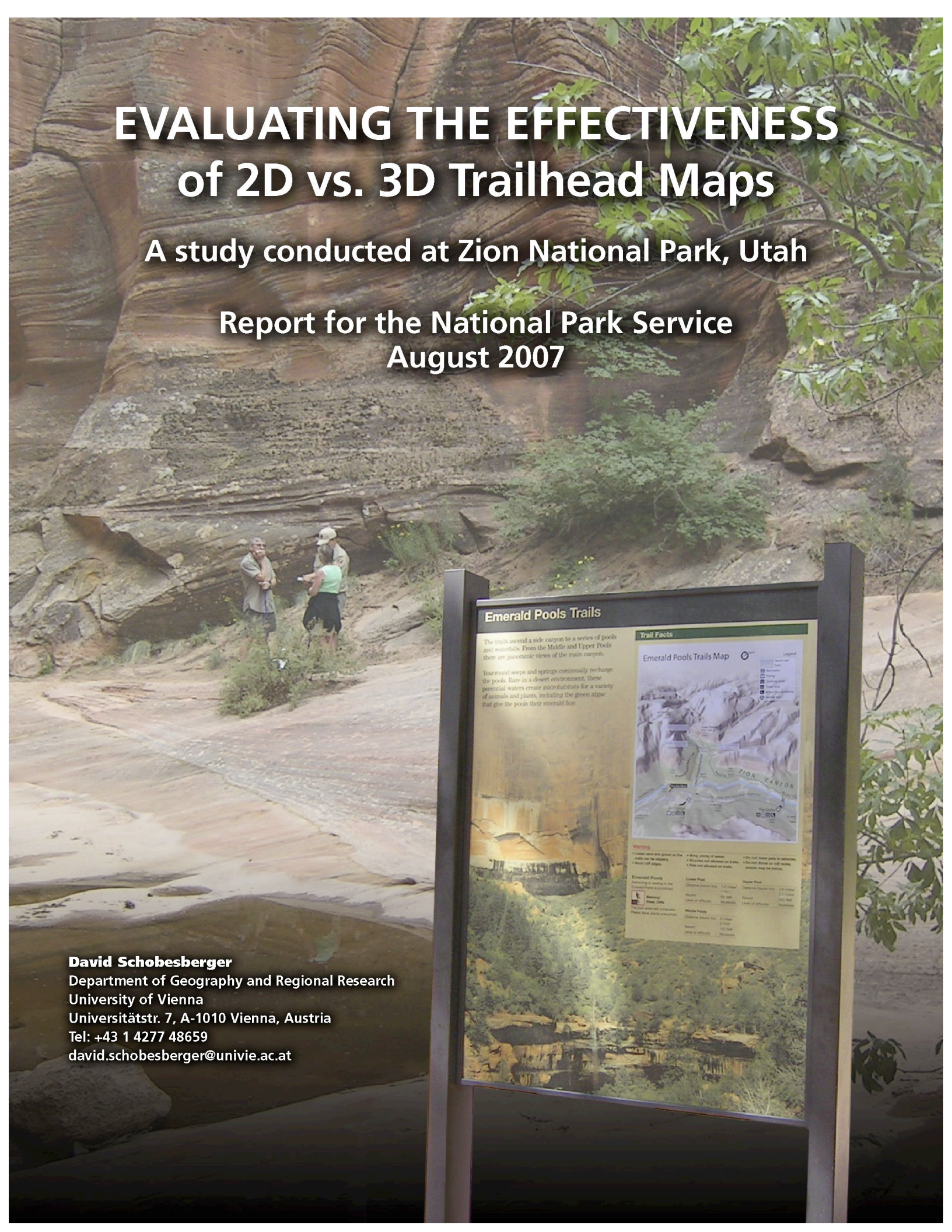
EVALUATING THE EFFECTIVENESS of 2D vs. 3D Trailhead Maps

A study conducted at Zion National Park, Utah

Report for the National Park Service
August 2007



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EXECUTIVE SUMMARY

This user study evaluated the effectiveness of two-dimensional (2D) hiking maps compared to three-dimensional (3D) hiking maps for communicating of trail information to park visitors. A masters-degree student in cartography from the University of Vienna, Austria, collaborated with staff at the National Park Service, Harpers Ferry Center to design and conduct the study. The study took place at Zion National Park, Utah, for three weeks in September 2006.

The National Park Service (NPS) uses two varieties of maps at trailhead exhibits: 2D maps are conventional maps that depict the landscape from a point directly overhead. Most maps found on existing NPS trailheads are 2D maps. 3D maps, sometimes called bird's-eye views or panoramas, depict the landscape from an oblique angle and in perspective *(see Figure 1 below for a comparison of 2D and 3D maps)*. Regardless of whether a map is of the 2D or 3D variety, at a trailhead its goal is to give hikers relevant information without burdening them with unnecessary detail that could detract from their understanding of the trail that lies ahead.

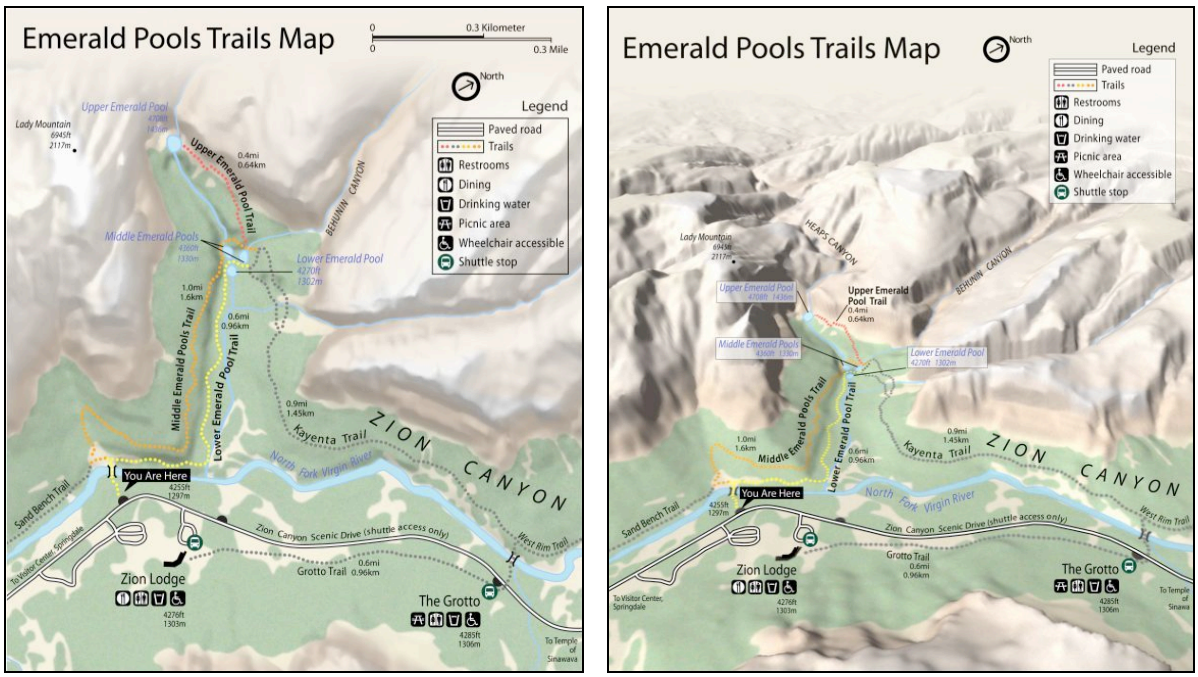

Figure 1. The 2D map *(left)* and 3D map *(right)* of the Emerald Pools trails used for comparative testing.

Both 2D and 3D maps have their assumed advantages. Many cartographers think that inexperienced map users more easily understand 3D maps because they present the landscape in a realistic manner and mimic what people see while on a trail. The advantage of conventional 2D maps is that they require less time and money to produce than 3D maps.

The user study aimed to answer these questions:

- Which map type communicates geographic information faster and more effectively?
- Which map type imprints itself better as a mental map in the mind of park visitors?

- Which map type attracts more visitors to read trailhead exhibits, holds their attention, and motivates them to go hiking?
- Which map type do national park visitors prefer?

Data collection took place on two trails, one popular with novice hikers, and the other more strenuous and frequented by experienced hikers. For both trails the researcher prepared 2D and 3D maps in a predefined format that mounted easily to the existing trailhead-signs. The collection of data with either the 2D or 3D maps mounted at trailhead exhibits took place on alternating days.

Map user study: Comparison of 2D and 3D trailhead maps	
Day one – 2D trailhead map on display / Day two – 3D trailhead map on display	
Part 1 Monitoring at trailhead	Part 2 Interviewing hikers on trail

The study used two approaches for collecting data: passive monitoring of park visitors as they read trailhead exhibits and a questionnaire given to hikers while on the trail. The final tally of collected data includes 340 observations of hikers at trailheads and 185 completed questionnaires. The average response rate for the questionnaire was approximately 90 percent.

The questionnaires consisted of four parts:

Part 1: Respondent characteristics (age, gender, hiking experience, etc.)
Part 2: Interaction with the trailhead map. Did the respondent look at the trailhead map and for how long?
Part 3: Questions about map content.
Part 4: Map positioning task (hikers marked their current location on a map) and map design preference.

The researcher analyzed the gathered data for statistical significance and correlations with the Chi-Square test. The analysis yielded interesting and significant correlations for many but not all of the key research questions.

Key findings:

- 3D maps enable hikers to more accurately identify their position on the landscape compared to 2D maps, especially for older people (over 60 years of age) and women.

- Hikers who looked at the trailhead exhibits prefer 3D maps (53%) over 2D maps (43%). Those who did not look at the trailhead exhibit prefer 2D maps.

- Older respondents, men, and native English speakers generally prefer 2D maps.

- Younger respondents, women, and non-native English speakers generally prefer 3D maps. Left-handed individuals prefer 3D maps by a wide margin.

- Less experienced hikers on the Emerald Pools trails rated the 2D map easier to read. More experienced hikers on the Observation Point Trail rated the 3D map easier to read.

- 3D maps were rated as more accurate by experienced hikers on the Observation Point Trail than by inexperienced hikers on the Emerald Pools Trail.

- Respondents on both trails generally agreed that 3D maps depict reality better.

- The two map types revealed differing strengths for cartographic communication. Readers of 3D maps had a better understanding of distances, topography, and environment. Readers of 2D maps could better recall place names.

- 3D maps attract more trailhead readers than do 2D maps.

- At the trailhead, 3D maps are on average viewed for a few seconds longer than 2D maps.

Considering the mixed results, the researcher recommends that Harpers Ferry Center continue—and even increase—the use of 3D trailhead maps, but on a case by case basis. The appropriate use of 3D maps depends on the trail and the kinds of hikers it attracts. 3D maps were found best suited for trails with considerable elevation gain frequented by younger individuals, non-native English speakers, women, and those who hike frequently. 3D maps also attracted more readers at the trailheads and held their attention longer. By comparison, conventional 2D maps were found better suited for flatter, less strenuous trails frequented by older individuals, men, native English speakers, and people who hike infrequently.

CONTENTS

INTRODUCTION

The objective of this study is to provide Harpers Ferry Center (HFC) with information about the effectiveness of 3D trailhead maps compared to 2D trailhead maps. In recent years HFC has begun making more 3D maps for mounting on trailhead exhibits to convey hiking information to park visitors. The New Media Mapping Services IDIQ contract (Indefinite Quantity-Indefinite Delivery contract) that HFC launched in 2007 now provides parks with commercially produced 3D maps for this purpose. However, because 3D maps are more expensive to produce than conventional 2D maps, knowing whether 3D maps are indeed more useful to users (i.e. hikers) is an important consideration for providing the most appropriate maps to the parks. This issue also is of interest to the Section of Cartography and Geoinformation, Department of Geography and Regional Research, University of Vienna, the home institution of the principal investigator.

At present, little research exists on the effectiveness of 3D maps for cartographic communication. Most research on the topic relies on small surveys of expert users (Häberling, 2003) or students tested in a controlled indoor setting. The research conducted here, in contrast, evaluates 2D and 3D maps outdoors in a national park setting and with a large sample of park visitors. Testing measured a variety of issues relating to trailhead maps, including communication effectiveness, user preferences, visual attraction rates, and map positioning ability. The data were collected from hikers on the trails by administering standardized questionnaires and monitoring maps displayed at trailheads.

2D and 3D maps defined

This study uses the term 2D maps to describe conventional maps that depict an area on the surface of the Earth from a theoretical vantage point of directly overhead. The majority of maps published today are 2D maps, including most NPS brochure maps and venerable USGS topographic maps. 2D maps accurately portray the spatial relationships (x and y dimensions) of a landscape but are intrinsically ill suited for depicting the height of terrain (z dimension). 2D maps employ a variety of abstract methods to portray terrain, such as contour lines, spot elevations, hypsometric (elevation) tints, shaded relief, and hachures.

3D maps differ from 2D maps in that they view a landscape from an oblique angle. Often called birds-eye views or panoramas, 3D maps depict the terrain with faux three-dimensionality and contain perspective that portrays distant (background) areas with diminished scale. The landscapes represented on 3D maps appear similar to the views people observe from high places, such as a mountain peak or airplane window. 3D maps can be displayed on printed brochures, computer monitors, outdoor exhibit panels, and a variety of other two-dimensional media surfaces.

Until recently the cartographic profession has regarded 3D maps as an exotic niche product compared to 2D maps, which are far more ubiquitous and familiar. Their pictorial appearance and variable scale make 3D maps seem imprecise and non-scientific in the eyes of many cartographers. However, now that computers have made 3D maps easier to produce and thus more common—for example, Google Earth is now a widely popular computer application for viewing 3D landscapes—the mapmaking community is reevaluating 3D maps as an acceptable means for giving a quick and concise overview of the topography and environment of an area. Many cartographers assume that inexperienced map-readers can more easily relate to the

information depicted on 3D maps because they closely mimic nature and are less abstract than 2D maps.

Advantages of 3D maps:

- They are assumed easier to read.
- The virtual camera position and viewing direction are customizable.
- Elevation differences and topographic formations are easy to understand.
- They appeal to readers. For example, eye-catching 3D maps are often used in ski resort advertisements.
- They can be overlaid with abstract or photo-realistic information.

Disadvantages of 3D maps:

- Scale varies from front to back within a scene.
- High topographic features can obscure information in the background.
- Printing of vector lines on 3D terrain is difficult.
- 3D map production requires more time than for 2D maps.
- 3D maps are more expensive to make than 2D maps.
- Successful production depends on a high-quality digital elevation model, which is not always available.
- Specialized software is needed for production.
- Standardized techniques for 3D map production are not familiar to most mapmakers.

Zion National Park study site

The research took place from September 4 to 21, 2006, in Zion National Park, Utah. With more than 390 parks in the NPS system to choose from, selecting the appropriate park and trails to study was a difficult decision. Zion National Park offered many advantages as an ideal study venue.

Topography was a top consideration. At Zion the dramatic landscape was conducive to making 3D maps with unambiguous three-dimensionality, a necessity for comparative testing with flat 2D maps. Zion is a park renowned for its hiking trails, and it offered two suitable trails for testing, one easy and the other moderately strenuous. Both trails attracted ample numbers of hikers needed for the study, but they were not overcrowded. In addition, the trailhead exhibits at these trails were well situated for unobtrusive monitoring of hikers as they read the maps.

