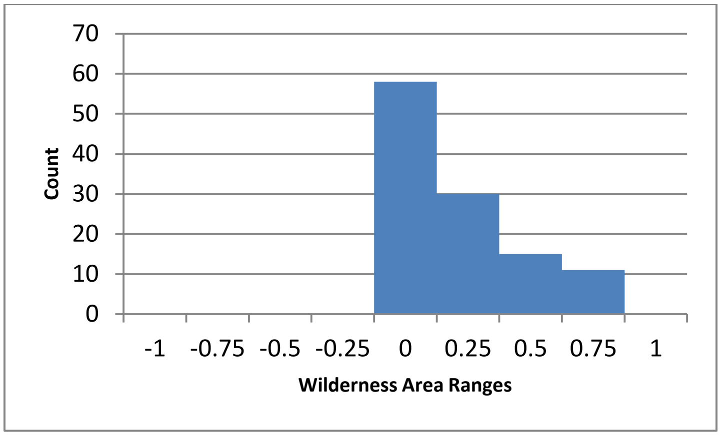

Figure 20: Pukaskwa National Park Backcountry Trails Strong Purism 3D Analysis Chart

Non-purist backcountry campsite locations

The resulting viewshed analysis generated clusters of perceived wilderness based on the ability to visually locate features identified as undesirable by non-purists. The clusters of perceived wilderness ranged in area from 0.38 km² to 4 km² (see Figure 22 and Figure 23). The area of the 15 backcountry campsite locations were summed together to provide an understanding of the total area of perceived wilderness in the non-purist class based on visual impact. Perceived wilderness of the 15 backcountry campsite locations for the non-purist class totaled 18.17 km² of the potential 60 km²; representing 30.28% of the total analyzed area.

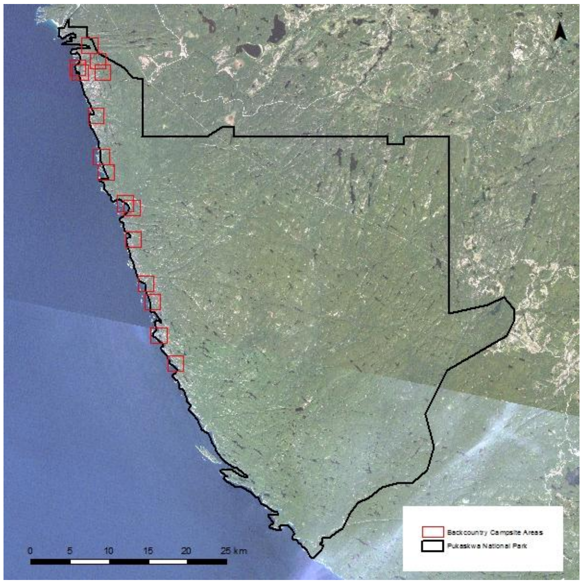

Figure 21: Pukaskwa National Park Backcountry Campsite 3D Analysis

The area of perceived wilderness calculated from the traditional Wilderness Perception Mapping technique totaled 10.19 km² of the potential 60 km²; which is 16.98% of the total analyzed area. The difference in area between the modified and traditional Wilderness Perception Mapping techniques was 7.97 km².

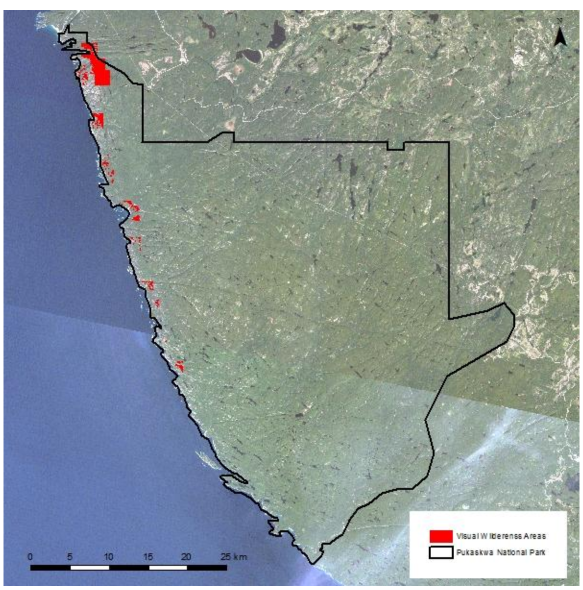

Figure 22: Pukaskwa National Park Backcountry Campsite Non-Purism 3D WPM

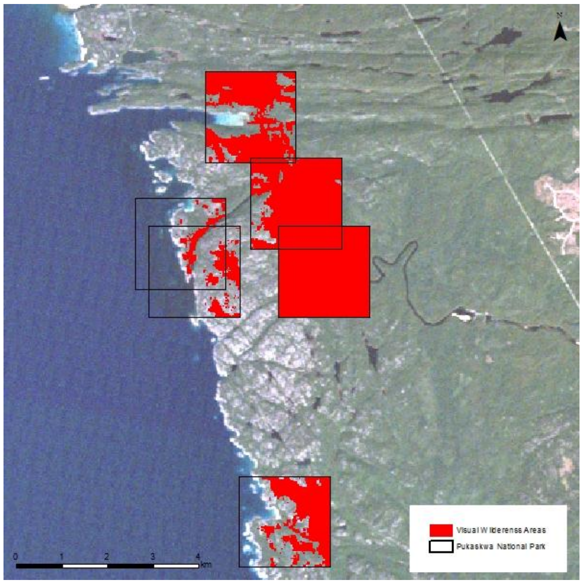

Figure 23: Pukaskwa National Park Backcountry Campsite Non-Purism 3D WPM

Statistical analysis was conducted on the area difference between the modified and traditional Wilderness Perception Mapping analysis to understand the affect visual perception has on the spatial distribution of wilderness perception. The mean area was calculated for each of the 57 backcountry trail locations from both the modified and traditional Wilderness Perception Mapping analysis and revealed a mean area of 1.21 km² for the modified Wilderness Perception Mapping analysis and an area of 0.68 km² for the traditional Wilderness Perception Mapping analysis (see Table 7).

WPM Area	WPM3D Area km²	WPM2D Area km²	WPM Difference	x - mean	(x - mean)²
Sum	18.17	10.19	7.97	0.00	4.80
Count (n)	15	15	15	15	15
Mean	1.21	0.68	0.53		
Variance (x²)					0.34
Std Dev.					0.59

Table 7: Pukaskwa National Park Backcountry Campsite Non-Purism 3D Analysis Results

A leaf and stem analysis was conducted on the modified and traditional Wilderness Perception Mapping analysis to understand the distribution of the data and provide information on which form of variance and standard deviation was most appropriate. The modified Wilderness Perception Mapping analysis was represented as positive values, while the traditional Wilderness Perception Mapping analysis was represented as negative values on the leaf and stem plot. The first leaf and stem analysis used nine classes (4 negative values, 4 positive values and 0), similar to the leaf and stem analysis of the backcountry trail locations. The backcountry campsite locations were larger in area, the leaf and stem ranges were classified as 0, 1, 2, 3 and 4 for the modified Wilderness Perception Mapping analysis and 0, -1, -2, -3 and -4 for the traditional Wilderness Perception Mapping analysis. The result of the leaf and stem analysis identified the distribution of the data as severe normal distribution (see Figure 24). Further leaf and stem analysis was conducted changing the ranges to simulate those identified in the backcountry trail locations. The distribution of the data with the new leaf and stem data ranges displayed the data as normal distribution (see Figure 25). Variance and standard deviation statistics were conducted to understand the statistical significance between the modified and traditional Wilderness Perception Mapping analysis. The variance of the analysis was 0.38, resulting in a standard deviation of 0.61 in the area difference between the modified and traditional Wilderness Perception Mapping analysis.

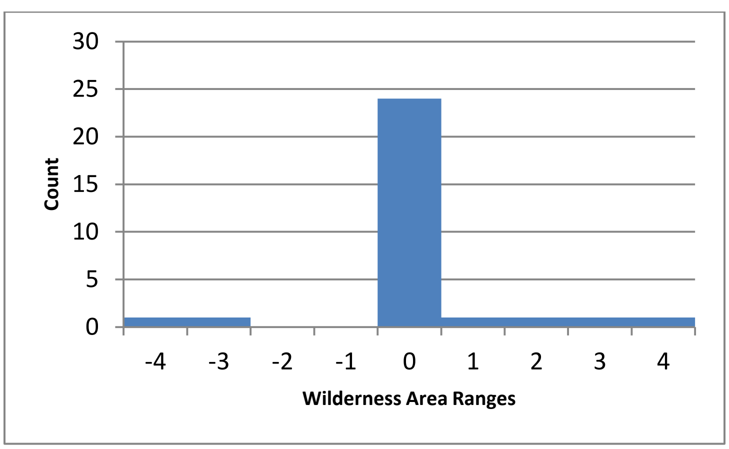

Figure 24: Pukaskwa National Park Backcountry Campsite Non-Purism 3D Analysis Chart

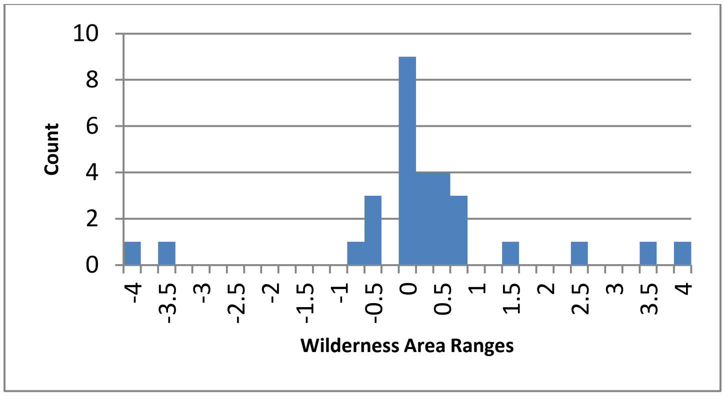

Figure 25: Pukaskwa National Park Backcountry Campsite Non-Purist 3D Analysis Chart

Neutral purist backcountry campsite locations

The resulting viewshed analysis generated clusters of perceived wilderness based on the ability to visually locate features identified as undesirable by neutral purists. The clusters of perceived wilderness ranged in area from 0.38 km^2 to 4 km^2 (see Figure 26 and Figure 27). The area of the 15 backcountry campsite locations were summed together to provide an understanding of the total area of perceived wilderness in the neutral purist class based on visual impact. The perceived wilderness of the 15 backcountry campsite locations for the neutral purist class totaled 18.24 km^2 of the potential 60 km^2; representing 30.40% of the total analyzed area.

