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In the Land of a Thousand Cities: Evaluating Patterns of Land Use in Bactria through Survey and Remote Sensing

Daniel Plekhov
Joukowsky Institute for Archaeology and the Ancient World
Brown University
daniel_plekhov@brown.edu

Evan Levine
Joukowsky Institute for Archaeology and the Ancient World
Brown University
evan_levine@brown.edu

Abstract

Bactria, a region today comprised of parts of Afghanistan, Turkmenistan, Uzbekistan, and Tajikistan, has historically been the homeland for a wide range of cultural groups that have produced a palimpsest of archaeological sites. Focusing on those parts of Bactria within the northern provinces of Afghanistan, this paper draws on decades worth of archaeological survey and excavation to investigate the history of land use in this region and its relationship to the highly variable landscape. Periods of increase and decline in site frequency are identified which, through analysis of topographic, environmental, and ecological data derived from remote sensing, are examined in respect to where increases are occurring and how that may reflect land-use and subsistence strategies of different groups. By doing so, a better understanding of how these different groups historically utilized the landscape is achieved, while also emphasizing the significant changes that occurred during transitions between different historical periods.

Keywords: Bactria, settlement pattern, land use, GLCC, spatial statistics

Introduction

Known since antiquity as the *land of a thousand cities*, a trope frequently employed by Mediterranean geographers and historians,[1] Bactria was a region that, at times, experienced periods of rampant urban development, wealth, and agricultural prosperity (Figure 1). However, this rather frequently contested region was also met with long stretches of unrest, destabilization, and settlement dispersal: an oscillating trend that can still be witnessed within some parts of the region today. This paper seeks to explore these periods of growth and contraction through the synthesis of archaeological, topographic, and environmental data. We outline the spatial characteristics of human occupation of the region on a diachronic scale, examining not only when there are expansions in the number of sites, but where. In so doing, we address the characteristics of land use and occupation during distinct chronological periods while also shedding light on long-term trends and patterns that continue despite abrupt changes in political or cultural organization.

At a general level, we predict that increases in the number of sites occur primarily in areas suitable for irrigated agriculture, and that it is primarily during such periods of growth that increases also occur in more marginal areas. Conversely, we predict that decreases in site counts result in the abandonment of these marginal areas and a contraction of occupation to rain-fed or irrigated agricultural areas. We also predict that increases in site counts will correspond to a higher density of sites with clustering positively correlating with site frequency at local scales. This

1 Apollodorus of Artemita (fr. 6.9), in his fragmentary history of the Parthian Empire, describes the region as εὐκρατίδαν γοῦν πόλεις χιλίας, an account redeployed by Strabo 15.686, who employs the same phrase. Likewise, Justin 41.1.8 refers to the region as *opulentissimum illud mille urbium* Bactrianum imperium in his broader geographical treatise on the region.

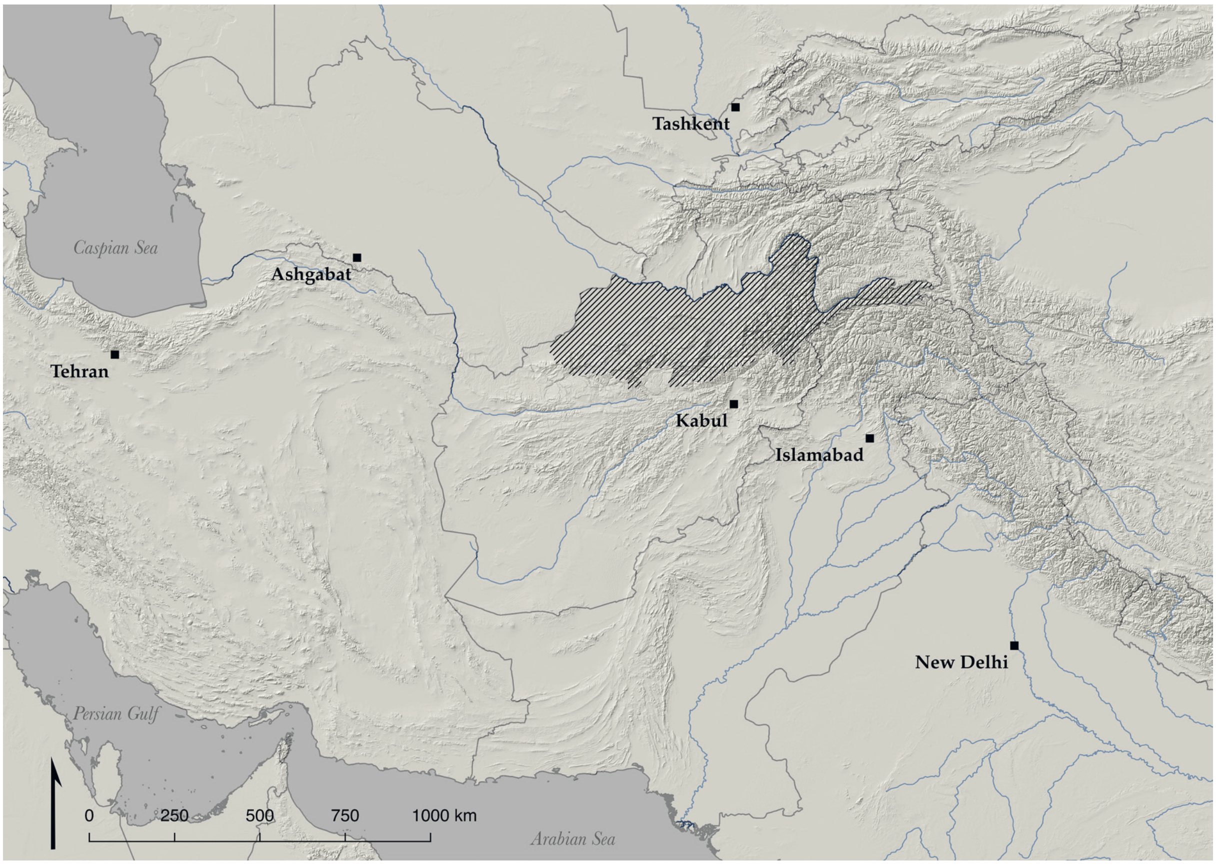

Figure 1. Map showing Bactria (hatched area) and neighboring modern countries.

would indicate the preferential occupation of areas with preexisting settlement. These predictions are largely based on the assumption that marginal areas, which we define as grassland and shrubland, will only be occupied if sufficient population pressure prevents exploitation of more productive areas, such as dryland and irrigated cropland – as behavioral models like the Ideal Free Distribution (IFD) predict (Fretwell and Lucas 1969; Winterhalder et al. 2010). We predict that variations from this model may be the result of conflict (i.e. preference for higher elevations for defensive reasons), an emphasis on particular subsistence strategies that exploit certain ecological zones (i.e. upland pastoralism), or a more variable land-use strategy in the region that other studies from north of the Amu Darya River have already noted (Stride 2007).

