HISTORIC REPEAT PHOTOGRAPHY AS A TOOL TO
ASSESS TOURISTIC LANDSCAPES: A CASE STUDY IN
PETRA, JORDAN

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Abstract
When a location is protected, a perceived value is placed upon it. That value, in turn, makes it more attractive for tourism and, arguably, more susceptible to anthropogenic landscape change. Understanding the nature and patterns of landscape change allows governing agencies to better allocate monetary and human resources to better manage irreplaceable cultural resources, such as the ancient ruins of Petra, Jordan. A multitude of factors impact Petra, and this preliminary research sought to identify tangible manifestations of tourism within the city using modern research methods. Utilizing several historic photographs from Sir Alexander Kennedy’s 1925 book, Petra: Its History and Monuments, this research employed a method known as historic repeat photography (rephotography) to assess landscape change in Petra over the past 90 years. The visual extent of physical landscape change—whether beneficial or detrimental—was assessed via five main criteria: large erosion events/obvious decay, vegetation change, impact of foot tread on ancient Roman pathways, reconstruction/restoration, and vandalism/utilitarian use of space. Restoration and tourism infrastructure development were among the most substantial landscape changes seen in Jordan’s most famous cultural tourism attraction, indicating the city’s current status as a touristic landscape is a possible continuation of Petra’s eclectic architectural and occupational history.

1. Introduction
The ancient city of Petra, hidden in the colorful sandstone cliffs of southern Jordan, has become one of the Kingdom’s most popular tourist destinations
attracting visitors from all over the globe. But at what cost? Similar to many other popular destinations, widespread tourism was not prevalent in Petra until post-World War II, when international travel became more accessible to the average consumer (Ringer, 1998). Within less than a century, the city of Petra went from a forgotten desert refuge to a booming tourist destination witnessing up to a million visitors every year (PNT, 2013). Understanding the effects of this radical transformation is imperative to the city’s survival, as many monuments have already begun to deteriorate more intensely under the strain of continual tourist activity (Paradise, 2005). To that end, the purpose of this research was to determine how the multifaceted influences of tourism have manifested in physical landscape change between 1925 and present day in Petra, Jordan, using historic repeat photography.

Tourism itself is a vastly complex international phenomenon (Ringer, 1998). Within the last two decades it has become one of the largest and fastest growing economic sectors in the world (WTO 1997). This rapid global expansion of tourism-focused development has unsurprisingly attracted the attention of the scientific community (Mitchell and Murphy, 1991; Hall and Page, 2014). While specific case studies and parameters differ, several common themes exist within tourism literature. These include but are not limited to the commercialization or commodification of space/culture for the consumption of the tourist (e.g. Rojek, 1993; Urry 1994), economic consumption theories such as supply and demand of touristic resources (Garrod and Fyaill, 2000), the creation of “touristic cultures” (e.g. Hitchcock et al., 1993), and gaining a better understanding how complex social processes are manifested in spatial configurations in the landscape (e.g. Mowl and Turner 1995). Prompted by the diverse range of travel purpose/touristic activities, tourism research is often broken into a myriad of subcategories such as ecotourism, sport tourism, religious tourism, shopping tourism, adventure tourism, resort tourism, cruise tourism, and cultural/heritage tourism (Timothy and Boyd, 2006). Historically, "heritage" has been defined as “present-day use of the past” (Ashworth, 2003; Graham et al., 2000), therefore, existing tourism research specializing on heritage tourism has focused on particular social, political, and economic trends.
The social influences and consequences of heritage tourism generally involve concepts of perception, identity, and authenticity (Timothy and Boyd, 2006). Inherent to the very concept a heritage, the idea of personal perception and identification with a certain place, people, or cultural has been heavily researched in tourism studies. Herbert et al. (1989) found that visitors to heritage tourist sites tended to be better-educated, bigger spenders, and more likely to travel in groups than other forms of tourist destinations. This may reflect a higher awareness of cultural significance or historical knowledge of the destination in question. There have also been several studies on the connections between heritage tourist destinations and individual associations with that place—many times surrounding tragedies or site of atrocities such as holocaust site (Coles and Timothy, 2004; Stephenson, 2002; Timothy, 1997).