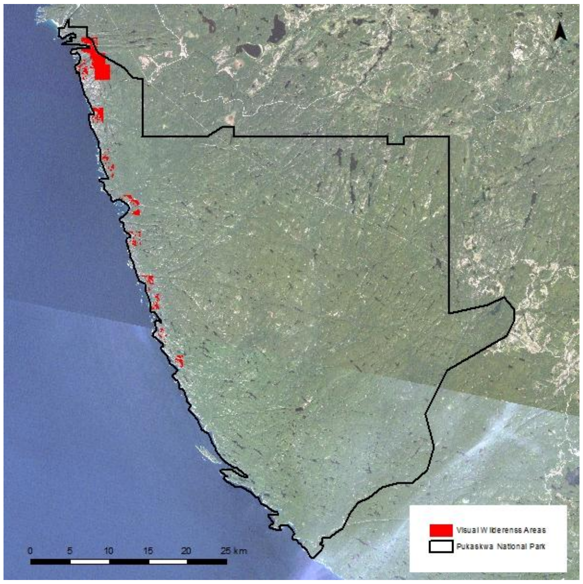

Figure 26: Pukaskwa National Park Backcountry Campsite Neutral Purism 3D WPM

The area of perceived wilderness calculated from the traditional Wilderness Perception Mapping technique represented 10.23 km² of the potential 60 km²; which is 17.05% of the total analyzed area. The difference in area between the modified and traditional Wilderness Perception Mapping techniques was 8.01 km².

Statistical analysis was conducted on the area difference between the modified and traditional Wilderness Perception Mapping analysis to understand the affect visual perception has on the spatial distribution of wilderness perception.

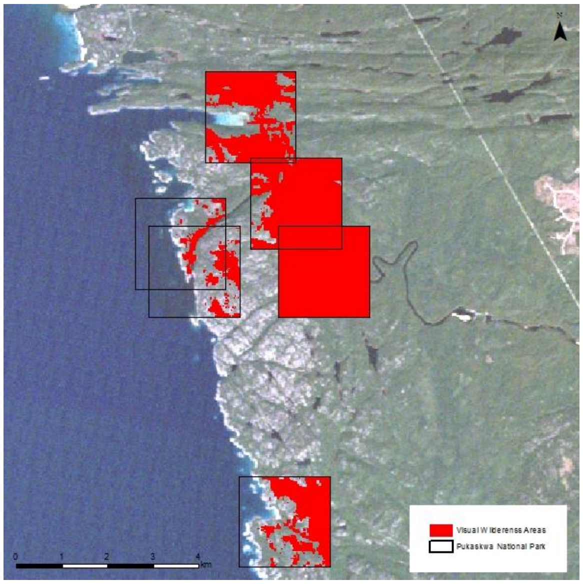

Figure 27: Pukaskwa National Park Backcountry Campsite Neutral Purism 3D WPM

The mean area was calculated for each of the 57 backcountry trail locations from both the modified and traditional Wilderness Perception Mapping analysis and revealed a mean area of 1.22 km² for the modified Wilderness Perception Mapping analysis and an area of 0.68 km² for the traditional Wilderness Perception Mapping analysis (see Table 8).

WPM Area	WPM3D Area km²	WPM2D Area km²	WPM Difference	x - mean	(x - mean)²
Sum	18.24	10.23	8.01	0.00	4.95
Count (n)	15	15	15	15	15
Mean	1.22	0.68	0.53		
Variance (x²)					0.35
Std Dev.					0.59

Table 8: Pukaskwa National Park Backcountry Campsite Neutral Purism 3D Analysis

A leaf and stem analysis was conducted on the modified and traditional Wilderness Perception Mapping analysis to understand the distribution of the data and provide information on which form of variance and standard deviation was most appropriate. The modified Wilderness Perception Mapping analysis was represented as positive values, while the traditional Wilderness Perception Mapping analysis was represented as negative values on the leaf and stem plot. The first leaf and stem analysis used nine classes (4 negative values, 4 positive values and 0), similar to the leaf and stem analysis of the backcountry trail locations. The backcountry campsite locations were larger in area, the leaf and stem ranges were classified as 0, 1, 2, 3 and 4 for the modified Wilderness Perception Mapping analysis and 0, -1, -2, -3 and -4 for the traditional Wilderness Perception Mapping analysis. The result of the leaf and stem analysis identified the distribution of the data as severe normal distribution (see Figure 28). Further leaf and stem analysis was conducted changing the ranges to simulate those identified in the backcountry trail locations. The distribution of the data with the new leaf and stem data ranges displayed a Chi Squared data distribution (see Figure 29). Variance and standard deviation statistics were conducted to understand the statistical significance between the modified and traditional Wilderness Perception Mapping analysis. The variance of the analysis was 0.35, resulting in a standard deviation of 0.59 in the area difference between the modified and traditional Wilderness Perception Mapping analysis.

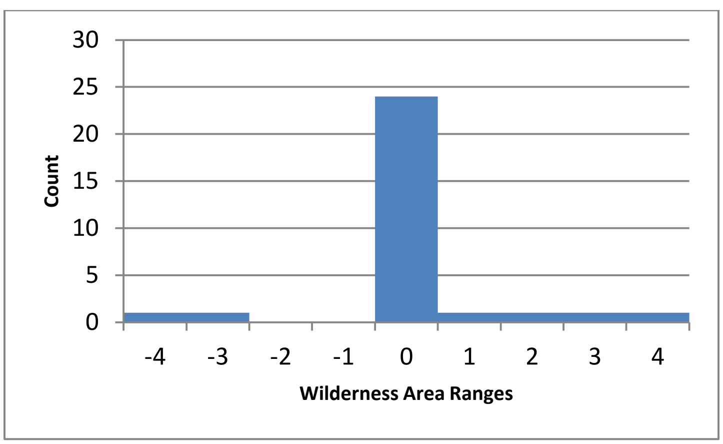

Figure 28: Pukaskwa National Park Backcountry Campsite Neutral Purism 3D Analysis Chart

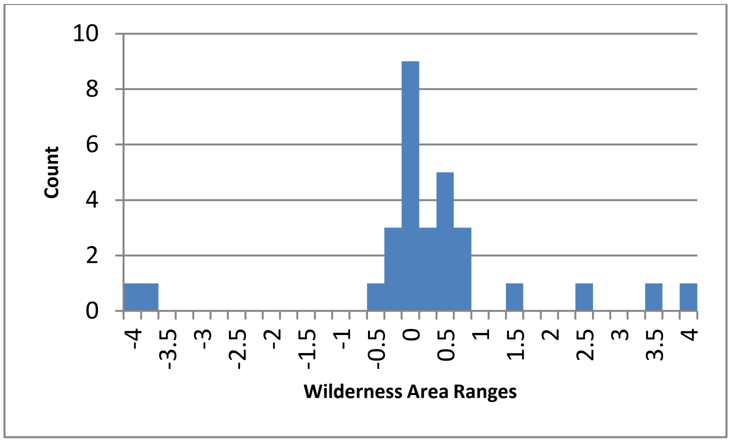

Figure 29: Pukaskwa National Park Campsite Neutral Purism 3D Analysis Chart

Moderate purist backcountry campsite locations

The resulting viewshed analysis generated clusters of perceived wilderness based on the ability to visually locate features identified as undesired by moderate purists. The clusters of perceived wilderness ranged in area from 0.29 km² to 3.59 km² (see Figure 30 and Figure 31). The area of the 15 backcountry campsite locations were summed together to provide an understanding of the total area of perceived wilderness in the moderate purism class based on visual impact. The perceived wilderness of the 15 backcountry campsite locations for the moderate class represent 16.81 km² of the potential 60 km²; representing 28.02% of the total analyzed area. The area of perceived

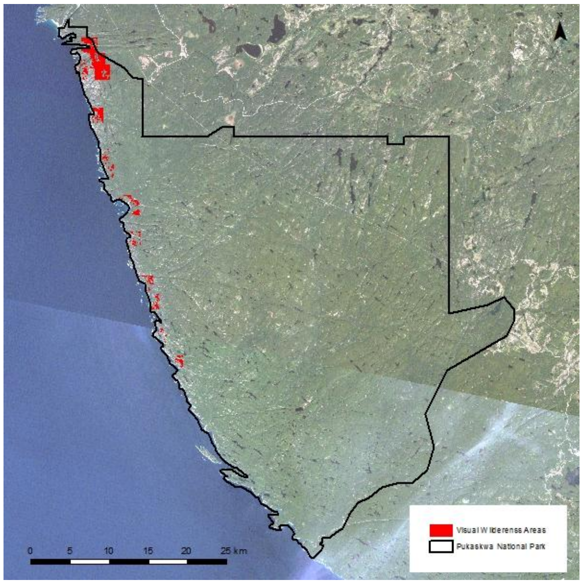

Figure 30: Pukaskwa National Park Backcountry Campsite Moderate Purism 3D WPM

wilderness calculated from the traditional Wilderness Perception Mapping technique represented 0.54 km² of the potential 60 km²; which is 0.009% of the total analyzed area. The difference in area between the modified and traditional Wilderness Perception Mapping techniques was 16.27 km².