Logistical concerns also were a factor for selecting Zion National Park as the study site. Because the principal investigator did not have a car, the free shuttle bus provided access to the trailheads and conveniences in the nearby town of Springdale. The pleasant weather that typifies Zion in September meant fewer interruptions to the research because of bad weather—few people will set off to hike on a rainy day. Last but not least was the supportive park staff with an interest in improving the maps used by park visitors. Tom Haraden, assistant chief of Visitor Services at Zion, provided the principal investigator with administrative support and local knowledge during the three weeks of the user study.

Research questions

This study, which compared 2D and 3D trailhead maps *(Figure 2, left and right),* addressed the following research questions:

- Which map type is more effective and faster for communicating geographic information?
- Which map type makes a better mental map for hikers?
- Which map type attracts more readers and motivates them to set out on a hike?
- Which map type do park visitors prefer?
- Which map type is better for orientation and allows hikers to identify where they are on the map?

Answers to these questions are important for Harpers Ferry Center (HFC), the National Park Service facility responsible for the production of trailhead maps. At HFC, knowing whether 3D maps are worth the extra time and money to produce is a priority. HFC Senior Cartographer Tom Patterson helped conceptualize the study and provided administrative support to the principal investigator.

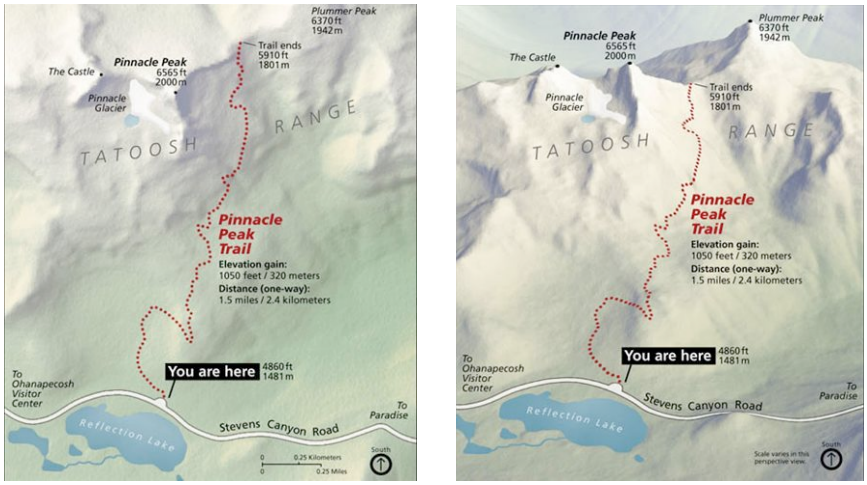

Figure 2. A 2D *(left)* and 3D *(right)* trailhead map of the same area designed in a similar fashion. Source: Patterson, 2004.

STUDY DESIGN

The user study had two main components. The first component involved monitoring trailhead exhibits where either 2D or 3D maps were put on display. Mounting the test maps to the exhibit panels was a simple matter of applying double-sided tape to inkjet prints of the maps and placing them over the existing maps. The taped maps blended inconspicuously with other graphical elements on the trailhead exhibits. The principal investigator (PI) monitored the trailhead exhibits from a sufficient distance that park visitors were not aware of his presence but close enough to accurately record their interactions with the exhibits.

Whenever a hiker or group of hikers came close to the exhibit, the PI noted the time, group size, and their characteristics, including the number of females, males, and children in the group. Once a hiker or group of hikers stopped and started looking at a trailhead map, the PI recorded their reading time with a stopwatch. He also he recorded whether they proceeded to hike the trail after studying the map. The monitoring was done in the morning or afternoon and on different days with alternating 2D or 3D maps mounted on the exhibits *(Figure 3)*. A sample size of 300 groups or single hikers was sought.

The second component of the user study was a questionnaire administered to hikers about midway on the trails. As with the trailhead monitoring, either 2D or 3D maps were mounted on the trailhead exhibits on the days that the questionnaires were given. Hikers were questioned on the Lower Emerald Pool and the Middle Emerald Pools trails, two short, mostly level trails that are popular with novice hikers. The Lower Emerald Pool and the Middle Emerald Pools trails share a common trailhead and run parallel to each other to a common destination. Questionnaires were also given on the Observation Point Trail, a longer and more strenuous trail frequented by experienced hikers. The assumption that the easy trails attract inexperienced hikers and strenuous trails attract expert hikers proved true in the course of the user study *(see page 17 for details)*.

The intent was to collect a sample size of 200 questionnaires for all three trails. The questionnaires were not handed out to the subjects but were filled in by the PI, who read the questions to hikers and recorded their oral responses. When a group of hikers was encountered on the trail, only one person would answer the questionnaire. Respondents were chosen randomly; the first hiker to pass a predefined interception line was approached by the PI and asked to participate voluntarily in the questionnaire. Completing the questionnaire interview took from 5 to 15 minutes.

A small minority of hikers declined to participate in the questionnaire. For each non-participant background information was noted in a refusal log, which included their estimated age, gender, whether they were in a group or hiking solo, and the reason for refusal. This information made it possible to compare the non-respondent characteristics with those of the respondents *(see page 18 for details)*.

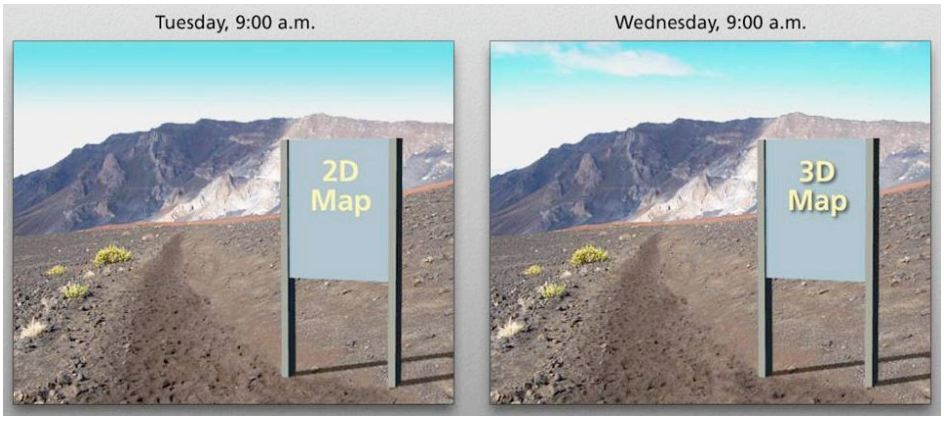

Figure 3. 2D and 3D trailhead maps were displayed for testing on alternating days and under similar conditions. Source: Patterson, 2004.

Test maps

Four different maps were produced for testing in the user study: a pair of 2D and 3D maps for display at the Emerald Pools trailhead and a pair of 2D and 3D maps for display at the Observation Point trailhead.

Guided by the map design standards developed by HFC, the test maps received an appealing design and generalized content, eschewing information not directly related to the hike itself. Except for their 2D or 3D appearance, the paired maps for each of the trailhead exhibits shared common information, orientation, and design qualities—with one exception. A bar scale was not shown on the 3D maps because their scale, as noted earlier, is not consistent.

The 2D maps depicted topography with shaded relief rendered as though the reader was looking straight down on the landscape from above. The 3D maps depicted topography in an oblique, three-dimensional manner with modulated illumination and shadow tones similar to those found on shaded relief. Neither type of map used contour lines. Information found on both map types included trails, trail distances, prominent summits with elevations, streams and ponds, roads, and important park facilities such as shuttle bus stops, toilets, lodges, etc. Wooded areas were shown with a green tint in the lowlands—the only area through which the hikers would pass that contained significant tree cover. Most of the remaining surface area on the maps was rock portrayed with a sandstone color that became lighter with increasing elevation.

Emerald Pools Maps

The NPS prefers to orient trailhead exhibits (and the maps mounted on them) in the same general direction of the trail. The trailhead is usually at the lowest elevation on the many trails that climb uphill toward a destination. In the case of the maps of Emerald Pools trails, the orientation is from southeast to northwest from the trailhead near the Zion Park Lodge and Virgin River. The Emerald Pools, although situated at the base of towering sandstone cliffs, have only a slightly higher elevation than the trailhead *(Figure 4)*. The trail network, which is the main focus of the map, appears in different colors.

The design of the 3D map had to take into account more variables than the 2D map. The position of the virtual camera, including its viewing azimuth and inclination, and the vertical exaggeration of terrain were chosen to create a pleasing and easily grasped view of the Emerald Pools area. Care was taken so that high foreground terrain did not hide portions of the trail in the background.

The vertical exaggeration of the 3D map of the Emerald Pools trails was kept at 100 percent, which does not alter the relationship of the x, y, and z dimensions as they exist in nature. The camera looks at the scene from a moderately low elevation and flat angle, emphasizing the rock walls in the background that loom over the trails. Virtual sunlight on the map originates from the southeast (lower left) and has a very steep angle to provide adequate illumination to the deeply recessed terrain near the base of the cliffs. Cast shadows were not included because they would have partially obscured the Emerald Pools. In addition, a distance mask was rendered to create atmospheric haze, giving the map enhanced 3D depth.

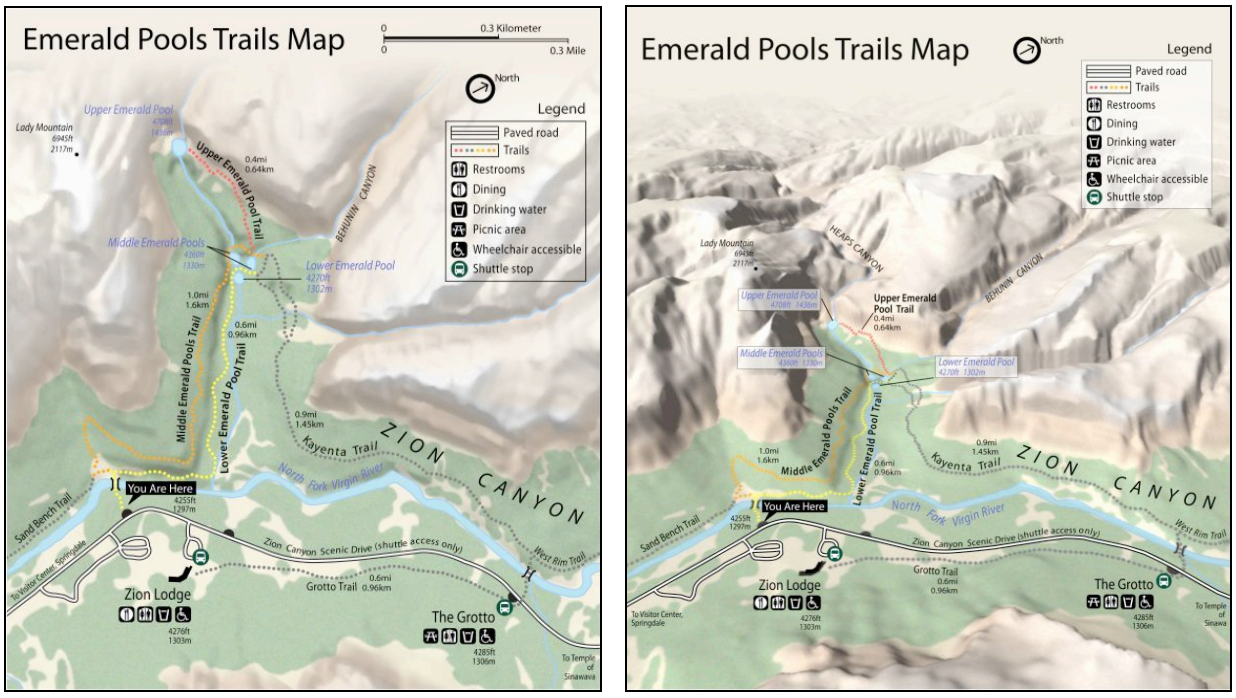

Figure 4. The 2D map *(left)* and 3D map *(right)* tested at the Emerald Pools trailhead.

Observation Point (East Rim) Maps

This pair of maps abandoned the NPS convention of orienting trailhead maps to the direction of the trail. Instead, the maps used the conventional north orientation to better depict a complex network of trails traversing steep cliff faces and winding through deep canyons. Avoiding obscured areas was a key issue in selecting the map orientation; conventional north orientation happened to prove best for this purpose.

The Observation Point 2D map had a design analogous to that of the Emerald Pools 2D map. The 3D map received no supplemental vertical exaggeration because of very high local relief (the vertical exaggeration was 100 percent, as it is in nature). An atmospheric haze effect was employed, and cast shadows were absent from the map. Illumination originated from the northwest and at a steep angle. In addition, the virtual camera looked down on the map from a steep angle to prevent narrow Echo Canyon from being totally hidden by adjacent higher terrain *(Figure 5, right)*.

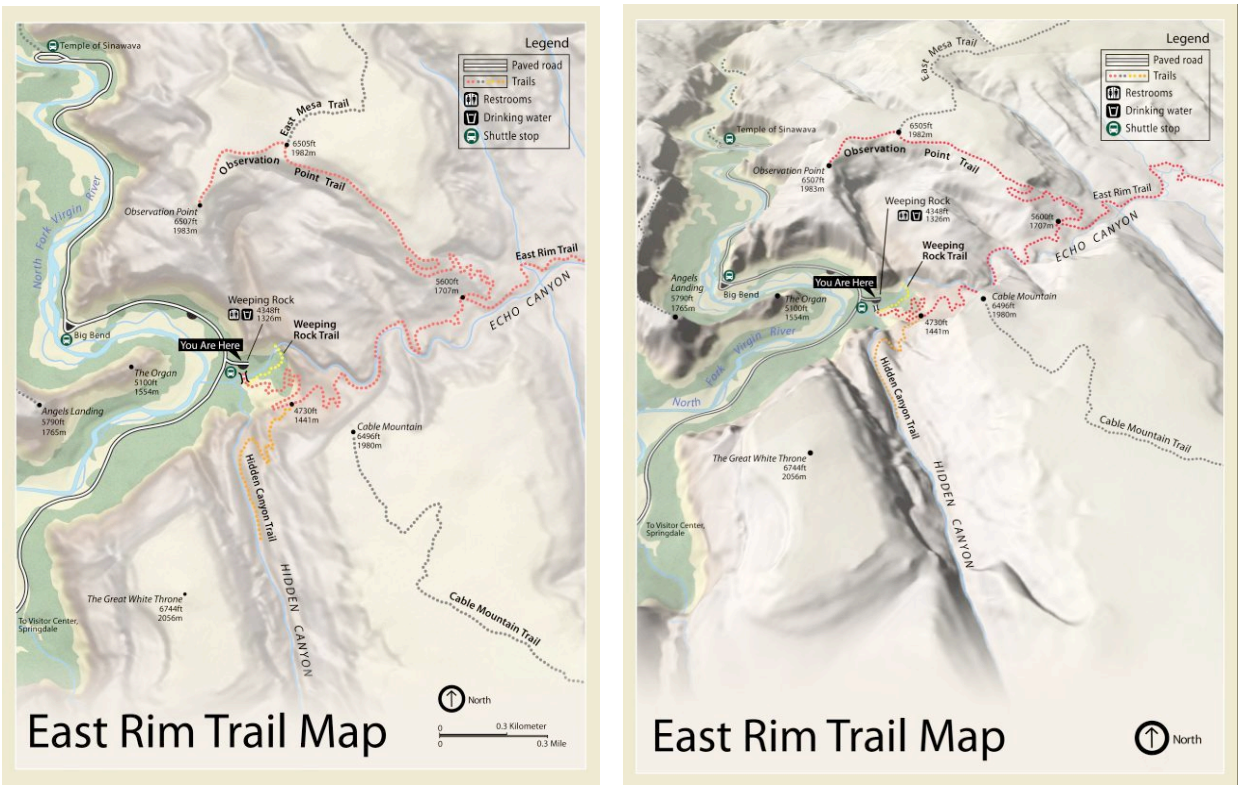

Figure 5. The 2D map *(left)* and 3D map *(right)* tested at the Observation Point trailhead where the Observation Point Trail and East Rim Trail originate.