Regional Historical Overview

The region of Bactria consists of a topographically varied landscape, bordered rather dramatically by the Hindu Kush mountain range on its southern and eastern edges, the Karakum desert and grass steppes of Margiana to the west, and the Pamir mountains of Sogdiana that lead to the Central Asian steppes to the north (Holt 1999: 10; Rawlinson 1912: 1-2). The Amu Darya River, known in antiquity as the Oxus, runs through the center of the region, from the east to the west, eventually turning to the northwest to empty in the now-shrunken Aral Sea. This seemingly divergent combination of hot and cold, wet and dry, high and lowlands was a theme that was continually evoked in ancient geographic treatises, serving to mark Bactria as something of a land of opposites. The first century CE Roman historian of Alexander the Great, Quintus Curtius Rufus (7.4.26), summarizes this concept, remarking on the variable topographic and ecological nature of the region.[2]

The earliest archaeological evidence for urbanism in the region is associated with the Bronze Age civilization termed the Bactria–Margiana Archaeological Complex (BMAC). Comprising a series of major urban centers spread throughout the regions

2 The full passage reads as follows: "Bactrianae terrae multiplex et varia natura est."

of Margiana and Bactria—from the arid Karakum Desert in southern Turkmenistan, through the fertile valleys on either side of the Amu Darya, to the harsh terrain of the Hindu Kush — BMAC culture thrived from the late third to the early second millennia BCE. These early urban centers are characterized by a planned urban form, large-scale mudbrick architecture, major fortifications, and intensive irrigation (Askarov and Sirinov 1994). This irrigation, drawing from the large Amu Darya, as well as the smaller rivers that flow into it from the plateaus to the north and south, served to create broad fertile oases within an otherwise oppressive landscape, and allowed for the development of intensive agriculture on a large scale, alongside the continued practice of extensive pastoralism.[3]

Despite this longstanding tradition of urbanism in the region, the first definitive historical attestation of Bactria does not occur until the Achaemenid period, in the middle of the first millennium BCE.[4] Bactria was brought under Achaemenid control by Cyrus the Great in the 6th century, and first mentioned by Darius I as a Satrapy of the Persian Empire in the Behistoun Inscription of 520 BCE.[5] This inscription stands as the first marker of direct external control of Bactria, a trajectory that saw foreign interventions in the region by Hellenistic Greeks, Indo-Iranian Yuezhi states, Sasanian Persians, Turks, Mongols, Huns, and several Islamic Persian empires, all of which mixed with the already multicultural indigenous population. These administrative interventions, coupled with continuous trade with the Mediterranean, as well as South and East Asia, served to mark Bactria as a multicultural, cosmopolitan space. Each new era of cultural control brought novel perspectives toward urbanism and settlement patterning—often adopting characteristics from multiple cultural groups simultaneously—a feature that is preserved within the broad archaeological record of the region.[6]

Methodology

We hypothesize that periods of overall increased site frequency correspond to higher site density at relatively local scales and a preference for low-elevation and topographically flat irrigated areas ideal for intensive irrigation, that is paired with the exploitation of more marginal areas necessary to support increased populations, such as upland pastures. Conversely, we predict that periods of overall low site frequency correspond to lower site density and a less variable land use pattern that exploits primarily low-elevation areas suitable for irrigation. The combination of site density and land use classification is meant to evaluate both first and second order effects on the data.

First order effects are those that describe the average intensity of point patterns over a given area and are usually influenced by external variables, such as those employed here. Second order effects are those that influence the location of data points across a study area due to the location of neighboring points, due to some forces of attraction or repulsion inherent to the points themselves (Bevan and Wilson 2013: 2416).

Archaeological site data for this project was compiled from Ball and Gardin's (1982) *Archaeological Gazetteer of Afghanistan*, which synthesizes several decades worth of archaeological survey, excavation, and exploration within Afghanistan. Though the *Délégation archéologique française en Afghanistan* (DAFA) is planning an updated edition of this by now quite dated volume, the period of conflict and instability that followed its publication makes it a valuable record of sites that have since been damaged or destroyed, while also remaining more or less cur-

3 Evidence for this combined practice is found at Gonur Tepe, one of the most significant and well-studied BMAC urban sites. At this site, Moore et al. (1994) have conducted a thorough review of the intensive agriculture, large-scale irrigation, and herding practices that worked in tandem to support the large Bronze Age population at the site.

4 Potential earlier attestations of both the region and the name of Bactria are found in the Avestan Vidēvdād, where it is called Bāx'iš or Bāxδriš (Humbach 1966: 52).

5 The Behistoun Inscription (ln. 6) describes Bactria (Bâxtriš) as one of the 23 kingdoms under the control of Darius the Great. It also recounts a tale of a revolt in Margiana (Marguš), one of the minor satrapies within Bactria, led by Frâda, which was quashed by Dâdarši, the satrap of Bactria proper in 521 BCE (ll. 38-39).

6 See, for instance, the characteristics of Aï Khanoum, which features several distinctly Greek urban features such as large ashlar fortifications, a theater, and a series of Hellenic temples, while actively engaging with local architectural and artistic traditions, a practice witnessed in the form taken by local sculpture, and the presence of Persian and Mesopotamian architectural forms (Bernard 1987; Leriche 1986).