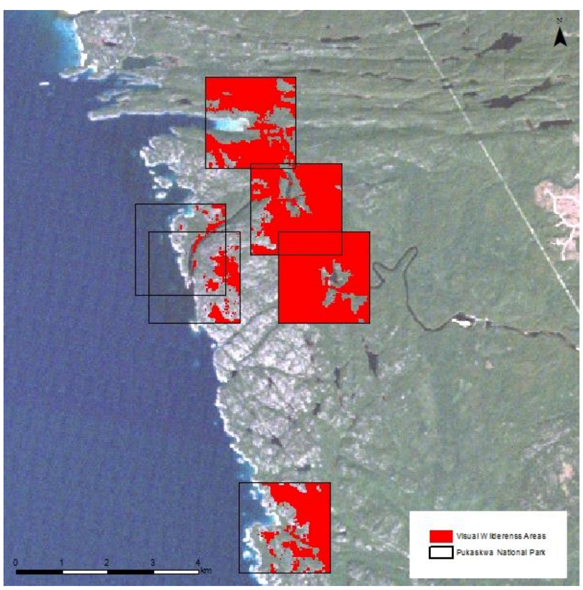

Figure 31: Pukaskwa National Park Backcountry Campsite Moderate Purism 3D WPM

Statistical analysis was conducted on the area difference between the modified and traditional Wilderness Perception Mapping analysis to understand the difference visual perception has on the spatial distribution of wilderness perception. The mean area calculation was conducted on from both the modified and traditional Wilderness Perception Mapping analysis and resulted in a mean area of 1.12 km^2 for the modified Wilderness Perception Mapping analysis and a mean area of 0.04 km^2 for the traditional Wilderness Perception Mapping analysis (see Table 9). A leaf and stem analysis was conducted on the modified and traditional Wilderness Perception Mapping analysis to understand the distribution of the data and provide information on which form of variance and standard deviation was most appropriate. The modified Wilderness Perception Mapping analysis was represented as positive values, while the traditional Wilderness Perception Mapping analysis was represented as negative values on the leaf and stem plot. The first leaf and stem analysis used nine classes (4 negative values, 4 positive values and 0), similar to the leaf and stem analysis of the backcountry trail locations. The backcountry campsite locations were larger in area, the leaf and stem ranges were classified as 0, 1, 2, 3 and 4 for the modified Wilderness Perception Mapping analysis and 0, -1, -2, -3 and -4 for the traditional Wilderness Perception Mapping analysis. The result of the leaf and stem analysis identified a severe Chi Squared data distribution (see Figure 32). Further leaf and stem analysis was conducted changing the ranges to simulate those identified in the backcountry trail locations. The distribution of the data with the new leaf and stem data ranges displayed a Chi Squared data distribution (see Figure 33). Variance and standard deviation statistics were conducted to understand the statistical significance between the modified and traditional Wilderness Perception Mapping analysis. The variance of the analysis was 1.01, resulting in a standard deviation of 1.10 in the area difference between the modified and traditional Wilderness Perception Mapping analysis.

WPM Area	WPM3D Area km²	WPM2D Area km²	WPM Difference	x - mean	(x - mean)²
Sum	16.81	0.54	16.27	0.00	14.20
Count (n)	15	15	15	15	15
Mean	1.12	0.04	1.08		
Variance (x^2)					1.01
Std Dev.					1.01

Table 9: Pukaskwa National Park Backcountry Campsite Moderate Purism 3D Analysis Results

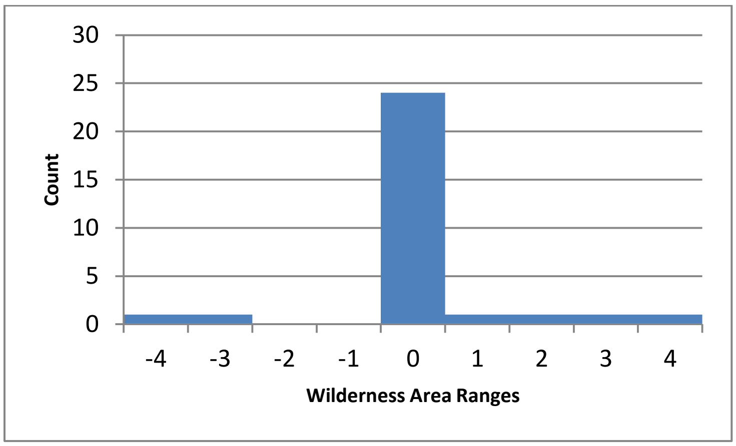

Figure 32: Pukaskwa National Park Backcountry Campsite Moderate Purism 3D Analysis Chart

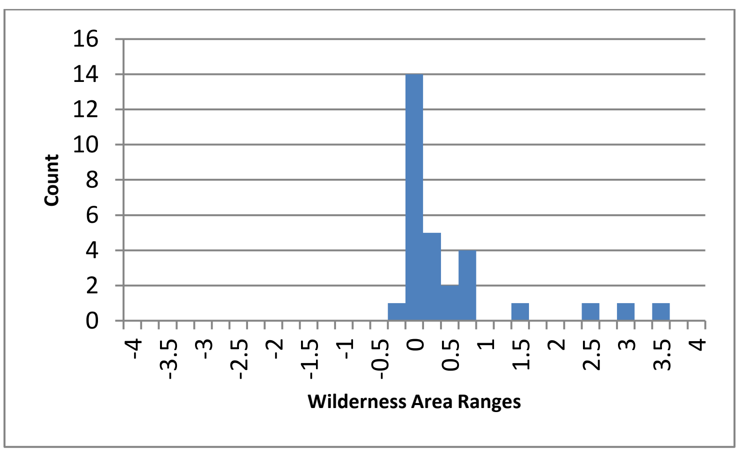

Figure 33: Pukaskwa National Park Backcountry Campsite Moderate Purism 3D Analysis Chart

Strong purist backcountry campsite locations

Viewshed analysis was conducted on each of the 15 4km² backcountry campsite locations using the established impacting features identified by the Wilderness Perception

Mapping methodology (see Appendix 1). The backcountry campsite locations are situated along the east coast of Lake Superior, starting in the northwestern portion of the park, continuing south (see Figure 21). Viewshed analysis was conducted on each of the15 locations to generate area information and compared to the area identified by the traditional Wilderness Perception Mapping techniques.

The resulting analysis generated clusters of perceived wilderness based on the ability to visually locate features identified as undesired by strong purists. The clusters of perceived wilderness ranged in area from 0.07 km^2 to 0.99 km^2 (see Figure 34 and Figure 35). The area of the 15 backcountry campsite locations were summed together to provide an understanding of the total area of perceived wilderness in the strong purist class based on visual impact. Perceived wilderness of the 15 backcountry campsite locations for the strong purist class totaled 6.78 km^2 of the potential 60 km^2; representing 11.30% of the total analyzed area. The area of perceived wilderness calculated from the traditional Wilderness Perception Mapping technique represented 0.00 km^2 of the potential 60 km^2; which is 0.00% of the total analyzed area. The difference in area between the modified and traditional Wilderness Perception Mapping techniques was 6.78 km^2.

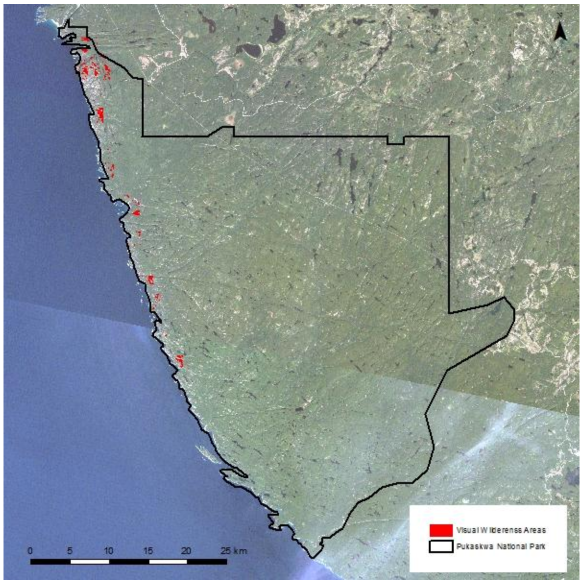

Figure 34: Pukaskwa National Park Backcountry Campsite Strong Purism 3D WPM

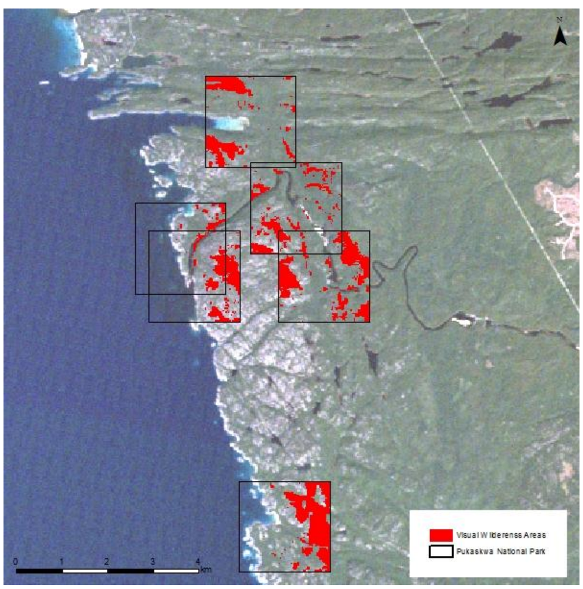

Figure 35: Pukaskwa National Park Backcountry Campsite Strong Purism 3D WPM

Statistical analysis was conducted on the area difference between the modified and traditional Wilderness Perception Mapping analysis to understand the affect visual perception has on the spatial distribution of wilderness perception. The mean area was calculated for each of the 57 backcountry trail locations from both the modified and traditional Wilderness Perception Mapping analysis and resulted in a mean area of 0.45 km² for the modified

Wilderness Perception Mapping analysis and a mean area of 0.00 km² for the traditional Wilderness Perception Mapping analysis (see Table 10).