Equally significant in the social realm is conceptualizing the “authenticity” of heritage. It could be argued that once a heritage site has been modified to accommodate tourism it has, in fact, become something entirely different and only reflects the level of authenticity desired by the tourist population – thus forfeiting true authenticity of the original place (Timothy & Boyd, 2003). Currently an industry buzzword, ensuring authenticity has been the focus of countless tourism-related agencies, host communities, and organizations—particularly in marketing campaigns and advertisement (Apostolakis, 2003).

From an academic standpoint, the “authentic experience” has been researched from a number of different perspectives including the correlation between perceived authenticity and tourist satisfaction (Moscardo & Pearce, 1986; Chhabra et al., 2003), the degree to which visitors are actually seeking reality or just experience culture different from their own (Halewood & Hannam, 2001; Moscardo, 2000; Schouten, 1995), and to what extent tourists are able to distinguish between authentic and falsified experiences (Urry, 1995; Herbert, 1995).

Similar to authenticity and perception of place, political research in heritage tourism varies significantly depending on the target population and complex histories. As discussed by Timothy and Boyd (2008), history is neither singular nor static and, therefore, the way in which heritage is presented to the tourism community is highly subjective and prone to particular biases or exclusions.
(Buchholtz, 2005; Mordue, 2005; Timothy & Boyd, 2003). In fact, there have been many instances in which attempts were made to actively ignore or erase unsavory histories associated with a culture, such as Romanian and Hungarian thwarted efforts to eradicate all evidence of communist rule—a significant period in their history (Light, 2000). Conversely, heritage tourism has also used to evoke patriotism in local communities and strengthen international relations via honoring shared heritage (Morales Cano & Mysyk, 2004; Chronis, 2005). These trends have influenced the direction of current tourism research in culturally significant landscapes—such as Petra, Jordan—but risk neglecting intellectual paucities regarding physical landscape change in junction with enhanced touristic activities. That said, there have been a handful of studies focused on the physical relationships of tourism and landscape change (e.g. Paradise, 2005; Mihai et al., 2009) but not to the same capacity of the humanistic research trends. Jamal and Kim (2005) illustrate how the tourism research community has become overly specialized and advocate for more holistic and interdisciplinary approaches to tourism studies. The preliminary research presented here is in attempt to produce such a comprehensive study on the multifaceted influences of tourism manifested in observable landscape change. Petra’s international fame and relative tourism stability, makes it an ideal case study to analyze the tangible manifestations in touristic landscapes—information applicable to worldwide heritage management.

2. Site Setting
Often called “The Valley of the Crescent Moon”, the dramatic Valley of Petra has a distinctive curve that resembles a crescent when seen from above. At an elevation of 900-1000m above sea level, Petra is in the transition zone between the more temperate Highlands and the harsh desert of the Wadi Araba. Petra’s climate can be categorized as a Mid-Latitude Dry Semiarid Steppe, specifically a BSk in the Köppen Classification, although the cool, wet winters and hot, dry summers often resemble a Mediterranean climate (Cordova, 2007). In Petra, average temperatures range from 6°-12°C in the winter months to 15°-32°C in the summer with less than 130 mm average annual precipitation (Jordanian Meteorological Division, 1971).
As part of the Northern Araba Drainage Basin, Petra is located in a valley surrounded by steep sandstone cliffs fed by slender canyons (siqs) and a myriad of wadis, or ephemeral streams, that run through the city center. Prone to flash floods, the namesake Wadi Musa is dangerous during storms and many precautions are taken during rainier winter seasons, especially in the narrow entrance of the Bab As-Siq, where 20 tourists drowned in a major flashflood in 1963 (Al-Weshah & El-Khoury, 1999). In fact, it has been speculated that Petra has experienced one or more catastrophic flood events in recent history, as indicated by large flood deposits discovered significantly above known water channels (Paradise, 2012). Other major drainages in Petra include the eastern Wadi ed-Mataha and Wadi Turkmaniyya from the north. Numerous other smaller wadis weave throughout the valley, which, with the aid of water entrapments and dams, allowed people to reside in the city for several hundreds of years (Browning, 1973).