Period	Abbre-viation	Duration
Paleolithic	PL	50,000-8,000 BCE
Neolithic	NL	8,000-4,000 BCE
Bronze Age	BA	4,000-1,500 BCE
Iron Age	IA	1,500-530 BCE
Achaemenid	A	530-330 BCE
Seleucid	SE	330-250 BCE
Greco-Bactrian 1	G1	250-180 BCE
Greco-Bactrian 2	G2	180 BCE-1 CE
Kushan 1	K1	1-100 CE
Kushan 2	K2	100-200 CE
Early Sasanian	ES	200-300 CE
Kushano-Sasanian	KS	300-400 CE
Hephthalite	H	400-550 CE
Late Sasanian	LS	550-650 CE
Turkish Khanate 1	T1	650-800 CE
Turkish Khanate 2	T2	800-875 CE
Samanid	SA	875-1000 CE
Ghaznavid	GZ	1000-1050 CE
Seljuk	SL	1050-1150 CE
Ghurid	GH	1150-1225 CE
Chaghatai Khanate	C	1225-1380 CE
Timurid	TM	1380-1500 CE

Table 1. Chronological periods used in this study (adapted from Ball and Gardin 1982).

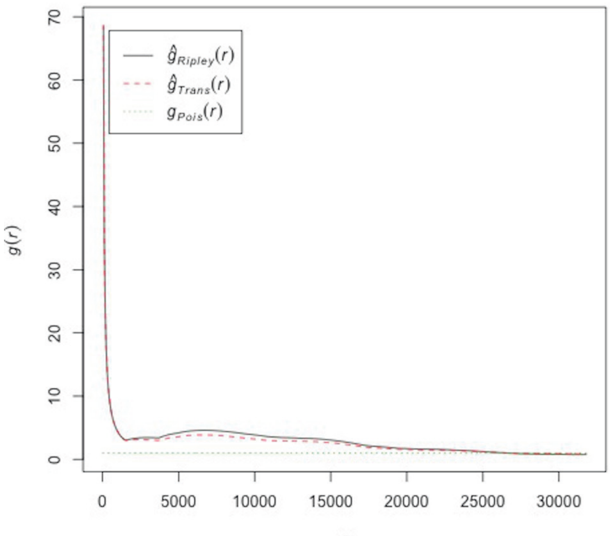

Figure 2. Plot of pair correlation function for sites during Paleolithic (PL) period. Distance (r) is in metres. gPois represents theoretical distribution of points under the assumption of CSR. gRipley and gTrans are empirical observations of the data. The farther above the gPois line, the more clustered the data.

rent. Even so, the synthesis of archaeological investigations by different projects over several decades, of varying intensity and analytical focus, necessarily makes a broad scale regional analysis of all these data problematic. Recording standards are inconsistent, with some projects recording a group of mounds as a single site while others recording such groupings as a series of individual sites. Overrepresentation of sites from certain periods may also be the result of differences in the diagnosticity of materials or the lack of specialists familiar with certain types of material, a problem common to all archaeological surveys (Millet 2000 53-59). For the identification of general trends and deviations, however, the wide temporal and spatial scope of the analysis should allow for the integration of these data despite their inconsistencies in recording or analysis.

With our survey area constrained within the boundaries of Afghanistan (a region of roughly 160,000 square kilometres), we selected sites from all provinces that bordered the Amu Darya River in the north. Working from the distribution maps provided in the Gazetteer, we then digitized the data provided for these sites. Attributes included coordinates provided in degrees minutes and chronological attestations, with sites lacking either of these attributes excluded from our dataset. While many site entries go into detail about possible functions of the site (e.g., urban settlement, fort, cemetery), we largely ignored these descriptions given their inconsistency and the unclear methods by which these characterizations were made. The sites used in this study thus represent cultural activity in general, rather than a focus on settlements of a particular function or nature. In total, 289 sites were mapped, covering a timespan from the Paleolithic to the Timurid period. This timespan follows the chronological divisions set by Ball and Gardin (1982: 372), which we adapted and divided into twenty-two periods (Table 1).

To test the above predictions about the relationship between site counts and density, we calculated nearest neighbor distances and the pair correlation. These statistics measure how site density changed between chronological periods while also measuring the scale at which these changes occurred. We recognize that chronological periods are not equal in length, and our analysis should be understood as

Code	Description	Characteristics
100	Urban and Built-Up Land	Majority of land covered by structures
211	Dryland Cropland and Pasture	Land alternates between periods of bare soil and vegetation, following rainfall trends
212	Irrigated Cropland and Pasture	Land alternates between periods of bare soil and vegetation, independent of rainfall trends
280	Cropland/Grassland Mosaic	Land covered by combination of cropland and grassland, with neither covering more than 60%
290	Cropland/Woodland Mosaic	Land covered by combination of cropland and woodland (vegetation exceeds 5 m in height), with neither covering more than 60%
311	Grassland	Land with herbaceous cover. Tree and shrub cover less than 10% of land
321	Shrubland	Woody vegetation less than 2 m tall and covering between 10-60% of land
330	Mixed Shrubland/Grassland	Land covered by combination of shrubland and grassland, with neither covering more than 60%
500	Water Bodies	Oceans, seas, lakes, rivers
770	Barren or Sparsely Vegetated	Most of land is exposed soil, sand, rocks, or snow with less than 10% vegetation

Table 2. USGS Land Use/Land Cover (Modified Level 2) classifications.

tracking changes between periods rather than over continuous time. The pair correlation function describes how density varies as a function of distance from each point (Baddeley, Rubak & Turner 2015: 225-230; Bevan et al. 2013; Stoyan and Stoyan 1994). It does so by creating rings around each point at certain distance intervals, within which points are counted. The statistic it provides is the probability of observing a pair of points separated by a distance (r) divided by the probability expected from a Poisson point distribution defined by complete spatial randomness (CSR). The empirical point pattern can then be evaluated as clustered or dispersed through comparison to this theoretical, null point pattern (Figure 2).

The distance at which point patterns deviate from CSR can also be assessed from this statistic, and in this study is used as a measure of the minimum distance at which the point pattern deviates most from CSR as calculated by the pair correlation function. A small minimum r value indicates clustering at a relatively small scale while a greater minimum r indicates clustering at larger scales – suggesting a more extensive pattern of clustered sites. For a more general measurement of distance between sites during each period, nearest neighbor distance was also calculated by averaging the distance from each site to its five nearest neighbors, per period, and then taking an average of all those values. The resulting value represents the average nearest neighbor distance of sites during each period, to the fifth neighbor. Evaluating these distances in conjunction with the information provided by the pair correlation function provides insights into the second order properties of site patterns in the region during each period and how they changed through time. These calculations were done in R using the *spatsat* package (Baddeley and Turner 2005).