WPM Area	WPM3D Area km²	WPM2D Area km²	WPM Difference	x - mean	(x - mean)²
Sum	6.78	0.00	6.78	0.00	1.16
Count (n)	15	15	15	15	15
Mean	0.45	0.00	0.45	0.00	
Variance (x^2)					0.08
Std Dev.					0.29

Table 10: Pukaskwa National Park Backcountry Campsite Strong Purism 3D Analysis Results

A leaf and stem analysis was conducted on the modified and traditional Wilderness Perception Mapping analysis to understand the distribution of the data and provide information on which form of variance and standard deviation was most appropriate. The modified Wilderness Perception Mapping analysis was represented as positive values, while the traditional Wilderness Perception Mapping analysis was represented as negative values on the leaf and stem plot. The first leaf and stem analysis used nine classes (4 negative values, 4 positive values and 0), similar to the leaf and stem analysis of the backcountry trail locations. The backcountry campsite locations were larger in area, the leaf and stem ranges were classified as 0, 1, 2, 3 and 4 for the modified Wilderness Perception Mapping analysis and 0, -1, -2, -3 and -4 for the traditional Wilderness Perception Mapping analysis. The result of the leaf and stem analysis identified a normal data distribution (see Figure 36). Further leaf and stem analysis was conducted changing the ranges to simulate those identified in the backcountry trail locations. The distribution of the data with the new leaf and stem data ranges displayed revealed a severe Chi Squared data distribution (see Figure 37). Variance and standard deviation statistics were conducted to understand the statistical significance between the modified and traditional Wilderness Perception Mapping analysis. The variance of the analysis was 0.08, resulting in a standard deviation of 0.29 in the area difference between the modified and traditional Wilderness Perception Mapping analysis.

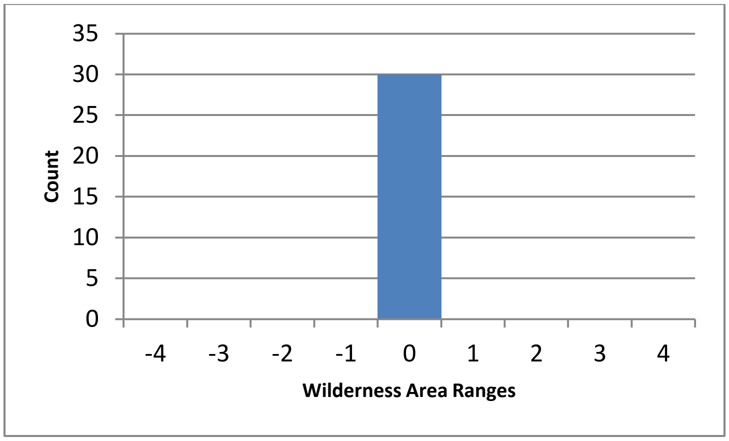

Figure 36: Pukaskwa National Park Backcountry Campsite Strong Purism 3D Analysis Chart

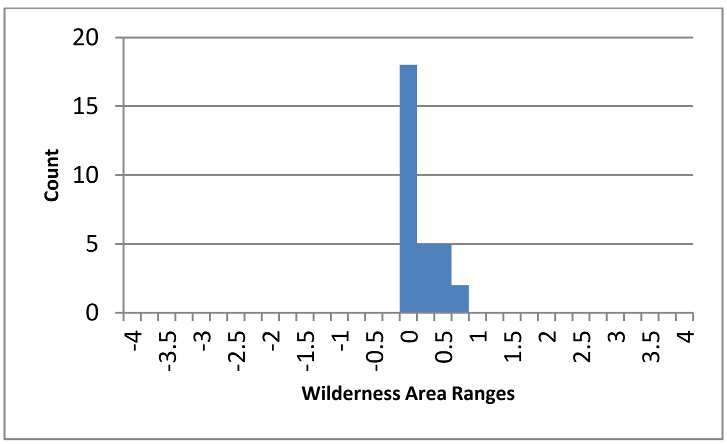

Figure 37: Pukaskwa National Park Backcountry Campsite Strong Purism 3D Analysis Chart

Chapter 5: Discussion

Impact of 3D Visualization on Wilderness Perception Mapping

An individual's wilderness perception can be formulated by many different factors. Lutz et al. (1999) and Jones et al. (2004) studied the impact visualization had on an individual's wilderness perception. Lutz et al. (1999) examined wilderness perceptions and how the use of visual representation of landscape features differed between urban and rural individuals. Lutz et al. (1999) found that urban and rural individuals have very different perceptions of wilderness. Jones et al. (2004) researched how visual impacts altered wilderness perceptions between two recreational groups; hikers and climbers. The findings suggest that the two recreational groups had different perceptions of wilderness based on visual perceptions and impacts. The research by Lutz et al. (1999) and Jones et al. (2004) suggest that an individual's perception of wilderness is influenced by visual components.

The Wilderness Perception Mapping techniques developed by Kliskey (1994) analyzed wilderness perception on a spatial context using 2D mapping techniques. The analysis of wilderness perception from a 2-dimentional process does not accommodate visual perception. Wilderness Perception Mapping with the addition of 3D analysis provides a means to further understand visual impact as it relates to development of wilderness perception. This study analyzed areas of perceived wilderness in Pukaskwa National Park with the use of traditional Wilderness Perception Mapping methodology and through modifying the Wilderness Perception Mapping methodology using 3D analysis. The modifications to the Wilderness Perception Mapping methodology included adding railway lines and bodies of water with mechanized travel, adding to the Wilderness Perception Mapping methodology. The addition of mechanized water travel to the Wilderness

Perception Mapping methodology provided the largest impact to the areas of perceived wilderness, both traditional Wilderness Perception Mapping and the modified Wilderness Perception Mapping with the use of 3D analysis. The backcountry trails and backcountry campsite locations that were analyzed with the modified Wilderness Perception Mapping methodology had three sources of impact used in the analysis; maintained trails, established campsites and areas of mechanized travel. Mechanized travel had the single greatest impact on the identification of perceived wilderness.

Analysis of traditional Wilderness Perception Mapping identified a reduction in perceived wilderness areas between the purism classes; non-purist, neutral purist, moderate purist and strong purist. The analysis also identified a sharp reduction in perceived wilderness area between the neutral purist and the moderate purist class in both the backcountry trail and backcountry campsite analysis areas (see Figure 38).

From these findings, I extrapolate that the traditional Wilderness Perception Mapping methodology identifies limited areas of wilderness for recreationalists that choose to participate in wilderness recreational activities. The modified Wilderness Perception Mapping analysis resulted in increased area of perceived wilderness, relative to traditional Wilderness Perception Mapping analysis and identified a reduction in perceived wilderness in the higher levels of purism class; between the moderate purist and the strong purist (see Figure 38).

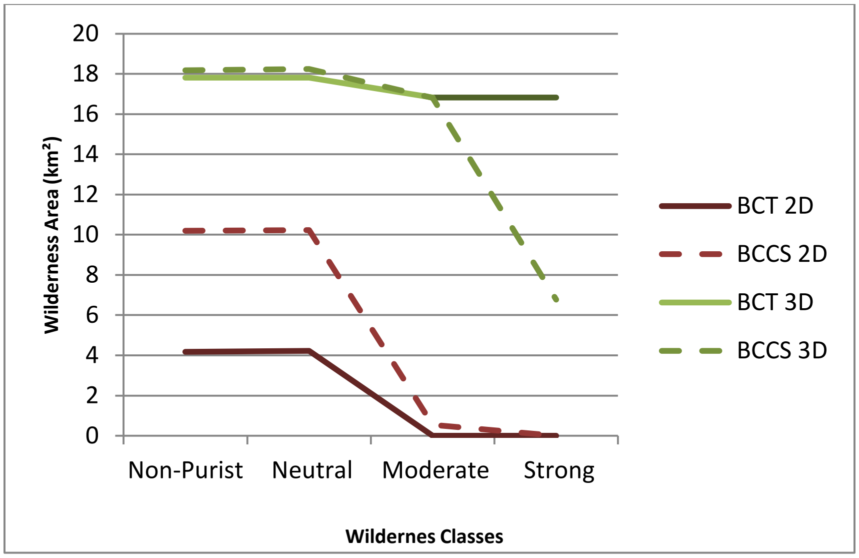

Figure 38: Comparing WPM results between 2D and 3D Analysis

* Note: BCT represents backcountry trail locations and BCCS represents backcountry campsite locations
** Note: 2D represents traditional Wilderness Perception Mapping

The difference between the two analysis techniques, traditional Wilderness Perception Mapping and modified Wilderness Perception Mapping, leads the researcher to believe that the use of 3D analysis as a method to map areas of perceived wilderness, results in greater areas of perceived wilderness (see Figure 39 and Figure 40). The difference in perceived wilderness areas from the 3D analysis provides a significant difference.