However, the most noticeable physical characteristic of Petra is also one of the most alluring: its vibrant sandstone (Figure 1). Along with the eclectic architecture and hewn monuments, the unique geology mesmerizes visitors and researchers alike. Displaying some of the oldest exposed sandstone on earth, Petra exists at the contact of two siliciclastic components of the Ram Group: the

![Figure 1: Image of the ad-Deir (left) and al-Khazneh (right) demonstrating the dramatic sandstone features in Petra, Jordan. Also note the presence of tourists despite these photos being taken during the off-season. Photographs by K.M. Groom.](image-url)
Cambrian Umm Ishrin Sandstone at the base and the Ordovician Disi Sandstone above. The Umm Ishrin Formation is a quartz arenite with cross-bedded components of siltstone and mudstone, feasibly representing the fringe of a fluvial system (Makhlouf & Abed, 1991). The Umm Ishrin is also responsible for the famous “Rose Red” color found in the city, although its color ranges from red to salmon, chocolate, or a deep mustard yellow. Continuing the culinary descriptors, the distinctively white or cream-colored Disi Formation is the “icing on top”. Significantly coarser, the Disi Sandstone lacks horizontal cross bedding and was deposited in a braided stream environment among numerous dunes and sandbars (Nairn & Alsharhan, 1997). The fairly uniform Disi across Jordan is more inconsistent in Petra due to irregular and unconforming contact with the as-Shara Limestone above the Bedouin village, Umm Sayhoun, and Wadi Musa.

Beyond its natural beauty, the city of Petra boasts an elaborate array of carved and constructed sandstone monuments from several well-known civilizations including Nabataean, Roman, Byzantine, and Crusader. Each occupational period contributed their own distinctive styles, architecture, and building methods to the existing infrastructure, creating the unique metropolis found today. The obvious historical significance of the city has invariably attracted countless archeologists from local (e.g. Al-Bashaireh and Hodgins, 2011) and international agencies and universities (e.g. Acevedo et al., 2001; Ortloff, 2005). Similarly, the myriad of stone structures also endorses geomorphologic research with a variety of foci, including: evaluating conservation techniques (Al-Saad and Abdel-Halim, 2001; Wedekind and Ruedrich, 2006), assessing restoration methods (Bani-Hani and Barakat, 2006), quantifying physical impacts of tourism (Franchi et al., 2009; Paradise, 2010), rock-fall hazard assessments (Delmonaco et al., 2013), and even uncovering evidence for past catastrophic events (e.g. Russell, 1980; Paradise, 2012). In modern history, the most significant turning point for Petra came December 1985: inscription into the United Nations Educational, Scientific, and Cultural Organization's (UNESCO) World Heritage Conservation program, effectively turning the once lost Nabataean Capital and its gateway town of Wadi Musa into the country's most visited tourist attraction with nearly a million visitors in 2010 (PNT 2013). But what kind of landscape change has resulted from such a dramatic shift from an unknown city to a major tourist attraction?
2. Research Methods

First employed soon after the invention photography itself, repeat photography has proven to be a useful and versatile tool in the social and physical sciences (Webb, Boyer, and Turner, 2010). One of the earliest pioneers of employing rephotography as a scientific tool was a Bavarian mathematician named Sebastian Finsterwalder, who, in 1888, used the technique to monitor glacial change over time (Hattersley-Smith, 1966). His research was so successful that repeat photography spread in popularity and has been a longstanding tool in glaciology (Byers, 2007; Fox and Cooper, 1998). Since then, the technique has spread to other disciplines such as ecology (Clements, 1905), geology (Bryan and La Rue, 1927), and geomorphology (Lobeck, 1939). Not limited to the physical sciences either, rephotography has also been used to assess social concerns such as land-use change (Kull, 2005), socio-economic influences of tourism (Finn et al., 2009), and to monitor the effectiveness of rock art conservation (Groom, Forthcoming; Loubser, 2011). The method has also been adapted for use in anthropology as a means to assess place meaning and awareness (Smith, 2007).