Questionnaire

The questionnaires probed the major differences between 2D and 3D trailhead maps from a map user's point of view. Answers to the following questions were sought:

- Which map type facilitates more efficient cartographic communication processes?
- Which map type permits users to form more precise and long-lasting mental maps?
- Which map type allows people to orientate themselves better and determine their own position on the map?
- Do certain demographic groups prefer one map type to the other?
- Do the respondents have any general comments about the maps or the user study?

The questionnaire consisted of four parts.

Questionnaire – Part One:
The first part sought background information about the respondent, including age, gender, whether hiking with a group or solo, hiking experience, native language, and whether they are left or right handed. Data about handedness provided insight about differing spatial perceptions and methods for constructing mental maps that might exist between left and right-handed hikers. The respondents were also asked if they had hiked the trail before or were carrying maps or any devices for orientation, such as a compass or GPS unit. Respondents answering yes to any of these questions were not eligible for Part Two and Three of the questionnaire, to eliminate the possibility of bias. The point of the study was to test respondents' recall of information acquired

exclusively from the trailhead map. Potentially biased respondents skipped ahead to Part Four of the questionnaire.

Questionnaire – Part Two:
The questions in this part concerned the respondent's interaction with the trailhead map. They were asked to estimate their time spent reading the trailhead map and to rate the graphic design, legibility, and how well the map they saw matches the actual landscape they were now walking through. The answers to these questions provided information about which type of map hikers preferred but without having to ask them to compare both and to name a favorite. A direct comparison would skew the results of subsequent questions asked in the questionnaire.

Questionnaire – Part Three:
This part investigated the effectiveness of cartographic communication processes and the mental maps of the users. Respondents were asked to recall specific facts presented on the maps to find out which type better communicated spatial information. In this part of the questionnaire the Emerald Pools questions and Observation Point questions differ because the maps show different areas. However, the type of questions asked about each map was kept rather consistent to maintain comparability.

Questionnaire – Part Four:
The last part of the questionnaire tested the ability of respondents to orient themselves by indicating their current position on a test map. To do this, the PI gave the respondents a copy of the map that they saw at the trailhead exhibit. The respondent then marked on the map where they thought they were. The PI afterwards measured the difference between their estimated position and their actual position. The sites on the trails where the questioning took place did not offer views of the surrounding landscape.

The last four questions in Part Four were devoted to the direct comparison of 2D and 3D maps. To begin, the PI handed the respondents a copy of a second map, either a 2D or 3D map depending on which type was not on display at the trailhead that day. The respondents were then asked to compare the 2D and 3D maps and indicate which they preferred, which better represented reality, was easier to read, and more accurate. Finally, the respondents were asked to give general comments about the maps and the user study.

The proposed questionnaires were submitted to NPS Social Science Program for expedited approval on July 16, 2006. After this step and making several small changes the questionnaires were submitted to the NPS Office of Management and Budget (OMB) on August 15, 2006. OMB granted final approval on August 22, 2006. The OMB control number is OMB Approval #1024-0224 (NPS #06-056). See Appendix E for the final questionnaires.

DATA COLLECTION

The user study was conducted in Zion National Park, Utah, from September 4 - 21, 2006. Trailhead monitoring was accomplished in three days at the Emerald Pools trailhead. In total, 340 observations were made at the trailhead. An observation sample could consist of either a single hiker or a group of hikers. Groups of hikers were tallied as one observation. Figure 6 shows the monitoring times, mounted map type, and the number of hikers/hiking groups passing the maps.

Date	Time	Map type	Groups / single hikers
Friday 9/8/06	09:40 – 12:00	3D	71
Saturday 9/9/06	10:30 – 12:20	2D	78
Sunday 9/10/06	11:00 – 12:00	3D	49
Sunday 9/10/06	12:15 – 13:15	2D	52
Sunday 9/10/06	13:30 – 14:30	3D	42
Sunday 9/10/06	14:50 – 15:50	2D	48

Figure 6. Monitoring the Emerald Pools trailhead

Monitoring the Observation Point trailhead, although part of the original research proposal, was abandoned because of the large numbers of visitors disembarking from the park shuttle bus and converging on the trailhead all at once. Observing just one of these many people gathered at the trailhead exhibit proved an impossible task. This was in stark contrast to the Emerald Pools trailhead, which proved ideal for monitoring. Solitary hikers or small groups of hikers would arrive at it incrementally throughout the day.

Questionnaires were given to hikers on nine days in total, five days on either the Lower or Middle Emerald Pools trails, and four days on the Observation Point trail. Figure 7 shows the days on which questionnaires were given, the trail, and which type of trailhead map was mounted at that time.

Date	Time of day	Trail	Trailhead map	Interviews conducted
Friday, 9/8/06	afternoon	Lower Emerald Pools Trail	3D	22
Saturday, 9/9/06	afternoon	Lower Emerald Pools Trail	2D	22
Monday, 9/11/06	whole day	Middle Emerald Pools Trail	3D	23
Tuesday, 9/12/06	whole day	Middle Emerald Pools Trail	2D	25
Friday, 9/15/06	whole day	Observation Point Trail	2D	19
Saturday, 9/16/06	whole day	Observation Point Trail	3D	26
Sunday, 9/17/06	whole day	Observation Point Trail	2D	21
Monday, 9/18/06	whole day	Observation Point Trail	3D	20
Wednesday, 9/20/06	afternoon	Middle Emerald Pools Trail	3D	10

Figure 7. Schedule for conducting hiker questionnaires

The position of the PI for conducting the questionnaires on the trails was chosen after careful inspection of the trails *(Figure 8)*. Sites chosen were sufficiently far along the trail for people to start forgetting the trailhead map, and the shaded sites made appealing rest stops. Thick tree cover on the Emerald Pools trails and the close confines of Echo Canyon on the Observation Point trail hid a view of the wider landscape from respondents; to answer the questionnaire they had to rely exclusively on their mental map of the trailhead exhibit.

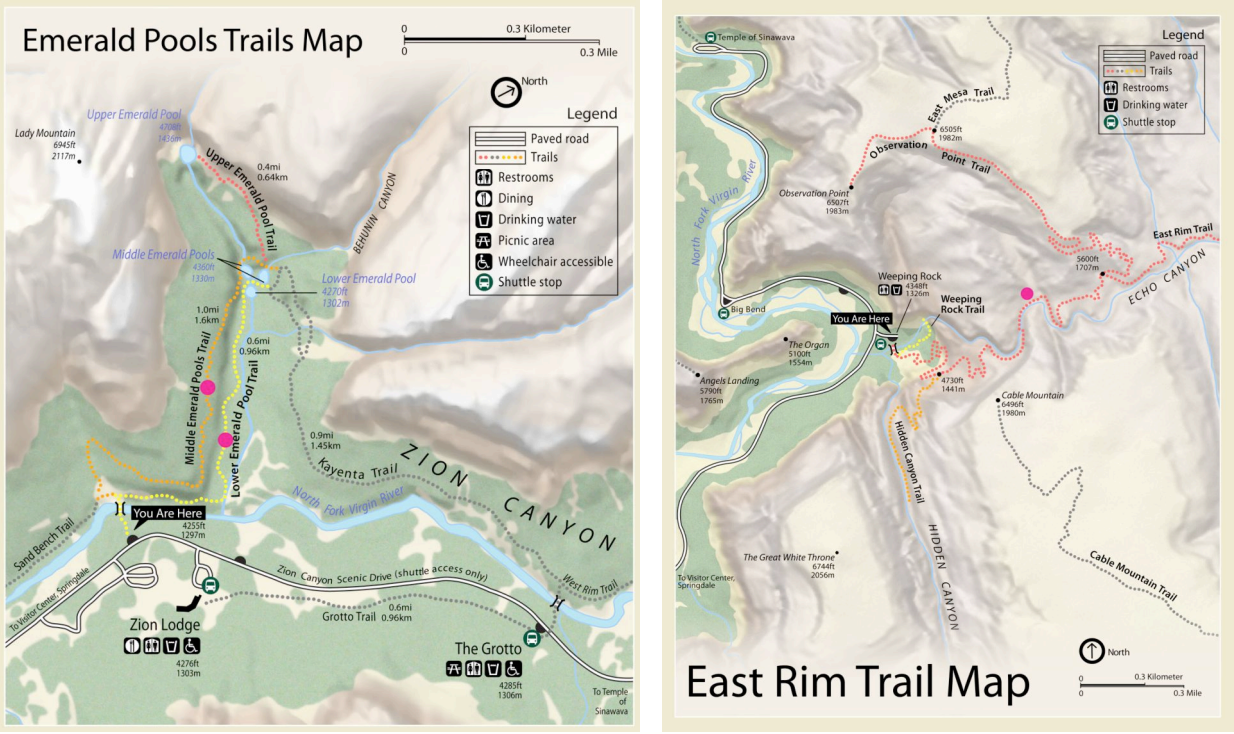

Figure 8. Interview positions indicated by magenta dots on the Emerald Pools trails *(left)* and Observation Point Trail *(right)*.

CHARACTERISTICS OF STUDY POPULATION

Questionnaire respondents

A total of 208 people were asked to participate in the questionnaire. Twenty people refused the survey for a variety of reasons, which are examined on page 18. Three of the completed questionnaires were deemed invalid and removed from the study. Of the remaining 185 valid questionnaires, 100 were collected on the easy Emerald Pools trails and 85 on the difficult Observation Point trail *(Figure 9)*.

Figure 10 illustrates the gender and age of the questionnaire takers by trail. Male respondents outnumber females on both trails 61.1% to 38.9%. This disparity was more pronounced on the Observation Point Trail, where males represented 68.2% and females 31.8% of the total respondents.

Looking at the age of the respondents reveals that younger people (15-25 years) were underrepresented. A probable explanation is that in mid-September school was back in session, and students were not free to go hiking. Couples between the ages 26 and 60 were the most common participants for the questionnaire.

	Both trails						Emerald Pools trails				Observation Point trail			
	total		females		males		females		males		females		males	
age	count	%	count	%	count	%	count	%	count	%	count	%	count	%
15-25	11	5.9	4	5.6	7	6.2	2	4.4	4	7.3	2	7.4	3	5.2
26-40	53	28.6	22	30.6	31	27.4	13	28.9	15	27.3	9	33.3	16	27.6
41-60	93	50.3	38	52.8	55	48.7	23	51.1	23	41.8	15	55.6	32	55.2
60+	28	15.1	8	11.1	20	17.7	7	15.6	13	23.6	1	3.7	7	12.1
Total	185		72		113		45		55		27		58	

Figure 9. Characteristics of questionnaire respondents (only valid questionnaires)

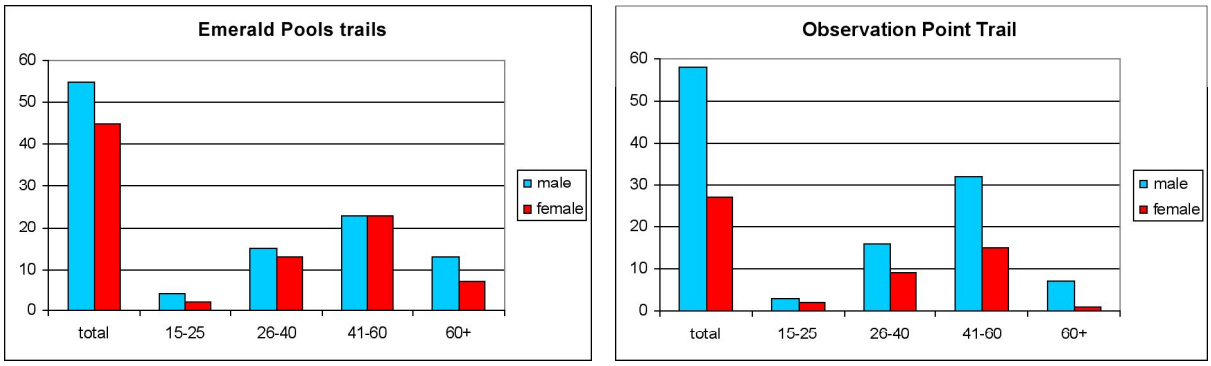

Figure 10. Gender and age of respondents on the Emerald Pools trails *(left)* and Observation Point Trail *(right)*

Hiking and map use experience

When designing the user study it was assumed that people hiking on the Emerald Pools trails would be inexperienced hikers and map users. Conversely, on the Observation Point trail it was assumed that the hikers would be more experienced with hiking and using maps. Verification of these assumptions was tested in Part 1 of the questionnaire. The questions in this part asked how often the respondent went hiking in the last 12 months, how often they went hiking in Zion National Park in the last 12 months, and how often they use maps when hiking.

The proposed assumptions about the characteristics of typical hikers on each of the trails proved true. A significant relationship (5% level, Chi-square test) existed between the trail where the interviews where taken and the hiking frequency of the respondents. The respondents on the Observation Point trail went hiking more often than those on the Emerald Pools trails *(Figure 11)*. A possible complicating factor to these statistics is that people who declared that they go hiking on a daily basis may in fact be counting their daily urban strolls as hikes.

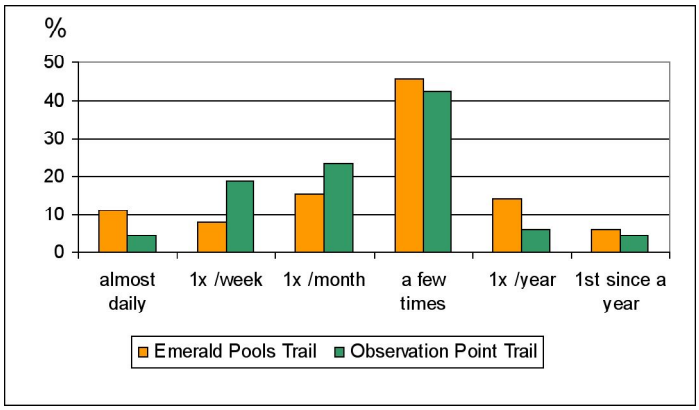

Figure 11. Hiking frequency by trail

The answers about having hiked in Zion National Park within the past 12 months exhibited considerable variability. On the Emerald Pools trails many respondents were on their first and often only hike in the park. On the Observation Point trail, the percentage of people who had already hiked other trails in Zion was higher. Figure 12 shows the hiking frequency in Zion National Park during the previous year based on trail where the questionnaire was given. The correlation is significant at the one-percent level.