While perceived wilderness areas in the backcountry trail areas gradually decrease from non-purist to strong purist, perceived wilderness areas in the backcountry campsite locations drastically decrease between the moderate purist and the strong purist in the modified Wilderness Perception Mapping analysis. The researcher attributes this to the collection of three analysis features; campsite locations, maintained trails and areas of mechanized travel. The spatial location of many of the backcountry trail locations eliminated mechanized travel regions from the analysis due to the distance from Lake Superior, resulting in a reduction in features to analyze and a greater total area of perceived wilderness.

Analysis of Wilderness Perception Mapping, traditionally and with the modified methods employing 3D analysis, generates insight into how visual components can impact the ability to visually identify features. When this concept is related to the research conducted by Lutz et al. (1999) and Jones et al. (2004), it is apparent that visual analysis can be utilized to spatially identify areas of perceived wilderness and form different outcomes than identical methods that solely utilize traditional 2D analysis. Pukaskwa National Park, is an area with moderate variations in topology has generated significant variation in total area of perceived wilderness between traditional and modified Wilderness Perception Mapping (see Figure 39 and Figure 40).

	BCT 2D	BCCS 2D	BCT 3D	BCCS 3D
Non-Purist	4.18	10.19	17.81	18.17
Neutral Purist	4.22	10.23	17.81	18.24
Moderate Purist	0	0.54	16.83	16.81
Strong Purist	0	0	16.83	6.78

Table 11: Comparison of Results between Traditional and Modified Wilderness Perception

Note: BCT represents backcountry trail locations and BCCS represents backcountry campsite locations

Modified Wilderness Perception Mapping generated significantly greater areas of perceived wilderness than traditional Wilderness Perception Mapping in each of the four purism classes in both the backcountry trail and backcountry campsite analysis locations (see Table 11). The mean total in square kilometres for the traditional Wilderness Perception Mapping analysis of backcountry trail locations ranged from 0 to 4.22 km^2, where the same location for the modified Wilderness Perception Mapping analysis generated between 16.83

to 17.81 km^2. Comparisons of the backcountry campsite locations between the two analysis types revealed similar findings. The backcountry campsite locations generated a mean area of perceived wilderness ranging from 0 to 10.23 km^2 for the traditional Wilderness Perception Mapping and 6.78 to 18.24 km^2 for the modified Wilderness Perception Mapping analysis. Considering the resulting output of mean perceived wilderness areas and revisiting the research question "Does the use of traditional and modified Wilderness Perception Mapping techniques provide different wilderness locations in Pukaskwa National Park?", it is the opinion of the researcher that modified Wilderness Perception Mapping, with the use of 3D analysis, provides different areas of perceived wilderness locations, and a greater abundance of perceived wilderness locations within Pukaskwa National Park. The identification of increased perceived wilderness locations within Pukaskwa National Park provides an alternative means for analyzing wilderness areas for park managers, which can alleviate potential conflict with users and wilderness zoning challenges.

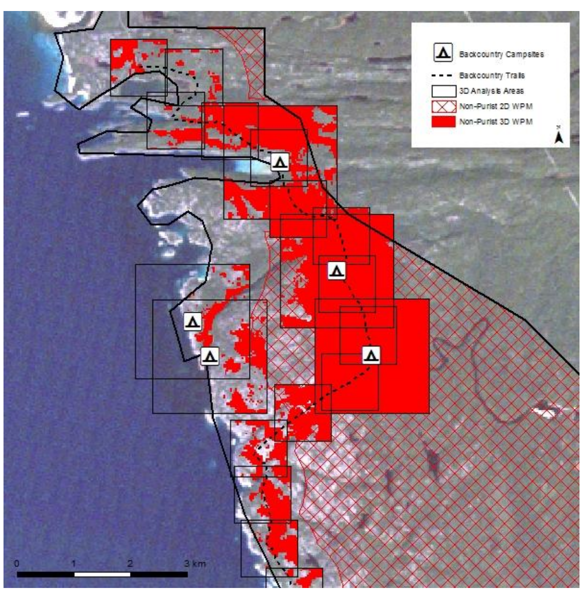

Figure 39: Comparison of traditional and modified Wilderness Perception Mapping - Non Purist Class

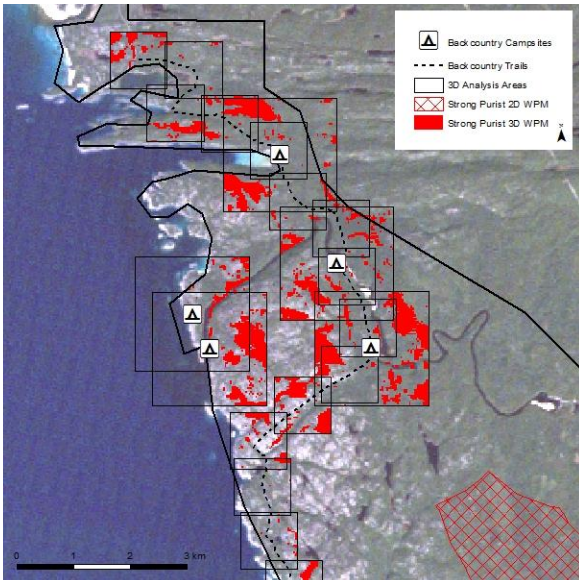

Figure 40: Comparison of traditional and modified Wilderness Perception Mapping - Strong Purist Class

Natural Visual Barriers and 3D Visualization

Perceived wilderness locations can be impacted by various types of infrastructure and human uses in the traditional 2D analysis, as well as in the modified 3D analysis. The research approach included ground truth field surveys, with the use of a Ricoh 500SE GPS-enabled digital camera to collect high resolution photographs of the study area, in order to understand the level of visual impact human-made infrastructure has on the wilderness landscape. Numerous spatially enabled digital photographs were collected along the Costal Hiking Trail and around the first backcountry campsite, the focus study area of the ground truth analysis (see Figure 41 and Figure 43). The digital photographs were processed with the use of Geospatial Experts GPS Photo Link, a software package which converts the collected GPS information stored in the JPEG exif and converts the GPS information to spatially enabled GIS layers. GPS recorded information such as latitude and longitude

Figure 41: Ground Truth Trail Photos

values, as well as digital compass azimuth information recorded in the JPEG exif, are converted into two GIS layers; a point file consisting of latitude and longitude positions of the collection location of the photograph taken, as well as a field- of -view polygon identifying the look direction and field- of- view of the photograph that was taken. Point file locations and field- of- view polygons were created for each field ground truth photograph taken and were overlaid with the resulting 3D viewshed analysis data to validate the areas of visual wilderness areas (see Figure 42 and Figure 44). Ground truth GPS- enabled digital photographs around the Coastal Hiking Trail visually identified dense forest cover, resulting in limited visual abilities (see Figure 41). Figure 41 identifies two photographs viewing both directions of the trail, southeast and northwest. Within each photograph the extent and distance that can be seen by a visitor is limited to a small spatial distance. Overlay analysis of the photographs taken in Figure 41 with the resulting 3D analysis of the area identifies that the area around the ground truth photographs are located within areas of non-purist, neutral purist and moderate purist; while the areas around the ground truth photographs would not be considered wilderness for strong purists (see Figure 42). The overlay analysis further identifies the fragmentation of the areas of wilderness, as identified by the modified Wilderness Perception Mapping analysis with the use of 3D analysis, which is clearly questionable when compared to the photographs in Figure 41.

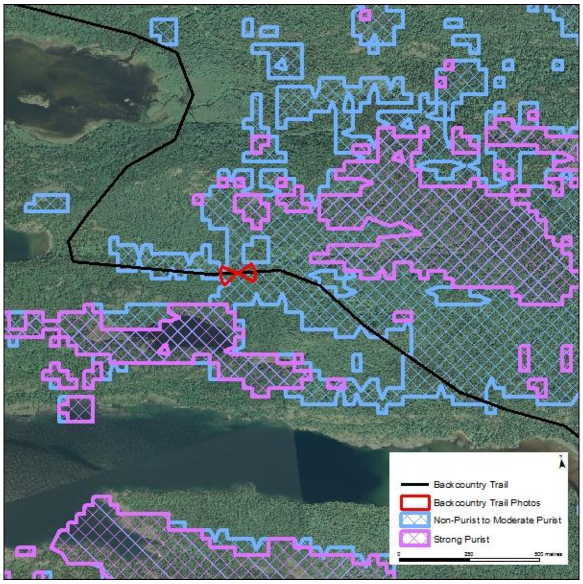

Figure 42: Ground Truth Backcountry Trail Map

Ground truth GPS enabled digital photographs around the backcountry campsite visually identified dense forest cover surrounding the backcountry campsite location and the body of water adjacent to the backcountry campsite; resulting in limited visual abilities (see Figure 43). Figure 43 identifies four photographs taken at 90º intervals with the backcountry campsite as the centre axis point. The photographs in Figure 43 identify dense and expansive forest cover surrounding an inlet from Lake Superior, with no evidence of human infrastructure.