While applications may vary, the fundamental idea behind repeat photography is comparing old and new (repeat) photographs taken from the same perspective. There are several methods for finding these perspectives, also known as vantage points or camera stations, but no one method is superior to another – each is case specific (Boyer, Webb, and Turner, 2010). Popular ways to find vantage points range from using the principles of parallax by identifying the cross lines between foreground and background elements in the photo (Malde, 1973) to utilizing geospatial technologies and advanced photogrammetry (Hanks, Blair, and Webb, 2010). The most common method, however, is what is known as the Brute-Force Technique, where the researcher looks for major landforms in the photo and ‘walks into the view’ (Hanks et al., 2010). Once the vantage point is located, the camera is then adjusted to match elevation, tilt, and azimuth to get the most accurate repeat photograph. The degree of precision necessary often depends on the research topic and the preference of the researcher (Boyer et al., 2010). However, many of these methods risk being too tedious and time consuming for the time allotted for the proposed research. Therefore, the
authors will use printed transparent slides of historic images in conjunction with the camera's optical viewfinder to accurately match the historic photo with the modern landscape.

Of course, repeat photography also has to work within some fairly tight constraints and limitations. First of all, obviously, researchers wishing to employ repeat photography are restricted to locations depicted in historic photographs. For some places, necessary photographic records simply do not exist and are, therefore, excluded from any kind of rephotographic assessment. Secondly, not all photographs are eligible for reliable replication. In almost all cases, camera stations are located by somehow interpreting the relationship between identifiable objects in the foreground versus those in the background (Boyer et al., 2010), so if a photograph lacks one of these two components then finding the exact camera location becomes significantly more complicated. Similarly, it would be exceedingly problematic to confidently find the vantage point of a photograph only showing indiscriminate or common landmarks, such as trees or hills.

Another limitation, or complication, with repeat photography involves technology. Photographic technology has advanced rapidly throughout the years, slightly altering photographs along the way (Boyer et al., 2010). Everything from focal lenses, film material, film size, even the jump to digital cameras influences the quality and shape of a photograph. Much like cartography, photographs are 2D representations of a 3D landscape and, therefore, some form of image distortion is inevitable and each camera evolution alters the degree of this distortion (Boyer et al., 2010). For that reason, researchers must be aware of differences in camera equipment used by the original photographers when interpreting landscape change between photographs.

Despite these restraints, repeat photography it still a valuable research tool for more holistic analyses of overall change. This can include everything from surface recession and rock decay, vandalism, litter, land use, to any other ways in which human or natural activity may have impacted the overall stability of the site. For culturally sensitive sites, such as the Petra archeological park, comprehensive evaluations are critical for the creation of better management policies and addressing issues often missed in traditional or overly focused
assessments. Landscapes are complex and interactive systems; therefore, the research designed to understand them should be equally dynamic—or at the very least capable of accommodating the multitude of factors influencing their development and change.

Specific to the proposed research in Petra, Jordan, the photographic record chosen for repetition comes from the book *Petra: Its History and Monuments* written by Sir Alexander Kennedy in 1925. Containing over 200 individual photographs, including some of the first aerial shots of the city, this volume depicts a very different Petra—one nearly devoid of tourism, something that would not come to Petra for another two decades. Structured comparison of Sir Kennedy’s pre-tourism photographs with modern repeats display considerable change in some ways and remarkable similarity in others, demonstrating the complex nuances of human and environmental influences in cultural touristic landscapes.