Archaeological data were complemented by environmental and topographic data meant to evaluate the first order relationships between sites and these various factors over time. Topographic data were derived from 30-metre resolution digital elevation models provided by the Shuttle Radar Topography Mission (SRTM). Mean annual precipitation was provided by WorldClim Version2 (Fick and Hijmans 2017). Together, these two datasets generally relate to the suitability of the environment for various agricultural strategies and provide a coarse perspective on the variation within the study area that may detect macro-level trends in site location in respect to these variables.

For a more nuanced and higher-resolution perspective, land-use classification data provided by the Global Land Cover Characterization (GLCC) were employed (Anderson et al. 1976; Loveland et al. 2000). This dataset is based on unsupervised classification of 1-kilometre resolution Advanced

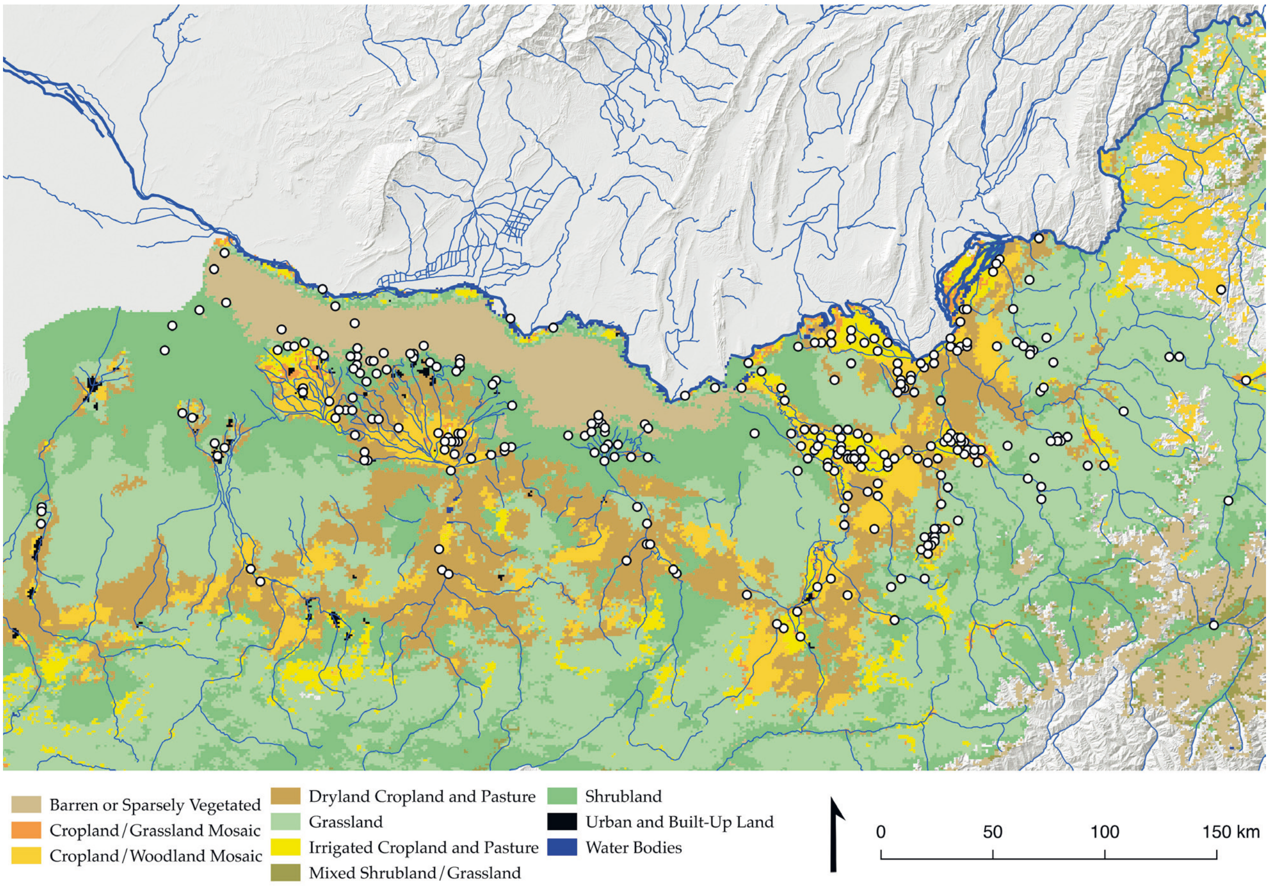

Figure 3. Land Use/Land Cover classifications with archaeological sites.

Very High Resolution Radiometer (AVHRR) 10-day Normalized Difference Vegetation Index (NDVI) composites, and provided by the Land Processes Distributed Active Archive Center (LP DAAC) and the United States Geological Survey (USGS). Of the twenty-four land-use types classified in the USGS Land Use/Land Cover System, ten had sites located within them (Table 2). The remainder were either land cover classes not found in this region (e.g. wooded tundra), or those that did not contain sites (e.g. herbaceous wetland). Long-term and high-resolution environmental data is required to determine whether significant environmental changes have occurred within this region during the temporal scope of this study that would alter the land-use classification of certain areas during periods of occupation. In lieu of such data, we assume that environmental conditions today generally reflect conditions during the majority of periods studied here, with areas suitable for irrigation today being those that could have been successfully irrigated in the past as well. On the other hand, the classification of some sites as within Urban and Built-Up Land or Water Bodies is due to the 1-km resolution modern imagery from which land-use types are derived, as well as the resolution of the spatial coordinates provided for the archaeological sites. Rather than reclassify these points into other classes, their classifications were maintained so as to remain consistent, and these sites and their land-use type were excluded from further analysis. Only one site was classified within mixed shrubland/grassland areas, during the K1-ES periods, and thus was also excluded from further analysis. Analyses of these data were conducted in R using the raster package (Hijmans 2016).

Bringing these data together, elevation, precipitation, and land-use information were extracted for each site, while spatial statistics and counts of sites were calculated for each period (Figure 3). From these data, we identify periods of relative site count increases and decreases, which are then explored further through analysis of environmental and topographic variables. In other words, we seek to identify when increases in site number and density within this region of northern Afghanistan occur, and in what ecological zones these increases occur.