Figure 43: Ground Truth Campsite Photos

Overlay analysis of the photographs taken in Figure 43 with the resulting 3D analysis of the area identify that the area around the ground truth photographs are located within areas of non-purist, neutral purist and moderate purist; while the areas around the ground truth photographs would not be considered wilderness for strong purists (see Figure 44).

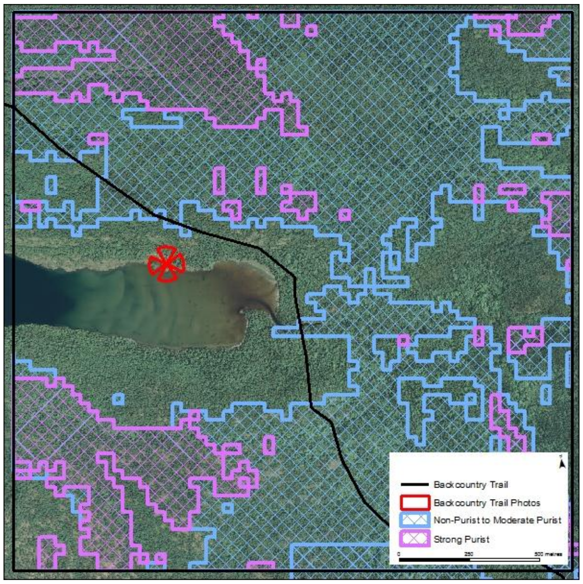

Figure 44: Ground Truth Backcountry Campsite Map

The overlay analysis further identifies the fragmentation of the areas of wilderness, as identified by the modified Wilderness Perception Mapping analysis with the use of 3D analysis, which is clearly questionable when compared to the photographs in Figure 43. The ground truth field survey analysis created questions related to the resulting modified Wilderness Perception Mapping analysis. The use of standard viewshed analysis with standard available DEMs resulted in fragmented areas of wilderness based on visual extent. Comparison of the resulting areas of "visual wilderness" with ground truth photographs resulted in conflicting regions of potential wilderness based on visualization. The researcher believes this conflict can be attributed to two elements; the input DEMs and the simplistic nature of the viewshed analysis algorithm.

Standard DEMs are representations of elevation values, which are free of obstructions, both natural and human generated (Llobera, 2003). The viewshed analysis algorithm available within ESRI ArcGIS 10.0 3D Analysis extension allows for the input of an elevation model and observer point locations. The observer point locations are placed on the elevation value associated with the X, Y spatial location of each observer point. The viewshed algorithm does not provide input for obstruction features, resulting in viewshed analysis that is clear of natural or human made obstruction features.

Limitations related to the DEMs and the viewshed analysis algorithm combined with the conflict between the results of the ground truth and results from the modified Wilderness Perception Mapping, analysis motivated the researcher to further understand the potential extent of the "visual wilderness" area. Visual analysis was conducted on the 4 km^2 area of the first backcountry campsite with the use of natural obstruction features. Forest Resource Inventory information was provided by Pukaskwa National Park which provided spatial extents of forest cover and forest height information in the form of a polygon vector file. Forest Resource Inventory information was converted from polygon to raster with a pixel posting of one meter with the new raster value representing the forest height information, resulting in a raster file of forest height information. The forest height raster was merged with the DEM to generate a single raster with elevation information that includes the surrounding forest height information. Pixel values in the forest height raster that intersected with the backcountry trail and backcountry campsite locations were substituted with the ground elevation values resulting in pixel values of the area of the backcountry trail and backcountry campsite represented with ground elevation and the surrounding pixel values with values representing ground elevation with forest cover heights (see Figure 45).

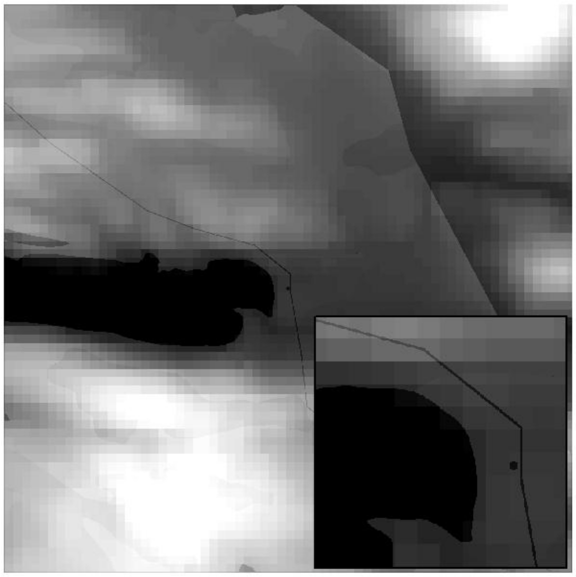

Figure 45: Modified DEM to include natural obstructions

Substitution of the pixel values for the backcountry trail and backcountry campsite locations place the observer points on the bare ground elevation, and the surrounding pixel values, representing the height of the forest combined with the ground height, provide a natural obstruction barrier that is spatially accurate for the area of analysis. The modified DEM with the addition of forest height information was used as the elevation source in the viewshed algorithm, in addition with the observer points of the backcountry trail and backcountry campsite locations, to provide further analysis of the areas visible when natural obstructions are utilized in the analysis (see Figure 46 and Figure 47). The process to create a 4 km^2 modified DEM that includes natural obstruction information from Forest Resource Inventory information and integrate the viewshed algorithm took 2 days with the use of a computer with a Quad Core 2.3 GHz i5 processor with 4 GB of RAM with a Radon 1,696 MB graphics card running on Windows 7 64-bit operating system.

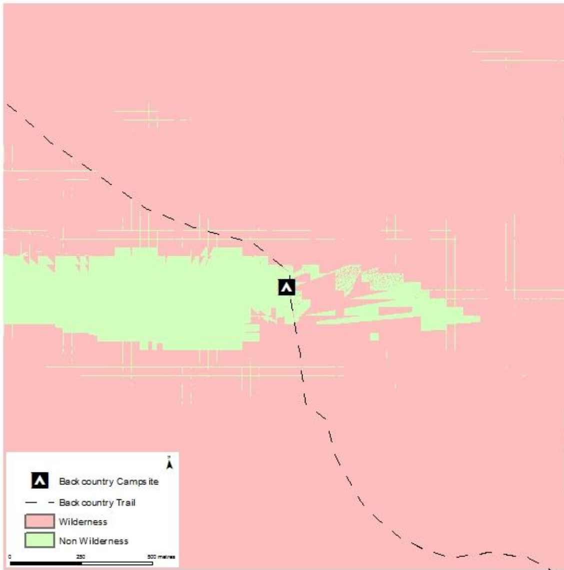

Figure 46: Non-Purist Modified 3D Analysis

Viewshed analysis with the use of the modified DEM was conducted for non-purists and strong purists, which were identified as the two distinct groups from the modified Wilderness Perception Mapping analysis, with non-purists, neutral purists and moderate purists generating similar "visual wilderness" areas. Viewshed analysis with the addition of natural obstructions generated significant "visual wilderness" areas (see Figure 46 and Figure 47) compared to the "visual wilderness" areas generated with the modified Wilderness Perception Mapping analysis. The two analysis parameters, non-purist and strong purist, generated very similar "visual wilderness" areas.

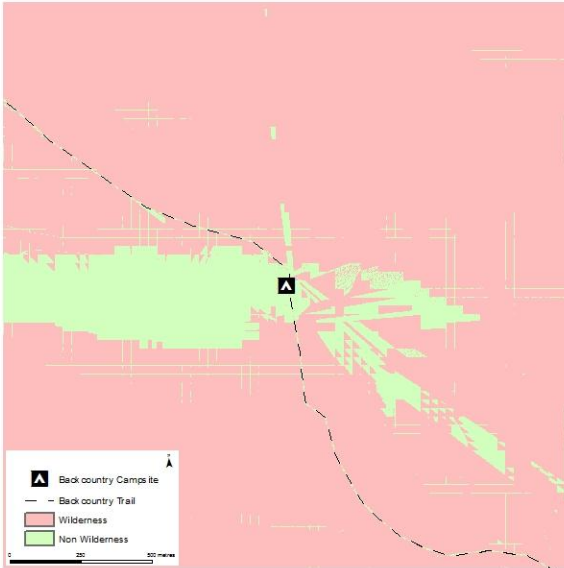

Figure 47: Strong Purist Modified 3D Analysis

Non-purist analysis identified 90.6% of the 4 km² area as perceived wilderness, where the strong purist analysis identified 88.3% of the 4 km² as perceived wilderness based on visual assessment. The researcher believes the close spatial proximity to bodies of water decreased the overall area of perceived wilderness based on visual assessment, which is a realistic assessment as the potential for viewing a motorized boat is considerably high. Comparative analysis between all three forms of analysis, traditional Wilderness Perception Mapping, modified Wilderness Perception Mapping and modified Wilderness Perception Mapping with the use of natural barriers, in the 4 km² backcountry campsite focus area, provides significant difference between the areas of perceived wilderness (see Table 12 and Figure 48).