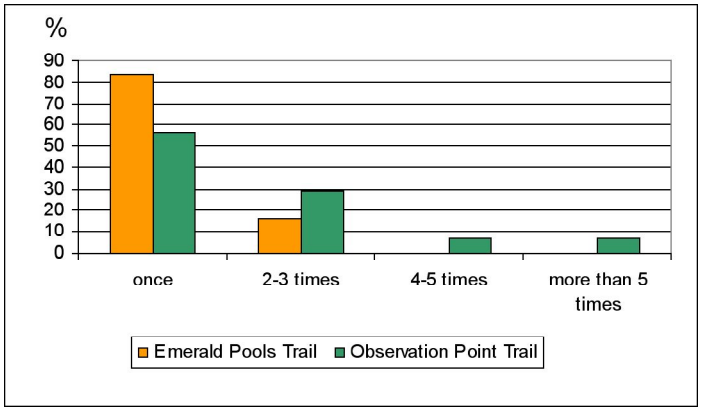

Figure 12. Hiking frequency in Zion National Park by trail

There were no significant correlations between map use and the trail where the respondents were interviewed. The findings indicate that experienced hikers are not necessarily more experienced map users than inexperienced hikers.

Questionnaire response rate and non-respondents

The trail questionnaires had an unusually high response rate. Along the Emerald Pools trails 85% of all hikers approached were willing to take part in the survey. On the Observation Point trail the response rate was 97.7%. The average response rate for both trails was 90.4%. By comparison, a wilderness experience study conducted in the remote backcountry of Zion National Park in 2002 had a response rate of 80%.

To learn who did and did not respond to the questionnaire, demographic characteristics of the non-respondents (gender and estimated age) were collected by visual observation *(Figure 13)*. Male hikers in the age group between 41 and 60 accounted for most refusals. Compared to the

total study population, the relative rate of refusals was noticeably higher for hikers between 15 and 25 years of age. Females accounted for only 20% of the refusals while males accounted for the remaining 80%.

Not one person over the age of 60 refused to participate in the questionnaire. The tendency of older people to participate and younger people not to participate further marginalized the under-represented 15- to 25-year-old age group in the study. However, looking beyond the small sampling of young hikers, the overall rate of refusals (~10%) was low enough to have a minimal effect on the analysis of data.

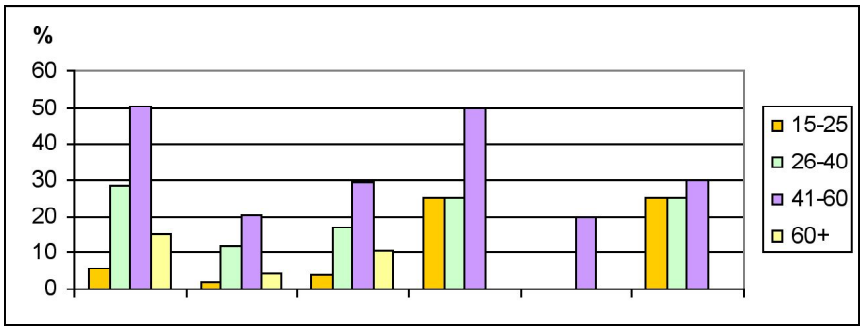

Figure 13. Questionnaire non-respondents by age group

The most common reasons given for not taking the questionnaire was a lack of time because of waiting family members on the trail (5 entries) or needing to catch tour busses at a specific time or other pending activities (7 entries). Five people who refused to answer the questionnaire also refused to give a reason for not responding.

Hikers observed at Emerald Pools trailhead

From a discrete location, which gave a clear view of the trailhead, the PI monitored a total of 340 groups/single hikers who together spent more than two hours looking at the maps. The monitoring was conducted on different weekdays, in the morning as well is in the afternoon, with only short breaks between the monitoring sessions. Because the Emerald Pools trail is one of the most popular trails in the park and the trailhead is close to the popular Zion Park Lodge, the findings reveal an interesting profile of general visitors to Zion National Park.

A total of 827 people passed by the Emerald Pools trailhead map during the monitoring sessions; 382 were females, 354 were males, and 91 children, whose the gender was not noted *(Figure 14)*. The highest percentage of hikers was couples (202 groups – 48.9%). The second highest percentage of hikers was those in other groups that were not classifiable (69 groups – 26.7%). Next were the families comprised of adult couples with one or more children (35 families – 17.2%), having an average of 2.06 children accompanying them. Single hikers (31 persons – 3.7%) and people with large tour groups (3 groups – 3.5%) accounted for a small percentage of the trailhead population. Figure 15 illustrates the estimated composition of hiking groups observed on the trails.

	Group count	Total hikers	% of all hikers	Male count	% of all hikers	Female count	% of all hikers	Child-ren count	% of all hikers
Couples	203	406	49.1	203	24.5	203	24.5	0	0.0
Various groups	69	221	26.7	88	10.6	114	13.8	19	2.3
Families	34	140	16.9	34	4.1	34	4.1	72	8.7
Singles	31	31	3.7	17	2.1	14	1.7	0	0,0
Tour groups	3	29	3.5	12	1.5	17	2.1	0	0,0
Total	340	827	100.0	354	42.8	382	46.2	91	11.0

Figure 14. Hikers observed at the Emerald Pools trailhead. Note: group count includes single hikers for comparative purposes

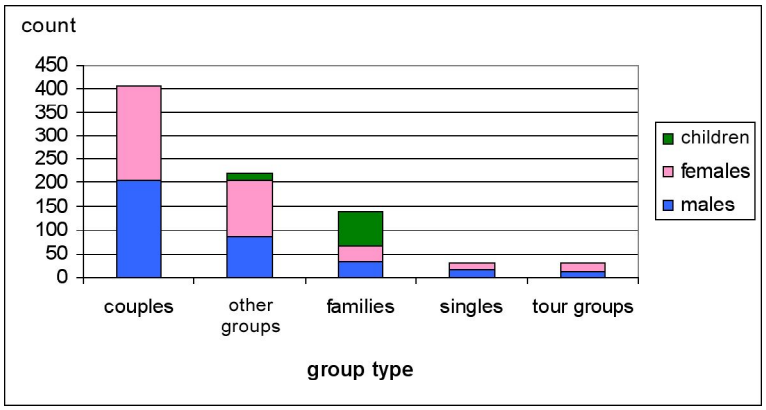

Figure 15. Estimated group type, Emerald Pools trailhead

STUDY FINDINGS

This section describes the evaluation of the data obtained from the questionnaires and trailhead monitoring. The findings include the rating of trailhead maps, positioning accuracy, map-type preferences, efficiency of cartographic communication processes, attraction of map types, ability to motivate, and the time spent reading the maps. Respondents' comments about the maps and the user study are listed on pages 33 and 34.

Rating of trailhead maps

The questionnaire asked hikers to rate the design of the maps, their readability, and the impression the maps gave of the landscape. For each of these issues, a short statement was read to the respondents, which they were asked to agree or disagree with, using a numerical point scale from 1 (disagree) to 7 (agree). The statements were:

- The design of the map at the trailhead sign was appealing (question 12).
- The map at the trailhead sign was easy to read (question 13).
- The impression of landscape I got from the map matches what I saw while hiking (question 14).

Each map type received an average rating based on the responses given to these statements. The 2D map was rated more appealing, with an average of 5.69 points compared to the 3D map with 5.37 points. As to readability, the 2D map was also rated better, with 6.15 points vs. 5.99 points for the 3D map. The impression of landscape that the 3D map imparted to hikers ranked higher than the 2D map, 4.86 points to 4.59 points.

Respondents interviewed on the Emerald Pools trails ranked the 2D map higher than the 3D map. However, more experienced hikers on the Observation Point Trail ranked the 3D map higher than the 2D map *(Figure 16)*.

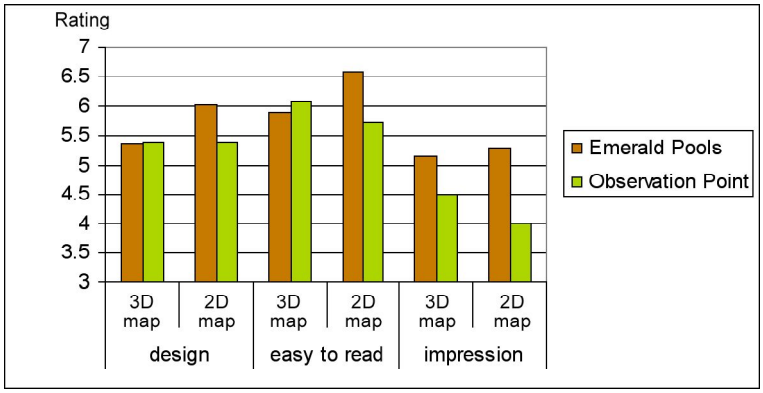

Figure 16. Average rating by map type and trail

Positioning accuracy

Part 4 of the questionnaire asked respondents to mark their present location on the trail on a paper print of the same map type that they observed at the trailhead. There were significant differences in positioning accuracy between the 2D and 3D maps.

In general, hikers accurately identified their positions with the 3D maps more than with the 2D maps. Including test results from both trails, the average difference between estimated position and actual position was 277 meters with the 3D maps and 337 meters with the 2D maps, 60 meters worse. A Chi-square test with the statistical program SPSS verified this correlation significant at the 1% level. In other words, the possibility that the better positioning accuracy achieved with the 3D maps was coincidental was less than one percent.

Looking at the positioning data for each of the trails separately, a strong correlation still exists at the 1% level of significance *(Figure 17)*. These results suggest that a broad spectrum of hikers perform better in orientating themselves, or at least finding their actual position, on 3D maps compared to 2D maps.

	2D map	3D map	significance
Average variation from actual position per person – both trails	337m	277m 82%	1% level
Average variation from actual position per person – Emerald Pools trails	139m	110m 79%	1% level
Average variation from actual position per person – Observation Point Trail	591m	476m 81%	1% level

Figure 17. Positioning accuracy by map type

Gender was a factor in positioning accuracy *(Figure 18)*. Female respondents showed considerably better results with the 3D maps compared to the 2D maps. The only case where the positioning accuracy was better with 2D maps was among male respondents on the Observation Point Trail.

The positioning errors on the Emerald Pools trails for male and female respondents together averaged 68m on the 3D map and 86m for the 2D map. On the Observation Point trail, the error was 37m for the 3D map and 46m for the 2D map. These are only half as much as the positioning errors on the Emerald Pools trails, which might be explained by the greater number of experienced hikers on the Observation Point trail *(see page 17 for details)*. Note: positioning errors when normalized for total trail-length are still lower on the Observation Point trail than on the Emerald Pools trails. To make data comparisons between both trail maps, normalization by trail-length was necessary because the map of the Observation Point Trail was at a smaller scale and had correspondingly larger positional errors.

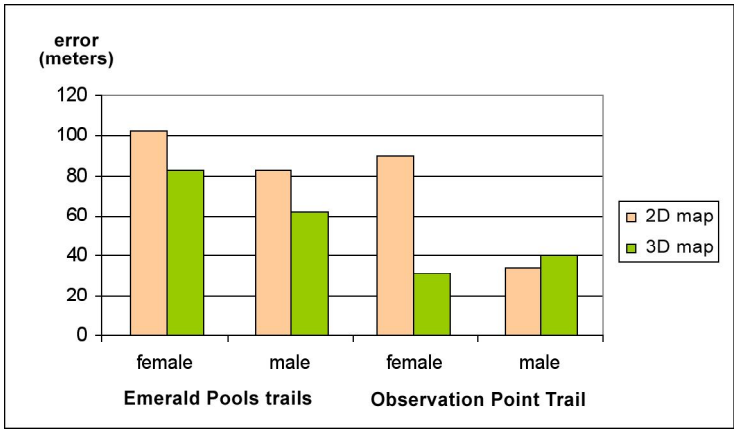

Figure 18. Average position error normalized by trail length by gender

Based on position error and age, respondents in the age group over 60 years achieved notably better results with 3D maps *(Figure 19)*. With the age groups 26 to 40 and 41 to 60, the positioning error disparity between the map types was not as dramatic. Findings for the 15–25 age group must be viewed with caution because of the small sample size.

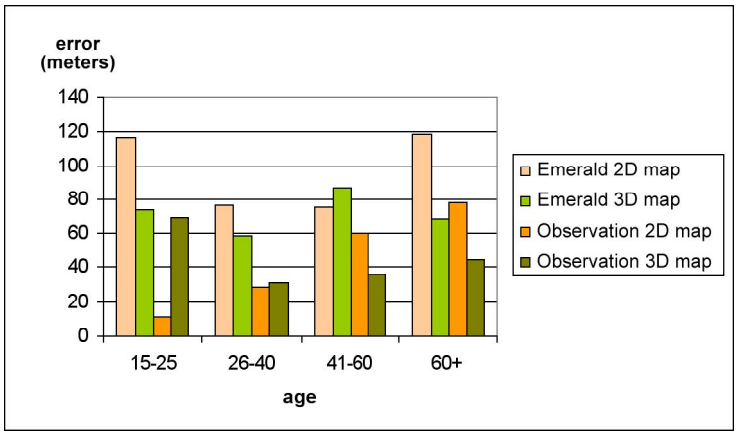

Figure 19. Average position error normalized by trail length by age groups

In summary, 3D maps bring the greatest benefit for orientation and positioning accuracy for females and people over the age of 60. However, despite this advantage, when asked which type of map they prefer, respondents over 60 years of age strongly indicated 2D maps. The next section discusses map preferences in detail.

Map preference

This part of the questionnaire involved showing respondents a 2D and 3D map of the trail they were on and asking which they preferred. Counting all respondents on both trails, a clear preference did not emerge between the 2D and 3D maps. Eighty-nine respondents (48%) declared that the 3D map was their favorite compared to 87 (47%) for the 2D map. Eight people (4%) had no preference.

Analysis of the data, however, indicated significant correlations between map type preference and gender, age, handedness, English as a native language, and whether a respondent had looked at the trailhead map before going on the hike. The results reveal that 3D maps were clearly preferred by the 26–40 age group *(Figure 20)*. With the other three age groups the preferences were more balanced, with a slight preference for the 2D maps—keeping in mind that results for the youngest age group are based on a small sample size. The correlation was tested with a Chi-square test and proved significant at the 1% level.

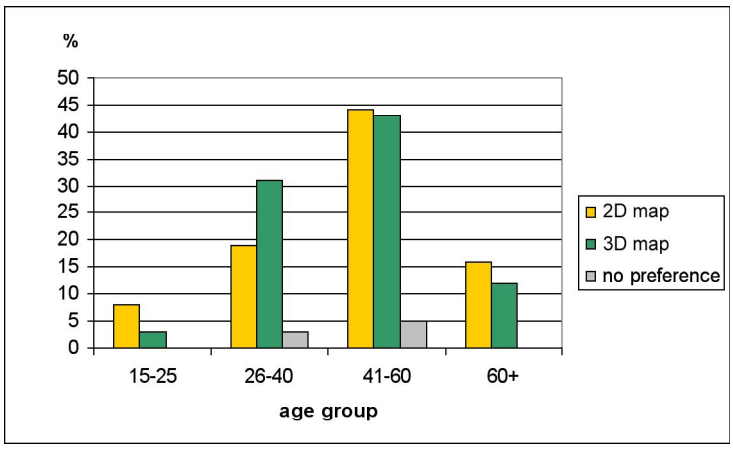

Figure 20. Map preferences by age groups

Based on map preferences grouped by gender *(Figure 21)*, the data show that females preferred 3D maps (52.1%) over 2D maps (43.7%). With males the preference was the opposite—49.6% prefer 2D maps compared to 46% for 3D maps (significant at the 1% level). Considering the preponderance of male respondents (113) to females (72), the overall preference trends stronger for 3D maps.

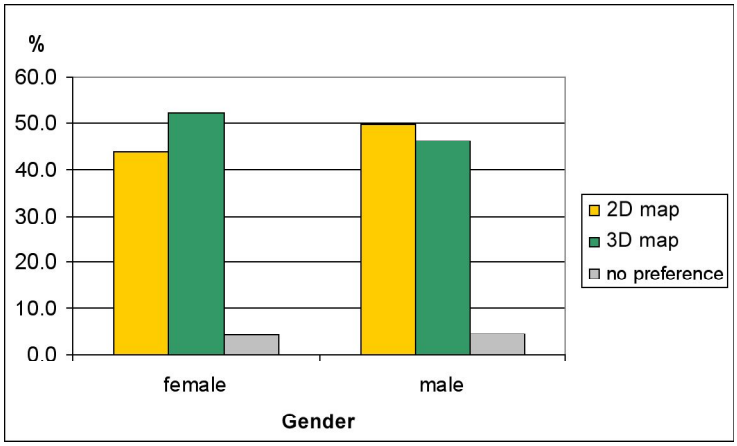

Figure 21. Map preferences by gender

A small but significant correlation exists between handedness (left-handed vs. right-handed people) and map preference. For the left-handed respondents, 45% prefer 3D maps, 40% prefer 2D maps, and 15% had no preference. Right-handed respondents, although evenly split between 3D and 2D maps, were more decisive than their left-handed counterparts. For the right-handed group, 48.8% preferred the 3D maps, 48.2% preferred the 2D maps, and only 3% had no preference.

A significant correlation was found between native English speakers and map type preference *(Figure 22)*. Respondents who were not native English speakers preferred 3D maps (52%) over 2D maps (42%). Among Anglophones, 2D maps were preferred over 3D maps 49% to 47%. The correlation was significant with a 1% level of confidence.

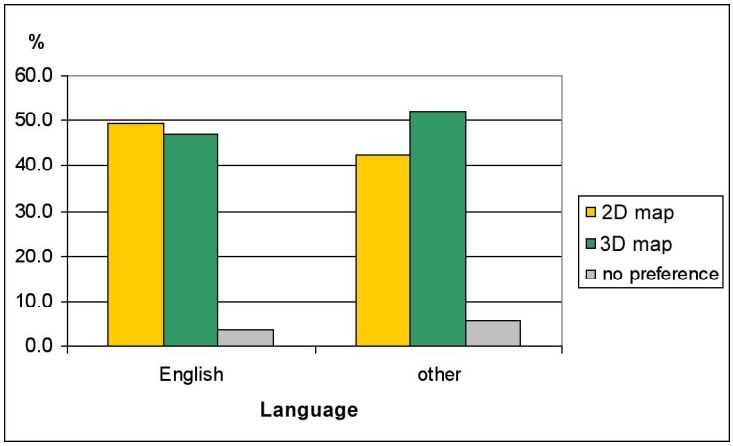

Figure 22. Map preferences by language

An unexpected correlation exists between map type preference and whether respondents looked at the trailhead map before setting off on their hike *(Figure 23)*. Respondents who passed the trailhead without looking at the map preferred 2D maps (55%) over 3D maps (41%). Those who looked at the map preferred 3D maps (53%) over 2D maps (43%). The reasons for this correlation, significant at the 1% confidence level, are not known. However, because NPS cartographers make maps explicitly for park visitors to use, and the visitors who actually read trailhead maps prefer the 3D versions, this finding suggests the need for more 3D maps.

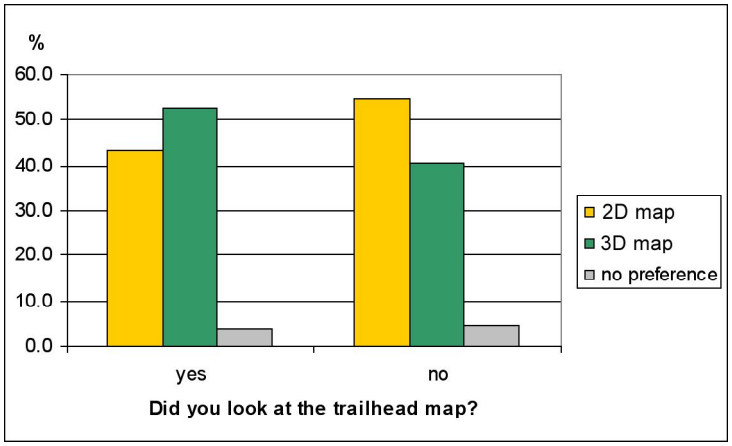

Figure 23. Map type preference depending on whether or not a respondent looked at the trailhead map

Respondents were also asked which map type was easier to read, which map type was more accurate, and which gave the better impression of reality. The accuracy of the 2D and 3D maps examined by the respondents was equal, although most rated one map type as being more accurate. However, the accuracy question was not a trick question. It was intended to give insight into perceived overall map quality, for which accuracy is an important criterion.

The answers to the three questions above revealed only small differences based on age and gender. In general, all groups have more faith in the accuracy of the 3D maps compared to 2D maps, with a single exception. People over age 60 regard 2D maps as more accurate than 3D maps. Many other respondents also stated that neither map type was more accurate.

This issue of perceived accuracy shows a strong linkage with map type preference. Females, left-handed individuals, and younger people tend to think that the 3D map was the more accurate of the two choices *(Figure 24)*.

Gender	2D	Neither	3D	Significance
Females	25.4%	22.5%	52.1%	1% level
Males	38.9%	18.6%	42.5%	1% level
Age group	**2D**	**Neither**	**3D**	**Significance**
15-25	36.4%	9.1%	54.5%	Caution: small sample size
26-40	30.2%	17.0%	52.8%	1% level
41-60	34.4%	18.3%	46.2%	1% level
60+	35.7%	35.7%	28.6%	1% level
Handedness	**2D**	**Neither**	**3D**	**Significance**
Right-handed	34.8%	20.7%	44.5%	1% level
Left-handed	25%	15%	60%	1% level
Language	**2D**	**Neither**	**3D**	**Significance**
Native English	33.3%	18.9%	47.7%	1% level
All others	34.6%	23.1%	42.3%	1% level

Figure 24. Perceived accuracy of 2D and 3D maps

Map readability answers did not correlate strongly with respondent characteristics. The 2D map was generally rated easier to read by respondents because it was planimetric (a map showing only the horizontal position of features on a planar surface) and the hiking trails appeared larger than on the perspective 3D map. Only left-handed hikers and those who were non-native English speakers specified that the 3D map was easier to read *(Figure 25)*.

Gender	2D	Neither	3D	Significance
Females	56.3%	11.3%	32.4%	1% level
Males	54.9%	11.5%	33.6%	1% level
Age	**2D**	**Neither**	**3D**	**Significance**
15-25	72.7%	0%	27.3%	Caution: small sample size
26-40	49.1%	15.1%	35.8%	1% level
41-60	56.5%	10.9%	32.6%	1% level
60+	57.1%	10.7%	32.1%	1% level
Handedness	**2D**	**Neither**	**3D**	**Significance**
Right-handed	56.7%	11.0%	32.3%	1% level
Left-handed	45%	15%	40%	1% level
Language	**2D**	**Neither**	**3D**	**Significance**
Native English	56.8%	12.9%	30.3%	1% level
All others	51.9%	7.7%	40.4%	1% level

Figure 25. Map type and rated readability

Responses about which map type depicts reality better were unequivocal *(Figure 26)*. In total, 75.5% of respondents indicated that the 3D maps depicted reality better, 21.7% indicated the 2D maps, and 2.7% had no preference. Within age groups, 81.1% of those in the 26 to 40 age bracket thought that 3D maps depicted reality better. Moreover, 90% of left-handed individuals thought that 3D maps depicted reality better. Only 5% of this group selected 2D maps—a very distinct result.

Gender	**2D**	**Neither**	**3D**	**Significance**
Females	23.9%	2.8%	73.2%	1% level
Males	20.4%	2.7%	77.0%	1% level
Age	**2D**	**Neither**	**3D**	**Significance**
15-25	54.5%	0%	45.5%	Caution: small sample size
26-40	15.1%	3.8%	81.1%	1% level
41-60	21.7%	3.3%	75%	1% level
60+	21.4%	0%	78.6%	1% level
Handedness	**2D**	**Neither**	**3D**	**Significance**
Right-handed	23.8%	2.4%	73.8%	1% level
Left-handed	5%	5%	90%	1% level
Language	**2D**	**Neither**	**3D**	**Significance**
Native English	21.2%	3%	75.8%	1% level
All others	23.1%	1.9%	75%	1% level

Figure 26. Map type and perceived depiction of reality

Cartographic communication

Part three of the questionnaire investigated whether 2D or 3D maps better communicate relevant trail information to hikers. The answers given by the respondents were converted to a point system to allow for statistical analysis. The following lists the questions asked on the three test trails and the points given for correct answers (partial points were awarded for partially correct answers).

Lower Emerald Pool Trail questions:

16. *What is the name of this trail?*
    Correct answer: Lower Emerald Pool Trail (1pt)
17. *Where does this trail go?*
    Correct answer: To the Lower Emerald Pool (1pt)
18. *This trail heads in which general compass direction?*
    Correct answer: Northwest (1pt), North (0.5pt), West (0.5pt)
19. *Are there any major uphill grades ahead on this trail?*
    Correct answer: no (1pt)
20. *In miles or kilometers, how long is this trail (one way)?*
    Correct answer: 0.6 mi, 1km (2pt), 0.5pt for 0.5–0.7mi or 0.8–1.2km

21. *Can you name any other trails shown on the map?*
    Correct answer: Middle Emerald Pools Trail, Kayenta Trail, Upper Emerald Pool Trail, Grotto Trail, Sand Bench Trail, West Rim Trail (0.75pt per trail)
22. *How many Emerald Pools are shown on the map?*
    Correct answer: 4 (2pt)
23. *Going from the trailhead to the Lower Emerald Pool, what percentage of the trail distance have you hiked so far?*
    Correct answer: 50% (2pt), 0.5pt for 40–60%
24. *In miles or kilometers, how far have you hiked from the trailhead to here?*
    Correct answer: 0.3mi (2pt), 0.5km (2pt), 0.5pt for 0.2–0.4mi or 0.4–0.6km
25. *What percentage of the total trail length goes through forest?*
    Correct answer: 90% (2pt), 0.5pt for 80–100%
26. *In feet or meters, about how high is Lady Mountain?*
    Correct answer: 6945ft, 2117m, 3pt for 6800–7100ft or 2100–2200m, 0.5pt for 6500–6800ft and 7100–7400ft, 0.5pt for 2000–2100m and 2200-2300m

Variants of the questions above asked on the Middle Emerald Pools trail:

16. *What is the name of this trail?*
    Correct answer: Middle Emerald Pools Trail (1pt)
17. *Where does this trail go?*
    Correct answer: To the Middle Emerald Pools (1pt)
20. *In miles or kilometers, how long is this trail (one way)?*
    Correct answer: 1mi (2pt), 1.6km (2pt), 0.5pt for 0.9–1.1mi or 1.4–1.8km
21. *Can you name any other trails shown on the map?*
    Correct answer: Lower Emerald Pool Trail, Kayenta Trail, Upper Emerald Pool Trail, Grotto Trail, Sand Bench Trail, West Rim Trail (0.75pt per trail)
23. *Going from the trailhead to the Middle Emerald Pools, what percentage of the trail distance have you hiked so far?*
    Correct answer: 60% (2pt), 0.5 pt for 50–70%
24. *In miles or kilometers, how far have you hiked from the trailhead to here?*
    Correct answer: 0.6 mi, 1 km (2pt), 0.5pt for 0.5–0.7 mi or 0.8–1.2 km

The questions asked on the Observation Point Trail were similar to those of the Emerald Pools trails, as was the point system for correct answers:

16. *What is the name of this trail?*
    Correct answer: Observation Point Trail or East Rim Trail (1pt)
17. *Where does this trail go?*
    Correct answer: To the Observation Point or to the East Rim (1pt)
18. *This trail heads in which general compass direction (only the part before the East Rim Trail junction)?*
    Correct answer: Northeast (1pt), East (0.5pt), North (0.5pt)
19. *Are there any major downhill grades ahead on this trail?*
    Correct answer: no (1pt)
20. *In miles or kilometers, how long is this trail (one way)?*
    Correct answer: 4mi, 6.5 km (2pt), 0.5 pt for 3.5–4.5 mi or 6–7 km

21. *Can you name any other trails shown on the map?*
    Correct answer: Weeping Rock Trail, Hidden Canyon Trail, East Mesa Trail, Cable Mountain Trail, East Rim Trail (0.75 pt per trail)
22. *How many shuttle stops are shown on the map?*
    Correct answer: 3 (2pt)
23. *Going from the trailhead to Observation Point, what percentage of the trail distance have you hiked so far?*
    Correct answer: 40% (2pt), 0.5pt for 30–50%
24. *In miles or kilometers, how far have you hiked from the trailhead to here?*
    Correct answer: 1.5mi, 2.5km (2pt), 0.5pt for 1.2–1.8mi or 2–3km
25. *What percentage of the total trail length goes alongside the Echo Canyon bottom?*
    Correct answer: 15% (2pt), 0.5pt for 5–25%
26. *In feet or meters, about how high is the Great White Throne?*
    Correct answer: 6744ft, 2056m (3pt), for 6600–6900ft or 2000–2100m (0.5pt), for 6300–6600ft or 1900–2000m (0.5pt), and for 6900–7200ft or 2100–2200m (0.5pt)

Points were tabulated based on the above schema. Of 20.75 possible points that a respondent could tally, the average was 6.14 points when the 3D maps were on display at the trailhead and 5.79 points when the 2D map were displayed. The 0.35-point advantage of 3D maps over 2D maps indicates that they are only slightly more efficient for cartographic communication. Moreover, the correlation was not significant at the 5% level. The likelihood that this finding was not coincidental is only 80%.

To learn if 2D and 3D maps have unique advantages for map communication, average points for differing tasks are displayed in Figure 27.

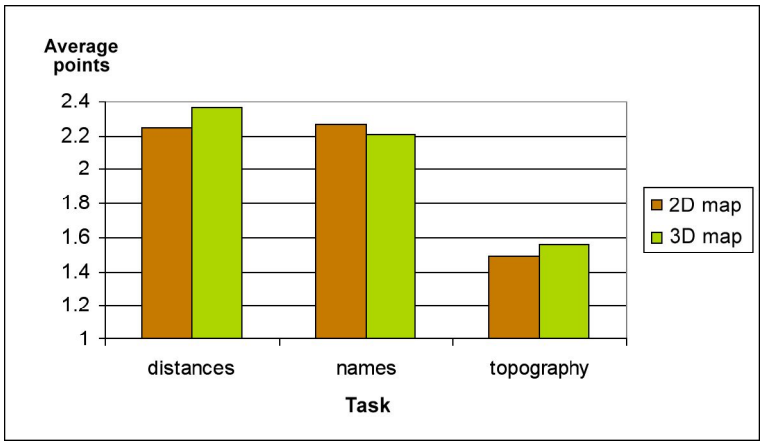

Figure 27. Points for different questions by map types

Looking at the distribution of points for different communication tasks reveals only small variations. 3D maps are slightly more suited to communicate distances and a general overview of topography and environment, whereas 2D maps are slightly better for communicating names.

Conclusion: Both map types are equally well suited for communicating spatial information. The 3D map provides only a small advantage in efficiency. The decision on which map type to place at a trailhead is not a matter of communication efficiency, but of other criteria such as user preferences, age, or the gender of prospective readers.

Map attraction

This part of the user study investigated which map type was more successful at attracting and holding the attention of hikers as they passed within viewing distance of a trailhead exhibit.

Monitoring at the Emerald Pools trailhead revealed that when the 3D map was on display, 50 percent of hikers viewed the map and the other half passed by without looking at it. When the 2D map was displayed, 44.9% looked at the trailhead exhibit and 55.1% did not. This correlation is significant on a 1% level (Chi-square test). The 3D map was more successful at attracting the attention of hikers. However, the fact that 50 percent of hikers did not read the map is not an encouraging statistic.

A determining factor for whether people looked at the trailhead map was if people were looking at it immediately before they arrived. This herding instinct was observed by the PI during the monitoring and was verified statistically. Because arrival and departure times of all hikers were recorded when they stopped at or walked past the trailhead, it was possible to analyze the data to identify clustered arrival times. The presumption was that if two hikers (or groups of hikers) viewed the trailhead within one minute of one another, then the probability was high that the later arrivals saw the prior party reading the trailhead map as they approached it.

If a hiker or group of hikers was looking at the trailhead beforehand, the likelihood that the arriving party would also look at the trailhead was 59.8%. If no one was present at the trailhead, this dropped to 42.7%, a decrease of 17.1%. This correlation was significant at the 1% level.

Motivation

An aim of this research was to find out if a 2D or 3D map was more likely to motivate people to go on a hike after reading it. This information, however, remains unknown because of the small number of people who did not go hiking after viewing the trailhead maps—only eight individuals (or groups) accounting for 2.4 percent of the total population observed. Statistical analysis of this small data sample would yield unreliable results.

The low number of people who did not go hiking was probably because most people had already decided to go hiking before they arrived at the trailhead—the map on display there did not sway them from their preconceived itinerary. The decision to hike the Emerald Pools trails, the start of which is only a short stroll from the popular Zion Lodge and a shuttle bus stop, was probably made from reading the park newspaper or the recommendation of shuttle bus drivers who mention the trails.

Viewing time

Map viewing time provides a coarse measure of the effectiveness of 2D and 3D maps for cartographic communication. One hypothesis is that the longer a person looks at the map, the more information they should get from it. The more effective map type would be the one that communicates more information in a shorter amount of time. A second hypothesis is that the amount of time a user spends with reading a map is as an indirect measurement of how much they like the map. Both hypotheses are tested in this section.

The total recorded time for all individuals and groups that approached the trailhead exhibit was 7,354 seconds (2.04 hours). The average time spent by individuals or groups in the vicinity of the trailhead was 21.6 seconds. Discounting those who did not bother to look at the trailhead exhibit, when the 2D map was mounted, hikers spent an average of 44.1 seconds viewing it. The average time for viewing the 3D map was 47.2 seconds, 3.1 seconds longer. The difference in viewing time failed to meet the 5% level of significance with a Chi-square test and is therefore not significant.

A crucial question: did hikers spend less time viewing the 2D maps because they were easier to comprehend (more effective), or were they were less attracted by the design of the 2D maps, or perhaps both?

A significant correlation (5% level) was found between the time the map was viewed and its design rating *(Figure 28)*. The longer the user read the map, the higher they rated it for design. Question 12 in the second part of the questionnaire asked hikers to assign points based on whether the design of the map at the trailhead was appealing (1 disagree – 7 agree).

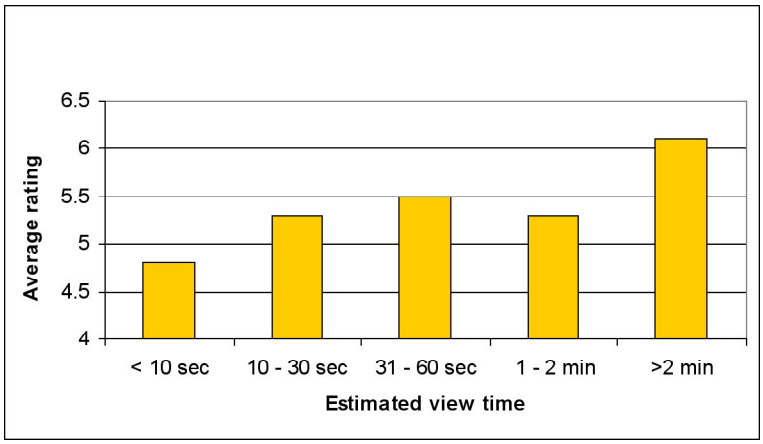

Figure 28. Average rating of map design by viewing time

To find out which map type was more effective at communicating geographic information, points were given for right answers to questions about the map content (part 3 of the questionnaire). Specific information on how the points were assigned and on the efficiency of cartographic communication can be found on page 27. No significant correlation exists between the points earned for right answers about the map content and the viewing time. This means that the hypothesis "shorter viewing time means more efficient cartographic communication" is false. In this study, viewing time is correlated only with how well users liked the map design.

Viewing time was also checked for significant correlations against the characteristics of the respondents. A correlation (5% level of significance) was found between the viewing time and the frequency of hiking within the last 12 months. For analysis, the answers of the respondents were aggregated as follows:

- Frequent hikers – Those who hike "once a week," or more.
- Occasional hikers – Those who hike "at least once a month" or "a few times in the last year."
- Infrequent – Those who hiked "once in the last 12 months" or less.

Figure 29 shows the correlation between hiking frequency and viewing time of the trailhead map. Respondents who hike more often spend a shorter time looking at the trailhead maps. A possible explanation for this is that frequent hikers are also more experienced with maps and thus do not need to spend as much time reading them.

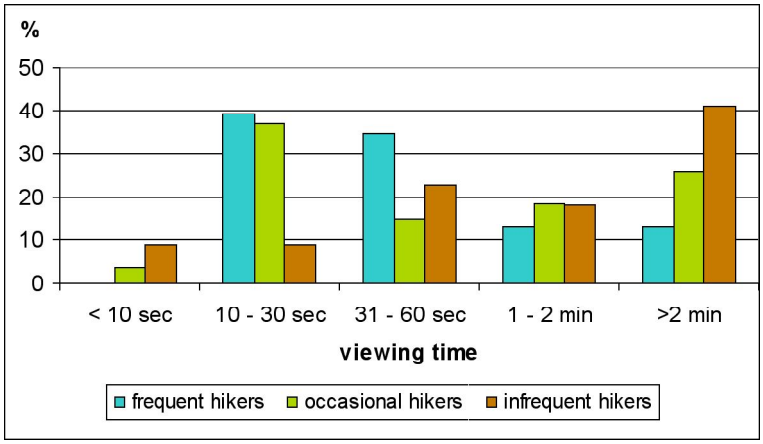

Figure 29. Trailhead viewing time and hiking frequency

Another significant correlation at the 1% level was found between viewing time and the rating given for how easy the trailhead map was to read *(Figure 30)*. The maps rated easiest to read are those that hikers viewed for a longer time. The correlation between viewing time and map readability rating is analogous to the correlation between viewing time and map design rating *(Figure 28)*.

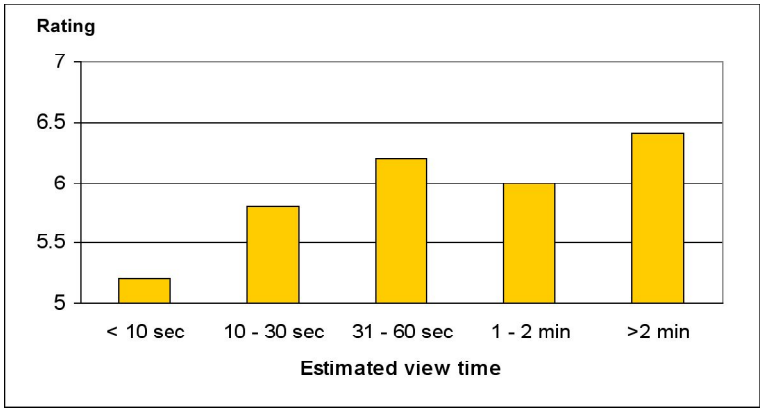

Figure 30. Viewing time and average readability rating

As revealed from the trailhead monitoring, respondents spent an average of 3.1 seconds longer viewing the 3D maps compared to the 2D maps. This difference is not related to effective cartographic communication but results from the fact that the hikers spend more time reading maps when they like the design.

Hikers taking the questionnaire overestimated their map reading time compared to map viewing times recorded at the trailheads. One third of questionnaire respondents reported having looked at the trailhead map for more than two minutes. Trailhead monitoring, however, revealed that only two percent of the hikers actually looked at the map this long.

Comments by respondents

The respondents were asked to make comments about the maps and on general matters, which follow:

2D Emerald Pools trails map
- Not enough height information
- The maps describe the landscape in a good way
- The trails are easy to follow
- Good colors, easy to read
- Map does not show heights
- Confused about height difference
- Good height information, likes that the trails are drawn in different colors, the maps should show a statement about the difficulty of the trails
- Heights are not shown clearly
- Not sure if the trails are single trails, or form a loop

3D Emerald Pools trails map
- The colors are good (2 similar comments)
- The trails are well marked
- Like the depiction of relief
- Heights are not shown clearly
- The muted colors are not nice
- Good height and distance information
- Not enough height information
- Does not show the height difference
- Would like more points with height specification
- Details about duration and slope are missing
- Wants more information about flora, fauna, trails, and important landmarks
- Likes the labeling boxes

2D Observation Point trail map
- Wants contour lines (3 similar comments)
- Easy to read, kept simple
- Map should be more detailed (2 similar comments)
- The topography should be shown better
- Would like more relief details
- Would like height profiles (2 similar comments)

3D Observation Point trail map
- Would like a copy of the trailhead map in a box at the trailhead to take away
- Likes the big lettering, map is easy to read, trails are easily identified
- Likes the color-coding of the trails, the height difference cannot be seen well
- Would like contour lines
- Likes the 3 dimensionality
- Would like maps to take away

- Likes the colors of the trail
- Map is clear and precise
- Good distance and height information

General comments

- The signs along the trails should be better visible
- Would like maps for take away (4 similar comments)
- The national parks always have good maps
- Good maps (2 similar comments)
- The 2D map is good
- Good maps, would like more signs along the trails
- Would like maps to take away at the visitor center or at the trailhead
- Likes the labeling boxes
- Would like mileage signs alongside the trail (2 similar comments)
- Would like more height information and information about the Kayenta trail at the Emerald Pools trailhead
- Would like the 3D map in a brochure to take away or in the park newspaper
- Enough information, would like mileage signs along the trail
- Would like maps to take away and mileage signs along trails
- Would like contour lines in the maps
- Good trailhead exhibits

SUMMARY

The main research questions of this study are answered as follows:

- *Which map type communicates geographic information faster and more effectively?*
  2D and 3D maps proved equally efficient for cartographic communication.

- *Which map type imprints itself better in the mind of park visitors as a mental map?*
  With 3D maps, respondents demonstrated better knowledge about distances, topography and environment. The 2D maps fostered better place name recall.

- *Which map type attracts more visitors to read trailhead exhibits, holds their attention, and motivates them to go hiking?*
  3D maps at trailheads attract more viewers and are on average viewed for a few seconds longer than 2D maps. That is not because of lower efficiency in cartographic communication but because readers find 3D maps interesting to look at. The question "Which map type better motivates people to go hiking?" was not answered because of the small sample of trailhead readers who did not go hiking afterwards.

- *Which map type do national park visitors prefer?*
  There is no universal answer: older respondents and men generally preferred 2D maps, younger hikers and women preferred the 3D versions. Respondents whose native language is English tended to prefer 2D maps while those who speak a different language preferred 3D maps. Also, left-handed individuals preferred 3D maps.

There is no clear winner in this map study as to which map type is best suited for hikers at a national park. Certainly the 3D maps are a good choice in many cases but not always. Additional significant findings are summarized as follows:

- 3D maps were rated as more accurate by more experienced hikers on the strenuous Observation Point Trail than by inexperienced hikers on the easy Emerald Pools trails.

- 3D maps allowed users to better locate their ground position on the map, especially for older people and women.

- An interesting correlation is that people who looked at the trailhead map preferred 3D maps (53%) over 2D maps (43%). By comparison, those who passed the trailhead map without looking at it preferred 2D maps. That 3D maps appeal more to prospective users is a strong argument for their use at trailhead exhibits.

- 2D maps were rated easier to read by less experienced hikers on the Emerald Pools trails. Experienced hikers on the Observation Point trail rated 3D maps easier to read.

- The majority of respondents on both trails agreed that 3D maps depict reality better than 2D maps.

Considering the mixed results, the researcher recommends that Harpers Ferry Center continue and even increase the use of 3D trailhead maps but on a case by case basis. The appropriate use of 3D maps depends on the trail and the kinds of hikers it attracts. 3D maps were found best suited for trails with considerable elevation gain frequented by younger individuals, non-native English speakers, women, and those who hike frequently. 3D maps also attracted more readers at the trailheads and held their attention longer. Conventional 2D maps were found better suited for flatter, less strenuous trails frequented by older individuals, men, native English speakers, and people who hike infrequently.

The finding that experienced hikers/map users on the expert trail rated the 3D map easier to read, and inexperienced hikers/map users rated 2D maps easier to read, seems to contradict the conventional wisdom that 3D maps are best suited for inexperienced users. A possible explanation is the prevalence of younger hikers on the strenuous trail who are familiar with 3D computer graphics and by extension are more comfortable with 3D trailhead maps. By comparison, the mostly older hikers on the easy trail with presumably less exposure to computer graphics may prefer more familiar 2D maps.

For trail maps published in newspapers and brochures, 3D maps are a good choice because readers can more accurately orient themselves and locate their position on these maps compared to 2D maps. This finding was unexpected considering the high spatial accuracy of 2D maps compared to 3D maps, where the scale diminishes from foreground to background within a scene. The existence of more easily identifiable visual cues on the 3D map may have assisted readers with the orientation task. For example, on the Observation Point Trail testing occurred in narrow Echo Canyon that is readily distinguishable on the 3D map but less so on the 2D map.

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HÄBERLING, Christian, Topographische 3D-Karten, Thesen für kartographische Gestaltungsgrundsätze, Diss. ETH Zürich, 2003.

IMHOF, Eduard, Kartenverwandte Darstellungen der Erdoberfläche. Eine systematische Übersicht. Internationales Jahrbuch der Kartographie, 1963.

PATTERSON, Tom, Slides for a presentation at the 4th high mountain cartography workshop of the ICA, Vall de Nuria – Catalonia, 2004.

APPENDIX A: Geodata requirements

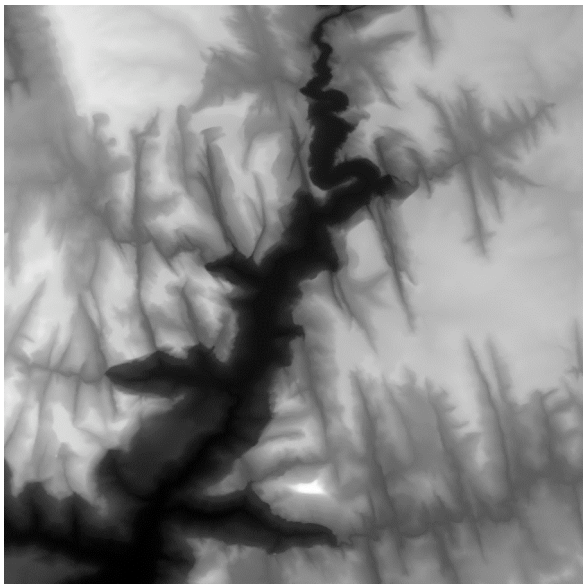
The geodata used for map production include raster and vector data. Vector data, including watercourses, roads, trails, and other man-made features as well as height points and labeling, were obtained from the National Park Service. The data for the vegetation overlay were derived from the 1:24,000-scale USGS topographic maps (http://www.usgs.gov) and from aerial ortho-photograph images obtained from the Utah Automated Geographic Reference Center (http://agrc.utah.gov).

The critical raster dataset was a digital elevation model (DEM) at 10-meter resolution originating from the USGS. The shaded relief on 2D maps and dimensional terrain on 3D maps derived from the DEM. The 10-meter resolution of the DEM was adequate for making the map of the Observation Point Trail, but was somewhat coarse for the large-scale map of the Emerald Pools trails. The use of manual touch-ups corrected for the lack of resolution in the DEM.

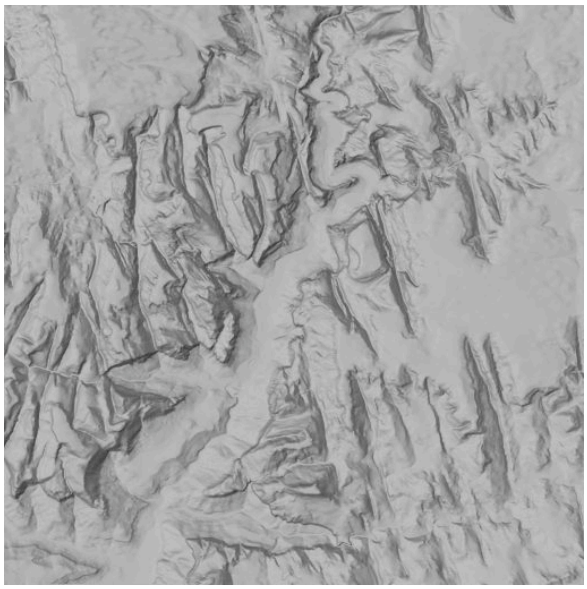
APPENDIX B: Production of the 2D maps

The maps had to conform to a precise format so that they could be pasted over the existing maps at the trailheads without readers knowing that this had been done. The Emerald Pools trails map measured 15.75 inches in width and 18 inches in height. The Observation Point Trail map measured 15.75 inches in width and 20.15 inches in height.

The first production step was to reduce the size of the DEM to 1,024 x 1,024 pixels. A shaded relief was produced from the DEM in Corel Bryce 5.0 (the software is named after Bryce Canyon National Park) using techniques analogous to those described by Tom Patterson in “Terrain presentation tips for Bryce and Photoshop” (www.shadedrelief.com). The shaded relief for the Emerald Pools trails map needed manual touch-ups due to the large scale.



DEM of Zion Canyon



Rendered shaded relief

To create the landcover overlay, the DEM was opened in Photoshop and a sandstone color gradient was assigned to it, appearing darkest at low elevations at the canyon bottom. Climbing the canyon walls the color gets brighter and less saturated with increasing height. Vegetation areas (trees and low woodland) at the canyon bottom were digitized from a digital color orthophoto and the USGS topographic map and then merged with the sandstone colored background in a light green tone with noise to give it a natural appearance. The illustration that follows shows the color overlay in combination with the shaded relief. Additionally, the highest summits are shown in white color to emphasize their height to the map-reader.

Base map merged with shaded relief

With the base map complete, the next step was to pre-process the line features such as rivers, roads, and trails in ArcGIS and clip them to the size of the base-map. Lakes (Emerald Pools) and park facilities (shuttle stops, Zion Lodge) were also prepared for the map.

The final preparation of the map was accomplished with Adobe Illustrator, after excess area on the map was clipped to the required format. This included labeling the features and inserting pictographic symbols that comply with National Park Service map design standards. In addition, the map title, legend, north arrow, and a bar scale were placed on the map. See Appendix D for final versions of the 2D maps.

APPENDIX C: Production of the 3D maps

The production of the 3D maps was similar to that of 2D maps, except for the use of the DEM and the expenditure of time. The format requirements (Emerald Pools trails map: 15.75-inch width and 18-inch height, Observation Point Trail map: 15.75-inch width and 20.15-inch height) were once again the main criteria for selecting a scale and clipping. The biggest differences between the 2D and 3D maps are the varying scale—the foreground of the 3D maps has a larger scale that gets progressively smaller toward the background—and the freely selectable viewing position.

The first production step was to create a base map overlay to drape on the DEM. This was accomplished in a manner similar to that used for the 2D maps (Appendix B).

The choice of the viewing point (in Bryce 3D software) was critical for the usability and stylish appearance of the 3D maps, and so that the area of interest is clearly visible. The viewing point should be kept low enough to give the user a familiar perspective (much like the view from the top of a mountain). On the other hand, the viewing point should not be too low or high mountains in the foreground, which partially obscure the area of interest, may hide important features. Obscured areas pose a big problem for 3D visualization, especially in canyons (see Observation Point Trail map, Appendix D).

After having chosen a favorable view for both maps, multiple renders of the maps were created in Corel Bryce 5.0. The first render depicted the 3D terrain draped with the base map overlay, including all line elements and park facilities. This image served as a template showing the position of trails, roads and buildings for drawing the final scene in Adobe Illustrator at a later production stage. The second render was an overlay with rivers and lakes. Human-made features were omitted in this step. A third render was a distance mask comprised of continuous grayscale tones for applying atmospheric haze to the map, thus enhancing the sense of three-dimensionality (see Terrain Presentation Tips for Bryce and Photoshop, Tom Patterson, www.shadedrelief.com).

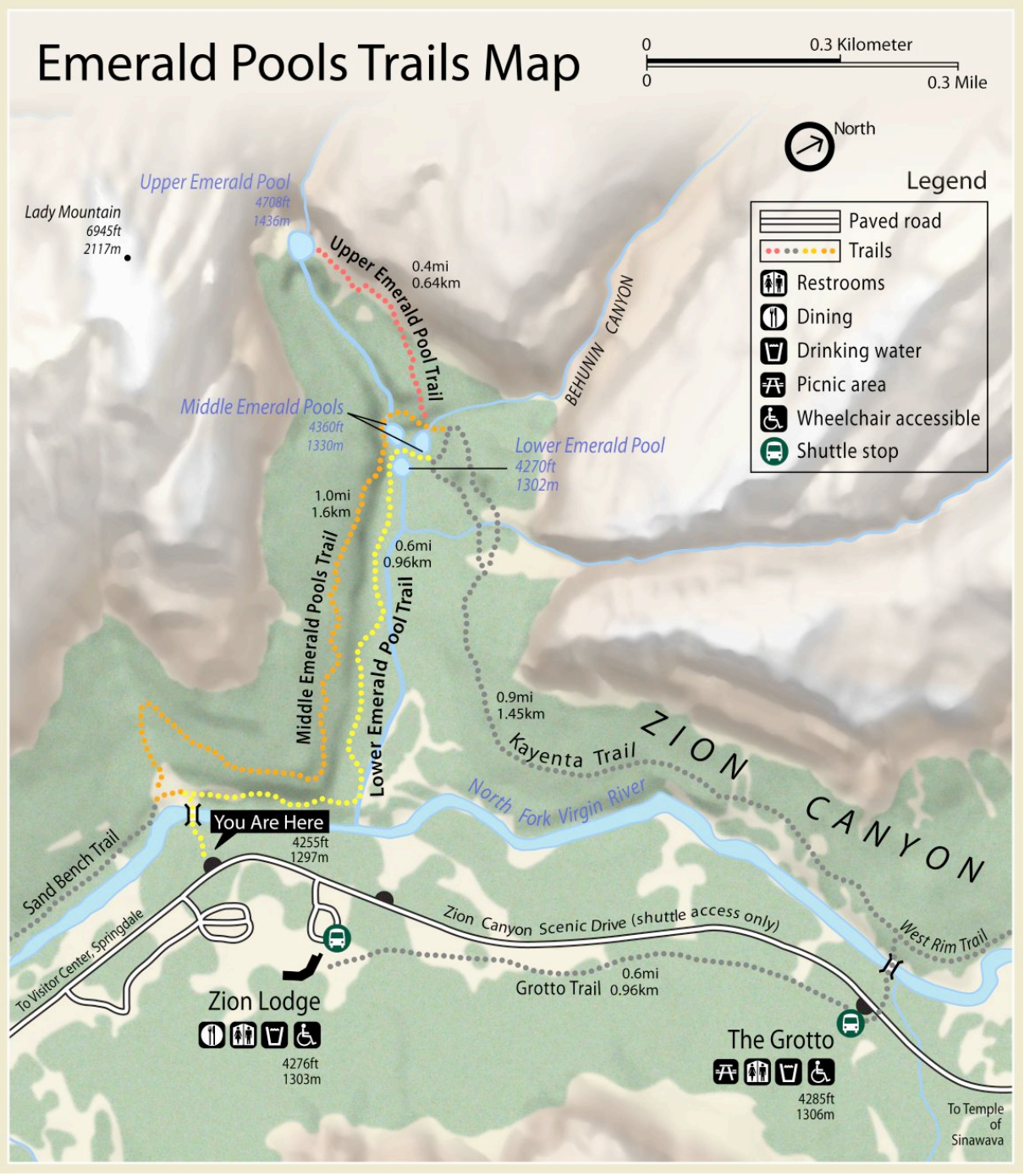
The rendered perspective views that include the water bodies were manually touched-up in Photoshop to improve the rendered images created with Corel Bryce 5.0 software. Also in Photoshop, compositing the distance mask with the map base provided the final atmospheric haze effect.

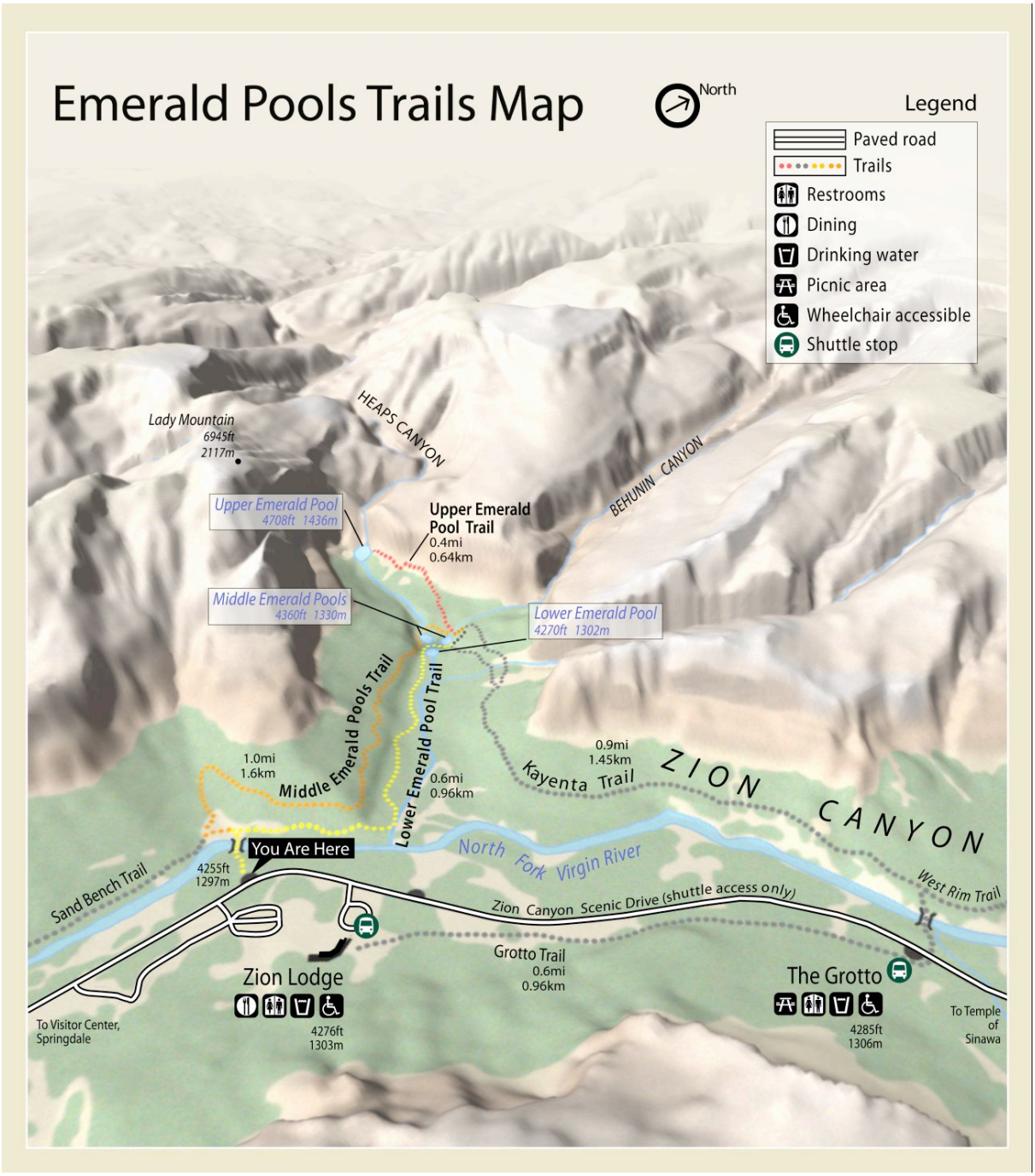
Next, the touched-up view and the view with the man-made features were opened in Adobe Illustrator to precisely trace the trails, roads, and other features. These vectors with a cleaner

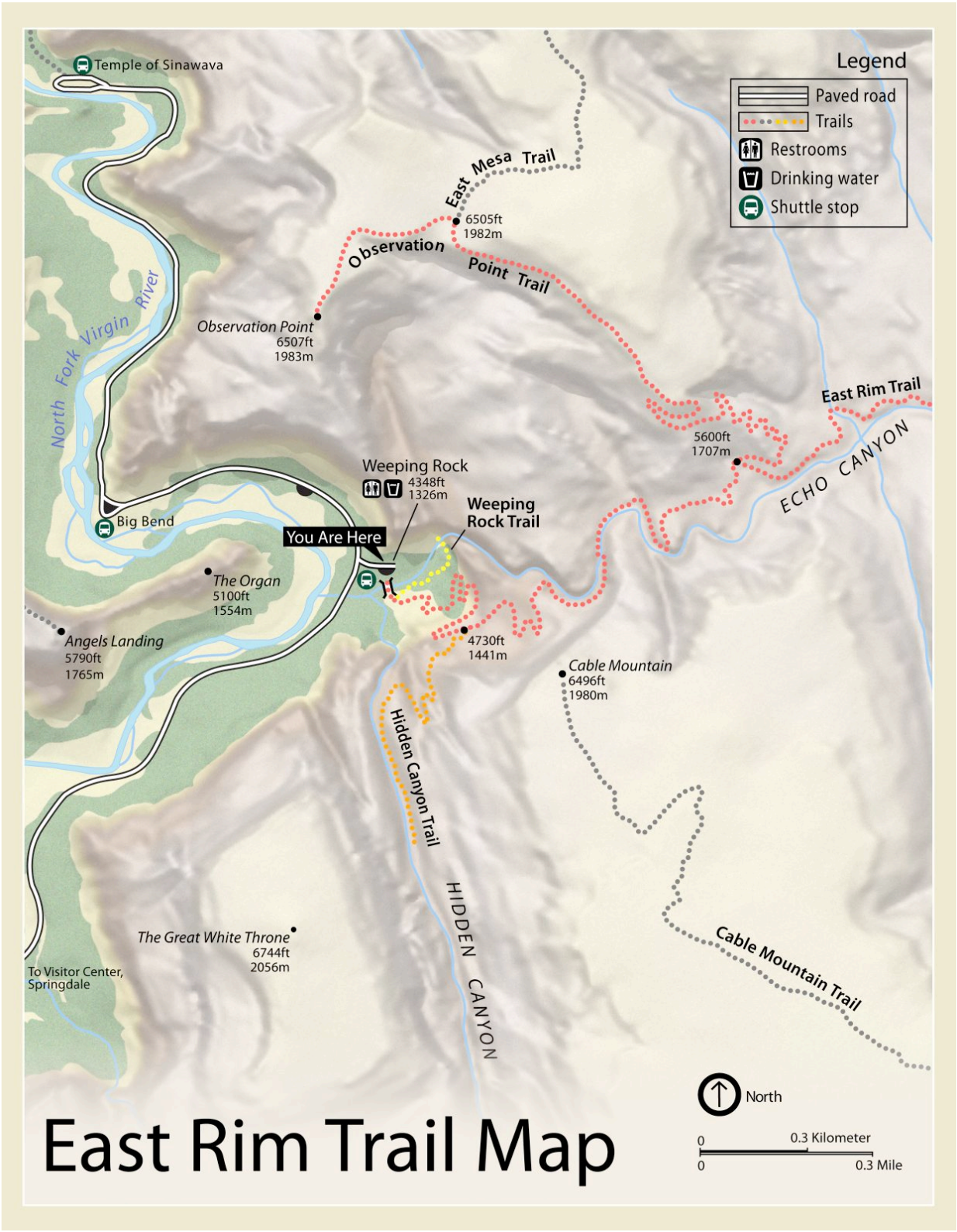
appearance were then copied from Illustrator and pasted into the Photoshop document of the revised 3D base map. Because the Illustrator document and Photoshop document had the same proportions, information was transferable from one to the other without misregistration.

The final step involved going back to Adobe Illustrator for placing the map labels, pictographs, map title, legend, bar scale, and north arrow. See Appendix D for final versions of the 3D maps.

APPENDIX D: Trailhead test maps




Emerald Pools Trails Map
North
Legend
Paved road
Trails
Restrooms
Dining
Drinking water
Picnic area
Wheelchair accessible
Shuttle stop
Lady Mountain
6945ft
2117m
HEAPS CANYON
BEHUNIN CANYON
Upper Emerald Pool
4708ft 1436m
Upper Emerald Pool Trail
0.4mi
0.64km
Middle Emerald Pools
4360ft 1330m
Lower Emerald Pool
4270ft 1302m
Middle Emerald Pools Trail
Lower Emerald Pool Trail
1.0mi
1.6km
0.6mi
0.96km
0.9mi
1.45km
Kayenta Trail
ZION CANYON
You Are Here
4255ft
1297m
North Fork Virgin River
Sand Bench Trail
Zion Canyon Scenic Drive (shuttle access only)
West Rim Trail
Grotto Trail
0.6mi
0.96km
Zion Lodge
4276ft
1303m
The Grotto
4285ft
1306m
To Visitor Center, Springdale
To Temple of Sinawa


Temple of Sinawava
Legend
Paved road
Trails
Restrooms
Drinking water
Shuttle stop
East Mesa Trail
6505ft
1982m
Observation Point Trail
Observation Point
6507ft
1983m
North Fork Virgin River
East Rim Trail
5600ft
1707m
ECHO CANYON
Weeping Rock
4348ft
1326m
Weeping Rock Trail
Big Bend
You Are Here
The Organ
5100ft
1554m
Angels Landing
5790ft
1765m
4730ft
1441m
Cable Mountain
6496ft
1980m
Hidden Canyon Trail
HIDDEN CANYON
Cable Mountain Trail
The Great White Throne
6744ft
2056m
To Visitor Center,
Springdale
North
0
0.3 Kilometer
0
0.3 Mile
East Rim Trail Map


Legend
Paved road
Trails
Restrooms
Drinking water
Shuttle stop
East Mesa Trail
Temple of Sinawava
6505ft
1982m
Observation Point Trail
Observation Point
6507ft
1983m
Weeping Rock
4348ft
1326m
East Rim Trail
5600ft
1707m
ECHO CANYON
Weeping Rock Trail
You Are Here
Angels Landing
5790ft
1765m
Big Bend
The Organ
5100ft
1554m
Cable Mountain
6496ft
1980m
4730ft
1441m
Virgin River
North Fork
Hidden Canyon Trail
Cable Mountain Trail
HIDDEN CANYON
The Great White Throne
6744ft
2056m
To Visitor Center,
Springdale
East Rim Trail Map
North

APPENDIX E: Questionnaires

EMERALD POOLS TRAIL MAP SURVEY

____ View ____

Part 1 – Background

1. What is your age? (Topic Area 1: Individual Characteristics)
15 to 25 ☐ 26 to 40 ☐ 41 to 60 ☐ over 60 ☐

2. Gender? (Topic Area 1: Individual Characteristics)
Female ☐ Male ☐

3. Are you hiking alone? (Topic Area 2: Trip/Visit Characteristics)
Yes, alone ☐ No, in a group ☐
3a. If in a group, how many people are you hiking with? _____

4. How often have you gone hiking in the last 12 months?
(Topic Area 1: Individual Characteristics)
- ☐ Almost daily
- ☐ At least once every week
- ☐ At least once every month
- ☐ A few times
- ☐ Once in the last 12 months
- ☐ This is the first time since 12 months

5. Including this hike, how often have you hiked in Zion National Park this year?
(Topic Area 3: Activities and use of park Resources)
- ☐ Once
- ☐ 2-3 times
- ☐ 4-5 times
- ☐ More than 5 times

6. How often do you use maps when hiking? (Topic Area 2: Trip/Visit Characteristics)
Frequently ☐ Occasionally ☐ Rarely ☐ Never ☐

7. Is English your native language? (Topic Area 2: Trip/Visit Characteristics)
Yes ☐ No ☐

7a. If no, what is your native language? _____

8. Are you primarily left or right handed? *(Note: This question is being asked because in some cases there are differences in the perception of space between left and right handed people, which may influence how they interact with different map types.)*
(Topic Area 1: Individual Characteristics)
Right handed ☐ Left handed ☐ Neither ☐

9. Did you bring your own map or a navigation device on the hike? (Topic Area 2: Trip/Visit Characteristics)
Yes, map ☐ Yes, GPS ☐ Yes, Compass ☐ No ☐
If you have a map or other navigation device, go to Part 4.

Part 2 – Trailhead sign

10. Did you look at the trailhead sign? Yes ☐ No ☐

(Topic Area 3: Activities and Use of Park Resources)

If you answered no, go to Part 4.

11. About how long did you look at the trailhead sign?
(Topic Area 3: Activities and Use of Park Resources)

- ☐ Less than 10 seconds
- ☐ 10 to 30 seconds
- ☐ 30 seconds to one minute
- ☐ One to two minutes
- ☐ Over two minutes

12. The design of the map at the trailhead sign was appealing.
(Topic Area 5: Evaluation of Services)

Disagree Agree

1 2 3 4 5 6 7

13. The map at the trailhead sign was easy to read. (Topic Area 5: Evaluation of Services)

Disagree Agree

1 2 3 4 5 6 7

14. The impression of landscape I got from the map matches with what I saw while hiking. (Topic Area 5: Evaluation of Services)

Disagree Agree

1 2 3 4 5 6 7

15. What specifically did you like or dislike on the trailhead map?
(Topic Area 5: Evaluation of Services)

Part 3 – Remembering the trailhead map

16. What is the name of this trail? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

17. Where does this trail go? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

18. This trail heads in which general compass direction? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

19. Are there any major uphill grades ahead on this trail?
(Topic Area 6: Individual Perceptions of Park Experience)

Yes ☐ No ☐ Not sure ☐

20. In miles or kilometers, how long is this trail (one way)? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

21. Can you name any other trails shown on the map? No ☐
(Topic Area 6: Individual Perceptions of Park Experience)

22. How many Emerald Pools are shown on the map? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

23. Going from the trailhead to the Middle Emerald Pools, what percentage of the trail distance have you hiked so far? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

24. In miles or kilometers, how far have you hiked from the trailhead to here? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

25. What percentage of the total trail length goes through forest? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

26. In feet or meters, about how high is Lady Mountain? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

Part 4 – Map comparison

The interviewer will give you a copy of the map on display at the trailhead.

Mark an "X" on the map where you are now.

The interviewer will give you a second map to compare with the first.

27. Which of these maps do you prefer? Map 1 ☐ Map 2 ☐ No preference ☐
(Topic Area 5: Evaluation of Services)

28. Which of these maps depicts reality better? Map 1 ☐ Map 2 ☐ Don't Know ☐
(Topic Area 5: Evaluation of Services)

29. Which of these maps is easier to read? Map 1 ☐ Map 2 ☐ No preference ☐
(Topic Area 5: Evaluation of Services)

30. Which of these maps do you think is more accurate? Map 1 ☐ Map 2 ☐ Don't Know ☐
(Topic Area 5: Evaluation of Services)

EAST RIM TRAIL MAP SURVEY

____ View ____

Part 1 – Background

1. What is your age? (Topic Area 1: Individual Characteristics)
15 to 25 ☐ 26 to 40 ☐ 41 to 60 ☐ over 60 ☐

2. Gender? (Topic Area 1: Individual Characteristics)
Female ☐ Male ☐

3. Are you hiking alone? (Topic Area 2: Trip/Visit Characteristics)
Yes, alone ☐ No, in a group ☐
3a. If in a group, how many people are you hiking with? _____

4. How often have you gone hiking in the last 12 months?
(Topic Area 1: Individual Characteristics)
- ☐ Almost daily
- ☐ At least once every week
- ☐ At least once every month
- ☐ A few times
- ☐ Once in the last 12 months
- ☐ This is the first time since 12 months

5. Including this hike, how often have you hiked in Zion National Park this year?
(Topic Area 3: Activities and use of park Resources)
- ☐ Once
- ☐ 2-3 times
- ☐ 4-5 times
- ☐ More than 5 times

6. How often do you use maps when hiking? (Topic Area 2: Trip/Visit Characteristics)
Frequently ☐ Occasionally ☐ Rarely ☐ Never ☐

7. Is English your native language? (Topic Area 2: Trip/Visit Characteristics)
Yes ☐ No ☐

7a. If no, what is your native language? _____

8. Are you primarily left or right handed? *(Note: This question is being asked because in some cases there are differences in the perception of space between left and right handed people, which may influence how they interact with different map types.)*
(Topic Area 1: Individual Characteristics)
Right handed ☐ Left handed ☐ Neither ☐

9. Did you bring your own map or a navigation device on the hike? (Topic Area 2: Trip/Visit Characteristics)
Yes, map ☐ Yes, GPS ☐ Yes, Compass ☐ No ☐ *If you have a map or other navigation device, go to Part 4.*

Part 2 – Trailhead sign

10. Did you look at the trailhead sign? Yes ☐ No ☐

(Topic Area 3: Activities and Use of Park Resources)

If you answered no, go to Part 4.

11. About how long did you look at the trailhead sign?
(Topic Area 3: Activities and Use of Park Resources)

- ☐ Less than 10 seconds
- ☐ 10 to 30 seconds
- ☐ 30 seconds to one minute
- ☐ One to two minutes
- ☐ Over two minutes

12. The design of the map at the trailhead sign was appealing.
(Topic Area 5: Evaluation of Services)

Disagree Agree

1 2 3 4 5 6 7

13. The map at the trailhead sign was easy to read. (Topic Area 5: Evaluation of Services)

Disagree Agree

1 2 3 4 5 6 7

14. The impression of landscape I got from the map matches with what I saw while hiking. (Topic Area 5: Evaluation of Services)

Disagree Agree

1 2 3 4 5 6 7

15. What specifically did you like or dislike on the trailhead map?
(Topic Area 5: Evaluation of Services)

Part 3 – Remembering the trailhead map

16. What is the name of this trail? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

17. Through which does this trail go? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

18. This trail heads in which general compass direction? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

19. Are there any major downhill grades ahead on this trail?
(Topic Area 6: Individual Perceptions of Park Experience)

Yes ☐ No ☐ Not sure ☐

20. In miles or kilometers, how long is this trail (one way)? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

21. Can you name any other trails shown on the map? No ☐
(Topic Area 6: Individual Perceptions of Park Experience)

22. How many shuttle stops are shown on the map? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

23. Going from the trailhead to Observation point, what percentage of the trail distance have you hiked so far? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

24. In miles or kilometers, how far have you hiked from the trailhead to here? (Topic Area 6: Individual Perceptions of Park Experience) Not sure ☐

25. What percentage of the total trail length goes alongside the Echo Canyon bottom? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

26. In feet or meters, about how high is The Great White Throne? Not sure ☐
(Topic Area 6: Individual Perceptions of Park Experience)

Part 4 – Map comparison

The interviewer will give you a copy of the map on display at the trailhead.

Mark an "X" on the map where you are now.

The interviewer will give you a second map to compare with the first.

27. Which of these maps do you prefer? (Topic Area 5: Evaluation of Services)	Map 1 ☐	Map 2 ☐	No preference ☐
28. Which of these maps depicts reality better? (Topic Area 5: Evaluation of Services)	Map 1 ☐	Map 2 ☐	Don't Know ☐
29. Which of these maps is easier to read? (Topic Area 5: Evaluation of Services)	Map 1 ☐	Map 2 ☐	No preference ☐
30. Which of these maps do you think is more accurate? (Topic Area 5: Evaluation of Services)	Map 1 ☐	Map 2 ☐	Don't Know ☐

Thank you for helping NPS to improve its service.

Other comments:

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