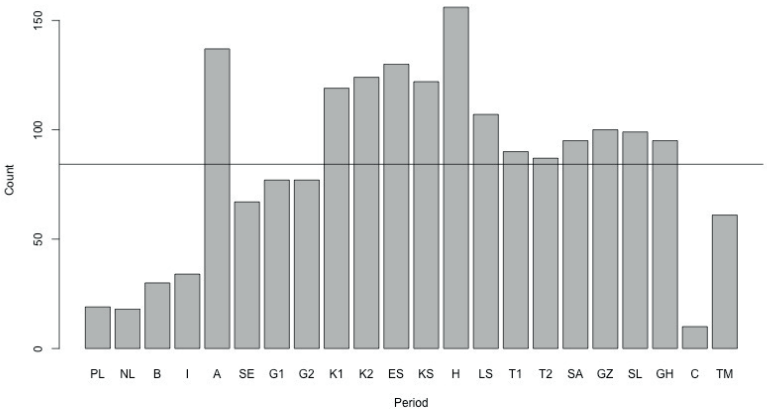

Figure 4. Number of sites per period, with average site count (84) shown by horizontal black line. For period abbreviations, see Table 1 and text.

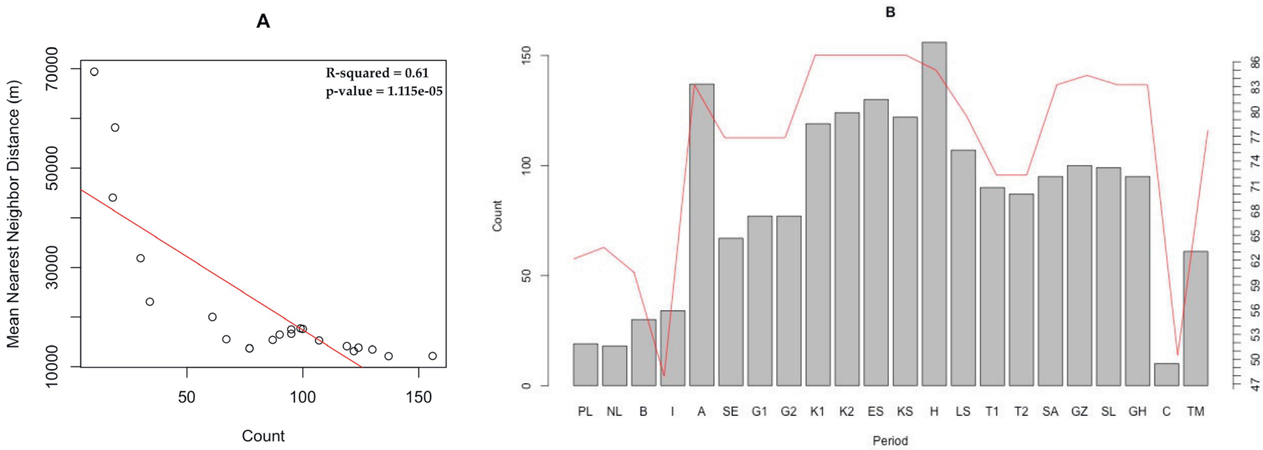

Figure 5. (a) Site distance plotted against site count per period and (b) minimum pair correlation function plotted against site counts per period.

Results

A simple breakdown of site counts per period reveals notable peaks in overall regional occupation (Figure 4). The Achaemenid period (A) is particularly pronounced and reflects the investment in the region attested in historical sources from the period (Leriche and Grenet 1988). This peak is notable both for the marked increase in site counts compared to preceding periods as well as the sharp fall during the Hellenic periods (SE-G2) that followed. Indeed, site counts in this region during the Bronze and Iron Ages (B-I) appears generally consistent, with a slight increase in count during the early first millennium BCE. The arrival of the Achaemenid Persians clearly had a massive impact on the region, with sites increasing by almost four times. After the conquest of Alexander, site counts decreased by half, with only a slight increase during the Seleucid and Greco-Bactrian periods. Yet even with this significant decrease, sites during the Hellenic periods were still about twice the number of sites before the Achaemenid period.

The Kushan and Sasanian periods (K1-KS) show another marked increase in site counts that, while fluctuating slightly over several centuries, comes close to matching the counts reached during the Achaemenid period. The gradual increases seen during the K1-ES periods, similar in magnitude to the increase seen during the SE-G2 periods, suggests stability and gradual growth, with the dip during the KS period historically attributed to conflict (Grenet 2006). Sharp peaks, as seen during the Achaemenid and Hephthalite period, seem to indicate intense investment and expansion that ultimately appear to be unsustainable. The Hephthalite period in particular, is a significant peak above the Kushano-Sasanian and Islamic periods surrounding it, which are,

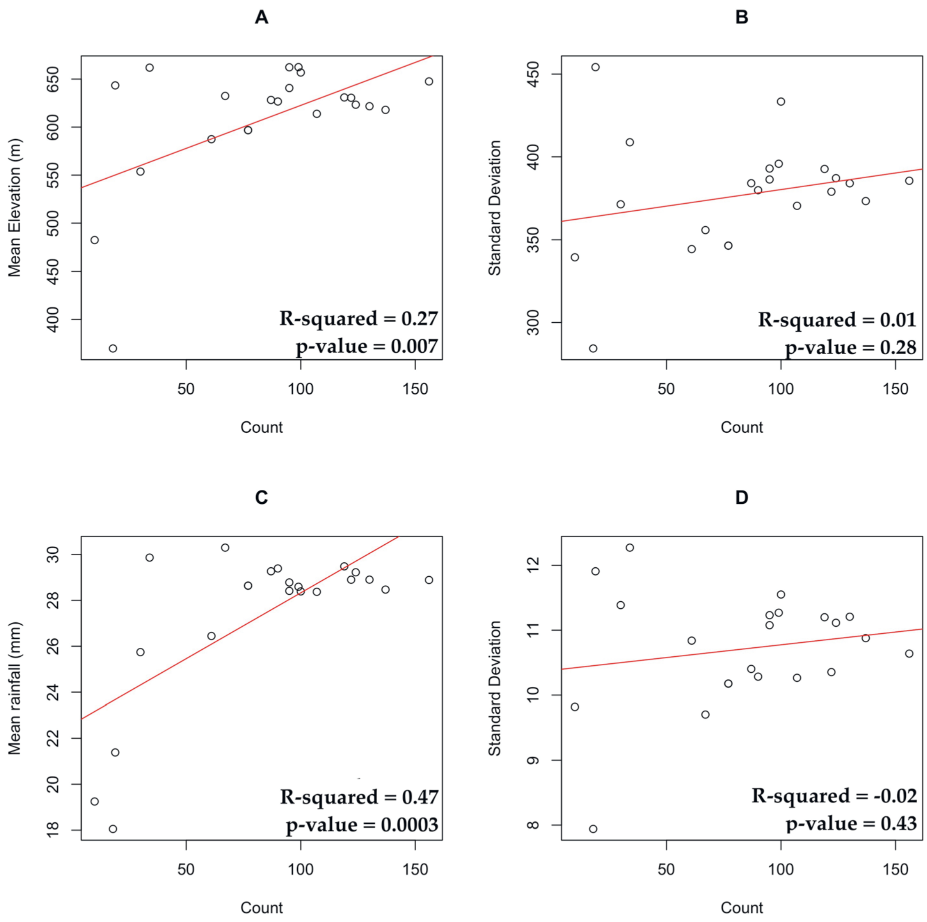

Figure 6. Plots showing relationship between environmental and topographic variables and site counts per period: (a) mean elevation, (b) standard deviation of elevation, (c) mean rainfall, (d) standard deviation of rainfall.

themselves, mostly above the site count average. Site counts during these latter periods (LS-GH) appears to show a return to levels last seen during the Hellenic periods, and more severe fluctuations that parallel the more frequent historically-attested conflicts that were prevalent in the region during these periods (Soucek 2000).

The significant drop in site counts during the Chaghatai period is particularly striking. While the severity of the Mongol and Chaghatai conquest during this period is not in doubt (Soucek 2000: 105-106; 121), the paucity of archaeological remains is also perhaps not surprising given the intent of conquest rather than settlement. The site counts during the subsequent Timurid period, while relatively modest, indicate that many abandoned or destroyed sites were quickly resettled. Unfortunately, it is not possible to evaluate the continuation of this rebound given the available data, as the archaeological scope of Ball and Gardin's (1982) *Gazetteer* ends during this Timurid period.

Bringing in environmental and topographic data adds further dimensions to this record. As stated, we predicted that periods of increased site count would correspond to both increased use of areas suitable for irrigated agriculture as well as exploitation of more marginal areas, while periods of low site count would be limited primarily to areas suitable for irrigated agriculture. Settlement density would be greater during periods of overall increased site count, and less during periods of low site count. This relationship is well supported by the data, showing a clear negative relationship between site counts and mean distance between sites (Figure 5a). Pair correlation function analysis also supports this, with minimum r values increasing as site counts increase (Figure 5b).

Looking at elevation and rainfall shows little evidence of significant patterns. The mean elevation of sites increases as site counts increase (Figure 6a), but much of the variation is unexplained by this variable. Variability, measured here by the standard deviation of elevation values of sites per period from the period mean, shows no significant relationship (Figure 6b). As site numbers increase, sites are not neces-

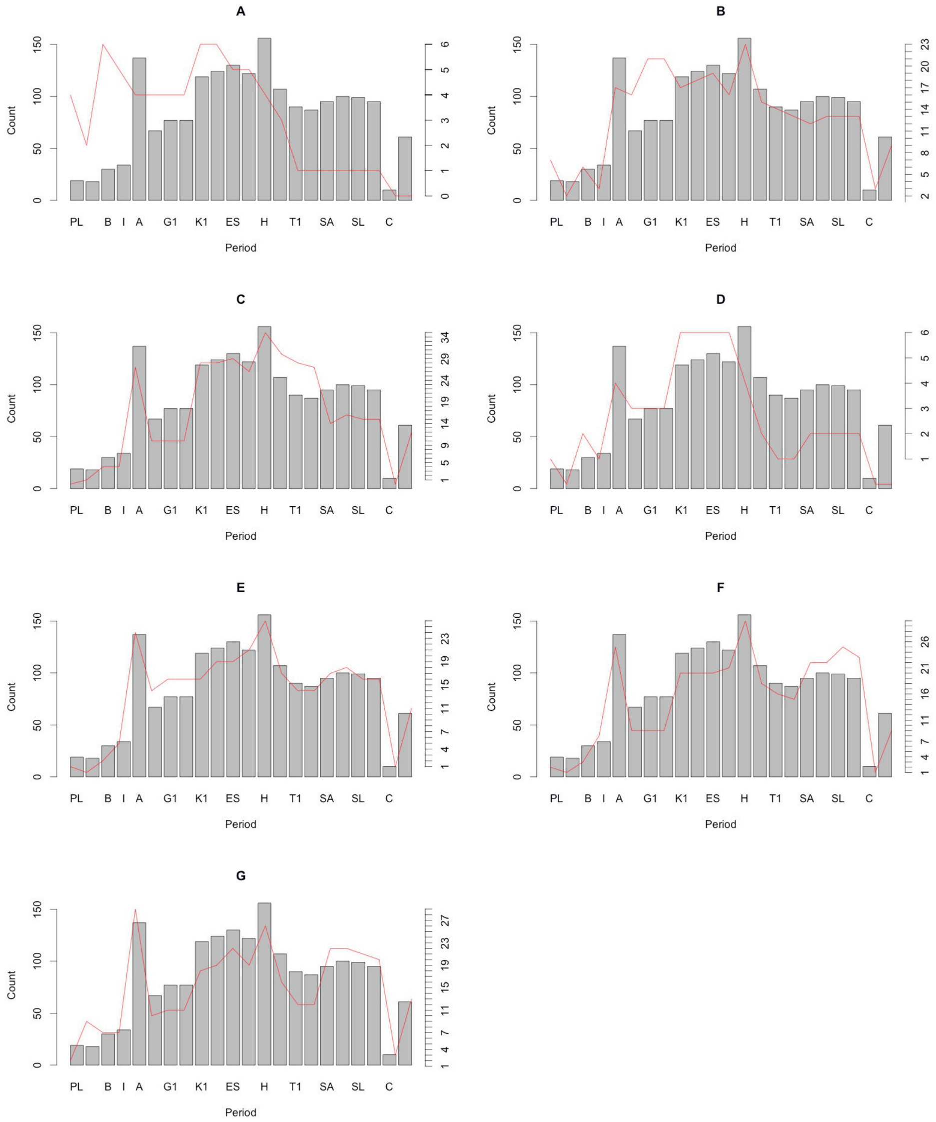

Figure 7. Graphs showing changes in site count per period (grey bars) against changes in occupation of Land Use/Land Cover areas (solid red line): (a) barren or sparsely vegetated, (b) dryland cropland and pasture, (c) irrigated cropland and pasture, (d) cropland/grassland mosaic, (e) cropland/woodland mosaic, (f) grassland, (g) shrubland.

sarily occurring in more topographically-varied areas. Mean annual precipitation (Figure 6c) shows a stronger relationship, with an increase in site numbers corresponding to expansion into areas of greater rainfall. Rainfall variability, again measured here by the standard deviation of rainfall values for sites per period, shows no relationship or trend (Figure 6d).

Sampling sites within land-use classifications adds further resolution to these changes in settlement pattern and identifies areas of significant occupation (Table 3). Per period, plotting site counts against sites per land-use types shows notable differences in the preference for certain areas during periods of increased site numbers, while also allowing for clearer detection of periods in which land-use occupation increases while site counts decrease. Barren or sparsely vegetated areas are apparently unaffected by changes in regional site counts, with occupation in these areas occurring during periods of both relatively high and low site counts (Figures 7a & 8a). Dryland cropland and pasture areas, on the other hand, have a strong positive correlation with site count (Figures 7b & 8b). Per period fluctuations in dryland cropland and pasture occupation follow overall regional trends of increases and decreases. The exception is a notable spike during the G1 and G2 periods, during which overall regional site counts decrease while dryland cropland and pasture occupation increases. Use of these areas decreases during the K1 period, despite the overall regional site count increasing. This spike is absent in irrigated cropland and pasture, which otherwise exhibits an even stronger positive correlation between site count and land-

Description	Count	R-squared	P-value
Dryland Cropland and Pasture	49	0.67	<0.0001
Irrigated Cropland and Pasture	48	0.83	<0.0001
Cropland/Grassland Mosaic	11	0.52	<0.0001
Cropland/Woodland Mosaic	53	0.93	<0.0001
Grassland	36	0.86	<0.0001
Shrubland	57	0.81	<0.0001
Barren or Sparsely Vegetated	17	0.001	0.32

Table 3. Land Use/Land Cover classifications with site counts and correlations values.

use occupation (Figures 7c & 8c). Increases and decreases in irrigated cropland and pasture area usage matches regional trends in site count increases.

Cropland/grassland areas demonstrate a moderately strong positive relationship with site counts per period and generally conform to regional trends through the KS period (Figures 7d & 8d). Beginning with the H period, usage of these areas decreases considerably and ceases entirely after the Chaghatai destruction, which to some extent mirrors the regional trends in site counts. Thus, increases in site counts during the SA-GH periods are matched by increases in occupation of these areas, though still remaining relatively scarce. In contrast, cropland/woodland areas show a much stronger positive correlation with regional site counts, while also following trends in site increases and decreases (Figures 7e & 8e). Whereas the highest number of cropland/grassland sites was seven, during the K1-KS periods, cropland/woodland areas had, on average, seventeen sites across all periods and as many as thirty-three during the Hephthalite period, during which cropland/grassland sites began to decline.

Grassland areas show a strong positive correlation with site counts and generally follow regional trends in site count fluctuation (Figures 7f & 8f). The only exception is a slight increase in grassland area occupation during the SL-GH period, while overall site counts decreased. Shrubland areas also exhibit a strong positive correlation with site counts, with increases and decreases mirroring changes in overall regional site counts (Figures 7g & 8g).

Discussion

We had predicted that increased site counts would result in greater use of irrigated croplands and expansion into marginal areas, while lower site counts would be mostly concentrated in irrigated croplands. The result of the above analyses show that irrigated cropland does indeed demonstrate a strong positive correlation with site counts, but remains high even during periods of population decline, such as during the LS-T2 periods (Figure 7c). Barren and sparsely vegetated areas, which we can define as the most marginal, remain largely unoccupied in general and otherwise bear little relationship to increases or decreases in site counts (Figure 7a). After the KS period, their numbers consistently decline and do not recover after the Chagatai period. Grassland and shrubland areas, which from an agricultural perspective are the next most marginal areas, actually have just as strong a positive correlation to site counts as irrigated cropland (Figures 7f-g). Up to the Hephthalite period, these areas generally follow overall trends in site increases and decreases, due to either parallel exploitation of irrigated and grassland/shrubland areas or exploitation because of over-exploitation of irrigated croplands. Both irrigated cropland and grassland/shrubland areas decline during the LS-T2 periods, suggesting overall demographic decline after the Hephthalite period. After the Hephthalite period, however, particularly during the Islamic SA-GH periods, exploitation of grassland and shrubland areas notably increases despite only slight growth in overall site counts and an actual decrease in irrigated cropland use. We interpret this reorientation as a change in subsistence or settlement strategies that favored these more upland areas, either for reasons of defense (difficulty of access and increased observation potential) or for pastoralism.

Other relatively marginal areas may be those classified as cropland/grassland mosaic and cropland/woodland mosaic (Figures 7d-e). They are classified as mosaicked because of their variability, being a combination of these various land classes. Cropland/grassland mosaic areas do not contain many sites, and perhaps for this reason do not demonstrate particularly insightful trends. They have a moderately strong positive correlation with site counts and peak during the Kushan periods. Cropland/woodland mosaic areas, on the other hand, demonstrate the stron-

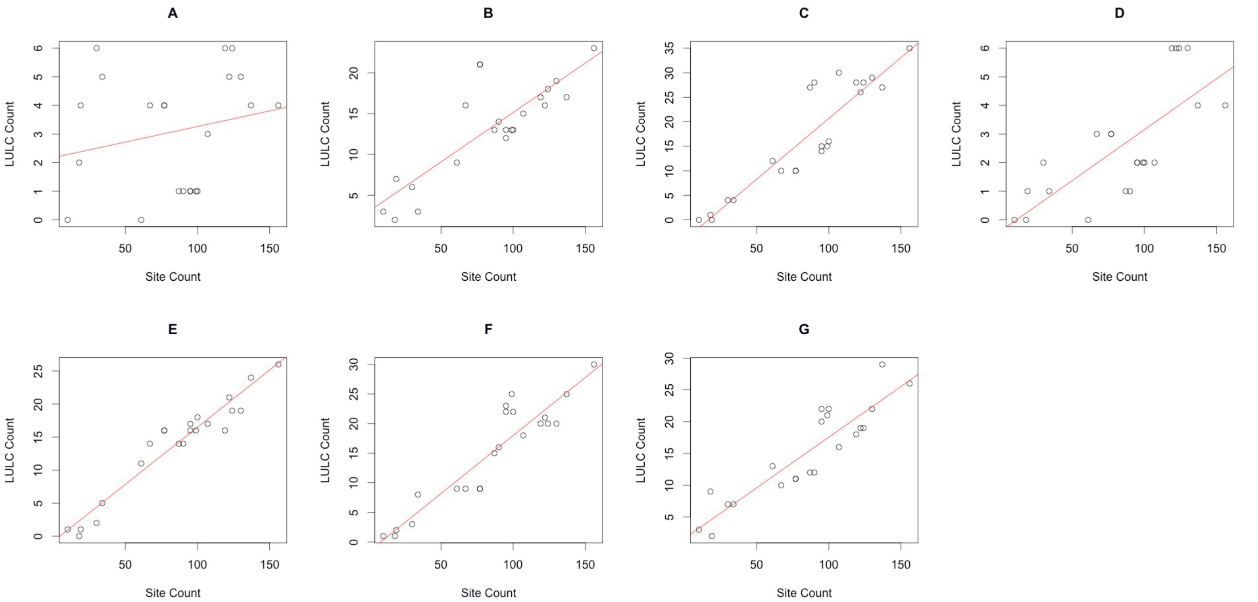

Figure 8. Plots showing linear relationships between Land Use/Land Cover occupation levels and overall regional site counts. See Table 3 for correlation values. (a) barren or sparsely vegetated, (b) dryland cropland and pasture, (c) irrigated cropland and pasture, (d) cropland/grassland mosaic, (e) cropland/woodland mosaic, (f) grassland, (g) shrubland.

gest positive correlation with site counts and mirror almost perfectly increases and decreases in overall regional site counts. These areas also see increased occupation during the SA-GH periods, while irrigated cropland declines. Assuming land-use characteristics today largely reflect conditions in the past, the high frequency of sites in these cropland/woodland areas and their continued exploitation during later periods, may be the result of this variability which allows for the exploitation of a wider range of resources during times of stress.

Dryland cropland areas were expected to largely mirror changes in irrigated cropland, which they do, albeit with a slightly less strong positive correlation. The most significant departure from regional site count trends occurs during the SE-G2 periods, where occupation of dryland cropland areas increases while regional site counts decrease. Use of irrigated cropland also decreases during this period, suggesting a greater focus on rain-fed agriculture as opposed to irrigated. From these analyses it is clear that the reputation of Bactria as the “land of a thousand cities,” most prevalent in Greek and Roman sources, must actually be based on settlement during the Achaemenid or the Kushano-Sasanian periods, rather than during any period of Hellenic occupation (Leriche 2007). While the paucity of material during the Bronze and Iron Ages can, on one hand, be attributed to the lack of focus on these periods by archaeological projects or the difficulty in identifying diagnostic material from these periods, the long-term effects of Achaemenid investment and development should not be undervalued. Investment in the region in terms of irrigation, demographic growth, and migration likely paid off in terms of providing the infrastructure necessary to encourage and support increased settlement in low-land irrigated areas (Rapin 2007: 35). The shift away from irrigated cropland towards dryland cropland is thus quite surprising, assuming that the irrigation infrastructure constructed by the Achaemenids remained largely intact during these periods. Irrigated agriculture was rare in ancient Greece and Macedonia, from which many settlers to Bactria had come (Mairs 2014: 38-39). Increased use of dryland cropland during these periods may then be the result of an interest of these settlers in occupying new, non-Achaemenid areas, and maintaining agricultural practices familiar to them from their homelands.

First order effects are therefore significant in the land use history of this region, with different land use/land cover classes having major influences on the presence and magnitude of occupation during different periods. Second order effects are also notable, however, and our prediction that site density would increase with site count is demonstrated to be largely true. Figure 5a shows a negative, though non-linear, relationship between the mean distance between neighboring sites and overall regional site counts, while Figure 5b generally shows the same trend. The exception, again, is during the SA-GH periods where the minimum distance at which sites are most clustered increases to larger distances, despite site counts being relatively low. The combination of this increased minimum distance with a reorientation towards grassland and shrubland areas during the SA-GH periods indicates significant changes in land use at this time that occurred in tandem with an increase in site count and expansion.

As discussed previously, there is always the risk that archaeological surveys over-represent certain periods, thus creating artificial spikes in site frequency or size that do not accurately reflect the settlement history of the region. Given the variability in the data that Ball and Gardin (1982) synthesize in their work, regional site counts appear to be quite consistent and generally demonstrate the long-term patterns expected based on historical sources. Thus, while site counts dropped substantially after the Achaemenid period, the levels they dropped too would become a more or less consistent baseline from which counts would increase, sometimes significantly, during later periods of investment and development. It is also worth noting that the periodization employed in this paper is not equal in terms of duration. The Bronze Age period itself covers as much time as the next fourteen periods, and likely experienced significant fluctuation within that time. Yet it is only through comparison to later time periods that the overall magnitude of changes between periods can be contextualized and multi-period trends in land use and site occupation can be identified.

Conclusions

The archaeological record of Bactria is understudied as a whole, and when studied often limited to specific periods or cultures. By making use of all the data and periods available to us from Ball and Gardin's (1982) Gazetteer, we demonstrate the value of taking such a broad diachronic and spatial approach. General models of settlement pattern and organization that predict relationships between land use and site count, such as the IFD, are shown to be useful frameworks within which much of the variety in the data can be explained. Deviations from this model are, however, also more noticeably evident when using these models and can be better explained through the examination of first and second order effects that consider exogenous and endogenous factors influencing the placement of sites. The results presented here are necessarily preliminary due to the nature of the data and scope of this paper. Yet we consider these results promising, and believe that they can be further improved through integration of larger datasets to increase site counts, and more consistent data that can add further resolution by breaking down what kinds of sites are increasing or decreasing in usage. While this study homogenized all sites to be generic, in reality the sites used here represent a variety of functions that, upon further investigation, will serve to provide a more nuanced understanding of the Bactrian landscape over time.

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