	2D Analysis	3D Analysis 1	3D Analysis 2
Non-Purist	4.3%	63.8%	90.6%
Strong Purist	0.0%	16.3%	88.3%

Table 12: Comparison of Perceived Wilderness Area using 2D and 3D Analysis

* Note: 2D Analysis represents the Traditional Wilderness Perception Mapping analysis
** Note: 3D Analysis 1 represents the Modified Wilderness Perception Mapping analysis
*** Note: 3D Analysis 2 represents the Modified Wilderness Perception Mapping analysis with the implementation of a modified DEM to provide natural visual barriers in the form of forested locations

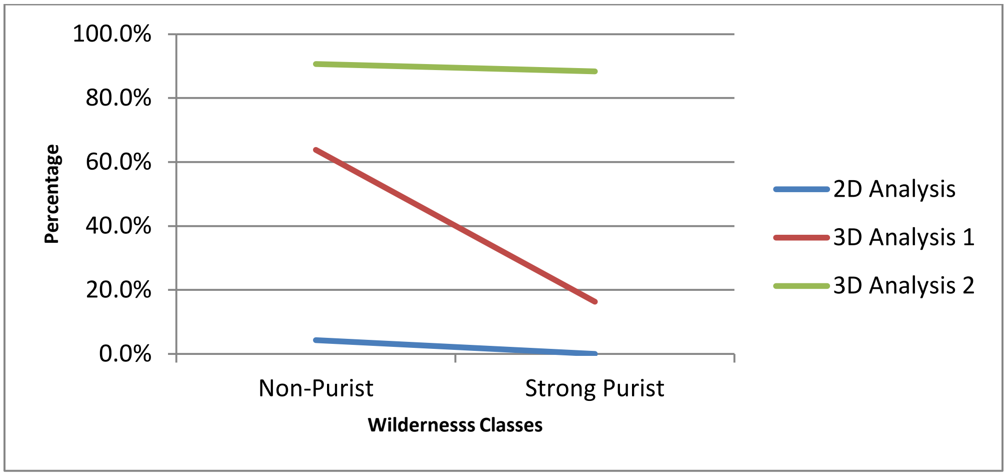

Figure 48: Comparison of Wilderness Area of Backcountry Campsite Area 1

* Note: 2D Analysis represents the Traditional Wilderness Perception Mapping analysis
** Note: 3D Analysis 1 represents the Modified Wilderness Perception Mapping analysis
*** Note: 3D Analysis 2 represents the Modified Wilderness Perception Mapping analysis with the implementation of a modified DEM to provide natural visual barriers in the form of forested locations

The comparison between the three forms of analysis identified a strong trend of increasing perceived wilderness areas with the use of 3D analysis. 3D analysis with the use of natural barriers reduces the gap of perceived wilderness areas between non-Purists and Strong Purists. The traditional Wilderness Perception Mapping analysis identified a range of perceived wilderness area ranging from 0% to 4.3%; the modified Wilderness Perception Mapping analysis identified a range of perceived wilderness area ranging from 16.3% to 63.8%; while the modified Wilderness Perception Mapping analysis with the use of natural barriers identified a range of perceived wilderness ranging from 88.3% to 90.6% between strong purists and non-purists. Within the two forms of 3D analysis, perceived wilderness increased by 26.8% in the non-purist class and by 72% in the strong purist classification with the use of natural barriers. The researcher believes from analyzing the increase in perceived wilderness locations between the three methodologies that the use of 3D analysis as a valuable tool for identifying potential wilderness areas increases areas of wilderness. In addition, the 3D analysis approach to identifying wilderness areas can provide greater information on the spatial location of potential wilderness locations for a wider range of wilderness users.

Chapter 6: Conclusions and Recommendations

Characterizing wilderness perceptions of wilderness recreationalists in a spatial context was originally conducted by Kliskey (1994) in New Zealand. Kliskey utilized Stankey's (1972) levels of wilderness purism to identify potential spatial locations related to wilderness perception. Kliskey adapted the purism scale developed by Stankey (1972) as the basis for data collection to be used in the mapping of a wilderness recreationalists' wilderness perception. The data collection survey used by Kliskey implemented sixteen questions which were related to four elements of wilderness purism; artefactualism, naturalness, remoteness and solitude. The questions were presented in a five point ordinal survey with values ranging from strongly desired to strongly undesired. Surveys were quantifiable which enabled the participant to be grouped into one of the four wilderness purism groups; purist, moderate purist, neutralist and non-purist. The categorization of each participant into a purism group provided the means for spatially identifying areas of wilderness according to the wilderness purism scale (Stankey, 1972). The Wilderness Perception Mapping survey provided a methodical approach to identify the impact that visual representation has on the spatial location of perceived wilderness areas.

Spatial analysis with the use of 3D analysis is a computationally expensive process, requiring computer systems with large quantities of RAM, memory, processing capabilities and graphical output. 3D analysis of the backcountry trail and backcountry campsite locations resulted in significant computer processing time, which was significantly smaller geographically, than the total area of the management zone of Pukaskwa National Park. Previous Wilderness Perception Mapping conducted by Kliskey (1994) and Flanagan and Anderson (2008) focused on the use of 2D analysis, which requires less computational resources than 3D analysis. The previous research by Kliskey (1994) and Flanagan and Anderson (2008) examined geographically large protected areas located in mountainous areas with topographical variance. Currently, industry available 3D analysis software is limited in 3D analysis abilities and processing efficiency. ESRI, the global leader in spatial analysis, has limited functionality with regards to 3D analysis. The current version of ESRI ArcGIS, version 10.0, has increased the 3D analysis functionality. However, the available toolsets have restricted analysis functionality, as well as the limitation of large geographical analysis capability. Open source applications provide the ability to perform 3D analysis. Usage of 3D analysis open source technology requires a significant level of software and algorithm development. Current commercial off- the- shelf (COTS) geospatial and open source 3D analysis software packages have limited functionality and algorithm development with regards to 3D analysis of large geographical regions with need for additional features as visual obstruction barriers.

Future Research

Wilderness perception research conduction during this project focused on analyzing the perceived areas of wilderness based on the Wilderness Perception Mapping methodology and the impact 3D analysis has on the identification of perceived wilderness areas. During the research process four areas of future research were identified; geographical and topographical impacts on wilderness perceptions, marine wilderness, spatial proximity impacts on wilderness perceptions and soundscape impacts on wilderness perceptions. These are explained next.

Geographic and topographical impacts on wilderness perceptions

Wilderness Perception Mapping research has been solely conducted in areas of high geographic topology; New Zealand Kliskey (1994) and southern Colorado Flanagan and Anderson (2008). The research conducted in this study occurred in Pukaskwa National Park, a region of rolling hills in the boreal forest on the shores of Lake Superior. The addition of this research makes it the second topographical region of study in Wilderness Perception Mapping and the third geographical region in the research area. Traditional Wilderness Perception Mapping has been conducted in three geographical areas, New Zealand, United States and Canada. Additional research related to Traditional Wilderness Perception Mapping should be conducted in regions with geographical variation. Within the three geographical areas, two regions of topographical geography were studied; mountainous and rolling hill boreal forest. The research conducted in Pukaskwa National Park identified the variation in potential wilderness areas based on the introduction of 3D analysis, which is directly impacted by geographic topology. Research in geographic topographically different locations, such as coastal marine, prairie, lake regions and arctic locations is required to better understand the range of Wilderness Perception Mapping variation that exists relative to geographic variation.

Marine wilderness perceptions

Pukaskwa National Park is situated on the eastern shore of Lake Superior, one of the world's largest fresh water lakes. The location of recreational participation follows the Coastal Hiking Trail along Lake Superior's coast. The analysis conducted in this research project identified Lake Superior as the largest contributor to the decrease of perceived wilderness areas. Mechanized travel on Lake Superior is the cause for the impacts on perceived wilderness areas. The realization of how mechanized travel on Lake Superior impacts perceived wilderness areas on terrestrial locations in Pukaskwa National Park, identified the need to understand marine wilderness perceptions. Shafer and Benzaken (1998) surveyed 383 users of the Great Barrier Reef Marine Park in Australia where the researchers found over 80% believed the Great Barrier Reef Marine Park provided areas of wilderness; above and below the water, there has been limited research in the field of marine wilderness perceptions, specifically on the Great Lakes of North America. Marine areas in the Great Lakes are areas of multiple use and represent recreational and commercial activities.

Spatial proximity impacts on wilderness perceptions

Wilderness research has utilized multiple methods for the analysis of individual wilderness perception. Within the literature there has been little research done where individuals have spatially identified areas of wilderness based on their wilderness perception. Mapping of individual's knowledge and experiences has been performed through the use of participatory GIS and grounded visualization. The use of GIS within a grounded GIS approach is a relatively new phenomenon in the research world (Steinberg and Steinberg, 2006). Traditionally, Grounded GIS has incorporated participant's local knowledge into a spatial domain and context. The advancements of technology have assisted with the development of Grounded GIS to incorporate a visual component. The addition of visual references to a GIS has developed Grounded GIS into a new realm; Grounded Visualization (Knigge, 2006). A participatory GIS or Grounded Visualization approach to research is suggested in-order to understand the impact spatial proximity has on the development of an individual's wilderness perception. The outcomes of this approach to wilderness perception research will provide direct information on the impact of infrastructure on an individual's wilderness perception from a spatial perspective.