To most reliably identify and assess visual differences between historic and repeated photographs four separate criteria were assessed:

- Vegetation change
- Foot tread and trail degradation
- Vandalism and utilitarian use of landscape (e.g. power cables)
- Reconstruction and restoration

Each criterion were analyzed in relation to known intrinsic and extrinsic rock decay forces, representing the relationship between natural occurrences and anthropogenic forcing. In terms of the last two criteria, most, if not all, change falling within these categories can be confidently assumed as being the direct result of human activity (i.e. tourism) with reconstruction and additional infrastructure being the most common, and striking, visual changes.

3. Results and Analysis

While this is an on-going endeavor, at least 15 historic images from Sir Kennedy's 1925 volume have been successfully repeated so far—with several other sites identified for future efforts (Figure 2). Although Kennedy (1925) contains a variety of images displaying everything from the local people, broad landscapes, viewsheds, and monuments, the subject matter of the repeated
images focus primarily on hewn and built facades throughout the valley as they were most readily identified and located in the field. For ease of interpretation and presentation, examples will be given for each of the five criteria instead of outlining changes seen in each of the fifteen pairings. More detailed assessments and discussion of specific changes depicted in every image will be provided in future publications, most likely a book or larger volume, once a greater number of repeat pairs have been collected.

Vegetation change
Popularly used in ecology and land-use management, repeat photography can be a very effective tool to assess vegetation change over time—and Petra is no different. Nearly every photograph pairing displayed a fairly dramatic decrease in vegetation size and distribution. Among the most significant examples of this are along the Royal Tombs, where widespread desert shrubs

Figure 2: Repeat pairing of the Corinthian Tomb along the Royal Tombs ledge. Right- Kennedy (1925). Left- Photo by author 2016.
have been reduced to a handful of small shrubs and grasses (Figure 2). The exact cause of this change is unknown and could be any number of factors influencing the region (e.g. over-grazing, land-use changes, climate change, increased foot tread, etc.). That said, it can be assumed that at least to some degree increased tourism and the lack of a set trail system limits vegetation regrowth (Marion & Leung, 2001), particularly around the monuments where foot tread and vehicle traffic are the most concentrated.

**Foot tread and trail degradation**

While vegetation loss is one potential impact from increased foot tread, trails and areas of significant foot traffic face several other management challenges in touristic landscapes, such as Petra. This particular criterion pertains to soil reduction, destruction of features along trails or popular routes, and the creation of trails themselves. Much of the cultural stone decay taking place in Petra occurs at a much finer scale than can be clearly seen in the repeat images, so this assessment focuses more on the broader landscape scale changes. The iconic view of the Khasneh (Treasury) through the Siq is a prime example of how trails and foot tread have influenced landscape change (Figure 3). For one, the sediment along the Siq has been considerably compressed and/or depleted over the past century, indicated by the lower ground level in the modern photograph. The texture of the trail is also much smoother as natural cobbles and stones have been moved to facilitate easier transportation, both by foot and horse cart. Beyond this, there are also clear signs of vegetation changes between the two photographs and the obvious tourism land-use of the Khasneh area in the modern image—exemplifying how repeat photography is a powerful tool to capture a more holistic representation of landscape change.
Figure 3: Repeat photo paring looking at the Treasury from the Siq—one of the many images that has made Petra famous. Right- Kennedy (1925). Left- Photo by author, 2016.

Of course, it can be argued that not all tourism-driven landscape is bad and that resources gained from tourism can, and should, be used to protect and responsibly share heritage with the world (Jamal & Kim, 2005)—such as the establishment of a trail system within Petra. While the movement of people is less controlled around many of the outer tombs and monuments, some of the main routes, such as the main entrance, have clear and defined trails, which help minimize visitor impact on the surrounding areas. The repeat pairing of the Djinn Blocks near the Bab al-Siq (Figure 3) show how the creation of a trail might have destroyed some desert vegetation but in the end constrain tourist traffic and allow for larger plants to grow. The installation of trashcans (seen in the lower left corner of the modern image) helps decrease litter and waste.
Vandalism and utilitarian use of landscape (e.g. power cables)