Soundscape and wilderness perceptions

The research conducted in this study analyzed how the use of 3D visualization techniques can identify potential areas of perceived wilderness. The use of 3D analysis was used to bridge the research conducted by Kliskey (1994) and Flanagan and Anderson (2008) related to spatially identifying wilderness perceptions and to the visual impact of wilderness conducted by Lutz et al. (1999) and Jones et al. (2004). The analysis of the use of 3D analysis identified a significant increase in potential wilderness areas compared to traditional 2D Wilderness Perception Mapping analysis. The results from the research on the use of 3D analysis, regarding visual impacts on perceived wilderness areas, identified the need to conduct research on soundscape analysis related to wilderness and wilderness perceptions. Soundscape research has been implemented to understand the acoustic impacts in urban environment and how acoustic sound impacts ecology (Wrightson, 2000; Coensel, 2006; Guastavino et al., 2005). Soundscape research has also been introduced into Geographic Information Systems to spatially understand and map the extent and impact of acoustic noise on a landscape (Kurakula, 2007; Kobayashi, 1997). While there has been research on soundscape and the attempt to apply soundscape to spatial mapping, there is a lack of research related to the level of acoustic noise individuals are willing to tolerate in wilderness areas and on the impact of acoustic noise on the development of an individual's wilderness perception.

Visual wilderness perception mapping in additional parks

Pukaskwa National Park is a park with low backcountry visitation with such activities as backpacking, sea kayaking and canoeing widely dispersed along the coastline, and to a smaller degree inland (canoeing the inland rivers). The backcountry activities at Pukaskwa National Park are generally enjoyed during the summer months and early autumn, with an unknown number of backcountry visitors. Research related to visual based wilderness perception mapping is required within other national parks in the Canadian National Park system, specifically national parks that experience greater visitation and are a destination for winter and summer recreationalists.

Conclusion

Wilderness Perception Mapping is a technique that can be employed to estimate the area and locations of potential wilderness within a region according to the four wilderness purism classes identified by Stankey (1972) and Kliskey (1994). The potential wilderness areas are measured according to the spatial location and distance from identified human disturbances and infrastructure that are considered to negatively influence an individual's wilderness perception. Traditionally, Wilderness Perception Mapping has been performed solely in the second dimension, excluding the relevant visual impact of human disturbances and infrastructure on an individual's wilderness perception. The research conducted in Pukaskwa National Park related to Wilderness Perception Mapping introduced 3D analysis as a means of evaluating wilderness areas according to the Wilderness Perception Mapping methodology, to provide insight into visual impact assessment and how the spatial distribution of human disturbances and infrastructure can affect an individual according to their ability to visually locate a feature. The introduction of 3D analysis into the Wilderness

Perception Mapping methodology significantly increased the potential wilderness areas within Pukaskwa National Park relative to the areas identified with the traditional Wilderness Perception Mapping approach using 2D analysis. Potential wilderness areas were increased in each of the four wilderness purism classes; non-purist, neutral purist, moderate purist and strong purist. Traditional Wilderness Perception Mapping analysis identified a range of potential wilderness areas within the study area around the first backcountry campsite, from 0% wilderness to 4.3% of wilderness, between strong purists and non-purists respectively. The introduction of 3D analysis increased the potential wilderness area in the same study area to 16.3% for strong purists and 63.8% for non-purists (see Table 12 and Figure 48 on page 96 and 97). The difference between the traditional Wilderness Perception Mapping analysis outcomes and the modified Wilderness Perception Mapping analysis outcomes clearly indicates that the use of 3D analysis identifies greater areas of potential wilderness. Further 3D analysis was conducted to simulate how natural barriers impact the 3D analysis of perceived wilderness. Natural visual barriers in the form of forested areas were introduced into the 3D analysis to provide a realistic impact assessment of the focus study area related to visual wilderness perceptions. The introduction of natural visual barriers increased the potential wilderness areas from 63.8% to 90.6% for non-purists and from 16.3% to 88.3% for strong purists (see Table 12 and Figure 48 on page 96 and 97). Comparison of the three Wilderness Perception Mapping analyses, traditional Wilderness Perception Mapping, modified Wilderness Perception Mapping and modified Wilderness Perception Mapping analysis with the use of visual barriers, identifies how the use of 3D analysis significantly increases the area of potential wilderness areas (see Figure 49).

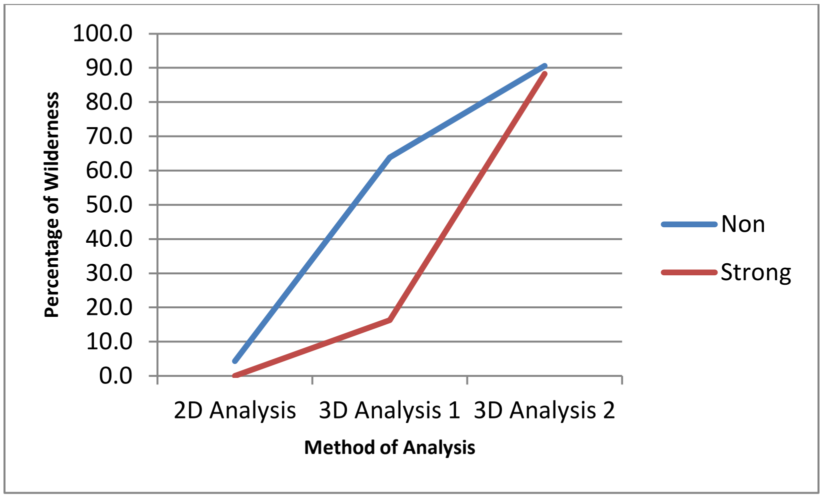

Figure 49: Perceived Wilderness Area Change between the three Analysis Approaches

*   Note: 2D Analysis represents the Traditional Wilderness Perception Mapping analysis
** Note: 3D Analysis 1 represents the Modified Wilderness Perception Mapping analysis
*** Note: 3D Analysis 2 represents the Modified Wilderness Perception Mapping analysis with the implementation of a modified DEM to provide natural visual barriers in the form of forested locations

Pukaskwa National Park is identified as a wilderness park with approximately 99% of its area zoned as "wilderness" (Canadian Heritage Parks Canada, 1995). The research conducted in the study aimed to understand how the results from traditional Wilderness Perception Mapping and modified Wilderness Perception Mapping with the use of 3D analysis, would compare to the identified wilderness areas within Pukaskwa National Park management plan. Traditional Wilderness Perception Mapping analysis identified a range in potential wilderness areas from 60.57% for strong purists to 90.97% for non-purists. Each of the four wilderness purism classes rated below the 99% identified as wilderness by the Pukaskwa National Park management plan. 3D analysis is computer resource intensive, requiring advanced computer systems and extensive periods of time to analyze large areas. The requirements associated with 3D analysis, both computer and labor, required focus areas to be established during the 3D analysis process of the study. 3D analysis was conducted in areas where backcountry wilderness recreationalists frequent Pukaskwa National Park; the Coastal Hiking Trail and the backcountry campsites. Comparative analysis was performed between the traditional Wilderness Perception Mapping and the modified Wilderness Perception Mapping with the use of 3D analysis and resulted in Traditional Wilderness Perception Mapping produces a more conservative delineation of perceived wilderness than Modified Wilderness Perception Mapping. Additionally, a comparative analysis was conducted between all three of Wilderness Perception Mapping analyses. The results clearly established that 3D analysis generated a significant increase in potential wilderness areas compared to traditional Wilderness Perception Mapping analysis, which focused on 2D analysis. 3D analysis has been considered a viable means of identifying wilderness areas in Pukaskwa National Park, which resulted in similar wilderness locational areas presented by Pukaskwa National Park in the park management plan. Viewshed analysis and other geospatial 3D analysis are techniques that can be used to help understand natural landscapes. Some park managers may gain a greater understanding of features within the park and the potential impacts these features can have on park users. Viewshed analysis provides such a method.

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Appendix 1: Traditional Wilderness Perception Mapping Spatial Distances for Pukaskwa National Park

Feature to Buffer	Non Purist	Neutralist	Moderate Purist	Purist
Artefactualism				
Campsites			1 km	2 km
Maintained trails				1 km
Huts / shelters				1 km
Logging sites / roads	1 km	1 km	2 km	3 km
Hydro development		1 km	2 km	3 km
Mining sites	1 km	1 km	2 km	3 km
Remoteness				
Roads				
Sealed / Paved	1 km	1 km	2 km	3 km
Metaled		1 km	2 km	3 km
4WD			1 km	2 km
Foot trails				1 km
Railway	1 km	1 km	2 km	3 km
Airfields				
Runways	1 km	1 km	2 km	3 km
Airstrips		1 km	2 km	2 km
Water Travel				
Mechanized boats	1 km	1 km	2 km	3 km
Naturalness				
Vegetation cover				
Urban / crop / pasture	1 km	1 km	1 km	2 km
Exotic scrub		1 km	1 km	2 km
Exotic forest			1 km	2 km
Solitude				
Tracks with unacceptable use		1 km	1 km	1 km
Huts with unacceptable use		1 km	1 km	1 km
Campsites with unacceptable use		1 km	1 km	1 km

Appendix 2: Pukaskwa National Park Spatial Datasets

Geospatial Data of Pukaskwa National Park	
Freely Available Geospatial Data	
	NTS Map Sheet
National Topographic Series Vector Data (1:50,000)	41M16
	41N13
	42C03
	42C04
	42C05
	42C06
	42C12
	42D01
	42D08
	42D09
Landsat Satellite Imagery	L5022026_02620050705
	L5022027_02720050923
	L5023026_02620060901
	L5023027_02720060816
National Topographic Series Elevation Data (1:50,000)	41M16
	41N13
	42C03
	42C04
	42C05
	42C06
	42C12
	42D01
	42D08
	42D09

Appendix 3: 3D Analysis Workflow