While vandalism is a major concern for any tourism destination, its prevalence in Petra as seen in the repeat photographs was surprisingly low—especially when it has devastated other sites in the region such as Wadi Rum further to the south. That said, the limited scale and distribution of historic photographs available does perhaps misrepresent vandalism issues in Petra, since many of the monuments’ inner chambers are marred by carved initials, spray paint, and other forms of graffiti. The focus then turns to land-use and, for Petra and other significant archaeological sites, this means excavation. Several repeat pairings display some measure of impact from scientific exploration and the chosen example portrays a row of tombs along the Outer Siq (Figure 5). In the pairing, the significant removal of vegetation and ground material has exposed two doorways into lower tombs—which are now vulnerable to vandalism and misuse. The light-colored line along the lower sections of the monuments also
suggests there might be some residue from previous soil levels, which can promote further rock decay across those surfaces. However, here is an informative sign and trashcan visible in the modern photo, which indicates efforts are being made to mitigate damage to the now-uncovered monuments.

Figure 5: Double story monuments in the Outer Siq. Right- Kennedy (1925). Left- Photo by author, 2016.

Reconstruction and restoration

By far, the most obvious and dramatic landscape changes captured in the repeat photographs deal with monument reconstruction and restoration. Not necessarily connected to archaeological research, reconstruction can also be considered almost solely the result of, or desire for, increased tourism. For example, the steps leading up to the Urn Tomb have been completely rebuilt with a mix of old stones and new material (Figure 6)—a new trail leading to the tomb lined with shops and local stalls selling souvenirs and handicrafts. The new path is also considerably safer than trying to scramble up the debris field that once occupied the slope. Other repeat pairings displaying reconstruction or restoration speak for themselves (Figure 7).
Figure 6: Urn Tomb with arches and stairway leading to it. Right- Kennedy (1925). Left- Photo by author, 2016.
Figure 7: Qasr al-Bint showing significant reconstruction as well as path developments behind and in front of the built structure. The canopy of the museum/visitor center/restaurant can be seen in the modern image. Right- Kennedy (1925). Left- Photo by author, 2016.

Discussion and Conclusions

"Since the notion of heritage in integrally related to the past, it can be argued that heritage tourism is intrinsically about life, existence, belonging, and
change – from the past into the present and future...

It is these multifaceted dimensions that makes heritage tourism such an important part of tourism studies.”


Increasing the understanding of tourism in a theoretical and comprehensive framework is of global concern (Jamal & Kim, 2005). Heritage-based tourism, such as UNESCO World Heritage sites like Petra, Jordan, play an even larger role as they not only encourage the exchange of currencies but also exposure to different cultures, people, and ideas – for both the tourists and hosts. As one of the fastest growing economic sectors in the world, tourism is ubiquitous, and nations worldwide struggle to maintain the balance between economic and experiential benefits with resource degradation and exploitation. At what costs are we enjoying the landscapes of the past? Understanding the various impacts of tourism on a landscape represents a vital function to furthering management and conservation efforts, as well as prolonging their viability as an economic resource.

Petra, Jordan is a dynamic and evolving place. The purpose of this study is not to determine if landscape change in Petra is good or bad, simply identifying what has changes and speculating on the connections with observed increases in tourism. The way landscapes are managed profoundly reflects how we perceive their value, so management can be interpreted as priority-driven interaction with the landscape. That said, empirically understanding how tourism-manifested landscape change could remove some inherent subjectivity in cultural resource and heritage management (Groom and Thompson, 2011).

Essentially, the preliminary research presented here does not focus on whether or not heritage tourism should exist, but on the fact that it does exist, by addressing the tangible impacts tourism has on its surroundings. Tourism, heritage-centered or not, is a complex global phenomenon and, while it would be easy to get lost in the ethical debates, the truth remains: this powerful economic resource is not disappearing any time soon. Existing within this reality, heritage tourism management creates a delicate balancing act between cultural exposure and resource conservation, finding the best-case scenario within a complex and
dynamic system. In order to accomplish this equilibrium, scientific exploration remains necessary to identify the exact nature of tourism impact with the purpose of better informing management policies and promoting effective mitigation/conservation efforts.

References:


