Satellites and Site Destruction: An Analysis of Modern Impacts on the Archaeological Resource of the Ancient Near East

EMMA LOUISE CUNLIFFE

Satellites and Site Destruction:

An Analysis of Modern Impacts on the Archaeological Resource of the Ancient Near East

Emma Cunliffe

~ Volume 2 of 3~

~ Chapters 5 to 10 ~

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Land of Carchemish	One of the areas surveyed as a part of this study –

Project (LCP)	Chapter 7- Case Study 2: Context to the Land of Carchemish Survey Area, p299
Land Use/Land Cover	A record of the state of the land at the time of a survey Section 4.5.5 – Recording Change: Type and Extent of Damage, p144
LCP	Abbreviation for one of the areas surveyed as a part of this study – 2.5 – Case Study 2: The Land of Carchemish Project
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- Sectional/ Partial	A Category of Horizontal Damage Extent Section 4.5.5 – Recording Change: Type and Extent of Damage, p147 Table 4-4: Definitions of Database Fields for Horizontal Damage Extents, p149
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Site Aspects	A categorisation of site situation to aid in analysis across similar sites Section 4.5.2 - Database Structure and Fields, p133
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- Site Heavily Dispersed/ Degraded	Category of Vertical Damage Extent Section 4.5.5 – Recording Change: Type and Extent of Damage, p147 Table 4-5: Definitions of Database Fields for Vertical Damage Extents
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Site Stability	Category of Site Stability Section 4.5.5 – Recording Change: Type and Extent of Damage, p152 Table 4-6: Definitions of Database Fields for Damage Stability, p153
- Site Destroyed	Category of Vertical Damage Extent Section 4.5.5 – Recording Change: Type and Extent of Damage, p147 Table 4-5: Definitions of Database Fields for Vertical Damage Extents

Site Types	A categorisation of sites to aid in analysis across similar sites Section 4.5.2 - Database Structure and Fields, p133 Also see Section 4.8.1 – Analysis by Amalgamated Site Type and by Site Unit, p163
Site Unit	Individual sites, some of which may be combined into an amalgamated site for some analysis Section 4.8.1 – Analysis by Amalgamated Site Type and by Site Unit, p163
SPOT 2004	A set of satellite images Section 4.3 – Remote Sensing – History and Value, p120 Table 4-1: Details of Imagery Used in the Study p123
Survey Areas	The areas used in this study Chapter 5 - Case Study 1: Context to the Tell Beydar Survey Area, p170 Chapter 7 - Case Study 2: Context to the Land of Carchemish Survey Area, p299
Tell Beydar Survey	One of the areas surveyed as a part of this study Chapter 5 - Case Study 1: Context to the Tell Beydar Survey Area, p170
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- Upper Levels	Category of Vertical Damage Extent

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"Throughout the upper Khabur Basin, modern settlement and land use has impacted the archaeological record. Modern villages cling to the southern slopes of tell sites and cover over low-mounded sites, making collection difficult or impossible. The mechanized disc plowing of grain fields has the ability to shift settlement debris across the surface of a site and can obscure field scatters… Construction of roads and railways in the area has also resulted in the levelling of sites… These issues are by no means unique to the Upper Khabur basin, and indeed large-scale modification of the landscape as part of state-sponsored agricultural products has been going on for several millennia."

~ Jason Ur (2010a: 28) ~

Chapter 5:
Case Study 1: Context to the Tell Beydar Survey Area

5.1 – Introduction

Two case study areas were chosen in which to examine damage to archaeological sites using satellite imagery. The first of these, the area around Tell Beydar in the western Khabur Basin (Chapter 2.3.1, Figure 2-12, is shown in Figure 5-1 and Figure 5-2. It was chosen as: firstly

> *"the Khabur is an analog for other similar regions of the northern part of the Near East, and in its recent development it also exemplifies social processes common to the entire Fertile Crescent. The modern pace and direction of the change in the Khabur is paralleled throughout the Near East and indeed throughout much of the world"* (Hole 2006: 492).

Results obtained here can therefore be generalised (in the broadest manner) to both wetter, more densely occupied areas, and drier, more marginal areas. This will allow the trends in damage identified in the Tell Beydar area to be extrapolated to the wider Middle Eastern region.

FIGURE 5-1: TELL BEYDAR SURVEY AREA AND SITES ON A 1960S CORONA MOSAIC

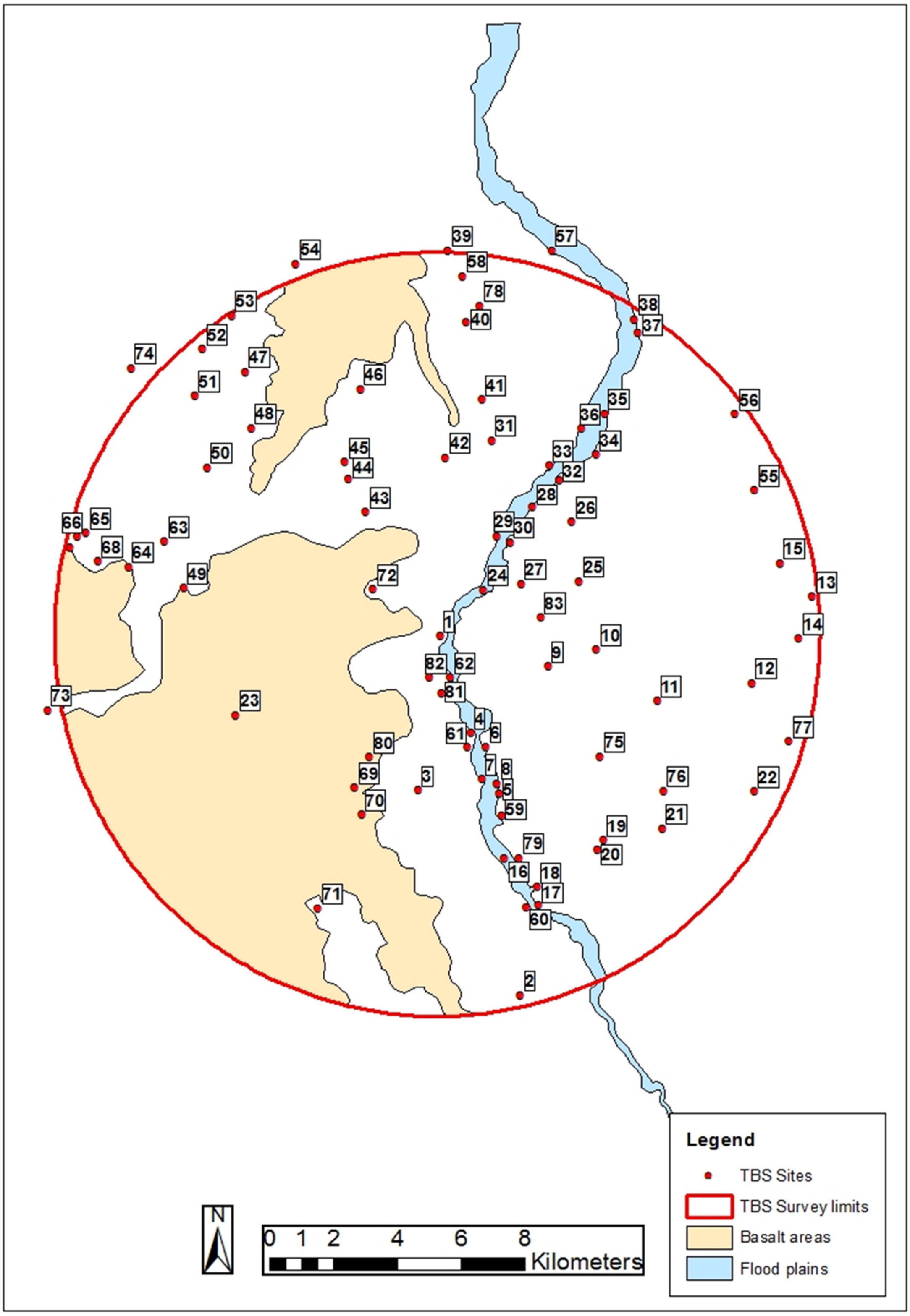

FIGURE 5-2: TELL BEYDAR SURVEY AREA, SHOWING SITES AND MAJOR LANDSCAPE FEATURES

(With thanks to Dr Jason Ur for the shapefiles of the area)

Secondly, the Khabur Basin contains evidence of settlement over a long period. The survey area comprises a variety of land types with correspondingly different site morphologies, enabling an examination of variations in damage. Sites and on and off-site features were recorded using maps, satellite imagery and field visits to develop the most comprehensive picture possible (Wilkinson 2000). As a result, this survey represents one of the most systematic surveys of settlement in the Upper Khabur. It provides a comparable sample size to the Land of Carchemish survey and, as both surveys were conducted by the Fragile Crescent Project, it provides a necessary level of consistency in implementation and interpretation.

Finally, due to the creation of the West Hasseke dam in the late 1990s, it is possible to directly study the effects of increasing irrigation and agriculture in an area where no planned rescue was implemented to deal with the increasing site damage. Although rescue excavations were undertaken in the proposed area of the dam reservoir, no plans were made to record the sites upstream of the dam, which would be affected by the increases in irrigation and agricultural intensification. The site visits were conducted not long after the dam was built and the reservoir was filled. The records now serve to act as a benchmark for the condition of the sites at the time of the dam's creation, and can be compared to satellite images of the area almost fifteen years later.

This chapter is split into three sections. The first describes the survey history, giving context to the data collected, and the exclusions. The second describes the environment of the area, so that natural taphonomic processes can be more easily discounted. The third, and perhaps most important, section describes the settlement history. This covers earlier cultural factors which may have affected site creation and destruction before and during the study period.

5.2 – Survey History of the Tell Beydar Region

The earliest recorded surveys of the area were in the 19th and early 20th century, by Layard, Sarre, Herzefeld, von Oppenheim, Poidebard, and Mallowan (Poidebard 1934; Mallowan 1936). However, the first systematic aerial surveys were conducted by van Liére and Lauffray (1954). More recently, Lyonnet carried out a large-scale reconnaissance survey, focused on the major (i.e. larger) sites of the region in 1990 (1996; 2000). Nearby regional surveys (Kouchoukos 1998; Hole 2002-3; Ur 2010b) were not carried out by the Fragile Crescent Project, and could introduce unnecessary subjectivity into the data collection and interpretation. Therefore they were not chosen as case studies (see Methodology Chapter 4), however, their findings do support the conclusions of the Tell Beydar survey. Some thematic surveys, such as rock art (Picalause 2004; van Berg et al. 2003) or prehistoric settlement (Nishiaki 1992), were also conducted but were excluded from this research as they focused either on features which are not detectable on satellite imagery, or did not cover the survey area.

The only intensive survey of the case study area was conducted by a team from the Oriental Institute of Chicago, led by Tony Wilkinson. There were two field seasons of survey conducted in a 12km radius (450 km^2) around Tell Beydar; three weeks in 1997 and two and half weeks in 1998. A third season was planned, but could not be completed. (For details of the survey, see Nieuwenhuyse and Wilkinson 2008; Ur and Wilkinson 2008; and Wilkinson 2000).

In total, 83 sites were recorded[76], including Tell Beydar[77], Tell Beydar III, and four sites already visited by Lyonnet (1996). These 83 sites can be broken down into 108 amalgamated parts and 194 individual units (as defined in Chapter 4.8.1, p163), and these were all examined on satellite imagery for damage.

5.3 – Physical Environment of the Upper Khabur Basin

The Khabur is one of the largest tributaries of the Euphrates, and can be split into the Upper Khabur (from Ras al-'Ain to Hasseke), and the Lower Khabur (from Hasseke to the Euphrates). The Upper Khabur Basin, where the survey is located, comprises level or slightly rolling terrain extending between the Jebel Sinjar and the River Tigris. (The following description is summarised from Courty (1994); The World Bank (1955); Wilkinson and Tucker (1995); and particularly Wilkinson (2000). Futher details can be found there).

Topographically, the survey area consists of three broad north -south wadi valleys and their axial alluvial plains. The wadi valley floors have been particularly subject to

[76] A remote sensing study of the area (Wilkinson and Cunliffe 2012; Cunliffe in press b) suggested the potential presence of several more sites, many of which were located in the 'empty' areas between the main wadi channels in the north and east of the survey area. Without ground verification, these sites cannot be confirmed. However, if those with the highest probability of being sites were counted, there would be another 30 sites. These have not been included as they have not been verified in the field as archaeological.

[77] The actual site of Tell Beydar has been excavated by an international team since 1992, and the results of the both the excavations of the site, and further studies of the area have been published in the Subartu volumes (1995 – on-going).

environmental changes as a result of shifting water channels, changes in climate and hydrology, and shifting vegetation. The wadi floodplains are generally a few tens of metres wide, but show considerable variable aggradation over the last four millennia. Alluviation varies from approximately 70cm over (probably) Parthian levels at TBS 34, to 80cm just east of Tell Beydar, and 140cm over early Bronze Age or late Halaf levels near Tell Rajab (TBS 4) (Wilkinson 2000). However, further out into the plain sedimentation levels can reach 3m deep. Numerous sites could therefore be buried, and unavailable for assessment. The terrain is continuously sloping, and is particularly susceptible to erosion, as described for similar terrain in the Iraqi Jazirah.

> *"Because the land rarely slopes at gradients of less than 1:300, runoff can always be generated once the infiltration capacity of the soil has been exceeded. As a result, drainage concentration features (rills or wadis) can form everywhere"* (Wilkinson and Tucker 1995: 4).

West of the Wadi 'Awaidj is the low basalt Hemma plateau (marked on Figure 5-2). It is fringed by a steep scarp slope and forms an extensive upland with thin, marginal soils at most 1m deep, and minimal water resources (Ur and Wilkinson 2008; Wilkinson 2000). The plateau would have provided upland grazing, a hunting resource and a source of stone.

The vast majority of rainfall occurs in the winter months: summers are very dry (particularly at present) due to the on-going drought (Irin and sb/at/cb 2010; Trigo et al. 2010). The area is located on the edge of the 250-300mm rainfall isohyet, however rainfall variability can exceed 100% (Hole 2006), although it more usually is between 25-50% (Map AIV4 - Middle East: Mean Annual Rainfall and Variability, Mittmann and Schmitt 2001). On average the area is just above the threshold for dry farming, but it can be precarious. Aridity increases the further south one goes.

5.4 – Settlement History of the Upper Khabur Region

Settlement in this area has predominantly followed the general Syrian pattern discussed in Chapter 2.3.3 (p27). The earliest known settlements are small, dispersed ceramic Neolithic settlements which were either abandoned, or developed into mounded nucleated sites by the Ubaid period. Settlement was concentrated along the wadis, particularly the Wadi 'Awaidj, and along the base of the basalt escarpment (Ur and Wilkinson 2008). Textual records imply that whilst the basalt plateau was largely unoccupied, it formed an important pastoral resource (Crewe and Hill 2012). The Early Bronze Age (EBA) landscape has remained exceptionally well preserved in the Jazirah. Ancient towns, villages, and the roads that connected them are clearly still visible on Corona imagery acquired in the 1960s. (The dating of the roads to the EBA is largely by association, some will have been earlier, and they will have almost certainly remained in use for some time (Wilkinson et al. 2010)).

Sedentary settlement decreased in the Middle Bronze Age (Hole 2006; Lyonnet 1996; Wilkinson 2000), and did not return until the Middle Assyrian period in the late second millennium, forming outer towns around the bases of the tells, such as the one around Tell Hassek (TBS 43), discussed in Chapter 6.9.3 (p284). By around 1,000BC (or slightly later) small dispersed settlements, extensive outer towns, and the first datable nomadic camps formed the greatest settlement numbers the area would see. Extensive irrigation is identifiable in the Lower Khabur, outside the zone of rain-fed agriculture, but not in the survey area (Ergenzinger et al. 1988; Hole 2006). At some point, the plateau area was probably cultivated – at site TBS3, relict fields and stone clearance mounds were recorded on the basalt scarp (Wilkinson 2000). Very dispersed settlements of up to 100ha have also been recorded, the majority of which are undated; however, the earliest datable well-defined settlements there are Iron Age (Picalause 2004; van Berg et al. 2003).

From the Hellenistic period settlement, and presumably population, steadily declined. Occupation, largely comprising small agricultural settlements, was concentrated to the north of the area, where rainfall, and therefore cultivation, was more reliable (Ur and Wilkinson 2008), expanding south again in the Roman-Parthian period. The plateau retained some occupation: rectangular constructions have been dated to the Seleucid and Parthian periods (van Berg et al. 2003). The general agricultural decline known elsewhere in the area began earlier here, from about AD 250, fluctuating in the early Islamic period. By the 13th century AD, extensive depopulation meant occupation was probably largely transient, and the 14th century AD Arab geographer, Ibn Batuta, described the area as "desolate" (in Hole 2006: 496).

Göyünç and Hütteroth's analysis of tax records (Göyünç and Hütteroth 1997; Hütteroth 1990; 1992; Hütteroth and Abdulfattah 1977) suggest that occupation continued in the northern parts of the Khabur basin. By the 16th century, the area had recovered: provincial tax records imply that between 1518 and 1564 the urban population almost doubled, and the rural population tripled[78], leading to land shortages. Compared to the rest of Syria, the Khabur Basin was particularly heavily

[78] Göyünç and Hütteroth note their figures are probably underestimated.

irrigated (Hütteroth 1990: 183). This extensive increase in cultivation can be seen on the TAVO map extract in Chapter 2 (Figure 2-16, p33) and may be partially responsible for some of the feature attrition seen today: the area they refer to in the northern Khabur Basin is an area where, today, many hollow ways have not survived.

Steppe tribes drove out the sedentary population by the mid-17th century: virtually no permanent settlement was reported for 200 years until the Government pacification and active resettlement of the area in the 19th century (Palmer 1999). In 1860 the frontier of cultivation in the Jazirah was halfway between Aleppo and the Euphrates: by 1900 it had reached the river (Lewis 1955). The French Mandate continued to encourage agricultural development and active resettlement.

During World War II, Allied policy encouraged the production of foodstuffs in the countries of the Middle East - the Jazirah, for example, was to be a grain-growing area. In 1942 there were about 30 tractors and 20 threshing and harvesting machines in the area. By 1950 there were 500 tractors and 430 combine harvesters. In 1942 about 50,000 acres of land were cultivated, out of the Jazirah's total cultivatable area of some 2.5 million acres. By 1946, about 783,000 acres were cultivated, and by 1949, a million acres were under the plough. By the 1960s, farming extended 50 miles south of the Jazirah into the marginal zone of uncertain rainfall, and the cultivated area covered 4 million acres (Lewis 1955; Nyrop 1971) (See Figure 5-3).

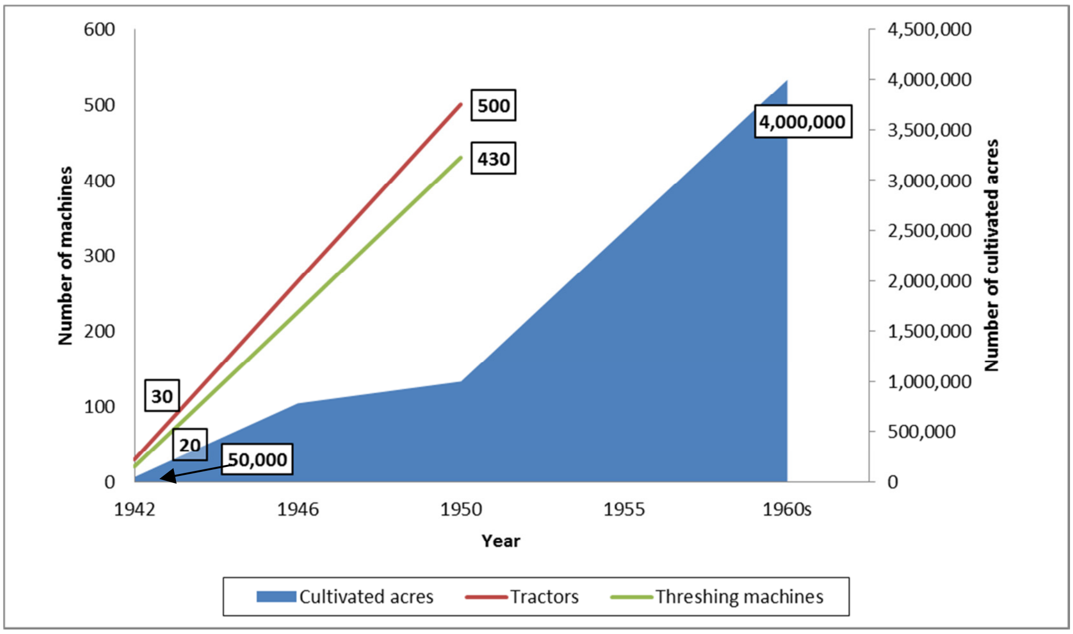

FIGURE 5-3: GRAPH OF INCREASING CULTIVATION MACHINERY AND CULTIVATED ACRES IN THE SYRIAN JAZIRAH

In the 1950s van Liére and Lauffray (1954) undertook field work in the Khabur area: their records suggest few sedentary settlements, but a large nomadic population. However, de Vaumas (writing just 2 years later) stated that by 1954 the entire basin had been brought under agriculture, using either machine or animal traction (de Vaumas 1956). The increase in availability of fertilisers and farm machinery allowed the mitigation of climatic variability (Hole 2006). Absentee landlords were able to buy up large areas of land, beginning the processes of converting the older traditional strip fields into the large open fields seen everywhere today.

Despite the increasing cultivation elsewhere in the Jazirah at this time, population density for the area in 1962 was very low, perhaps because of the absence of large urban centres. The Khabur Basin is part of the provinces of Ar-Raqqa and Dayr ez-Zor (alternative names include Deir ez-Zor). The population density of Ar-Raqqa province was the lowest in Syria at 15 people per square mile, and Dayr ez-Zor province was the second lowest at 22 people per square mile (adapted from the Syrian Arab Republic Ministry of Planning Directory of Statistics, Statistical Abstract 1962 p39-39, in Nyrop 1971). According to the TAVO Atlas, (Map A VIII 3 – Middle East Population Density, Mittmann and Schmitt 2001), by 1978, the eastern Jazirah had a settlement density of perhaps 2 to 5 inhabitants per km^2 increasing to between 31 - 100 inhabitants per km^2 in the Khabur Basin.

According to the TAVO Land Use classifications (Map A X 1 – Middle East Land Use, Mittmann and Schmitt 2001), in the 1980s the Khabur Basin consisted of a combination of marginal cultivated steppe and pasture with scattered irrigated land towards the south of the basin. Dams were built further up the Euphrates, and the increasing demand for water gradually lowered the water table. Many rivers ceased to flow, and the ground water became too brackish or too low to pump.

The West Hasseke dam was completed just south of the survey area in the late 1990s, and satellite imagery confirms an increase in channel-irrigated farming. According to the Syrian Agricultural Database (NAPC 2007), between 1985 and 2007 in Ar-Raqqa province, the amount of cultivated irrigated land increased by 1,040ha, but the amount of rain fed cultivated land decreased by 984ha, a sign of the dropping water table and increasing dependence on the irrigation water from the West Hasseke dam. Dayr ez-Zor also showed an increase in irrigated cultivation of 552ha, and a slight increase of 32ha in rain fed cultivation. Steppe and pasture decreased by 192ha, also presumably brought under cultivation. By 1998 the Upper Khabur, including the thin soils of the basalt plateau, was mainly under cultivation, although the scarp slopes of the plateau were still largely untouched. Variable rainfall and intermittent occupation allowed the plateau to become a Zones of Preservation where fragile rock art, stone alignments, and other features survived (Ur and Wilkinson 2008; Wilkinson 2000).

Although rescue work was undertaken in advance of the flooding of the West Hasseke Dam reservoir, no such work was undertaken to evaluate the effects of the dam elsewhere. Today it is suspected that the intensive irrigated cultivation and changes in land utilisation will have caused substantial damage to the archaeology of the area, even in the short time since the field visits of the late 1990s. The earliest known sites were found on the valley floors and floodplains of the wadis, and settlement was of the longest duration there. This area has potentially been under near-constant cultivation for 8000 years. As a result, many smaller features and maybe even some sites could have been reduced to little more than artefact scatters or ploughed away entirely, reducing the estimate. Negative features such as mudbrick extraction pits may also have been infilled by sheetwashed soil loosened as a result of ploughing, or otherwise obscured (Ur and Wilkinson 2008: 305). As agriculture continues to intensify even those features in the Zone of Preservation are threatened.

5.5 – Concluding Remarks

The data from the surveys conducted in this region provide an important foundation from which to assess damage to sites. The area has an extensive history of occupation dating back to the Neolithic, with later fluctuations in settlement attesting to political and climatic changes. In particular, the Early Bronze Age is especially well preserved, but both older and newer sites have also been recorded. The 83 identified sites are composed of several types spread across different physical locations (that is to say, on the basalt plateau, by wadis, and so on). Each of these areas has undergone extensive changes over time, with corresponding effects on the archaeological record. In particular, the last seventy years have seen rapid settlement increase, and the conversion of large parts of the Jazirah and the Khabur Basin to agriculture. We can never know for certain what changes early settlers to this area wrought on the archaeological record: what remains now is almost certainly only a fragment of what was once present. Nonetheless, the greatest changes may well have occurred in the last twenty years, after the building of the West Hasseke Dam and the ensuing agricultural intensification. The increasing availability of modern machinery has allowed the modification of the landscape on a scale that would have been extremely difficult for earlier farmers. The changes that have occurred and the ensuing threats to the sites will be discussed in the following chapter, which examines the damage in the area, looking at cause, extent, site type, and location. Key trends are identified, and exploratory case studies are drawn from within the larger case study survey area to give specific local examples of damage patterns.

"When I passed by Kastal, five years before, it was uninhabited and the land around it uncultivated, but a few families of fellahīn had established themselves now under the broken vaults and the young corn was springing in the levels below the walls, circumstances which should no doubt warm the heart of the lover of humanity, but will send a cold chill through the breast of the archaeologist. There is no obliterator like the plough share…"

~ Gertrude Bell (1907) ~

Chapter 6:

Case Study 1: Damage in the Tell Beydar Survey Area

6.1 - INTRODUCTION

This chapter examines damage to sites in the Tell Beydar area. The chapter is broken into 12 sections[79]. Firstly, it introduces the area and the sites under examination. This is followed by a brief discussion of the certainty ratings of the results in Section 6.3. These results frame the ensuing discussion, and should be borne in mind at all times. Section 6.4 discusses the visibility of the sites on imagery, a factor which also influences the data collection and discussion. Section 6.5 discusses the land cover on and around the sites and provides environmental context to the data.

Section 6.6 covers general damage trends across the area, and Section 6.7 breaks these damage trends down by the different causes of the damage, examining the prevalence of the damage threats, and the type of damage each one causes. Section 6.8 discusses the stability of the sites, and the extent to which the damage is on-going and increasing.

Section 6.9 presents three case studies within the larger area case study. The first of these (Section 6.9.1) discusses the sites on the basalt plateau. These sites are too few

[79] This chapter is structured the same as Chapter 8, and therefor contains some repetition, as each Chapter is intended to be readable as a standalone chapter for those only interested in the results from one survey area.

in number to be specifically part of the analysis: only a qualitative discussion is possible, which nonetheless highlights some interesting trends. The second case study (Section 6.9.2) looks at the outer towns around tells, an area which has traditionally received little attention from archaeologists. When presenting the data as a summarised examination of damage according to individual threats, it is easy to lose track of the cumulative damage experienced by individual sites, and the risk posed to them. Therefore the third case study (Section 6.9.3) is a qualitative discussion of Tell Hassek and its lower town (TBS 43).

Finally, the key findings are summarised in Section 6.10, and a brief conclusion given in Section 6.11.

Due to the volume of data only key graphs and tables are included in the text. Where necessary, relevant information about how to read the tables is in Appendix F. All supporting data is included in Appendix G. It should be remembered that the counts of damage on the tables relating to SPOT imagery are informed by the field visit records, and are not a direct representation of what was visible on the SPOT image.

It is important to note that when the findings from Corona are compared to those from the later SPOT and Geoeye, far more threats were identified on the later images. Therefore, as an example, a threat which affected 10 sites on Corona and 10 sites on Geoeye will evidence very different proportions, as it is a substantially different sample size. Key numbers and percentages are given in the text, but rarely both. The full figures should be consulted in the tables in the text and in Appendix G.

6.2 – Overview of the Tell Beydar Area

In total 83 sites were surveyed, including Tell Beydar, and Tell Beydar III, an Ubaid site discovered by the excavation team, not the survey team. This has been broken down into 108 amalgamated site types (groupings of tells, complexes of low mounds, etc.), and 194 individual units (as defined in Chapter 4.8.1 – Analysis by Amalgamated Site Type and by Site Unit, p163).

The distribution of site types according to site location is shown in Table G-1 and Table G-2, Appendix G. The Tell Beydar region is split into 8 distinct areas, determined by a combination of location on imagery, and field visit notes. These were: 1. the basalt plateau, 2. the plateau escarpment, 3. the plain to the west of the Wadi ‘Awaidj, 4. the plain to the east, 5. the plain north of the basalt plateau, 6. the river and wadi terraces, 7. the wadi bottoms and wadi banks and 8. the wadi flood plains. However, this sometimes subdivided the data too much for meaningful analysis, so these were occasionally combined into three similar sub-regions. The plain west of the wadi 'Awaidj, the dry plain to the east, and the plain to the north of the basalt were usually combined into 'sites on plains' for analysis, and compared to 'sites on river terraces, wadi bottoms, wadi banks'; the third land type was 'the flood plain'. Sites can be present on more than one location type– some sites are at the intersection of location types, for example where the flood plain meets the plains either side, and cannot be said to be in one area or the other.   The highest numbers of sites are to be found on the plains, specifically the alluvial upland plain to the east of the Wadi 'Awaidj, although there are more small mounds (and therefore complexes of small mounds and tells with lower town complexes) on the plain to the west.

Most sites in this area are low mounds: 158 (80%) of the sites display some mounding. Of those 158, 106 are part of a complex of low mounds.   In total, there are 34 complexes of low mounds. 42 amalgamated mounds are complex topographic mounds, meaning they have more than one visible peak. If these separate peaks were counted separately in the field survey, they have also been counted separately in the Unit analysis (except for the large tells, which were classed as single sites). 109 of the 194 separate units are part of a complex of low mounds, and 82 are complex topographic mounds. 24 of the sites are tells. 8 sites were walls, flat sites / scatters, or irregular enclosures.

Groups of small low mounds are the most common site type in this area. It is possible that some complexes of low mound are in fact complex topographic mounds where the ground level has risen to such an extent as to make a single complex mound appear to be separate mounds. However, this could only be determined by excavation. Site extent and definition is discussed in more detail in the next section.

Field scatters (as defined in the field visit notes) which may form extensions to sites were recorded at several sites. A small number of irregular structures were also surveyed on the basalt plateau and its escarpment. These do not reflect the total number of irregular structures and enclosures, many of which were later surveyed and recorded by van Berg et al. (2003) and Picalause (2004). As discussed in more detail in Chapter 5.2, surveys of sites or features which were not visible on satellite imagery, such as the surveys by van Berg and Picalause were excluded from this study. Nonetheless, even with the difficulties in identification, it is possible to make some statements about damage to this type of site: it forms a case study at the end of the chapter.

Three phases of imagery were used to examine the sites, and these were compared to and informed by the field visit notes and other publications. It was not possible to obtain full strips from the Corona missions of this area, so a mosaic of the Khabur Basin was used[80]. Sites were examined on a combination of Coronas from the 1021, 1102, 1105 and 1117 missions. All sites were visible on at least one image, and some were visible on two or three. The data is taken from the image the site was clearest on. Google Earth contains[81] SPOT 2004 imagery, and also Geoeye imagery from July, August and October 2010.

6.2.1 – The Extent of Sites in the Tell Beydar Area

The problems of defining site boundaries were discussed in detail in Chapter 2.2, and again in Chapter 4.8.1 and 4.9.1. It is entirely possible that several sites are larger than originally defined in the field, or at least were larger in the 1960s, based on a detailed analysis of the imagery. Equally, these enlarged soil marks could be the reflectance signature of a non-archaeological feature, or eroded soil from the site which is making it seem larger than recorded. Due to this uncertainty, these additional mounds have not been included in the analysis. However, in several cases the features are not present on the latest imagery, and have probably been destroyed. This would augment the extent of damage in the area, which should be remembered.

Additional mounds or sites which may have extended further than mapped were:

- TBS 5, where the identification of mound B / 2 is uncertain when compared to the location on the field visit notes. If incorrectly identified, a third mound has been identified
- TBS 6, where the four identified mounds all appeared to be part of one large complex
- TBS 9, where a third mound is visible to the north east on Corona 1105
- TBS 10, where a soil mark indicative of a mound was visible between the two mounds already identified

[80] Thanks go to Dr Ur of Harvard and the Ancient Landscapes Project for providing most of the georectified Corona of this area.
[81] Data accessed from Google Earth in February 2012

- TBS 11, where a fourth soil mark indicative of another mound was visible to the south west of the village
- TBS 13, where a soil mark on SPOT indicates a possible site extension (Figure 6-53)
- TBS 20, where an additional soil mark indicating another mound was visible, and further soil marks suggest all of the site may be connected
- TBS 24, as discussed above
- TBS 26, where a second mound was visible on Corona, and to a lesser extent on SPOT
- TBS 33, where soil marks suggest the whole site may be connected
- TBS 35, where a large soil mark on Corona and SPOT suggests the main mound may extend further than thought
- TBS 49, where soil marks which field boundaries avoid on Corona suggest 2 new mounds
- TBS 55, where an additional mound is visible on Corona (see Figure 6-63, Figure 6-64)
- TBS 60, which appears to have an unrecorded lower town on Corona (Figure 6-66)
- TBS 65, where a large soil mark suggests either a possible lower town, or the extension of the site
- TBS 66, where soil marks suggest mounds A and B are the same mound, and are much larger than previously thought
- TBS 72_1, where a large soil mark and plough line disruption suggests the site is bigger than thought.

6.3 - CERTAINTY

Certainty ratings were defined in Methodology Chapter 4.7 (p158) - brief definitions are repeated here as footnotes. The following analysis is split according to the amalgamated sites and the site units, as defined in Methodology Chapter 4.9.1 (p163).

6.3.1 - CERTAINTY: AMALGAMATED SITES

(Supporting data for these figures can be found in Table G-3 to Table G-5, Appendix G).

On all images, over half of the sites (57-61%) have a Definite certainty of identification[82]. 80% of sites had a Definite or High certainty of identification on Corona, dropping to 73% on Geoeye. As can be seen from the following graph (Figure 6-1) most sites are identified.

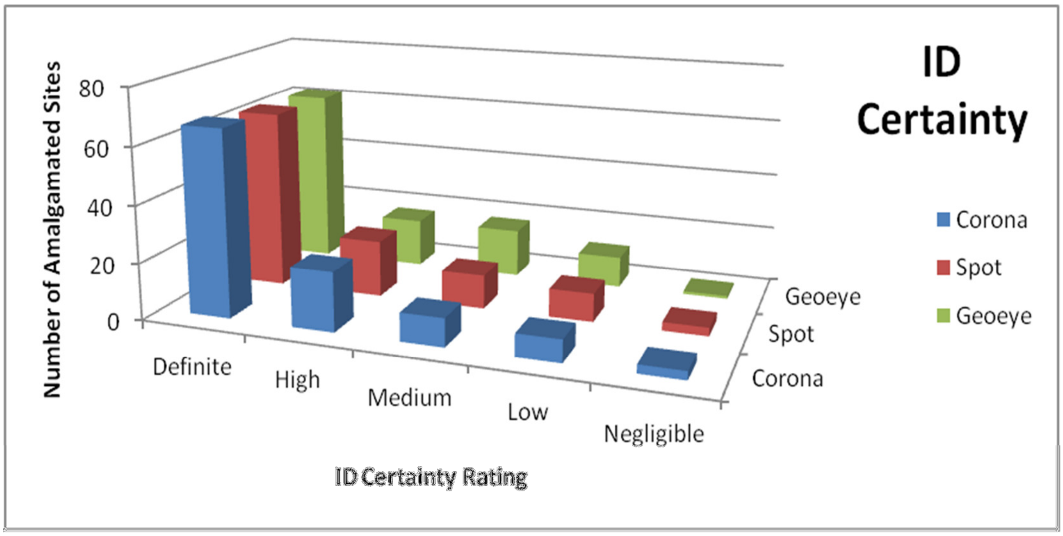

FIGURE 6-1: GRAPH OF ID CERTAINTY RATINGS ON IMAGERY (AMALGAMATED SITES)

Boundary certainties[83] are shown on the following graph (Figure 6-2). They were almost all Low or Negligible. Although many of the sites had a sketch map from the field, these field maps were not instrumentally surveyed; instead, key dimensions were paced, which has a reasonably high standard of accuracy, and is still advocated by organisations such as the British Ordnance Survey (Ordnance Survey n.d.). The sizes of the individual mounds were paced, the distances between them and relative locations were not. Furthermore, due to the multiplicity of issues around defining sites in the Near East, site boundaries are rarely definitive anyway. Even those sites that had clear, measured boundaries on sketch maps often did not match the size of the site visible on imagery. This was particularly noticeable on Corona images, but was also an issue on other images. In some cases sites appeared to have unrecorded additional mounds, and in others they were simply much larger. Without excavation, no sites could be given a definite site boundary, and even then it would be open to numerous methodological and definitional arguments. The only site to be given a

[82] See Chapter 4.7.1: Identification certainty, also known as Geographical precision, refers to the types of data available when locating and inputting the site, and the impact the data has on the likelihood that the identification point which they have drawn is correctly located.

[83] See Chapter 4.7.2: Given that drawing GIS polygons around sites on satellite imagery is inherently subjective, boundary certainty refers to the quality of the data available when drawing the shape and extent of the site, and the level of confidence that the drawn site boundary is accurate.

Definite boundary certainty was the Corona imagery boundary for Tell Beydar. This boundary was drawn by Dr Réy, who has worked at Beydar, and is extremely familiar with it. Due to the damage the site later experienced, in particular the expansion of the modern village onto and past the walls, parts of the site were not visible, therefore no certain site boundary could be drawn on later imagery.

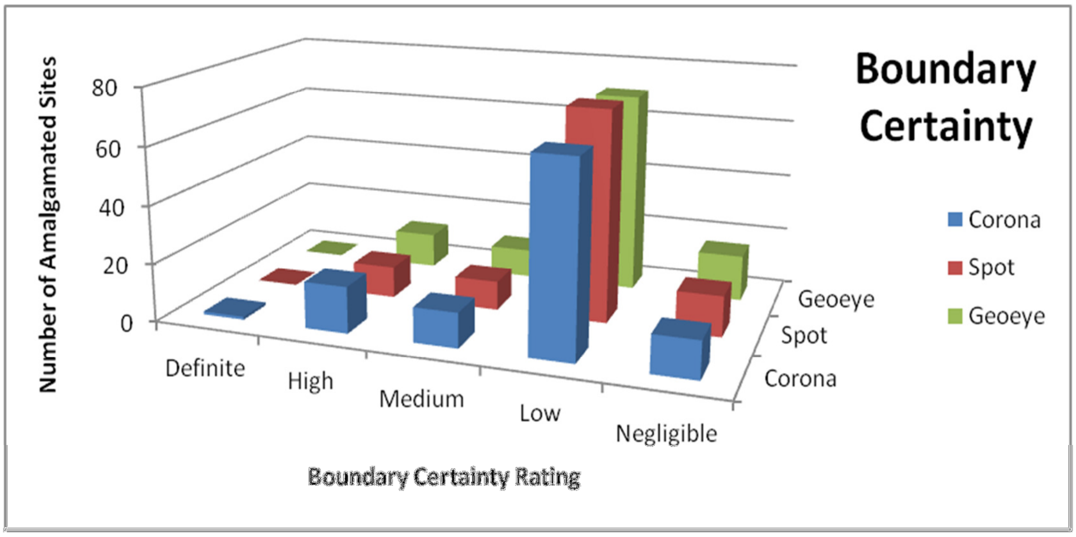

FIGURE 6-2: GRAPH OF BOUNDARY CERTAINTY RATINGS ON IMAGERY (AMALGAMATED SITES)

Damage certainty[84] varied (Figure 6-3): 45% of sites had a High certainty on Corona, dropping to only 30-35% on later imagery. It was hard to be sure of the damage without recent height data (See Section 6.3.3 – A Note on Generalisations and Height). The camera angle and the time of year have created few shadows which could indicate height. Mounds viewed from the top down often appear nearly flat no matter how high they are: therefore the recognition of threats which affect site height, such as bulldozing, is rarely given a High certainty. Damage estimates are very conservative so as not to potentially exaggerate the results, and follow the principle of least damage as defined in the Methodology Chapter 4.7.3 (p161). Damage certainties were relatively evenly spread between High, Medium and Low. Given the lack of recent field visits to confirm the damage in this area, no sites could be given a Definite certainty.

[84] See Chapter 4.7.3: Damage Certainty relates to the damage threats identified on imagery and represents certainty that all damage causes and extents affecting sites have been correctly identified, particularly when bearing in mind the uncertainties of boundary definition and of site visibility.

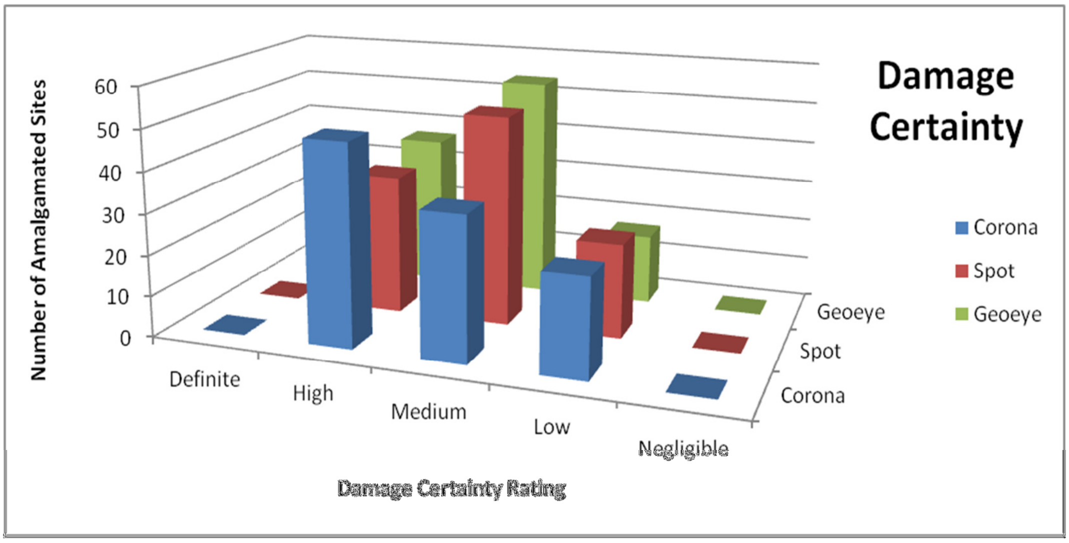

FIGURE 6-3: GRAPH OF DAMAGE CERTAINTY RATINGS ON IMAGERY (AMALGAMATED SITES)

Overall certainties are displayed on Figure 6-4. Only one site, Tell Beydar, was given a Definite Overall certainty[85], and that was on the Corona imagery. Almost 40% of sites were given a High Overall certainty on Corona, and the number was less than 30% on SPOT or Geoeye. This is partly due to the conservative nature of the estimates, and the attempt to account for the subjective nature of the process.

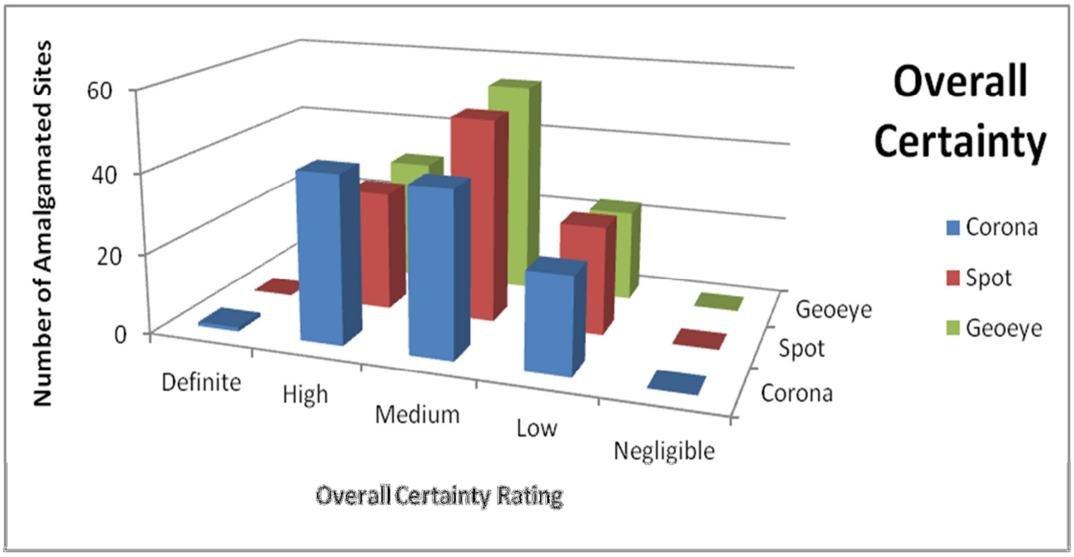

FIGURE 6-4: GRAPH OF OVERALL CERTAINTY RATINGS ON IMAGERY (AMALGAMATED SITES)

[85] See Chapter 4.7.3: Overall Certainty is the amalgamated certainty of the previous three categories. It is the level of confidence that, given the data constraints, uncertainties, and subjectivity, the site has been correctly located, its extent correctly determined, and the damage threats affecting it have been correctly recorded.

6.3.2 - *Certainty: Unit analysis*

(Supporting data and graphs can be found in Table G-6 to Table G-8 and Figure G-1 to Figure G-4, Appendix G).

In a sense, the overview inflates the true visibility, because whilst some parts of the site could be identified, others could not. Whilst 75% of site units had a Definite or High certainty of identification on Corona, this dropped to only 58% on Geoeye. This is particularly interesting as not only is the imagery resolution increasing, but a GPS system was used in the field, together with a GIS system, aiding the identification of sites, so certainty should also increase. The visible traces of the sites do not always match the GPS points in GIS, which, if there is nothing to see on the imagery, leads to low certainty. In some cases this is almost certainly due to the selective availability error incorporated into early GPS systems (sites could be within 50m of the GPS point), but in some cases estimates of site locations are out by as much as 300m. This is most likely due to rectification issues with the imagery. Also affecting certainty estimates is that the Corona is known to be distorted, and to be more distorted the nearer it is to the edge or ends of the negative. As the imagery used in this area is composed of a mosaic of frame sections, it is not known how near the edge of the negative they were and thus the distortion cannot be completely accounted for. As a result, GPS points cannot be relied on to mark the location of a site on a georectified image, decreasing the identification certainty ratings of sites in this area.

Although it is not known what rectification method was used on Google Earth, modern imagery collection methods are better than in the 1960s and the imagery should not be particularly distorted. Theoretically then, GPS points should match the visible location of the sites on modern imagery fairly closely: despite this, it became harder to describe the location of sites as Definite or High as time has passed. The patterns for Boundary Certainties, Damage Certainties and Overall Certainties are similar to the amalgamated sites.

The lack of certainty in the results should be remembered at all times in the following analysis. Tables and trends indicate general estimates and potential patterns only, not definite results.

6.3.3 - *A Note on Generalisations and Height*

As was seen in Table G-1 and Table G-2 (Appendix G), the most common type of site surveyed in this area is a low mound / low tell, and only small numbers of scatters and enclosures were surveyed. As a result, no reliable trends can be detected or analysis conducted on these latter classes of site type, giving them a low certainty in terms of any generalisations made.

Perhaps the hardest feature to identify on sites from satellite imagery is the height of a mound. This obviously has huge implications for the condition of the site. A tentative assessment was also made for the certainty of the remaining height of mounds on each image. If height was recorded during the field visit, then height was recorded as "Certain" on the Corona data. On SPOT and Geoeye, on the other hand, height had to be clearly visible, such as on a tell. This could be indicated by shadows, or for example plough lines appearing to go up and over a site. Figure 6-5 shows how a mound has been ploughed separately to the rest of the field. On flat sites, farmers plough in straight lines, but here, whilst most of the field is ploughed that way, the mound has been ploughed in a circle. Presumably some of the height of the mound remains, causing an impediment to farmers, therefore making it easier to plough it this way. Figure 6-6 shows another mound where height probably remains. The arrow indicates a change in the soil colour suggestive of a shadow and an outline of a site. As long as even part of a site had height remaining, it was recorded as height "Certain", so this does not reflect bulldozed sections of sites.

As shown on the following tables - Table 6-1 and Table 6-2 - the certainty of height remaining decreases from the Corona. These Tables record whether it was certain that the mounds still had height on the different images. Some sites are clearly flat, either because they were recorded as such during the field visits, or substantial damage was recorded to them. In many cases however, although a site may have had height during a field visit, it was not clear on recent satellite imagery whether that height was still present. In these cases, height was recorded as Uncertain. (Height is recorded as Certain on Corona if it was recorded on the field visits: mounds will not get taller over time, therefore height recorded during a field visit is taken as indicative of a site having height in the 1960s).

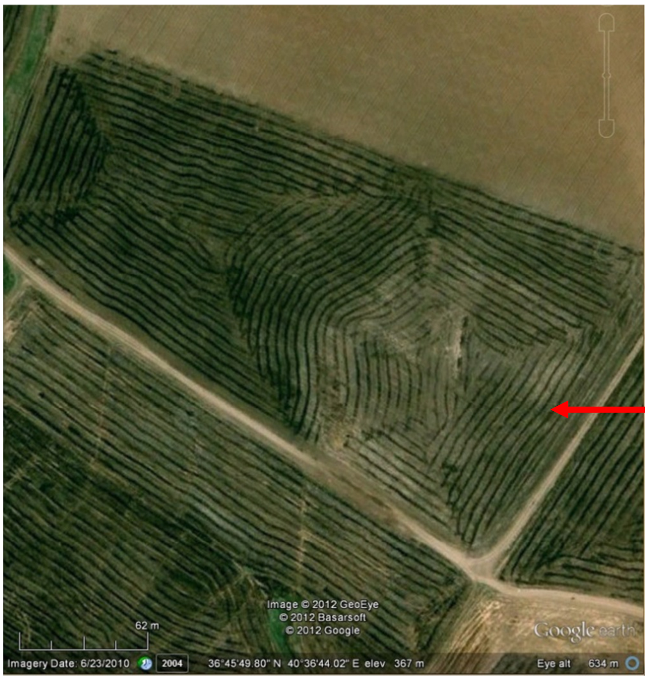

FIGURE 6-5: GEOEYE IMAGE OF PLOUGH LINES AT TBS 30 (INDICATED BY THE ARROW)[86]

Note how the surrounding fields are ploughed in straight lines but at the location TBS 30, the plough has gone round the mound separately to the rest of the field.

FIGURE 6-6: GEOEYE IMAGE DEMONSTRATING HEIGHT AT TBS 62_1_0

Height is suggested by the shift in soil colour at the location of the arrow, and also by the slight curvature of the horizontal plough lines at the point at which the soil colour changes. The red boundary indicating the site is drawn just outside the edge of the site.

[86] Geoeye Image, 23 June 2010. Taken from Google Earth 25 April 2012

The certainty of whether a mound still retains height is used to inform decisions about damage and the certainty of correctly recording the damage. For example, if height is still Certain, it is less likely that a site has been bulldozed (although as was demonstrated in Chapter 3.5.8 – Bulldozing, it is still not impossible). The certainty of whether height remains also acts as an indicator of sites where the damage could potentially be worse than recorded. If height is uncertain, then the site may have sustained worse damage than is definitely visible on imagery (remembering that the only certain damage is recorded). Finally, recording whether height remains also serves to mark sites which have been flattened. A site which had height during the field visit will be recorded as "Site type: mound or tell" regardless of its later height. If the certainty of height remaining changes from Certain to Flat site, this makes it easier to identify sites which have been flattened.

TABLE 6-1: CERTAINTY OF HEIGHT REMAINING (AMALGAMATED SITES)

Does Height Remain?	Number / % of 108 sites on Corona	Number /% of 108 sites on SPOT 2004	Number / % of 108 sites on Geoeye 2010
Certain	98 (90.7%)	63 (58.3%)	64 (59.3%)
Uncertain	3 (2.8%)	36 (33.3%)	35 (32.4%)
Flat Site	7 (6.5%)	9 (8.3%)	9 (8.3%)

TABLE 6-2: CERTAINTY OF HEIGHT REMAINING (UNIT ANALYSIS)

Does Height Remain?	Number / % of 194 sites on Corona	Number /% of 194 sites on SPOT 2004	Number / % of 194 sites on Geoeye 2010
Certain	180 (92.8%)	78 (40.2%)	81 (41.8%)
Uncertain	4 (2.1%)	104 (53.6%)	101 (52.1%)
Flat Site	10 (5.2%)	12 (6.2%)	12 (6.2%)

In the Tell Beydar area height was certain on most of the amalgamated sites on Corona imagery (reflecting the site's status during the field visit), but on more recent imagery height was uncertain on a third of sites. Height was certain on almost all the individual site units on Corona, but by 2010, height could not be definitely determined on over half of the individual mounds (marked Uncertain). The 2 sites / mounds which had height and are now flat sites are the two mounds which have been completely bulldozed (TBS 29_3_0, and TBS 58). However, the number of site units on which the height is Uncertain suggests many more sites could be damaged.

6.4 – VISIBILITY

All sites are covered by at least one set of Corona imagery, the 2004 SPOT imagery, and 2010 Geoeye imagery, from either June or August, allowing comparisons. Of course, this does not mean sites are visible on all the imagery, just that the potential exists to see them. A variety of factors influences site visibility, which is discussed throughout the Methodology Chapter, and defined in Section 4.6.3 (p138).

6.4.1 - VISIBILITY: SEEING SITES

Sites in the Tell Beydar area are visible in different ways depending on the type of imagery, the type of site and the land cover at the location of the site.

High sites on Corona cast visible shadows, and are therefore evident as a light half and a dark half (Figure 6-7). Many sites are visible as soil marks which appear a different colour to the area around them, or as areas of speckling, as discussed in the Methodology Chapter. (Notice how, on Figure 6-9, the speckling crosses the field boundaries). Sites on SPOT, in particular often show up in this way, as the resolution is too low to see shadows cast by sites, or indications of height. Other sites are visible as crop marks, or as areas where the site is evident as a light mark against darker soil or crops (Figure 6-10), or show up as darker areas of high moisture retention. If such a mark crosses field boundaries, then it is more likely to be a site. On Corona, sites tend to be visible as pale areas against dark backgrounds, or occasionally darker areas. Sites on SPOT are usually pale beige against darker crops or earth. Sites on Geoeye, on the other hand, fall into two types. The Geoeye imagery taken in June is similar to SPOT in that sites show up with a similar profile. Sites on Geoeye on the August imagery, on the other hand, can show up as grey soil marks against the pinker soil (Figure 6-11). The grey soil is often evidence of anthropogenic deposits – degraded mudbrick, ash and refuse from sites (Wilkinson and Tucker 1995). The presence of sites can also be indicated by disruption in plough lines on Geoeye, where farmers have changed their ploughing patterns, or buried deposits have disrupted the plough.

6.4.2 - VISIBILITY: SEASONALITY IN THE TELL BEYDAR AREA

Ur (2003; 2010b: 78) has commented on the impact of seasonality on the different Corona images available: the same is almost certainly true of other sets of imagery. Although it has not been possible to obtain sets of the same imagery type in different seasons in order to compare them in this area, a study of three Geoeye images from

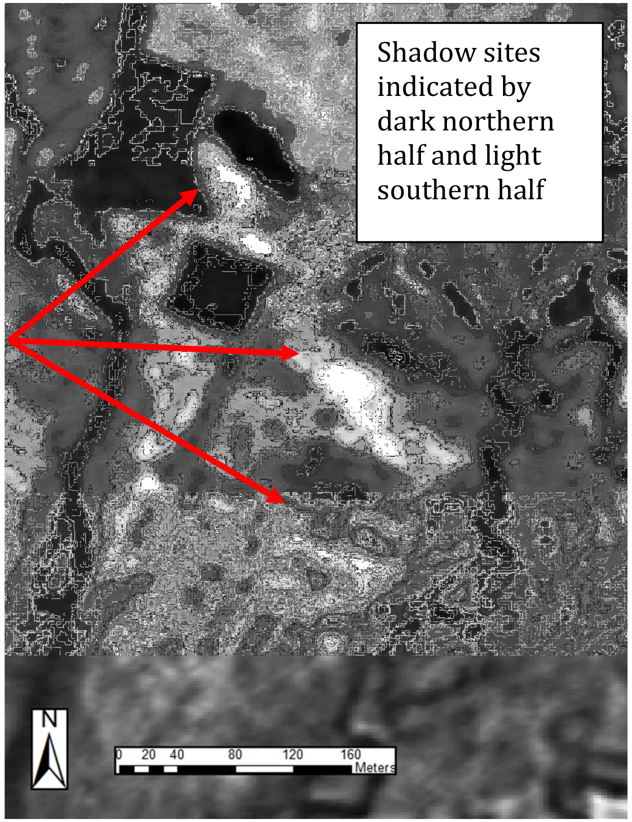

FIGURE 6-7: TBS 29 ON CORONA VISIBLE BY SHADOWS[87]

FIGURE 6-8: TBS 29 ON JUNE GEOEYE VISIBLE IN SEVERAL WAYS[88]

87 Left: Corona Image, 1102-1025DF006-1_37N, standard deviation stretch, 09 December 1967

88 Right: Geoeye Image, 23 June 2010. Taken from Google Earth 25 April 2012

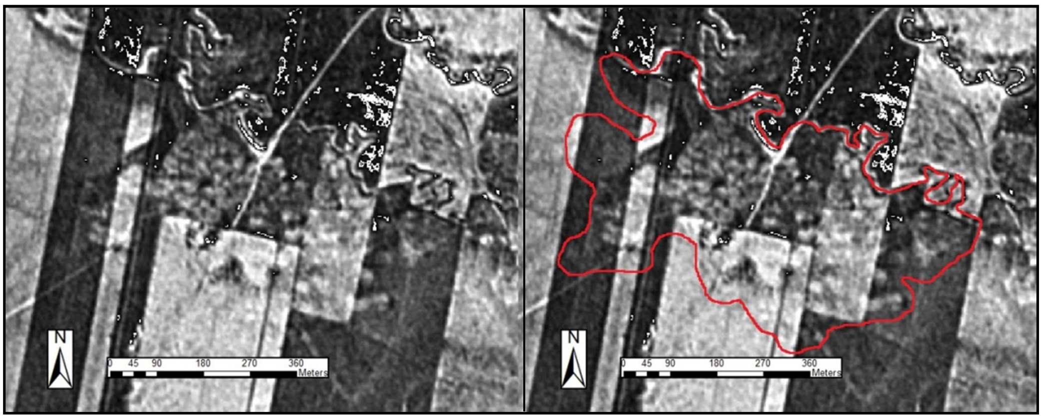

FIGURE 6-9: SITE VISIBLE AS SPECKLING ON CORONA (TBS 57) [89]

The site is outlined in red on right-hand image

FIGURE 6-10: TBS 5 ON SPOT[90]

FIGURE 6-11: TBS 5 ON AUGUST GEOEYE

The red arrows on Figure 6-10 and Figure 6-11 indicate location of TBS 5. Note the pale mark of smeared soil around it which crosses the field boundaries (this is particularly visible on Figure 6-10).

three consecutive months in the Carchemish area showed very little difference in areas where the images overlapped. Two Geoeye images were available on Google Earth taken in June and August 2010, and a third from July 2010 which only covered two sites. Although there was very little overlap to allow comparison of sites directly, the way sites appear on imagery did not change between the images.

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[89] Corona Image, 1105-1025DF056-6_37N, standard deviation stretch, 03 November 1969
[90] Left: SPOT Image, 31 December 2004 (?). Right: Geoeye Image, 17 August 2010. Taken from Google Earth 25 April 2012.

Sites on Corona images taken in different seasons, for example, may be lighter or darker depending on the absorption abilities of the soil and moisture levels. This suggests that when Geoeye images are taken may only affect visibility in a very seasonal way, in that different seasons will affect the extent of crop cover and bare fields, for example, rather than directly affecting the visible spectral signature.

Table G-9 and Table G-10 in Appendix G count the presence or absence of soil colour differences visible on imagery or recorded on site visits. At the site level, soil marks were rarely reported in field visits (approximately 1 in 10 times), but were noted in two thirds of the images. 65% of the sites mounds had some sort of visible indicator, such as a soil mark, on Corona, compared to nearly 72% on SPOT and dropping to 69% on Geoeye. Sites in the Near East do not produce crop marks in the same way as sites do in British archaeology, where the presence of sites leads to differential growth and ripening times of crops. Instead they are normally recorded by soil marks or their distinctive morphology. However, several sites on SPOT were identified through the differing colours of crops, suggesting there may be similarities. At the individual mound level, there are slightly fewer soil marks on each image, again showing the difficulties of seeing the smaller individual mounds. The highest proportion of soil marks are visible on SPOT: many of the sites show as crop marks, but a substantial number show as soil marks. The level of crop in the fields is unclear – it may be that the sites are showing in the chaff after harvest, or in the full grown crop. Without a month to date the image, it is hard to tell.

6.4.3 - Visibility: Amalgamated sites

Table G-11 to Table G-13 in Appendix G show the visibility of sites on Corona, SPOT and Geoeye for amalgamated sites. There is a statistically significant difference between visibility levels on the three sets of imagery, which is mostly attributable to the difference between Corona imagery and the later imagery. A Kruskal-Wallis test was conducted on all three sets of images, where 1 = Visible and 5 = Not Visible: a higher mean rank indicates less visible sites. (X^2 = 12.259, df 2, p=0.002. Mean ranks: Corona = 138.15, SPOT = 178.65, Geoeye = 170.69). 50% of surveyed sites are Visible on Corona, dropping to less than 32% on later imagery. 11% of surveyed areas are Obscured or Not Visible on the Corona, compared to 23% on SPOT and 19% on Geoeye, despite the increase in resolution. This is shown more clearly in Figure 6-12 and Figure 6-13 on the following page.

The drop in the number of areas which are Visible is clear on Figure 6-12. Sites are far more likely to be Barely Visible or Not Visible on later imagery. Figure 6-13 (the stacked percentage graph) shows the different proportions of visibility of imagery.

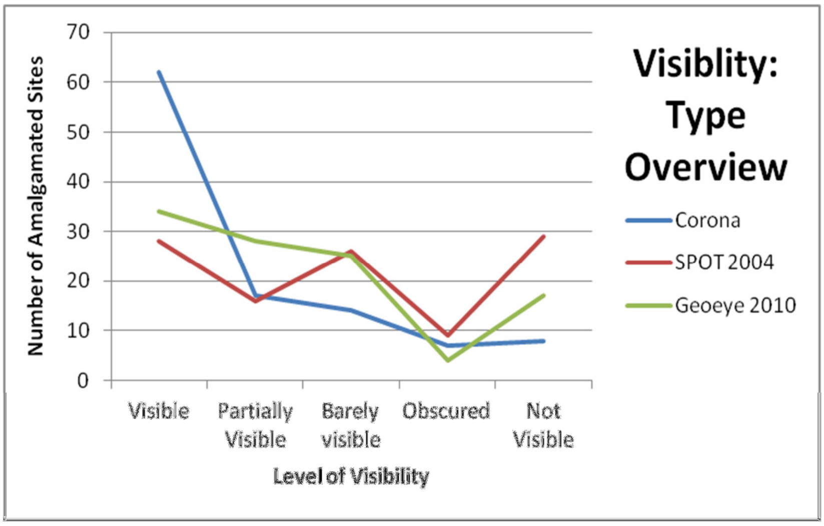


FIGURE 6-12: GRAPH OF VISIBILITY OF SITES ON IMAGERY (AMALGAMATED SITES)

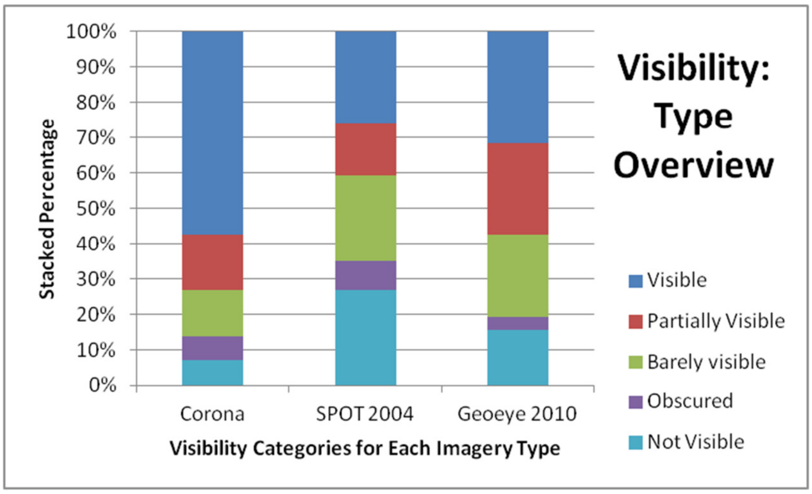


FIGURE 6-13: GRAPH OF STACKED VISIBILITY OF SITES ON IMAGERY (AMALGAMATED SITES)

Figure 6-12 shows the raw number counts of each visibility category on each imagery type. Corona clearly had the highest proportion of Visible sites. Figure 6-13 shows the proportions of visible sites on each image displayed as a stacked percentage. Proportions allow a more direct comparison of the imagery visibility between survey areas, as they are less dependent on the number of sites in each sample.

The decrease in visibility could be due to the season or angle the later images were taken in, but is as likely to be due to the increase in agriculture: the ploughing and on-going erosion may have dispersed the more reflective sediments as time passes, making sites harder to see.

6.4.4 - VISIBILITY: UNIT ANALYSIS

Table G-14 to Table G-16, Appendix G, show the visibility of sites on Corona, SPOT and Geoeye for the individual site units. The Unit analysis shows a similar pattern of visibility to the amalgamated sites, but is much more pronounced. Again, a Kruskal-Wallis test demonstrated an even more statistically significant difference between visibility levels on the three sets of imagery, which is mostly attributable to the difference between Corona imagery and the later imagery (1 = Visible and 5 = Not Visible, $X^2 = 52.814$, df 2, $p<0.000$. Mean ranks: Corona = 222.98, SPOT = 332.27, Geoeye = 319.24). Almost twice as many mounds are visible on Corona as on SPOT or Geoeye, despite the fact that smaller features such as walls are only visible on Geoeye. 15% of surveyed areas are Obscured or Not Visible on the Corona, compared to 31% on SPOT and Geoeye, despite the increase in resolution. This is again apparent on Figure G-5 and Figure G-6 in Appendix G, which show the different proportions of visibility of imagery. These graphs are similar to the amalgamated site graphs (Figure 6-12 and Figure 6-13) but there are fewer Partially Visible site units on Geoeye, presumably because smaller sites are either Visible or not: in most cases they are too small for only part of them to be visible. Imagery resolution is clearly not a factor in visibility.

6.4.5 – VISIBILITY: SITE LOCATION

Site visibility is also affected by site location, as well as by imagery type, and time of image. Table G-17 and Table G-18 in Appendix G, and Figure 6-15 to Figure 6-16 on the following pages show the Amalgamated Site analysis and the Unit analysis of sites by site location and visibility, totalled for all imagery in both percentage and numerical terms. The counts are formed from the sum of visibility by site location for all three images, and it is the cumulative totals shown. It should be remembered that few sites were recorded on the plateau or its escarpment, or on the wadi terraces (and even fewer were visible on the satellite imagery), so at this level of analysis, trends in these areas should be taken as no more than possible indicators of patterns.

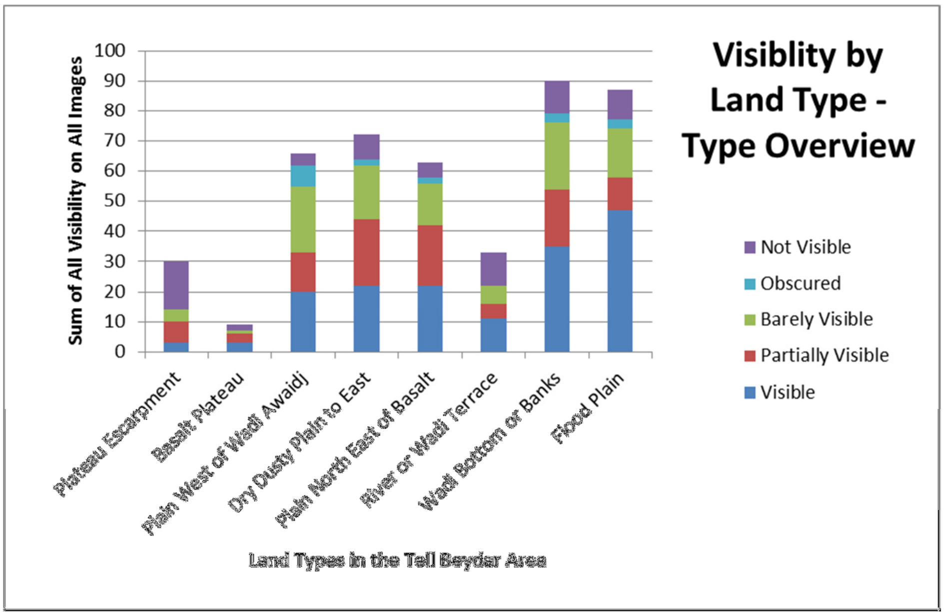


FIGURE 6-14: GRAPH OF VISIBILITY BY LAND TYPE (AMALGAMATED SITES)

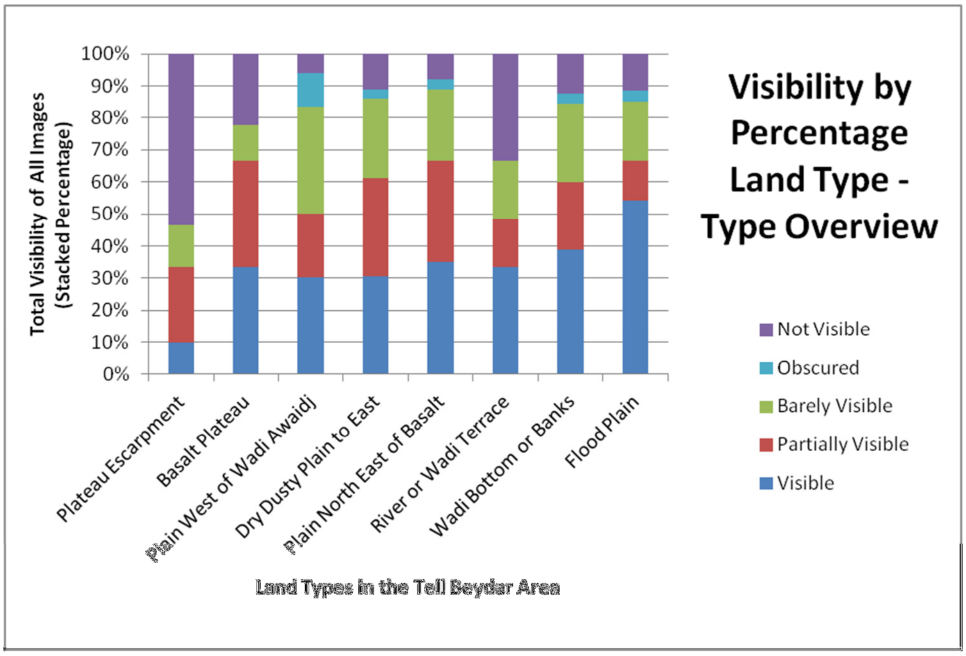


FIGURE 6-15: GRAPH OF PERCENTAGE VISIBILITY BY LAND TYPE (AMALGAMATED SITES)

Figure 6-14 shows the visibility of sites in each area. The counts of visibilities of sites on all images are combined into total figures for each area, to give an indication of visibility in each area regardless of the qulity of the image. Figure 6-15 displays this figure as a stacked percentage: this allows the visibilities in each area to be compared directly, regardless of the number of sites in each location. This is repeated for the Unit analysis on the following page (Figure 6-16 and Figure 6-17).

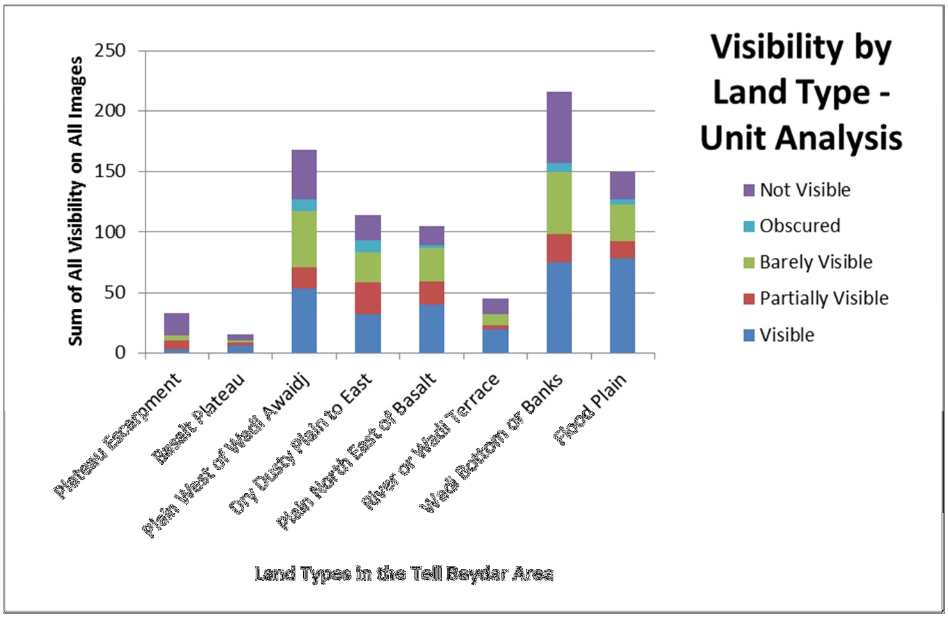


FIGURE 6-16: GRAPH OF VISIBILITY BY LAND TYPE (UNIT ANALYSIS)

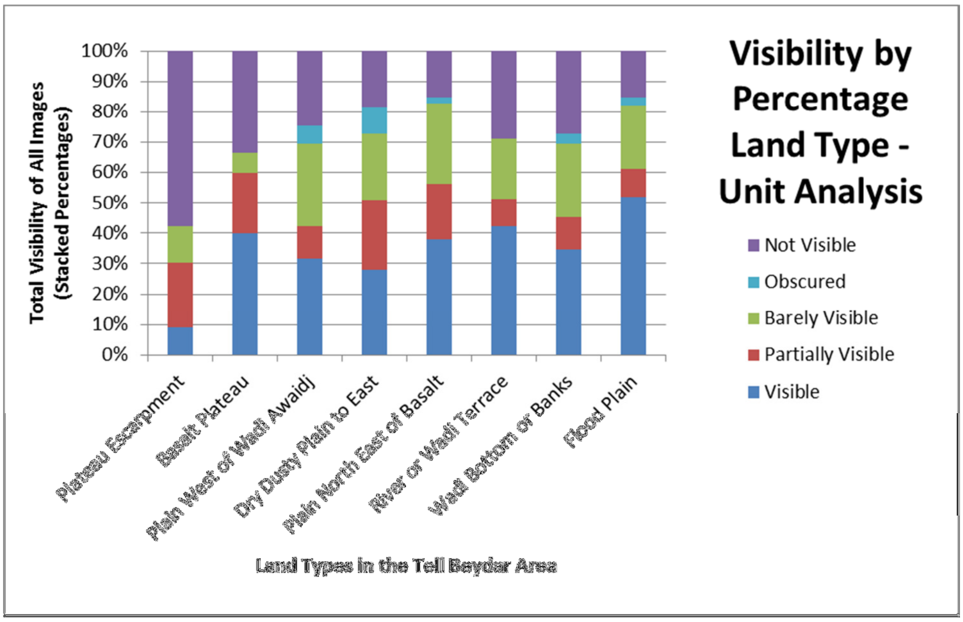


FIGURE 6-17: GRAPH OF PERCENTAGE VISIBILITY BY LAND TYPE (UNIT ANALYSIS)

Most sites on the plains fall into the Visible category. In comparison, according to field surveys, there are very few sites on the basalt plateau, and they are less likely to be Visible on satellite images. This is easier to understand when viewed proportionally by percentage land type (Figure 6-15 and Figure 6-17). For example, 53% of sites on the plateau escarpment are Not Visible in any period, whereas 54% of sites on the floodplain are Visible.

When considering the actual counts of each visibility category of sites in each area (Figure 6-14 and Figure 6-16), the differences in visibility between amalgamated sites and individual mounds becomes clearer. Individual mounds are far more likely to be Not Visible: in the amalgamated figures, as long as part of the site is visible, it must be categorised as Partially Visible, or at least Barely Visible. When viewed in the specific context of location, this is even more striking.

Mounds on wadi bottoms or banks are more likely to be Not Visible than amalgamated sites. Mounds on the plain to the west of the Wadi 'Awaidj are also less likely to be Visible: a higher number are Not Visible.

However, there are also some changes through time, or varying by imagery (Table G-19 and Table G-20, and Figure G-7 to Figure G-10, Appendix G). At this level, in order to analyse the trends, some land types were excluded or combined, due to low numbers.

Amalgamated sites are most likely to be in the Visible category on Corona and least likely to be Visible on SPOT, regardless of land type (Appendix G, Table G-19). On the whole, the distribution of visibility remains broadly similar for all imagery types and land types, but sites were far more likely to be Partially Visible on SPOT 2004 than on any other imagery. On the plains to the east and west of the wadis on Corona, no sites were recorded as Not Visible, and very few were recorded as Not Visible on the flood plain: these are areas of reasonable visibility for sites on satellite imagery. The flood plain in particular is an area that has experien**c**ed extensive landscape change, and this is probably reflected in the visibility of sites in this area. More sites on the plateau, on the other hand, were recorded as Visible on Geoeye, as they are often irregular enclosures which cannot be seen without high resolution imagery. Sites on Corona could be located and seen fairly easily, although it can be hard to make out details with any certainty.

The pattern for the individual mounds (Appendix G, Table G-20) is different to the amalgamated site pattern, reflecting the fact that for amalgamated sites, as long as most of the site can be seen, the site is recorded as Partially Visible. An analysis of individual mounds is a better reflection of the state of the sites. (A visual comparison is possible on Figure G-7 and Figure G-8, Appendix G). Mounds on Corona had the best visibility in all locations, except the plateau. Interestingly, the individual parts of the plateau sites are equally visible on Corona and Geoeye. Sites on the flood plain were most visible on Corona, and far more likely to be Barely

Visible or Not Visible on Geoeye: this probably reflects the changes in the landscape in that area, which will be discussed in the next Section 6.5 - Land Cover/ Land Use. The mounds on the plain to the west of the Wadi ‘Awaidj have also undergone a substantial decrease in visibility between the different images. This is not evident when looking at overall site visibility, suggesting it is the smaller outlying mounds which are more heavily affected in this area. However, whilst the overall numbers of amalgamated sites and site units are different, the proportions of Visible mounds and Visible amalgamated sites in the different areas on the different imagery (Appendix G, Figure G-9 and Figure G-10) are fairly similar. Amalgamated sites are slightly more likely to be Visible on SPOT, and more site units, which are generally smaller, were Not Visible on Corona.

A detailed look at the sites on the plains (Appendix G, Table G-21 and Table G-22, and Figure G-11 to Figure G-14) shows where the differences are most pronounced. There are more Not Visible small mounds in the Unit analysis, and more Partially Visible sites on the amalgamated sites Overview. A site of which only some of the mounds can be seen is recorded as Partially Visible, whereas when counting the individual mounds, a higher proportion of them are Not Visible. Sites on the plains are slightly more likely to be Visible on Corona and Not Visible on SPOT and Geoeye.

When looking at sites adjacent to water - by the wadi bottoms, on the banks of wadis or on the terraces by them (Appendix G, Table G-23 and Table G-24, and Figure G-15 to Figure G-18) - sites are far more likely to be Visible on Corona, and Not Visible on later imagery. As will be discussed in Section 6.5, wadis and their immediate environment are one of the areas demonstrating the greatest change during the study period. This has presumably also affected the sites located there.

The apparent decrease in visibility between the Corona images and the later images suggests that either seasonality plays an important part or these sites have suffered extensive attrition in the last decade. The survey results suggest the flood plain is the area which has been occupied the most over the last millennia, so it would be strange for this to be the area which has only recently experienced the most damage. Possible alternative reasons for this, such as the impact of seasonality on imagery, were examined earlier in this section.

On Corona, the visibility of sites adjacent to wadis is the same as sites elsewhere: the deposition of sediment, and the increased possibility of site erosion does not affect site visibility. Although it is hard to make out site detail on SPOT, in this area sites show up particularly clearly as crop or soil marks. As the Wadi 'Awaidj has now been directed by humans into a controlled concrete channel, and many other wadis have dried up, many sites are no longer located directly by flowing water: the effect this has had on sites is discussed in more detail in Section 6.5 – Land Use/ Land Cover, p207, and Section 6.7.7– Water Erosion.

6.4.6 – Visibility: Site Type

A Mann-Whitney-U test (Table 6-3) showed there are statistically significant differences in the visibility of tells and low tells, with one exception. There is less statistical difference in the visibility of the amalgamated sites on Corona, although there is still moderate evidence of a statistical difference in the visibility of tells and low mounds. Low tells are less likely to be recorded as Visible in all imagery types.

Table 6-3: Mann-Whitney-U Test Results for Differences in Visibility of Tells and Low Tells (Amalgamated Sites and Unit Analysis)

Imagery	Analysis Type	U	p	Mean Rank: tells	Mean Rank: low tells
Corona	Amalgamated Sites	436.00	0.011	31.90	55.44
	Unit Analysis	1352.5	0.011	68.85	95.96
SPOT	Amalgamated Sites	174.5	<0.000	19.31	58.79
	Unit Analysis	432.00	<0.000	30.5	100.77
Geoeye	Amalgamated Sites	209.00	<0.000	20.95	58.35
	Unit Analysis	432.00	<0.000	36.13	99.91

As the study of site visibility is broken down further, both the effect of imagery choice and the importance of site type become apparent. Table G-25 to Table G-30 (Appendix G) show Visibility by Image Type and Site Type. Although large tells have remained clear because of their size, (91% visible on Corona, Table G-25, and Geoeye, Table G-27), low tells have become far more difficult to see. 67% of low tells were Visible or Partially Visible on Corona, dropping to less than 50% on later imagery. The component parts of sites, examined in the Unit analysis, are becoming considerably harder to see. 72% of low tells (counted as individual units, rather than as complexes of low mounds) were Visible or Partially Visible, dropping to only 32% on SPOT, or 37% on Geoeye. More than half the surveyed low tells are less visible in 2010 than in the 1960s, despite the increase in image resolution. The reasons for this are almost certainly related to the intensive landscape changes and ensuing damage to sites, which will be discussed in the following sections. In 2010, only 34 of the 194 units were Visible, compared to 88 units fifty years earlier.

There are too few sites in the other site type categories to identify any meaningful trends at this level of analysis.

6.4.7 - Visibility Change

Not all sites are visible, and those which can be easily seen are not the same on different imagery. If visibility is considered as an ordinal variable, and counted numerically, then change in visibility can be considered.

Visible = 1, Partially Visible = 2, Barely Visible = 3, Obscured = 4, Not Visible = 5

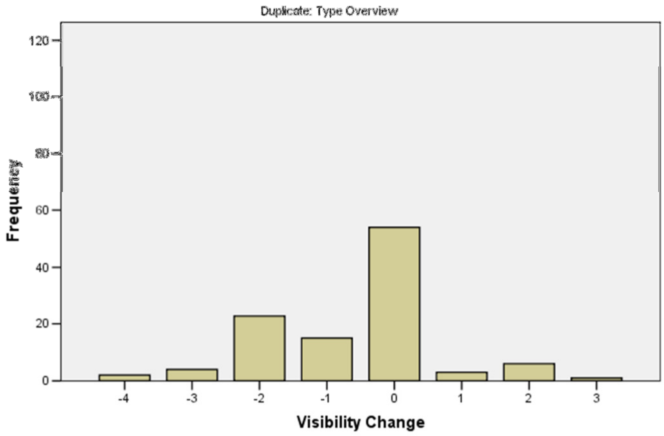
A site which was Visible in 1967 but becomes Not Visible by 2010 would then move from 1 to 5, and have a -4 rating. Equally, a site which becomes more visible would have a positive rating. Using this, the following graphs (Figure 6-18 and Figure 6-19) show the frequencies of change in visibility of sites between Corona, SPOT and Geoeye.

Figure 6-18 shows the Amalgamated site analysis: overall there is a relatively even spread of change in visibility from the Corona to the modern imagery. Approximately half the sites have stayed the same (0 change), and a more or less even number have increased or decreased in visibility. There is a greater disparity between the individual units (Figure 6-19). Whilst again, about 60 have stayed the same, this is only one third of the total number of mounds. Of the remaining two thirds, very few have improved in visibility: most have decreased or stayed the same. Both graphs showing the change from Corona are distinctly right skew: there has been a negative change in visibility indicating sites have become less visible.

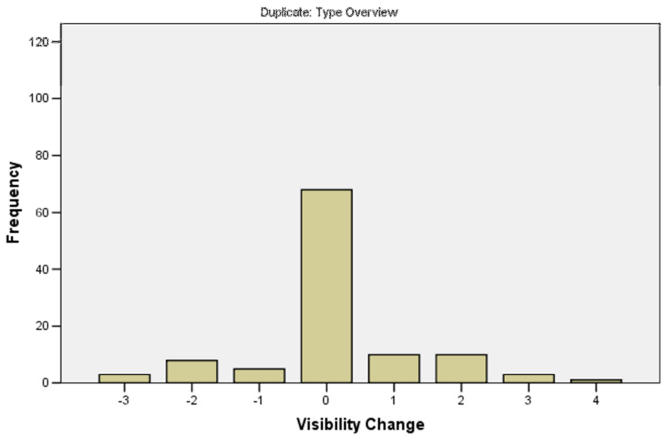
The graph of change from SPOT 2004 to Geoeye 2010 highlights changes that may have occurred in the last 6 years. Two thirds of sites have not changed: this is not unexpected. Most changes to the landscape occurred prior to 2004. However, the resolution of the Geoeye is substantially better than the SPOT imagery, so it would not have been surprising if sites were more visible, and in fact 24 amalgamated sites could be seen more clearly, compared to 16 which have become less visible.

FIGURE 6-18: GRAPHS OF FREQUENCY OF CHANGE IN VISIBILITY OF SITES BETWEEN CORONA, SPOT 2004 AND GEOEYE 2010 (AMALGAMATED SITES)

Visibility Change from Corona to SPOT 2004



Visibility Change from SPOT 2004 to Geoeye 2010



Visibility Change from Corona to Geoeye 2010

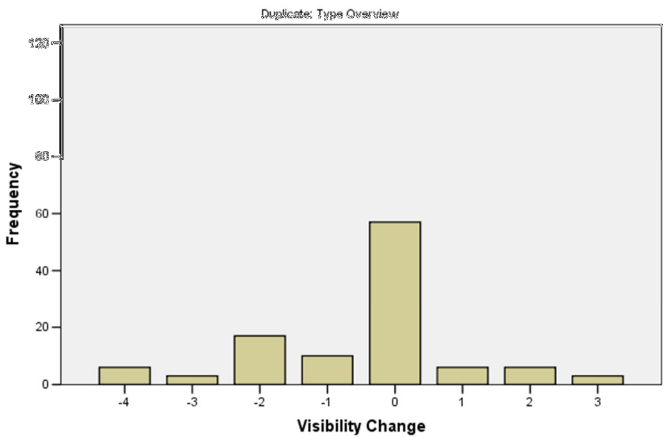
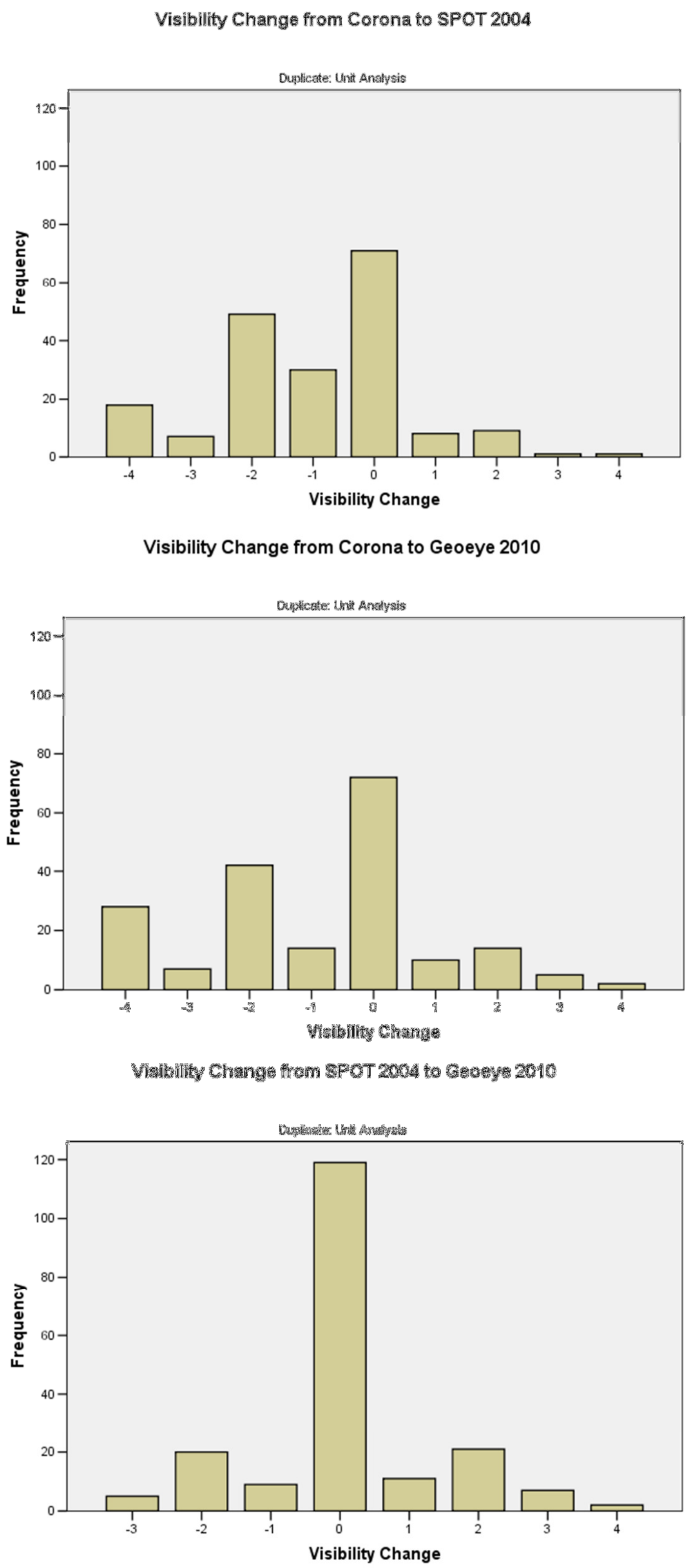


Figure 6-19: Graphs of Frequency of Change in Visibility of Sites between Corona, Spot 2004 and Geoeye 2010 (Unit Analysis)



Of the individual units, 119 have stayed the same, 34 have become less visible, and 41 have improved in visibility, presumably because of the higher resolution of Geoeye. In general, however, the probability of finding a site today which was visible on Corona is just over half (0.55) for amalgamated sites, and not even that for site units (0.48)[91] (using Geoeye as the most recent imagery as the proxy for today). Although most damage occurred prior to 2004, the fact that the visibility of some sites is decreasing suggests that these may be the sites which have been damaged in the last decade: the landscape continues to change and that damage to sites is on-going.

6.5 - Land Use / Land Cover

Land use and land cover play an important part in site damage, as defined and described in the Methodology Chapter 4.5.4, where the land uses / covers recorded on the sites are listed in Table 4-3 (p142). This section will examine whether land use can act as a predictor of damage threats in the Tell Beydar area. [The term land use will be used for simplicity].

The land use in some areas could not be determined to be arable or low scrub, particularly on Corona. These Unclassified areas are included in the Tables, but not in the totals.

6.5.1 - Land Use Around Sites

Land use around sites can be indicative of the damage sites are likely to experience, either at the time of the study or in the future, and by monitoring the change, it can act as a predictor of the risk to a site in the future. Land use around sites was rarely recorded during the field visits, so this analysis presents only the results from imagery observations. (Percentages are the percentage of sites around which a land use was reported).

Each site can have multiple land uses around it - for example, an agricultural field on one side, a wadi on another, and a track crossing the site which extends past it. In total, on Corona 379 land uses were recorded around the 108 amalgamated sites. The total land uses around sites have increased slightly over time: there were 391 recorded land uses on SPOT (including those recorded during the field visits which

[91] Where "visible on Corona" is defined as falling into the Visible or Partially Visible categories and "Finding a site" is defined as still falling into the Visible or Partially Visible categories.

were not visible, such as graves). 409 were visible on the higher resolution Geoeye (Table G-31, Appendix G). This is an average of 3.4 different land uses around each site on Corona, 3.6 on SPOT, and 3.8 on Geoeye.

Although the difference in the numbers of land uses around sites between Corona and Geoeye appears statistically significant (Wilcoxon Signed Rank test, Table 6-4), the Corona total is almost certainly lower because smaller features are not visible on lower resolution imagery. If the Geoeye counts of small features (for example, the 22 pits) are included on the Corona totals as proxy data, the total count of land uses present on Corona imagery would be 401 (an average of 3.7 land uses per site). This is very similar to the count on the Geoeye imagery of 409, and slightly higher than that from the SPOT imagery. This suggests land use around amalgamated sites has not actually increased. Nor is there a statistically significant difference in the number of land uses around the individual mounds. 685 land uses were recorded around the 194 mounds in the 1960s (or 724 if all the pits counted on Geoeye were present), dropping to 675 on SPOT and 704 on Geoeye (an average of between 3.5-3.6 land uses per mound).

TABLE 6-4: WILCOXON SIGNED RANK TEST RESULTS FOR CHANGE IN LAND USE AROUND SITES (AMALGAMATED SITES AND UNIT ANALYSIS)

Wilcoxon Signed Rank test	Analysis	Z value	p value
Corona to SPOT 2004	Amalgamated Sites	-0.703	0.482
Corona to Geoeye 2010	Amalgamated Sites	-2.395	0.017
SPOT 2004 to Geoeye 2010	Amalgamated Sites	-2.633	0.008
Corona to SPOT 2004	Unit Analysis	-0.480	0.631
Corona to Geoeye 2010	Unit Analysis	-1.191	0.234
SPOT 2004 to Geoeye 2010	Unit Analysis	-3.468	0.001

Upon closer examination, this lack of change is almost entirely due to the change in water bodies. 154 mounds were near water bodies (usually intermittent wadis) in the 1960s. Only 48 were on Geoeye: most wadis have dried up and been ploughed out. If water bodies are excluded, a statistically significant increase in land use types can be seen at all levels of analysis (Wilcoxon Signed Rank Test, Table 6-5). For the Amalgamated Site analysis, on Corona the total number of visible land use types excluding wadis is 292, increasing to 359 on SPOT imagery, and 380 on Geoeye imagery (an average of 2.7, 3.3 and 3.5 land uses per site). The pattern is the same on the Unit analysis. On Corona, 531 land uses were recorded (570 if the 39 pits on Geoeye were included), increasing to 620 and 656, respectively (an average again of 2.7 land uses (or 2.9 with pits), 3.2 on SPOT and 3.4 on Geoeye).

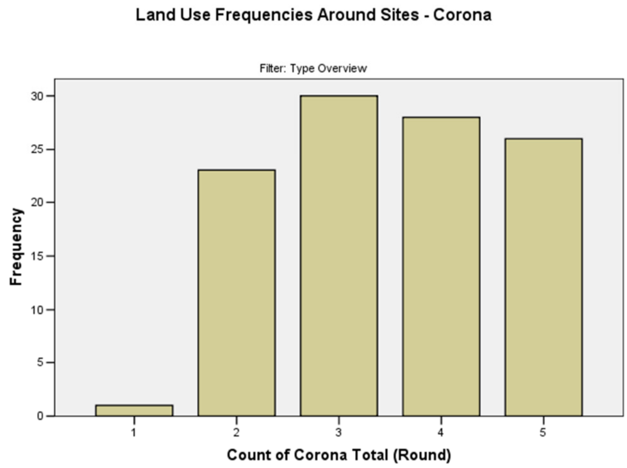
TABLE 6-5: WILCOXON SIGNED RANK TEST RESULTS FOR CHANGE IN LAND USE AROUND SITES – WADIS EXCLUDED (AMALGAMATED SITES AND UNIT ANALYSIS)

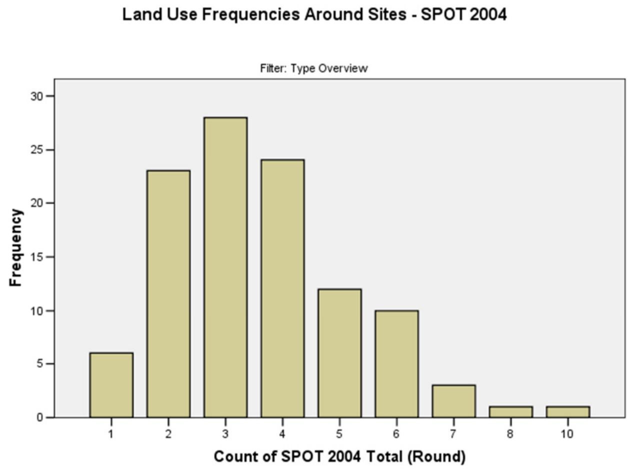
Wilcoxon signed rank test	Analysis	Z value	p value
Corona to SPOT 2004	Amalgamated Sites	-5.204	<0.000
Corona to Geoeye 2010	Amalgamated Sites	-6.000	0.000
SPOT 2004 to Geoeye 2010	Amalgamated Sites	-2.992	0.003
Corona to SPOT 2004	Unit Analysis	-6.454	<0.000
Corona to Geoeye 2010	Unit Analysis	-7.609	<0.000
SPOT 2004 to Geoeye 2010	Unit Analysis	-3.709	<0.000

Details of the relationship between land use and damage are analysed in Section 6.7. However, some general trends can be discerned (Table G-31: Counts of Land Use / Land Cover Around Sites). Mounds / site units which were in bare land or covered by low scrub have decreased from 101 on the Corona to 80 on the Geoeye (52.1% to 41.2%). Settlements are common, but contrary to the expected trend of an increasing population necessitating expanding development, they have decreased. 51 sites had modern settlement around them in the 1960s, but only 46 on Geoeye. A large number of settlements were built during the 1940s to 1960s (see Chapter 5.4), but several of these villages were abandoned by the time of the field visits, or on the SPOT imagery (see Section 6.7.1 – Development). Several of the field visits record abandoned villages, and several more are apparent on imagery: some were later resettled. This may be due to the fact that over time, the rural population has gradually drifted towards the towns (Sands 2011). Small single buildings, however, have tripled between the 1960s and 2010: these are presumably agricultural storage / processing installations, or small farmsteads.

Table G-32 (Appendix G) and Figure 6-20 (following page) show the frequencies of total number of land uses / covers around each site for the Amalgamated site analysis. Table G-33 (Appendix G) and Figure 6-21 (following page) show the Unit analysis. In these counts, no distinction is made between the different land use types to see which types are increasing. All land use types are considered to cause damage to a site except for bare land or low scrub. Counts of land covers which do not damage sites are all grouped together as a single type. Any increase in the number of land use types demonstrates that damaging land uses are increasing. As each damaging land use correlates to a damage threat, increases in the individual land uses are discussed in the damage analysis in Section 6.7.

FIGURE 6-20: GRAPHS OF FREQUENCIES OF TOTAL LAND USE / LAND COVER AROUND EACH SITE ON IMAGERY (AMALGAMATED SITES)





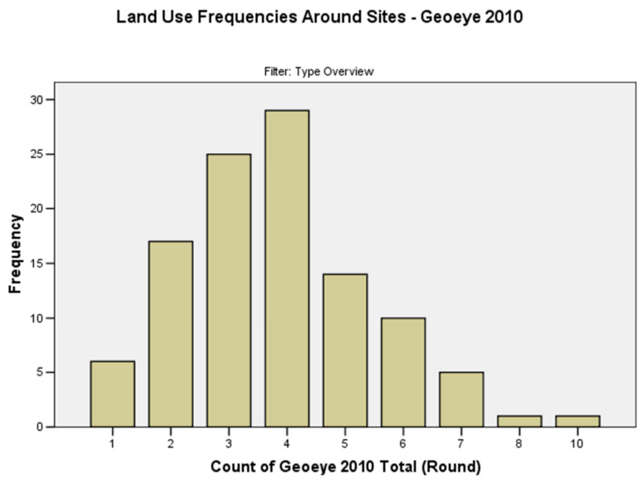
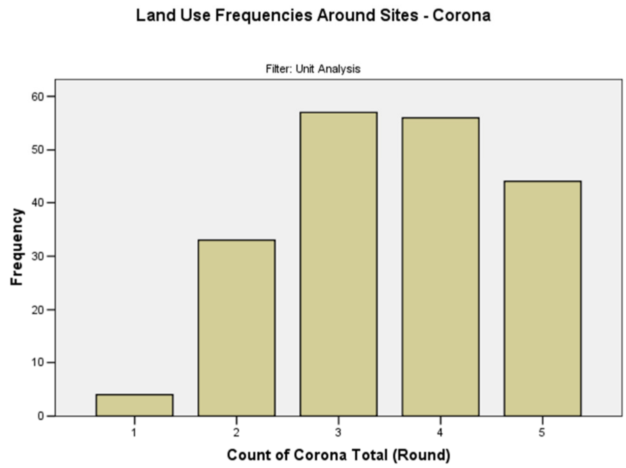
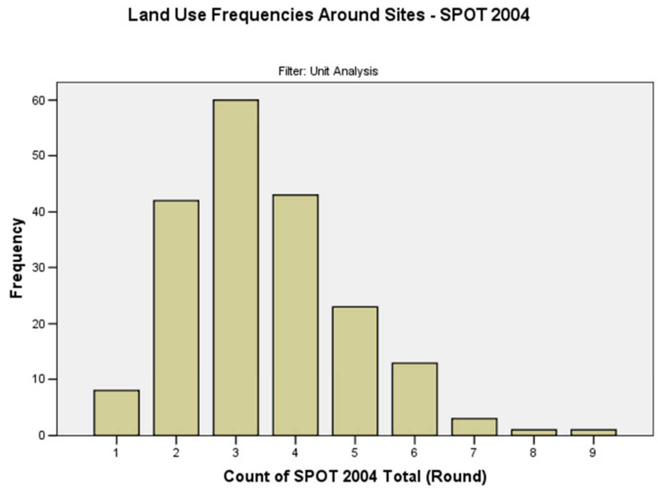
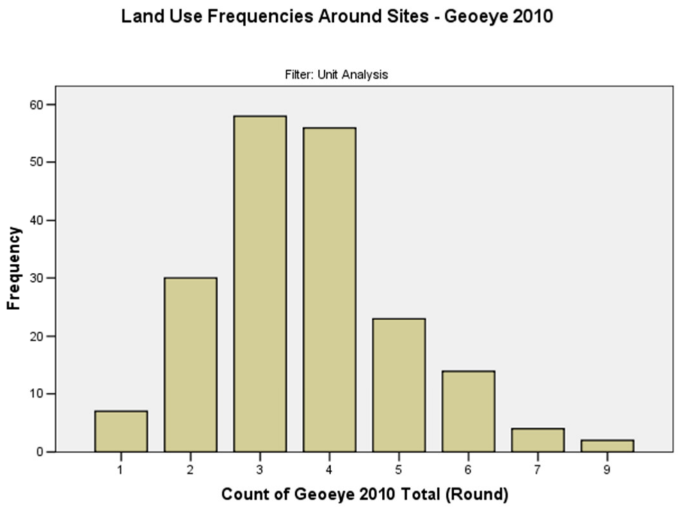


FIGURE 6-21: GRAPHS OF FREQUENCIES OF TOTAL LAND USE / LAND COVER AROUND EACH SITE ON IMAGERY (UNIT ANALYSIS)







Only one amalgamated site on Corona has a single land use around it: all other sites had between 2 and 5 types of land use around them. Sites viewed on Geoeye, on the other hand, were more likely to have 4 types of land use around sites. One site has 10 different land uses on it. This demonstrates the increase in land use around sites, and thus the increase in potential damage threats. This pattern is similar on the individual mounds.

6.5.2 - LAND USE / COVER ON SITES

Table G-34 and Table G-35 (Appendix G) show the different land uses and land covers which are actually on the sites. These are broken down according to the land use counts on the different sets of imagery for both the Amalgamated site analysis and the Unit analysis. Table G-36 and Table G-37 (Appendix G) and Figure 6-22 and Figure 6-23 (following pages) show the frequencies of the numbers of different land uses on each site for the Amalgamated sites and the Unit analysis. These tables demonstrate how the land uses which were once around the sites have spread onto them. As in the previous section, land uses which did not damage sites were combined into a single category, so any increases in the number of land uses represents an increase in damage which will be discussed in detail in the following sections.

The field visits recorded approximately half of the land uses on and around sites where they had a strongly visible impact on the site, but the recording was not consistent. 172 land uses / land covers were reported on sites by field visits, compared to 273 (or 309 including pits) on the Corona images, 347 on SPOT, and 371 on Geoeye. (This is an average number of land uses on a site of 2.5 in the 1960s (or 2.9 including later pits), rising to 3.44 of Geoeye). The Unit analysis shows the same – 233 land uses were recorded on individual mounds during the field visits, compared to 424 on Corona (or 462 including pits), 480 on SPOT, or 511 on Geoeye (average land use around each unit increased from 2.2 / 2.4 on Corona, to 2.6 on Geoeye). The increase in land use is statistically significant, even in the 6 year gap between SPOT and Geoeye (Table 6-6).

FIGURE 6-22: GRAPHS OF FREQUENCIES OF LAND USE / LAND COVER ON SITES (AMALGAMATED SITES)

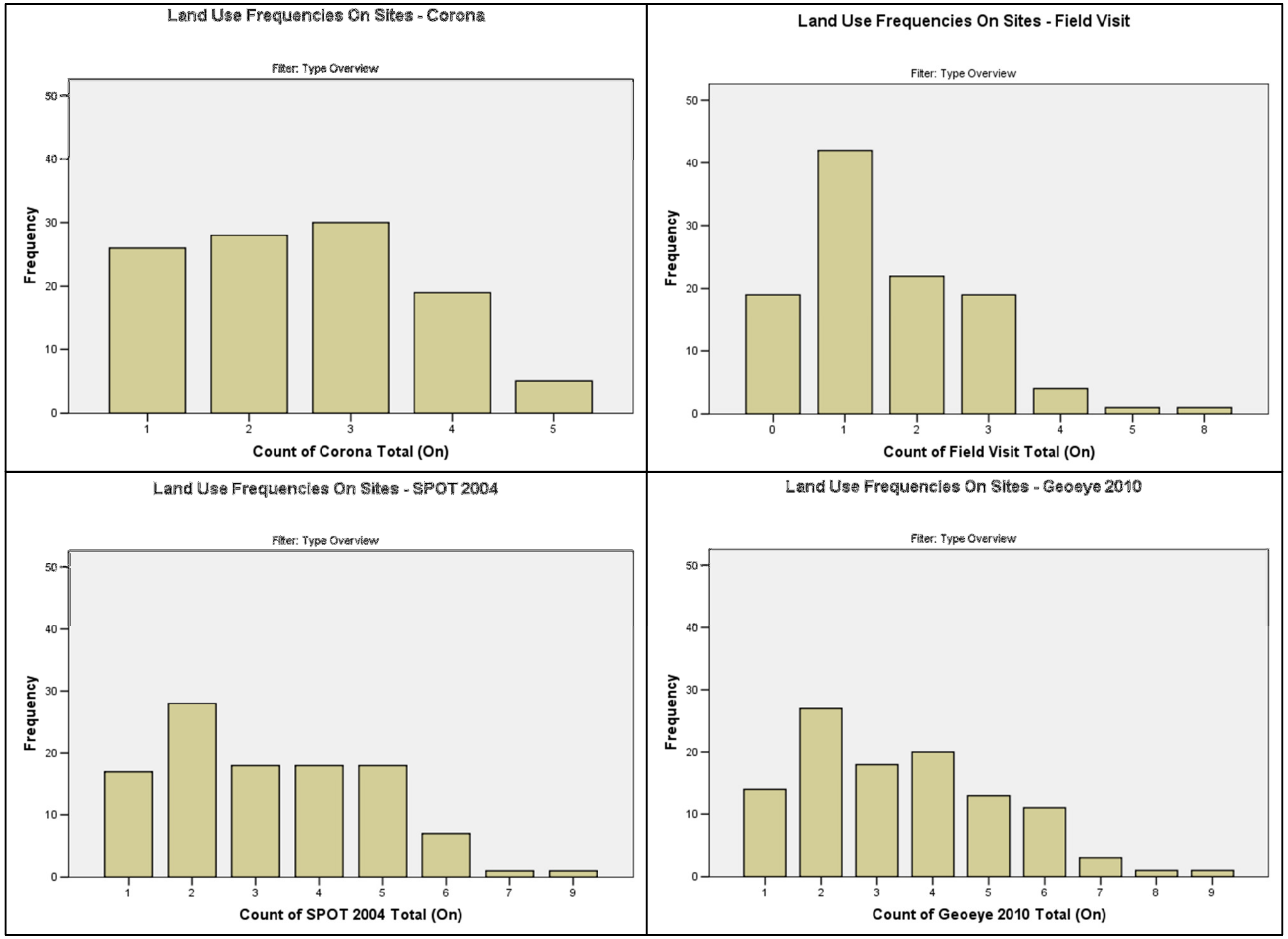


FIGURE 6-23: GRAPHS OF FREQUENCIES OF LAND USE / LAND COVER ON SITES (UNIT ANALYSIS)

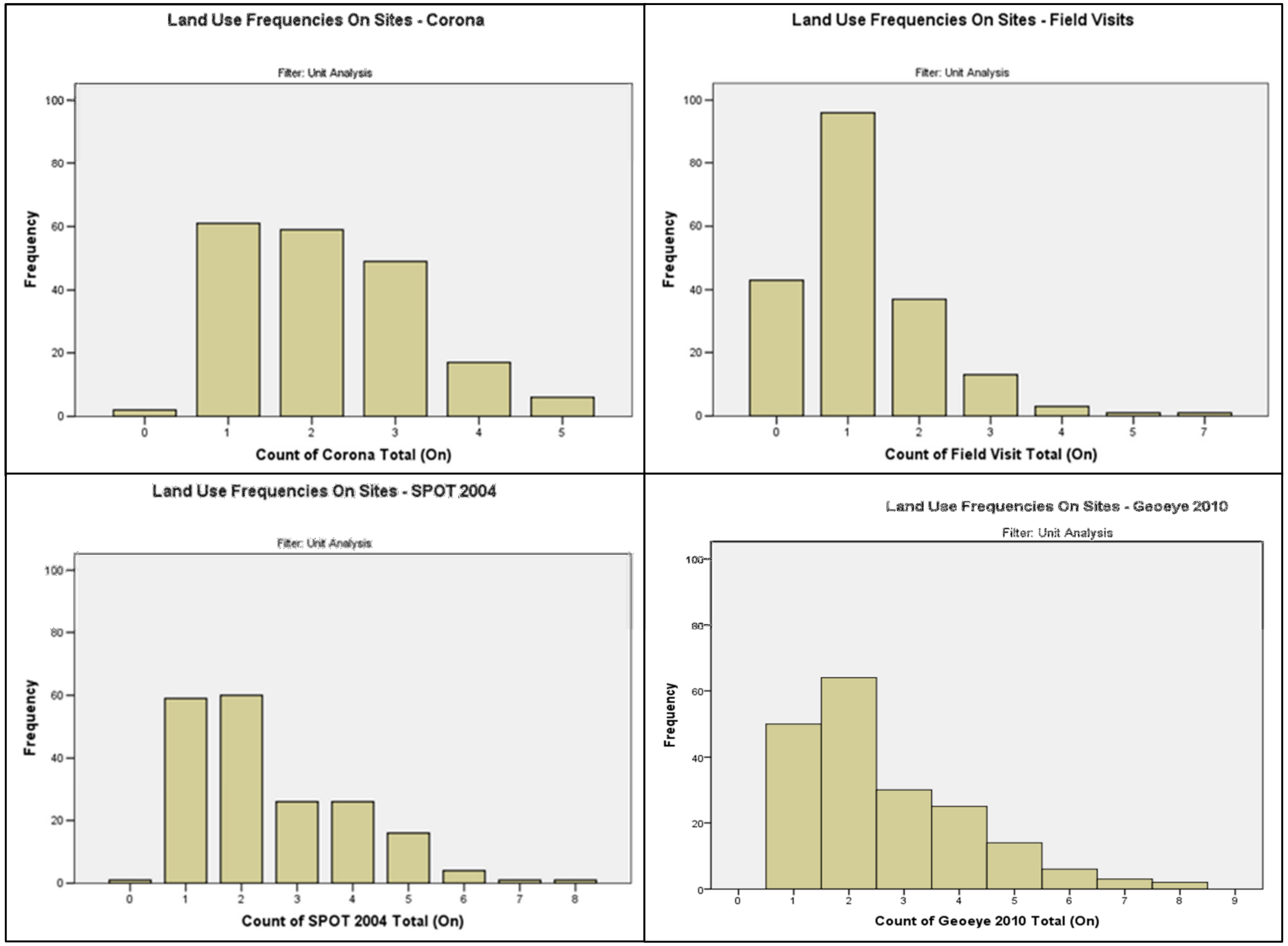


Table 6-6: Wilcoxon Signed Rank Test Results for Change in Land Use On Sites (Amalgamated Sites and Unit Analysis)

Wilcoxon signed rank test	Analysis	Z value	p value
Corona to SPOT 2004	Amalgamated Sites	-4.853	<0.000
Corona to Geoeye 2010	Amalgamated Sites	-5.537	<0.000
SPOT 2004 to Geoeye 2010	Amalgamated Sites	-3.611	<0.000
Corona to SPOT 2004	Unit Analysis	-2.943	0.003
Corona to Geoeye 2010	Unit Analysis	-4.072	<0.000
SPOT 2004 to Geoeye 2010	Unit Analysis	-4.169	<0.000

If we assume that a site under arable agriculture on all sets of examined imagery was probably also under agriculture at the time of the field visit, arable agriculture was most under-reported land use on field visits. This might be because the agriculture was intermittent – the practice of leaving the land fallow can leave gaps of several years between ploughings, therefore sites were only recorded as being under arable cultivation if they were visibly ploughed. (In the LCP area, many upland areas appeared to be uncultivated, but Corona image manipulation, such as the application of histogram equalise stretches, revealed abandoned fields).

Agriculture was reported on only 46% of mounds in field visits, but from the Corona and the Geoeye, the true total is somewhere between 70 – 90%, only slightly lower than the agriculture around mounds (c.95%). Roads and tracks were also under-reported in the site notes. Only 25 mounds were recorded as affected by a road or track. However, they are visible on 74 mounds on Corona, and on 99 mounds on Geoeye.

Land use on amalgamated sites which are bare or covered in scrub have hardly changed (totals = 66/57/62), but the number of individual mounds left bare or covered in low scrub has decreased from 101 on the Corona to 80 on the Geoeye –less than half the sites are now bare.

Single small built structures increased slightly between the Corona, the field visits, and SPOT and Geoeye, reflecting the general trend of increasing structures on and around sites. Modern settlement has expanded to cover only one mound which was not previously affected: this is not an area with a high settlement density. This is discussed in more detail in Section 6.7.1 -Development.

Much as they have around sites, water bodies have decreased from 35 on amalgamated sites on the Corona (32%) to 10 on SPOT or 12 on Geoeye (11%). This change is much more pronounced for individual mounds – 61 mounds appeared to have a water body present cutting into the mound on Corona (31%), dropping to 12 on SPOT and 15 (8%)

on Geoeye. Figure 6-24 shows TBS 8, a mound on the flood plain of the Wadi ‘Awaidj, on Corona and on Geoeye. The multiple wadi channels visible on Corona have been largely ploughed out, and the wadi itself now only flows in a deliberately dug, prescribed diversion channel.

On Corona only a quarter of amalgamated sites had more than 3 different land uses on them. No site had more than 5. By 2010, nearly half had 4 or more, and one site had 9 land uses on it. The pattern for the individual mounds is somewhat different. 2 mounds on Corona had no land uses marked – these were unclassified. Most mounds on Corona had less than 4 land types, but on Geoeye, 2 mounds had 8 land use types, demonstrating the increase. On Corona, mounds were most likely to have between 1 and 3 land use types, whereas on later imagery, 1 or 2 land use types were by far the most common.

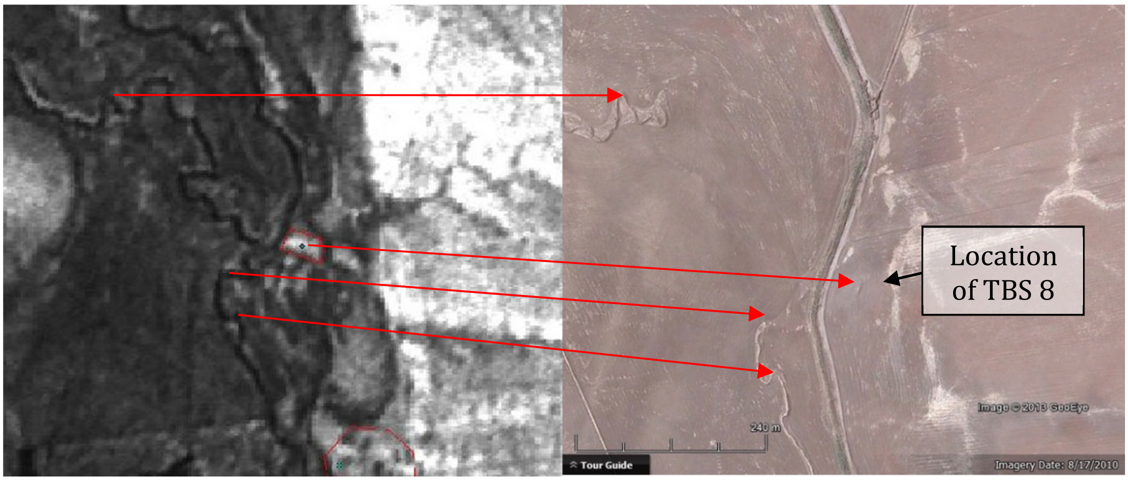


FIGURE 6-24: CHANGES IN THE WADI 'AWAIDJ AT TBS 8 ON CORONA AND GEOEYE[92]

Red arrows indicate the old channels of the Wadi ‘Awaidj on Corona (left), and the matching locations of remaining fragments of the wadi channel in 2010 (right). The black arrow indicates the man-made concrete diversion channel which prescribes the flow of the Wadi ‘Awaidj. The scales on the two images are not the same. The Corona image (left) shows slightly more of the landscape, to demonstrate the previous multiplicity of wadi channels, whilst the Geoeye image (right) shows how little of those channels remains around TBS 8.

The changing land use patterns reflect the increasing land uses on sites. In particular, the scale of the increase in counts of land use between the 1960s the 2010 reflects the intensification of landscape use. Sites and their component mounds are becoming part of an increasingly complex landscape.

[92] Left: Corona Image ,1102-1025df006, standard deviation stretch, 11 December 1967
Right: Geoeye Image, 17 August 2010. Taken from Google Earth 12 February 2013.

6.5.3 - *LAND USE AND SITE LOCATION*

Many of these changes in the landscape are linked to the location of the sites and to the smaller mounds rather than the amalgamated sites. Land use around sites was considered by comparing sites on the plains to sites elsewhere, and by comparing sites on the flood plains, wadi bottoms and wadi banks to sites elsewhere.

Amalgamated sites on the plains showed no statistically significant difference in the number of land uses around sites, but there is a difference for the unit mounds. Mounds on the plains in the 1960s had a significantly higher number of land uses than elsewhere. Fifty years later, there was little difference (Table 6-7).

TABLE 6-7: MANN-WHITNEY-U TEST RESULTS FOR DIFFERENCES IN TOTAL LAND USES AROUND SITES ON THE PLAINS AND ELSEWHERE

Imagery	Analysis Type	U	P	Mean Rank: On Plains	Mean Rank: Elsewhere
Corona	Amalgamated Sites	1247.5	0.274	57.20	50.72
SPOT 2004	Amalgamated Sites	1294.5	0.432	56.46	51.76
Geoeye 2010	Amalgamated Sites	1165.0	0.109	58.51	48.89
Corona	Unit Analysis	3268.0	0.004	105.86	82.36
SPOT 2004	Unit Analysis	3994.5	0.383	100.04	92.89
Geoeye 2010	Unit Analysis	3675.0	0.080	102.60	88.26

Recalculating the test excluding the wadis from the land use totals shows a statistically significant difference between both amalgamated sites and site units in all time periods in the total number of land use types around sites on the plains compared to sites elsewhere (Mann-Whitney-U Tests, Table 6-7). Sites on the plains had statistically significantly higher total numbers of land uses than elsewhere. There is no significant difference in the number of land uses around sites or site units on flood plains, wadi bottoms and wadi banks when compared to elsewhere. (The bodies of water which have given rise to the existence of the flood plains, wadi bottoms and wadi banks have been automatically excluded from this calculation as a distorting factor).

TABLE 6-8: MANN-WHITNEY-U TEST RESULTS FOR DIFFERENCES IN TOTAL LAND USES AROUND SITES ON THE PLAINS AND ELSEWHERE, EXCLUDING WADIS

Imagery	Analysis Type	U	P	Mean Rank: On Plains	Mean Rank: Elsewhere
Corona	Amalgamated Sites	987.0	0.004	66.33	44.93
SPOT 2004	Amalgamated Sites	955.5	0.003	61.83	44.23
Geoeye 2010	Amalgamated Sites	884.0	0.001	62.97	42.64
Corona	Unit Analysis	2494.0	<0.000	112.05	71.14
SPOT 2004	Unit Analysis	2780.5	<0.000	109.76	75.30
Geoeye 2010	Unit Analysis	2659.0	<0.000	110.73	73.54

Location plays an important part in the patterns of land use on sites, too. Amalgamated sites on the plains show no statistically significant differences in the numbers of land use types on sites compared to sites elsewhere (Mann-Whitney-U test, Table 6-9).

TABLE 6-9: MANN-WHITNEY-U TEST RESULTS FOR DIFFERENCES IN TOTAL LAND USES ON SITES ON THE PLAINS AND ELSEWHERE

Imagery	Analysis Type	U	P	Mean Rank: On Plains	Mean Rank: Elsewhere
Corona	Amalgamated Sites	1246.5	0.272	57.21	50.70
SPOT 2004	Amalgamated Sites	1263.0	0.327	56.95	51.07
Geoeye 2010	Amalgamated Sites	1173.0	0.122	58.38	49.07
Corona	Unit Analysis	4095.0	0.546	99.24	94.35
SPOT 2004	Unit Analysis	4184.0	0.723	96.47	99.36
Geoeye 2010	Unit Analysis	4244.5	0.851	98.04	96.51

However, there are statistically significant differences in the numbers of land uses on sites around water bodies (water bodies are not excluded here as few water bodies are actually on the sites themselves) (Table 6-10). Amalgamated sites and site units which are on flood plains, wadi bottoms and wadi banks on Corona show more land uses on the sites, compared to sites located elsewhere. This difference is less pronounced on later imagery: there is no statistical difference in land use counts on site units in these locations compared to elsewhere on later imagery.

TABLE 6-10: MANN-WHITNEY-U TEST RESULTS FOR DIFFERENCES IN TOTAL LAND USES ON SITES ON WADI BOTTOMS, WADI BANKS AND FLOOD PLAINS AND ELSEWHERE

Imagery	Analysis Type	U	P	Mean Rank: On Flood Plains, Wadis	Mean Rank: Elsewhere
Corona	Amalgamated Sites	1001.0	0.004	62.63	45.75
SPOT 2004	Amalgamated Sites	1101.5	0.026	60.83	47.68
Geoeye 2010	Amalgamated Sites	1127.0	0.040	60.38	48.17
Corona	Unit Analysis	3637.5	0.021	104.67	86.36
SPOT 2004	Unit Analysis	4238.5	0.506	95.42	100.73
Geoeye 2010	Unit Analysis	4116.0	0.320	94.38	102.34

This analysis confirms that the areas around wadis are the locations of greatest change. Once the plains were settled at the turn of the century, sites were quickly incorporated into the land use strategies around them, regardless of size. In areas like the flood plains, wadi banks and wadi bottoms, sites were often located at the margins of arable fields, but not incorporated into them, and roads led to fields, but not to the wadis. As time has passed, the wadis have ceased to flow and have been ploughed out, and as part of this, sites have also been incorporated into the fields, lessening the number of land types they are a part of directly, but reflecting the increasing activity around them. The floodplain land by the wadis, which was so distinctively visible on Corona, is now as likely to be farmed as any other area (for example Figure 6-47).

6.6 - DAMAGE ANALYSIS: GENERAL TRENDS

The list of potential sources of damage is discussed in Chapter 3.5 - Damage Threats to Sites (p46), and in Methodology Chapter 4.5.5 – Recording Change: Type and Extent of Damage (p144). At the level of the individual site, damage is ordered into primary, secondary, tertiary (etc.) damage, based on the relative Severity of the effect on a site (Chapter 4.5.5 -Ordering Damage, p147). The number of sources of damage increases as time passes (and often as resolution increases). Whilst some consideration will be given to the main (primary and secondary) causes of damage to sites, it is more valuable to consider the scale of extent of damage to sites, and the factors which affect it; therefore extents are collated according to how often they occur for analysis.

This section analyses general trends regarding damage to sites, distilled from the supporting tables in Appendix G. (Appendix F details how to read the tables, and what information is in each one). These trends are not related to specific causes of damage, but examine how damage manifests on sites, and what effects it has. Damage causes will then be examined separately in the following section, considering how much damage each threat causes, and what factors affect it in the Beydar region. As discussed in Section 4.4.5 - Damage Extent: Horizontal and Vertical, (p148), damage would ideally be calculated as a quantitative reduction in site volume or measured area, but this was not possible. Instead qualitative ordinal categories which could be consistently and accurately applied and analysed using non-parametric statistics were used.

6.6.1 – TOTAL DAMAGE CAUSES AND HEIGHT

<u>Number of Causes of Damage (Damage Threats):</u>

On the amalgamated sites analysis, a total of 213 causes of damage were recorded on Corona, 314 on SPOT 2004 and 333 on Geoeye 2010 (Table G-84) (including sites where the damage is Unknown). If the Unknown sites are excluded, the increase is even more apparent, as a greater number of sites were marked as Unknown on Corona. Excluding Unknown damage, 187 threats were recorded on Corona, 303 on SPOT, and 324 on Geoeye. In part, this reflects the increasing resolution of the later imagery. However, the physically small sources of damage which require higher resolution to see (cemeteries, mudbrick extraction pits, etc.) account for only half of the increase in causes of damage between the Corona and the Geoeye imagery (not including Unknown damage). The number of causes of damage is increasing, irrespective of resolution or size of damage extent.

This is even clearer on the Unit analysis: damage causes have increased from 326 on Corona to 461 on Geoeye, but only 50 of the damage causes are small pits which could not be seen on Corona, leaving an increase of 85.

Height:

Height (as discussed in Section 6.3.3) was recorded on 98 of the 108 amalgamated sites during the field visits (7 were recorded as flat sites on the field visits). By 2010, 64 still had definite height.

However, height was uncertain on 101 of the individual mounds, and it is these mounds where the damage may have been underestimated. Known remaining height does not equate with "no damage", but does mean at least part of the site is still preserved. In at least one case (which is discussed in Section 6.7.6 - Bulldozing, p262), a site was partially bulldozed from an original height of 6m to a new height of 3m. Height is still remaining, but the upper half of the site is destroyed.

6.6.2 – Horizontal Damage Trends

Horizontal Damage Extent Across the Site:

The extent of damage across the site is referred to as the horizontal damage extent, and is compared by imagery type / year of recording on Table G-38 and Table G-39, Appendix G. The distributions of horizontal extents for amalgamated sites and site units can be seen on Figure 6-25 and Figure 6-26 on the following page. The most common horizontal damage effect on the amalgamated sites was Sectional damage, affecting parts of 37% of sites on Corona and 45% on Geoeye (Table G-38).

The most common horizontal extent on the individual mounds on Corona (Table G-39) was Peripheral (affecting 29% of mounds and sites), but by 2010 it had increased to Sectional (affecting 36% of mounds). Individual mounds appear to have been largely unaffected (or at least only affected Peripherally) in the 1960s, but by 2010 Sections of at least 1 in 3 mounds are affected. This change is clearest on the graphs Figure 6-25 and Figure 6-26. Notably, on the Unit analysis Graph (Figure 6-26), the number of mounds with Total / Wholesale damage has increased compared to the Corona. Small mounds which were once ignored by the people living near them are now more likely to be Totally affected across the entire site.

(*The low Corona line for Peripheral damage on the graph may well be a factor of image resolution – smaller damage causes are harder to see).*

The total numbers of all damage extents have increased, and it is clear how much greater the damage extents are.

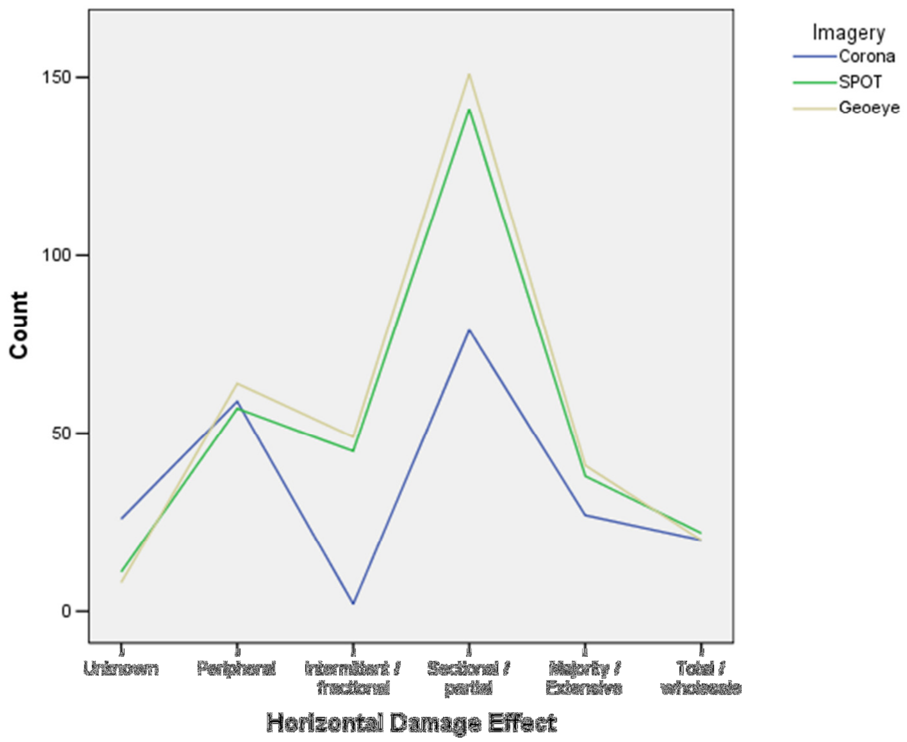


FIGURE 6-25: GRAPH OF EXTENT OF HORIZONTAL DAMAGE BY IMAGE (AMALGAMATED SITES)

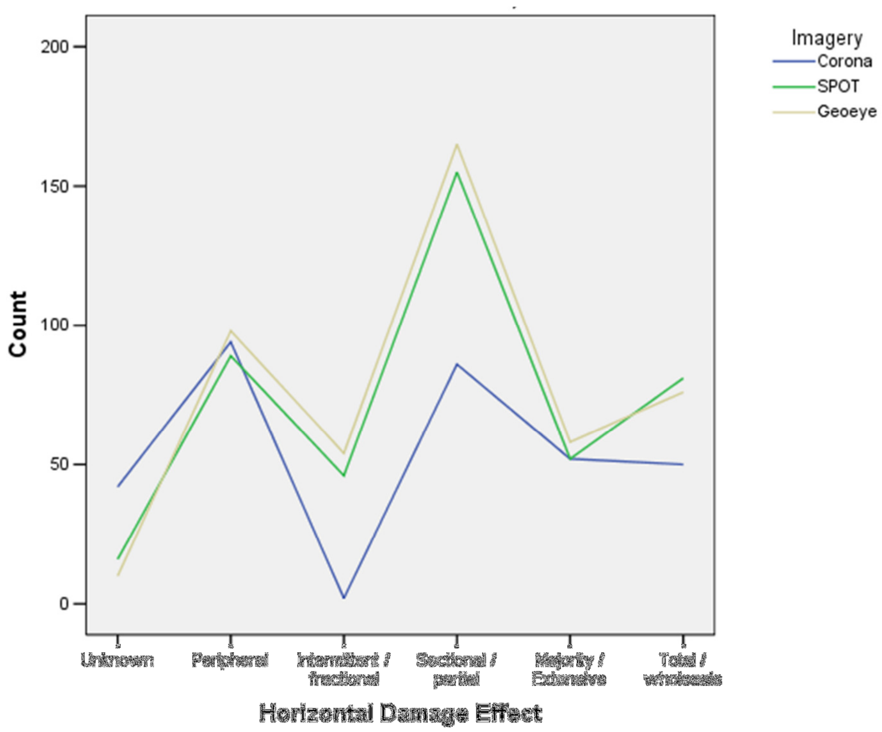


FIGURE 6-26: GRAPH OF EXTENT OF HORIZONTAL DAMAGE BY IMAGE (UNIT ANALYSIS)

Severity of Horizontal Damage:

When multiple damage causes are evident on a site, they are subjectively ordered according to which appears to have the greatest effect. The biggest threat is the primary damage; the next is the secondary damage, then tertiary damage, and so on. This is useful when considering individual site units, but in an overall analysis, all threats are combined. In order to simplify the analysis, in the majority of the ensuing discussions only the primary and secondary threats will be considered, therefore it is worth noting how much damage is caused on average.

For the individual mounds on Corona and on Geoeye (Appendix G, Table G-41 and Table G-45, respectively), primary damage threats are more likely to affect most or all of the site (Majority and Total). Secondary damage threats are more likely to affect the Periphery or a Section. However, as threats expanded over time to cover more of the site, Peripheral damage decreased - it was recorded on only 11 mounds on Geoeye, compared to 30 on Corona - and Sectional damage increased. By 2010, primary damage Totally affected more than 1 in 3 mounds.

Once the units are combined into amalgamated sites, on Corona and on Geoeye (Appendix G, Table G-40 and Table G-44, respectively) the primary and secondary damage causes are most likely to affect a Section: it is rare for the threat to disturb the entirety of the site.

Horizontal Extent and Site Location:

Appendix G, Table G-46 to Table G-51, contains counts of horizontal damage extent by site location. Unfortunately, due to the small numbers of sites in each location, it was not possible to discern any relationship between location and horizontal extent on any imagery type.

Horizontal Extent and Site Type:

Looking at the amalgamated site analysis, tells were the site type most likely to experience Peripheral damage (33 counts or 75% on Corona - Table G-52, Appendix G). Given their size and steepness, this is not surprising. By 2010 (Table G-56), 33 threats to tells still affected the Periphery, but this represented only 36% of threats to tells. The number of threats affecting Sections of tells rose from 7 to 34 as increased access to mechanisation has made it easier to affect larger sites. The pattern for individual units is similar.

On all imagery (Table G-52, Table G-54, and Table G-56, Appendix G), complexes of low mounds were most likely to have damaged Sections.

On Corona (Table G-53, Appendix G), individual low mounds were most likely to experience Sectional damage (almost 1 in 3). On Geoeye (Table G-57, Appendix G), whilst Peripheral threats to them have remained almost exactly the same, threats affecting a Fraction of low mounds have increased from 2 to 30; Sectional threats have increased from 73 to 123, and threats Totally affecting sites have increased from 48 to 71.

The horizontal extent is covering more of the sites over time, regardless of site type.

<u>Change Over Time of Horizontal Damage Extents:</u>

Many of the proportions, and some of the actual numbers, show little change over the fifty year study period, implying that the horizontal effects of the threats have remained steady. This is not the case. Table 6-11 and Table 6-12 on the following page examine whether each threat that was present in the 1960s still causes the same level of horizontal damage in 2010, or whether the increasingly worse threat effects are new threats. (For information on reading the tables, see Appendix F.2).

As seen in the tables, far more threats increase in horizontal extent over the study period than decrease. 91 threats to amalgamated sites have remained steady. The horizontal extent has increased for 63, and decreased for only 27 threats. (It should be noted that of the 27 threats which have decreased, 10 are a decrease from Total coverage: this is not a reduction in damage, but reflects the fact that multiple threats become apparent on the sites, necessitating multiple extents). The trend is the same in the Unit analysis table.

This is seen clearly on the Graphs in Section 6.7 (Figure 6-31 to Figure 6-36): they relate the horizontal effects of damage to cause, and demonstrate the change over time.

TABLE 6-11: CHANGE IN HORIZONTAL EFFECT FROM THE 1960S TO 2010 (AMALGAMATED SITES)

			Horizontal Effect (Geoeye 2010)						
			Unknown	Peripheral	Intermittent / fractional	Sectional / partial	Majority / Extensive	Total / wholesale	Total
Horizontal Effect (Corona)	Unknown	Count	5	5	1	9	4	1	25
		% within Horizontal Effect (Corona)	20.0%	20.0%	4.0%	36.0%	16.0%	4.0%	100.0%
	Peripheral	Count	0	13	9	32	1	1	56
		% within Horizontal Effect (Corona)	.0%	23.2%	16.1%	57.1%	1.8%	1.8%	100.0%
	Intermittent / fractional	Count	0	0	0	1	0	0	1
		% within Horizontal Effect (Corona)	.0%	.0%	.0%	100.0%	.0%	.0%	100.0%
	Sectional / partial	Count	1	1	4	55	13	3	77
		% within Horizontal Effect (Corona)	1.3%	1.3%	5.2%	71.4%	16.9%	3.9%	100.0%
	Majority / Extensive	Count	0	1	0	10	13	3	27
		% within Horizontal Effect (Corona)	.0%	3.7%	.0%	37.0%	48.1%	11.1%	100.0%
	Total / wholesale	Count	0	0	0	7	3	10	20
		% within Horizontal Effect (Corona)	.0%	.0%	.0%	35.0%	15.0%	50.0%	100.0%
Total		Count	6	20	14	114	34	18	206
		% within Horizontal Effect (Corona)	2.9%	9.7%	6.8%	55.3%	16.5%	8.7%	100.0%

Both numbers and percentages indicate change. The extents of damage in the 1960s form the rows, and the extents in 2009/10 form the columns. This can be read as follows: for example, on the Tell Beydar Amalgamated Sites Table 6.3, reading across the Peripheral Damage row (i.e. Corona), 13 amalgamated sites continued to experience peripheral damage on Geoeye (23.2% of sites which had experienced peripheral damage on Corona). A further 9 sites which had experienced peripheral damage on Corona now experience Intermittent damage in 2010 (16% of those who had experienced Peripheral damage), and so on. It should be noted that if a site experienced Total damage, i.e. damage all over the site, on Corona but no longer does on Geoeye, it is unlikely to be an improvement. For example, if a site was entirely covered by agriculture, but then an irrigation channel is built through it, it would initially be marked as Total extent, but this would then change to Majority extent for the agriculture and a Section extent would be added to reflect the Irrigation channel.

TABLE 6-12: CHANGE IN HORIZONTAL EFFECT FROM THE 1960S TO 2010 (UNIT ANALYSIS)

			Horizontal Effect (Geoeye 2010)						
			Unknown	Peripheral	Intermittent / fractional	Sectional / partial	Majority / Extensive	Total / wholesale	Total
Horizontal Effect (Corona)	Unknown	Count	7	7	1	15	5	6	41
		% within Horizontal Effect (Corona)	17.1%	17.1%	2.4%	36.6%	12.2%	14.6%	100.0%
	Peripheral	Count	1	29	10	36	1	7	84
		% within Horizontal Effect (Corona)	1.2%	34.5%	11.9%	42.9%	1.2%	8.3%	100.0%
	Intermittent / fractional	Count	0	0	0	1	0	0	1
		% within Horizontal Effect (Corona)	.0%	.0%	.0%	100.0%	.0%	.0%	100.0%
	Sectional / partial	Count	0	6	4	52	9	10	81
		% within Horizontal Effect (Corona)	.0%	7.4%	4.9%	64.2%	11.1%	12.3%	100.0%
	Majority / Extensive	Count	0	2	0	10	21	19	52
		% within Horizontal Effect (Corona)	.0%	3.8%	.0%	19.2%	40.4%	36.5%	100.0%
	Total / wholesale	Count	1	1	0	12	7	29	50
		% within Horizontal Effect (Corona)	2.0%	2.0%	.0%	24.0%	14.0%	58.0%	100.0%
Total		Count	9	45	15	126	43	71	309
		% within Horizontal Effect (Corona)	2.9%	14.6%	4.9%	40.8%	13.9%	23.0%	100.0%

6.6.3 – *Vertical Damage Trends*

Vertical Damage Extent Across the Site, and Severity of Damage:

The depth of damage to a site is described as the vertical damage extent, and is compared by imagery type / year of recording on Table G-58 and Table G-59, Appendix G. The distributions of vertical extents for amalgamated sites and site units can be seen on Figure 6-27 and Figure 6-28 on the following page. The Severity of the different extents is in Table G-60 to Table G-65, Appendix G.

Damage to the Upper Levels of a site is by far the most common vertical effect in all imagery analyses, and is the most common primary effect. This is partly because it is a 'catch-all' term. If very little is known about how deeply a site is damaged, then this is the minimum a site will be damaged. For example, if agriculture is suspected of heavily disturbing a site, but it cannot be confirmed, then only the lowest level of damage possible will be recorded – damage to the Upper Levels of a site – according to the principle of least damage (p161), so as not to overstate the damage. Nonetheless, it must be remembered that in some cases, it is likely to be worse. The damage patterns of depth are more or less the same over the last fifty years: there are simply more causes of damage present as time progresses. Small extents of damage, such as pitting, are also more visible on later images.

Vertical Extent and Site Location:

Appendix G, Table G-66 to Table G-71, contain counts of vertical damage extent by site location. Unfortunately, due to the small numbers of sites in each location, it was not possible to discern any relationship between location and horizontal extent on any imagery type.

Vertical Extent and Site Type:

It can be argued that their size renders large tells invulnerable to more serious damage. Examining them on Corona (Amalgamated sites Table G-72, Appendix G), large tells were equally likely to be subjected to threats which damaged their Upper Levels (22 instances), or to be only Slightly Degraded (17 instances). In only 3 cases did threats Heavily Degrade them (3 threats), supporting the argument. However, this no longer the case. By 2010 (Table G-76, Appendix G), damage to the Upper Levels was still the most common threat to tells (45 instances), but 4 threats Destroyed parts of tells To Ground Level, and 22 threats Heavily Degraded them.

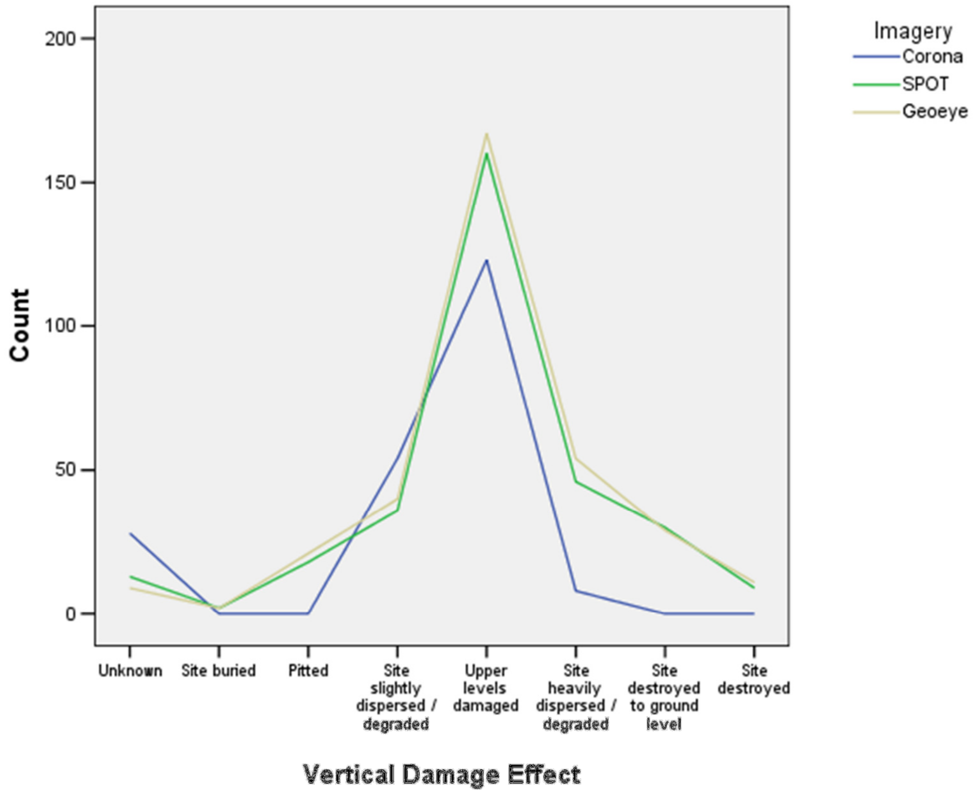


FIGURE 6-27: GRAPH OF VERTICAL DAMAGE EXTENT BY IMAGE (AMALGAMATED SITES)

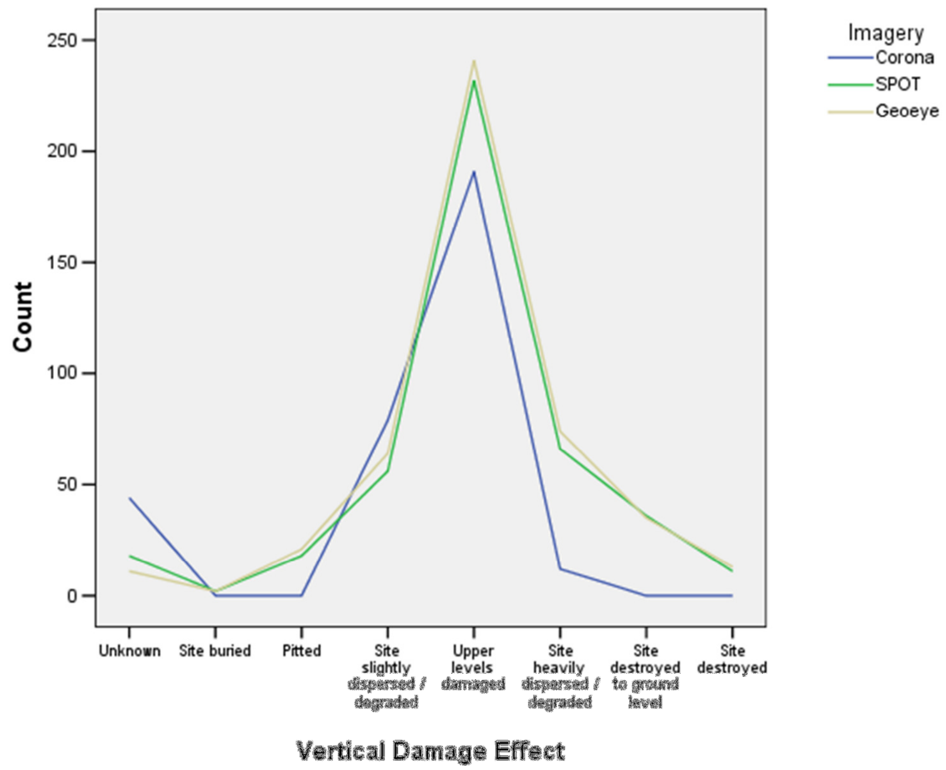


FIGURE 6-28: GRAPH OF VERTICAL DAMAGE EXTENT BY IMAGE (UNIT ANALYSIS)

On the Corona imagery almost a quarter of threats Slightly Degraded amalgamated low mounds, but damage was most likely to affect the Upper Levels (100 threats, 62%). Only 5 amalgamated groups of low tells had damage worse than this. However, by 2010, 60 threats did deeper damage which went beyond the Upper Levels of the site. As the individual site units are smaller, they are more vulnerable to these deeper threats – 6 mounds have been completely destroyed.

The pattern of destruction for the Unit analysis is very similar (Table G-73, Table G-75, and Table G-77, Appendix G).

Change Over Time of Vertical Damage Extents:

Although vertical extent is more strongly linked to the cause of the damage than the horizontal extent, which might suggest that existing threats are more likely to remain stable, there is still a clear trend in vertical damage extent increasing over time. This change is at the level of the individual damage threat. It is not just that new, more extensive threats are being recorded, but that threats present in the 1960s are getting worse (Table 6-13 and Table 6-14, following page).

When looking at the amalgamated sites, only 7 threats of 180 decreased (not including the extents which were Unknown on Corona). 93 threats remained the same, 80 increased in vertical extent, demonstrating the increasing damage to sites over time. These changes are also strongly pronounced for individual mounds. Of the 267 threats identified (excluding Unknown damage), 152 remained the same, but 99 increased, and only 16 lessened in extent.

This is seen clearly on the Graphs in Section 6.7 (Figure 6-37 to Figure 6-42): they relate the vertical effect to cause, and demonstrate the change over time.

TABLE 6-13: CHANGE IN VERTICAL EFFECT FROM THE 1960S TO 2010 (AMALGAMATED SITES)

			Vertical Effect (Geoeye 2010)								
			Unknown	Site buried	Pitted	Site slightly dispersed / degraded	Upper levels damaged	Site heavily dispersed / degraded	Site destroyed to ground level	Site destroyed	Total
Vertical Effect (Corona)	Unknown	Count	5	1	2	3	6	4	1	4	26
		% within Vertical Effect (Corona)	19.2%	3.8%	7.7%	11.5%	23.1%	15.4%	3.8%	15.4%	100.0%
	Site slightly dispersed / degraded	Count	0	0	0	12	23	11	4	0	50
		% within Vertical Effect (Corona)	.0%	.0%	.0%	24.0%	46.0%	22.0%	8.0%	.0%	100.0%
	Upper levels damaged	Count	1	0	1	3	76	18	20	4	123
		% within Vertical Effect (Corona)	.8%	.0%	.8%	2.4%	61.8%	14.6%	16.3%	3.3%	100.0%
	Site heavily dispersed / degraded	Count	0	0	0	0	2	5	0	0	7
		% within Vertical Effect (Corona)	.0%	.0%	.0%	.0%	28.6%	71.4%	.0%	.0%	100.0%
Total		Count	6	1	3	18	107	38	25	8	206
		% within Vertical Effect (Corona)	2.9%	.5%	1.5%	8.7%	51.9%	18.4%	12.1%	3.9%	100.0%

TABLE 6-14: CHANGE IN VERTICAL EFFECT FROM THE 1960S TO 2010 (UNIT ANALYSIS)

			Vertical Effect (Geoeye 2010)								
			Unknown	Site buried	Pitted	Site slightly dispersed / degraded	Upper levels damaged	Site heavily dispersed / degraded	Site destroyed to ground level	Site destroyed	Total
Vertical Effect (Corona)	Unknown	Count	7	1	2	2	14	6	6	4	42
		% within Vertical Effect (Corona)	16.7%	2.4%	4.8%	4.8%	33.3%	14.3%	14.3%	9.5%	100.0%
	Site slightly dispersed / degraded	Count	0	0	1	23	29	14	4	0	71
		% within Vertical Effect (Corona)	.0%	.0%	1.4%	32.4%	40.8%	19.7%	5.6%	.0%	100.0%
	Upper levels damaged	Count	2	1	1	8	124	25	21	5	187
		% within Vertical Effect (Corona)	1.1%	.5%	.5%	4.3%	66.3%	13.4%	11.2%	2.7%	100.0%
	Site heavily dispersed / degraded	Count	0	0	0	0	3	5	1	0	9
		% within Vertical Effect (Corona)	.0%	.0%	.0%	.0%	33.3%	55.6%	11.1%	.0%	100.0%
Total		Count	9	2	4	33	170	50	32	9	309
		% within Vertical Effect (Corona)	2.9%	.6%	1.3%	10.7%	55.0%	16.2%	10.4%	2.9%	100.0%

For a description of how to read the table, please see the corresponding horizontal damage table on p224, or Appendix F.5.6.2, p516.

6.6.4 - *The Relationship Between Horizontal and Vertical Damage Extents*

The relationship between horizontal and vertical extent is displayed in Table G-78 to Table G-83, Appendix G. These tables were created to investigate whether any relationship between horizontal damage and vertical damage existed, to see if any particular damage extent was more likely to be associated with any other damage extent at any given time, and whether that relationship was likely to change. However, it was discovered that the category Upper Levels Damaged was so prevalent that it skewed the data to the point where no other pattern was evident. This was a particular problem on the Corona data, but it also skewed the data collected from the Geoeye imagery.

In general, it can be said that less extensive threats in one direction were more likely to be associated with less extensive threats in the other direction. For example, Peripheral threats were more likely to Slightly Degrade sites or damage the Upper Levels. Correspondingly, threats that Slightly Degraded sites were more likely to damage the Periphery or a Section of the site. Threats which damaged the Upper Levels of sites were so prevalent that they affected all horizontal extents. Very few of the more extensive vertical damages (i.e. Site Destroyed to Ground Level, and Site Destroyed) affected the entire horizontal extent of the site: these were more likely to affect Sections of the site. This is important, as it means that even the most destructive threats to sites may leave some of the site intact: it is rare for sites to be destroyed in their entirety.

6.6.5 - *Most Affected and Unaffected Sites*

In total, 2 amalgamated sites were Totally Destroyed to Ground Level by 2010, and 8 mounds (Table G-82 and Table G-83, Appendix G). It is possible that they have been completely destroyed, but due to the changing ground levels, excavation would be required to confirm this. The Majority of a further 2 amalgamated sites / mounds were Destroyed to Ground Level.

Imagery cannot definitively be used to state whether a site has suffered no man-made damage: such instances are recorded as Unknown, the same as sites which cannot be seen clearly. By 2010, on the highest resolution imagery available, only 8 amalgamated sites (10 mounds) had Unknown damage – about 5%. Of those, most were sites located on the basalt plateau and which were not visible. (They are suspected to have been destroyed – see the case study of sites on the Hemma plateau, Section 6.9.1, p275). Only 2 sites appeared to be relatively undamaged, although as the original descriptions were vague, this cannot be said with certainty.

6.7 - Damage Effects: Analysis of Damage Sources

This section analyses the individual causes of damage to sites, as identified from the imagery and the field visits. The following pages display the most important tables and graphs relating to damage causes. Table 6-15 (following page) displays total counts of each damage cause. The predominance of damage causes for the Amalgamated sites analysis is displayed graphically on Figure 6-29, and the predominance of damage causes in the Unit analysis is displayed graphically on Figure 6-30. The relationship between horizontal damage extent and cause on each imagery type is displayed on graphs in Figure 6-31 to Figure 6-36. The relationship between vertical damage extent and cause on each imagery type is displayed on graphs in Figure 6-37 to Figure 6-42.

The information presented in these tables and graphs is supported by a number of tables in Appendix G:

- Table G-84 and Table G-85 count the total number and percentage of each damage cause on the three imagery types for amalgamated sites and site units
- Table G-86 to Table G-91 display counts and percentages for each damage cause by Severity of threat
- Table G-92 to Table F-97 display damage causes by location
- Table F-98 to Table G-103 display the damage causes in relation to site types.
- Table G-104 to Table G-109 display the relationships between damage cause and horizontal damage extent, and Table G-110 to Table G-115 display the relationships between damage cause and vertical damage extent.

To avoid excessive repetition, these tables will only be referred to by their numbers in the rest of the discussion, rather than their full location.

Each threat is discussed according to an analysis of prevalence, extent and relationship to key factors, such as site type of location.

TABLE 6-15: COUNT OF SITES AFFECTED BY EACH DAMAGE CAUSE

	Amalgamated Sites	% of 108	Sub Units	% of 194
Arable Agriculture	98	90.7%	174	89.7%
Bulldozing	21	19.4%	25	12.9%
Cuts	4	3.7%	4	2.1%
Development	54	50.0%	68	35.1%
Dumping Pits	0	0.0%	0	0.0%
Grave Pits	26	24.1%	26	13.4%
Irrigation Channels	19	17.6%	23	11.9%
Looting	1	0.9%	1	0.5%
Military Damage	0	0.0%	0	0.0%
Mudbrick Pits	18	16.7%	18	9.3%
Natural Erosion	2	1.9%	3	1.5%
Orchards	16	14.8%	16	8.2%
Pits (Other)	3	2.8%	3	1.5%
Quarries	0	0.0%	0	0.0%
Railway	0	0.0%	0	0.0%
Roads / Tracks	72	66.7%	109	56.2%
Visitor Erosion / Vandalism	1	0.9%	1	0.5%
Water Erosion	15	13.9%	21	10.8%
Unknown	28	25.9%	44	22.7%

Whilst no source of damage is recorded more than once per site, each site can be affected by multiple sources of damage (that is, multiple buildings on a site would only be recorded once as a threat from development, but the site could also be threatened by a road and an orchard). Many of the identified damage threats are related – for example development can serve an agricultural purpose, such as the building of a storage facility to house agricultural machinery or crops. It is important to remember that most of the damage types listed are man-made threats, and are far greater than many natural threats. Whilst each threat is presented separately here, in reality they are interrelated. Arable agriculture, for example, causes erosion, and is correlated with increasing development and new roads. For ease of analysis, however, each threat is discussed as if it were isolated.

FIGURE 6-29: GRAPHS OF FREQUENCY OF DAMAGE SOURCES BY IMAGE (AMALGAMATED SITES)

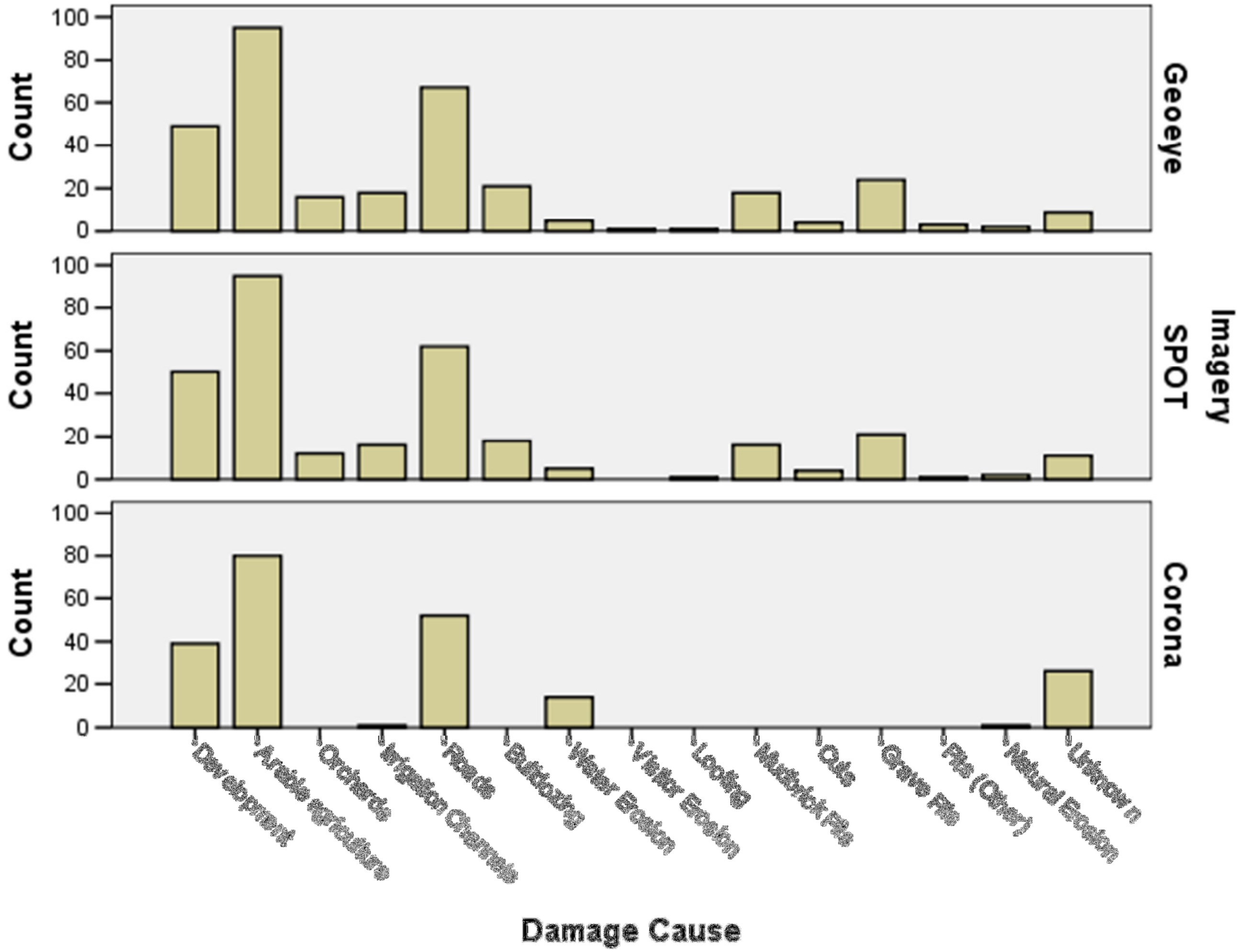


FIGURE 6-30: GRAPHS OF FREQUENCY OF DAMAGE SOURCES BY IMAGE (UNIT ANALYSIS

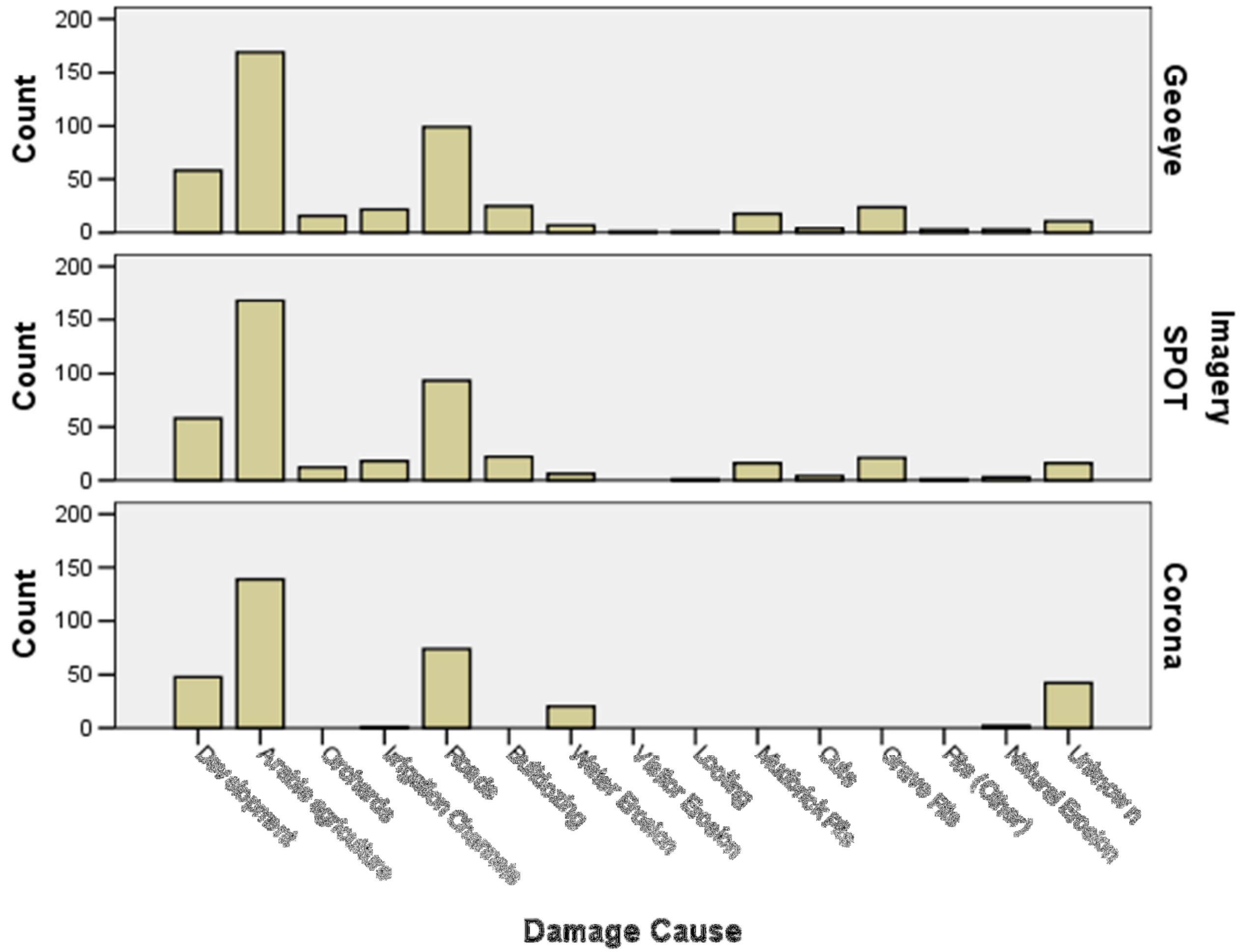


FIGURE 6-31: GRAPH OF HORIZONTAL EXTENT OF DAMAGE BY CAUSE (CORONA) (AMALGAMATED SITES)

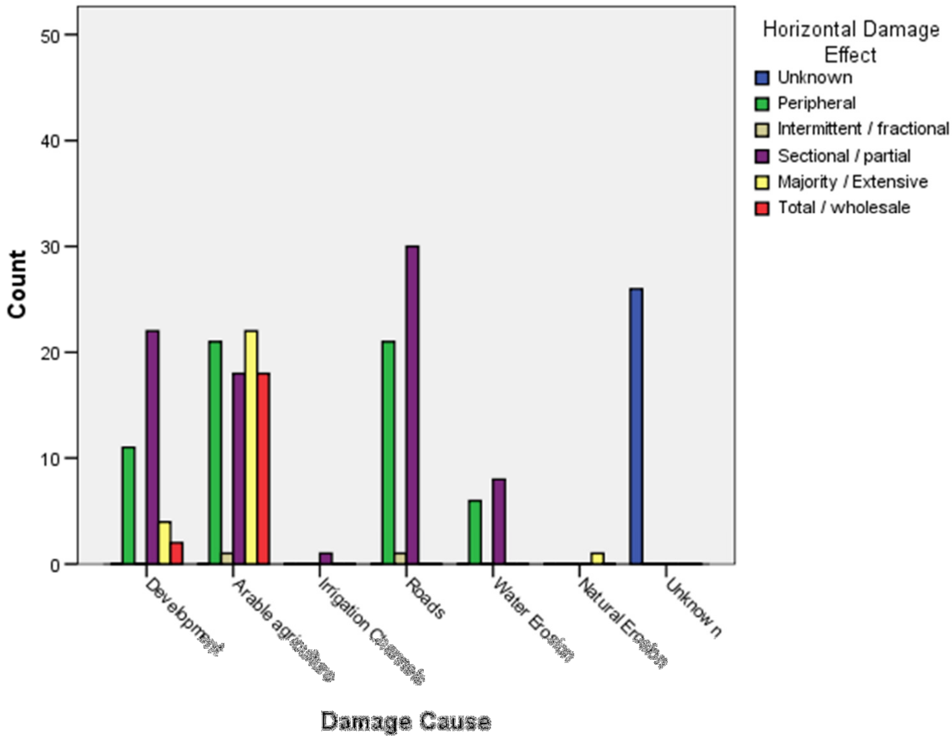


FIGURE 6-32: GRAPH OF HORIZONTAL EXTENT OF DAMAGE BY CAUSE (SPOT 2004) (AMALGAMATED SITES)

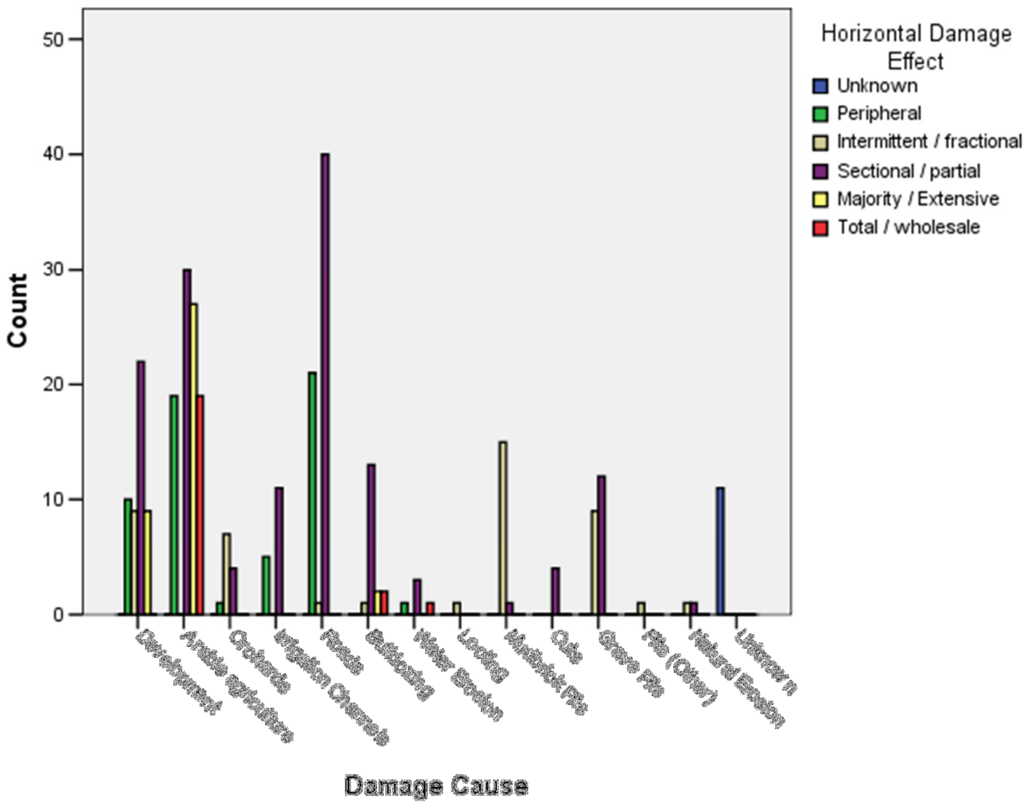


FIGURE 6-33: GRAPH OF HORIZONTAL EXTENT OF DAMAGE BY CAUSE (GEOEYE 2010) (AMALGAMATED SITES)

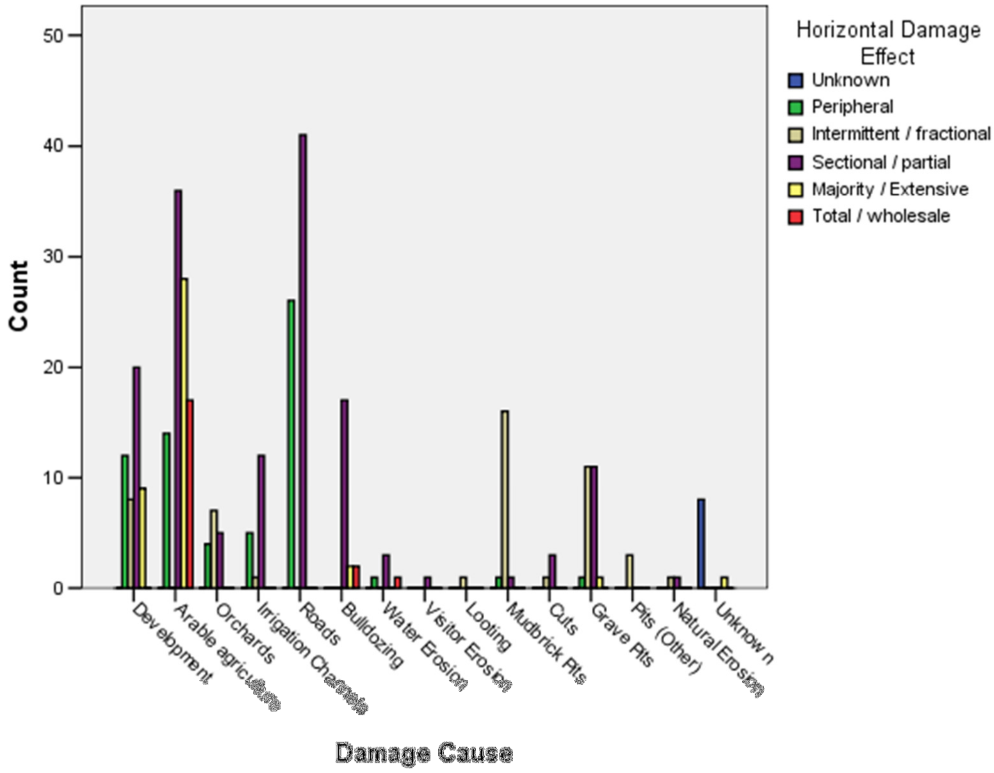


FIGURE 6-34: GRAPH OF HORIZONTAL EXTENT OF DAMAGE BY CAUSE (CORONA) (UNIT ANALYSIS)

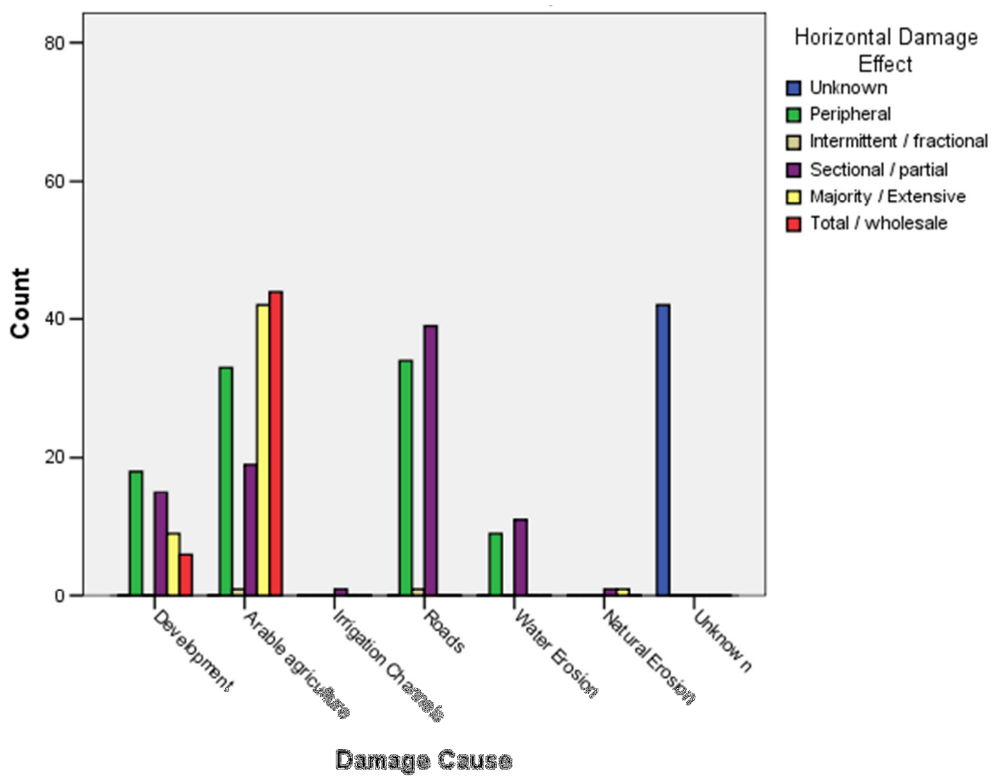


FIGURE 6-35: GRAPH OF HORIZONTAL EXTENT OF DAMAGE BY CAUSE (SPOT 2004) (UNIT ANALYSIS)

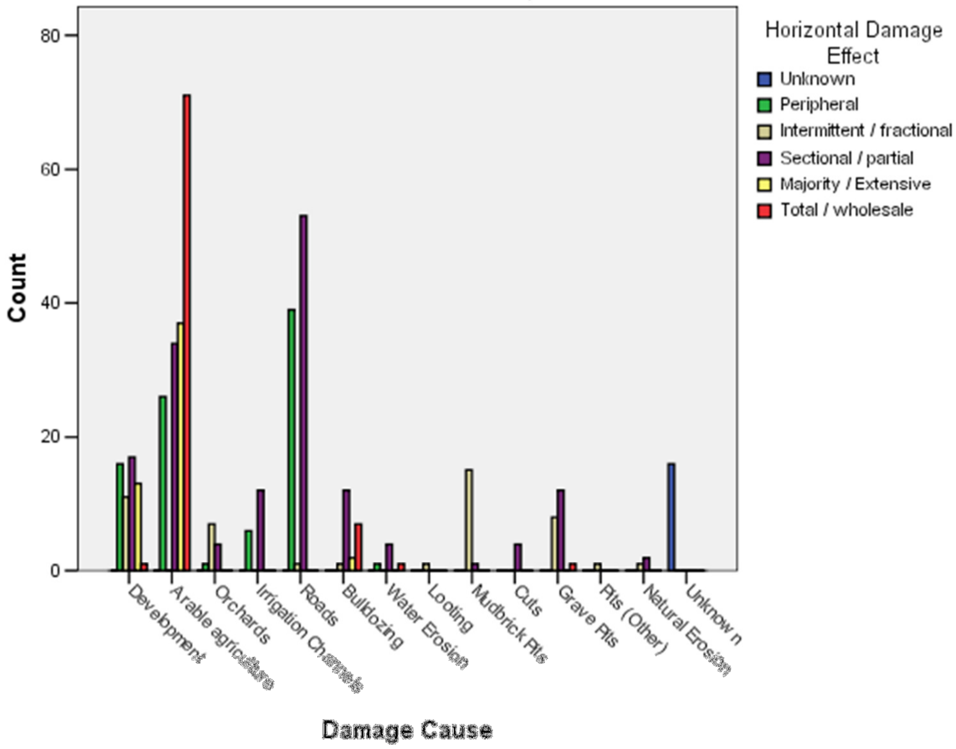


FIGURE 6-36: GRAPH OF HORIZONTAL EXTENT OF DAMAGE BY CAUSE (GEOEYE 2010) (UNIT ANALYSIS)

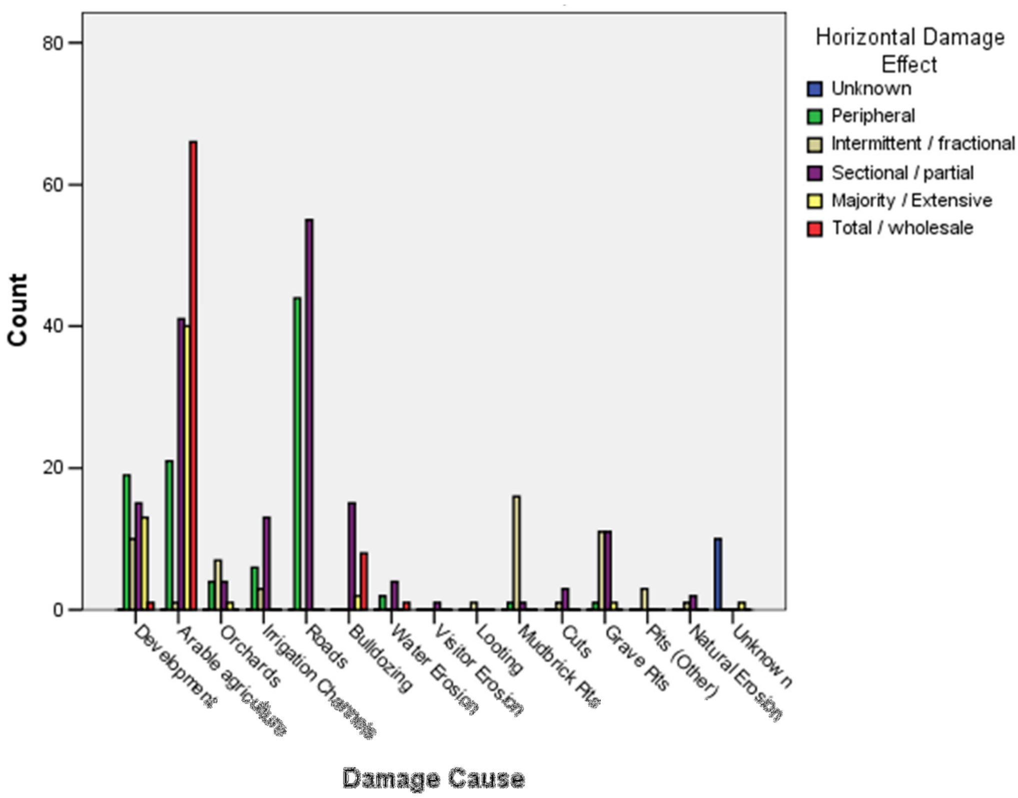


FIGURE 6-37: GRAPH OF VERTICAL EXTENT OF DAMAGE BY CAUSE (CORONA) (AMALGAMATED SITES)

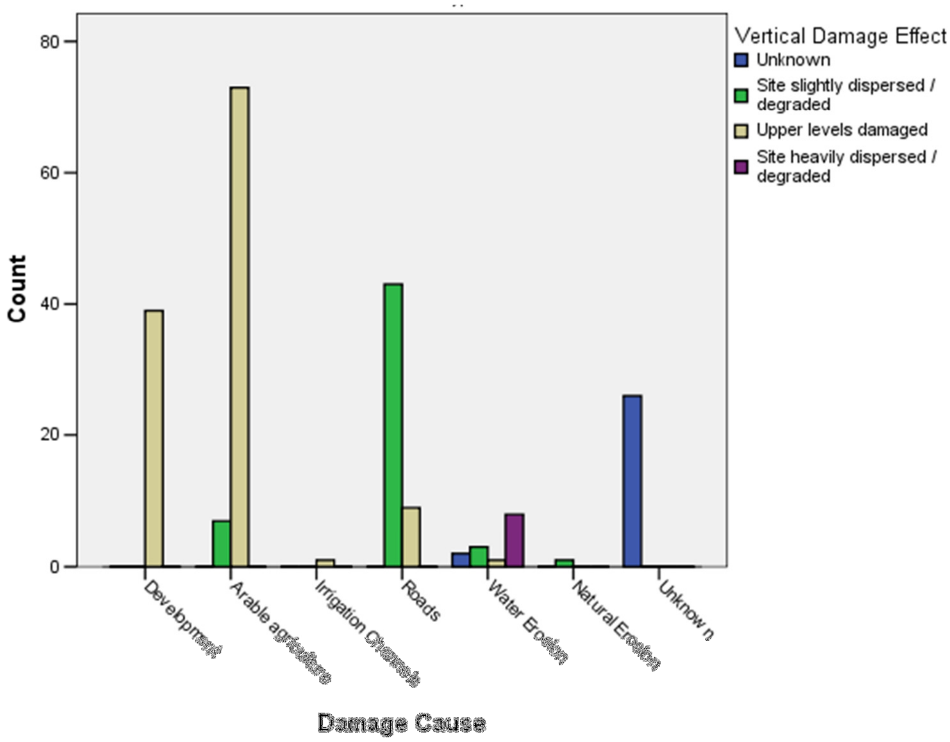


FIGURE 6-38: GRAPH OF VERTICAL EXTENT OF DAMAGE BY CAUSE (SPOT 2004) (AMALGAMATED SITES)

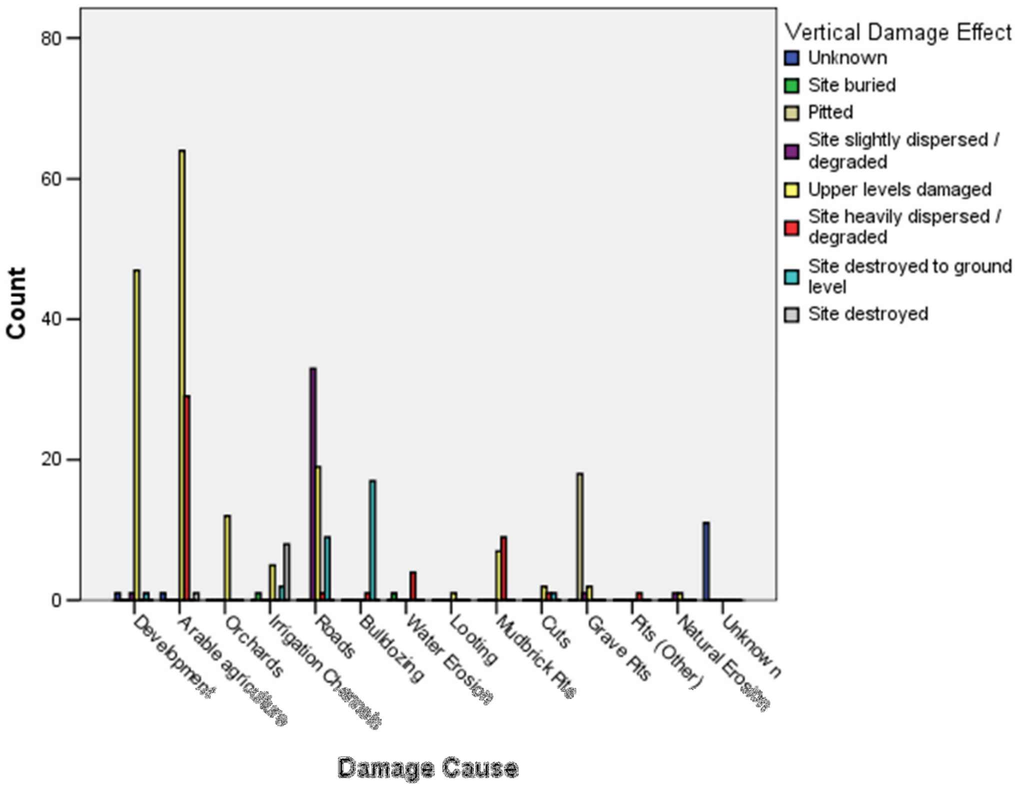


FIGURE 6-39: GRAPH OF VERTICAL EXTENT OF DAMAGE BY CAUSE (GEOEYE 2010) (AMALGAMATED SITES)

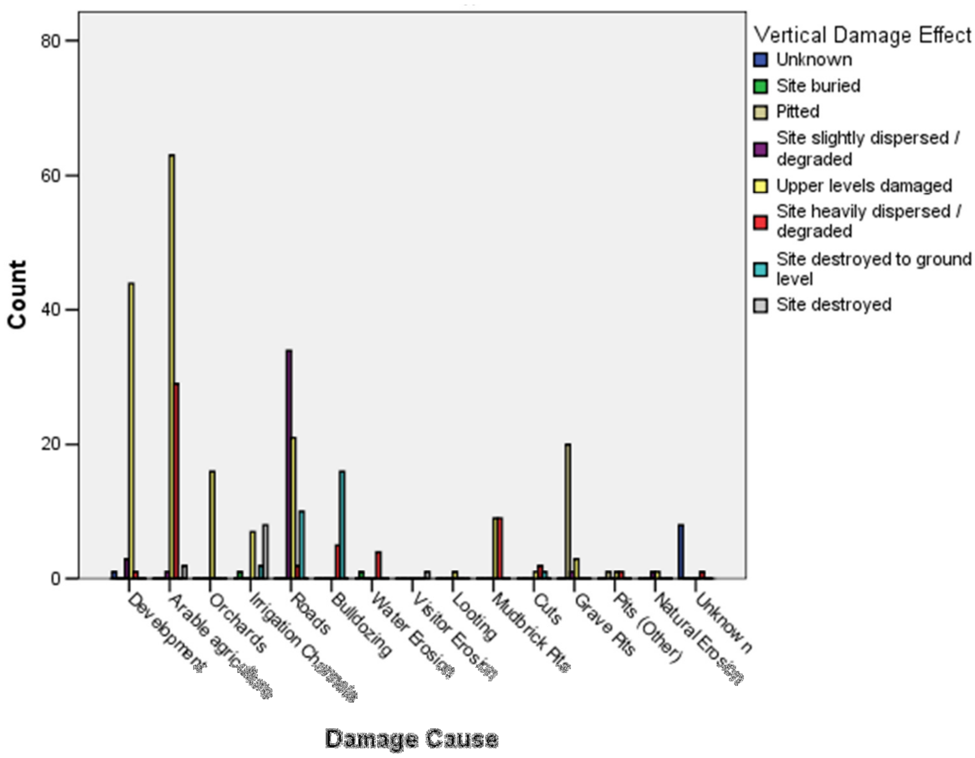


FIGURE 6-40: GRAPH OF VERTICAL EXTENT OF DAMAGE BY CAUSE (CORONA) (UNIT ANALYSIS)

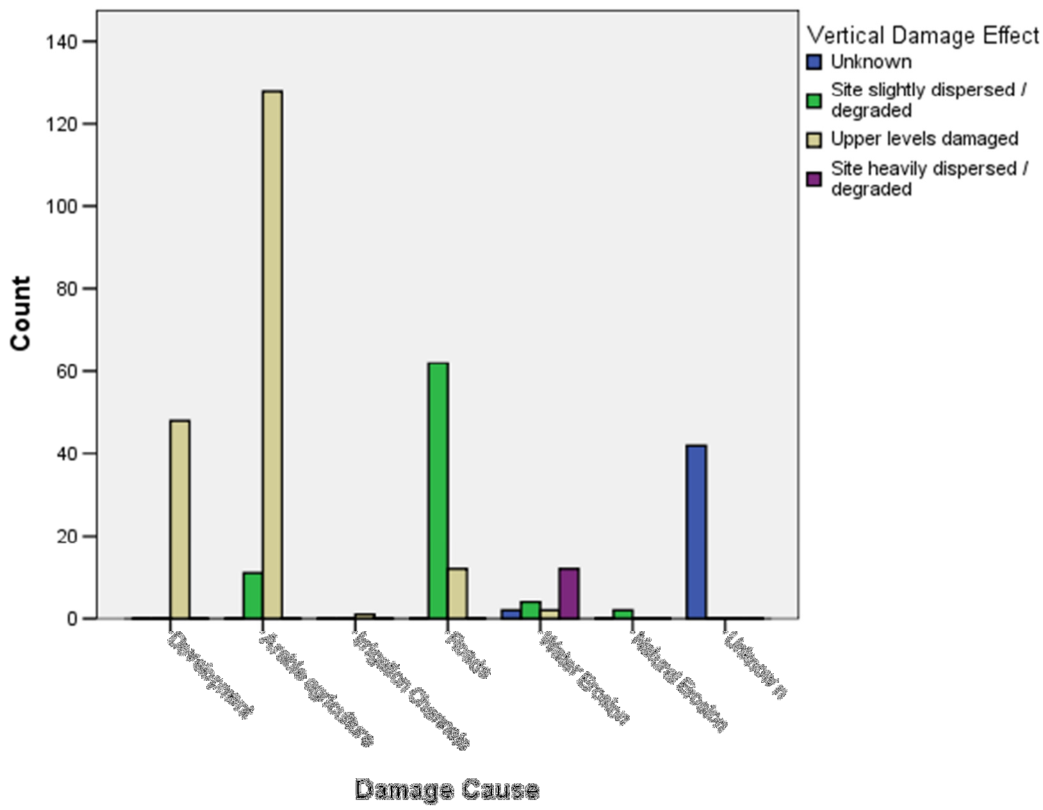


FIGURE 6-41: GRAPH OF VERTICAL EXTENT OF DAMAGE BY CAUSE (SPOT 2004) (UNIT ANALYSIS)

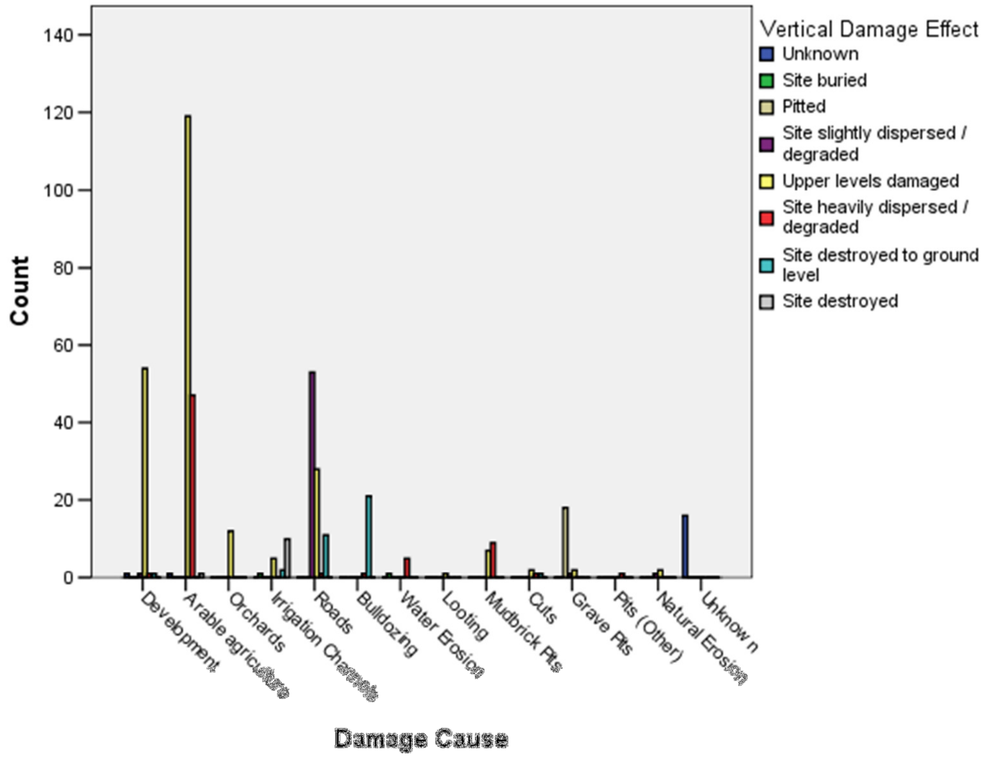
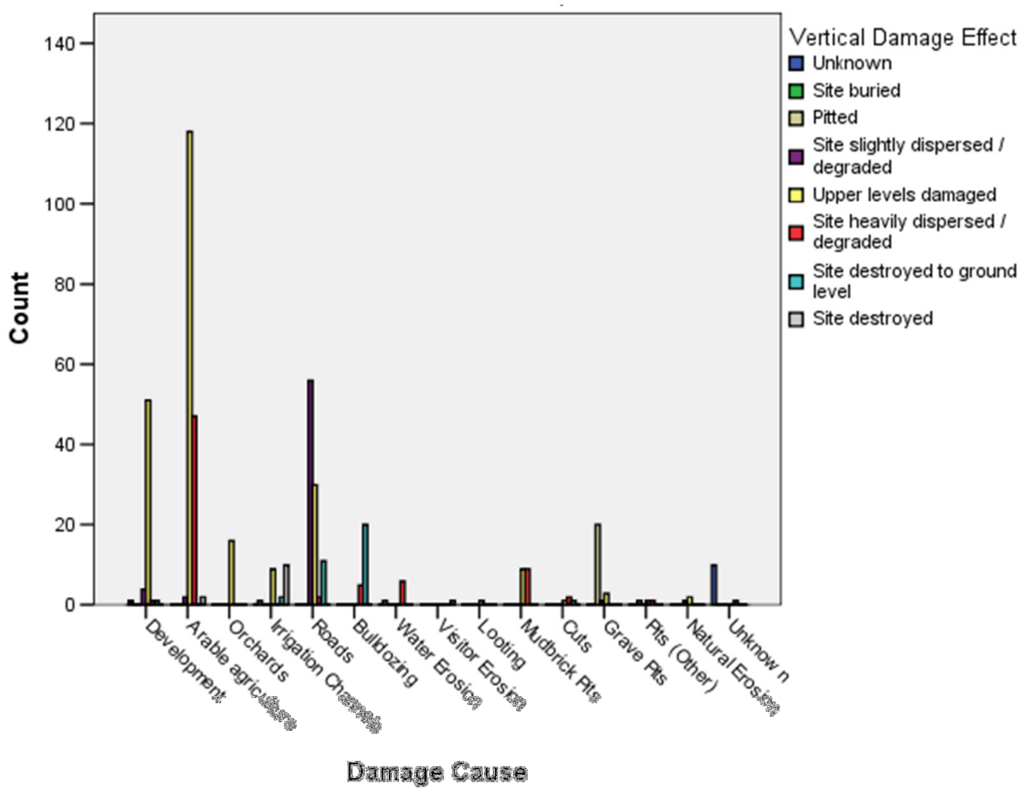


FIGURE 6-42: GRAPH OF VERTICAL EXTENT OF DAMAGE BY CAUSE (GEOEYE 2010) (UNIT ANALYSIS)



6.7.1 - *Development*

The threat of development is discussed in Chapter 3.5.1, p46. New villages are often situated next to or on existing mounds, therefore smaller outlying mounds or sections of larger mounds can be destroyed by the creation of modern villages and their spread over time. This is why the percentages of individual mounds affected by development are smaller than the percentages of amalgamated sites affected by development – the creation and expansion of villages rarely affects the entirety of a site. However, over time land use patterns have changed, and many villages have been abandoned. This may be a response to the on-going drought, which has seen thousands of people leave the Jazirah for the cities (Sands 2011). Yet even by the time of the field visits in the late 1990s, villages were reported as abandoned, and some villages which were reported during the field visits have clearly been bulldozed and turned to fields by 2004. For example TBS 56 was visible on the Corona imagery next to a village (Figure 6-43). In the field visits, the site was apparently located in a very large area that was ploughed as one field. It was heavily ploughed, with low visibility: there was no mention of the village. On the SPOT imagery (Figure 6-44), the village was gone, leaving only a crop mark. By 2010, even the crop mark appeared to be gone, and the site could not be located on imagery. Given the low visibility reported during the field visit due to the crop cover, this is not surprising.

The location of the site and ownership of said location is key to the state of the site. For example, TBS 42 consists of several mounds which were clearly evident on Corona with a small village on them (Figure 6-45). At some point before the field visits, a road bisected the site, and the field visit notes record the main mound as having "low foundations of recent village". No trace, not even a crop or soil mark, remains of the part of the site north of the road, which presumably has a different owner to the part to the south. The plough lines are neat and straight and show no sign of being disturbed by buried archaeological material, or of having had to plough over an uneven / non-flat surface. The southern part of the site, on the other hand, shows up as a distinctive soil colour on SPOT, and the plough lines visible on Geoeye clearly indicate something which had to be ploughed separately, suggesting height (Figure 6-46). However, it is fairly safe to say that even if this part of the site has not been bulldozed, very little remains of the village, most of the foundations have been ploughed away. Correspondingly, a plough strong enough to remove wall foundations will certainly have damaged at least the Upper Levels of a nearby archaeological site.

The fluctuations in developments reflect changing agricultural systems, as well as changing settlement practices, and variations in the local and national environment. In particular, several pump houses were reported during the field visits: only their remains can be seen on Geoeye. Figure 6-47, for example, shows the remains of a pump house on TBS 18, and a small structure built next to it. Presumably the pump houses have gone out of use as people are forced to rely more on irrigation channels from the Hasseke Dam and new wells are drilled. Pumps may have dried up as there is less ground water to pump (see Section 5.4, p175) due to the drought and to the decreased water flow coming from Turkey after new dams were built.

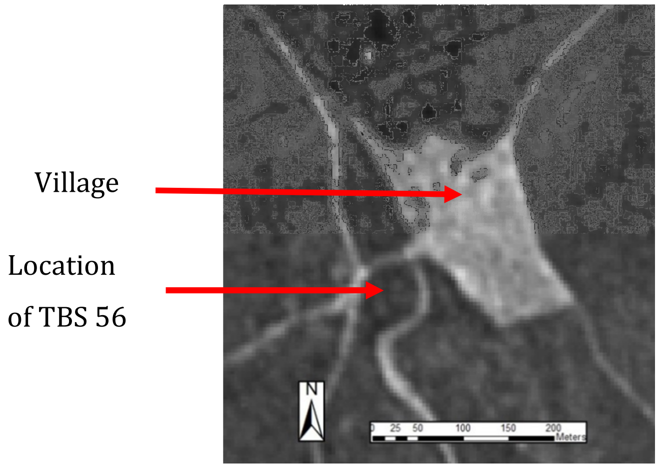


Figure 6-43: Village by TBS 56 in 1965[93]

Figure 6-44: Location of TBS 56 and Village on SPOT (left) and Geoeye (right)[94]

[93] Corona Image, 1021-2120df008-5_37n, 18 May 1965

[94] Left: SPOT Image, 31 December 2004 (?). Right: Geoeye Image, 23 June 2010. Taken from Google Earth 20 April 2012

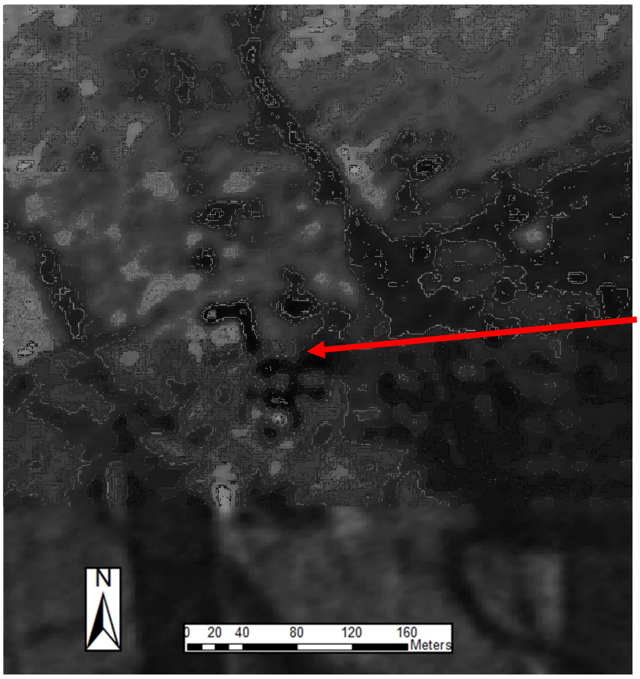


FIGURE 6-45: VILLAGE ON TBS 42[95]

(For a more detailed drawing of the village, see Appendix B, Figure B-5, p468)

FIGURE 6-46: TBS 42 ON SPOT AND GEOEYE[96]

The village was present in 1967 (red arrow): it was clearly abandoned in 2004, and was turned to a ploughed field by 2010.

[95] Corona Image, 1102-1025DF006-1_37N, 09 December 1967
[96] Left: SPOT Image, 31 December 2004 (?). Right: Geoeye Image, 23 June 2010. Taken from Google Earth 20 April 2012

FIGURE 6-47: THE ABANDONMENT OF A PUMP HOUSE (INDICATED BY THE RED BOX) AT TBS 18[97]

TBS 18 is visible on the edge of the Wadi 'Awaidj on Corona (left). The deposited wadi silts are the dark soil on the lower half of the image. The site is still faintly visible on SPOT (outlined in red) (Centre), but a pump house was located on the site, abandoned by 2004 when the image was taken. Only a slight soil discolouration, the remains of ploughed out wadi silt, marks the location of the site on Geoeye (right) (indicated by the black arrow).

Prevalence of Development:

In total, development was recorded on 54 sites (50% of amalgamated sites – Table 6-15), or 68 units (35%). This is substantially less than the percentage for the total number of sites, and is therefore lowered by the inclusion of the individual small mounds which are otherwise grouped. Most small mounds are not affected by development.

Overall, development is the third most common type of damage to both amalgamated sites (Table 6-15) and individual site units. This pattern was consistent across all imagery periods (Table G-84 and Table G-85). There were 39 counts of development to amalgamated sites on Corona, and 48 counts affecting individual units. This increased to 49 counts affecting amalgamated sites on Geoeye, and 58 affecting individual units.

On the Corona imagery, it accounts for over a quarter of primary damage to amalgamated sites (Table G-86) and almost a fifth of primary damage to individual site units (Table G-87). It is the joint second most common primary damage on Geoeye (Table G-90), accounting for almost a fifth of primary damage to amalgamated sites,

[97] Left: Corona Image, 1102-1025DF006-1_37n, 09 December 1967. Middle: SPOT Image, 31 December 2004 (?). Right: Geoeye Image, 23 June 2010. Taken from Google Earth 20 April 2012

and the second most common primary damage threat to individual site units (Table G-91).

An increasing number of amalgamated sites were affected by development, but a decreasing percentage: this is a reflection of the increasing amount of damage recorded. The majority of these are settlements, but some are single built structures (recorded in Section Of the individual units, 119 have stayed the same, 34 have become less visible, and 41 have improved in visibility, presumably because of the higher resolution of Geoeye. In general, however, the probability of finding a site today which was visible on Corona is just over half (0.55) for amalgamated sites, and not even that for site units (0.48) (using Geoeye as the most recent imagery as the proxy for today). Although most damage occurred prior to 2004, the fact that the visibility of some sites is decreasing suggests that these may be the sites which have been damaged in the last decade: the landscape continues to change and that damage to sites is on-going.

6.5 - Land Use / Land Cover). 3 single structures were visible on Corona; on SPOT 15 were recorded, and 13 were recorded on Geoeye.

The increase in small single structures is particularly well illustrated at TBS 58 (Figure 6-48). Although the site is not visible on SPOT, and is only faintly visible on Geoeye, the rapid increase in buildings is clear.

FIGURE 6-48: INCREASING DEVELOPMENT AT TBS 58[98]

The site is not easily visible on satellite imagery: its location is indicated by the red GPS point.

[98] Left: SPOT Image, 31 December 2004 (?). Right: Geoeye Image, 23 June 2010. Taken from Google Earth 20 April 2012

Development and Site Type:

In the 1960s a quarter of large tells were affected by development, reflecting the tradition of building in previously occupied areas. However, development mostly affected small low mounds: 72% of development was on or around amalgamated low mounds (although this may simply be a reflection of the larger number of them) (Table F-98). When all the individual mounds are counted, 75% of development affected low mounds.

In 2010 (Table G-103), only 16% of the damage to tells was caused by development: approximately 25% of development was still located on or by tells. Only 12% of the damage to low tells was caused by development, although almost three quarters of all damage caused by development was located on or by low tells.

Development and Damage Extent:

As shown on Table G-104 to Table G-109, development is most likely to affect Sections of amalgamated sites, but is more likely to affect the Periphery of the individual mounds. This is true on both Corona and on Geoeye. Developments are still a major threat, however: on Corona, 2 amalgamated sites (6 mounds) were Totally covered by developments, and the Majority of a further 4 (9 mounds). By 2010, only 1 mound was Totally covered, but the Majority of 9 sites (13 mounds) were covered, showing the increase in development.

Many new settlements were located near sites, but did not actually threaten them in the 1960s. Examining those sites now on Geoeye, the developments have expanded to reach the Periphery of a further 12 sites (19 mounds). If the pattern witnessed on the sites already affected by development continues, these sites will soon have damaged sections, and may ultimately be Totally absorbed into the expanding settlements.

Excavation would be necessary to discover the true extent of damage to sites under buildings, as it requires knowledge of the type of foundations, and the machinery used to install them. As well as the foundations, infrastructure is also laid down to support the new development. This is an area of archaeological investigation which has not yet been undertaken in the Middle East (and rarely elsewhere, as shown in Chapter3.5.1 – Development), and which would probably be hard to get permission from the landowner for. However, the damage caused to sites by building can be estimated. Anecdotally, it varies between bulldozing of sites to make way for new developments, to digging into the sides of tells to provide a level surface on which to build (Figure 6-49), to simply building on top of sites with minimal foundations for the new construction. Given the lack of knowledge, the threat of development is therefore almost always marked as damaging the Upper Levels of sites (Table G-110 to Table G-115).

On Geoeye, 90% follow this pattern, but 3 developments Slightly Degrade amalgamated sites, and one Heavily degrades it (Table G-115). Those which Slightly Degrade sites are small buildings located on the Periphery of sites, whereas the one which Heavily Degrades the site is the large development on the Periphery of Tell Beydar.

FIGURE 6-49: DEVELOPMENT IN THE SIDE OF THE TELL (TBS 65)[99]

(An approximate site boundary is marked in red)

[99] Geoeye Image, 23 June 2010. Taken from Google Earth 25 April 2012

Figure 6-50 shows development at Tell Ghazal Foqani (TBS 50). The site consists of a tell to the south of the village, and a mound to the north east. By 2010, the village had expanded up to the edge of the tell, and there is a large house on top of the northern mound. This is a fairly typical development pattern. As can be seen from Figure 6-49, development then often extends into the side of the tell itself.

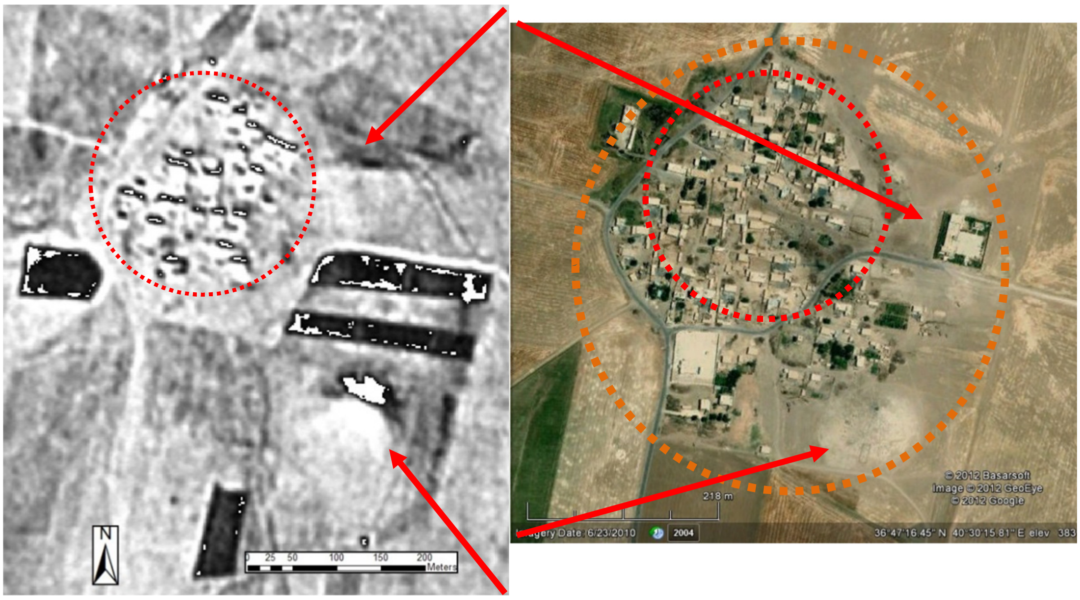


FIGURE 6-50: DEVELOPMENT AT TELL GHAZAL FOQANI (TBS 50)[100]

The red arrows indicate the location of each part of the site (identifiable on Corona through the white southern half and black northern half) on each image. The village has substantially expanded to the south to reach the edges of the southern part – the tell, and there is a large building on the northern part. The approximate extent of the village in 1967 is marked by the dotted red circle. The greater extent in 2009 is marked by the orange circle.

6.7.2 – AGRICULTURE

Agricultural damage is common in this region: all three forms– arable agriculture, orchards and animal grazing - are visible on imagery in the Tell Beydar area and therefore all three will be discussed here. Although in some areas, orchards are the most destructive form of agriculture, in the Tell Beydar region most orchards are small whilst, as will be shown, arable agriculture in this region is extensive and extremely detrimental to sites, as well as leading to several secondary damage effects, such as bulldozing. Grazing is an extremely minor form of damage to sites, and is included only

[100] Left: Corona Image, 1105-1025df057-6_37n, 03 November 1968. Right: Geoeye Image, 23 June 2010. Taken from Google Earth 20 April 2012.

for completeness. All three damage extents are defined and discussed in detail in Chapter 3.5.2 – Agriculture (Arable and Grazing) (p54) and 3.5.3 – Orchards (p67).

Arable Agriculture:

Arable agriculture is the damage type usually referred to here by the term "agriculture". Arable agriculture and ploughing were recorded in the field visits only in the sense that the amount of crop chaff affected the visibility of pottery collection. For example, on TBS 12, the field notes (1997) record "*Part of site is ploughed, and this was not collected*", or at TBS 16, the note for the western mound reads "*S part ploughed, not collected*". According to the field visits, 43 amalgamated sites had agriculture on them, of which 17 sites were not ploughed, and 6 were. The status of the rest is unknown.

Of the 95 arable land use counts visible on SPOT, marks of ploughing were visible on 50 of them. Geoeye imagery is so detailed, that of the 95 arable land uses, plough lines could be seen on 82 of them. This leaves only 13 unaccounted for. Clearly, although not all arable sites were ploughed in the late 1990s, ploughing is increasing. This may be because machinery is more easily available, or agriculture has intensified, and the yields are better from ploughed soil compared to unploughed soil, or perhaps even because it is seen as a sign of progress.

Prevalence of Arable Agriculture:

Cereal or cotton cultivation is so common that it is a primary cause of damage in 50% of cases on Corona, and is a secondary cause in a further third of amalgamated sites (Table G-86). It is the highest primary and secondary cause of damage on SPOT and Geoeye for the amalgamated sites (Table G-88 and Table G-90). The number of such sites with agriculture as a primary damage cause decreased but this did not represent a reduction in the amount of agriculture affecting sites. In actuality, on many sites other, more damaging threats occurred, and due to this agriculture was marked as a less severe threat. Secondary threats from agriculture increased to more than 1 in 3 amalgamated sites on Geoeye (Table G-90).

For individual units arable agriculture is the most common primary damage source on Corona, SPOT and Geoeye (Table G-87, Table G-89, and Table G-91). However, the most common secondary source of damage on individual site units is damage caused by roads.

Arable Agriculture and Site Type:

Cultivation is recorded on 98 of 108 amalgamated sites (91%) in total (Table 6-15). In the 1960s agriculture was the most common damage on tells – 32% of damage to tells was caused by agriculture, compared to 22% in 2010 (Table F-98 and Table G-102). The number of tells affected by the threat of agriculture have increased from 14 counts to 20. However, the percentage of tells affected has decreased as agriculture is now only one amongst an increasing number of other threats.

More than 80% of the agriculture recorded affected the amalgamated complexes of low mounds on Corona. By 2010, almost a third of the damage recorded on the individual low mounds was caused by agriculture, and a fifth of the damage to tells (Table G-99 to Table G-103). The number of threats from agriculture increased over time, although as there were more threats recorded, the percentage dropped.

Arable Agriculture and Damage Extent:

The damage done by agriculture varies. If substantial changes to the agricultural programme are visible on the imagery then agriculture is assumed to affect a site more than if only slight changes or no changes can be seen. For example, if a field is under agriculture on Corona, and the field visit notes say it is not ploughed, this is considered to Slightly Degrade the site. However, if on Geoeye the field boundaries have clearly moved, or a part of the landscape has changed (for example, a wadi which was by the site has been ploughed out), then it is assumed that corresponding effort has been applied to ploughing the site. The removal of small field boundaries and ensuing creation of large fields is usually related to increasing mechanisation of agriculture and commercialised farming of the landscape. Ploughs are capable of the removal of recent (but abandoned) building foundations, such as at TBS 42 (Figure 6-46). The field notes for TBS 56 demonstrate the move towards large field farming, rather than older traditional systems of strip field farming: "*To E a shallow wadi … is completely ploughed over… Very large areas are today ploughed as one field*" (1997). As discussed in Chapter 3.5.2, and shown on Figure 3-13 (p64), the ploughing out of wadis and 'smoothing' of the land indicates a similar threat to any nearby archaeological sites, shown in this chapter at TBS 2 (Figure 6-59 p259, and Figure 6-67 p266), at Tell Hassek (Figure 6-79 to Figure 6-83, p287 to 291), and at TBS 8 (Figure 6-24, p216).

Mechanisation capable of ploughing out wadis or removing buildings will have a greater effect on a site than normal farming practice. Evidence of height could not be determined on 101 mounds: therefore it is possible that some of them have been ploughed away. For example, the field notes for TBS 62_1_0 (seen in Figure 6-6, p191) refer to a "*low rounded mound with numerous stones on surface, apparently ploughed-out building foundations*" (1997). The site is still 2m high, but its original size may have been much greater.

On Corona, agriculture is almost as likely to affect any horizontal extent of an amalgamated site as any other (Table G-104). By 2010, it was more likely to affect a Section, or the Majority (Table G-108). Affected Sections, for example, doubled.

Agricultural threats to the individual site units on Corona affected far broader extents than the threats recorded to the amalgamated sites, presumably as the separate site units are smaller and therefore easier to cultivate. 86 agricultural threats affected the Majority of the unit or Totally affected them (Table G-105). In 2010, agriculture affected a Section or the Majority of 81 mounds (48%) and Totally affected a further 66 (39%). That is to say, almost 90% of agricultural threats covered at least part of the site, rather than only damaging the edges. Peripheral damage became less common over time, dropping from 33 to 21 sites (Table G-105 and Table G-109). Increased mechanisation is making it easier for farmers to plough small mounds so they no longer avoid them.

On Corona, agricultural threats mostly affect the Upper Levels of sites, or Slightly Degrade them. On Geoeye, whilst most agricultural threats damage the Upper Levels of amalgamated sites, 31% Heavily Degrade sites (Table G-114). Numerous site units are also Heavily Degraded by agriculture in 2010 (Table G-115).

As discussed in Chapter 3.5.2, archaeologists often dismiss agriculture as an important threat. Whilst this may have been true once, these results demonstrate that agriculture is now capable of causing extensive damage to sites.

These results have interesting implications on the effects of farming in antiquity on sites. It is assumed (see Chapter 2.3.3, p27) and Chapter 5.4, p175) that agriculture has damaged sites throughout history. Whilst this is almost certainly true to some extent, the evidence suggests that farmers have at least partly avoided archaeological sites, ploughing round them. It is only recently, with better machinery, that it has become more common to practice cultivation on them. Early site damage, then, may not be as extensive as previously supposed.

Grazing:

Grazing animals were recorded on 6 sites during the field visits, and grazing (presumably on cereal stubble) can be assumed to have occurred on more. The practice still continues now – animals were visible on 6 amalgamated sites. Figure 6-51 shows animals grazing just north of TBS 58_0_0, visible on Geoeye (the small ring is the animals, and the larger circle highlights byres and trampled crops). Animals grazing can also be seen on the bottom of the Geoeye image in Figure 6-46 (p243).

FIGURE 6-51: ANIMALS GRAZING JUST NORTH OF TBS 58_0_0[101]

6.7.3 - ORCHARDS

The third form of agricultural damage is the creation of orchards, which appear to be increasing. No orchards were recorded on Corona. This may be the result of low resolution, but it is more likely to reflect the growing trend towards the owning of pistachio and olive orchards witnessed across most of Syria in the last 20 years, even in semi-arid areas where orchards are not traditionally grown. No orchards were recorded during the field visits, and most of those seen on the more recent imagery are

[101] Geoeye Image, 23 June 2010. Taken from Google Earth 19 April 2012

small, backyard orchards. Only two major orchards were recorded during this research, both affecting outer towns of large tells (Tell Jamilo, TBS 59 - Figure 6-52, Tell Effendi, TBS 55 - Figure 6-64, p265), although another one was noticed on a suspected previously unrecorded lower town (Tell 'Aloni, TBS 60, Figure 6-66, p265).

As orchards mostly affect the larger mounds, there was no difference between the Amalgamated sites and the Unit analysis. In total they were recorded on 12 sites in 2004, and by 2010, they were found on 4 tells and 11 low mounds. As orchards in the Tell Beydar area are small, they tend to cover only a Section or a Fraction of the site or mound, and are assumed to only affect the Upper Levels. No orchards were recorded as destroyed: given they are a long term investment this is not surprising.

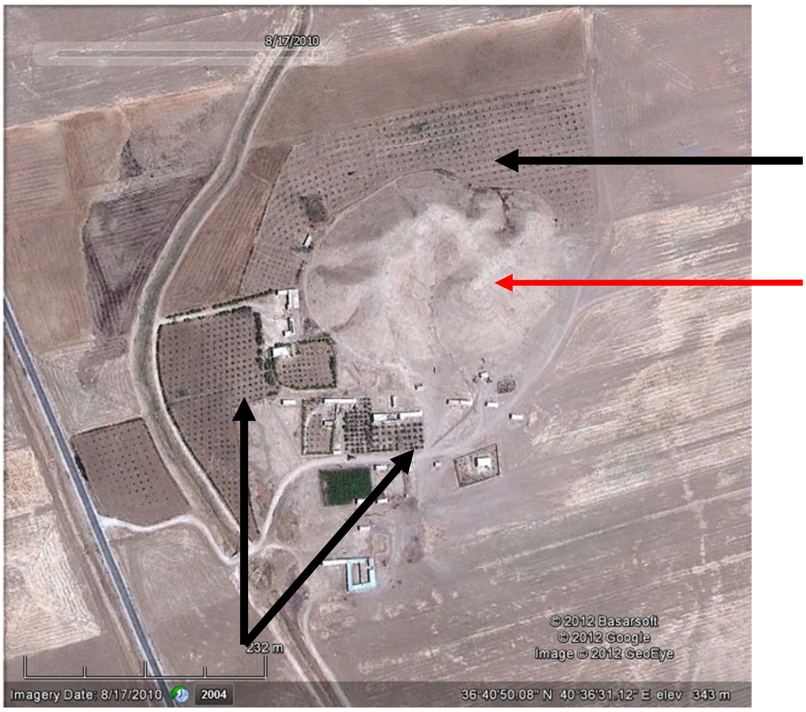


Figure 6-52: Orchards at Tell Jamilo (TBS 59_1_0, TBS 59_2_0, and TBS 59_3_0)[102]

Black arrows indicate major orchards and small backyard orchards present on the lower town, and around the edges of Tell Jamilo (indicated by the red arrow).

6.7.4 – Irrigation

With the building of the West Hasseke Dam in the late 1990s, irrigation has become common in this area. The irrigation channels which have been built were not part of a planned scheme, such as the large irrigation programme implemented in Iraq after the

[102] Geoeye Image, 17 August 2010. Taken from Google Earth 20 April 2012

Eski Mosul Dam was built (Wilkinson and Tucker 1995), so no planned rescue work was conducted on any of the archaeological sites in the survey region.

Irrigation water in this area is still pumped from wells, but channel irrigation is more common. Figure 6-53 shows a concrete lined irrigation channel passing next to TBS 13. The site is apparently under the village, but the soil colour visible to the south east of the site suggests it may extend further. If so, it is now cut by the channel. Figure 6-54 shows a detail of the end of the channel, giving a better idea of its form.

FIGURE 6-53: IRRIGATION CHANNEL AT TBS 13[103]

The site is indicated by the red GPS point.

FIGURE 6-54: DETAIL OF A CONCRETE LINED CHANNEL[104]

There are also small, shallower channels dug by farmers. In the Tell Beydar area, the small channels are far more prevalent, but still destructive. Irrigation channels can be seen in Figure 6-55 at TBS 29_2_0, visible as straight dark green lines of increased vegetation in the green cotton fields. Aside from the direct destruction of removing a section of the site, and disturbing the levels, by conducting water directly to the sites, the risk of erosion is also increased (albeit only slightly).

[103] SPOT Image, 31 December 2004 (?), taken from Google Earth 20 April 2012
[104] Geoeye Image, 17 August 2010. Taken from Google Earth 19 April 2010

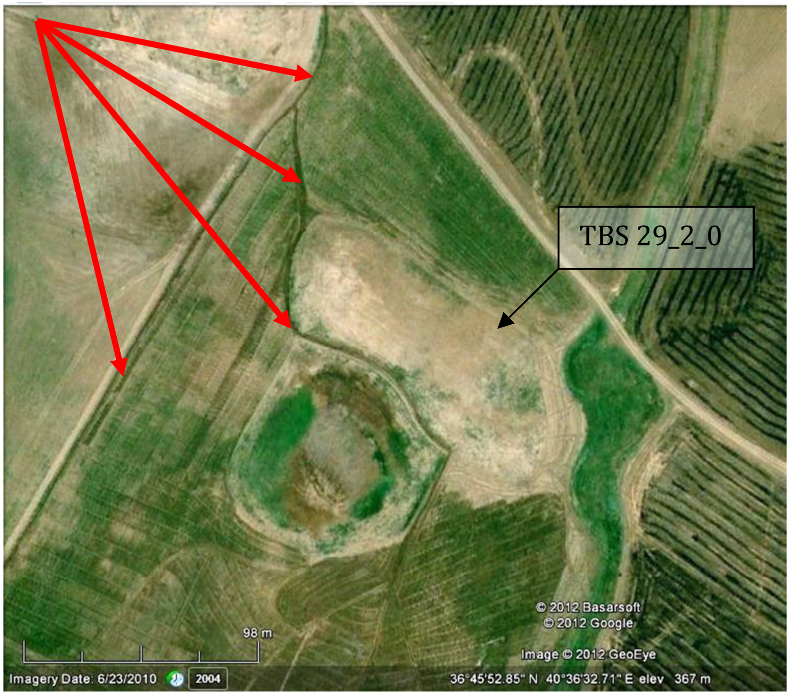


FIGURE 6-55: IRRIGATION CHANNELS AROUND TBS 29_2_0[105]

The irrigation channels, visible as straight dark green lines, are indicated by red arrows.

Prevalence of Irrigation:

Only one possible irrigation channel is visible on Corona. What seems to be an irrigation channel on TBS 30 is visible as a straight black line extending from the wadi through the site into and edging a field (Figure 6-56). This line is not visible on any other imagery, nor is it recorded on field visits. It is presumably a line of prosopis plants or other vegetation marking some form of channel. The line lacks the radial associations of most hollow ways and is also more distinct: it most resembles irrigation channels seen elsewhere in the Jazirah. Kühne (1989) and Ergenzinger et al. (1988) have examined the evidence for irrigation along the Lower Khabur, and theorised that it would have been equally possible, and in fact likely, that small localised irrigation was in use in the Upper Khabur from the Early Bronze Age, and well established by the Middle Assyrian period, allowing extensive cultivation in the climatically variable area. Although there is no direct evidence for irrigation in the 1960s in the Upper Khabur, it is certainly a possibility on at least this site, and therefore has been recorded but given a Low Damage certainty rating.

[105] Geoeye Image, 23 June 2010. Taken from Google Earth 20 April 2010

In total, irrigation channels were recorded on 19 (18%) sites, including the one on Corona (Table 6-15). Only 6 were recorded on field visits, but the channels went through 23 site units. 18 of these were on SPOT and 22 on Geoeye. One channel fell out of use (Table G-103).

Irrigation and Site Type:

In 2010, most irrigation channels disturbed low mounds (Table G-102 and Table G-103). Only 2 irrigation channels affected tells, compared to 15 which affected amalgamated low mounds / complexes of low mounds or 19 which affected site units. Given most irrigation channels are gravity fed, this is presumably a factor of the increased difficulty in digging through a large tell, compared to a smaller mound.

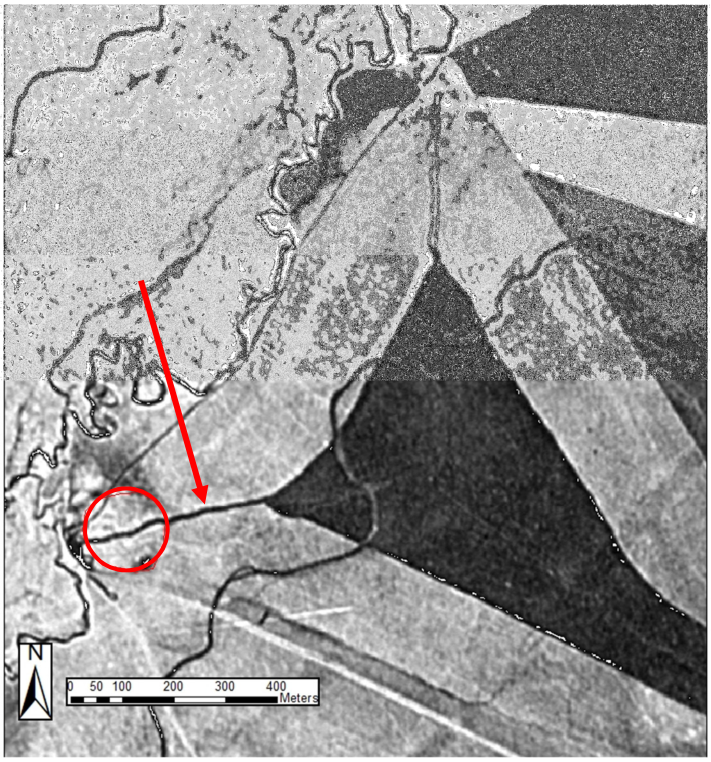


FIGURE 6-56: POSSIBLE IRRIGATION CHANNEL AT TBS 30[106]

TBS 30 is circled in red. The possible irrigation channel is visible as a straight black line going from the wadi to the west, through the site, to the field. It is marked with an arrow.

Irrigation and Damage Extent:

The level of destruction caused by irrigation channels is assessed partly from the visible size of the channel compared to the size and type of the site, and partly from the

[106] Corona image, 1105-1025df057-6_37n, 03 November 1968

field visit notes. Irrigation channels tend to affect the Upper Levels of Sections of the site, rather than go around them: they are usually small channels. However, some are much larger and cause more damage to both amalgamated sites and site units. 2 irrigation channels have Destroyed Sections of amalgamated sites to Ground Level (at least). Sections of a further 8 amalgamated sites or 10 mounds have been entirely Destroyed (Table G-114 and Table G-115).

Irrigation can cause more damage than simply that of the channels themselves. Also included in the count of irrigation damage are sites TBS 2 and TBS 17. These sites are located partly (TBS 2) or entirely (TBS 17) in the reservoir zone for the West Hasseke Dam. The damage cause has been listed as irrigation, but the damage is recorded as Site Buried. It may be that more damage has been done - TBS 17 is now not visible on satellite imagery (Figure 6-57) and – as it is near the edge of the reservoir – it may have been flattened in the creation of the bulldozed embankments around the edges reservoir plain. (These embankments are shown in more detail in Figure 6-59). Although the site may have been destroyed, since it is not visible the least principle of least damage has been applied (Chapter 4.7.3 – Damage Certainty, p161).

Although TBS 17 was recorded as one mound in the field visits, a complex of mounds are visible on Corona (Figure 6-58). It is possible that they were all destroyed as part of the building of the reservoir, but as described in the Methodology Chapter 4.8.5, p165, the site extent is treated as that recorded during the field visit, although the Boundary Certainty is Low.

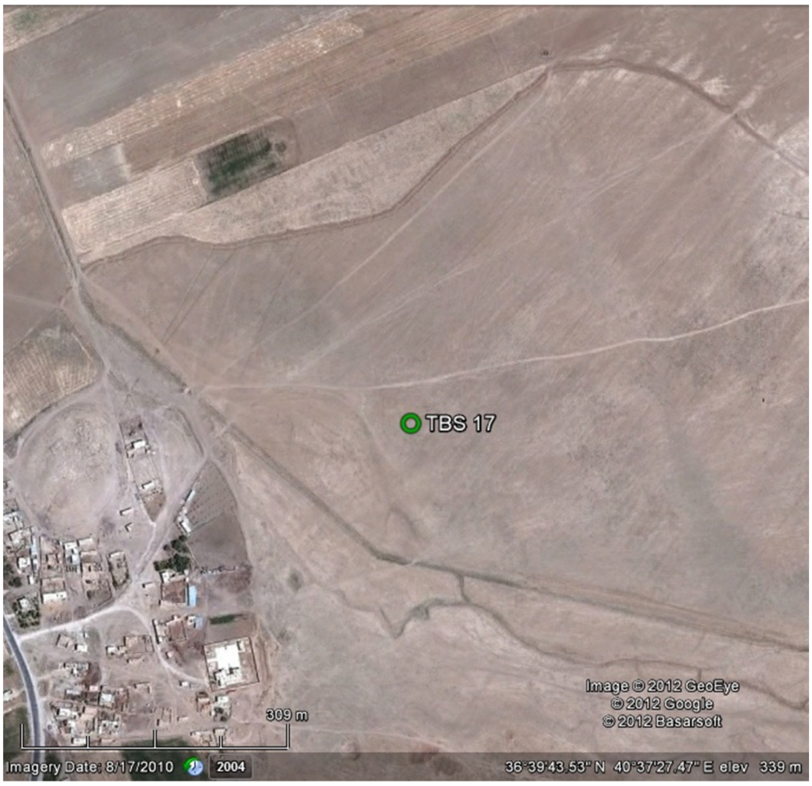


FIGURE 6-57: GPS LOCATION OF TBS 17[107]

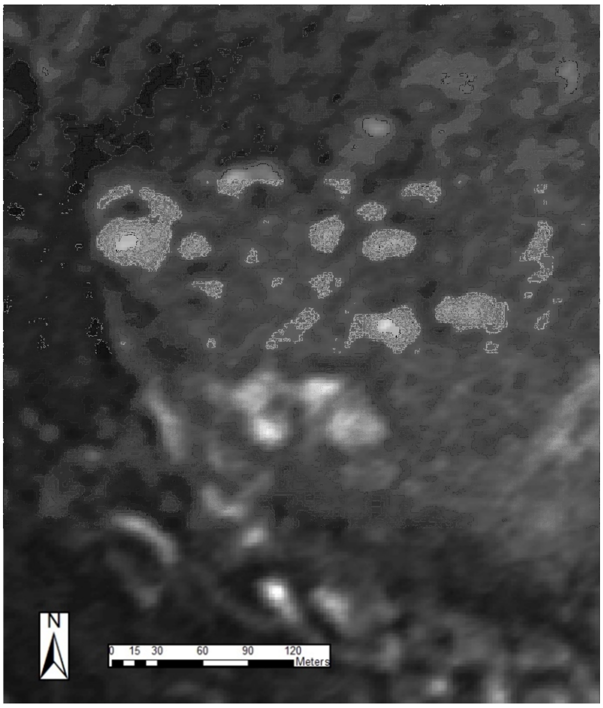


FIGURE 6-58: TBS 17 (THE RING OF WHITE MARKS) ON CORONA[108]

[107] Geoeye Image, 17 August 2010. Taken from Google Earth 25 April 2012
[108] Corona image, 1102-1025DF006-1_37N, standard deviation stretch, 09 December 1967

Part of TBS 2_1_0 lies within the reservoir plain: at the time of the field visit a bulldozed strip was recorded through it (Figure 6-59). It is now clear that the strip marked the edge of the reservoir plain and the piled earth was presumably to stop the water escaping. This damage was also visible at a possible unrecorded lower town at Tell ‘Aloni (TBS 60, Figure 6-66).

FIGURE 6-59: BULLDOZED STRIP FOR IRRIGATION AT TBS 2[109]

According to Lenihan (Lenihan 1981), it is sites in the fluctuating shoreline zone that are at most risk from dam creation as the changing water levels intensify the erosion to the site . As the drought in the area has continued, however, the water has retreated far from the sites. On the Geoeye satellite imagery, the water is now nearly 3km away from TBS 2 (Figure 6-60). It will be some time before the sites are again at risk from the reservoir.

[109] Geoeye Image, 27 October 2010. Taken from Google Earth 19 April 2012

FIGURE 6-60: SITES IN THE TELL BEYDAR SURVEY AREA AFFECTED BY THE WEST HASSEKE RESERVOIR[110]

6.7.5 - ROADS

Prevalence of Roads:

In total, 72 roads were recorded around amalgamated sites – two thirds of sites had roads close enough to affect them at some point in their lifespan (Table 6-15). 52 of these roads were visible on Corona (a quarter of amalgamated sites), increasing to 67 on Geoeye, which is 1 in 5 (Table G-84).

A total of 109 roads were recorded crossing individual site units (this is over half the site units - Table 6-15). 74 of these were visible on Corona, and 99 on Geoeye: this is roughly the same proportions as the amalgamated sites.

[110] Geoeye Image, 27 October 2010. Taken from Google Earth 19 April 2012

These are not always the same roads through time. Some tracks which were visible on Corona no longer appeared to be in use on later imagery and have vanished, reflecting the changing field boundaries, shifting settlement patterns, and alterations in land use, but numerous new roads were built. Only 18 were mentioned on field notes – roads are a very under-reported form of damage, perhaps because most of them are assumed to cause very little damage. However the damage caused by even rough tracks is similar to that caused by grazing (see 6.7.2 – Agriculture, p248).

Roads are usually a secondary damage cause, and are the most common secondary cause of damage on Corona (48% of amalgamated site cases, and 54% of site units). In 2004 and 2010, they are the most common tertiary cause of damage for amalgamated sites, and the most common secondary and tertiary damage on site units (Table G-86 to Table G-91).

<u>Roads and Site Type:</u>

Examining amalgamated sites, in the 1960s roads affected 12 tells (this is 27% of all damage to tells). 16 tells were affected in 2010 (18%). Roads crossed 40 low mound complexes in the 1960s, rising to 51 in the 2010. (This was 60 separate mounds on Corona, rising to 81 in 2010) (Table F-98 to Table G-103).

<u>Roads and Damage Extent:</u>

Roads either pass along the edge of the site (Peripheral damage: Corona: 21 sites / 34 mounds; Geoeye: 26 / 44), or affect a Section (Corona: 30 sites / 39 mounds; Geoeye: 44 / 55). More roads go through or over sites than around them, although in most cases the road goes over the edge of the site or cuts into the edge, rather than through / over the middle of it (Table G-104 to Table G-109).

34 roads on Geoeye Slightly Dispersed parts of sites (56 mounds), compared to 43 on Corona (62 mounds). These were generally small gravel tracks that cause no more than very gradual erosion or tracks that ran along the Periphery of sites. 21 damaged the Upper Levels of sites (30 mounds), compared to 9 on Corona (12 mounds): these were either more substantial roads, perhaps larger tarmacked roads, or roads in more built-up areas, and therefore likely to see more use. This was the deepest damage caused by roads or tracks recorded on Corona. In 2010, 10 Sections of amalgamated sites were Destroyed to Ground Level (or 11 Sections of mounds): whether anything remains below them could only be determined by excavation (Table G-110 to Table

G-115). As can be seen, the shallower damage extents are decreasing, and the deeper damage extents are increasing.

6.7.6 - Bulldozing

<u>Prevalence of Bulldozing:</u>

Bulldozing was not recorded on Corona, the earliest record of the state of the sites: it is first mentioned in field visit notes. It is one of the few forms of damage that is fairly accurately represented in the field visit notes – 15 sites apparently had bulldozing damage, ranging from "trimmed" to "destroyed". By 2010, however, 21 amalgamated sites (25 units) are at least partly bulldozed, that is 1 in 5 amalgamated sites with bulldozing damage (Table G-84, Table G-85, Table G-90, and Table G-91). Since bulldozing damage is so all-encompassing, it is almost always a primary damage cause. However, although arguably the most destructive form of damage, bulldozing accounts for only 6% of the damage sources to amalgamated sites (or 5% of units) in 2010.

<u>Bulldozing and Damage Extent:</u>

Bulldozing usually affects a Section of a site (17 amalgamated sites, Table 108) or the Majority of it (2 / 2). It rarely Totally affects a site, because there is usually a secondary cause of damage after the bulldozing, such as farming, which disperses the bulldozed remains further (Table G-88 and Table G-89). However, 8 mounds have been Totally bulldozed. In terms of the vertical extent, bulldozing Heavily Degraded 5 sites, and Destroyed some or all of 16 (20 mounds) to Ground Level (Table G-114 to Table G-115). As levels of alluviation are unknown, the amount of site which may remain below the ground can only be determined by excavation.

<u>Bulldozing and Site Type:</u>

On SPOT, bulldozing was recorded affecting sections of 5 tells, rising to 7 on Geoeye (Table G-100 and Table G-102). Figure 6-61 to Figure 6-63 display bulldozed sections of three different large tells. At Tell Sekar Foqani (Figure 6-61), for example, the western edge of the tell was probably bulldozed for the road: part of the tell is still visible to the southwest on the other side of the road (indicated by a red arrow), showing how big a section has been removed. On the side of the road by the tell, a field is indented into the side of the tell (second red arrow). Field creation into the side of the tell is also visible on the eastern side of Tell Sekar Tahtani (TBS 41 - Figure 6-62), and the north of TBS 55 (Tell Effendi - Figure 6-63) (p264). 13 amalgamated low mounds were affected by bulldozing, rising to 14 on Geoeye (18 actual mounds) (Table G-100 to Table G-103). The increase in bulldozing of small mounds is expected: more worrying is the increase in parts of large tells which are bulldozed, either for roads or the extension of fields.

The true extent may be slightly higher. TBS 17, for example, cannot be seen, and may have been buried by the dam reservoir, but it may have been bulldozed to build the reservoir (as discussed in Section 6.7.4). The principle of least damage (p161) may lead to the true extent being underestimated (or may keep the count accurate): a further 5 amalgamated sites, or 11 units, may also have been bulldozed – height was indeterminate, and the soil dispersal pattern was indicative of bulldozing - but the certainty was so low that it could not be definitely recorded.

Some tells may also have outer towns or additional mounds that were not recorded but which may now be bulldozed. At TBS 55, for example, there are several mounds surrounding the tell, including one which is visible on the 1102 and 1105 Coronas, but which is not recorded on the field visits. It is also not visible on later imagery, suggesting it has been destroyed.

Tell 'Aloni appears to have a lower town on Corona which was not recorded during the field visit (Figure 6-66). If this is the case, a strip was bulldozed though the north and north eastern part during the development of the West Hasseke reservoir, similar to TBS 2 (Figure 6-59, p259). The cotton field to the north of the tell also appears to have been extended through bulldozing.

FIGURE 6-61: TBS 39 - BULLDOZING AROUND EDGE OF TELL SEKAR FOQANI

FIGURE 6-62: TBS 41 - BULLDOZING AROUND EDGE OF TELL SEKAR TAHTANI

FIGURE 6-63: TBS 55 – BULLDOZING ALONG NORTHERN EDGE OF TELL EFFENDI

Red arrows indicate the original extent of each tell where the bulldozing, which does not extent all the way around each tell, has stopped.

Figure 6-64: Location of Mound at TBS 55 in 2010[111]

Figure 6-65: Additional Mound at TBS 55 (red circle) in 1968[112]

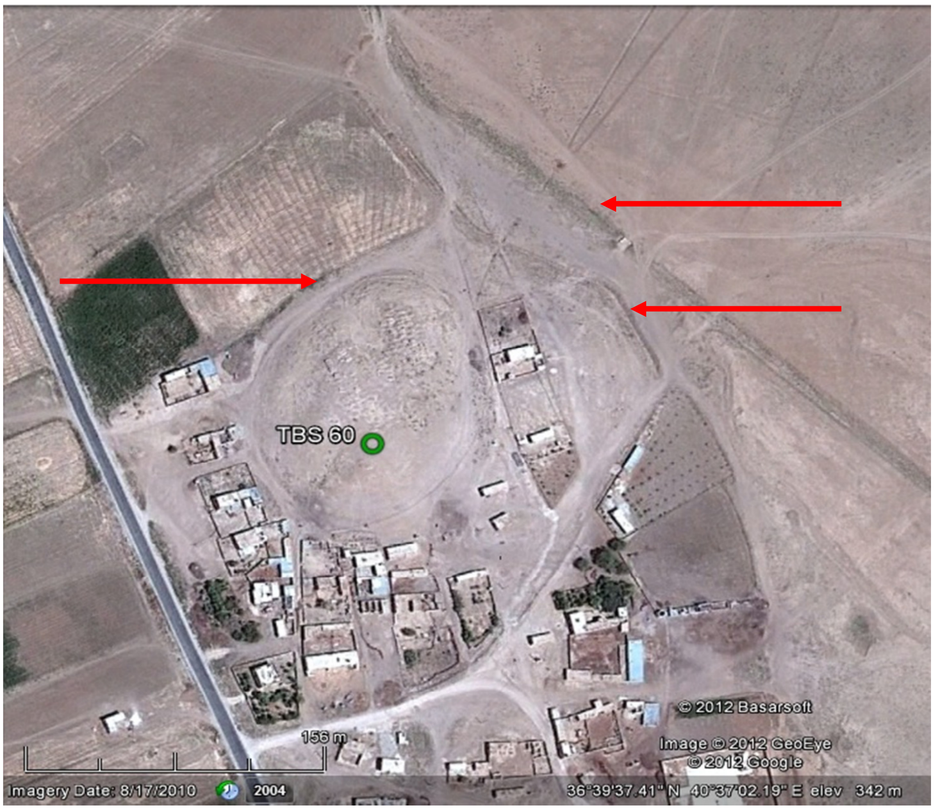


Figure 6-66: Possible Bulldozing at Tell 'Aloni (TBS 60)[113]

[111] Geoeye Image, 23 June 2010. Taken from Google Earth 20 April 2012
[112] Corona Image, 1105-1025df057-6_37n, standard deviation stretch, 03 November 1968
[113] Geoeye Image, 01 August 2010. Taken from Google Earth 19 April 2012

6.7.7 - *Water Erosion*

Water erosion was discussed briefly in Section 6.5 - Land Use / Cover, and changes in the landscape were demonstrated. It is also touched on in Section 6.8 - Site Stability. Water bodies are rarely present now on sites: many have now been ploughed out, such as at TBS 8, shown on Figure 6-24 (p216).

<u>Prevalence of Water Erosion:</u>

Water erosion is hard to determine from the field notes and the imagery. Many sites were built by wadis, and their original form is unknown: even excavation may not be able to determine the original extent of the site and if it has been eroded. As a result, water erosion was only recorded as a damage threat if it was extremely clear on the imagery, or mentioned in the field visit notes. In total, it was recorded on 15 amalgamated sites, and 21 units - around 1 in 10 units (Table 6-15). However, given how many sites were located close to water sources, this figure is only a minimum estimate. Today there are very few sites where water erosion is still an issue as most wadis have now dried up and no longer flow. (This was discussed in more detail in Section 6.5.1, p207). Figure 6-67 shows wadis around TBS 2, and can be compared to Figure 6-59, which shows TBS 2 on Geoeye, where no wadis are present.

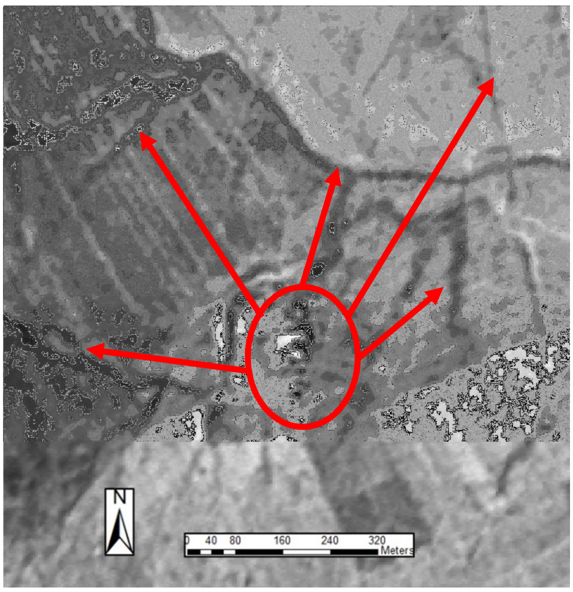


Figure 6-67: Wadis Around TBS 2[114]

It is possible that some of these NNE-SSW wadis are hollow ways oriented on TBS 59 and 60.

[114] Corona Image, 1102-1025df007-1_37N, standard deviation stretch, 09 December 1967

Water Erosion and Site Type:

Water erosion was recorded on 4 tells in the 1960s , but only 1 in 2010, as most of the wadis no longer appear to flow (in both the Amalgamated and the Unit analysis - Table F-98 to Table G-103). 10 complexes of low mounds were affected (15 mounds), compared to only 4 mounds / mound complexes in 2010. The wadis which are still flowing are affecting 4 separate sites: those which affected multiple mounds within a complex of mounds no longer flow. (Although it is not possible to see the water in the wadis, they are assumed to still flow for at least some of the year as many of them cross ploughed fields, but the dark vegetation visible in them has not been ploughed away).

Water Erosion and Damage Extent:

Water erosion affects either the edge of a site, or, if it particularly severe, it affects a section. For example, Figure 6-68 shows Tell Beydar in 1934, taken by Poidebard: the wadi at the back of the image has eroded the tell wall. Another reference in the field notes at Tell Rajab (TBS 4) states "*steep N-facing slope appears to have been heavily trimmed and eroded by Wadi Aouej*" (1997). Given that only the most severe water erosion was recorded, it is not surprising that it usually Seriously Degrades or Disperses sites.

FIGURE 6-68: AERIAL PHOTOGRAPH OF TELL BEYDAR BY A. POIDEBARD 1934.

6.7.8 - VISITOR EROSION

Visitor Erosion was only recorded on 1 site – TBS 69_1_0. It was not visible on Corona or SPOT but on Geoeye, tyre tracks are visible through the probable location of old stone walls from relict terraces (Figure 6-78). (It should be stressed this identification is tentative at best). As a result, it is recorded as completely destroying the section of site. (This site is discussed in more detail in the case study of sites on the basalt plateau in Section 6.9.1, p275.)

6.7.9 - Natural Erosion

Erosion as a damage type is recorded on only one site, Tell Beydar itself, where the effects on the site, and the cause of the erosion, are known. In a lecture presented in Tübingen (2006), Lebeau, one of the principal excavators, stated "the natural erosion has unfortunately destroyed the Early Jezirah IIIb inner rampart." This rampart is located on the edge of the inner tell, meaning the erosion was presumably caused by natural weather conditions, rather than the erosion of the outer wall, which was attributed to the wadi. Lebeau went on to say that "The NE corner of the Palace at the 2nd and 3rd phase [of the period being excavated] is unknown due to the natural erosion of the tell." As this is the only site where erosion has been quantified, and a stratigraphically dated sequence is available for the site, it is the only erosion categorically counted in the damage assessment.

However, erosion is mentioned on a number of the field visit notes, and appears to be visible on some of the satellite imagery. For example, the field notes for TBS 70 refer to "*weathered wall foundations*" (1998). No cause is given – aeolian deflation, rain and wadi action are all equally likely (environment allowing).

6.7.10 - Looting

Looting was recorded on 1 site – at TBS 15_0_0 – and this was during the field visit when "a few possible robbing pits to the south" were noted. However, the surveyors also commented that the site was "so meagre" it may not be a site at all: the identification is therefore tentative at best.

However, what appears to be looting holes are visible just south of the suspected location of TBS 64 (although due to difficulties identifying the site, it may be TBS 64 which is being looted). (See Section 6.9.1 – Case Studies: Sites on and by the Basalt Plateau, p275*).*

6.7.11 - Mudbrick pits

Mudbrick extraction pits were usually limited to large sites and mounds, so there is very little difference in the two sets of analysis figures (amalgamated and units). They were recorded either from the field visit notes or from imagery (usually Geoeye). 18 mounds were recorded as affected in total, 16 on SPOT and 18 on Geoeye (these are almost all the larger mounds) (Table G-84 and Table G-85). Although the figures imply mudbrick excavation pits are increasing, this is more likely to because of the higher image resolution, as they cannot be seen on SPOT, and so are only recorded as part of the field visits, whereas they can be seen on Geoeye, although their purpose is not always clear. Mudbrick pits are usually small and localised, affecting only a fraction of the site, although on one site (TBS 32_2_0) they were numerous enough to be considered to affect a section (Figure 6-69). The depth of damage done by mudbrick pits is an extremely tentative assessment. Stone (2008) attempted to assess the depth of pits from satellite imagery using various techniques, but the success of this approach is debated (for example, see comments by Tompa on a blog (Gill 2008)). As a result the assessment of damage is largely based on the apparent size of the pits relative to the size of the site. Mudbrick pits may have affected the Upper Levels of 9 sites, and Heavily Degraded a further 9.

Figure 6-69: Mudbrick Pits on Lower Town of TBS 32[115]

[115] Geoeye Image, 23 June 2010. Taken from Google Earth 19 April 2012

6.7.12 - Cuts

Cuts are hard to distinguish as a separate damage type, and could never be seen on Corona. A cut usually serves a purpose, and there is overlap with other damage types. Examples of cuts for known purposes include cuts for roads, such as the cut into the side of Tell Sekar Foqani (Figure 6-61, p264) and the cut in the north of the mound under the village at TBS 11. As a result, defining a damage type as a cut is either taken from the field visit notes, or marked where it is clearly visible and no other damage cause is attributable. Any damage assessment is as tentative as the initial identification. At Tell Sekar Wastani (TBS 40), cuts are visible in the west side of the tell: it is unclear for what purpose (Figure 6-70). It may be for development, given the houses clustered along the edge of the tell, but this cannot be said with any certainty. Cuts were clear (or directly mentioned in field notes) on only 4 sites and were only visible on Geoeye.

Figure 6-70: Cut into the West of Tell Sekar Wastani (TBS 39)[116]

[116] Geoeye Image, 23 June 2010. Taken from Google Earth 20 April 2012

6.7.13 - *Grave Pits*

Prevalence of Graves:

26 modern cemeteries were recorded on sites (Table 6-15). In general graves and cemeteries protect the site from further damage, but in 2 cases, graves recorded on the field visits could not be identified on imagery, and new buildings were present at their locations. Several sites were also heavily farmed, and possibly even bulldozed up to the edge of the cemeteries. No site had more than one recent cemetery: there is no difference between the Amalgamated sites and the Unit analysis figures.

Graves were recorded on 20 sites in the field visits, but in total they were present on 26 mounds (more than 1 in 10) (Table 6-15). Cemeteries were usually either on tells or on a low mound near a tell, but almost never on both. Although cemeteries and graves are not visible on SPOT, if they were recorded on the field visits, they are recorded as present on SPOT. (The reasons for this were discussed in detail in Chapter 4. 5.5, p126). In total, 21 cemeteries were recorded on SPOT: the cemetery on TBS 82 was visible, but not recorded on the field visits. 24 graves / cemeteries were visible on Geoeye (Table G-84 and Table G-85). A Christian shrine and burial were recorded on TBS 31 on the field visits, but on the Geoeye, the adjacent village (and part of the site) appears to have been bulldozed, so it is impossible to say if the shrine is still present. Several recent graves were also recorded on TBS 15 which are not visible on Geoeye, although there is a new building on top of the mound. Given how obvious the other graves are, and that the land will have been disturbed for the development, it is unlikely that the graves are still present, but this cannot be said for certain.

Cemeteries were also visible on TBS 13, TBS 21, TBS 29_1, TBS 55, and TBS 65 which were not visible on SPOT or recorded on the field visits. It is extremely unlikely that these cemeteries appeared between 1998 – 2010 when the graves were visible on Geoeye. The practice of burial on tells was declared illegal by the Syrian government: most modern Syrian graves date to before the field visits, making it more likely these are cemeteries which were simply not observed during the field visits.

Graves and Damage Extent:

The horizontal extent of damage caused by graves is dependent on the number of graves relative to the size of the site. 11 sites had only a Fraction affected, whilst another 11 had a Section covered by cemeteries (Table G-108 and Table G-109). 20 of the 24 graves 'Pitted' sites (Table G-114). 1 site (TBS 35_1_0), which appeared to have 2 graves on it, was marked only as Slightly Degrading the site, as the site is substantial compared to 2 graves (Figure 6-71: a close up of the graves can be seen in Chapter 3, Figure 3-57, p100). Cemeteries were considered so extensive on three mounds that they were marked as damaging the Upper Levels of the site (Figure 6-72).

FIGURE 6-71: 2 GRAVES ON TBS 35_1_0[117]

FIGURE 6-72: CEMETERY COVERING SUBSTANTIAL PART OF TBS 82[118]

[117] Geoeye Image, 23 June 2010. Taken from Google Earth 19 April 2012
[118] Geoeye Image, 23 June 2010. Taken from Google Earth 19 April 2012

6.7.14 - Pits Other

2 mounds had pits whose purpose was unclear (presumably mud-brick extraction, but little is known about them). They each affected only a fraction of the site, but had different depths.

6.7.15 - Unknown

Damage of Unknown type, or sites where it was Unknown if they were damaged, was recorded in 26 cases on the Amalgamated site analysis and on 42 site units on Corona. This dropped to 9 amalgamated sites (11 mounds) by 2010, accounting for less than 2% of the damage. As the imagery resolution becomes higher, it is easier to see what affects sites. Most of the sites where damage was still Unknown in 2010 were on the basalt plateau (Table G-84 and Table G-85).

6.8 - Damage Levels and Site Stability

As demonstrated in the preceding section, damage, and therefore sites, are not always stable. Over time, the damage caused by some threats increases, and others decrease. Unfortunately for the archaeological resource, the former is far more likely than the latter. Settlements may expand, for example, affecting a greater extent of a site, or fields may become more intensively ploughed (as described in Chapter 3.6, p113). Equally, settlements may be abandoned, and cemeteries may be dug up, as was likely at TBS 31. Table G-116 to Table G-119 in Appendix G contain the supporting figures for increasing and decreasing damage.

Damage could be seen to have increased between the 1102 Corona imagery (1967) and the 1105 imagery (1969). On 2 sites agriculture increased (TBS 10_1 and TBS 10_2), and the irrigation channel noted in Section 6.7.4 - Irrigation was visible on the 1105 imagery but no earlier imagery.

In the Amalgamated site analysis, damage threats which were recorded on SPOT imagery showed pronounced worsening. Almost 75% of identified damage threats to sites showed some increase in damage between the 1960s and 2004. Almost two thirds had increased since they were first identified on Corona. Less than 10% stayed the same, and only 1 threat showed less damage. About 20% of threats known to be present were not visible due to the low resolution, so it was unknown whether they had worsened, lessened or stayed the same.

Similarly, on the Geoeye imagery, it was unknown whether damage was increasing on 20% of threats, and 10% of threats stayed the same. Only 6 identified threats lessened. A closer examination of the worsening threats on Geoeye provides a picture of the speed at which threats are increasing:

- 140 threats (42%) were worse than when identified on the 1960s Corona,
- 28 (8%) were worse than when recorded in the 1998/9 field visits
- 57 threats (17%) were worse than when recorded on SPOT in 2004 – almost 1 in 5 threats worsened in the 6 years between the SPOT and Geoeye images being taken, suggesting that the speed at which threats are worsening is increasing.

Agriculture was particularly likely to get worse: it could be seen to have expanded and / or intensified in all bar 7 cases. Development was the most likely threat to lessen, as settlements were occasionally abandoned, although it only happened in a few cases.

Earlier analysis has been based upon recognisable threats to the individual site types in each category over time. Analysis in this fashion masks the potential creation and abandonment of individual threats as it masks the total numbers of each threat. A road which goes over a complex of low mounds and a tell, for example, will be recorded twice, but it is only one road. The following paragraphs highlight some of the actual figures for change of key threats. They are based on the total number of sites (83), are not subdivided by site type, and count the change in the presence or absence of damage threats. Developments, for example, could be seen to have increased on 22 sites since they were first observed on Corona, and even increased in the 6 years between SPOT and Geoeye in a further 2 cases. However, 7 of these cases were marked as "Unknown" on Corona, and the damage could not be assessed until later imagery, so the apparent high increase may be illusionary. On 12 sites, development decreased from that observed on Corona. On 3 sites, development increased from the level observed on Corona to a higher level on SPOT, but then decreased again in the 6 years between SPOT and Geoeye.

In comparison with state of sites in the 1960s, when the Corona images were taken, new agriculture was recorded on 35 sites (of which 22 had previously Unknown levels of damage, so it may not all be 'new' damage). Agriculture definitely decreased on 2 sites. 3 sites which had been under agriculture on SPOT were no longer farmed on Geoeye (one of which had shown an increase between Corona and SPOT).

Roads were also not as stable as might be assumed: 6 tracks identified on Corona were no longer visible later, although on one site, a new road / track became visible between SPOT and Geoeye. Another 43 tracks / roads came into use after the 1960s, of which 4 were created in the period between SPOT and Geoeye.

Water erosion ceased to be a threat on 20 sites, as wadis were no longer present. However on 2 sites it apparently became an issue (in that it did threaten the sites before). On TBS 17, the site has been (presumably) buried by the West Hasseke Dam, and on TBS 24_1_0, the site could not be seen previously to make any judgement on its state, and when it then became visible it was marked as suffering from water erosion.

Orchards, mudbrick pits and bulldozing were never recorded on Corona, due to poor resolution, and therefore can only be recorded as new since Corona. Irrigation also increased, except for the possible irrigation channel seen on TBS 30, which was only visible on Corona.

This demonstrates that it is not just that the numbers of threats to sites are increasing: many are also intensifying or expanding and therefore causing more damage. However, it is not a problem which should be over-simplified – the multiple uses for the landscape are created and abandoned in a continuous cycle which will newly affect some sites even as others are no longer threatened.

6.9 - CASE STUDIES

The following section presents 3 case studies: one of area, one of site type, and one site, to illustrate the damage identified.

6.9.1 - CASE STUDIES: SITES ON AND BY THE HEMMA PLATEAU

The basalt plateau, known as the Hemma plateau, comprises a main escarpment (west of Tell Beydar) and a second higher escarpment upon which lies the village of Qasrik. This plateau, in turn, is overlooked by the high, roughly conical upland (description taken from the field visit notes for TBS 23).

Only 9 sites were surveyed on the basalt plateau and escarpment, so the results cannot be generalised. TBS 23 was located partly on the plateau and partly on the escarpment; TBS 49 was located at the junction of the plateau and the alluvial plain, as was TBS 73. TBS 64, TBS 69, TBS 70, TBS 71, TBS 72 and TBS 80 were all located on the escarpment. A number of other features - mostly desert kites but also some ruined buildings and rock art – were noted (Picalause 2004; van Berg et al. 2003) but these have not been included, as discussed in Chapter 5.2 – Survey History of the Tell Beydar Region, p173).

TBS 23 (Figure 6-73) consisted of 3-4 low building mounds indicated by piles of stones which were cleared for agriculture. There was a possible enclosure wall around the settlement and a faint concentration of walls to the west. Although the site consisted of a combination of mounds and irregular structures, the sketch plan highlighted the walls and enclosures so this was given as the site type, since there was not enough information to subdivide the site. The site was only partially visible on the Geoeye imagery, and was mostly located from features on the sketch map, (proximity to track, loam plain and Qasrik), assisted by the GPS point. Although one building outline is still visible, stones appear to have been cleared and the site seems heavily ploughed: no walls are visible (although a possible enclosure wall is visible three quarters of a kilometre east, but this seems too far to be the walls referred to).

Khirbet Shuniya (TBS 49) was located where the plateau escarpment meets the alluvial plain, but the site characteristics are largely those of sites on the plains. The site consists of 3 low mounds to the east of the village of Shuna. During the survey the site was unploughed but under dry-farmed cereals. By 2010, mound A (TBS 49_1_0) appears (relatively) untouched (assuming it was correctly identified on imagery, which is uncertain based on the field visit description). Mound B was easily identified, but the end may have been bulldozed. This is uncertain as it was reported in the field visits that the lower slopes were under agriculture, so they may just be hard to see on imagery. The sketch map drawn in 1998 showed mound B to be crescentic, whereas it is now clearly oval. The sketch map also showed the southern three quarters to be covered in graves, whereas almost the entire mound on Geoeye imagery is covered in graves. The entire area around B is ploughed, although there is evidence of disruption in the plough lines for almost one third of a kilometre northeast of Mound B, suggesting buried deposits, and the possibility that the site was larger than recorded during survey. The field east of Mound B also shows a large amount of (possibly cultural) grey soil. Mound C (TBS 49_3_0) is not visible, but the area is ploughed. There is no evidence of grey cultural soil, and no evidence of disruption to the plough lines. The mound was only recorded as 1m high, and 100m in diameter during the field visits, so it may not disrupt the field boundaries. It was one of the few sites where grey soil was recorded during the field visit.

TBS 64 consists of a mound and circular enclosure (Figure 6-74). It was again identified from its field visit description (1998):

> *"On edge and a little below basalt plateau below … scarp edge … Low undulating mound. Mounding can be seen to comprise reddish mudbrick over stone footings… To the SE a large depression … To S a large oval structure appears to be the remains of an animal enclosure…"*

This site was particularly difficult to locate as directly to the south is an area marked by cleared stones which is covered in grey (probably cultural) soil, and pockmarked with holes, which may be looters holes. As a result the identification and resulting damage analysis remain tentative at best, and very little can be said about any possible damage.

Of the other sites, most were stone concentrations and rough alignments which appear to be the remains of weathered walls, with occasional low building mounds. Some building plans were evident during the survey (for example at TBS 71), but most sites were not visible and could not be located. TBS 80 was (briefly) described as "circular stone features (6)". From this and the GPS point it has been tentatively identified.

Some sites are partly visible. TBS 69 has multiple features, shown on Figure 6-75 - the field visit sketch map of the site, and Figure 6-76, which shows all the features on satellite imagery. These images demonstrate the relationships between the different features. The site consists of an irregular scatter of stone circles and rough alignments which appear to be the remains of weathered walls, as well as some recent circular stone tent clearance features. To the west are a series of horizontal relict terraces. The low mound (point #178 on the sketch map) is clear on imagery. Some more relict terracing was visible on the southern escarpment, and is marked on the sketch map. Many (although not all) of these features are (relatively) clear. Figure 6-77 and Figure 6-78 show them on Geoeye imagery. The northern relict terraces and the enclosure of TBS 69 are clear, whilst what may be tyre tracks are visible along the location of the southern relict terraces, suggesting they have perhaps been damaged or destroyed (recorded as visitor erosion in the damage analysis).

Given the level of resolution available on Geoeye, where individual clearance cairns and stone walls can be seen easily, it must be asked why the other sites cannot be found.

Given the intensified agriculture on and around the plateau, and the increase in traffic, it is possible that many of the sites have been disturbed beyond recognition or destroyed. However, sites consisting of small mounds like this are also harder to see, so without further fieldwork, their status must remain unknown.

In general those sites on and around the plateau which consist of large visible mounds seem no better or worse preserved than sites anywhere else. The more fragile sites with shorter or seasonal occupations which may elucidate information about nomad / settled interactions or land use away from major sites are often not visible, and it is possible they are too damaged to recognise, in which case these sites are suffering a higher rate of attrition than other sites. A significant effort was made to identify some of the 11 desert kites recorded on the Hemma plateau by Picalause (2004), to try and use them as a benchmark against which to assess to the sites recorded by Oriental Institute, but none could be identified on any satellite image. Features like kites are normally only visible on high resolution satellite imagery, but they are usually clear, as demonstrated by the sites on the basalt escarpment, such as TBS 69 (Figure 6-77). It is unknown whether the kites on the plateau itself are simply not visible, or whether they have been destroyed in the period between their identification (1999-2002), and the acquisition date of the available high resolution imagery for this area (Geoeye 2010). As it is difficult to recognise any sites on the Hemma plateau, it is even more difficult to determine any damage which may be affecting them, which is one of the paradoxes of this type of study.

FIGURE 6-73: STONE CLEARANCE AND BUILDING MOUNDS AT TBS 23[119]

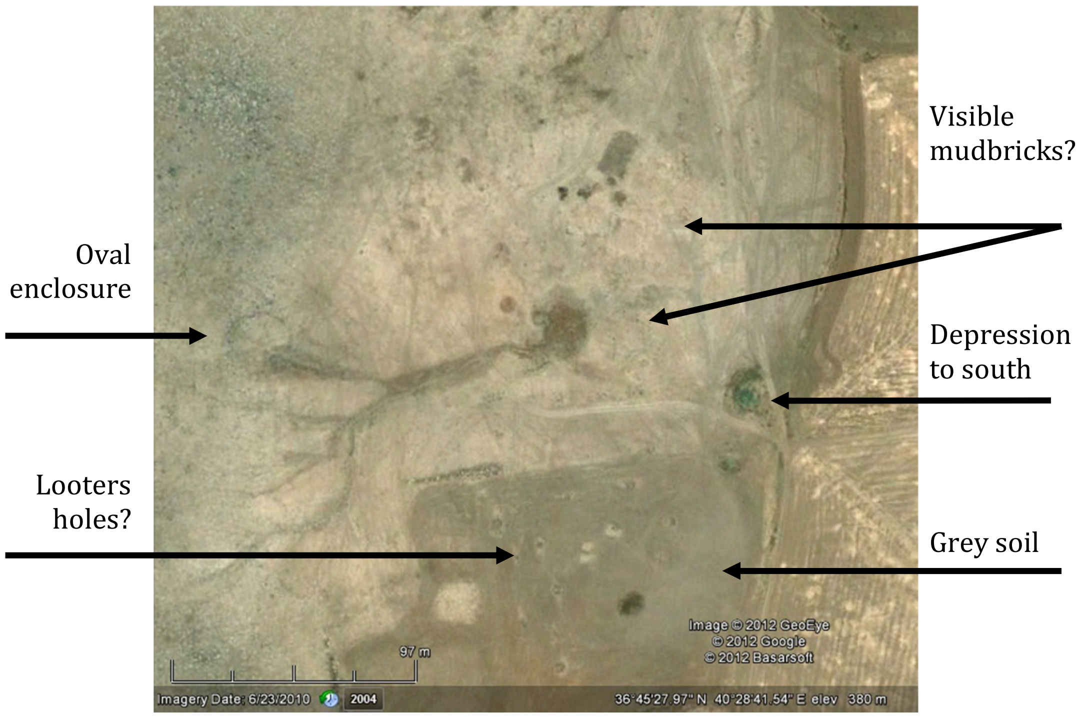


FIGURE 6-74: TBS 74[54]

[119] Geoeye Images, 17 August 2010, 23 June 2010, respectively. Taken from Google Earth 24 April 2012

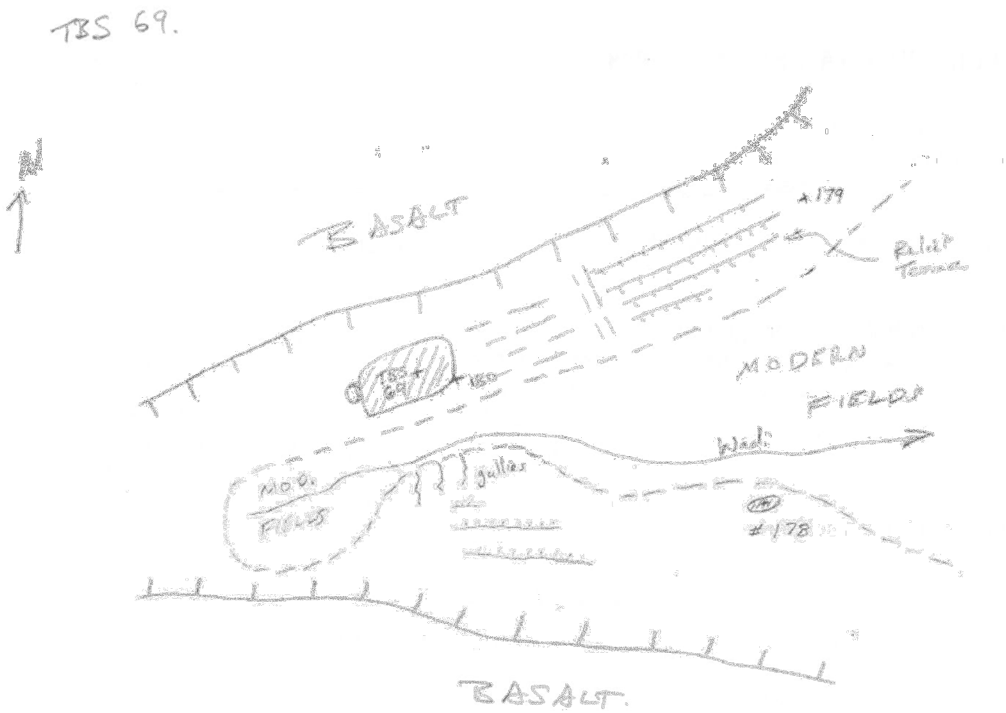


Figure 6-75: Sketch map of TBS 69, Demonstrating the Relationship Between the Different Features

Figure 6-76: TBS 69 on GeoEye image, Demonstrating the Relationship Between the Different Features

Red arrows indicate the mound at #178 (right), the gullies identified on the sketch map (bottom), and the enclosures (left). The following images show various features in more detail.

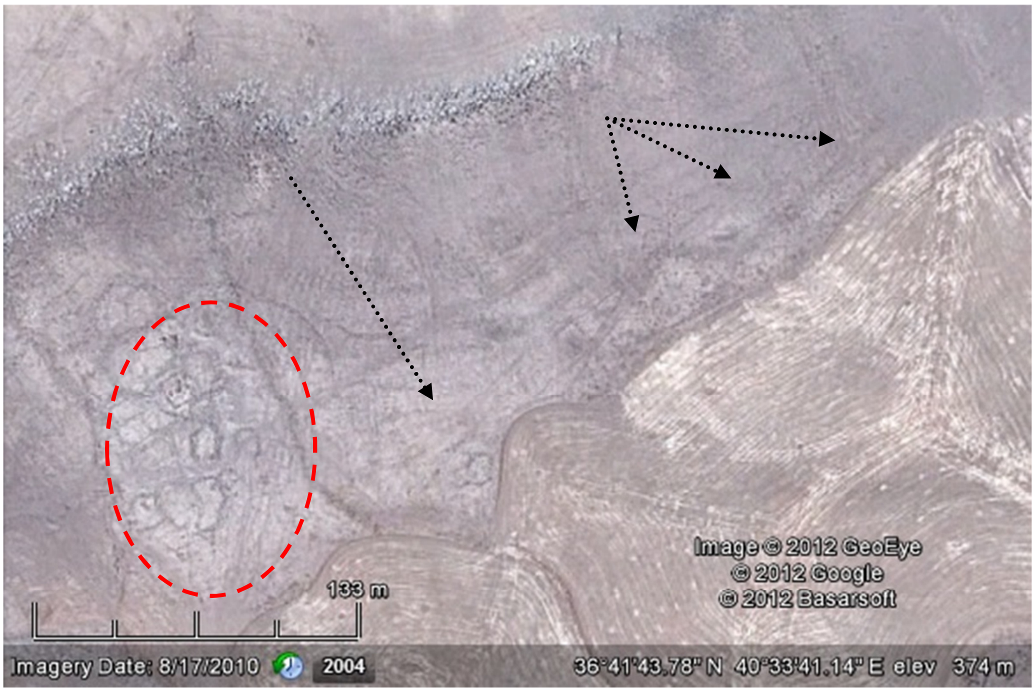


FIGURE 6-77: TBS 69, ENCLOSURES TO LEFT AND RELICT TERRACES TO RIGHT

The enclosures are encircled in red. Dotted black arrows indicate the northern relict terraces.

FIGURE 6-78: TBS 69 - DESTROYED SOUTHERN RELICT TERRACES[120]

The red arrow indicates the gullies which are marked on the sketch map in Figure 6-75. No trace of the terraces is now visible: the pale horizontal lines are not relict terraces but tyre marks from driving along the escarpment. This has presumably damaged the terraces, which were already faint, beyond recognition.

[120] Geoeye Images, 17 August 2010, 23 June 2010, respectively. Taken from Google Earth 24 April 2012

6.9.2 - *Case Studies: Outer Towns*

Outer towns are a particular source of concern: as will be demonstrated they experience considerably more damage than other low mounds. The term "outer town", or 'lower town' is a difficult one, and usually refers to a particular type of site. It is usually defined as the area of mounding around a tell, where there is no clear distinction between the base of the tell, and the mounding around it, other than possibly an outer perimeter wall / fortification delineating the various levels of the city. In the Tell Beydar area, however, very few sites show this distinctive morphology. Although later peoples continued the tradition of building on or around earlier sites, many later settlements are founded in small mounds around major third millennium tells. For the purposes of this study, outer towns are here defined as either those mounds marked as "outer towns" in the field survey, or the complexes of small mounds clustered around the base of large tells which were surveyed together with the tell. 16 outer towns were identified using this definition. These complexes of small mounds and occasional areas of low mounding around tells are compared to the other low mounds surveyed throughout the Tell Beydar area, of which there were 64. (For this analysis, sites were amalgamated, and there is no Unit analysis, as the point of the analysis is the cumulative damage experienced by outer towns compared to other low mounds).

Outer towns around tells are being damaged at a much greater rate than low mounds. Table 6-16 shows the number of damage threats identified on each set of imagery on outer towns compared to other low mounds.

Table 6-16: Number of Damage Threats Identified on Lower Towns

		Corona	SPOT 2004	Geoeye 2010
No. of damage threats identified	Lower Towns	43	64	64
	Low Mounds	120	168	176
Average no of threats per site	Lower Towns	2.69	4.00	4.00
	Low Mounds	1.88	2.63	2.75

For comparative purposes (as there are far more low mounds than outer towns) the average number of threats identified has also been calculated. On Corona, the average number of threats to outer towns is 2.69, compared to only 1.88 threats to low mounds. On Geoeye this rises to an average of 4.00 threats to outer towns, compared to 2.75 to other mounds. The number of threats to outer towns is almost a third as high again as the number affecting low mounds.

There is no difference between the amount of horizontal damage on low mounds or outer towns on any set of imagery (Mann-Whitney-U test, Table 6-17). This suggests that while the number of threats is increasing, the amount of the site they cover is increasing evenly. Consideration of the vertical damage extent is more complicated: the mean rank of vertical damage is significantly higher on outer towns on Corona (mean damage rank is higher on outer towns) (Mann-Whitney-U test, Table 6-18). On SPOT there is no difference, and on Geoeye, there is only weak evidence of a difference. The mean damage rank on low mounds on Geoeye has increased to be slightly higher than that on the outer towns. Small damage threats (such as cemeteries, causing "pitted" damage) are not visible on Corona. However, as they are visible on Geoeye, they could affect the average vertical damage extent, lowering the average. As can be seen on Table G-120 to Table G-123 (Appendix G - damage causes by imagery for low mounds compared to outer towns), the damage threats that were visible on Corona are those which tend to damage the Upper Levels of mounds, and these are far more common on outer towns. By 2010, more damage types are visible, and the number of threats causing more serious damage has increased.

TABLE 6-17: MANN-WHITNEY-U TEST RESULTS FOR HORIZONTAL DAMAGE EXTENTS COMPARING LOWER TOWNS TO LOW MOUNDS

Imagery	Analysis Type	U	P	Mean Rank: Lower Towns	Mean Rank: Low Mounds
Corona	Amalgamated Sites	9532.5	0.265	141.75	152.06
SPOT 2004	Amalgamated Sites	13205.5	0.165	163.23	176.9
Geoeye 2010	Amalgamated Sites	14030.0	0.237	168.05	179.78
Corona	Unit Analysis	24197.0	0.329	236.27	224.22
SPOT 2004	Unit Analysis	33430.0	0.716	259.82	264.49
Geoeye 2010	Unit Analysis	35457.0	0.947	267.09	267.95

TABLE 6-18: MANN-WHITNEY-U TEST RESULTS FOR VERTICAL DAMAGE EXTENTS COMPARING LOWER TOWNS TO LOW MOUNDS

Imagery	Analysis Type	U	P	Mean Rank: Lower Towns	Mean Rank: Low Mounds
Corona	Amalgamated Sites	7509.0	<0.000	162.09	123.08
SPOT 2004	Amalgamated Sites	13830.5	0.518	166.88	173.18
Geoeye 2010	Amalgamated Sites	14586.5	0.588	171.30	176.62
Corona	Unit Analysis	20055.0	<0.000	251.12	201.59
SPOT 2004	Unit Analysis	30988.0	0.049	251.07	274.50
Geoeye 2010	Unit Analysis	33100.0	0.122	258.64	277.20

Table G-124 to Table G-126, Appendix G, show damage causes on each set of imagery, and show the percentage of sites of each type affected by each threat for comparison. On Corona, for all visible threats except water erosion, a higher proportion of outer towns were affected. On Geoeye, on the other hand, a far higher number of low mounds are now affected by development, irrigation channels, and a number of other threats have significantly increased. Nonetheless, it is worth noting that 100% of outer towns are affected by agriculture (and nearly 87.5% of low mounds), and 2 out of 3 are affected by development. Roads affect nearly 90% of outer towns, and a quarter (4 of 16) have been partially bulldozed. 11 low mounds have been partly bulldozed, which is nearly 1 in 5.

Traditionally, tells have been a major focus of excavation in the near east. However, these figures illustrate an increasing trend of damage to small low sites, and particularly to the outer towns around tells, which are experiencing a catastrophic rate of attrition.

6.9.3 - Case Studies: Tell Hassek (TBS 43)

Tell Hassek is a high tell with an extensive lower town extending to the N and NW and apparently spreading under the modern village. It is situated below and immediately to the north of the spur of the basalt plateau. The tell has primarily Bronze Age occupation. The lower town extends over some 700m by 600m E-W: pottery dates it to the Late Bronze Age, Iron Age, Hellenistic Byzantine, and Early Islamic periods (Wilkinson 2000). A modern village is located in the NE corner.

The tell was surveyed by Lyonnet (site ref: Lyonnet 28) in her survey of the Upper Khabur (Lyonnet 1996; 2000). Her plan of the tell shows the classic erosion pattern of a tell site surrounded by a partially eroded outer fortification, with gullies probably aligned to the main gates (Rosen 1986). She noted a village nearby, graves on Area C, and commented that the top of the tell was boggy, highlighting the on-going erosion processes. There is no mention of the lower town, although she does note the village.

The site was revisited by the Oriental Institute survey team in 1997. A large area of mounding was noted to the west of the village, and another area under the village, with grey cultural soil and sherds spread between them and the tell. The main tell had eroded gullies to the NW and ESE, and was uncultivated. It was thought to be larger to the south. The lower town was under cereals and at the time of the visit was partly ploughed and partly unploughed. The height of the lower town mounds varied between 2-4m.

In 1998, the team returned and carried out a more extensive survey of the tell and the lower town. 3 additional separate mounds were recorded to the east of the tell, and the lower town mounding was determined to extend from slightly to the east of the village to about 700m to the west. The roads visible on Corona were confirmed cutting across the tell and lower town. The form of the tell was recorded as circular, as shown in the Corona images.

Figure 6-79 to Figure 6-81 show Tell Hassek on three different Corona images: the boundaries were drawn by Jason Ur from the data gathered during the field visits. (TBS 44, which was classified as a separate site in the survey, is visible in the top left). Each image shows slightly different information, such as changes in field boundaries. The lower town is probably clearest in the 1105 image (Figure 6-81). Some field boundaries appear to go around parts of the lower town, suggesting it was of sufficient height that it could not be easily ploughed at that time. In some places the lower town mounding extends over field boundaries and obscures them. The village is also clear, as are several roads and 3 intermittent wadis; one on the top left of the lower town, one in the top right, and one beneath the tell. The wadis are clearest in the 1102 image, whereas the roads show up best on the earliest image – the 1021 image.

The tell is visible on all three images, and is largely undisturbed, other than a track running along the western edge, and agriculture coming up to the edges. It is a round, complex topographic tell, with a visible peak in the centre, suggesting an upper town or citadel. Erosion gullies are also visible.

Mottling on the Corona imagery implies that, at this point, the lower town extended right up to the northern edge of the tell, although as discussed in 6.7.9 - Natural Erosion, p268, this may simply be eroded soil which has run off the tell and / or lower town. Mottling on the 1021 image also suggests that the site extended slightly west of the boundaries, and that the track and the agriculture are over part of the site.

Figure 6-82 shows the site on SPOT in 2004, and Figure 6-83 shows the site on Geoeye. By 2010, very little of the lower town mounding is present. All three wadis have been ploughed out, and most of the lower town is now visibly ploughed. The road cutting along the east of the tell has been tarmacked, and there is no sign of the lower town mounding visible on the 1105 image which obscured the line of the road. However, a closer examination of the imagery shows that, in several areas at least, farmers have had trouble ploughing the site, implying that some level of dense cultural deposit is still there (Figure 6-84). Grey cultural soil is still visible, even if the predominant soil is now brown, and the plough lines are not straight, suggesting that the plough was disturbed from the usual straight lines. The area at the bottom does not show recent plough lines, nor does the area east of the village: cultural deposits presumably remain to a significant enough depth that farming has not been attempted.

Most worryingly, however, along the east of the tell, and to the area between the north east of the tell and the road is a field. The line of the field against the tell is very artificial (seen in the top right of Figure 6-83), and when the shape of the tell is compared to the boundaries drawn by Ur during the field visit, or the sketch map he made of the tell, which showed a reasonably circular tell, it is clear that at least the south west edge of the tell, and possibly the north west edge, have been bulldozed to extend the fields for agriculture.

It is not possible to say whether the lower town has also been bulldozed. As bulldozing rarely destroys the entire site, but may only smooth it out, or leave deposits below the ground, the true extent of damage at Tell Hassek can only be guessed at. According to the principle of least damage (Chapter 4.7.3 – Damage Certainty, p161), only farming, development, and roads have been recorded on the lower town. Bulldozing (which is clear), agriculture, the road, and the graves, are recorded on the tell, but the possibility of much more extensive damage cannot be ruled out. Furthermore, the tell has a classic shape which suggests dense outer fortification walls, which have helped prevent soil creep, and slowed the erosion of the tell (Rosen 1986). Once part of the walls has been removed, erosion on that side of the tell will increase much more rapidly, placing the site at much greater risk.

FIGURE 6-79: TELL HASSEK (TBS 43) ON CORONA 1021[121]

[121] Corona image, 1021-2120df008-5_37N, standard deviation stretch, 18 May 1965

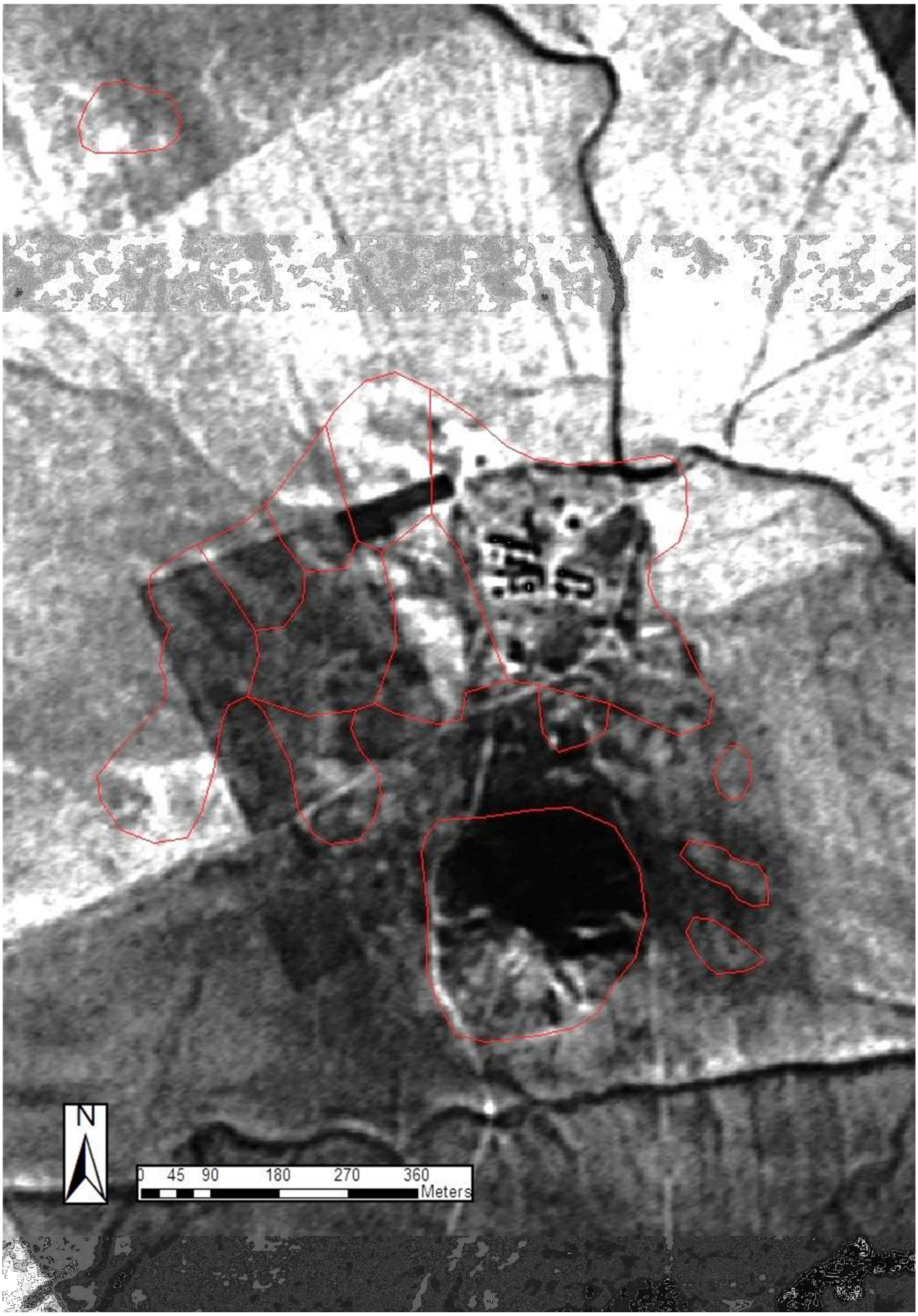


FIGURE 6-80: TELL HASSEK (TBS 43) ON CORONA 1102[122]

[122] Corona Image, 1102-1025DF006-1_37N, histogram equalise stretch, 09 December 1967

FIGURE 6-81: TELL HASSEK (TBS 43) ON CORONA 1105[123]

[123] Corona image, 1105-1025df057-6_37n, standard deviation stretch, 03 November 1968

FIGURE 6-82: TELL HASSEK (TBS 43) ON SPOT 2004[124]

[124] SPOT Image, 31 December 2004(?). Taken from Google Earth 24 April 2012

FIGURE 6-83: TELL HASSEK (TBS 43) ON GEOEYE 2010[125]

A close up of the bulldozing damage to the tell (indicated by the arrow) is in the top right corner

[125] Geoeye Image, 23 June 2010. Taken from Google Earth 24 April 2012

FIGURE 6-84: CLOSE UP OF FARMING OF LOWER TOWN AT TELL HASSEK (TBS 43)[126]

Note the irregularity of the plough lines, particularly when they go over grey soil. This soil colour is usually associated with anthropogenic deposits. The irregular plough lines suggest that the deposits may have some depth and density to them.

[126] Geoeye Image, 23 June 2010. Taken from Google Earth 24 April 2012

6.10 - Key Findings

- In total, 83 sites were surveyed, broken down into 194 individual units (e.g. separate mounds, enclosures, etc.) and 108 amalgamated sites (individual units amalgamated into types of site present on each site - tells, complexes of low mounds, etc.). The Tell Beydar area has been subdivided into plains, wadi banks and bottoms and the basalt plateau and escarpment for comparison of the effect of area. The analysis and interpretation was informed by the field survey notes from 1997/1998.

- Sites were examined on Corona imagery from the 1960s, SPOT imagery from 2004, and Geoeye imagery from 2010 (both from Google Earth). Over 70% of sites had a Definite or High certainty of identification on all imagery, but it was harder to identify individual mounds within the sites.

- Estimates of damage are conservative and follow the principle of least damage in which the least possible confirmed damage a threat can cause is recorded: this ensures that the assessment will not overstate the damage. Less than 50% of the analysis was given a High certainty of correct damage identification.

- Sites were not always visible on the different images. Furthermore, many sites have decreased in visibility between the 1960s Corona and the 2010 Geoeye. However, the resolution has increased markedly. Despite this, only approximately 1 in 5 sites became easier to assess.

- The total number of land uses on and around sites has increased significantly. Wadi bottoms and the flood plains are the areas experiencing the greatest change. Sites on the plains had a significantly higher number of land uses around them than sites elsewhere. Sites by wadis and on the flood plain had significantly higher numbers of land uses on them. However, the differences are decreasing over time, as the landscape becomes increasingly homogenised through industrialisation and sites are increasingly incorporated into the land use strategies around them.

- Damage to sites is definitely increasing. On the Amalgamated sites analysis, 213 causes of damage were recorded on Corona, 314 on SPOT 2004 and 333 on Geoeye 2010. This is even clearer on the Unit analysis: damage causes have increased from 326 on Corona to 461 on Geoeye.

- By 2010, development accounted for almost a fifth of primary damage. Many villages have expanded, some have been abandoned, and numerous small buildings have been erected across the landscape. Development mostly affects Sections of sites, and usually only disturbs the Upper Levels. In total, it was recorded on half the amalgamated sites and about one third of the individual units. 72% of development was on or around low mounds, although a quarter of large tells were affected.

- Agricultural damage comes in several forms: cereal or cotton cultivation, grazing and orchard planting. Arable agriculture presents an on-going risk to sites, both by disturbing the Upper Levels of the site through ploughing, and opening the site to erosion through the removal of scrub and breaking up of sod. Ploughing is hard to determine on Corona: several sites were under cultivation but not ploughed during the field visits. By 2010, most cultivated sites were ploughed. Cultivation is recorded on 98 of 108 amalgamated sites (91%) and is the most common cause of damage (often the primary cause). Agriculture on tells has increased from 14 counts to 20. There were 65 counts of agriculture affecting amalgamated low mounds on Corona, and 71 on Geoeye. More than 80% of agricultural damage is to low mounds: counts on the individual low mounds increased from 120 to 140. By 2010, arable agriculture affected 169 of the 194 site units. The damage extents have increased significantly over time, both vertically and horizontally. By 2010, Sections of sites are the most common horizontal extent. Two thirds of amalgamated sites have Upper Levels damaged by cultivation, and a further 31% are Heavily Degraded (118 mounds have damaged Upper Levels, and 47 have Heavily Degraded sections). Agriculture was also the damage threat most likely to get worse over time, as well as causing on-going damage to a site. Since Corona, new agriculture was marked on 13 sites, but only decreased on 2.

  Grazing is known to occur on sites, and causes damage to the artefact assemblage, but the extent is unknown.

  Orchards are increasing – no orchards were recorded on Corona or during the field survey, but they were recorded on 12 sites in 2004, increasing to 16 in 2010. Most were small, backyard orchards, although 2 major orchards were visible. Orchards disturb the Upper Levels of sites when they are planted, and can cause deeper damage depending on the planting method used, but also protect sites from further damage.

- Irrigation is increasing. There is a large lined irrigation channel passing through the area, and several small channels dug by farmers through sites. In total, irrigation channels were recorded on 19 (18%) sites. Irrigation channels are much more likely to affect low mounds than tells. As most channels are small, they primarily affect the Upper Levels of sites, however some are much larger and cause significantly more damage. 2 channels have Destroyed Sections of sites at least to ground level, and 8 channels have entirely Destroyed Sections of sites.   2 sites were also damaged by the building of the West Hasseke Dam reservoir.

- In total, roads were recorded on 72 amalgamated sites (two thirds of them), usually as secondary damage. Most roads go along the edges of site, rather than through the middle of them, but as time has passed, many new roads have been created and old roads have been widened and tarmacked, which is more likely to cause deeper damage. No road damaged more than the Upper Level of a site on Corona, but in 2010, 10 roads Destroyed Sections of sites (11 mounds) at least to ground level: whether anything remains below them could only be determined by excavation.

  Six tracks visible on Corona were not visible later: on one site, a new road / track became visible between SPOT and Geoeye.   Another 43 tracks / roads came into use after the 1960s, demonstrating the increasing population and need for access to the land.

- Bulldozing is becoming more common. It almost never occurs by itself, but serves another purpose, such as the extension of fields, or the creation of the dam reservoir. It is difficult to detect from imagery as it shares characteristics with several other forms of damage. According to the field survey notes, in 1998, 15 sites had bulldozing damage, ranging from “trimmed” to “destroyed”. By 2010, however, 21 amalgamated sites - 1 in 5 - are at least partly bulldozed (25 units). Although arguably the most destructive form of damage, in 2010 bulldozing accounts for only 6% of the damage threats to amalgamated sites. Bulldozing Heavily Degraded 5 amalgamated sites, and Destroyed 16 (20 mounds) to Ground Level. Excavation would be needed to determine what remains below ground level. Size did not protect sites: by 2010, the edges of 7 tells had been bulldozed for roads or the extension of fields. A further 18 small mounds were damaged. Bulldozing is only recorded when the evidence is good: the true extent could be higher, as there are several sites with possible evidence of bulldozing.

- Water erosion damaged several sites in the 1960s, but as the wadis have dried up and been ploughed out, it is now a less significant threat. 20 sites which were affected in the 1960s were no longer affected by 2004.
- Visitor erosion damaged only one site – some relict terrace walls – and the damage identification is tentative. Looting was also recorded at one site, taken from the field survey notes, although what appears to be looting holes are visible next to another site.
- 18 sites may have been dug for mudbrick, but this identification is tentative. On at least one site, however, the field notes record extensive damage to the lower slopes of the site resulting from mudbrick extraction.
- 25 modern cemeteries were recorded on sites. In general this protects that part of the site from further damage, but in 2 cases, graves that were recorded on the field visits could not be identified on imagery, and new buildings were present at their locations.
- The number of damage threats has visibly increased over time, as have the damage extents. On Geoeye, 225 recorded damage threats became more extensive and / or intensive since they were first recorded. Almost 1 in 5 of these threats worsened just in the 6 years between the 2004 SPOT and 2010 Geoeye images being taken.
- Sites on the basalt plateau and escarpment are particularly difficult to identify, even on very high resolution imagery. It is possible that these sites have been destroyed by farming.
- Outer towns around tells experience significantly more damage than other low mounds. The average number of threats identified was calculated for outer towns and low mounds - the number is almost a third as high again as the number affecting low mounds. Outer towns also experience significantly greater vertical damage, i.e. the damage is deeper than on mounds elsewhere.

6.11 – Concluding Remarks

The Tell Beydar area and the damage recorded are not unique, far from it. Yet in comparison with many areas, such as the North Jazirah in Iraq, it is considered relatively well-preserved. Nonetheless, it is an area undergoing extensive modernisation. The West Hasseke dam has led to the implementation of a huge system of irrigation channels, and the area is now being extensively (and intensively) cultivated. New roads have been built to transport the increased crop loads, and the villages have expanded as the population has received better access to health care and more work has become available. This growth in cultivation has meant that a large number of sites are being damaged, although few have definitely been destroyed. However, whilst the dam has clearly been at least partly indirectly responsible for many of these changes, it has not been possible to discount the effects of many of the other regional influences, such as the drought. As a result, it has not been possible to estimate the rate of damage resulting from the building of the dam.

Nonetheless, the value of satellite imagery as a prospection and monitoring tool is clear: the location of many sites could be identified with certainty, many were visible, and assessments could be made of their condition.

Sites are clearly being degraded: the level of clarity of features is dropping, despite the fact the resolution of the imagery is increasing. Some sites have been destroyed, and some that are not visible, or where height cannot be confirmed, are probably gone. Imagery cannot definitively be used to say a site has suffered no damage, but by 2010, only 6 amalgamated sites and 10 mounds had "unknown" levels of damage – about 5%. Of those, most were not visible – only 2 sites appeared relatively undamaged, although as the original descriptions were vague, this cannot be said with any certainty.

Sites are now facing a number of threats – some immediate, like road building, and some longer term, like agriculture. The slow threat of agriculture is a serious issue. Almost all the sites are under cultivation, and cultivation has intensified and expanded. The main cause of damage is agriculture, affecting 91% of amalgamated sites, and 80% of the individual mounds. Development affected 54 of the 83 sites, and whilst it is not reflected in the number of sites damaged by developments, almost all of the settlements have expanded since the Corona images were taken. In the 1960s, very few villages had amenities such as power lines for electricity, water, oil or gas, but as the agriculture has intensified, villages and new buildings which support it will be updated.

Agriculture encourages a lot of secondary damage: sites are bulldozed to extend fields or build new roads to support the agricultural intensification; and irrigation channels criss-cross the landscape. Farming patterns are moving away from the old systems of strip field farming towards homogenised commercial fields which are heavily ploughed. The old intermittent wadis are largely gone, and even their channels are infilled by the ploughwash or simply ploughed down.

The last fifty years in the Tell Beydar area have been years of change to support a growing, modernising population: where the archaeological sites will fit in is unknown. This problem is also seen in the second case study, which provides a vital comparison to the area examined here. The following chapters detail the context to and analysis of damage to sites identified during the land of Carchemish Project, which has similarities to the Khabur region but also important differences. Trends identified in both areas can then be more securely extrapolated to the wider area, but localised effects can also be studied.

"Unfortunately, as seems to be the case during every field survey in the Near East, we were confronted with the evidence that the archaeological resources are being progressively destroyed as a result of modern activities. Not only have the Tishrin, Carchemish and Biricik Dams submerged numerous sites within the Euphrates Valley, the extension of agricultural fields and the construction of houses and other buildings is resulting in a progressive destruction of sites. One such site (Tukhar Saghir al-Janubi: Site 45) illustrates just how destructive such activities have become, and urges us to re-double our efforts to record as many sites as possible before they are lost forever"

~ T. J. Wilkinson and E. Peltenburg (2009: 38-39) ~

~ According to the field notes site 45 has been almost entirely bulldozed away. ~

Chapter 7:

Case Study 2: Context to the Land of Carchemish Survey Area

7.1 – Introduction

The second case study is the survey conducted around the area of the city of Carchemish in the Middle Euphrates Valley (located on Figure 2-12, Chapter 2.3.3, p22). It is one of the most recent Fragile Crescent Project (FCP) surveys, the other being the Vanishing Landscapes survey in the Homs area (Philip and Dunford 2013). The survey area and identified sites are shown in Figure 7-1 and Figure 7-2. The field visits were all conducted within the last decade, utilising modern GPS and GIS techniques and a high standard of data collection. The area has a long history of fluctuating settlement and comprises a variety of land types with correspondingly different site morphologies, enabling an examination of variations in damage.

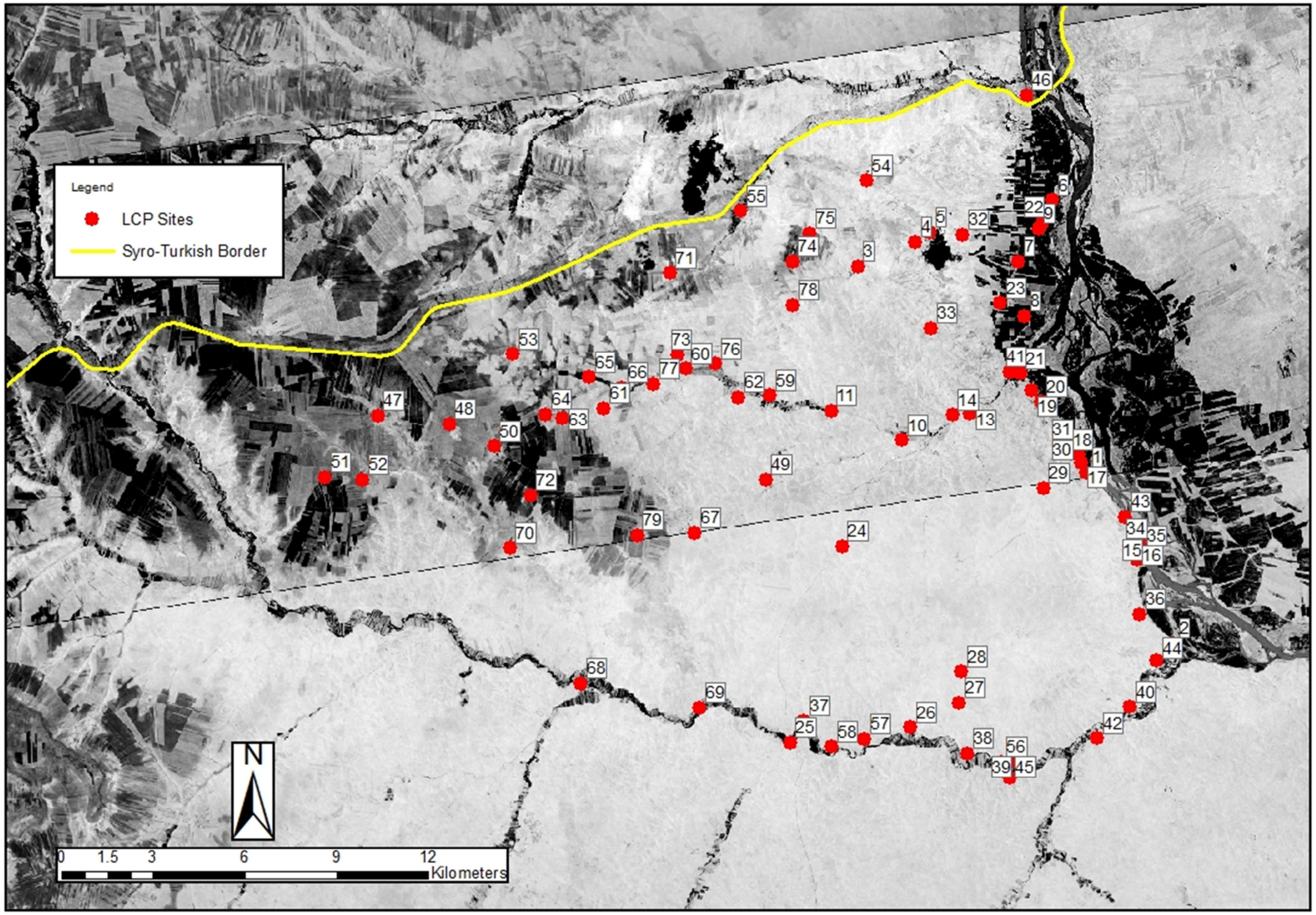


FIGURE 7-1: LAND OF CARCHEMISH PROJECT SURVEY AREA ON A 1960S CORONA MOSAIC

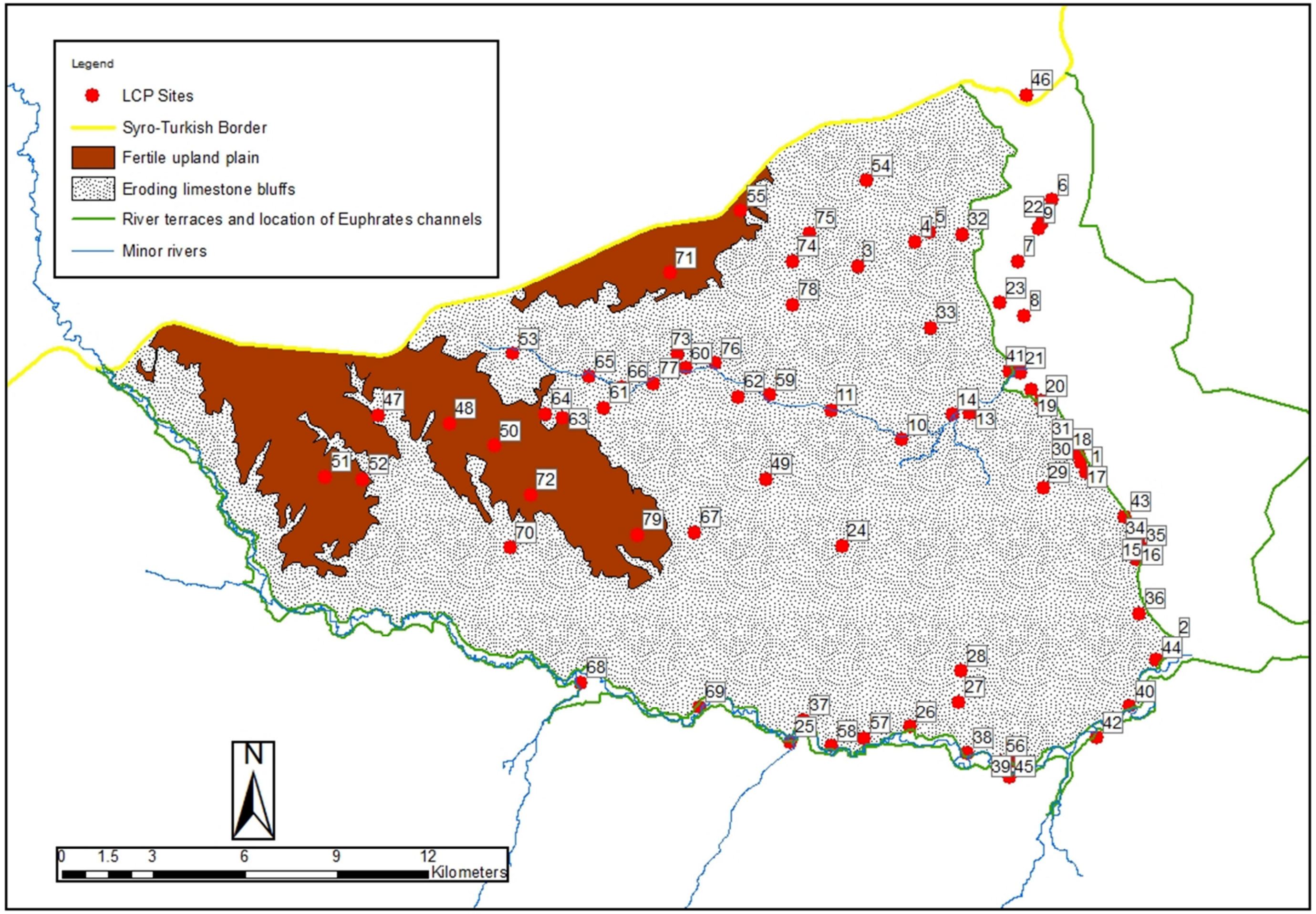


FIGURE 7-2: LAND OF CARCHEMISH PROJECT SURVEY AREA SHOWING SITES AND MAJOR LANDSCAPE FEATURES

Furthermore, the area provides both a contrast to the Tell Beydar area and some similarities. Most of the land consists of limestone hills with thin marginal soils: these have been farmed only rarely in the past, affecting both settlement levels in antiquity and preservation levels today. This can be contrasted to the fertile upland plains and river terraces, which are in some ways more comparable to the Khabur Basin. Although the area lacks the exceptional preservation of the Jazirah, and features such as hollow ways are barely visible, it has many other well-preserved off-site features such as qanats, rock cut tombs, a Roman road and even possible pigeon lofts.

Much like in the Tell Beydar area, the building of dams on the Euphrates in the 1980s provided an opportunity for planned rescue work. However, no consideration was given to how the wider landscape changes would affect the archaeology of the area, which is studied here for the first time.

This chapter is split into three sections. The first describes the survey history, giving context to the data collected, and the exclusions. The second describes the environment of the area, so that natural taphonomic processes can be more easily discounted. The third describes the settlement history, detailing cultural factors which may have affected site creation and destruction before and during the study period.

7.2 – Survey History of the Euphrates Region on the Syrian-Turkish border

Other than brief excavations at and nearby the major regional site of Carchemish around World War 1 (Hogarth 1914; Woolley 1921), the area has been largely neglected by archaeologists. This was partly due to the post World War partitioning of the land, which saw the inner town and citadel mound of Carchemish placed on the Turkish side of the new border in no-man's land, whilst some 60% of the lower town was in the Syrian side. The Turkish side was mined and it was not until 2010 that the mines were removed, and new excavations started (Marchetti 2012). However, as these excavations have only just begun, they have been excluded from this study.

Some limited surveys were conducted in the 1970s, but in the 1980s the Tishrin Dam plans were approved. The resulting rescue excavations were largely tell focused with some survey work, and attention was concentrated on the soon-to-be-flooded valley floor[127] (see del Olmo Lete and Montero Fenollos 1999; Wilkinson et al. 2007; 2012 for

[127] As discussed in Chapter 3.5.4 - Dam Reservoir Beds, p72, inundation does not always destroy sites, but does remove access to archaeological information.

summary). Sites excavated within the LCP survey area were

- Tell Jerablus Tahtani (LCP 22) (Peltenburg 1999; Peltenburg et al. 1997)
- Tell Amarna (LCP 21) (Tunca 1999; Tunca and Molist 2004; Valdés Pereiro 1998)
- Wadi Amarna (LCP 19) (Cruells 2004; Tunca and Molist 2004).

From the rescue work sprang further survey work: the *Archaeology of the Land of Carchemish Project* (LCP). It focused on the region directly to the south of the Carchemish on the western bank of the Euphrates, providing a more even and intensive coverage of settlement and landscape use and features within this area. There were four survey seasons – 2006, 2008, 2009 and 2010. Further fieldwork was planned, but was unfortunately cancelled due to the political situation. (See Peltenburg 2006; 2007a; b; Peltenburg and Wilkinson 2008; Wilkinson 2007a; b; Wilkinson et al. 2012; Wilkinson and Peltenburg 2009; 2010; Wilkinson et al. 2007).

The LCP area is bordered to the north by the Syrian-Turkish frontier, and extends to the confluence of the Sajur and Euphrates Rivers to the south (see Figure 7-2). The Project has recorded 79 sites so far, of which detailed information is available for 78, providing a dataset of a size comparable to the confirmed Beydar sites. Although all sites were visited by the LCP team, field data for two of the tells – Tell Jerablus Tahtani and Tell Amarna– was also provided by the excavation teams (Peltenburg 1999; Peltenburg et al. 1997; Tunca 1999; Tunca and Molist 2004, respectively; and Valdés Pereiro 1998). Not all sites in the area are included: the large citadel of Qal'at Halwanji was not visited by the LCP team and so was excluded in order to standardise the data used as far as possible. Excavations also restarted on the Turkish area of Carchemish in 2011 (Marchetti 2012). However, as these excavations began when the fieldwork on the Syrian side ended, are on-going, and are not conducted by Wilkinson and his team, it was decided to exclude the information from this research to maintain as much consistency in data used as possible.

Several possible sites were identified on satellite imagery, but these could not be visited to confirm their nature and were excluded. As in other regions, historical cultivation will have affected the landscape, and sites may have been buried or eroded by the Euphrates, the Sajur and the shifting wadis. The oldest and longest duration settlements are known elsewhere on river banks and terraces: although probably also the case here, the evidence is largely gone.

7.3 – PHYSICAL ENVIRONMENT OF THE EUPHRATES REGION ON THE SYRIAN-TURKISH BORDER

The area south of the Syrian-Turkish border can be split into three main geographic types, outlined in Figure 7-2. (These are taken from Wilkinson et al. 2012; and Wilkinson and Peltenburg 2010: 10, where more detail on the physical environment can be found).

The first geographic area is the river valleys of the Euphrates, the Sajur and the al-Armarna, and their flood plains and terraces. The lowland river valleys are highly cultivatable and will have been a focus for settlement throughout history. Settlement is probably under-represented here, partly because of the later flooding of the Euphrates due to the dam. Furthermore, the lowest terraces are only 5 or 6m above the river, and will have been subject to frequent flooding. At Khirbet Seraisat (LCP 1), for example, parts of the industrial quarter by the junction of Wadi Seraisat and the Euphrates are buried under 2-3m of gravel deposited by wadi flow. The main lower Euphrates terrace is today some 10m above the river level and 6m above the main floodplain terrace. This is sufficiently above the level of the Euphrates' annual flood that major archaeological sites like Tell Jerablus Tahtani, as well as some modern villages, are located there (Wilkinson et al. 2012). 5-20m above the river is an intermediate terrace complex, and 20-50m above that is an upper terrace. A large area of relict flood plain remains near Tell Jerablus Tahtani, probably forming the only extant remains of the cultivated territory of Carchemish (Wilkinson et al. 2012; Wilkinson et al. 2007).

The second region is the eroded limestone bluffs with thin soils which cover the majority of the area. Finally, to the west of the area is a fertile upland plain which would have provided plentiful agricultural soil and pastureland. The late Holocene flood plain is without archaeological sites, or they have been covered by the waters of Lake Tishrin: it is therefore excluded.

Rainfall in the present day is approximately 400mm per annum (Chapter 2.3.2, Figure 2-14, p27), close to the climatic limit for many of the crops grown here, and early settlement would probably have been vulnerable to climatic fluctations. However, a series of east-west tributary valleys would have conducted water across the area.

7.4 – SETTLEMENT HISTORY OF THE EUPHRATES REGION ON THE SYRIAN-TURKISH BORDER

The following summation of the settlement history is taken from the publications resulting from the surveys conducted by the Archaeology of the Land of Carchemish Project (Marro 2007; Peltenburg 2000; Peltenburg 2006; 2007a; b; Wilkinson 2007a; b; Wilkinson et al. 2012; Wilkinson and Peltenburg 2009; 2010; Wilkinson et al. 2007).

Sites can be split into three main types: hilltop settlements (varying from scatters to approximately a metre of cultural deposit); small, low sites of around 1ha or less and with less than 2m of cultural accumulation (including the lower towns around tells); and the multi-period tells so prevalent in the Near East.

Settlement in this region has an extensive history, but early sites are poorly preserved, and much of that record has been eroded or buried (Wilkinson et al. 2007). The earliest known sites date to the Late Pleistocene / Early Holocene, and agriculture was practiced. Mughar Seraisat (LCP 20), for example, dates to the early Ceramic Neolithic (between 7,000 – 6,000 cal. BC).

Limited evidence of 5th - or possibly even 6th - millennium BC settlement was found. Settlement increased into the 4th millennium BC, and continued into the 3rd millennium in the form of small dispersed villages on low terraces or alluvial fans along the Euphrates and its tributaries (although at least two sites were situated on hilltops and high terraces) (Peltenburg 2007b; Wilkinson et al. 2012). By the mid-third millennium BC, tells "became defining features in the cultural landscape" (Wilkinson et al. 2007: 243) and there was a dense expansion of settlement along the Euphrates and its tributaries. There is good evidence of site reoccupation during the Iron Age: for example Carchemish attained its maximum size, and the settlement trend towards small and dispersed sites began. Many of the new sites established in this period remained occupied into the Post-Assyrian (Iron Age III) period, despite political turmoil, suggesting a level of settled continuity in the area.

Dispersed settlement increased into the Hellenistic / Roman period, although some tell-based occupation continued. Some sites are also associated with a developing network of canals and roads, and many other off-site features are documented, illustrating increasing use of the entire landscape. Sections exposed in valley floor sediments and on the lower hill slopes illustrate the effect of this increasing industrialisation and agriculture: a significant amount of soil erosion is evident in the post-Roman period, presumably due to the reduction in vegetation cover and destabilisation of soils.

The Late Roman and Byzantine periods provide some of the first evidence of settlement on the marginal soils of the upland limestone bluffs, demonstrating the intensity of settlement and cultivation on the more fertile areas on the plains and river valleys. However, these sites are small low mounds and artefact scatters, and may be under-represented in the archaeological record: occupation during other periods cannot be ruled out.

Small dispersed settlements continued into the Byzantine and early Islamic periods, with even less tell-based occupation, although some tells, such as Tell Amarna, developed sprawling lower towns. After the 8th or 9th centuries AD uneven tell-based settlement also resumed. Ottoman administration appeared to make little difference, and the area was sparsely populated. The Euphrates liwā (district) had only 3 main settlements – a town and two villages: it was mainly populated by nomadic tribes. There are no records of irrigation (Göyünç and Hütteroth 1997; Hütteroth 1990; 1992; Hütteroth and Abdulfattah 1977).

Unlike in the Jazirah, by the twentieth century, settlement still consisted mostly of small villages between 1 and 3 km apart throughout the higher zone of the flood plain. The agriculture of these villages benefitted from the mechanical pumps which became widely available in the 19th century. However, most of them were flooded by the waters of Lake Assad and the Tishrin Dam.

7.5 – Concluding Remarks

The data acquired during the Land of Carchemish Project provides an excellent foundation on which to study damage to the identified sites. The data collection was conducted to a high standard, utilising multiple sources, and the supporting analysis and interpretation of the fieldwork data allows for a far more nuanced damage assessment than would otherwise have been possible.

This area has rarely been intensively occupied – the only record of occupation of the limestone hills, for example, is during the Roman period. Whilst large multi-period tells were not uncommon, there is no evidence of the extensive network of roads and villages that mark the Jazirah and Upper Khabur Basin - although as mentioned this is almost certainly in part due to the changing levels of the Euphrates, and on-going erosion of the flood plain. In particular this area lacks the intensive recent settlement programs established after 1850, and whilst dams were built in this area, their effects are focused on the flood plain and river terraces, providing a counterpoint study to the Tell Beydar area. The following chapter will examine the damage to sites south of Carchemish, looking at cause, extent, site type, and location. Key trends are identified, and exploratory case studies are drawn from within the larger case study survey area to give specific local examples of damage patterns.

"When we arrived in the land of Carchemish we arrived with a sense of great urgency. Dams were being built and the land was to be flooded. We needed to rescue excavate and we needed to survey. This is a key area of the Ancient Near East since Carchemish was the Hittite Empire's capital of its Syrian provinces, and thereafter the centre of a paramount kingdom ….

However, we have new challenges: … with the current huge investments in dams, earth-moving machines and industrialised agriculture, the landscape is being transformed to such a degree that we are rapidly losing the archaeological record. Modern surveys are therefore trying to record as much as possible of the archaeological record before it is lost for ever. Such work is therefore more pressing than ever before."

~ E. Peltenburg and T. J. Wilkinson (2008) ~

Chapter 8:

Case Study 2: Damage in the Land of Carchemish Survey Area

8.1 - INTRODUCTION

This chapter examines damage to the sites which were surveyed as part of the Land of Carchemish Project (LCP), detailed in the previous chapter. The chapter is broken into 12 sections[128]. It begins by introducing the area and the sites under examination in Section 8.2. This is followed by a brief discussion of the certainty ratings of the results in Section 8.3. These results frame the ensuing discussion, and should be borne in mind at all times. Section 8.4 discusses the visibility of the sites on imagery, a factor which also influences the data collection and discussion. Section 8.5 discusses the land cover on and around the sites and provides environmental context to the data.

[128] This chapter is structured the same as Chapter 6, and therefor contains some repetition, as each Chapter is intended to be readable as a standalone chapter for those only interested in the results from one survey area.

Section 8.6 covers general damage trends across the area, and Section 8.7 breaks these damage trends down according to the separate causes of the damage, examining the prevalence of the different threats, and the type and extent of damage each one causes. Section 8.8 discusses the stability of the sites, and the extent to which the damage is on-going and increasing.

Section 8.9 discusses three case studies within the larger survey case study. The first of these (Section 8.9.1) is the limestone hills (defined in Chapter 7.1, Figure 7-1 p300, and Figure 7-2, p301), a marginal area of land with only rare occupation in antiquity: however it has seen extensive changes over the last fifty years. This allows the recent damage to be studied, as the effects of earlier occupation on the archaeological record can be largely discounted. The second case study (Section 8.9.2) looks at outer towns around tells, an area which has traditionally received little attention from archaeologists. Outer towns were shown to be highly damaged in the area around Tell Beydar. Whilst there are far fewer outer towns in the LCP area, the data still permits a comparison (conducted in the following Chapter 9), potentially supporting the findings and highlighting the risk. The third case study (Section 8.9.3) is a detailed study of one site, using it as an example to highlight the effects of the cumulative threats sites face. The site chosen is LCP 1, Khirbet Seraisat, which is in the limestone bluffs. It has a tell, a large area of field scatters around it, suggesting possible later settlement, and a lower industrial area by the wadi, providing evidence of how various types of ancient settlement are affected by the different threats, and the effects they have on the site overall.

Finally, the key findings are summarised in Section 8.10, and a brief conclusion given in Section 8.11.

Due to the volume of data only key graphs and tables are included in the text. Where necessary, the keys to the tables are in Appendix F. All other supporting data is included in Appendix H. It should be remembered that the counts of damage on the Tables relating to SPOT imagery are informed by the field visit records, and are not a direct representation of what was visible on the SPOT image.

It is important to note that when the findings from Corona are compared to those from the later SPOT and Geoeye, far more threats were identified on the later images. Therefore, as an example, a threat which affected 10 sites on Corona and 10 sites on Geoeye will evidence very different proportions, as it is a substantially different sample size. Key numbers and percentages are given in the text, but rarely both. The full figures should be consulted in the tables in the text and in Appendix H.

8.2 – Overview of the Land of Carchemish Area

In total 79 sites were visited, with detailed notes available for 78 of them, including Tell Jerablus Tahtani, Tell Amarna and the outer town of Carchemish, but excluding Qal'at Halwanji, which was not visited by the field team. This has been broken down into 100 separate site units, as recorded in the field notes, and 85 amalgamated sites (see Methodology Chapter 4.8.1 – Analysis by Amalgamated Site Type and by Site Unit, p163). For example, LCP 1 - Khirbet Seraisat, consists of five units in the original field survey: a large flat field scatter which was collected as three separate areas; a tell; and a lower industrial area on the river terrace. This is counted as three sites in the Amalgamated site overview: the three flat parts, A, B, D, are amalgamated into one site, and the tell and the industrial area are counted separately. This difference is not significant in this area, but is important in Tell Beydar, and therefore tables of site units are included in Appendix H for comparison. *However, all analysis here is conducted on the amalgamated sites only*.

Tables 1, 2 and 3 in Appendix H show the distribution of sites and site types by site location. The site locations were determined by a combination of location on imagery, and field visit notes, and follows the distinction made by Wilkinson and Peltenburg (2010: 10). The survey area is subdivided into three geographic regions, as discussed in Chapter 7.1 and 7.2: the river terraces flanking the Euphrates and the Sajur rivers, the upland plains, and the limestone bluffs. No site is present in more than one location. The highest numbers of sites are to be found on the limestone bluffs, and the least on the river terraces. Whilst acknowledging the erosive role played by the Euphrates, this is largely a factor of area size – the limestone bluffs are by far the largest area in this study.

Most sites in this area are flat sites and scatters, with almost equal numbers of tells and low tells. There are 18 tells, although one of these - site 54 - is a tell on a bench, and this is subdivided into two tells in the unit analysis. There are 19 clusters of low mounds. Many of these clusters may be single sites, but the extent of a site was sometimes hard to determine (see Section 8.2.1). Flat sites and field scatters account for almost half the sites.

Some sites had rock cut tombs listed in the features. As there was rarely much information about the tombs (only one case was detailed), these were included as a part of the site unit they were described with, for example at LCP 70, the field notes read "*The site is flat and extends along the hilltop… There are two chamber tombs at the S end…*" (2009). The site was recorded and collected as one site, even though it consists of the tombs and pottery scatters. Although tombs are obviously not 'flat', this was recorded as a 'flat' site. The height appellation in this survey is intended to distinguish sites which have height above ground, and which are therefore more prone to damage from sources such as agriculture. Tombs are subterranean: 'height' refers to the site above and around them. Only one tomb was recorded as a separate site unit. At LCP 2, shaft tombs were recorded at waypoint #1033. Although almost no other information is available, the sketch map makes it clear that this point is not part of the four main subdivisions of the site. It was therefore recorded as a separate unit (LCP 2_5_0), but is not separate in the amalgamated sites analysis – it is considered together with all the other parts of the site.

Four phases of imagery were used to support the field visit data and published data when analysing the sites: Corona, DigitalGlobe, SPOT 2004 and Geoeye. The Corona data (the 1038 and 1104 missions) belongs to the FCP: most other data was available through Google Earth. Google Earth hosts (as of February 2013) two sets of DigitalGlobe data in this area – 2003 and 2008. The 2008 DigitalGlobe data covered only a few sites, so was excluded from the time sequence analysis, although it was used to help site and feature identification. In some cases it also allowed more accurate dating of the damage visible in the other imagery, as it could be said to have occurred just between 2006-2008 or 2008-2009. However, nothing was visible on DigitalGlobe 2008 that was not also visible on later Geoeye imagery, hence its exclusion from the majority of the analysis for simplicity.

Neither Geoeye nor DigitalGlobe covered the whole area – this has affected all percentage counts in this analysis, and should be remembered when comparisons are made to the Tell Beydar analysis. As well as the pan-sharpened Geoeye imagery on Google Earth, the FCP also obtained Geoeye data, which included image acquisition from November, which was not available on Google Earth and which covered a slightly larger area: 7 of the 78 sites were only visible on the panchromatic FCP November Geoeye data. 24 out of 85 amalgamated sites and 31 out of 100 units (i.e. 1/3) were not covered by DigitalGlobe imagery: 10 out of 85 amalgamated sites and 16 out of 100 units were not visible on Geoeye. Although all sites were visible on SPOT and Corona, the resolution of SPOT was often too poor for good time-sequenced damage analysis in these cases However, as the SPOT records were also used as a proxy for the field visit data, they provide good supporting evidence for some forms of damage in areas where there was no Geoeye coverage .

8.2.1 – The Extent of Sites in the Carchemish Area

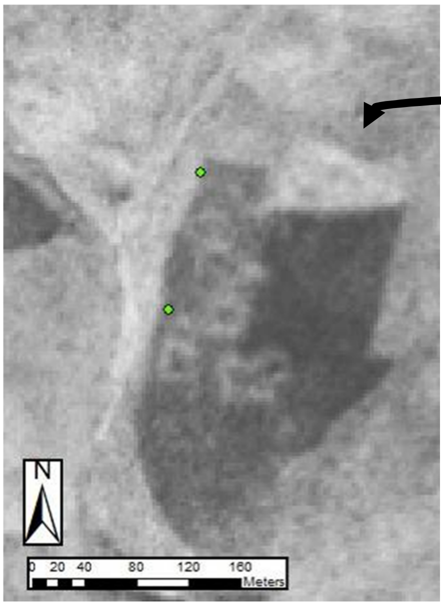
Site definition was discussed in detail in Chapter 2.2 (p10). As stated, some sites appear much larger on imagery than they do in the field. In most cases, this is probably due to the reflectance of eroded soil which has slipped or washed down the sides of the tell onto the surrounding fields. In the LCP area, many sites are adjacent to wadis, and these wadis have left sediment which has a very similar reflectance pattern to that of archaeological soil: this is probably the case at LCP 11 (Tell Ma'zala), for example (discussed later on p319). However on some sites, it could indicate an extension of the site which was not visible in the field visit (although as the transects undertaken at several sites testify, the field teams were careful to look for such features). Where potential site extensions are visible on Corona, for example, it could have been bulldozed or ploughed away before the field visit, and any sherd scatter masked by crops. In some cases, the field visit notes state it was not possible to determine the full extent of the site, and that it may extend further. At LCP 28 (Umm Dash), for example, the field notes (2008) record

"*Although the dimensions are estimate [sic] at ca 110 x 80m, a brief visit to the site on top of the hill to the NE suggests the site continued here, but field was obscured by wheat".*

This hypothesis is borne out by the imagery, demonstrated in the comparison on the following page (Figure 8-1 and Figure 8-2).

- Sites on Corona which appear larger than suggested by the field visit are LCP 11, LCP 28, LCP 48, LCP 58, LCP 60, LCP 62, and LCP 65.
- On DigitalGlobe 2003, LCP 11, LCP 29 and LCP 31 are larger.
- On SPOT 2004, LCP 48 and LCP 60 appear larger.
- On Geoeye 2009, LCP 11, LCP 28, LCP 29 and LCP 31 appear larger.

As discussed in Chapter 4.7.2 and 4.8.5, sites which are larger than previously supposed could have been exposed to greater damage than recorded. Some sites, on the other hand, could be smaller than estimated, and therefore exposed to fewer threats. LCP 33, for example, is a 'meagre site' with only 'trace occupation' according to the field visit notes, and may be smaller (or not a site). Nonetheless, for the purposes of this study, damage is recorded to all surveyed sites using the extents defined in the field. The least possible horizontal and vertical extents are recorded according to the principle of least damage (see Chapter 4.7.3 - Damage Certainty, p161) so as not to overstate damage to sites in this area.



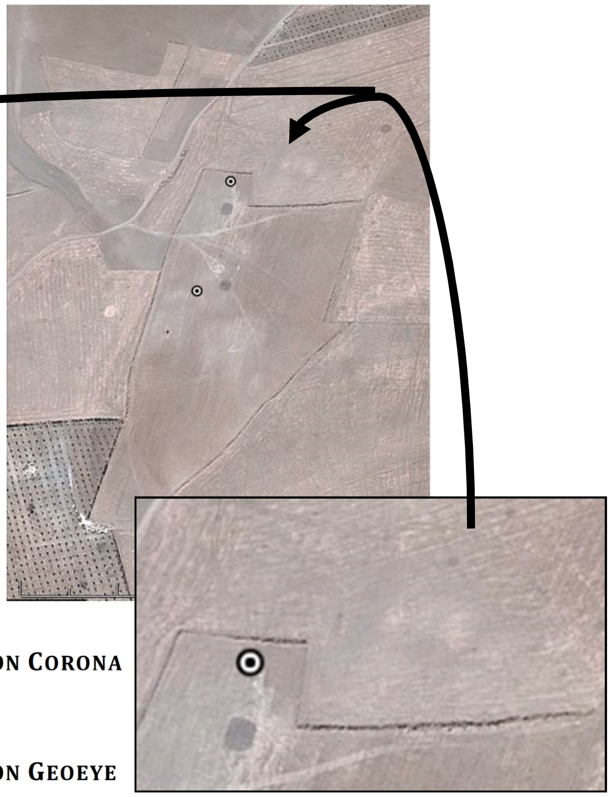


FIGURE 8-1: SITE EXTENTS AT LCP 28 ON CORONA 1038

FIGURE 8-2: SITE EXTENTS AT LCP 28 ON GEOEYE 2009[129]

The two dots are waypoints (GPS points) taken during the survey which mark the north and south ends of the site. As can be seen from the close up, the site does appear to extend north of the field, but also south and south east of the southern GPS point.

8.3 - CERTAINTY

Certainty ratings were defined in Methodology Chapter 4.8: brief definitions are repeated here as footnotes. The following analysis is split according to the amalgamated sites and the site units, as defined in the Methodology Chapter 4.8.1 (p163).

[129] Top: Corona 1038 image, 1038-2120df067_67, 22 January 1967. Bottom: Geoeye Image, 22 September 2009. Taken from Google Earth 17 February 2013

8.3.1 - Certainty: Amalgamated Sites

(Supporting data and the unit analysis figures can be found in Appendix H, Table H-4 to Table H-13, and Figure H-1 to Figure H-4).

Only 80 of the 85 amalgamated sites had a Definite certainty of identification[130]. For example, LCP 1_5_0 is the industrial part of Khirbet Seraisat. Although it is referred to in the field visit notes, it is not included on the field sketch map and there are no GPS points for it. As a result, it has only a High certainty of identification, even during the field visit, as a confirmed location cannot be extrapolated from the notes.

Many sites in this area were hard to identify for certain on imagery. Most sites had a sketch map, and all sites had at least one GPS point, but this did not always align with the site. In some cases there was nothing visible on a satellite image which could indicate the site's presence. It is unknown what rectification method Google Earth used for their imagery, but in some cases GPS points do not line up by tens of metres. Where there are no other features to identify the sites, this can lower the certainties considerably. As seen on Figure 8-3, Geoeye gave the most certain results: just over half the sites (44 of 75) could be identified with Definite certainty. However, in all cases at least two thirds of sites visible on each image type could be identified with Definite or High certainty.

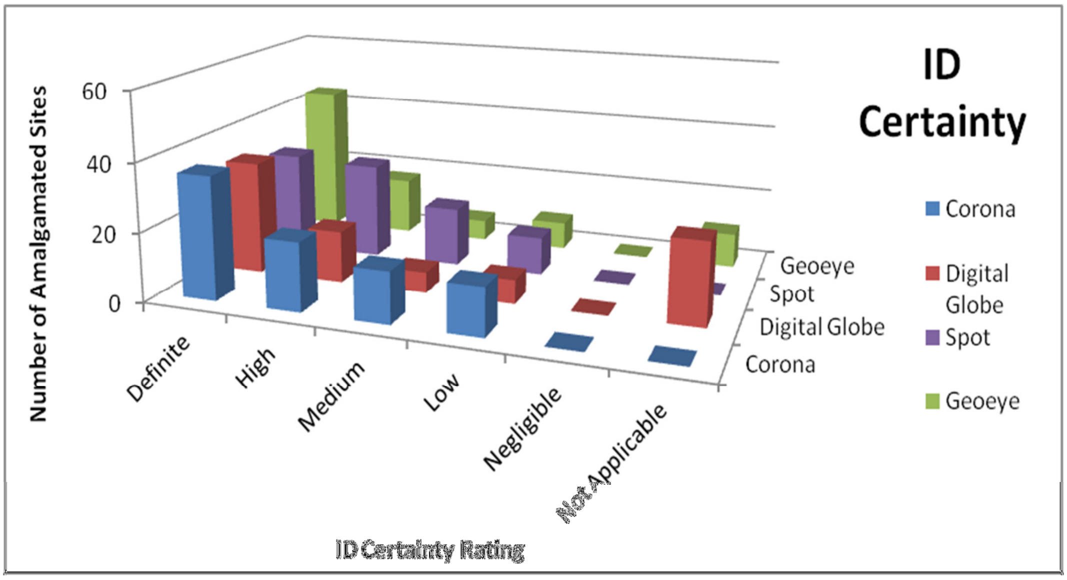


Figure 8-3: Graph of ID Certainty Ratings on Imagery (Amalgamated Sites)

[130] See Chapter 4.7.1: Identification certainty, also known as Geographical precision, refers to the types of data available when locating and inputting the site, and the impact the data has on the likelihood that the identification point which they have drawn is correctly located.

Boundary certainties[131], particularly on Corona, were mostly Low or Negligible (Figure 8-4), with boundaries that were assessed on SPOT having the lowest certainties. Most sites, particularly from the early seasons, had good sketch maps and for some sites the extents were measured in the field and multiple GPS points were taken. This gave approximately one quarter of sites a High certainty. The boundaries of both the tell and the outer town of Carchemish were assigned Definite certainties: the site was extensively mapped by Woolley and Guy in 1920, and their work was checked by the LCP team in the outer town, and on the tell by S. Bernardoni and R. Trojanis (2012, unpublished poster from the International Conference on the Archaeology of the Ancient Near East 8, Warsaw).

It was harder to be certain about the boundaries for sites located in later field seasons. The sketch maps for drawn for sites LCP 49 – LCP 78 were useful for locating sites, but not of a good enough quality to provide much information about the site itself. Furthermore, defining site extents in the field and on imagery can be a complex process: without excavation, site boundaries are open to numerous methodological and definitional arguments. This was discussed in detail in Chapter 2.2 (p10), where work into the problem of multiple boundaries by the Fragile Crescent Group was detailed (Philip et al. 2012).

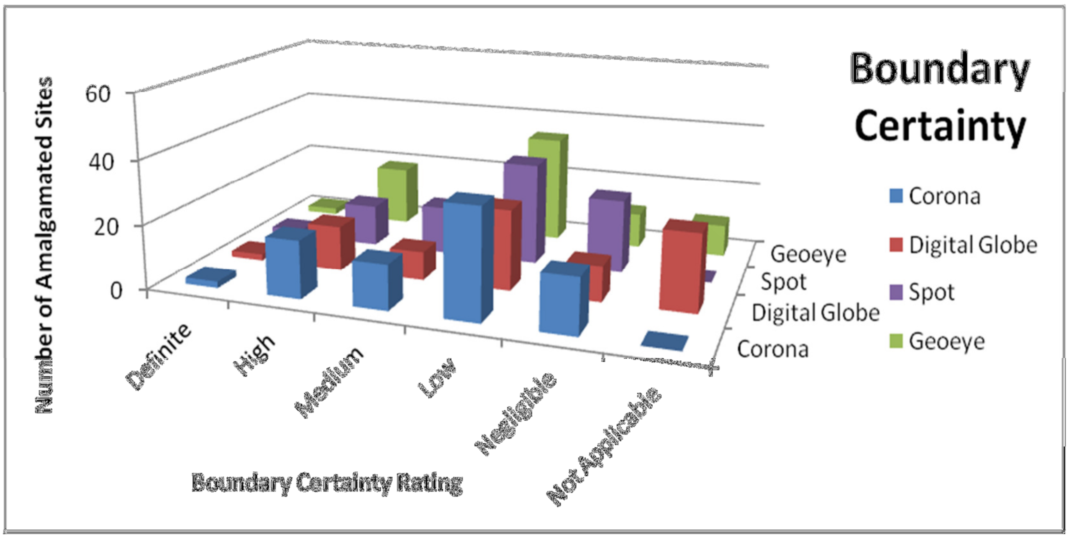


FIGURE 8-4: GRAPH OF BOUNDARY CERTAINTY RATINGS ON IMAGERY (AMALGAMATED SITES)

[131] See Chapter 4.7.2: Given that drawing GIS polygons around sites on satellite imagery is inherently subjective, boundary certainty refers to the quality of the data available when drawing the shape and extent of the site, and the level of confidence that the drawn site boundary is accurate.

Damage certainty[132] varied (Figure 8-5): the lowest damage certainty was on SPOT imagery (71% of sites had Low certainty of damage identification) and the highest was on Geoeye imagery (38% of sites had a High damage certainty). The resulting damage analysis is conservative due to these low certainties.

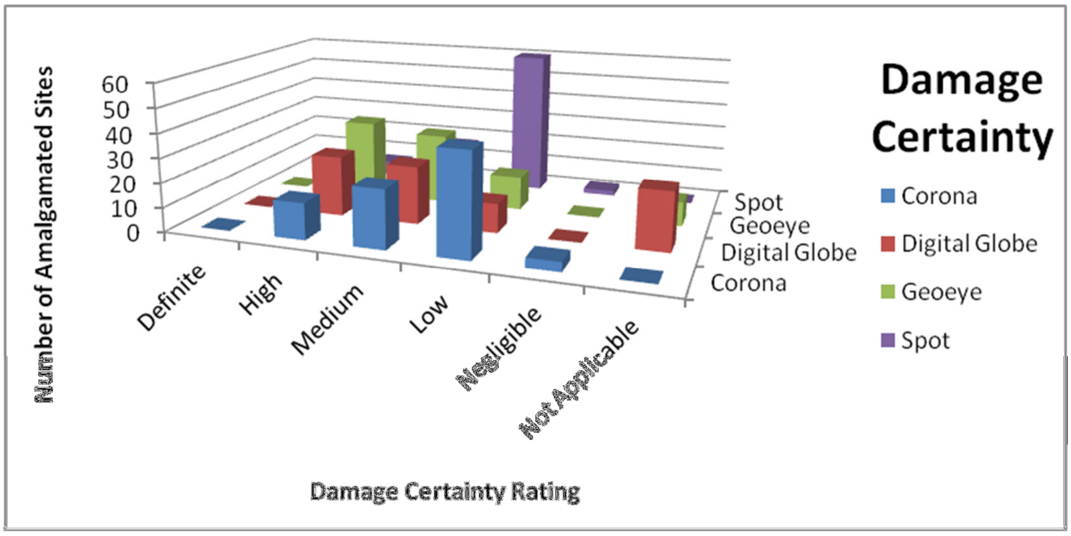


FIGURE 8-5: GRAPH OF DAMAGE CERTAINTY RATINGS ON IMAGERY (AMALGAMATED SITES)

Overall certainty[133] of the data collected for each site varied depending on the imagery type (Figure 8-6). Data recorded from analysing Corona and SPOT were largely of a Low certainty, as whilst the sites could be located, the resolution was not high enough to be certain about the extent of damage affecting the sites. Geoeye data was largely given a High or Medium certainty, as the resolution allowed more certainty of site identification and recording damage. The analysis of the information from the DigitalGlobe imagery was mostly given a Medium certainty as fewer sites could be identified with a High certainty, and the damage assessment was not as clear.

[132] See Chapter 4.7.3: Damage Certainty relates to the damage threats identified on imagery and represents certainty that all damage causes and extents affecting sites have been correctly identified, particularly when bearing in mind the uncertainties of boundary definition and of site visibility.

[133] See Chapter 4.7.3: Overall Certainty is the amalgamated certainty of the previous three categories. It is the level of confidence that, given the data constraints, uncertainties, and subjectivity, the site has been correctly located, its extent correctly determined, and the damage threats affecting it have been correctly recorded.

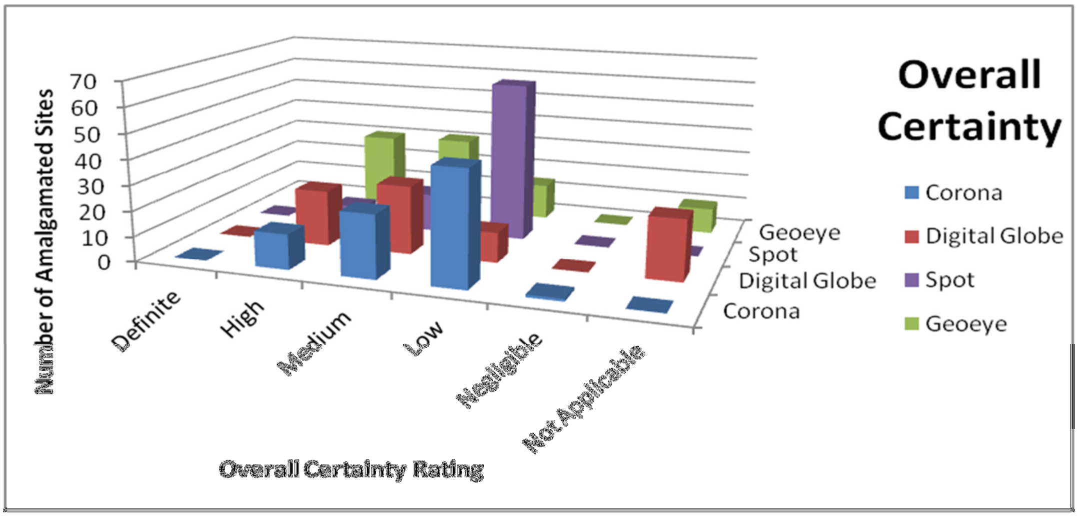


FIGURE 8-6: GRAPH OF OVERALL CERTAINTY RATINGS ON IMAGERY (AMALGAMATED SITES)

8.3.2 - A NOTE ON GENERALISATIONS AND HEIGHT

Most sites in this area are flat scatters, low mounds and tells, with field scatters extending beyond them (Table H-2 and Table H-3, Appendix H). There are too few of the other site types to undertake any analysis. When the sites are subdivided into the three geographic regions discussed in Chapter 7, each individual area has few sites: results are rarely statistically significant, but provide evidence of general trends.

Height can act as a proxy indicator of damage – a site which is visibly lower than it used to be has clearly been damaged in the past. Height of low mounds in this area was particularly hard to recognise from imagery; however it was recorded as part of the field visits. These took place between the acquisition of the DigitalGlobe and the Geoeye images. The height of the site as recorded during the field visit acts as a minimum estimate of the height of the site on DigitalGlobe and Corona. In the Tell Beydar area there was a considerable time gap between the field visit and the later imagery, so the height as recorded during the field visit could not be assumed on later imagery. However, the DigitalGlobe acquisition occurred only 3 years before the earliest field visits: if the site height (from the field visit) was visible on that image, and the site appeared the same on the Geoeye image (taken 6 years later) then height could be assumed later. However, more than half of the sites in the Carchemish area existed only as flat sites by the time of the field visit. (For more information on the estimation of remaining height, see Chapter 6.3.3, p189).

Table 8-1 shows height certainties for the amalgamated sites. (The Unit analysis is Table H-14, Appendix H). The field visits recorded uncertain height on 3 sites. The notes give no information about the lower settlement next to LCP 5 (LCP 5_2); LCP 61 may or may not be a tell under houses – it was identified by sherds in alleyways. LCP 63 may be a flat site on a natural ridge – it was impossible to tell without excavation.

TABLE 8-1: CERTAINTY OF HEIGHT REMAINING (AMALGAMATED SITES)

Does Height Remain?	Number of sites on Corona	Number of sites on Field Visits	Number of sites on DigitalGlobe 2003	Number of sites on SPOT 2004	Number of sites on Geoeye 2009
Certain	39 (45.9%)	39 (45.9%)	29 (46.8%)	39 (45.9%)	32 (42.7%)
Uncertain	4 (4.7%)	3 (3.5%)	3 (4.8%)	4 (4.7%)	8 (10.7%)
Flat Site	42 (49.4%)	43 (50.6%)	30 (48.4%)	42 (49.4%)	35 (46.7%)
Not Applicable	*0/85*	*0/85*	*23/85*	*0/85*	*10/85*

Percentages are of sites covered by the imagery, to allow comparisons between the images.

Sites on Corona are accorded the same height as that recorded on the field visit, as if a site had height during the field visit, logically it must have had height in the 1960s. Although in many cases, height appears to become less certain, it must be remembered that not all imagery covers all sites. So, for example, whilst height was certain on 39 sites during the field visit, and on only 29 sites on DigitalGlobe, this is almost certainty due to the fact that 23 sites were not covered by DigitalGlobe. The number of sites marked as uncertain increased from only 3 during the field visits to 8 on the Geoeye records, just 6 years later. Given the improvements in imagery resolution, this may indicate an increase in damage.

8.4 – VISIBILITY

All sites are covered by the 1038 Corona imagery, which dates to 1967. They are also covered by the 1104 Corona, which dates to 1968, but few sites are visible: the imagery is over-exposed in this area, even after enhancements in GIS. Almost all references to Corona therefore refer to the 1038 mission. 2004 SPOT imagery also covers the entire area. As mentioned in Section 8.2, neither DigitalGlobe nor Geoeye covered the entire area – 10 amalgamated sites, and 16 units were not covered by any high resolution imagery. Of course, image coverage does not mean sites are visible on the imagery, just that the potential exists to see them.

8.4.1 - *Visibility: Seeing Sites*

A variety of factors influence site visibility and appearance: as discussed in the Methodology Chapter 4.4 (p126), they are a function of spectral reflectance. They are dependent on the site type, the image type, and the environmental conditions and date of image acquisition. This section details the specifics of site recognition in the Carchemish area, as sites appear substantially differently to the Beydar area.

Flat sites are usually visible as a soil mark: on Corona this is usually white against the grey of the fields, whilst on Geoeye it is usually grey against pink soil. Soil marks in the Carchemish area are particularly difficult to identify for two reasons. Firstly, what appears to be deposited sediment from relict wadis has the same characteristics as the soil associated with sites, and covers substantial parts of the area. For example, Figure 8-7 shows Tell Ma'zala (LCP 11) on Corona and Geoeye. Out of context, the mark around the tell on Corona shares the same characteristics as a lower town and has the same grey colouring on Geoeye as soil associated with sites. However, when viewed against the soils of the area, the soil marks are probably from the wadi to the north of the site. Secondly, the outcroppings of eroding limestone across the area, and particularly on the eastern bluffs have a similar reflectance signature to the sites.

Some large sites are visible as speckling on Corona: in the Beydar area this would not be likely to indicate a site. For example, Figure 8-8 to Figure 8-11 show LCP 67, a large flat site which is visible as a speckled mark on Corona, and a whitish soil mark on DigitalGlobe and Geoeye which is becoming less pronounced over time.

Visibility in the area around Carchemish is predominantly related to location, as will shortly be discussed.

Tell Ma'zala is circled in red on the Corona image (bottom left) and zoomed in Geoeye image (top left), and by a red arrow on the larger Geoeye image. Note the soil mark (visible as a pale area) around and to the south of the site on Corona. This is visible on Geoeye as an area of greyer soil around the tell and to the east of the village.

FIGURE 8-7: SOIL MARKS ON TELL MA'ZALA (LCP 11) ON CORONA AND GEOEYE[134]

[134] Bottom left: Corona Image, ds1038-2120df066, standard deviation stretch, 22 January 1967. Other images: Geoeye Image, 22 September 2009. Taken from Google Earth 17 February 2013

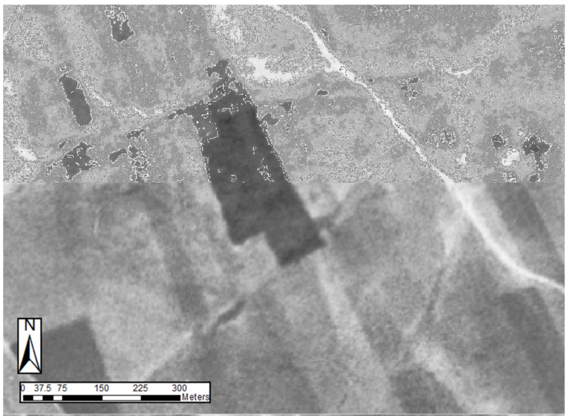


FIGURE 8-8: LCP 67- SOIL MARK ON CORONA[135]

The two grey lines running NE / SW are wadis. The speckling between them indicates the site. This is highlighted on the following image: the blue dots are GPS points, taken around the edge of the site in the field. The red lines are the GIS polygon indicating the site boundary.

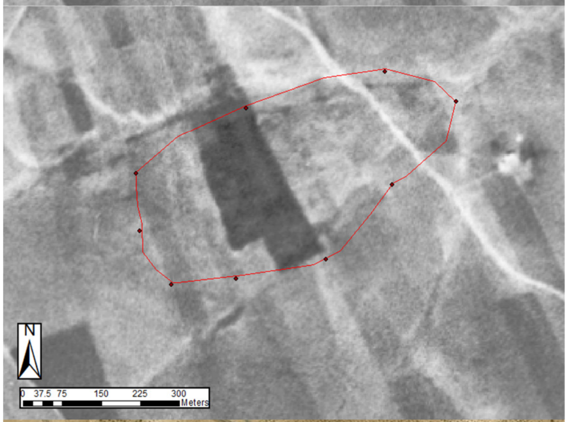


FIGURE 8-9: LCP 67 – SOIL MARK ON CORONA, WITH GPS POINTS AND BOUNDARY[136]

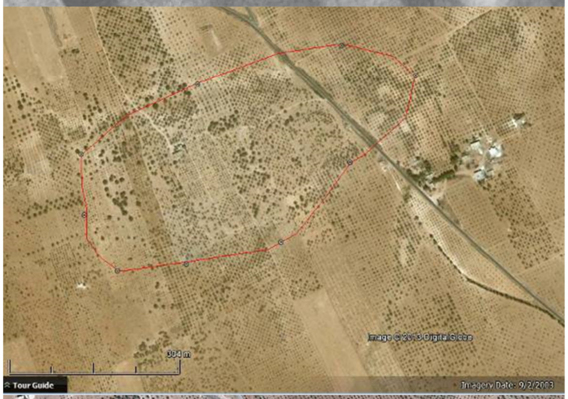


FIGURE 8-10: LCP 67 - SOIL MARK ON DIGITALGLOBE WITH BOUNDARY[137]

On later imagery the site is visible as an area of grey soil between the two wadis, which are now far less visible.

FIGURE 8-11: LCP 67 - SOIL MARK ON GEOEYE WITH BOUNDARY[138]

135 Corona Image, ds1038-2120df066, standard deviation stretch, 22 January 1967
136 Corona Image, ds1038-2120df066, standard deviation stretch, 22 January 1967
137 DigitalGlobe Image, 2 September 2003. Taken from Google Earth 17 February 2013
138 Geoeye Image, 22 September 2009. Taken from Google Earth 17 February 2013

8.4.2 - Visibility: Seasonality in the Carchemish Area

The impact of seasonality on different imagery has been discussed elsewhere (Methodology Chapter 4.4). Although it is an important factor in the Beydar area, it has less impact in the Carchemish area. Sites were usually under cereal crops at the time of imagery acquisition on Corona and SPOT imagery. (Most data from Corona images in this region was taken from the 1038 image, which was acquired in January. As discussed in Appendix A.1.2, the date of the SPOT image acquisition is debatable). Soil marks are visible in orchards and bare soil to some extent on all images. The resolution on the SPOT imagery is such that in many areas, land which is (probably) covered by crops appears the same colour as relatively bare land on the limestone terrain, and sites are not visible. Some sites on DigitalGlobe and Geoeye are clearly covered by cotton (usually grown in the late spring through to September, unlike the cereal crops), but this often completely masks all traces of the site. As a result, no study has been done of the impact of seasonality and its effects on imagery and data collection in this area, as there is not enough data.

8.4.3 - Visibility: Amalgamated Sites

Table H-15 to Table H-26 (Appendix H) show the visibility of sites on Corona, DigitalGlobe, SPOT and Geoeye. Due to the complex topography and geology, many sites were difficult to distinguish on satellite imagery. In order to accurately compare the percentages against each other, and against the Tell Beydar data, a second table was created for the Digital Globe data (Table H-17) and the Geoeye data (Table H-20). These exclude the sites which were not covered by those images, giving more accurate proportions.

The different levels of site visibility on the various satellite images are displayed on Figure 8-12 and Figure 8-13. Very few sites in this area are obscured by modern settlements. Many sites were, of course, obscured by the rising of the Euphrates, but these were not included in the original field survey or in this study. A third of sites covered by DigitalGlobe and Geoeye were Visible, and almost that number on Corona, compared to only 15% on SPOT. Nearly half of the sites were Not Visible on Corona, compared to a third on DigitalGlobe, just over a fifth on Geoeye, showing how, as resolution has increased fewer sites could not be identified. Almost two thirds of sites on SPOT were Not Visible: as a result it will rarely be referred to in this analysis, as it provided little information.

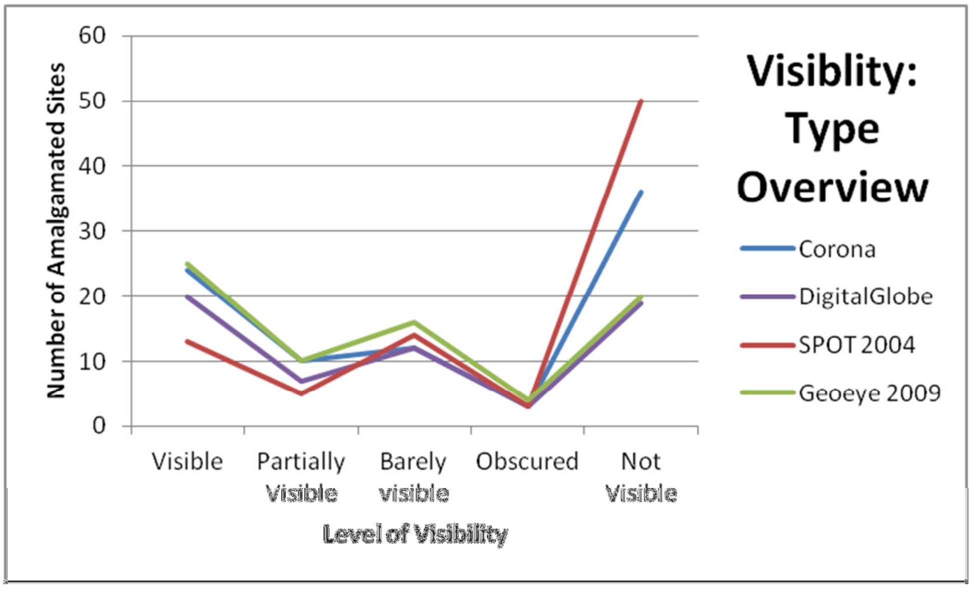


FIGURE 8-12: GRAPH OF VISIBILITY OF SITES ON IMAGERY (AMALGAMATED SITES)

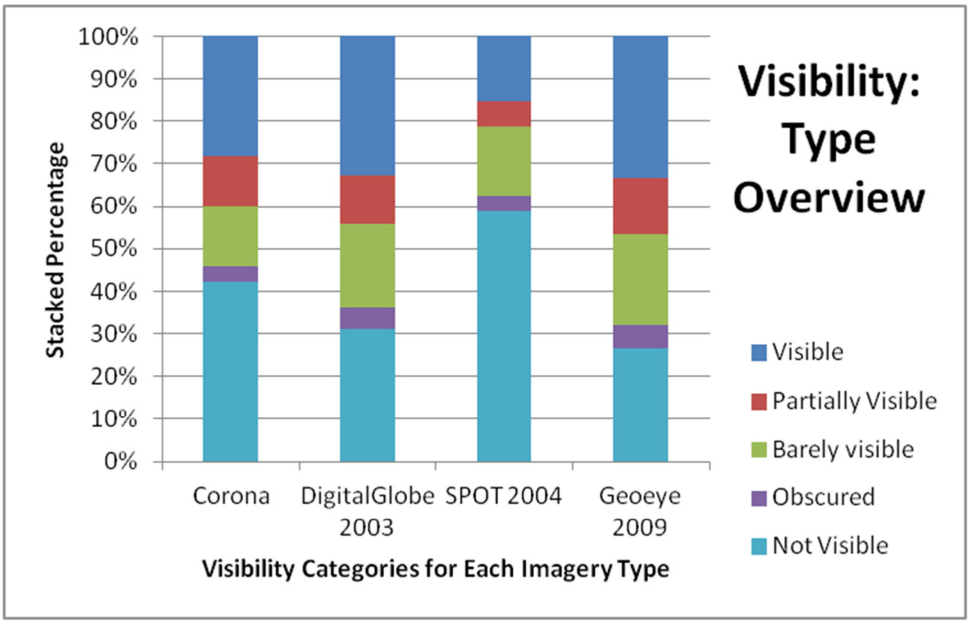


FIGURE 8-13: STACKED GRAPH OF VISIBILITY OF SITES ON IMAGERY (AMALGAMATED SITES)

Figure 8-12 shows the raw number counts of each visibility category on each imagery type. Geoeye 2009 clearly has the highest proportion of visible sites. Figure 8-13 shows the proportions of visible sites on each image displayed as a stacked percentage. Proportions allow a more direct comparison of the imagery visibility, as Geoeye and DigitalGlobe cover fewer sites. This demonstrates that those sites which are covered by DigitalGlobe imagery are as likely to be visible as those on Geoeye. Proportions also allow a more direct comparison of the imagery visibility between survey areas, as they are less dependent on the number of sites in each sample.

A Kruskal-Wallis test of mean visibility rank on all four sets of images (where 1 = Visible and 5 = Not Visible, so a higher mean rank indicates less visible sites) has shown that there is a significant difference between visibility levels on the sets of imagery: sites are clearly more visible on the most recent higher resolution imagery. This is the case, whether all 85 sites are compared, or only the sites covered on the imagery. (Sites which are not covered are marked as Not Applicable, but have been included in some analyses for comparison of the maximum number of sites). (N = variable, X^2= 19.351, df 3, p<0.000. N=85, X^2 = 46.776, df 3, p<0.000).

TABLE 8-2: KRUSKAL-WALLIS TEST: MEAN VISIBILITY RANKS (AMALGAMATED SITES)

Imagery	Corona	DigitalGlobe 2003	SPOT 2004	Geoeye 2009
Mean Ranks (Variable N)	152.8	137.35	185.15	131.55
N	85	61	85	75
Mean Ranks (N = 85)	186.80	127.91	219.15	148.14

It could be expected that over time, the reflective sediments which determine the visibility of sites have been dispersed by the action of wind, water and the plough, so sites would become less visible over time. Alternatively, the high resolution of new imagery could render sites more visible. However, as many sites are Visible on Corona as on Geoeye, despite the passage of time and the much higher resolution of the Geoeye imagery. This suggests that site visibility is, in fact, a combination of both factors. More sites are at least Partially or Barely Visible on the higher resolution images, whilst more sites are Not Visible on Corona. This suggests that on the lower resolution Corona imagery, sites were in better condition and so were more easily visible. Those sites which were already degraded by the passage of time only became visible on higher resolution imagery.

8.4.4 – VISIBILITY: SITE LOCATION

As well as the obvious factors of time and image resolution, site visibility is also affected by the geographic location of each site. Table H-27 and Table H-28 and Figure H-& and H-8 (Appendix H) show totals of site visibility in different locations for the amalgamated sites and the unit analysis without the biasing factors of the different image resolutions, and the different environmental conditions at the time of the image acquisition (see the note in Appendix F.1).

The following graphs (Figure 8-15 and Figure 8-14) display the numbers and proportions of amalgamated sites (a Type Overview) in each of the three regions.

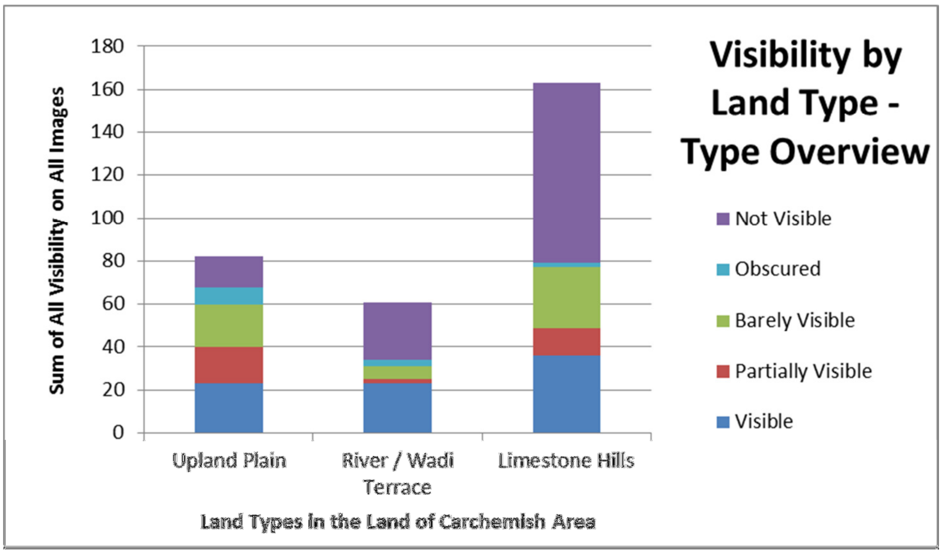


FIGURE 8-14: GRAPH OF VISIBILITY BY LAND TYPE (AMALGAMATED SITES)

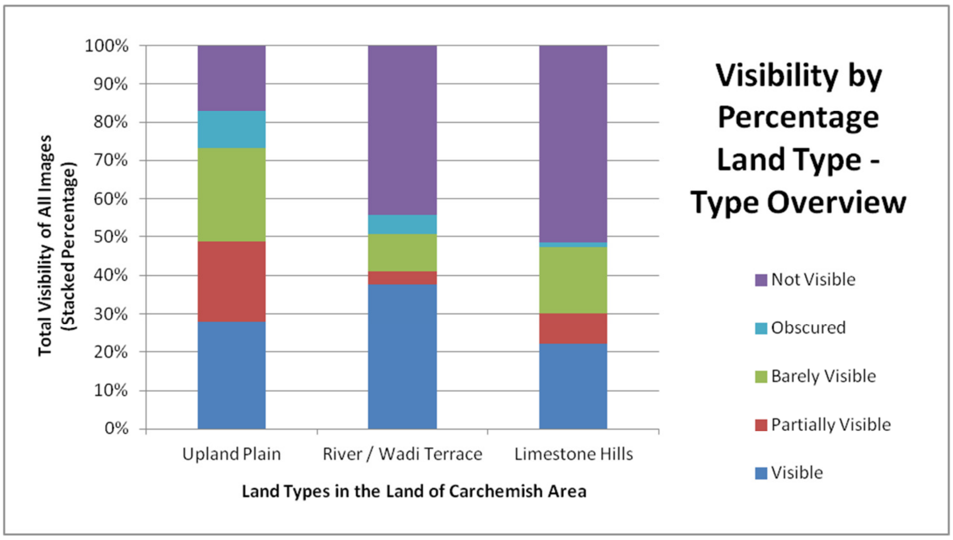


FIGURE 8-15: GRAPH OF PERCENTAGE VISIBILITY BY LAND TYPE (AMALGAMATED SITES)

Figure 8-14 shows the visibility of sites in each area. The counts of visibilities of sites on all images are combined into total figures for each area, to give an indication of visibility in each area regardless of the qulity of the image. Figure 8-15 displays this figure as a stacked percentage: this allows the visibilities in each area to be compared directly, regardless of the number of sites in each location.

Proportionally, the largest numbers of Not Visible sites are on the limestone hills, regardless of time or imagery resolution, whereas sites on the river terraces are equally likely to be Visible or Not Visible. This is determined by the site type – sites on the river terrace are mostly either buried sites identified in cuts during field visits, or large tells. Visibility of sites on the upland plains is evenly distributed: location does not predispose sites in this area to be more visible or less visible. This is surprising:

one would expect the greyer anthropogenic soils associated with sites (recorded on field visits and visible on some satellite images) to show up more clearly against the red *terra rossa* type soils of the plains.

Comparisons of site visibility in different locations for each imagery type can be found on Table H-29 and Table H-30 and Figure H-9 to Figure H-12 of Appendix H. Sites on the upland plains were more likely to be Visible or Partially Visible on Corona than on any other imagery. This may be a proxy indicator of damage, suggesting that sites here have become less visible over time, even as imagery resolution has increased. Sites on the limestone terrain, on the other hand, were more visible on higher resolution imagery. On Corona, the soils of the limestone area masked many site traces, as the limestone outcroppings have a similar spectral signature to sites, and are extensive, thereby masking the sites.

On DigitalGlobe, the highest proportion of sites which were Not Visible were located on the upland plains; many sites in this location were also Barely Visible. Sites which were Not Visible on Geoeye were evenly distributed by location, suggesting that if sites could be seen, location was not a factor. Visibility of sites on the river terraces was largely evenly distributed for each imagery type.

8.4.5 – Visibility: Site Type

Visibility is obviously affected by site type (Table H-31 to Table H-38, Appendix H). Tells are almost all Visible (in part thanks to the shadow, and in part due to the size), although it is a mark of how poor the visibility is on SPOT that 4 tells are Barely Visible, compared to only 2 Barely Visible tells on Corona and only 1 on Geoeye. Low tells are equally likely to be Visible or Not Visible: many of them are less than a couple of metres high: almost none of them are visible on SPOT. The actual mounding is rarely detectable on imagery, even if the site itself is visible: most are Partially Visible on Geoeye. Many of the low tells are located in the area which is not covered by DigitalGlobe.

Most field scatters and flat sites are Not Visible – even on Geoeye, just under three quarters of them are Barely Visible, Obscured or Not Visible. However, 13.5% were Visible or Partially Visible on Geoeye, but almost 30% were Visible or Partially Visible on Corona – this suggests flat sites are potentially being damaged to an extent that makes them harder to see over time, which has obvious implications for future survey and research.

Sites which still have intact walls (the Buildings category) are visible on the higher resolution imagery, but less so on lower resolution imagery, reflecting the fact that the walls are usually smaller than individual pixels on lower resolution images (i.e. the walls are thinner than 3m). Sites with multiple components have a variety of visibilities, reflecting the visibility of the individual components.

Whilst some sites have become easier to see on the higher resolution imagery, many sites which were once clear have become harder to see, despite the improvements in imagery resolution. This may well be due to the damage sustained by the sites, and will be explored in the following sections.

8.4.6 - Visibility Change

The increases and decreases discussed in the previous sections can mask the changes in individual sites – if one site becomes more visible, and one less visible, this will balance out in the total numbers. Not all sites are visible, and those which can be easily seen are not necessarily the same on different imagery. This section considers visibility as an ordinal variable which can be counted numerically, allowing change in visibility at the level of individual sites to be considered.

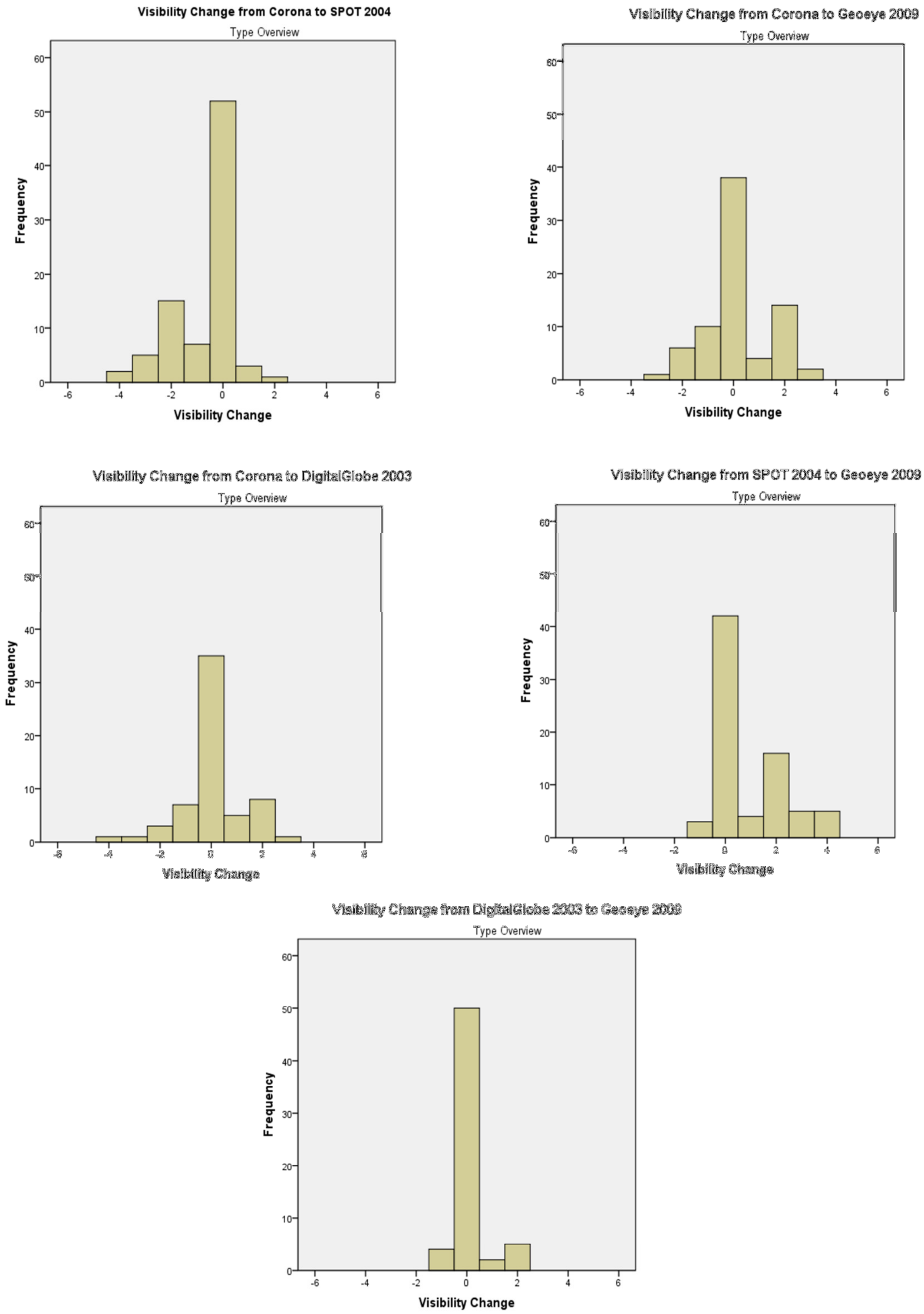
Visible = 1, Partially Visible = 2, Barely Visible = 3, Obscured = 4, Not Visible = 5

A site which was "Visible" in 1967 but becomes "Not Visible" by 2009 would then move from 1 to 5, and have a -4 rating. Equally, a site which becomes more visible would have a positive rating.

Figure 8-16 (and Figure H-13 in Appendix H) show bar charts of the frequencies of change in visibility of sites between Corona, DigitalGlobe, SPOT and Geoeye. Given the low resolution of SPOT, it is unsurprising that sites assessed on earlier imagery decrease in visibility on SPOT, and sites assessed afterwards on higher resolution imagery increase in visibility. No comparison has been conducted between DigitalGlobe and SPOT as they are only a year apart in acquisition date.

The main comparisons are between Corona, and the higher resolution imagery, as the aim is to consider whether time has had an effect on the visibility of the sites. If they are becoming more damaged, they should become less visible, despite the availability of better resolution imagery, (unless in some way the damage creates a distinctive shadow (such as was demonstrated at TBS 16 in Chapter 3.5.8, Figure 3-29, p80). The visibility of about half the sites does not change between Corona and DigitalGlobe or

FIGURE 8-16: FREQUENCY OF CHANGE IN VISIBILITY OF SITES BETWEEN CORONA, DIGITALGLOBE 2003, SPOT 2004 AND GEOEYE 2009 (AMALGAMATED SITES)



Geoeye. However, the rest are equally split between those which become more visible on higher resolution imagery (20), and those which become less visible, despite the increase in resolution (17) (Numbers are for Corona / Geoeye change). Almost a quarter of amalgamated sites which are visible on both Corona and Geoeye decrease in visibility over time. Four sites even become less visible in the 6 year period between 2003 when the DigitalGlobe images were acquired and 2009, when the Geoeye images were acquired.

The probability of finding a site today which was visible on Corona is still high (0.74)[139], although it is slowly getting harder (using Geoeye as the most recent imagery as the proxy for today).

The decrease in visibility is almost certainly related to the changes in the landscape which have occurred, and the resulting changes to the condition of the sites. This will be discussed in the following sections.

8.5 - LAND USE / LAND COVER

Land use and land cover play an important part in site damage, as defined and described in the Methodology Chapter 4.6.4, where the land uses / covers recorded on the sites are listed in Table 4-3 (p142). This section will examine whether land use can act as a predictor of damage threats in the Carchemish area. [The term land use will be used for simplicity].

Land use in some areas could not be determined to be arable or low scrub, particularly on Corona. These Unclassified areas are included in the tables, but not in the totals.

8.5.1 - LAND USE AROUND SITES

Land use around sites can be indicative of the damage they are likely to experience, either at the time of the study or in the future. By monitoring the change, it can act as a predictor of the risk to a site in the future. Land use around sites was rarely recorded during the field visits, so this analysis presents only the results from imagery observations. (Data is in Appendix H, Table H-39 to Table H-48, and the Unit Analysis Graphs are Figure H-14 and Figure H-15. Percentages are the percentage of sites on which a land use was reported).

[139] Where "visible on Corona" is defined as falling into the Visible or Partially Visible categories and "Finding a site" is defined as still falling into the Visible or Partially Visible categories.

Each site can have multiple land uses around it - for example, an agricultural field on one side, a wadi on another, and a track crossing the site which extends past it. In the Carchemish area, the total land use around sites has remained similar over time. A total of 305 land uses were visible around amalgamated sites on Corona, only 291 on DigitalGlobe, 382 on SPOT and 365 on Geoeye (including those recorded during the field visits which were not always visible, such as graves). (The DigitalGlobe total is lowest as not all sites are covered).

This is an average of 3.58 threats around each site on Corona, 4.77 threats on captured DigitalGlobe sites, 4.49 on SPOT, and 4.87 threats on captured Geoeye sites. A clear increase can be seen: unlike the Tell Beydar area, this is not due to the better resolution of the later imagery allowing the identification of smaller features. If the 14 counts of sites with some form of pits visible on Geoeye (Table H-38, Appendix H) were added to Corona as if they had been visible then, this would rise to only 3.75 threats per site. (This may be slightly lower than is actually the case: the 10 sites which are not covered by Geoeye may also have some form of pits on them. However, even if it was assumed all 10 did have pits on them, and these were added to the total land uses visible on Corona, this would still only be an average of 3.87 land uses per site). Furthermore, the increase between DigitalGlobe and Geoeye (a 6 year period between imagery with similar high resolution) demonstrates a genuine increase in the number of threats around each site. In fact, across all imagery types the increase is significant (Table 8-3)[140].

TABLE 8-3: WILCOXON SIGNED RANK TEST RESULTS FOR CHANGE IN LAND USE AROUND SITES

Wilcoxon signed rank test	Analysis	N	Z value	p value
Corona to DigitalGlobe 2003	Amalgamated Sites	61	-4.753	<0.000
Corona to SPOT 2004	Amalgamated Sites	85	-5.512	<0.000
Corona to Geoeye 2009	Amalgamated Sites	75	-5.606	<0.000

Table H-38 to Table H-40 (Appendix H) show land uses around sites. Using Corona and Geoeye imagery as proxies for the earliest and latest records of land use, increases can be seen in many land covers, even though 10 sites are not covered by the imagery. Looking at the most common land uses which may have been visible on Corona, major increases can be seen. Agriculture, for example, has increased from 67 counts to 69:

[140] For comparative purposes with Tell Beydar, the increase from Corona to Geoeye has also been estimated without wadis. Results are still significant:

Wilcoxon signed rank test	Analysis	N	Z value	p value
Corona to Geoeye 2009	Amalgamated Sites	75	-6.600	<0.000

this may not seem a major increase, but on Geoeye it affects 92% of the sites which were covered by the image. 65% of sites were surrounded by orchards on Geoeye, whilst almost none were visible on Corona. Modern villages have increased from 31 to 34: this is 45% of sites on Geoeye. 37% of sites on Geoeye also have a modern structure near them. This increasing development is one of the clearest potential threats, although it appears to follow agriculture, rather than prefigure it.

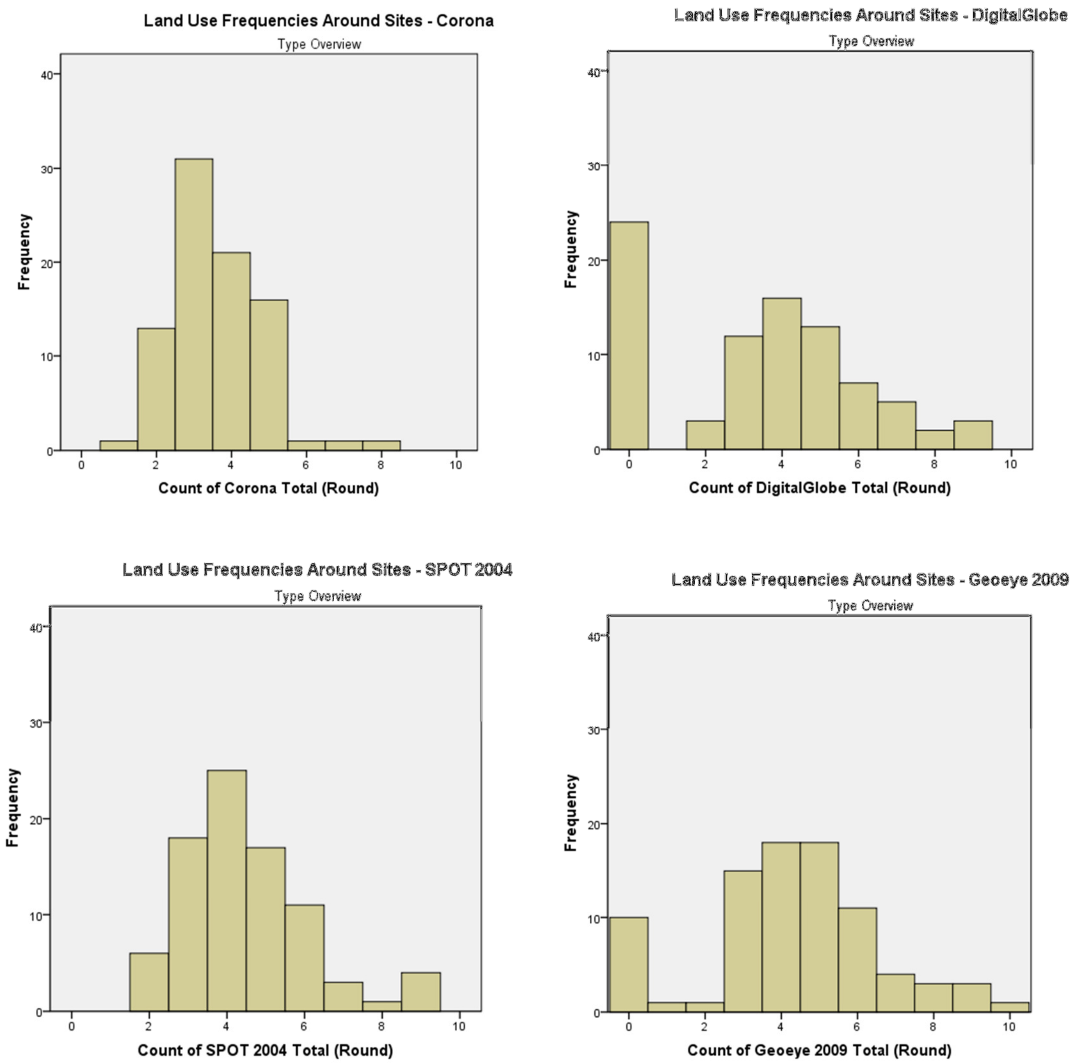
Counts of wadis have decreased, reflecting the general landscape change visible across the whole of Syria, which were discussed in the previous chapters. 76 sites had wadis or rivers near them or on them in 1967 (89.4%). Only 42 were recorded in 2009 (56%). Many of those which were still present in 2009 will have been the Euphrates or Sajur rivers, rather than perennial wadis.

Field visit data was better for Carchemish than it was in the Tell Beydar area: land uses on and around sites were recorded more regularly, therefore field visit counts of land use will be briefly considered (Table H-39, Appendix H). Most land use types around sites are under-recorded, which is not surprising given they were not the focus of the survey. Agriculture, in particular, was not mentioned as often as it was present: there were 69 counts on the 75 sites covered by Geoeye, and only 51 counts on all the sites in the field visits. This may be due to the elapsed time: 49 orchards were recorded on Geoeye, but only 22 during the field visits. Whilst fields can be left fallow and may not be obvious, orchards are harder to miss, and may have been planted later (certainly only 32 were visible on DigitalGlobe). Water bodies were regularly mentioned during the field visits, although this may be as they often flow onto sites and erode them. Many of those recorded no longer appear to flow, however.

Figure 8-17 shows the frequencies of total number of land uses around each site for the Amalgamated site analysis (The supporting data, and the data and graphs for the Unit analysis are in Appendix H, Table H-41 and Table H-42, and Figure H-14). All land use types are considered to cause damage to a site except for bare land or low scrub. Counts of land covers which do not damage sites are all grouped together as a single type. Any increase in the number of land use types therefore demonstrates that damaging land uses are increasing. As each damaging land use correlates to a damage threat, increases in the individual land uses are discussed in the damage analysis in Section 6.7.

More than a third of sites on Corona had 3 land uses around them: although some had more, only 3 sites had more than 5. By 2009, 4 and 5 were the joint most common number of land uses, and more were frequent: 1 site had 10 threats recorded around it. More than two thirds of sites had more land uses than the average in 1967 (i.e. >3).

FIGURE 8-17: FREQUENCIES OF LAND USE / LAND COVER AROUND SITES ON IMAGERY (AMALGAMATED SITES)



8.5.2 - Land Use / Cover on Sites

Table H-44 to Table H-46 show the different land uses and land covers on the sites in the different sets of imagery for the Amalgamated Site Analysis and the Unit analysis. Table H-47 and Table H-48 and Figure H-15 (all in Appendix H) show the frequencies of the numbers of different land uses on each site for the Amalgamated site analysis and the Unit analysis. These tables and graphs demonstrate how the land uses around the sites have spread onto them. The changes in land use frequency are summarised on Figure 8-18 on the following page (for the amalgamated sites). As in the previous section, land uses which did not damage sites were combined into a single category, so any increases in the number of land uses represents an increase in damage which will be discussed in detail in the following sections.

166 land uses were recorded on amalgamated sites on Corona, 184 were recorded on DigitalGlobe, 243 were recorded on SPOT and 230 were recorded on Geoeye. In order to account for the differential coverage of the images, this is calculated as the average number of land uses recorded on each site covered. 1.95 land uses were recorded per site on Corona, 3.02 land uses were recorded on DigitalGlobe, 2.86 land uses were recorded on SPOT, and 3.07 land uses per site were recorded on Geoeye, the highest total. All increases are significant when compared to Corona (Table 8-4).

Table 8-4: Wilcoxon Signed Rank Test Results for Change in Land Use On Sites

Wilcoxon signed rank test	Analysis	N	Z value	p value
Corona to DigitalGlobe 2003	Amalgamated Sites	61	-5.101	<0.000
Corona to SPOT 2004	Amalgamated Sites	85	-5.602	<0.000
Corona to Geoeye 2009	Amalgamated Sites	75	-6.023	<0.000

In total, there are far fewer land uses on sites than around them. This may be a factor of size – due to the lack of certainty regarding site boundaries, the size of sites could not be reliably estimated with the necessary degree of accuracy: sites in the Carchemish area may be small which would lessen the number of land uses on them. Alternatively, they may not have been incorporated into the land uses strategies around them.

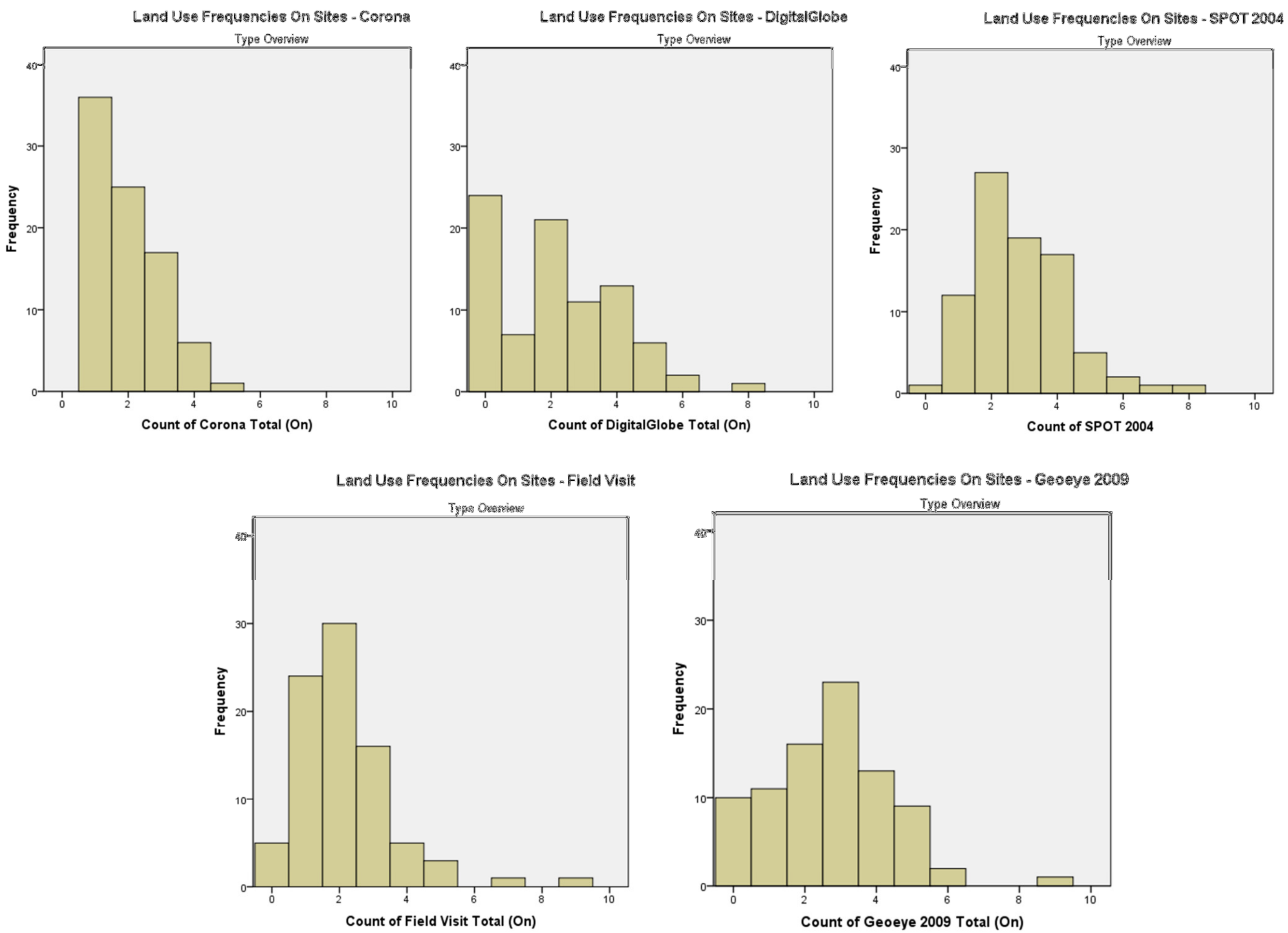
Comparing Corona and Geoeye as proxies for 1967 and 2009, sites which were bare or only covered by scrub have noticeably decreased from 56 counts to 31 counts (or 66% of sites on Corona to 41% of sites on Geoeye – a decrease of about a fifth). Water bodies (that is, the rivers and perennial wadis) decreased from 15 to 9 (17.6% to 12%). This is only a small decrease as most sites do not have water bodies going through them: they are built next to them, although the various water bodies have, of course, shifted in their course over the millennia. Land uses which cause damage have increased - arable agriculture on sites, for example, was present on 57.6% of sites in 1967, and in 2009 was present on 74.7% of sites covered by Geoeye.

Only 199 land uses were recorded on the field visits (2.34 threats per site). If SPOT is used as a comparator for the field visits (as the imagery of the closest date and the same coverage extent), then it appears that the field visits were particularly likely to ignore small buildings. Only 5 were recorded compared to 14 on SPOT, and only half the roads were noted (22 compared to 40). Agriculture, both arable and orchards, was also slightly under-recorded. SPOT is not a perfect comparator as it is at least 2 years earlier than the first field visit, and the resolution is too poor to see many smaller features, so the under-recording of land uses during field visits may be even greater.

As shown on Figure 8-18 on the following page, the average number of land uses increased dramatically – many sites on Corona had only one land use on them (42%), and only one site even had 5 land uses on it. 3 land uses were the most common on Geoeye, and one site had 9: this is the outer town at Carchemish (which is also the largest site). 1 or 2 were the most common number of land uses recorded on the field visits, demonstrating, again, the under-recording of land use.

Discussion of the effects of the land uses on the sites will be discussed in the damage analysis.

FIGURE 8-18: FREQUENCIES OF LAND USE / LAND COVER ON SITES (AMALGAMATED SITES)



8.5.3 - Land Use and Site Location

Land use is strongly associated with the geographic region, particularly as time passes; i.e. in the Carchemish area the limestone terrain, the plains and the river terraces (as defined in Chapter 7, Figure 7-2, p301). Counts of threats on and around sites in each geographic region are in Table 8-8: the total number of sites covered by the respective imagery types in each area is also included (columns 3, 6 and 9), and this is used to calculate 'Proportion of threats per site'.

The highest numbers of land uses on and around sites were always on the river terraces, leading to the highest average number of threats per site. As discussed in earlier sections, this area has always been the area with the most intensive occupation history. This area also saw the largest increase in the average number of threats between Corona and Geoeye. The upland plains, on the other hand have changed very little.

There were statistically significantly more land uses on amalgamated sites on the upland plains on Corona compared to other locations (perhaps because so many sites in the limestone hills at that time were Unknown). In all other images, amalgamated sites in the upland plains did not have significantly more land uses on or round them when compared to other areas (Table 8-5).

Table 8-5: Mann-Whitney-U Test Results for Differences in Total Land Uses Around and On Sites on the Plains and Elsewhere (Amalgamated Sites)

Imagery	Count	U	p	Mean Rank: Plains	Mean Rank: Elsewhere
Corona	Around sites	615.0	0.416	46.55	41.76
DigitalGlobe 2003	Around sites	648.5	0.649	42.29	45.02
SPOT 2004	Around sites	566.5	0.194	37.25	45.01
Geoeye 2009	Around sites	570.0	0.211	37.41	44.95
Corona	On sites	471.0	0.018	53.09	39.48
DigitalGlobe 2003	On sites	554.0	0.154	49.32	40.79
SPOT 2004	On sites	667.5	0.792	44.16	42.60
Geoeye 2009	On sites	595.0	0.317	47.45	41.44

On the river terraces on Corona there were statistically significantly more land uses around sites than around sites elsewhere. This was also the case on SPOT, DigitalGlobe and Geoeye. By 2009, on Geoeye, sites on the river terraces also had significantly more land uses on them than elsewhere as the land use in this area has continued to intensify (Mann-Whitney-U test, Table 8-6).

TABLE 8-6: MANN-WHITNEY-U TEST RESULTS FOR DIFFERENCES IN TOTAL LAND USES AROUND AND ON SITES ON THE RIVER TERRACES AND ELSEWHERE (AMALGAMATED SITES)

Imagery	Count	U	p	Mean Rank: River Terraces	Mean Rank: Elsewhere
Corona	Around sites	381.5	0.007	55.92	39.28
DigitalGlobe 2003	Around sites	404.0	0.017	54.74	39.62
SPOT 2004	Around sites	330.5	0.001	58.61	38.51
Geoeye 2009	Around sites	371.0	0.006	56.47	39.12
Corona	On sites	530.0	0.278	48.11	41.53
DigitalGlobe 2003	On sites	468.5	0.087	51.34	40.60
SPOT 2004	On sites	473.5	0.096	51.08	40.67
Geoeye 2009	On sites	365.0	0.005	56.79	39.03

On the limestone hills on Corona there were statistically significantly fewer land uses on and around sites than elsewhere. There were also significantly fewer land uses on sites in this area on DigitalGlobe and Geoeye, demonstrating that sites in this area have remained relatively untouched compared to other areas (Mann-Whitney-U test, Table 8-7). As there is no significant difference in the number of land uses around sites in this area compared to elsewhere, it not the uses of the land itself that is the issue, but perhaps the sites themselves, which are more likely to be left alone.

TABLE 8-7: MANN-WHITNEY-U TEST RESULTS FOR DIFFERENCES IN TOTAL LAND USES AROUND AND ON SITES ON THE LIMESTONE HILLS AND ELSEWHERE (AMALGAMATED SITES)

Imagery	Count	U	p	Mean Rank: Limestone Hills	Mean Rank: Elsewhere
Corona	Around sites	627.5	0.016	37.57	50.04
DigitalGlobe 2003	Around sites	593.0	0.008	38.85	50.97
SPOT 2004	Around sites	785.0	0.350	40.85	45.78
Geoeye 2009	Around sites	819.5	0.538	41.57	44.85
Corona	On sites	553.0	0.002	36.02	52.05
DigitalGlobe 2003	On sites	571.5	0.004	36.41	51.55
SPOT 2004	On sites	761.0	0.247	40.35	46.43
Geoeye 2009	On sites	597.5	0.009	36.95	50.85

Table 8-8: Land Use Totals and Proportions by Area and by Imagery Type (Amalgamated Sites)

	Area: Upland plain	Total sites covered	Proportion threats per site	**Area:** Limestone terrain	Total sites covered	Proportion threats per site	**Area:** River terraces	Total sites covered	Proportion threats per site
Corona Total (On)	49	21	2.33	79	48	1.65	38	16	2.38
Corona Total (Around)	78	21	3.71	158	48	3.29	69	16	4.31
DigitalGlobe Total (On)	51	19	2.68	80	28	2.86	53	14	3.79
DigitalGlobe Total (Around)	77	19	4.05	130	28	4.64	84	14	6.00
SPOT 2004 Total (On)	57	21	2.71	129	48	2.69	57	16	3.56
SPOT 2004 Total (Around)	85	21	4.05	204	48	4.25	93	16	5.81
Geoeye 2010 Total (On)	60	21	2.86	109	39	2.79	61	15	4.07
Geoeye 2010 Total (Around)	84	21	4.00	191	39	4.90	90	15	6.00

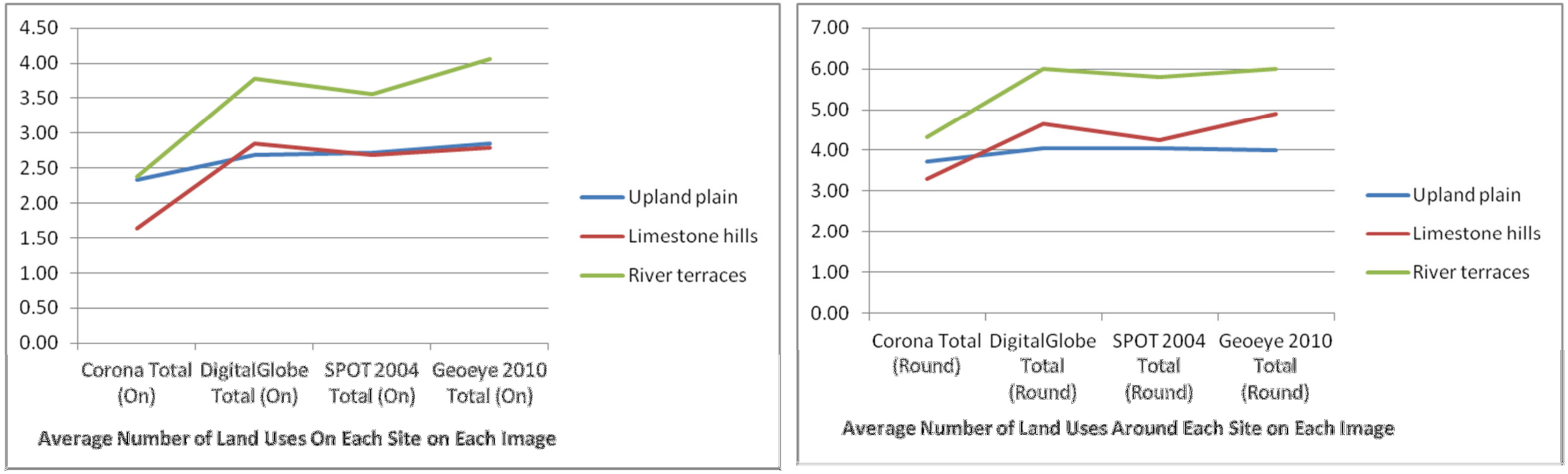


Figure 8-19: Graphs of Change in Average Land Uses per Site Over Time by Area (Amalgamated Sites)

8.5.4 – Land Use Discussion

The number of land uses on each site can indicate damage, and to some extent the more complex the land use on a site is, the more damaged it is. Obviously some land uses are more damaging than others, and this must be remembered. A single act of development may represent the obliteration of an entire site. In some cases, the land uses around sites can act as early indicators of possible threats – for example agriculture around sites frequently spreads onto it, but many sites in the Carchemish area are flat sites which are already under arable cultivation.

Considerations of land use in different areas can also help prioritise threats. Figure 8-19 demonstrates the rates of change in each area. The fact that land use in the upland plains has changed the least over time suggests that sites in this area are perhaps the least threatened, in the sense that any threats sites face have existed for some time, and they are the least likely to be subject to rapid landscape change. Sites on the limestone bluffs have experienced considerable landscape change, but sites on the river terraces are experiencing the greatest change, even though this was one of the most intensively utilised areas in the 1960s. However, now it is even more heavily utilised. Surprisingly, it is not marginal areas which are most at risk from increasing use of the landscape, but the heavily occupied areas. However, the rate of change on the limestone terrain is also concerning, and suggests it will become more heavily utilised as time passes, posing an increasing threat to the sites.

8.6 - Damage Analysis: General Trends

The list of potential sources of damage is discussed in Chapter 3, and in Chapter 4 - Methodology. At the level of the individual site, damage is ordered into primary, secondary, tertiary (etc.) damage, based on the relative severity of the effect on a site. The number of sources of damage increases as time passes (and often as resolution increases). Whilst some consideration will be given to the main (primary and secondary) causes of damage to sites, it is more valuable to consider the scale of extent of damage to sites, and the factors which affect it; therefore extents are collated for analysis according to how often they occur.

This section analyses general trends regarding damage to sites, distilled from the supporting tables in Appendix H. (Appendix F details how to read the tables and what information is in each one). These trends are not related to specific causes of damage, but examine how damage manifests on sites, and what effects it has. As discussed in

Section 4.4.5 - Damage Extent: Horizontal and Vertical, (p148), damage would ideally be calculated as a quantitative reduction in site volume or measured area, but this was not possible. Instead qualitative ordinal categories which could be consistently and accurately applied and analysed using non-parametric statistics were used. Damage causes will then be examined separately in the following section, considering how much damage each threat causes, and what factors affect it in the Carchemish region.

The only imagery available after the majority of the field visits occurred is the 2009 Geoeye (although some sites were visited in 2010). As a result, most imagery interpretation is informed to some extent by the field visits. Although Geoeye does not cover all the sites, as discussed in Section 8.2, it is the most recent imagery, and therefore provides the best comparison against the 1960s Corona data for general damage trends. It was considered more important to have a high resolution comparator to examine change over time, as whilst the SPOT imagery was taken only a few years earlier, the visibility of sites and damage threats on it is very poor, and it would not give an accurate reflection of the changes. It should therefore be remembered in the following comparisons that 10 of 85 amalgamated sites, and 16 of 100 units are excluded.

8.6.1 – Total Damage Causes and Height

<u>Number of Causes of Damage (Damage Threats):</u>

On the Amalgamated sites (Table H-112 Appendix H, Unit analysis Table H-113,), 146 damage threats were recorded on Corona, 168 on DigitalGlobe, 220 on SPOT and 224 on Geoeye (including sites where the damage is Unknown - Chapter 3.5.20, p112). Even without the Unknown damage, 98 threats were visible on Corona, 164 on DigitalGlobe, 201 on SPOT and 221 on Geoeye. The increasing damage threats reflect three factors. The first is the higher resolution of the later imagery compared to Corona. Physically small sources of damage, such as graves and looting holes were not visible on Corona: they require high resolution imagery to see them. However, if these small damage threats are counted and then removed from the totals, 107 threats are recorded on Corona, 143 on DigitalGlobe, 171 on SPOT and 182 on Geoeye (not including unknown damage threats). This is still a clear increase in the numbers of threats to sites, irrespective of resolution or extent of damage threat.

The second confounding factor is the timing of the image acquisitions. Despite the poor visibility of sites on SPOT, the number of damage threats increases between

DigitalGlobe and SPOT, even though as discussed in Section 8.4 the number of visible sites decreases. Damage threats which are visible on DigitalGlobe and Geoeye must logically have been present on SPOT, and are therefore recorded, even though they are not visible (although the fact they are not visible is also recorded. This was discussed in Chapter 4.5.5 (p144). In general however, in order to minimise the risk of overstating the increases in damage, conclusions drawn from SPOT imagery will not be used in the analysis, unless they can be supported using other data, or no other information is available.

The third confounding factor is the timing of the field visits and availability of imagery. This study had two main aims: to assess damage to sites and to examine the usefulness of imagery in achieving this. For some sites in this area, the field notes recorded damage to sites but the only available imagery was SPOT imagery. Each site imagery record is also a proxy record for damage at that point in time. If no other imagery was available for the site, the damage recorded on the field visit was listed on the SPOT record, but marked as not visible. In a sense this artificially inflated the assessment of what damage was visible on SPOT imagery (and in some cases on Geoeye), as damage was recorded during the field visit but was not actually visible on the imagery. However, it does not alter the total amount of damage sites were experiencing at that point in time, if the record is taken as an indicator of damage at a given point in time, rather than an indicator of what was visible on each image. Nonetheless, it is clear that the number of damage threats to sites is increasing over time.

Height:

Height was discussed in Section 8.3.2, where it was demonstrated how it may act as a proxy indicator for damage. Only 5 sites changed from Certain to Uncertain height remaining. However in the Carchemish area, on satellite imagery the height of most sites is often only evident for the higher tells, and not on most of the low mounded areas, many of which are less than 2 metres tall. Furthermore, only DigitalGlobe and Geoeye are comparable (in terms of resolution). Given the small sample number of sites, in this area possible changes in height cannot be used to inform damage assessments.

8.6.2 – Horizontal Damage Trends

Horizontal Damage Extent Across the Site:

The extent of damage across the site is referred to as the horizontal damage extent (data is in Appendix H, Table H-49 and Table H-50). These extents are displayed graphically for the Carchemish area in Figure 8-20 (and Figure H-16, Appendix H). The most common horizontal damage effect on amalgamated sites was Sectional damage, affecting parts of 26.7% of sites on Corona, 43.5% of sites on DigitalGlobe, 42.7% of sites on SPOT and 42.9% on Geoeye. It is clear from the graph that there is a large increase in the number of damage threats affecting Sections of the site from Corona to the later images.

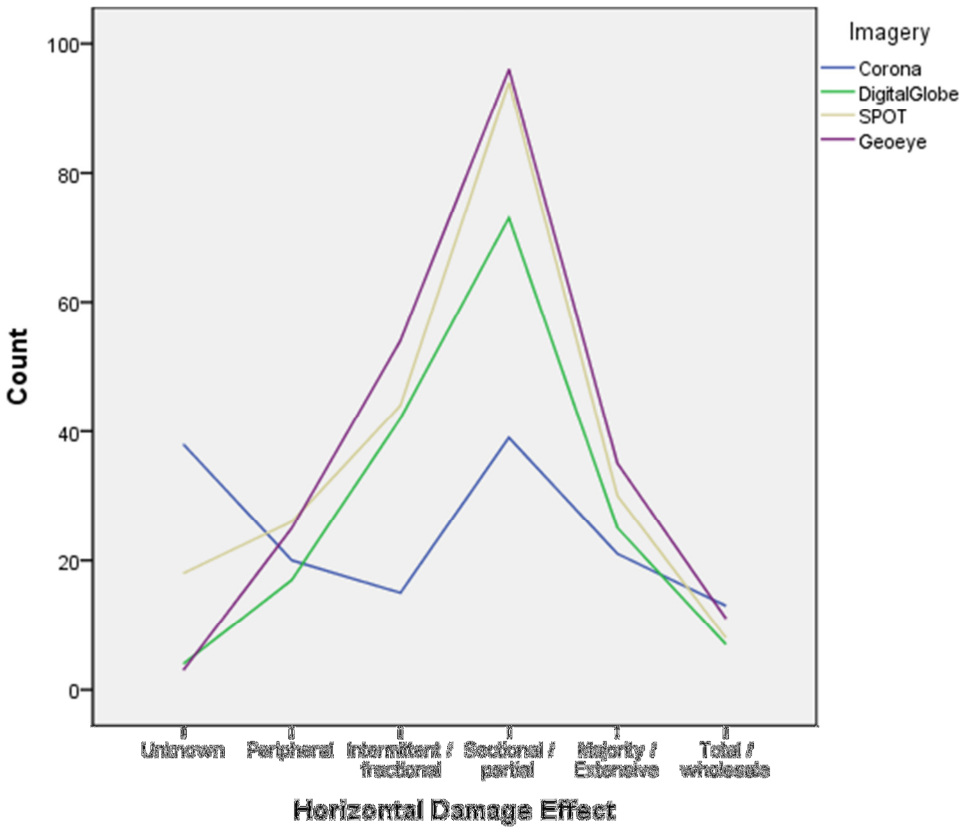


Figure 8-20: Graph of Extent of Horizontal Damage by Imagery (Amalgamated Sites)

Severity of Horizontal Damage:

When multiple damage causes affect a site, they are subjectively ordered according to primary damage, which does the most damage to the site, then secondary damage, tertiary damage, and so on (Table H-51 to Table H-58, Appendix H). This is useful at the level of the individual site, but in an overall analysis, all threats are combined.

However, in order to simplify the analysis, in the majority of the ensuring discussions only the primary and secondary threats will usually be considered, therefore it is worth noting how much damage is caused on average.

On Corona (Table H-51), the primary damage cause and its extent are unknown on one third of amalgamated sites. On sites where damage was visible, the primary damage cause affects a Section of the site for almost a quarter of primary and a third of secondary threats. Sectional damage is the most common extent of primary and secondary damage on DigitalGlobe and Geoeye as well. The number of sites where the primary damage threat affected the Majority of the site increased from a fifth in the 1960s to just under one third in 2003. Although the affected extents have remained similar between 1967 and 2009 for primary damage, the affected extents for secondary damage have more than doubled since the 1960s, covering larger proportions of sites. As the number of threats increases so do their extents.

<u>Horizontal Extent and Site Location:</u>

Appendix H, Table H-59 to Table H-66, contain counts of horizontal damage extent by site location. In the 1960s, 40% of amalgamated sites on the upland plain experienced threats affecting Sections of the site, increasing to nearly 50% in 2009.

On Corona, 1 in 3 threats to sites on the River Terraces were to Sections of the site, increasing to 50% of threats on Geoeye. However, a further third only affected a Fraction of the site: not all threats caused extensive damage.

Half of the threats to sites on the limestone hills were unknown on Corona, but of the known extents the highest proportion (16.9%) was Sectional. When this study concluded, more than 1 in 3 threats affected Sections of the site.

Regardless of location, damage threats were most likely to affect Sections of the site, particularly as time has passed.

<u>Horizontal Extent and Site Type:</u>

When considering amalgamated sites, according to the Corona imagery, tells were most likely to experience Peripheral damage – 10 of 36 damage threats recorded on tells were around the edges (27.8% - Table H-67 and Table H-68, Appendix H). Almost as many had affected Sections (25.0%). Sectional damage was also the most common horizontal extent on low mounds, flat sites and sites with multiple components.

Buildings were rarely visible on Corona: the damage extent on half of them was Unknown.

When compared to damage recorded in 2009 on the Geoeye imagery (Table H-73 and Table H-74), extents can be seen to be increasing. Recorded threats on tells, for example, have almost doubled: only 16.7% of them were Peripheral, and almost 40% affected Sections of the tell. Damage threats affecting the Majority of the tell increased: the size of tells did not protect them. The pattern of increasing horizontal damage extents is the same for all the site types.

<u>Change Over Time of Horizontal Damage Extent:</u>

Many of the proportions, and some of the actual numbers, show little change over the fifty year study period, implying that there has been little change in threats causing that damage. This is not the case. Table 8-9 displays change over time in the actual threats to amalgamated sites, examining whether each threat that was present in the 1960s still causes the same level of damage in 2010, or whether the increasingly serious threat effects are actually new threats. This table, like the others, is explained in more detail in Appendix F.6.1. (The Unit analysis is on Table H-75 in Appendix H).

As can be seen in the table, more threats have increased in horizontal extent over the study period than have decreased, although the majority have remained steady. 46 threats did not change in extent. 32 threats have increased in horizontal extent, and 25 have decreased. (It should be noted that of the threats which have decreased, 9 are a decrease from Total coverage: this is not a reduction in damage, but reflects the fact that multiple threats become apparent on the sites, necessitating multiple extents. This may also be the case for threats which no longer cover the Majority of sites).

This is seen clearly on the Graphs in Section 8.7 (Figure 8-23 to Figure 8-26): they relate the horizontal effect to cause, and demonstrate the change over time.

TABLE 8-9: CHANGE IN HORIZONTAL EFFECT FROM THE 1960S TO 2009 (AMALGAMATED SITES)

			Horizontal Effect (Geoeye)						
			Unknown	Peripheral	Intermittent / fractional	Sectional / partial	Majority / Extensive	Total / wholesale	Total
Horizontal Effect (Corona)	Unknown	Count	1	2	4	10	6	5	28
		% within Horizontal Effect (Corona)	3.6%	7.1%	14.3%	35.7%	21.4%	17.9%	100.0%
	Peripheral	Count	0	4	4	10	1	0	19
		% within Horizontal Effect (Corona)	.0%	21.1%	21.1%	52.6%	5.3%	.0%	100.0%
	Intermittent / fractional	Count	0	1	3	9	1	0	14
		% within Horizontal Effect (Corona)	.0%	7.1%	21.4%	64.3%	7.1%	.0%	100.0%
	Sectional / partial	Count	0	2	4	25	6	1	38
		% within Horizontal Effect (Corona)	.0%	5.3%	10.5%	65.8%	15.8%	2.6%	100.0%
	Majority / Extensive	Count	0	0	0	9	10	1	20
		% within Horizontal Effect (Corona)	.0%	.0%	.0%	45.0%	50.0%	5.0%	100.0%
	Total / wholesale	Count	0	0	0	6	3	4	13
		% within Horizontal Effect (Corona)	.0%	.0%	.0%	46.2%	23.1%	30.8%	100.0%
Total		Count	1	9	15	69	27	11	132
		% within Horizontal Effect (Corona)	.8%	6.8%	11.4%	52.3%	20.5%	8.3%	100.0%

Both numbers and percentages indicate change. The extents of damage in the 1960s form the rows, and the extents in 2009/10 form the columns. This can be read as follows: for example, on the LCP Amalgamated Sites Table 8-9, reading across the Peripheral Damage row (i.e. Corona), 4 amalgamated sites continued to experience peripheral damage on Geoeye (21.1% of sites which had experienced peripheral damage on Corona). A further 4 sites which had experienced peripheral damage on Corona now experience Intermittent damage in 2009 (a further 21.1% of those who had experienced Peripheral damage), and so on. It should be noted that if a site experienced Total damage, i.e. damage all over the site, on Corona but no longer does on Geoeye, it is unlikely to be an improvement. For example, if a site was entirely covered by agriculture, but then an irrigation channel is built through it, it would initially be marked as Total extent, but this would then change to Majority extent for the agriculture and a Section extent would be added to reflect the Irrigation channel.

8.6.3 – Vertical Damage Trends

<u>Vertical Damage Extent Across the Site, and Severity of Damage:</u>

The depth of damage to a site is described as the vertical damage extent, and is displayed according to imagery type and year of recording on Figure 8-21. (Table H-76 and Table H-77 and Figure H-17 in Appendix H provide supporting data and the Unit Analysis. The Severity of the different extents is in Table H-78 and Table H-85).

Damage to the Upper Levels of the site is the most common vertical extent in all imagery analyses, and it is the most common primary effect. This is partly because this is the assumed threat extent for some causes where the full extent could not be determined, such as development, where the depth of building foundations can be difficult to determine from satellite imagery. The number of damage threats increase over time, and the counts and percentages of each vertical threat increase proportionally. The most common secondary extent on Corona was Slight Degradation of the site (46.3% of secondary extents). However, by 2009, 56.9% of secondary threats affected the Upper Levels of sites.

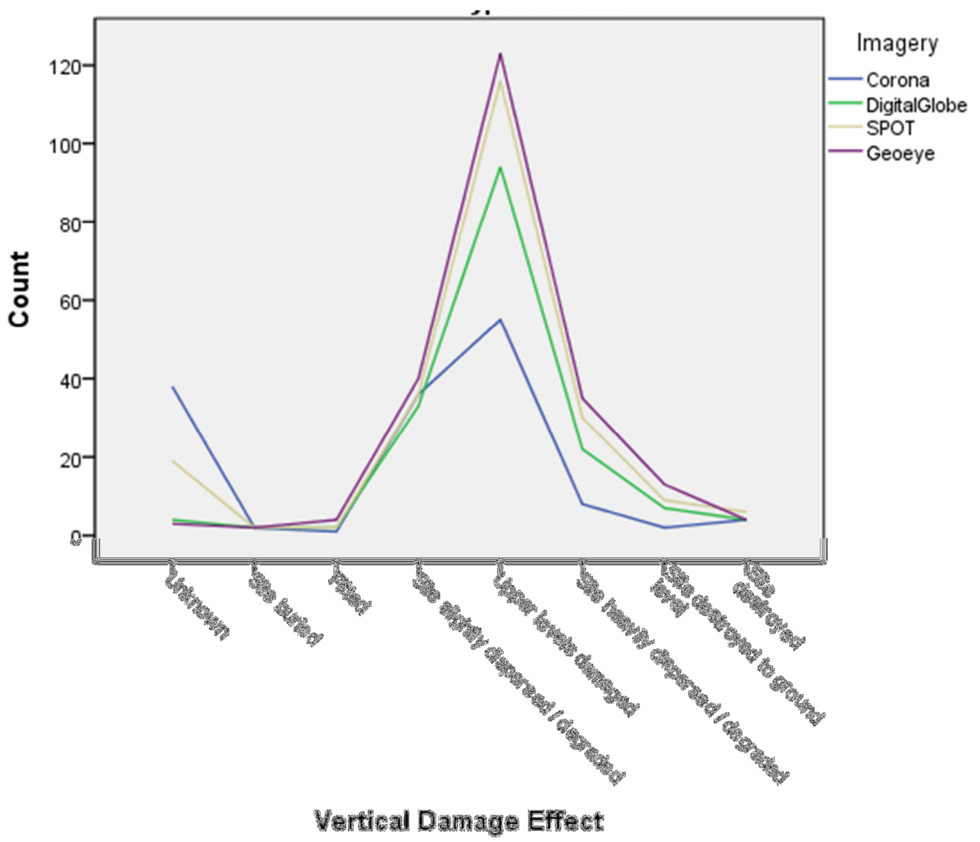


Figure 8-21: Graph of Extent of Vertical Damage by Imagery (Amalgamated Sites)

Vertical Extent and Site Location:

(Appendix H, Table H-86 to Table H-93, contains counts of vertical damage extent by site location). Damage to the Upper Levels of sites was the most common damage depth in all areas, and the proportion of sites so affected also increased. It is hard to say whether damage to sites on the river terraces or on the limestone terrain is increasing faster than in the other areas. Threats which Heavily Degraded the sites on the river terraces increased from 2.9% to 18.8%. A similar increase was noted on the limestone hills. By 2009, the highest proportion of sites which had been Destroyed to Ground Level was also on the limestone hills.

Vertical Extent and Site Type:

(Table H-94 to Table H-101, Appendix H detail the relationship between site type and vertical extent). In the 1960s, threats to tells were most likely to only Slightly Degrade them (44.4%), presumably their size protected them. In 2009, 42.4% of threats damaged the Upper Levels of the tell, and 16.7% Heavily Degraded it. If even large sites made of dense mudbrick can be heavily degraded, this suggests that small sites and flat sites are at increasing risk. This pattern of increase from threats which Slightly Degraded sites to threats which Heavily Degrade them is the same for all site types.

Change Over Time of Vertical Damage Extents:

Many of the proportions, and some of the actual numbers discussed, show little change over the fifty year study period, implying that the vertical effects of the threats have remained steady. This is not the case. When the extents of damage from the 1960s are compared to the extents in 2009 (Table 8-10, following page, and Table H-102 in Appendix H. The tables are explained in more detail in Appendix F.6.2), many have not changed, but a substantial number have increased in extent. As can be seen, 51 threats stayed the same; only 7 decreased and 46 damage threats increased.

The biggest changes are in those threats which Slightly Degraded sites on Corona. Only 3 of those threats still Slightly Degraded sites in 2009, whilst 24 now damaged the Upper Levels of Sites, 6 Heavily Degraded sites and 2 sites were Destroyed or Destroyed to Ground level.

This is seen clearly on the Graphs in Section 8.7 (Figure 8-27 to Figure 8-30): they relate the vertical effect to cause, and demonstrate the change over time.

8.6.4 - The Relationship Between Horizontal and Vertical Damage Extents

The relationship between horizontal and vertical extent is complicated. Table H-103 to Table H-110, Appendix H, were created to investigate whether any relationship between horizontal damage and vertical damage existed, to see if any particular damage extent was more likely to be associated with any other damage extent at any given time, and whether that relationship was likely to change. There is a clear relationship between depth and extent, particularly for less damaging threats, in that - to some extent - the more of the site the threat covers the deeper the damage is. However, it was discovered that the category Upper Levels Damaged was so prevalent that it skewed the data to the point where no other pattern was evident. This was a particular problem on the Corona data, but it also skewed the data collected from the Geoeye imagery.

Vertical damage extents are slightly related to horizontal extents. In general, threats which horizontally cover the entirety of a site (the greatest horizontal extent) are unlikely to reach the greatest vertical extent and Destroy the site. Fortunately for archaeology, only Sections of most sites were Destroyed, although the Majority of one amalgamated site was Destroyed to Ground Level, and one site was Totally affected across the site and the affected depth was recorded as Destroyed to Ground Level – which is to say the site was destroyed unless any sub-surface remains are preserved.

TABLE 8-10: CHANGE IN VERTICAL EFFECT FROM THE 1960S TO 2009 (AMALGAMATED SITES)

			Vertical Effect (Geneye)								
			Unknown	Site buried	Pitted	Site slightly dispersed / degraded	Upper levels damaged	Site heavily dispersed / degraded	Site destroyed to ground level	Site destroyed	Total
Vertical Effect (Corona)	Unknown	Count	1	0	1	1	18	5	2	0	28
		% within Vertical Effect (Corona)	3.6%	.0%	3.6%	3.6%	64.3%	17.9%	7.1%	.0%	100.0%
	Site buried	Count	0	1	0	0	1	0	0	0	2
		% within Vertical Effect (Corona)	.0%	50.0%	.0%	.0%	50.0%	.0%	.0%	.0%	100.0%
	Pitted	Count	0	0	1	0	0	0	0	0	1
		% within Vertical Effect (Corona)	.0%	.0%	100.0%	.0%	.0%	.0%	.0%	.0%	100.0%
	Site slightly dispersed / degraded	Count	0	0	0	3	24	6	1	1	35
		% within Vertical Effect (Corona)	.0%	.0%	.0%	8.6%	68.6%	17.1%	2.9%	2.9%	100.0%
	Upper levels damaged	Count	0	0	0	0	39	9	3	1	52
		% within Vertical Effect (Corona)	.0%	.0%	.0%	.0%	75.0%	17.3%	5.8%	1.9%	100.0%
	Site heavily dispersed / degraded	Count	0	0	0	2	3	3	0	0	8
		% within Vertical Effect (Corona)	.0%	.0%	.0%	25.0%	37.5%	37.5%	.0%	.0%	100.0%
	Site destroyed to ground level	Count	0	0	0	0	0	0	2	0	2
		% within Vertical Effect (Corona)	.0%	.0%	.0%	.0%	.0%	.0%	100.0%	.0%	100.0%
	Site destroyed	Count	0	0	0	0	0	1	1	2	4
		% within Vertical Effect (Corona)	.0%	.0%	.0%	.0%	.0%	25.0%	25.0%	50.0%	100.0%
Total		Count	1	1	2	6	85	24	9	4	132
		% within Vertical Effect (Corona)	.8%	.8%	1.5%	4.5%	64.4%	18.2%	6.8%	3.0%	100.0%

For a description of how to read the table, please see the corresponding horizontal damage table on p345, or Appendix F.5.6.2, p516.

8.6.5 - Most Affected and Unaffected Sites

By 2009, out of 78 surveyed sites, broken down in 85 component site types (i.e. amalgamated sites), one was Totally / Entirely Destroyed to Ground Level, the Majority of another was Destroyed to Ground Level, and the Majority of a third was Totally / Entirely Destroyed. It is possible that the sites Destroyed to Ground Level are completely destroyed, but excavation would be required to confirm this (Table H-109 and Table H-110).

Imagery cannot be used to say that a site has definitely suffered no damage from human interference, or even natural erosion, which may affect the condition of a site making it more prone to damage from humans. Sites where no damage is visible are marked as Unknown. In 2009, on imagery with a 0.5m resolution, only 3 sites had Unknown damage. These sites were all in the limestone hills: their location was known on imagery, but no damage was visible, and their exact condition is uncertain.

8.7 - Damage Effects: Analysis of Damage Sources

This section analyses the individual causes of damage to sites, as identified from the imagery and the field visits. The following pages display the most important tables and graphs relating to damage causes. Table 8-11 (and Table H-111, Appendix H) display total counts of each damage cause. The predominance of damage causes for the Amalgamated sites analysis is displayed graphically on Figure 8-22 (the Unit analysis is displayed on Figure H-18, Appendix H). The relationship between horizontal damage extent and cause on each imagery type is displayed on graphs in Figure 8-23 to Figure 8-26. The relationship between vertical damage extent and cause on imagery types is displayed on graphs in Figure 8-27 to Figure 8-30 (Unit analysis graphs are in Appendix H, Figure H-19 to Figure H-26).

The information presented in these tables and graphs is supported by a number of tables in Appendix H:

- Table H-112 to Table H-113 count the total number and percentage of each damage cause on the four imagery types for amalgamated sites and site units;
- Table H-114 to Table H-121 display counts and percentages for each damage cause by Severity of threat;
- Table H-122 to Table H-129 display damage causes by location;

- Table H-130 to Table H-137 display the damage causes in relation to site types;
- Table H-138 to Table H-145 display the relationships between damage cause and horizontal damage extent, and Table H-146 to Table H-153 display the relationships between damage cause and vertical damage extent.

Each threat is discussed according to an analysis of prevalence, extent and relationship to key factors, such as site type or location. Whilst no source of damage is recorded more than once per site, each site can be affected by multiple sources of damage (that is, multiple buildings on a site would only be recorded once as a threat from development, but the site could also be threatened by a road and an orchard). Many of the identified damage threats are related – for example development can serve an agricultural purpose, such as the building of a storage facility to house agricultural machinery or crops. It is important to remember that most of the damage types listed are man-made threats, and are far greater than many natural threats. Whilst each threat is presented separately here, in reality they are interrelated. Arable agriculture, for example, causes erosion, and is correlated with increasing development and new roads. For ease of analysis, however, each threat is discussed as if it were isolated.

Table 8-11: Count of Amalgamated Sites Affected by Each Damage Cause

	Amalgamated Sites	**% of 85**
Arable Agriculture	65	76.5%
Bulldozing	12	14.1%
Cuts	10	11.8%
Development	26	30.6%
Dumping Pits	3	3.5%
Grave Pits	11	12.9%
Irrigation Channels	5	5.9%
Looting	15	17.6%
Military Damage	1	1.2%
Mudbrick Pits	0	0.0%
Natural Erosion	11	12.9%
Orchards	30	35.3%
Pits (Other)	7	8.2%
Quarries	3	3.5%
Railway	1	1.2%
Roads / Tracks	47	55.3%
Visitor Erosion / Vandalism	1	1.2%
Water Erosion	10	11.8%
Unknown	41	48.2%

FIGURE 8-22: BAR CHARTS OF FREQUENCY OF DAMAGE SOURCES BY IMAGERY (AMALGAMATED SITES)

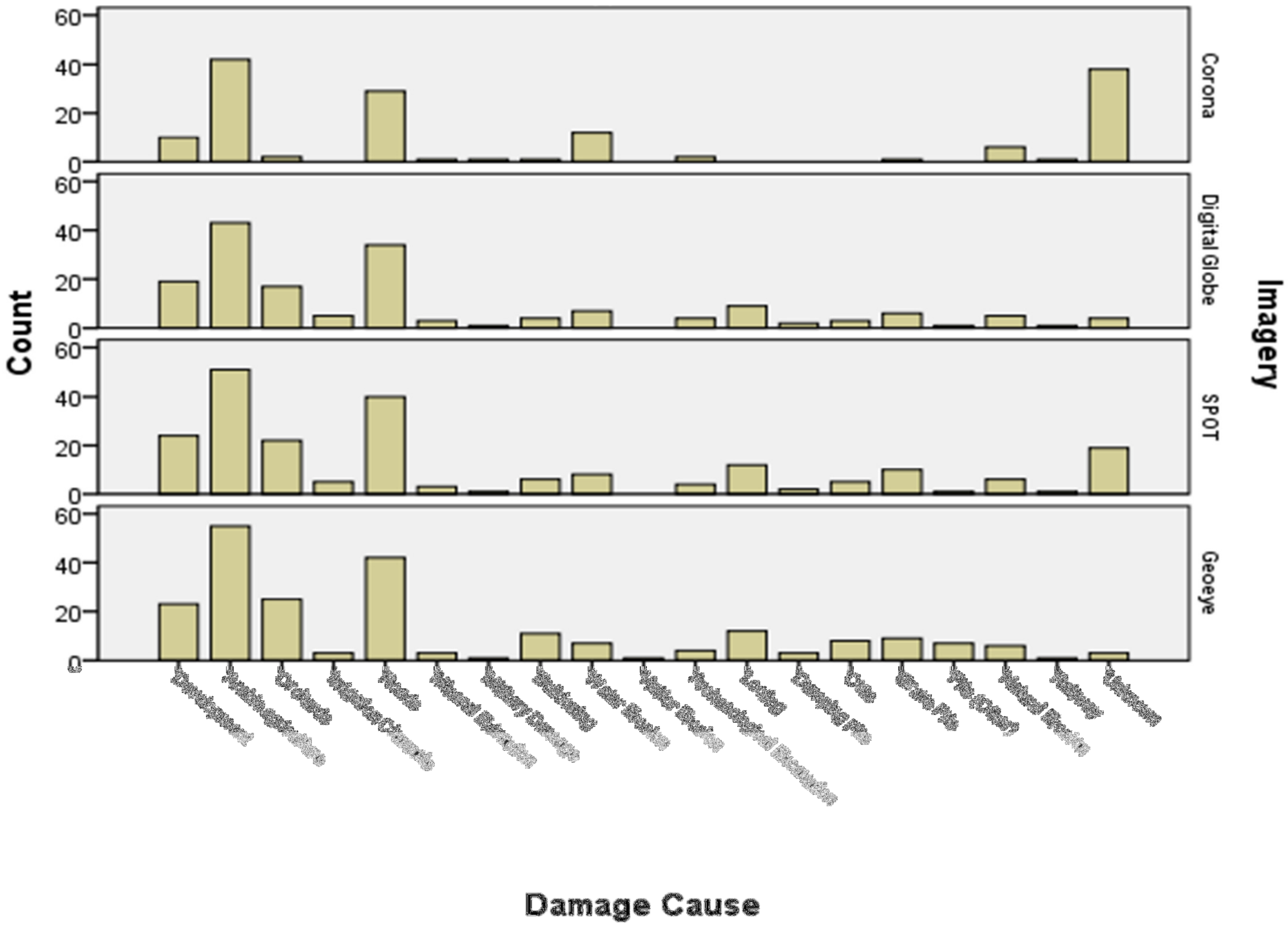


FIGURE 8-23: GRAPH OF HORIZONTAL EXTENT OF DAMAGE BY CAUSE (CORONA) (AMALGAMATED SITES)

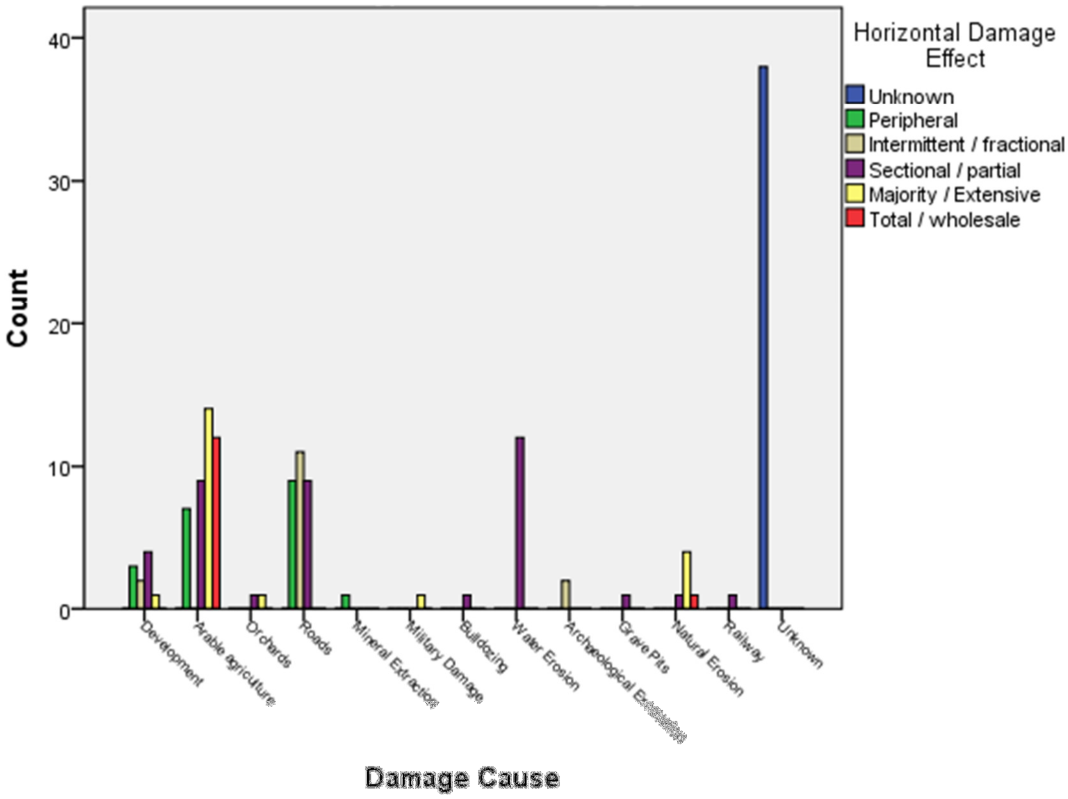


FIGURE 8-24: GRAPH OF HORIZONTAL EXTENT OF DAMAGE BY CAUSE (DIGITALGLOBE 2003) (AMALGAMATED SITES)

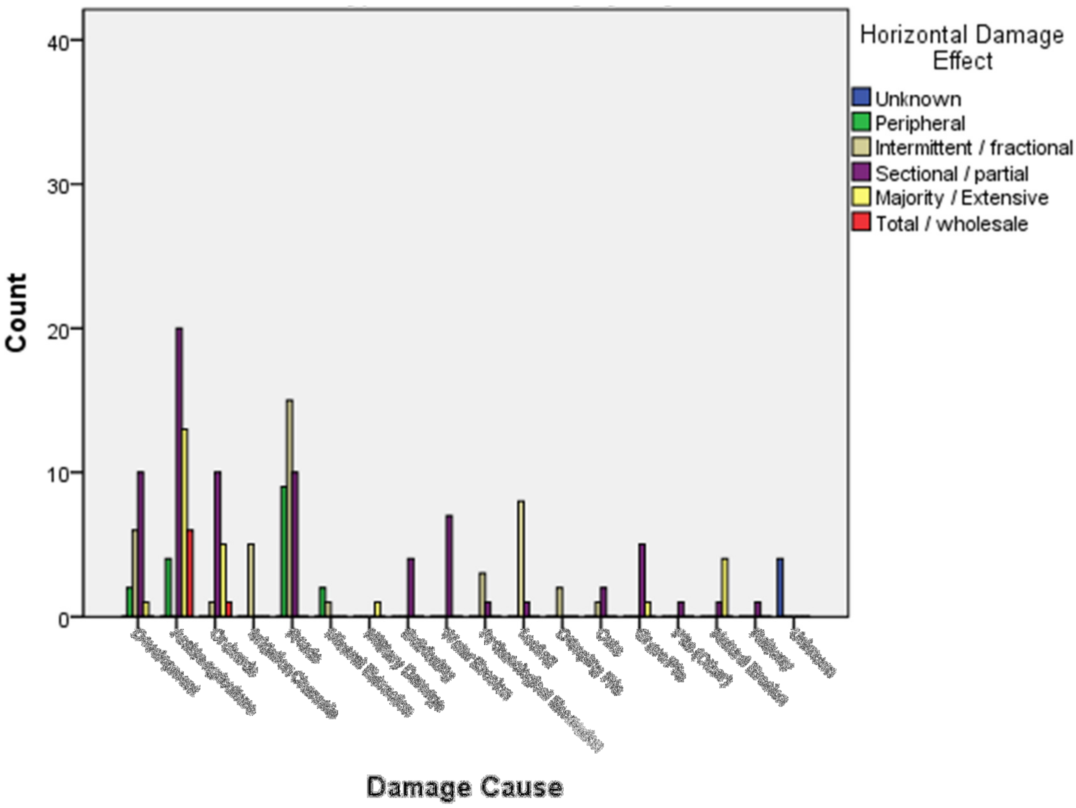


FIGURE 8-25: GRAPH OF HORIZONTAL EXTENT OF DAMAGE BY CAUSE (SPOT 2004) (AMALGAMATED SITES)

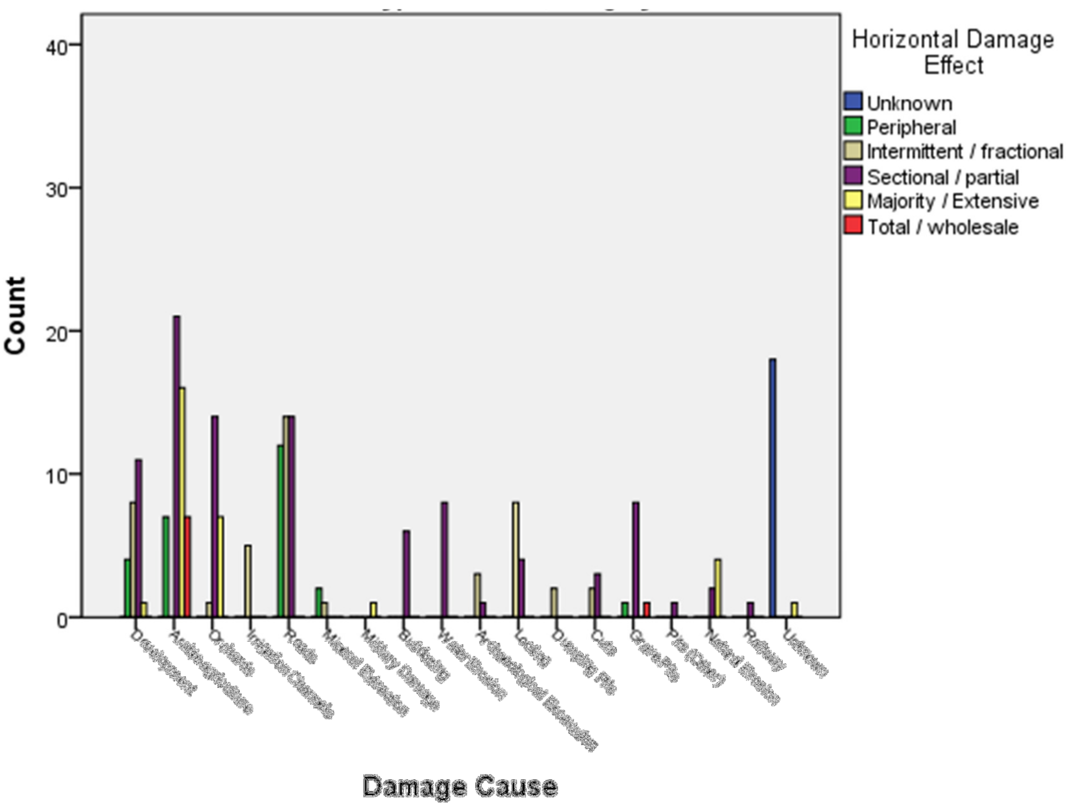


FIGURE 8-26: GRAPH OF HORIZONTAL EXTENT OF DAMAGE BY CAUSE (GEOEYE 2009) (AMALGAMATED SITES)

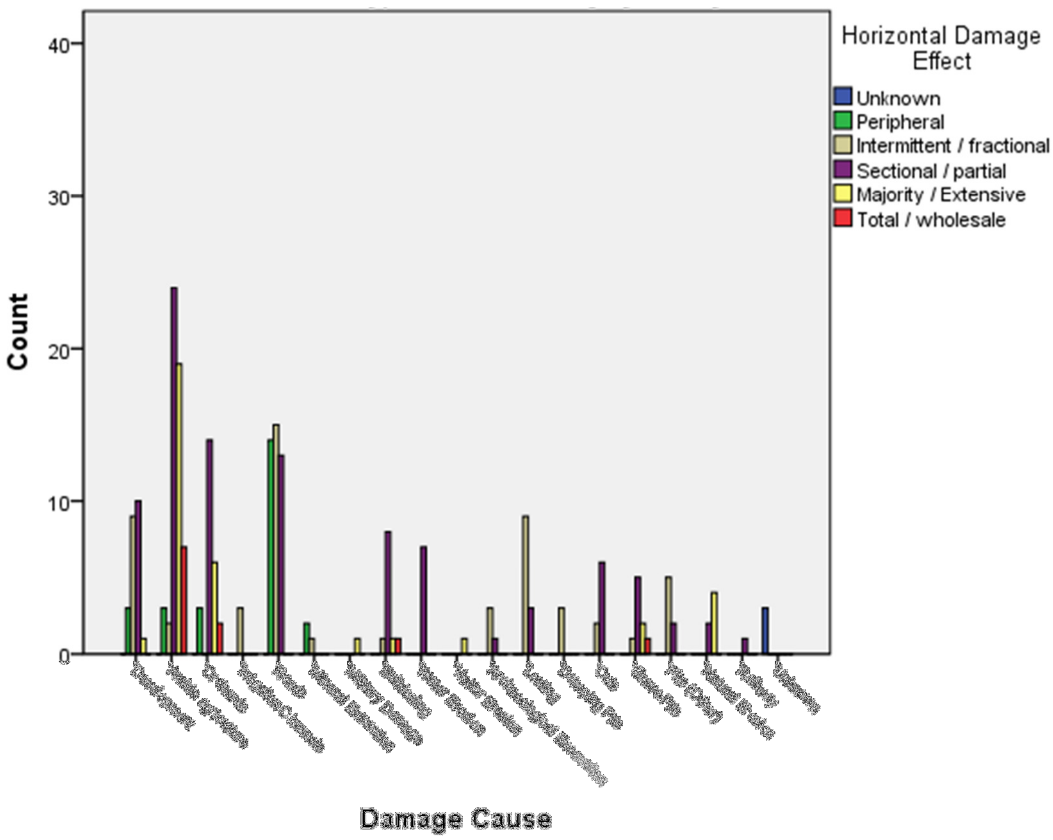


FIGURE 8-27: GRAPH OF VERTICAL EXTENT OF DAMAGE BY CAUSE (CORONA) (AMALGAMATED SITES)

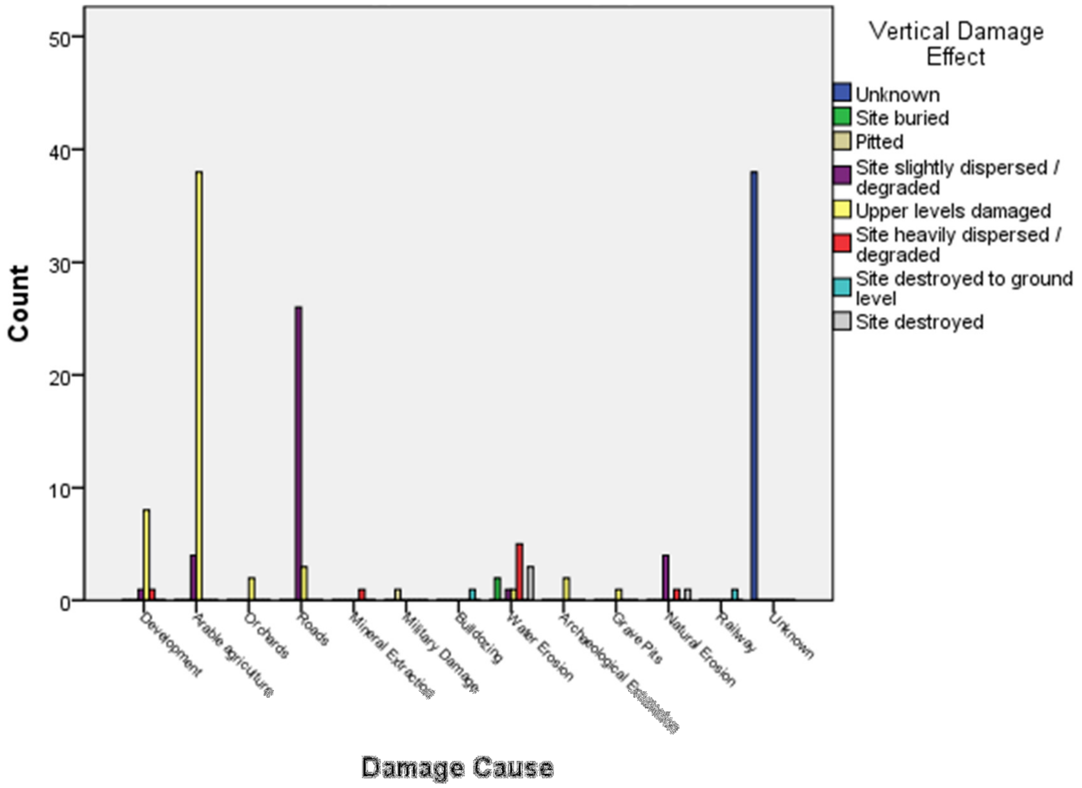


FIGURE 8-28: GRAPH OF VERTICAL EXTENT OF DAMAGE BY CAUSE (DIGITALGLOBE 2003) (AMALGAMATED SITES)

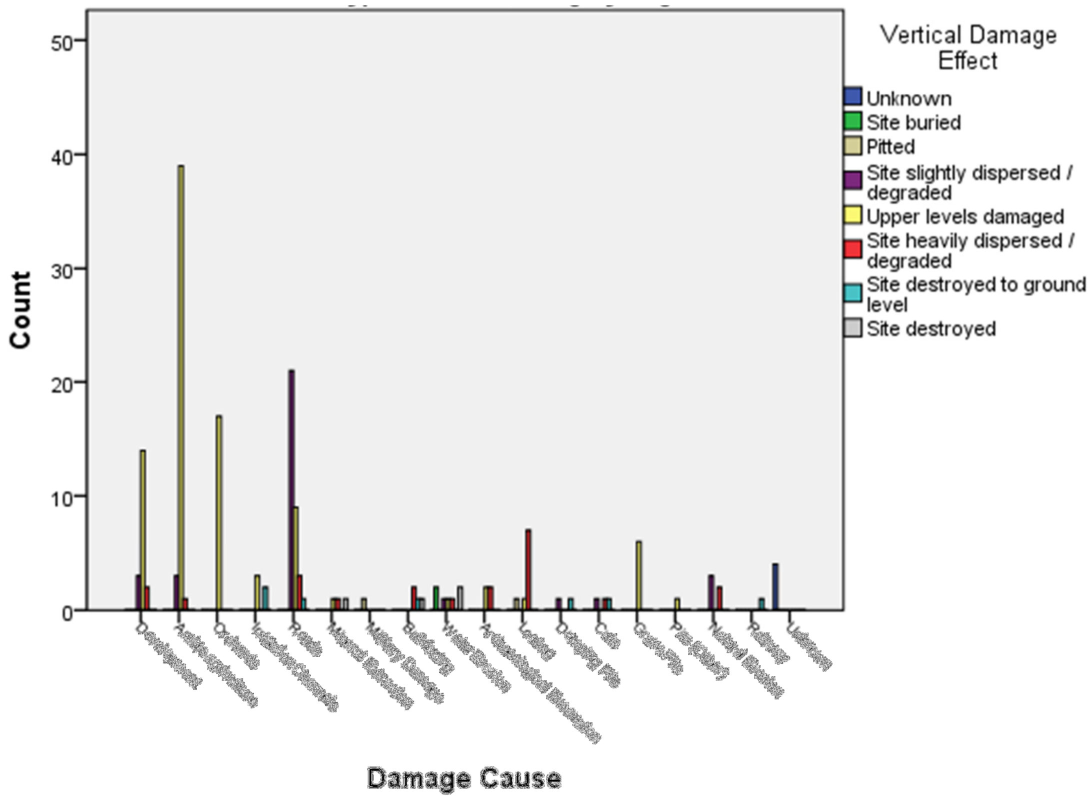


FIGURE 8-29: GRAPH OF VERTICAL EXTENT OF DAMAGE BY CAUSE (SPOT 2004) (AMALGAMATED SITES)

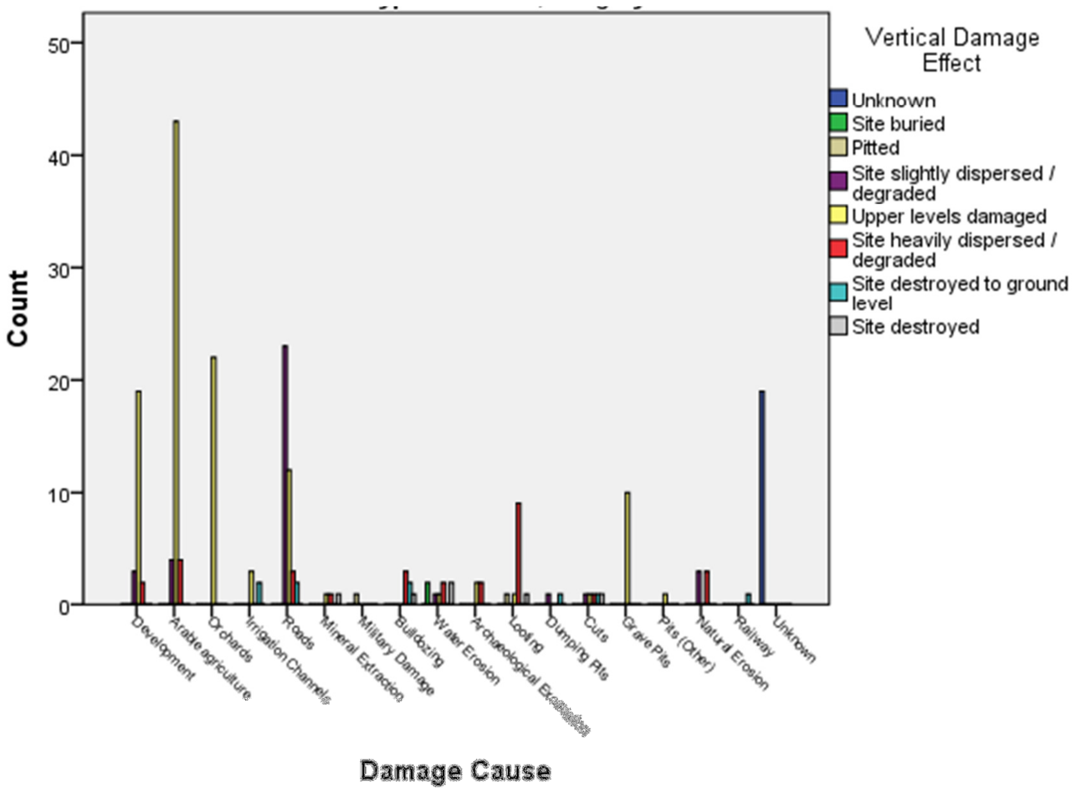
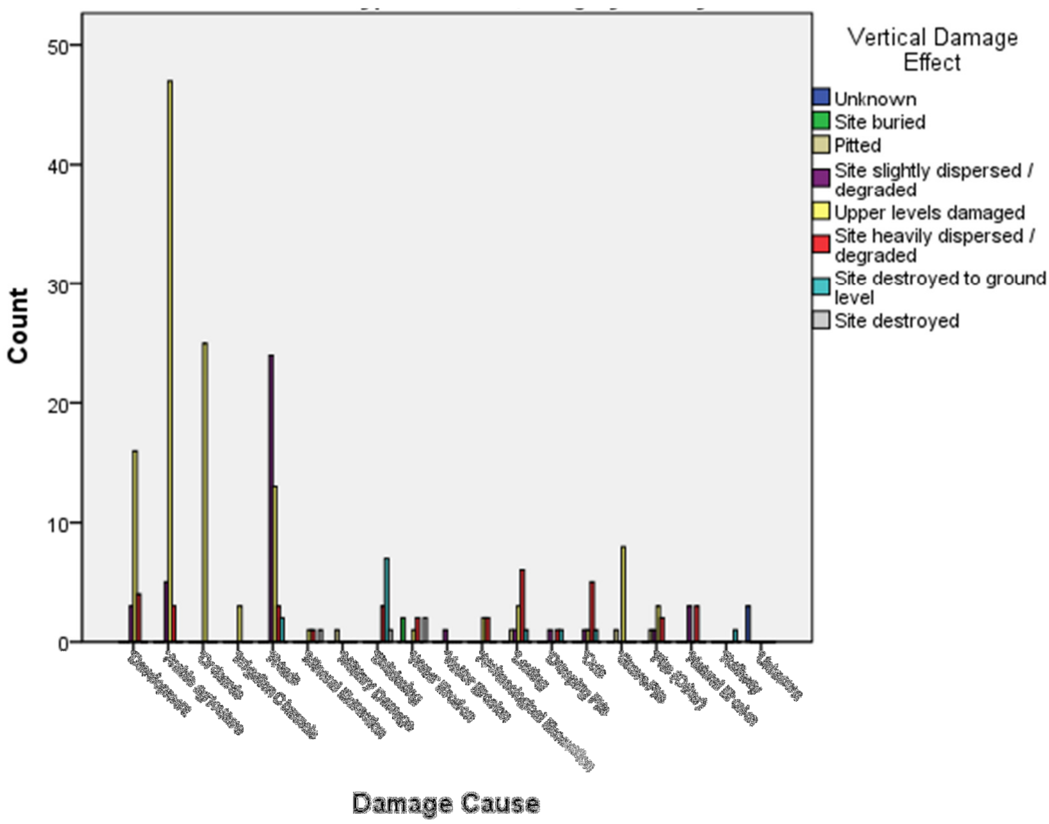


FIGURE 8-30: GRAPH OF VERTICAL EXTENT OF DAMAGE BY CAUSE (GEOEYE 2009) (AMALGAMATED SITES)



8.7.1 – Development

As elsewhere in the Middle East, modern villages are often situated on or near archaeological sites. Development is less common here than it is in regions such as the Jazirah, although modern settlements are still built on and around tells and flat sites, such as at Koulliye (Figure 8-31) and development is increasing. Not all tells have settlements on or by them: Tell Amarna and Tell Jerablus Tahtani are both large tells with no settlements immediately adjacent to them, for example. As much - if not more - of the development on sites in this region consists of small single buildings, presumably agricultural buildings or small farm complexes. These are built on flat sites (Figure 8-32) and tells alike (Figure 8-33). There are no small pump houses, or remnants of them, as seen in more heavily irrigated areas. A pigeon house is located on the lower town of Carchemish: in appearance this building is indistinguishable on imagery from any other small building - the actual purpose of most buildings is unknown.

Figure 8-31: Buildings on Koulliye (LCP 50) (possible site boundary in red)[141]

Figure 8-32: Small Farming Complex on LCP66 (site boundary in red)[142]

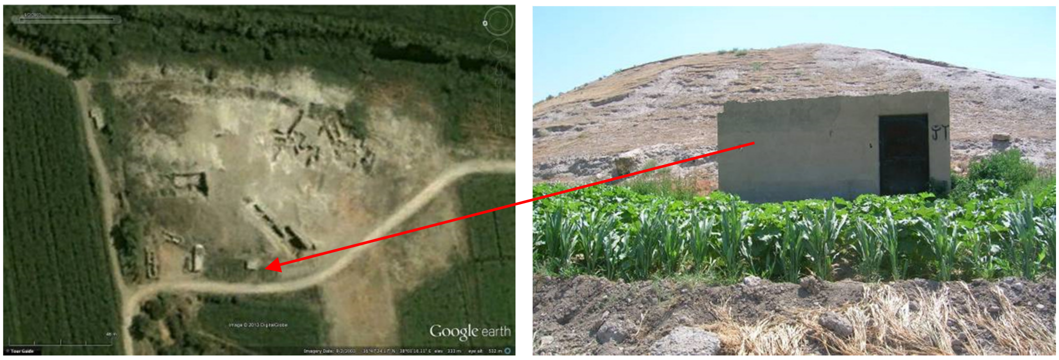


Figure 8-33: Building on Tell Jerablus Tahtani (LCP 22) on Satellite Imagery and Photograph[143]

[141] DigitalGlobe Image, 27 May 2003. Taken from Google Earth 17 February 2013
[142] Geoeye Image, 22 September 2009. Taken from Google Earth 17 February 2013

Development in this area rarely decreases. In the Jazirah, entire (small) villages are abandoned and the area turned to fields. In the area around Carchemish the field visits mention abandoned houses, such as at LCP 65 – "A *inhabited house and [an] abandoned one stand at the top of the tell, while two abandoned houses are located in a nearby field.*" This process of abandonment is visible only twice on imagery. For example, a cluster of 3 small buildings are visible on DigitalGlobe imagery on the lower town around Tell Amarna (LCP 21) in 2003, but by 2009 on the Geoeye imagery, most of these are abandoned and turned to fields (Figure 8-34).

In general, however, development increased in all land areas. There is little fluctuation, reflecting the increasing in the population, and in ensuing agriculture in this area.

FIGURE 8-34: DECREASING DEVELOPMENT ON THE OUTER TOWN OF TELL AMARNA (LCP 21)[144]

Red arrows indicate the 3 buildings on the imagery. The right-hand building is largely gone, and a section of the centre building is now a ploughed field (indicated by the centre right arrow)

Prevalence of Development:

Between 1967 and 2009, counts of development damage more than doubled from 11 to 24. Overall, it is the fourth most common damage type, making it the second most common primary damage type on Corona, and third most common primary damage type on Geoeye, accounting for 10% of all primary damage threats. However, this masks an actual increase of only 2 primary counts of development (from 6 to 8). Given that many development threats are small single buildings, it is not surprising that development appears more often as a non-primary threat. As a secondary threat, for

[143] DigitalGlobe Image, 2 September 2003. Taken from Google Earth 17 February 2013. Photo copyright the author, 2010

[144] Left: DigitalGlobe Image, 2 September 2003. Right: Geoeye image, 22 September 2009. Both taken from Google Earth 17 February 2013

example, it increases from only 1 threat to 6, and as a tertiary threat counts increase from 1 to 4.

Development on the upland plains increased from 4 counts to 10 between 1967 and 2009. It also more than trebled on the river terraces, increasing from 2 to 7 counts (1 in 10 threats in that area). It affected almost half the sites in those areas, and two thirds of the sites on the limestone terrain.

This increase is partly a factor of image resolution: only 1 single modern structure was recorded on Corona, whereas 13 were visible on Geoeye. The resolution of Corona is often too poor to distinguish them, and the reflectance patterns of the limestone bluffs make it hard to distinguish anything in that area. However, 9 villages were recorded on sites on Corona, increasing to 11 on Geoeye, demonstrating a small but genuine increase.

The increase in both small buildings and larger villages and towns can be seen clearly on al-Hadira (LCP 67). The site is situated just to the south of the modern village of al-Hadira. Figure 8-35 to Figure 8-37 show the site on Corona, DigitalGlobe and Geoeye. The development at the top left (indicated by the red arrow) is the expansion of the village: the increasing development between 1967 and 2003 is clear. Note also the small building in the middle of the site on the DigitalGlobe image (Figure 8-36). The red circles indicate buildings which were not present on the previous image, highlighting the increase in development.

<u>Development and Site Type:</u>

In the 1960s only 3 damage threats to tells were caused by development. Whilst the number of development threats to tells increased slightly, proportionally this has remained at approximately 1 in 10 threats to tells. One third of development threats were on tells, despite their size (Table H-130 to Table H-137). This is presumably a reflection of the practice of building new settlements around old ones.

Development was most likely to affect low tells in the 1960s – 40% of development threats were on low tells. As time passed it has become more widespread, affecting all types of sites. However, it was still not a particularly common threat to low tells, accounting for approximately 1 in 10 threats over the study period.

The largest increase is on flat sites, where development has increased from 3 counts to 10, effectively tripling.

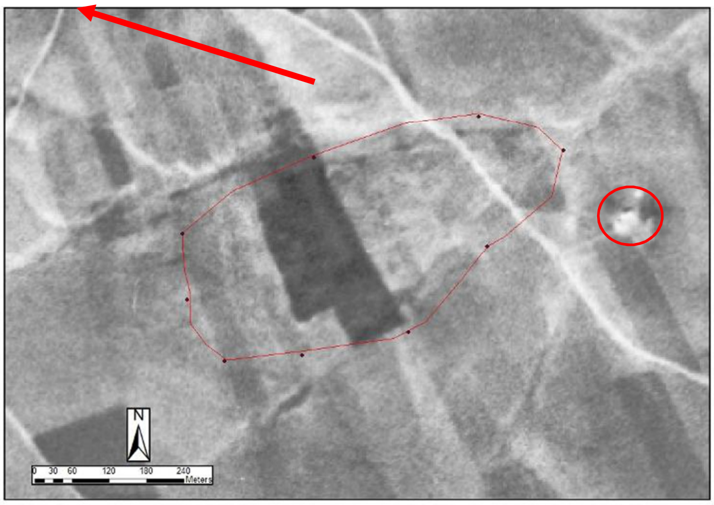


FIGURE 8-35: LCP 67 ON CORONA IMAGE

The red arrow indicates the location of al Hadira village (outside the frame of the image). The blue dots are the GPS points around the edges of the site, joined by a red outline. The red circle shows a farm near the site.

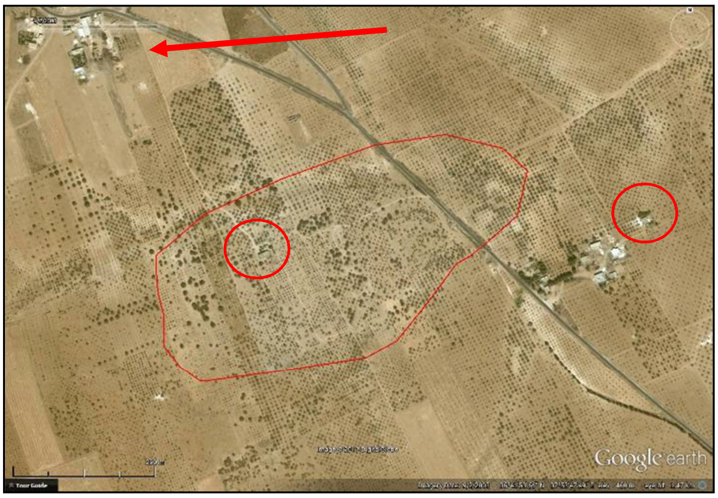


FIGURE 8-36: LCP 67 ON DIGITALGLOBE IMAGE

The red arrow indicates the spread of the modern village, which had not spread far enough to enter the frame of the image in the 1960s. Red circles highlight places where development has increased.

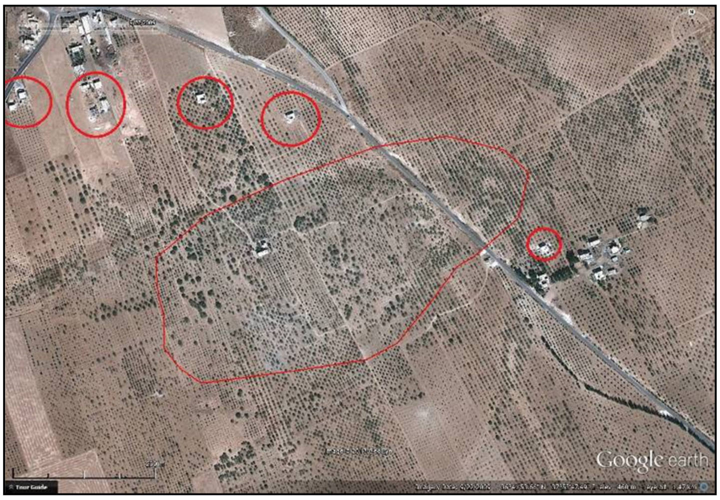


FIGURE 8-37: LPC 67 ON GEOEYE IMAGE[145]

Red circles indicate places where new buildings are visible which were not present on the 2003 DigitalGlobe image.

[145] Top: Corona Image, ds1038-2120df066, standard deviation stretch, 22 January 1967. Middle: DigitalGlobe Image, 2 September 2003. Bottom: Geoeye Image, 22 September 2009. Taken from Google Earth 17 February 2013

Whilst development is increasing, it is not increasing as much as many other threats. However, it must be remembered that a single building with deep foundations can do significantly more damage than many other threats.

Development and Damage Extent:

Development is almost always recorded as damaging the Upper Levels of sites as the proportion of the site which has been destroyed is hard to estimate. Without excavation, the buried site depth remains unknown, and it is very difficult to know the depth of building foundations, particularly from satellite imagery. Once the site is built over, excavation becomes impossible, and, as detailed in Chapter 3.5.1 (p3.5.1 – Development46), not enough is known about how harmful development can be.

Further information is sometimes provided by the field visits. At Ghasaniyah (LCP 61) the field notes (2009) state

> *"The site, which might originally have been a tell, is located in the middle of the village and surrounded by houses. Sherds have been found … in the alleyways that lead up to the highest point… where a residual of soil some 5x3m and 1m high containing mudbricks and stone fragments was found. This could be the remains of a tell…"*

In this case the development has been so destructive, it is not even possible to determine if it was a site.

At Koulliye (LCP 50) or Yousef Bek (LCP 59) on the other hand, the field visits (2009) record houses up the sides of both tells, but does not mention them damaging the site, whereas at al-Zahiriya (LCP 63)

> *"it remains unclear if the [modern] cemetery is standing on a low shallow tell as … modern constructions have deeply and intensively altered the original context"* (2009).

The extent of the damage to the outer town of Carchemish, caused by the development of the modern town of Jerablus, was the subject of the 2010 field season of the Land of Carchemish Project Team. This represents the only detailed study of the effects of modern development on a major archaeological site which could be accessed, and provides definite evidence for just how destructive development can be. In many places, the expansion of Jerablus destroyed large sections of the outer town and reduced other parts to their foundations (Wilkinson et al. 2011; Wilkinson and Wilkinson 2010). Figure 8-38 (p363) shows the increase in the extent of Jerablus over the outer town of Carchemish (the orange boundary). It compares the boundary mapped on Corona to the town boundary mapped today (the pink and the red boundaries). In 1967 the modern town lay just outside the Iron Age outer town whereas today the modern buildings overlay significant parts of the site. It is the largest town in the area, and as well as the development of shops and houses, the supporting infrastructure includes roads and a football field surrounded by a concrete wall (over what was a section of the outer town wall).

Site type and site depth do play a major part. Obviously if the site is shallow, which is often unknown, development would cause greater damage. In some cases holes in sites have demonstrated that even flat sites in this area can have more than a metre of buried deposits, showing the change in ground level over time. At Dadate-North (LCP 37), an extensive flat site, according to the field notes "*a significant depth of occupation deposits remain in place, estimated at ca. 1m+*" (2008). Unfortunately, in other cases sites are known to be very shallow, and therefore more easily damaged. Looters holes at Meshirfe (LCP 15), for example, indicate a shallow stratigraphy of c30cm, which would be catastrophically disturbed by development.

Looking at the survey area overall (Table H-138 to Table H-145), in the 1960s development was most likely to affect a Section of a site. Demonstrating the increase in development, by 2009, the number of site Sections affected had more than doubled.

Given that in one case it was not even possible to confirm that it was a site under the development, and given the diversity of effects recorded for development, unless the field notes specifically stated an approximate damage extent and/or site depth, development was always recorded as damaging the Upper Levels of the site (the minimum damage the laying of foundations is assumed to cause to a deep site), hence the prevalence of this damage extent.

The increase in development also acts as a warning of future damage. According to the Geoeye imagery, 9 sites have development affecting a Fraction of them (39%), compared to only 2 in 1967. These sites are at serious risk if the development around them continues to expand as it has done on other sites. However, fortunately for the archaeological record, development rarely affects more than part of a site. Over the study period, only 1 site was mostly covered by development, and even then not entirely. This is seen more clearly on Figure 8-23 to Figure 8-26, which show the causes of damage, and their extents. The relative increases in the different damage threats are clear.

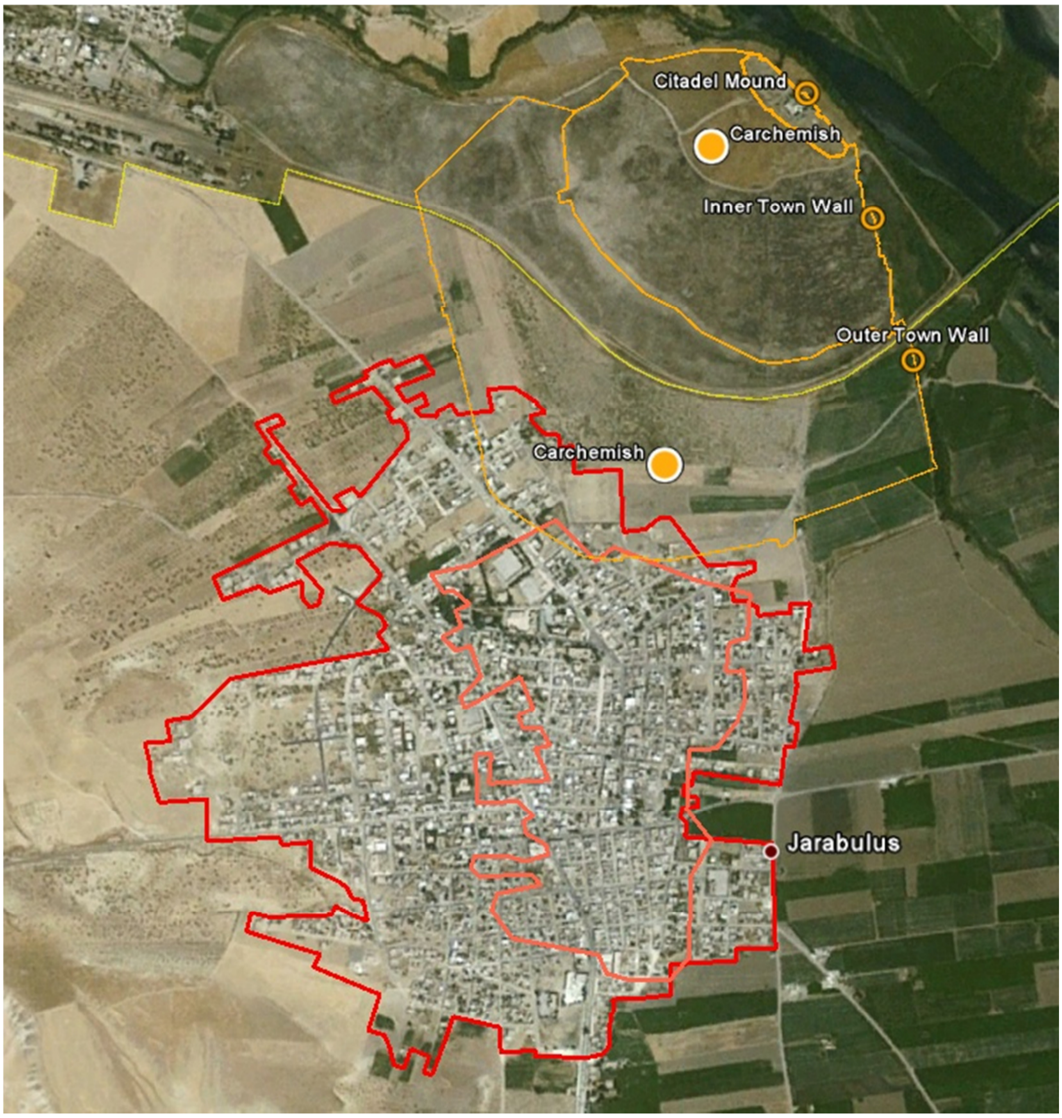


FIGURE 8-38: DEVELOPMENT OF MODERN JERABLUS OVER THE OUTER TOWN OF CARCHEMISH[146]

The orange lines indicate the extent of the ancient town of Carchemish, and the lower town, upper town, and citadel.

The pink boundary indicates the extent of the town of Jerablus in 1967, taken from historic 1038 Corona satellite imagery (1967).

The red line is the extent of the modern town, taken from Geoeye imagery (2009).

[146] DigitalGlobe Image, 2 September 2003. Taken from Google Earth July 2011

8.7.2 – Agriculture

All three forms of agricultural damage – arable agriculture, animal grazing and orchards - are visible on imagery in the Carchemish area and therefore all three will be discussed here. There are clear links between agriculture and other forms of damage, such as bulldozing. As will be shown, several sites in the area have been bulldozed to create terraces for cultivation. However, for ease of discussion, all threats will be treated separately.

Arable Agriculture:

Arable agriculture is the damage type usually referred to when the term agriculture is used, as discussed in Chapter 3.5.2 (p54). As in other areas, the ploughing of the sites and ensuing crop cover and chaff affect the visibility of the site during the field visit, potentially masking its extent, such as at LCP 28 (discussed on p313), and hampering collection of diagnostic pottery. For example, at LCP 53, the field team recorded

> *"Crop cultivations, some fields are not yet harvested, but compact straws cover the terrain where harvesting has already taken place. Therefore the ground visibility was very bad. Only one elongated field … was open, cleared up of straws, and therefore with good visibility".*

Equally ploughing may also artificially 'extend' a site. At LCP 34, for example, the field notes (2008) record

> *"The heavy ploughing of the field may have exaggerated the spread of the sherdage, and the 70x30m figure may be high".*

Ploughing furrows were not visible on Corona. Unlike the Jazirah where the marks of envelope ploughing are often visible, there were no traces of ploughing around Carchemish. This is not to say there was no ploughing at that time: it requires very high resolution imagery to see. Nonetheless, few field boundaries are visible in the limestone area on Corona. Given the marginal nature of the soil, and the settlement history of the area discussed in Chapter 7.4, it is unlikely that entire region was ploughed as it is today.

The field visits recorded ploughing on 18 of the 85 amalgamated sites, although arable agriculture was recorded on 45 sites. Ploughing was also recorded under 7 orchards, which doubled as arable sites. As demonstrated by the rise in the number of tractors (in Chapter 2.3.3, p30), mechanised ploughing has become increasingly common in all parts of the Middle East over the last 50 years, and the field visits are very recent, suggesting ploughing is more widespread than recorded. The Geoeye imagery is contemporaneous with some of the field visits: ploughing was visible on 45 of 56 amalgamated sites with arable agriculture on them, and also 14 of 25 orchards, which may be a more accurate reflection of its extent.

Three sites which had visible agriculture in 1967 were not covered by DigitalGlobe imagery, and one of these (LCP 47) was not covered by Geoeye either, so the actual totals of extent in 2009 may be slightly higher than stated.

<u>Prevalence of Arable Agriculture:</u>

In total, arable agriculture was recorded on 65 of the 85 amalgamated sites (76.5%) over the study period (Table 8-11). It is the most common form of damage recorded, and is a third again as prevalent as the next most common damage threat. However, cultivation fluctuates: a site which is under crops may not always be so. In this region, many arable sites were converted to orchards, although in some cases, crops were still farmed under and around the trees. Even allowing for the widespread conversion of the land to orchards, arable agriculture still increased between 1960s and 2009. 42 counts of agricultural damage were recorded on amalgamated sites on Corona (which is just under a third), and 55 on Geoeye (which represented a quarter of all threats). All of the sites which had agriculture present on Corona also had visible agriculture on DigitalGlobe and Geoeye (Table H-114 and Table H-120).

As the most common damage threat, it is no surprise that agriculture accounts for 42% of primary damage threats on Corona. However, it accounts for only 33.3% of primary damage on Geoeye, and was the most common secondary damage (29%).

Unsurprisingly, it was the most common damage threat on Corona on the upland plains (41.5%): this area is very fertile and has a long history of agriculture. However, by 2009, it accounted for less than a quarter of the damage to sites (23.3%), as threats to sites have increased in both number and variety (Table H-122 to Table H-128).

Only 1 in 5 sites on the limestone hills were definitely affected by agriculture in the 1960s. The actual number may be higher – 49% of sites in this area were recorded as Unknown damage, because the sites were not visible, and it was not possible to determine whether the large amounts of the land cover in the area was arable fields or low scrub covering the hills. Perhaps representing an increase in arable agriculture, or possibly just demonstrating the increase in site visibility and land cover visibility, 28% of damage threats to sites in this area on Geoeye were caused by agricultural damage.

Just over a third of threats on the river terraces were from agriculture on Corona. This dropped to 20% on Geoeye, but the decreasing percentage is a reflection of the increasing number of damage threats. In real terms, the number of damage threats from agriculture increased from 12 to 13.

Arable agriculture has become more common as time has passed in all areas, even though this is not a heavily agricultural area and large areas of the land are now covered by orchards.

Arable Agriculture and Site Type:

(Arable agriculture and site type are shown on Table H-130 to Table H-137). Arable agriculture is more likely to affect flat sites: given they require less effort to farm this is not surprising. 52% of damage threats to flat sites were caused by arable agriculture in the 1960s. Although figures suggest this has decreased slightly over time, some flat sites (specifically archaeological building ruins) have become visible on the higher resolution imagery, and agricultural damage which could only be suspected before is now confirmed.

Approximately 1 in 5 agricultural threats affect large tells, despite their size (although on Corona, at least, this is mostly Peripheral damage). On Corona, 4 agricultural threats Slightly Degraded the tells, caused by farming on their Periphery, and on Geoeye, 1 in 10 threats are to the Periphery of sites. As this part of the tells, which are often rather steep in this area, is mostly eroded soil, agriculture is not particularly damaging to the site itself. However, in slowly loosening and removing the soil from the bottom of the tell, it will gradually open the tell up to undercutting caused by aeolian and water-borne erosion and erosion from the top of the tell, where the archaeological layers are closest to the surface, may increase.

A similar proportion of low tells and mounds also experience cultivation.

Arable Agriculture and Damage Extent:

The horizontal extent of arable agriculture can be seen on Tables 138 to 145 in Appendix H, and Figure 8-23 to Figure 8-26 in this Chapter. The vertical extents are in Table H-146 to Table H-153 in Appendix H, and are displayed in Figure 8-27 to Figure 8-30 in this Chapter.

Even in the 1960s, agriculture affected the Majority of the site in a third of cases, and in almost a further third, it affected the site Wholesale. Damage entirely covering a site, in fact, was caused by agriculture in 92% of cases. As threats to sites increased, it became less likely that agriculture would entirely cover a site, as space was needed for other threats, like roads. Peripheral agriculture decreased as improved access to machinery allowed areas that would once have been difficult to farm to be brought under the plough, allowing cultivation to spread across sites. By 2009, agriculture still covered the Majority of the site in a third of cases. Of those threats which affected the entirety of the site, agriculture was still the cause in two thirds of cases.

In 90% of cases arable agriculture affected the Upper Levels of amalgamated sites on Corona, decreasing only slightly to 85.5% on Geoeye. The effect on Corona is largely assumed due to the low resolution, which prevents a more detailed analysis, in much the same way as it is for development.

As also discussed in the Development Section 8.7.1, the extent to which agriculture affects a site depends in many ways on the depth of the site, and historical magnitude of cultivation, which is rarely known for certain. As a result, it is likely that agriculture is doing more damage to sites than is recorded here, but this cannot be known without excavation, and monitoring over time to determine the full effects of the slow removal of topsoil and gradual accompanying erosion, particularly on tells. According to Geoeye, many tells are now experiencing agricultural damage to entire Sections, and in 4 cases the site is affected Wholesale: as noted by (Ur 2010b), this will contribute to a slow but steady decrease in height as erosion causes the sites to gradually slump.

<u>Grazing:</u>

Grazing on sites is a form of agriculture in the sense that it is a by-product of animal husbandry, but is also dependent on cereal cultivation. As stated in Methodology Chapter 4.5.4, the recording of grazing is almost entirely dependent on the animals happening to be in the field during imagery acquisition, so it is not considered quantitatively.

Grazing was visible once on an (amalgamated) site on DigitalGlobe, and twice around sites (Figure 8-39): all three occurrences were on sites on the limestone terrain. On Geoeye, grazing was never visible on a site, but was recorded 3 times around sites on the limestone hills, and once around a site on the upland plain. It was never recorded on field visits, and the resolution was too low on Corona and SPOT to see animals.

Although a rarely recorded (and relatively minor) damage effect, it is likely that it is much more prevalent than it appears, and probably affects most farmed sites over the course of each year. However, grazing can also be indirectly beneficial, as valuable grazing land may become protected from other uses (see Chapter 3.5.2, p65).

FIGURE 8-39: GRAZING ANIMALS (BOTTOM) BY LCP 14_1 AND LCP 14_2 (TOP)[147]

8.7.3 - ORCHARDS

The second form of agricultural damage is the creation of olive and pistachio orchards, which have become extremely prevalent. Unlike in the Jazirah, where orchards are small, large parts of this area have been converted to orchards over the last forty years, as well as many small private orchards in back gardens. Whilst the lack of orchards on Corona is usually attributed to the lower resolution, in this area 2 orchards were visible, and in one case it was possible to date the orchard's creation between the 1038 and 1104 Corona (i.e. between 1967 and 1968) (Figure 8-40). According to the field

[147] Geoeye Image, 22 September 2009. Taken from Google Earth 19 February 2013

visits, many of the orchards today are used for both olives and pistachios, such as at LCP 77: although 2 orchards were specifically for olives, 4 were specifically pistachio orchards, and one was a vegetable orchard.

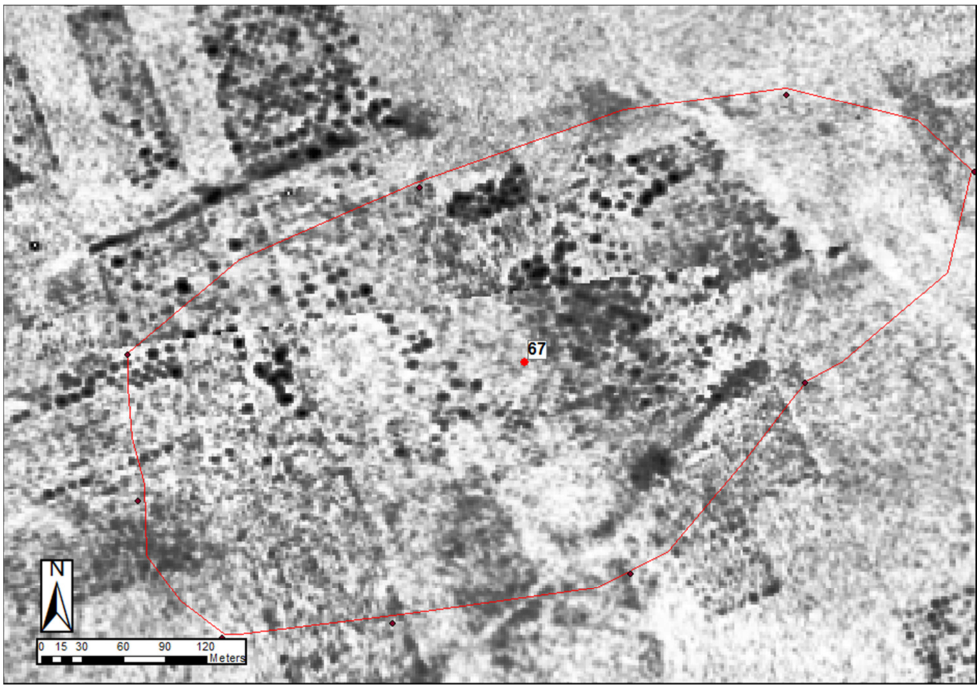


FIGURE 8-40: ORCHARD AT LCP 67 ON CORONA 1104[148]

This image should be compared to Figure 8-35, which was taken a year and a half earlier and shows only cultivated fields. The regular pattern of black dots indicates an orchard – the same orchard which is visible on more recent imagery (for example on Figure 8-36 and Figure 8-37).

Orchards are a paradoxical form of damage in that in many cases they protect as much as they damage sites. At the outer town of Carchemish, for example, as noted in the Conservation Report, "*the areas under pistachio orchards provide some protection to the archaeological materials underneath*" from the more destructive development of the town of Jerablus (Wilkinson and Wilkinson 2010). Examination of wells in the orchard demonstrated that the outer town is deeper than the orchard: whilst the upper levels are damaged, the lower levels are therefore protected.

Prevalence of Orchards:

Only 2 orchards were visible on the Corona imagery: many have been created in the last decade. 17 orchards were recorded on DigitalGlobe, and 25 on Geoeye. Of the

[148] Corona Image, 1104-1009da014, histogram equalise stretch, 08 August 1968.

latter, 10 orchards were either created more recently than the site field visit or were not recorded during the field visits.

They were the second most common primary damage on Geoeye, and they increased from the fourth most common secondary damage to become the second most common.

The increase in orchards compared to arable agriculture can be seen on Figure 8-41.

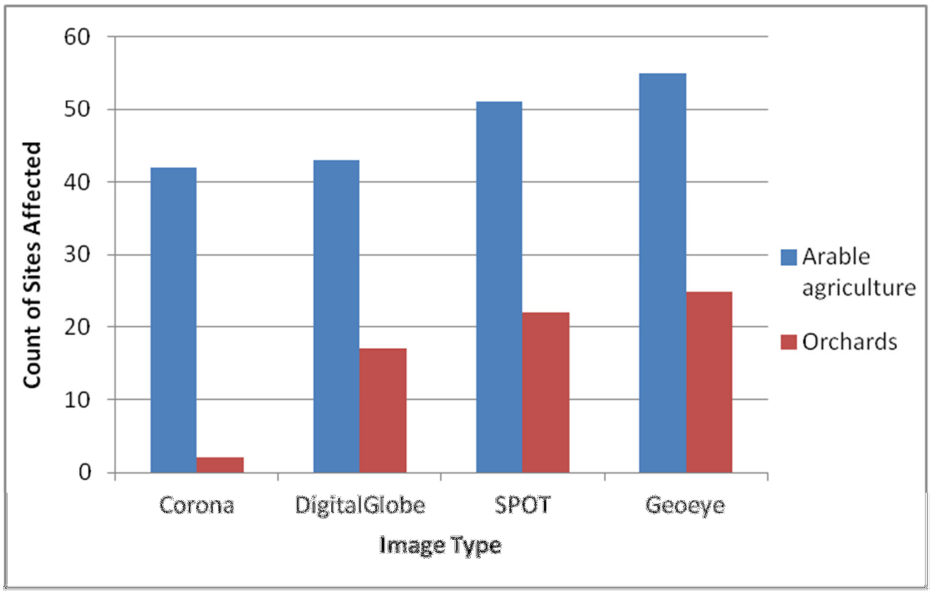


FIGURE 8-41: GRAPH OF INCREASE IN ORCHARDS AND ARABLE AGRICULTURE

Whilst most orchards were large orchards covering extensive areas, a small number of private orchards were planted in back gardens, such as at the site of Ghasaniyah (LCP 61). It is in the middle of a village surrounded by orchards. However, there are also many private orchards within the village (Figure 8-42).

Initially most orchards were located on the upland plains: in 2003 11 orchards were on the plains, 3 on the limestone hills and 3 on the river terraces (this accounts for almost 1 in 5 threats to sites on the upland plains). By 2009, there were 13 orchards on the plains (still 1 in 5 threats) but the number on the limestone hills has increased to 8 (more than doubling in 6 years). Orchards are one of the fastest increasing threats to sites in this area.

FIGURE 8-42: PRIVATE ORCHARDS IN THE VILLAGE OF GHASANIYAH[149]

(Black arrows indicate orchards, visible as a regular dot pattern, and LCP 61 is circled in red)

Orchards and Site Type:

Orchards are predominantly (although not exclusively) found on flat sites. There is an orchard on a Section of LCP 65 for example: despite the fact the tell is 7m high the northern slopes are planted with fruit trees. By 2009, 7 low mounds had orchards on them: however, twice as many flat sites had orchards on them.

Orchards and Damage Extent:

Most orchards covered only a Section of the site, perhaps because the field boundaries where the land use changed enabled easier identification of sites, giving a slight bias towards this damage extent. Many sites are partly covered by both arable agriculture and orchards in fields next to each other, and in some cases there were crops planted underneath the trees. Only 1 orchard covered the entirety of a site in 2003, and 2 in 2009. However, a large number of orchards covered the Majority of the site also had roads, tracks, or a small building on them as well.

Like arable agriculture, orchards were most likely to damage the Upper Levels of sites. Whilst there have been some studies on the damage caused by ploughing to archaeological sites (see Chapter 3.5.2. p57), there have been no detailed studies on the

[149] Geoeye Image, 22 September 2009. Taken from Google Earth 19 February 2013

damage caused by orchards. It is therefore assumed that orchards cause only damage to the Upper Levels of the site, although in areas such as Homs it is known that holes dug for orchards can go right through a site to the bedrock (Prof. Graham Philip, *pers. comm*. 2010). As mentioned in the Section 8.7.1 - Development, it is also dependent on site depth. Meshirfe (LCP 15) would be very heavily damaged by an orchard, for example, given the site is only 30cm deep.

8.7.4 – Irrigation

Although becoming increasingly common in many parts of the Middle East, large irrigation channels are still relatively rare in the area around Carchemish. This is presumably due to the easy availability of water from the Euphrates and the Sajur. For the same reason, the drought which has affected large parts of Syria has had less impact here. Rather than channel based irrigation, in this area, water is pumped from the rivers using machinery and pipes or wells are dug (see Figure 3-18, p69, in Chapter 3.5.4).

<u>Prevalence of Irrigation:</u>

Irrigation is not a major threat to sites in this area: it is never a primary threat. No irrigation is visible on Corona, and none was recorded during the field visits. 5 threats from irrigation channels are visible on DigitalGlobe, but only 3 are visible by 2009. When it is recorded, it is always on the river terraces.

<u>Irrigation and Site Type:</u>

Irrigation is not associated with any particular site type. 2 threats from channels were recorded around the edges of a tell, 1 on a low tell, and 2 on flat sites.

<u>Irrigation and Damage Extent:</u>

In all cases irrigation channels only affected a Fraction of the site, because the channels themselves were small compared to the size of the sites. However, whilst three of the 5 recorded channels only damaged the Upper Levels of the sites, the other 2 were tentatively marked as having Destroyed the Site to Ground Level.

These latter two are actually the same channel, recorded as affecting an outer town and the main tell at Tell Jerablus Tahtani (LCP 21). The assessment of depth of damage is partly based on the excavation (discussed in Chapter 7.2, p302), which suggested that the subsurface remains were not very deep. The channel appears to have fallen out of use, and is no longer visible on Geoeye (Figure 8-43).

FIGURE 8-43: IRRIGATION CHANNEL AT TELL JERABLUS TAHTANI (LCP 21) IN 2003 AND 2010[150]

Tell Jerablus Tahtani is indicated by the red dot. The red arrow on the left image indicates the irrigation channel, visible as a dark green line of increased vegetation. On the right-hand image, in the same location the irrigation channel appears to have become a tractor track, as can be seen in the close up image (bottom).

[150] Left: DigitalGlobe Image, 2 September 2003. Taken from Google Earth 17 February 2013 Right and close up: Geoeye Image, 22 September 2009. Taken from Google Earth 17 February 2013

8.7.5 – Roads

As discussed in Chapter 3.5.5 (p72), roads take three main forms: tractor tracks, gravel tracks, and tarmac roads.

Prevalence of Roads:

55% of amalgamated sites had a road or track on them, and it was the second most common damage type (after agriculture) on all images. Like most damage types, the number of roads and tracks increased over time, from 29 on Corona to 42 on Geoeye, bearing in mind that small tracks like tractor tracks were not visible on the lower resolution imagery.

Roads were the most common secondary damage type on Corona, despite the fact that small tracks were not as visible. On Geoeye, roads were much more likely to be a tertiary threat: many small tracks became visible on the higher resolution imagery, but they caused little damage (compared to the other visible threats)

In the 1960s roads were as likely to be located on the upland plains (13 counts) or the limestone hills (11 counts), which is surprising given that the river terraces are the areas of greatest occupation. However, by 2009, roads were equally likely to be located anywhere. This is particularly interesting given the relative sizes of each land type – proportionally one would expect far more roads on the limestone hills given it is the largest area. This presumably reflects the relative concentrations of the population.

Roads and Site Type:

There is no correlation between roads and site type: no site type is more likely to be driven through or over, or to be avoided.

Roads and Damage Extent:

Given the relative width of a road compared to a site, no road had a particularly large horizontal extent. They were as likely to go around the Periphery of a site, to cover a Fraction of it, or to cover a Section. Crucially, sites do not factor when the placement of roads is decided – in general, no attempt is made to go around them.

On Corona, it was not usually possible to determine whether roads were tarmacked or covered in gravel: both have a similar spectral reflectance. As the tarmacking of roads in the period between SPOT and Geoeye was visible, it has been assumed that most of the roads in the 1960s are gravel-covered tracks (at best), and therefore cause little damage. Therefore, following the principle of least damage (p161), most roads on Corona were assumed to only Slightly Degrade site (26 of 29 threats).

However, the rapid improvement (i.e. widening and surfacing with tarmac) was visible between 2003 and 2009. By 2009, 13 roads damaged the Upper Levels of the site, 3 Heavily Degraded the site, and in 2 cases, roads Destroyed the site to Ground Level. These greater damage extents were assigned when it was clear either from satellite imagery or field notes where roads cut deeply into a site. At Koulliye (LCP 50), for example, the field notes (2009) record that the road may have removed part of the tell's slopes, and on satellite imagery, there are clear shadows where roads and tracks around the tell have trimmed it (Figure 8-44).

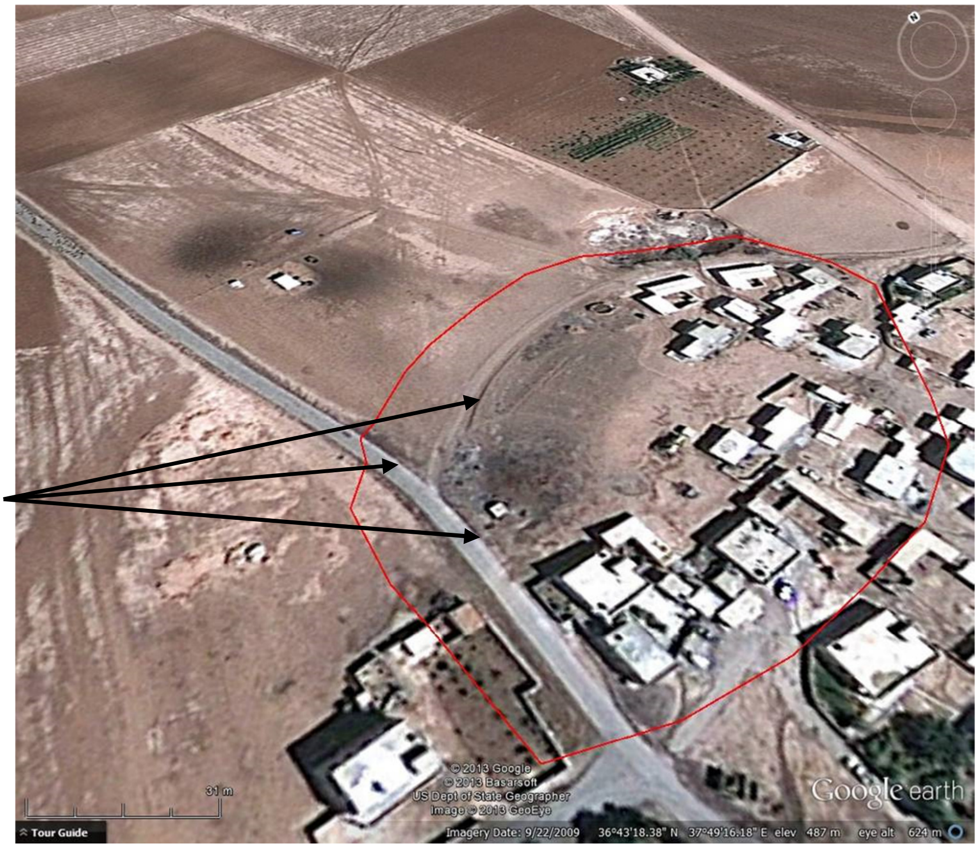


FIGURE 8-44: ROADS DAMAGING TELL KOULLIYE (LCP 50)[151]

The site is outlined in red. Black arrows point to a small track around the northern edge of the tell (top), and to shadows where the road cuts into the slopes of the tell (middle and bottom).

[151] Geoeye Image, 22 September 2009. Taken from Google Earth 19 February 2013

8.7.6 – Quarries / Mineral Extraction

In total, 3 quarries were recorded, on LCP 1, LCP 5 and LCP 13. Of these, two are small localised quarries, such as the one seen in Figure 8-45. This quarry was recorded during the 2010 field visit (although other, older quarries were recorded previously which are assumed to be historical). Although small, the damage is clear: Figure 8-46 shows the exposed archaeological sections of wall in the quarry. The quarry at Tashatan (LCP 5), on the other hand, is a major industrial quarry which is threatening the entire site. Fortunately, in 2009 it was only on the Periphery of the site, but it presents a major risk.

Figure 8-45: New Quarry at Khirbet Seraisat (LCP 1_2), July 2010

Figure 8-46: Walls in the Exposed Section by Quarrying at Khirbet Seraisat[152]

[152] Photo July 2010. Copyright: the author

8.7.7 – MILITARY DAMAGE

Whilst military damage can refer to a wide variety of threats to sites caused by combat, armed occupation, and the building of military installations (to name a few), in this case there was only one site whose damage had a military cause. The tell of Carchemish and a section of the outer settlement on the Turkish side of the border were covered in land mines at the time of this study (2010) (although they have since been removed).

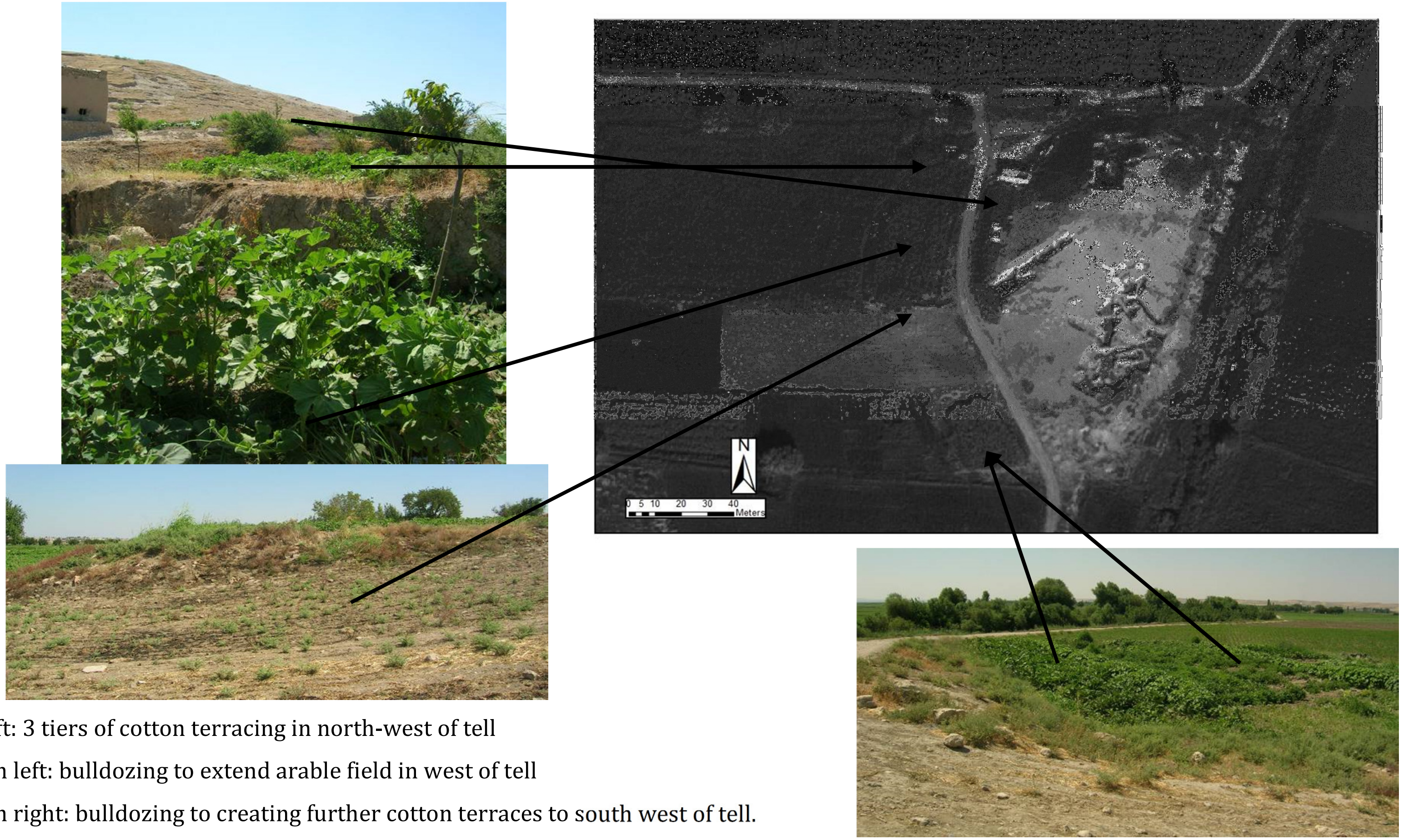
> "*When in 1956 the border was demarcated again, it was systematically mined, resulting in a stretch of explosive mines 500 km long (averaging 300–500 m in width) along the Syro-Turkish border. After signing the Ottawa Convention of 1996, Turkey started demining the whole area. Thanks to the strenuous efforts of the Gaziantep authorities, the ancient city of Karkemish was one of the first sectors completed, in February 2011"* (Marchetti 2012: 132).

As discussed in Chapter 3.5.7 (p76), mines are not usually buried particularly deeply, although they clearly cover a large horizontal extent of Carchemish. As it is unknown what type the mines were, or how deeply they were buried, using the Principle of Least Damage (p161) a minimal depth is assumed: they are recorded as Pitting the Majority of the site. However, should they detonate, the damage to Carchemish would be significant, and so this is marked as the most serious threat to the site.

8.7.8 - BULLDOZING

Bulldozing is a common way of shaping the land in this area: in several cases field notes record the bottoms of relict wadis have been bulldozed into make-shift roads, demonstrating the easy access to such machinery, and the willingness to use it.

Bulldozing to sites, however, is particularly difficult to identify in this area. Whilst field visits have shown that it occurs as much as in other parts of Syria, it is rarely visible on imagery. Site visits at Tell Jerablus Tahtani (LCP 22), for example, showed that farmers had bulldozed the lower slopes of the tell in order to extend the fields for farming (Figure 8-47), and to create terraces for cotton. Three levels of terracing were cut into the north west side of the tell, and two more into the south west side.



Top left: 3 tiers of cotton terracing in north-west of tell

Bottom left: bulldozing to extend arable field in west of tell

Bottom right: bulldozing to creating further cotton terraces to south west of tell.

FIGURE 8-47: BULLDOZING FOR AGRICULTURE AT TELL JERABLUS TAHTANI (LCP 22)[153]

[153] Panchromatic Geoeye, po_3801419_pan_001_1, 10 November 2009. Photos: July 2010. Copyright: the author

At Carchemish, bulldozing has been particularly destructive: for example, the location of the West Gate of the Outer Town (as excavated by Woolley) was identified, "*although unfortunately only a few ashlar blocks now remain loose among the bulldozed soil*" (Wilkinson and Wilkinson 2010). The effects of bulldozing into the outer town wall on the West Gate can be seen in Figure 8-48.

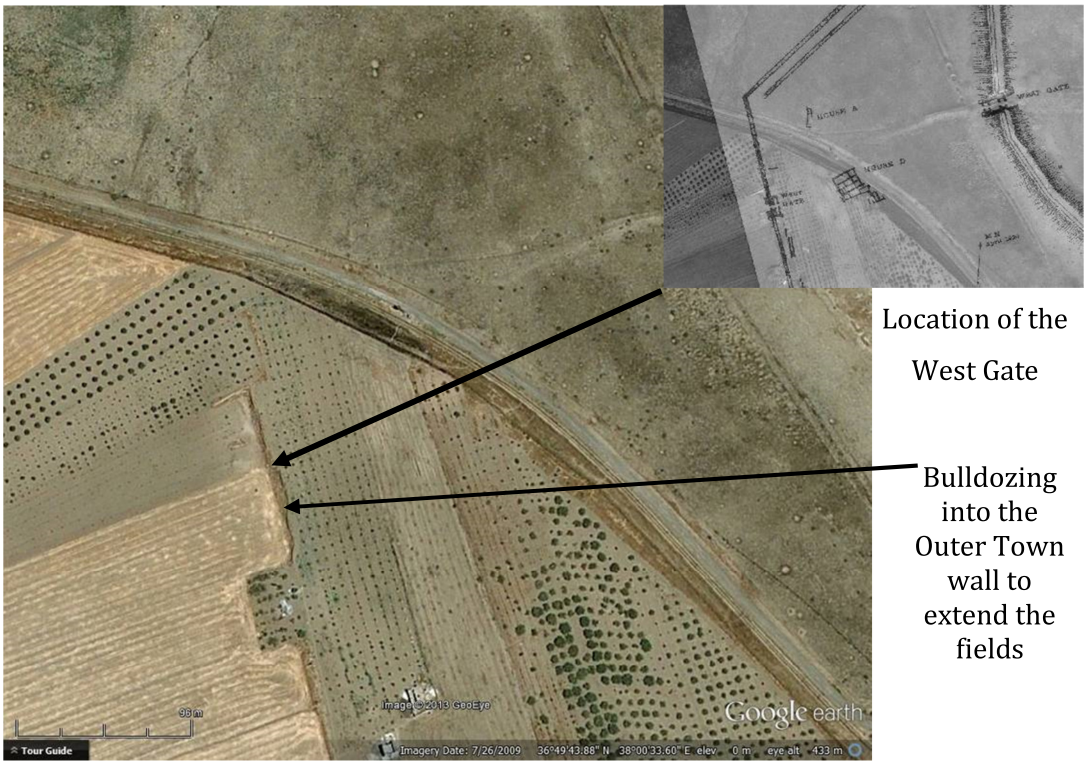


FIGURE 8-48: BULLDOZING ON THE OUTER TOWN WALL AND WEST GATE AT CARCHEMISH[154]

<u>Prevalence of Bulldozing:</u>

In total, bulldozing was recorded 12 times (Table 8-11). On Corona, only one feature, which according to the field visit notes had been created by bulldozing, was visible. It was visible (or reported on field visit notes) 11 times on Geoeye, demonstrating the increase. (The twelfth site is LCP 42 – bulldozing was recorded on the field visit notes, and therefore recorded on SPOT for the sake of tracking damage, but the site is not covered by DigitalGlobe or Geoeye).

In most cases bulldozing was marked as a primary threat due to the severity of the damage it causes. However, on some particularly badly damaged sites, or large sites of which only very small sections had been bulldozed, it was marked as a secondary

[154] Left: Geoeye, 22 September 2009. Taken from Google Earth 22 February 2013
Top right: Woolley's1921 Map of Carchemish over Panchromatic Geoeye, po_3801419_pan_001_1, 10 November 2009

threat. Once it was a tertiary threat, and once (on Geoeye) it was only the 4th most serious threat to a site. This last was at the Outer Town of Carchemish: whilst bulldozing is clearly a very serious problem, it is indicative of the greater extent of the other recorded hazards that this was only the 4th most serious. The Outer Town is very large, and bulldozing, whilst extremely destructive, only affects a small section (Table H-114 to Table H-121).

Bulldozing was only recorded once on the upland plains, perhaps due to the relatively flat nature of the land, whereas on Geoeye it was recorded 5 times on the limestone hills, and 5 times on the river terraces (despite the fact they cover a much smaller area than the hills). LCP 42 is also located on the hills just above the river terraces, which makes a 6th instance in this area (Table H-122 to Table H-129).

Bulldozing and Site Type:

Bulldozing is largely associated with flat sites and field scatters (5 counts - Table H-136) (remembering the flat sites became so through natural taphonomic processes, rather than the bulldozer, which cut into sections of them). It can therefore be assumed that site damage was a collateral effect of the bulldozing, rather than the intended effect. 3 tells were also affected, and some buildings. At LCP 42, for example "*Site appears to have been partially bull-dozed … at least 2-3 buildings have been flattened*" (field notes 2008). However, this is relatively rare.

Bulldozing and Damage Extent:

Only one site was Totally bulldozed – this was the Roman / Byzantine site Tukhar Saghir Janubi (LCP 45) (Figure 8-49). Most sites are like LCP 42, which was "*partially bulldozed*" (field notes 2008). In 8 cases on Geoeye, Sections of sites were affected.

FIGURE 8-49: BULLDOZING AT LCP 45

The image on the left shows the site circled in red on Geoeye in 2009[155]. The photo on the right shows the site during the 2008 field visit: there is nothing left. It is visible as paler disturbed soil against the darker undisturbed soil.

In one case, it was possible to see bulldozing increasing on the imagery. Field visit notes confirm that LCP 12 is cut on all sides by bulldozing. The extent of the bulldozing has also clearly increased since 2003 (Figure 8-50).

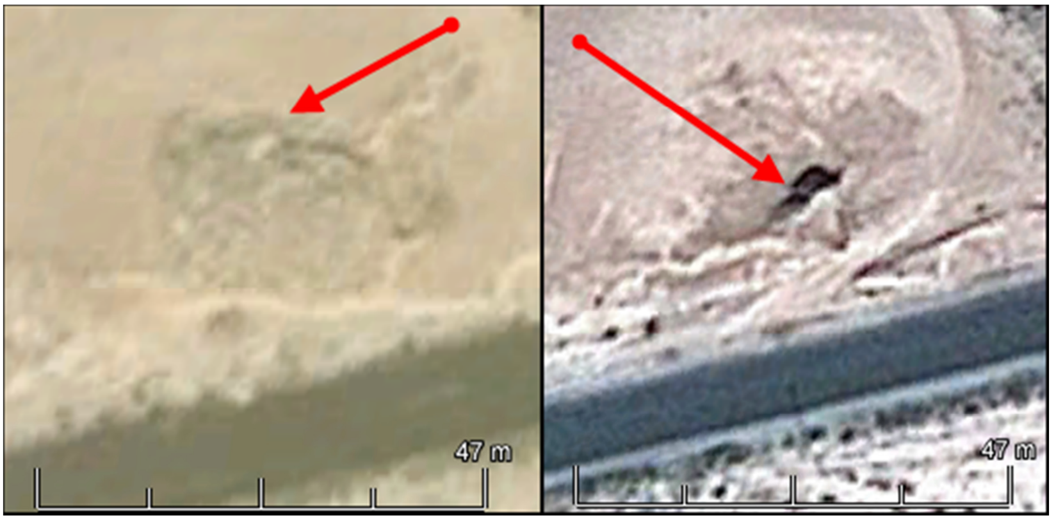


FIGURE 8-50: BULLDOZING OF LCP 12[156]

Arrows indicate the site in 2003 (left) and the mound remnant in 2009 (right).

[155] Geoeye Image, 22 September 2009. Taken from Google Earth 17 February 2013. Photo copyright: Fragile Crescent Project

[156] Left: DigitalGlobe Image, 02 September 2003. Right: Geoeye Image, 22 September 2009. Both taken from Google Earth 17 February 2013.

Bulldozing rarely destroys a site entirely, although it is very destructive whenever it occurs. Therefore it either Heavily Degrades or Destroys a site to Ground Level on the database record. It is never marked as destroying a site completely, as most sites in this area have not been excavated to determine their depth. Examination of wells and looters holes have demonstrated that in many cases there is a significant depth of sub-surface deposit which could theoretically be preserved. The oldest remains in many sites are in the lowest part of the site and are usually buried under later remains. It was hoped that bulldozing may at least provide access to these remains, which cannot normally be studied without excavation. However, whenever the survey team examined a bulldozed site, no such material was evident.

Whilst it is rare for a site to be completely bulldozed, and sub-surface deposits may be preserved, this should not detract from the amount of damage being done by bulldozers. Even if only a section of a tell is destroyed, this can open it to further damage from erosion. Subsurface deposits may remain, but these are only a fraction of what was once there.

8.7.9 - Water Erosion

Water erosion is defined in Chapter 3.5.9, p88: the changes to the wadis which cause it are also discussed in the context of landscape change in Section 8.5. It is recorded on several field visit records, but in most cases, it appears that the wadis are long dried up. The intensive landscape change which has occurred over the last forty years, coupled with the (artificially induced) changes in the levels of the Euphrates have made this form of damage particularly hard to monitor. However, as many wadis no longer flow, it has rapidly become one of the less common threats. As mentioned in the Methodology Chapter 4.5.5 (p144), water erosion is one of the only damage types which is recorded retrospectively from the field visits, in that it is marked on the Corona imagery rather than SPOT imagery.

<u>Prevalence of Water Erosion:</u>

In total, water erosion was recorded on 10 of the 85 amalgamated sites (Table 8-11). It is one of the only damage types which decreases, reflecting the decline in perennial wadis. It was recorded 12 times on Corona, and only 7 times on Geoeye. [This highlights a slight methodological irregularity, in that despite the term, Water Erosion covers sites which are buried by water action, as well as those which are eroded, hence why 10 sites are affected 12 times. Two sites are partially eroded in one place and partially buried in another. As these are different damage effects, it is recorded twice on each site].

It is equally likely to be a primary or secondary effect on Corona, and when it is recorded on Geoeye, it is almost always a primary effect (Table H-114Table H-121). Unsurprisingly, it is predominantly an effect on the river terraces, reflecting the changing course of the Euphrates over the previous millennia (Table H-122 to Table H-129).

<u>Water Erosion and Site Type:</u>

Half the Water Erosion threats on Corona and Geoeye are recorded on flat sites: the rest are evenly distributed amongst the other site types (Table H-130, Table H-136).

<u>Water Erosion and Damage Extent:</u>

All water erosion affects a Section of the site. In the case of the erosive wadis, the channels can still be seen where parts of the site have been slowly washed away. In the case of erosion caused by the Euphrates or Sajur rivers, it is unknown how much of a site may have previously been present. At Serai (LCP 18) for example, "*on the satellite images, a branch of the Euphrates has eroded the floodplain where the wadi reaches the Euphrates valley, and this branch may have eroded away the lower settlement*" (field notes 2006/8). Al-Hadira (LCP 67) was also incised by wadis. Field notes (2009) record that "*two wadis have incised the ground for at least approx. 4m*". However, as could be seen on Figure 8-11 (p321), orchards are planted in the old wadi beds, so they cannot still flow.

In two cases, water action Buried sites, such as at the industrial area of Khirbet Seraisat (LCP 1_5), where "*buildings are buried beneath the aggrading deposits of the earlier alluvial fan*" (field notes 2006/8). Using the field visit notes as the guide, it is assumed that where water erosion occurs, it Heavily Degrades the site, or in 3 cases completely Destroys it.

8.7.10 - Visitor Erosion

Visitor erosion is almost never detectable from satellite imagery unless the level of damage is exceptional, or the feature is large. In this case, it was recorded on the field visit notes at LCP 13. The site itself it not visible on the imagery: it is a flat site defined only by a scatter of small chipped stone tools. According to field notes (2006), the recent presence of shepherds has disturbed the remains, meaning that it is not possible to verify the antiquity of the tools.

Despite the lack of visibility of the site or the damage, it is recorded in order to complete the record of damage to sites in the Carchemish area and to contribute to the assessment of the usefulness of imagery as a monitoring tool.

8.7.11 - Natural Erosion

Obviously taphonomic processes are gradually eroding all sites. However the recording of natural erosion as a damage type indicates that either it was recorded on the field notes, or that it has occurred to such an extent that it may be visible, and may potentially be used as a proxy for later intense cultivation.

Prevalence of Natural Erosion:

Natural erosion (defined in Chapter 3.5.18, p102) was recorded on 11 sites in total although never more than 6 in any one time period. It was taken from a combination of satellite imagery and the field notes.

Erosion was not restricted to a particular land type on Corona: it was equally likely to be found anywhere. On Geoeye, however, 5 of the 6 sites where erosion was recorded were on the limestone hills, a function of the geomorphology of the region (Table H-128).

Natural Erosion and Site Type:

Erosion is largely associated with tells on Corona (5 of 6 counts) (Table H-130). The tells have a 'halo' of soil the same colour as the tell, suggesting that soil has gradually washed off the tell onto the surrounding fields (e.g. Figure 8-51). Over time, as agriculture around tells increases, this soil is often ploughed away, and is no longer visible. This is not to say erosion is no longer occurring on tells, but the evidence is no longer present. Furthermore, the evidence for it is not categorical proof: these 'halos' could be created by other causes, such as sediment layers. Any erosion noted on Geoeye (Table H-136) is usually also mentioned in the field visit notes in contexts which did not exist on Corona. At LCP 71, for example, dispersed soil is eroding from robber trenches, which post-date the Corona images. As a result, on Geoeye 3 tells are affected, 1 low mound and 2 flat sites.

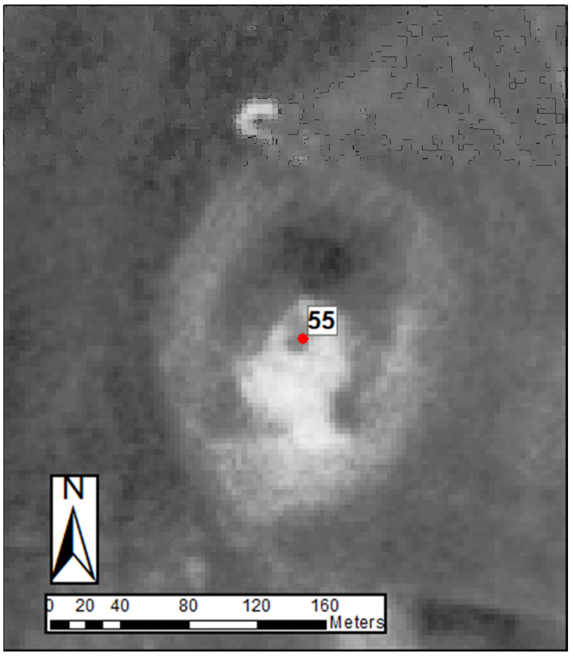


FIGURE 8-51: NATURAL EROSION AROUND TELL DOUKNOUK / TELL HOULWANJA (LCP 55)

Note the halo of pale soil around the tell which is of a similar colour to the tell itself. (However, as discussed in Appendix B, p479, it also has the same spectral signature as deposited wadi silt, and its presence does not guarantee significant erosion has occurred.

Natural Erosion and Damage Extent:

Erosion often confuses the extent of sites, blurring the edges of tells and masking sites which are on slopes, so the extents listed are estimates. At Mughar Seraisat (LCP 20) for example,

> *"The site appears small, but the slopes to the NE may either be wash and midden material from the site, but equally may represent the extension of the site on the slopes*" (field notes 2008).

At LCP 70 erosion combined with ploughing has confused the site to such an extent that it is no longer possible to tell if it is one site area or two.

Erosion most affects the Majority of sites (Table H-146 to Table H-153), as it is caused by natural processes. Whilst they do not affect all areas of a site equally (aeolian deflation, for example, is more prevalent on north facing slopes (Rosen 1986)), they still usually affect all of the site to some extent.

8.7.12 - LOOTING

Looting (in this research) is used primarily to describe holes dug in sites. However, in this area there are a large number of rock cut tombs, which have also been looted.

Although it is likely the majority were looted in antiquity, in at least one case (LCP 70) the looting of the tomb is recent. All the tombs are therefore included for completeness.

Prevalence of Looting:

Looting was recorded on 15 sites - almost 1 in 5. It was never recorded on Corona (the holes are too small to be detected on the low resolution images), but was recorded 12 times on SPOT records (as a proxy for the field visits), and 12 times on Geoeye. In three cases, looting was recorded on field visits (and on SPOT) but the site was not covered by Geoeye imagery (Table H-120).

In half the cases, it was a primary damage cause on Geoeye (Table H-112).

On SPOT, all the looted sites are on the limestone hills, and on Geoeye, all bar 2 are. A quarter of the sites there have been looted. The remaining two sites are on the river terrace: there is no evidence of looting on the upland plain (Table H-122 to Table H-129).

Looting and Site Type:

Looting is not restricted to any particular site type with one exception. Every single tomb recorded has been looted, and whilst most were probably looted in antiquity, at least one was looted (relatively) recently, as spoil can still be seen on the site.

Looting and Damage Extent:

Looting, particularly if it takes the form of dug holes, mostly affects a Fraction of the site. Where it affects a Section of a site, this represents the tombs, which cover a section of a site. However, extensive looting was also noted: large robber trenches have been dug through some sites.

Several potential new sites have been identified on satellite imagery by the concentration of looters holes (Figure 8-52), as have several possible site extensions. There are many concentrations of robber holes in the Carchemish area.

These damage categories mask the fact that looting has increased at many sites in the 6 years between DigitalGlobe and Geoeye. More holes were visible at Tell Khirbet Seraisat (Figure 8-53). At Tell Sha'ir Sajur (LCP38), the field visit noted that the pit had been dug deeper between the 2008 field visit and 2009 field visit, from at least 3m to at least 4-4.5m. A wine press, also at Tell Sha'ir Sajur, was noted in a field visit in

December 2009, which was destroyed by plunderers at some point before a field visit in July 2010 (the damage at this site was illustrated in Chapter 3.5.11, p94).

Looting in this area is an increasing problem, which is almost certainly under-recorded. Damage to features, such as the wine press, are not recorded as they too small to see on imagery. Small looting holes of the type seen at Tell Sha'ir Sajur (also discussed in Chapter 3.5.11, p96) are also rarely visible.

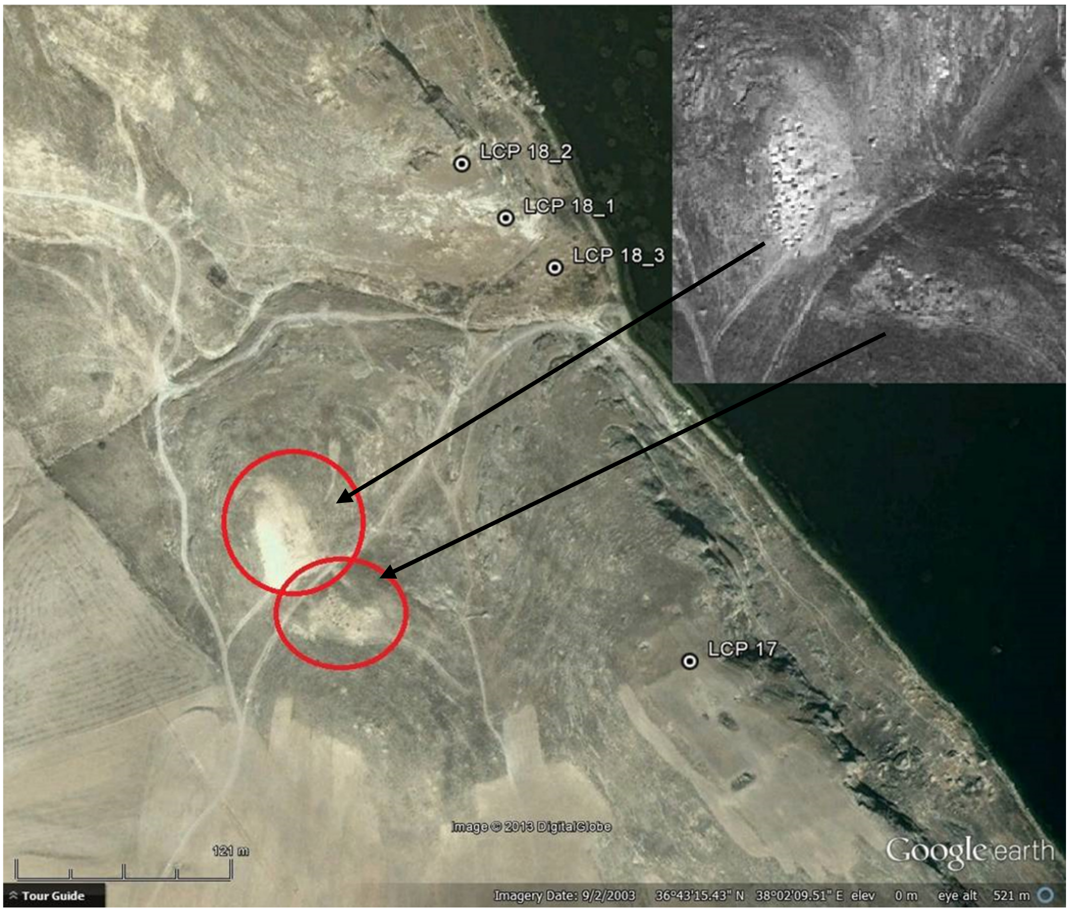


FIGURE 8-52: POTENTIAL NEW SITES IDENTIFIED THROUGH LOOTING[157]

[157] Main picture: DigitalGlobe Image, 2 September 2003. Taken from Google Earth 22 February 2003. Inset: Panchromatic Geoeye, po_3801419_pan_001, 10 November 2009.

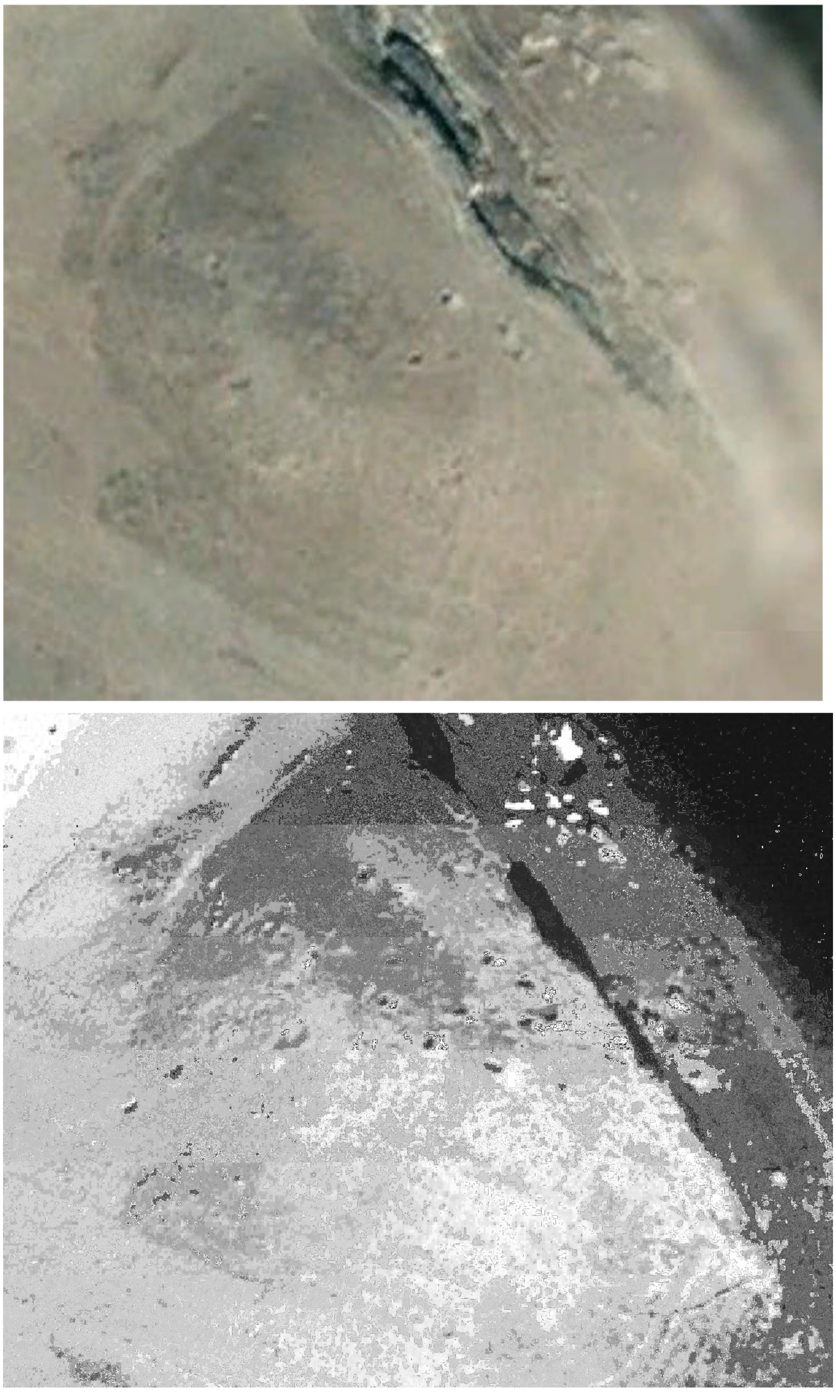


FIGURE 8-53 - INCREASING LOOTING AT TELL KHIRBET SERAISAT (LCP 1) BETWEEN 2003 AND 2009[158]

Top: Looting holes on the tell at LCP 1 on a DigitalGlobe satellite image from 2003. When compared to the Geoeye image from 2009 (bottom), there is a clear increase in the number of looting holes on the tell.

[158] Top: DigitalGlobe Image, 2 September 2003. Taken from Google Earth 17 February 2013
Bottom: Panchromatic Geoeye, po_3801419_pan_001, 10 November 2009

8.7.13 - Mudbrick pits

In order to determine if the purpose of a pit was for mudbrick extraction, site visit notes were used. No mudbrick extraction pits were recorded in the Carchemish area.

8.7.14 – Dumping Pits

The size of pits used to dump rubbish usually makes them clear on higher resolution imagery (although not on Corona). However, as many pits were dug for other purposes, such as soil extraction to make mudbricks, and then filled with rubbish later, dumping pits are categorised based on descriptions from the field visit notes.

3 were recorded on Geoeye. They are always round the bottom of tells near villages, and due to the comparative size of the tell, only affect a Fraction of the site. The extent of the site which is affected is variable. An example of a dumping pit can be seen on the north of LCP 50 (Figure 8-31 in this chapter, and shown more clearly in Figure 3-54, p98, Chapter 3.5.14). The field visit noted that the pit had probably removed part of the tell, as at least a mudbrick wall and floor were visible in the section.

8.7.15 - Cuts

Cuts are never clearly defined in the field visits, although they are recorded. This damage type is only assigned when it is used in the field visits and no more specific damage type is clear.

10 cuts were recorded in total, increasing from 3 on DigitalGlobe to 5 on SPOT to 8 on Geoeye (2 of the sites on SPOT were not covered by Geoeye imagery – LCP 2 and LCP 15).   They are usually a secondary damage threat, and - like the bulldozing which may be responsible for them - are usually located on the limestone hills or river terraces. There is a slight correlation between cuts and tells, but the numbers are too small for it to be a definite trend, and other site types are also affected. They affect Fractions or Sections of the site, sometimes trimming them. The actual affected extent would often require excavation to determine. However, due to their depth, cuts are extremely destructive and are usually recorded as Heavily Degrading a site.

Paradoxically, some sites were only discovered in existing cuts – for example LCP 9 (which may be an extension of LCP 22) was only evident in the cut running south from the tell (LCP 22). It is not visible on imagery.

8.7.16 - Grave Pits

As in other areas of the Middle East, cemeteries are often associated with archaeological sites.

<u>Prevalence of Graves:</u>

Cemeteries and grave pits are recorded on 11 sites (Table 8-11). Only 1 cemetery was visible on Corona, at LCP 63 (Figure 8-54). However, 10 were recorded on SPOT and 9 on Geoeye (2 sites which were covered by SPOT (as a proxy for the field visits) were not covered by Geoeye). Cemeteries were likely to be a primary or secondary damage cause. Almost all the cemeteries were located on the limestone hills, showing they are not necessarily linked to where modern settlements are concentrated. The large cemeteries located near Tell Amarna and Tell Jerablus Tahtani, for example, are not adjacent to any major settlements.

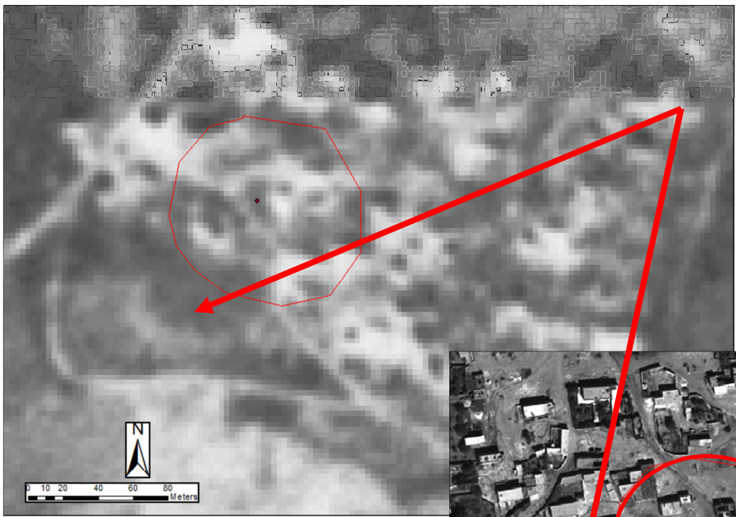


Figure 8-54: Visible Cemetery at LCP 63 (red circle) on Corona, Compared to Geoeye[159]

The cemetery is visible on Corona as a dark area with no (white) roads or buildings. The area was determined to be the cemetery after comparison with later imagery.

[159] Top: Corona image, ds1038-2120df066_66, standard deviation stretch, 22 January 1967. Bottom: Panchromatic Geoeye image, po_3801419_pan_000, 22 September 2009

Graves and Site Type:

Cemeteries are not associated with any particular site type, although in at least one case, the cemetery is covering the site to such an extent that the site type cannot actually be determined – it is not clear if it is a low tell or a flat site!

Graves and Damage Extent:

There are almost no single graves in this area, except on El Akhbar (LCP 47), which has a single modern grave on the summit. Most graves are part of cemeteries which cover site Sections, although one cemetery completely covers a site. At Khirbet Seraisat (LCP 1), a large cemetery covers a Section of the site: the number of graves can be counted, and they are definitely increasing, demonstrating that the cemetery is still in use.

8.7.17 - Pits (Other)

7 sites had pits of unknown purpose on them: these were all recorded on Geoeye. In one case the purpose was known – the conservation report for the outer town at Carchemish mentioned gravel extraction pits being present on the site in 2010, so they were recorded on the 2009 Geoeye as the closest proxy record ((Wilkinson and Wilkinson 2010)). However, the pits were not visible, so no new damage cause category was created for them. Pits are equally likely to be a primary, secondary or tertiary threat, and to be located anywhere on any site type. Where they are large enough to be visible, they usually affect a Fraction or a Section of a site. They are equally likely to damage the Upper Levels of a site (the default for a large pit on a site of unknown depth) or to Heavily Degrade it if further information was available. For example, at LCP 45, a hole indicated a depth of 1.3m of occupation deposit: in that area of the site, the hole completely Destroyed the occupation layers.

8.7.18 - Railways

Only one site was affected by a railway: the Baghdad railway runs along the Turkish Border through the outer town of Carchemish. Although proportionally it has not affected much of what is a very large site, it has almost certainly destroyed the parts of the site it covers and a small area around it during its building.

8.7.19 - Unknown

Unknown damage was recorded on 38 amalgamated sites on Corona, 4 on DigitalGlobe, 19 on SPOT and 3 on Geoeye. It was almost always located on sites on the limestone hills, as on Corona it was not often possible to distinguish between sites which were covered by scrub and sites which were under arable farming. On the higher resolution imagery, the locations of the sites were visible, but for reasons discussed on p112, no site was declared to have suffered "No Damage", so they were marked as Unknown.

This category also includes LCP 30, a sparse but consistent sherd scatter with some blocks from eroded walls. It was not visible on imagery, even though the higher resolution imagery is extremely clear in that area. The GPS point is situated on the border between two land use types, however given the uncertainties already discussed regarding the rectification of imagery, and the possible error margin, it could not be said whether the site was heavily ploughed or largely untouched.

8.8 - Damage Levels and Site Stability

As demonstrated in the preceding section, damage, and therefore sites, are not always stable. Over time, the damage caused by some threats increases, and others decrease. Unfortunately for the archaeological resource, the former is far more likely than the latter. Settlements may expand, for example, affecting a greater extent of a site, or fields may become more intensively ploughed (as described in Chapter 3.6, p113). Table H-154 to Table H-161 in Appendix H contain the supporting figures for increasing and decreasing damage.

This analysis is based largely on Geoeye as the most recent source of information on the sites, even though it does not cover all the sites. Sites and threats are not sufficiently visible on SPOT to accurately monitor changes which may have occurred since the Corona imagery acquisition. Therefore true totals could be slightly higher if information was available for all sites. Totals between imagery will also not match exactly due to differential imagery coverage.

On 267 identified threats, two fifths appeared to have stayed the same (for example, agriculture affecting the same extent, or cemeteries which had not expanded). 170 threats (a further quarter) appeared to be new when the image being studied was compared to an earlier image: these could not, therefore, be said to have 'increased'.

Only 4 damage threats decreased over the study period: in almost 30% of cases, the damage worsened. In 2 cases the increase could be dated to having occurred between the capture of the 1038 Corona image (January 1967) and the 1104 image (August 1968). In total 129 threats increased since the date of the acquisition of the Corona imagery. Of these, 61 appeared more extensive, and / or more intensive over the last decade, reflecting the recent increasing changes and intensification of the different uses of the landscape. 1 in 5 threats grew worse in the last 6 years. 1 threat even worsened between the 2008 DigitalGlobe acquisition and the 2009 Geoeye acquisition.

The cause of the threat is clearly linked to whether it is likely to increase (tables 154-161). Several settlements expanded, for example, but 12 new threats were recorded. Arable agriculture was one of the most common threats: approximately half intensified or covered a greater area, and 15 new threats were recorded.

Road building was particularly likely to increase: 11 new roads were recorded on DigitalGlobe, another 3 on SPOT, and a further 4 on Geoeye. Many roads were also developed - the application of gravel to what were once simple tractor tracks, and the widening of and application of tarmac to what were once gravel tracks can be clearly seen, in 6 cases between 2003 and 2009. Only 2 tracks fell out of use.

Looting in particular has increased in the last decade. 3 new examples were recorded on SPOT that were not present on DigitalGlobe (these may have been recorded on the field visits, or were on sites which were not covered by DigitalGlobe), and on Geoeye, another 3 new threats were recorded. Looting increased between the field visits on another site, and on 5 sites there was a clear increase in the looting between 2003 and 2009. In almost all cases, looting became more prevalent, posing a clear threat to sites.

No new military damage or railways were recorded, and water erosion was never recorded as increasing.

Most damage increased, either as new threats were recorded, or existing threats became worse. This demonstrates the clear risk posed. If these changes indicate a rapidly increasing trend towards greater damage to sites, then the results presented here could be only the start of devastating damage to sites in this area, and elsewhere.

8.9 - Case Studies

The following section presents three case studies: one of area, one of site type, and one site, to illustrate the damage experienced.

8.9.1 - Case Studies: Sites on the Limestone Hills

The limestone area was defined in Chapter 7.1, and shown on Figure 7-1 (p300) and Figure 7-2 (p301). It is the largest land type in the survey area: 45 of the 78 sites studied were located here, covering all site types. Of the three geographic regions, it is also the area which has undergone some of the greatest change over the last forty years, which deserves attention.

Despite being the area with the largest number of sites, a Wilcoxon Signed Rank test (Table 8-12) showed the sites were significantly less visible in any time period: the limestone hills had the smallest number of Visible sites and half were classed as Not Visible. Regardless of the increase in resolution, visibility also worsened significantly over time, unlike sites in other areas which improved or stayed the same.

TABLE 8-12: WILCOXON SIGNED RANK TEST RESULTS FOR CHANGES IN VISIBILITY

Wilcoxon signed rank test	Area	N	Z value	p value
Corona to Geoeye 2009	Plains	61	-1.828	0.068
Corona to Geoeye 2009	River Terraces	85	-1.063	0.288
Corona to Geoeye 2009	Limestone Hills	75	-3.741	<0.000

Land use in this area has increased significantly, both on and around sites, although there are fewer land uses on sites in this area than on the upland plains or the river terraces, reflecting the marginal nature of the land. Land use on sites increased markedly in the period between 1967 and 2003, but has increased only a little since. Intensity of land use around sites, on the other hand, is comparable to the other geographic regions (Section 8.5.3), and has continued to increase over time. This provides a study area where the sites have initially remained relatively untouched over time compared to other parts of the Carchemish region, but where the multiple land uses around the sites still pose a threat.

There is more evidence of bulldozing here when compared to areas like the upland plains. This may reflect the hilly terrain and regular limestone outcroppings, which presumably interfere with the utilisation of the land. Certain threats are largely specific to this area, such as looting, which is far more common on sites in the hills. Threats like development and roads have not increased noticeably more in this area than any other, so the looting is presumably not a function of increasing access to the area, or an increase in population. It could be linked to the increase in agriculture, which has increased more in this area than any other, as can be seen from the following graph (Figure 8-55). Agriculture is, in fact, the only other threat in this area to have increased so much.

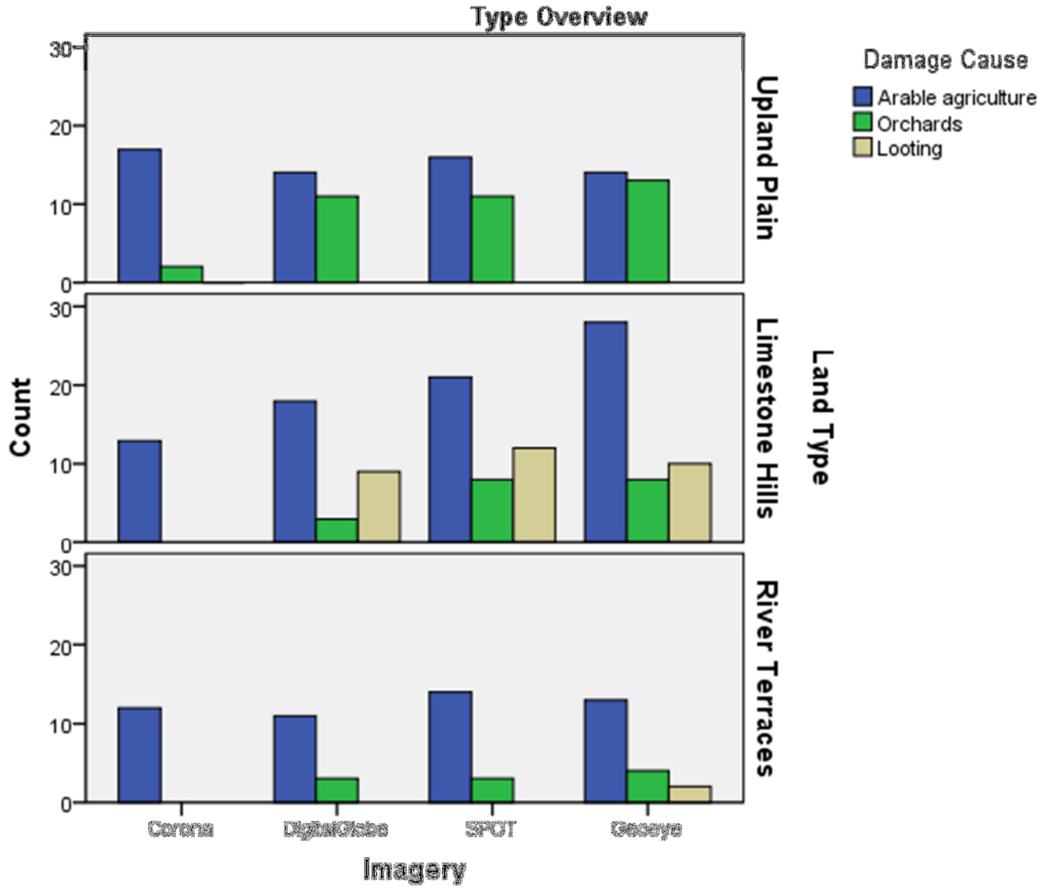


FIGURE 8-55: COMPARATIVE GRAPHS OF INCREASING AGRICULTURE AND LOOTING BY REGION

The limestone terrain represents the increasing utilisation of marginal land, reflecting the intensification of arable agriculture. Settlements continue to expand, but the rate of growth is not as great as in other areas. To focus on development as an indicator of human activity would be to miss the great changes occurring in the landscape. The increasing presence of the bulldozer and the expansion of agriculture suggest that cultivation not only damages sites by its presence, but that it has an ensuing effect of opening up sites to further threats.

8.9.2 - CASE STUDIES: OUTER TOWNS

This section examines the outer towns recorded during the survey, in order to compare them to the outer towns in the Tell Beydar region. As only 5 were recorded, it is not possible to undertake a quantitative analysis: the following are generalisations which may indicate possible trends. These conclusions form part of the comparison of the two case study areas in Chapter 9.

The five identified outer towns are around Khirbet Seraisat (LCP 1), Tashatan (LCP 5), 'Ain al-Beida (LCP 10), Tell Amarna (LCP 21), and Carchemish (LCP 46). It should be noted that the outer town by Tashatan was not visited, it was observed from the tell. Carchemish, on the other hand, had an entire field season devoted to recording damage on the lower town, which may further bias the results. An outer settlement of Late Uruk / Early third millennium BC date was also reported around Tell Jerablus Tahtani (Wilkinson 2007b). However, although it covers some 12ha, there are no boundaries and the notes state it "comprised a scatter of activity in the form of pits and pottery scatters sealed below some 50-75cm of flood-plain sediments and soil … It indicates that was human activity, temporary occupation and the disposal of refuse" (Wilkinson 2007b: 74). No further details are available. As a result, it was not included in this analysis.

All the outer towns were flat sites, rather than low mounded areas, and so the 5 outer towns will be compared to the other 33 flat sites. 3 outer towns were located on the limestone hills and 2 on the river terraces. None of the tells on the upland plains appeared to have a lower or outer town.

By 2009, all 5 lower towns were affected by arable agriculture, compared to only 19 of the 33 flat sites, and 3 of the 5 had orchards on them as well, compared to 12 of 33 flat sites. Most also had roads on them (Table H-162 to Table H-166).

Outer towns experience significantly more threats than other flat sites (Table H-162, Appendix H). There was an average of 3.4 threats per outer town in the 1960s, which is substantially higher than the damage to other flat sites (an average of 1.4 threats per site). This increased to 5.2 threats per outer town in 2009, compared to only 2.1 threats per flat site.

Damage extents are also greater on outer towns compared to other flat sites. Due to the small numbers involved, and disparate sample sizes, this has been considered in two ways. The first set of graphs (Figure 8-56, A-D) display horizontal extents and vertical extents as proportions of the total possible for each site type. For example, there are 12 unknown horizontal extents recorded to 33 flat sites (a proportion of 0.36) and 2 recorded to the 5 outer towns (a proportion of 0.4). Displaying the information proportionally allows easier comparison. As can clearly be seen, damage appears more severe to outer towns.

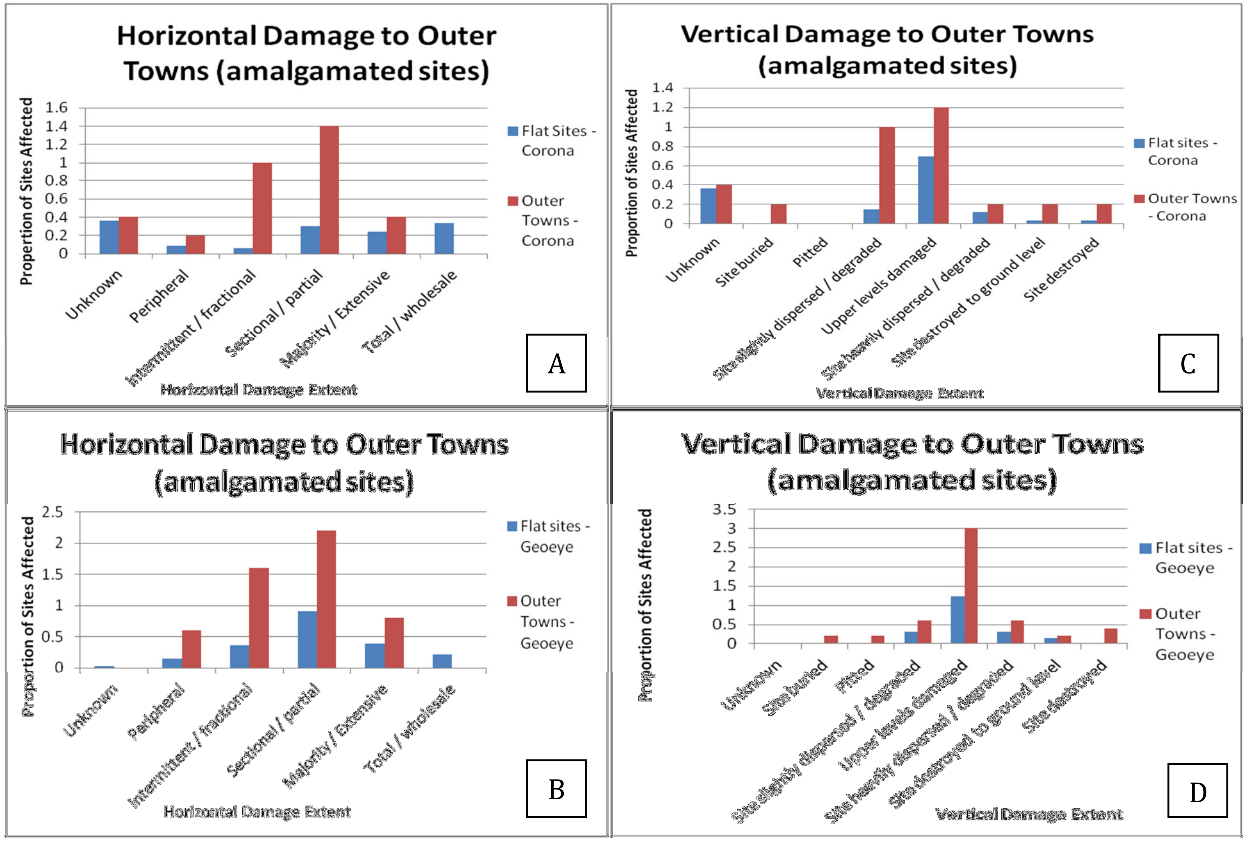


FIGURE 8-56: GRAPHS OF PROPORTIONS OF DAMAGE EXTENTS ON OUTER TOWNS AND FLAT SITES

Graphs A and B compare the proportions of the different horizontal damage extents on the different images, and Graphs C and D compare the different vertical extents. (Corona, on the top, is compared to Geoeye, on the bottom). On Corona and Geoeye, the proportions of damage experienced are higher on the outer towns compared to the flat sites. This is the case for both vertical and horizontal imagery.

An alternative way to consider the data is displayed the graphs in Figure 8-57, E - H. These graphs show the counts of each type of horizontal extent and each type of vertical extent recorded on each site, but displayed on comparative scales. This can be used to assess how likely a given extent is on a site type by comparing the different distributions. Each scale reflects the maximum number of times any given extent was counted on the site type, for example there are 11 counts of Total horizontal extents on flat sites on Corona, and 7 Sectional counts for outer towns. These are amongst the highest the respective scales go. From this, it can be demonstrated that Unknown damage was far more likely on flat sites (it is the highest count), for example, but Sectional damage was more likely to occur on outer towns. On Geoeye, the proportions of most horizontal types of damage are similar, except for fractional damage, which, again, was more common on outer towns. The pattern for vertical extents is similar.

However, these results may be a reflection of the larger sizes of outer towns compared to the other flat sites, or an illusion created by unequal sample sizes. A Mann-Whitney-U test (Table 8-13) of average damage ranks on flat sites and outer towns suggests that there is no statistically significant difference between damage recorded on any specific imagery.

TABLE 8-13: MANN-WHITNEY-U TEST RESULTS FOR DIFFERENCES IN EXTENT OF HORIZONTAL AND VERTICAL DAMAGE ON OUTER TOWNS AND FLAT SITES (AMALGAMATED SITES)

Imagery	Count	U	p	Mean Rank: Outer Towns	Mean Rank: Flat Sites
Corona	Horizontal Damage	321.50	0.272	27.91	33.51
DigitalGlobe 2003	Horizontal Damage	581.00	0.295	36.24	41.74
SPOT 2004	Horizontal Damage	827.00	0.407	46.08	51.32
Geoeye 2009	Horizontal Damage	687.50	0.080	39.94	50.39
Corona	Vertical Damage	382.50	0.889	32.50	31.82
DigitalGlobe 2003	Vertical Damage	606.00	0.398	42.76	38.72
SPOT 2004	Vertical Damage	889.00	0.746	51.44	49.51
Geoeye 2009	Vertical Damage	863.00	0.841	46.69	47.81

However, if damage recorded on all imagery is pooled, then there is a significant difference in the horizontal damage (Table 8-14): the average damage rank is greater on flat sites than on lower towns[160] (i.e. flat sites are more likely to experience more extensive horizontal threats than outer towns). This is probably not intrinsically significant. It is a reflection of the fact that outer towns are much larger than other flat

[160] This may be a reflection of the large number of 'Unknowns' on the Corona imagery. The test works out mean rank for ordinal data, where Unknown is 0 and the worse damage has the highest number. As seen on the second set of graphs above, there are lots of unknowns on the flat sites on the Corona imagery, pulling down the denominator

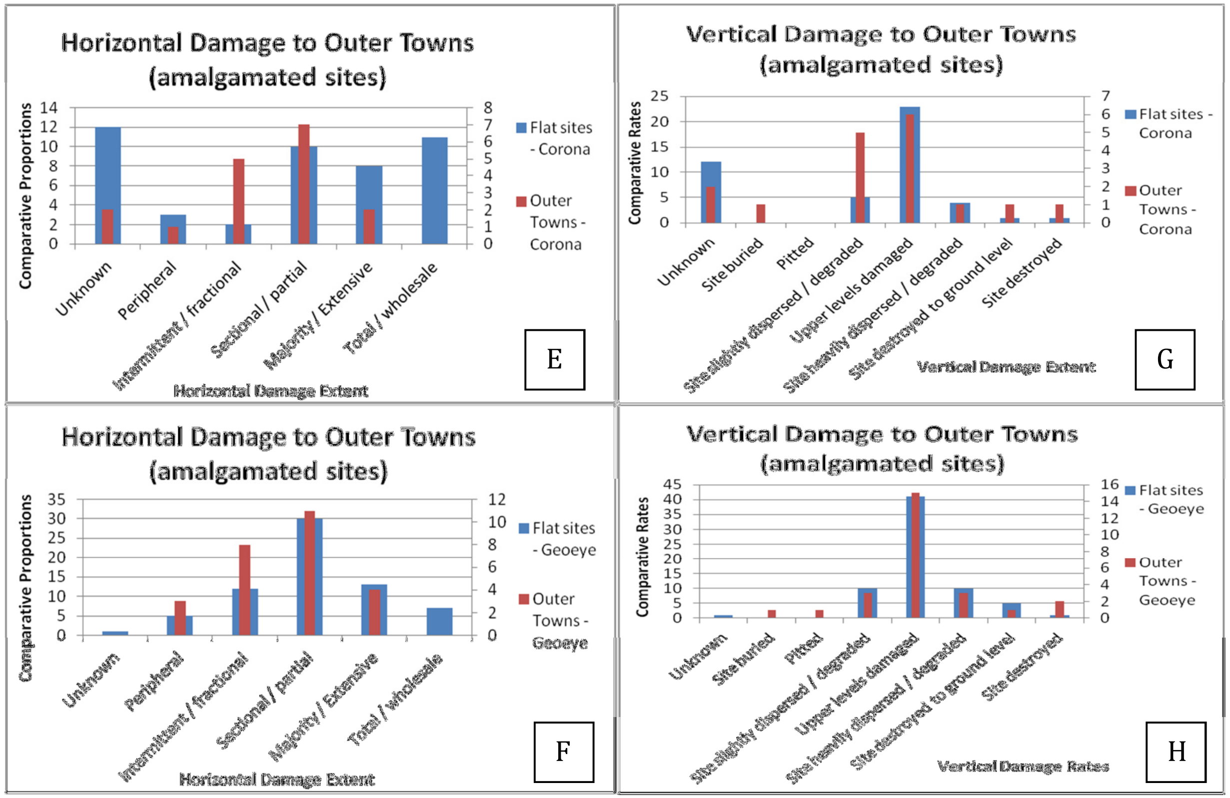


FIGURE 8-57: GRAPHS COMPARING DAMAGE EXTENTS ON OUTER TOWNS AND FLAT SITES

These graphs show the different damage extents on the comparative scales. Flat sites (shown in blue) are on the left scale, and outer towns are on the right hand scale (shown in red). Graphs E and F compare the different horizontal damage extents on the different images, and Graphs G and H compare the different vertical extents. (Corona, on the top, is compared to Geoeye, on the bottom). On Corona and Geoeye, the proportions of damage experienced are higher on the outer towns compared to the flat sites. This is the case for both vertical and horizontal imagery.

sites, and so they are more likely to be affected by multiple threats, thus reducing the extent of each individual threat.

TABLE 8-14: MANN-WHITNEY-U TEST RESULTS FOR DIFFERENCES IN EXTENT OF ALL DAMAGE ON OUTER TOWNS AND FLAT SITES (AMALGAMATED SITES)

Count of Pooled Damage	U	p	Mean Rank: Outer Towns	Mean Rank: Flat Sites
Horizontal Damage	9456.00	0.018	143.68	175.43
Vertical Damage	10907.00	0.627	171.72	166.57

There is also no statistically significant difference in the amount of damage experienced over time on lower towns (Table 8-15), but there is a significant increase in the extent of vertical threats sustained by flat sites. This suggests that whilst, in general, damage to flat sites is increasing in depth (as discussed on p347), it is not significant whether or not the site is a lower town, although the very small sample size should be borne in mind.

TABLE 8-15: MANN-WHITNEY-U TEST RESULTS FOR DIFFERENCES IN EXTENT OF DAMAGE ON OUTER TOWNS AND FLAT SITES OVER TIME (AMALGAMATED SITES)

Location	Count	U	p	Mean Rank: Corona	Mean Rank: Geoeye 2009
Outer Town	Horizontal Damage	200.00	0.5.82	20.76	22.81
Outer Town	Vertical Damage	163.00	0.124	18.59	24.23
Flat Sites	Horizontal Damage	1516.00	0.775	56.46	58.21
Flat Sites	Vertical Damage	11200	0.005	47.86	64.02

This size differential in the flat sites and the small numbers makes them hard to compare. However, even if the apparent greater damage extents are a factor of size, the fact that the number of threats to outer towns is so high is important, and represents a substantial risk to these sites. Traditionally, tells have been a major focus of excavation in the near east, but these figures illustrate an increasing trend of damage to outer towns, which are experiencing a catastrophic rate of attrition.

8.9.3 - CASE STUDIES: KHIRBET SERAISAT (LCP 1)

Khirbet Seraisat is a complex site on limestone bluffs between the junctions of the Nahr Amarna and the Nahr Sajur with the Euphrates. This was the first site recorded by (Wilkinson et al. 2007) in the Land of Carchemish survey. Site boundaries can be seen on Figure 8-58 and Figure 8-59. It consists of a tell (LCP 1_3), two flat sections under the cemetery to either side of the road (LCP 1_1 and LCP 1_2), and the flat section between them and the tell (LCP 1_4). As well as the tell and the outer town, ancient quarries and rock-cut tombs were recorded away from the tell, as well as an industrial section consisting of a complex of water management features, lime and pottery kilns, an aqueduct, a rock-cut road, and part of a possible water mill, below the main site along the wadi banks. It was not given a section number at the time but is recorded in the database as LCP 1_5. Sections 1, 2 and 4 form one of the outer towns discussed in the previous section, identified by a large area of pottery scatter.

The outer town areas are Byzantine / Early Islamic. The tell has a longer history of occupation: mid/late Early Bronze Age (EBA), Late EBA, Middle Bronze Age (MBA) and possibly Iron Age as some pottery was also found. The wadi area was predominantly Hellenistic / Roman / Late Antique (field notes 2006/8; Wilkinson et al. 2007).

Although it is covered by all 4 sets of imagery, very little of the site is visible. The tell is barely visible on Corona and SPOT, and only the tell and some of the features are visible on the later imagery, such as the quarries and the aqueduct. It is on the edge of the DigitalGlobe coverage, so only parts of the tell and industrial area are visible. Figure 8-58 shows the site in 1967, superimposed over the 2003 imagery in order to demonstrate the site and surroundings, which are not clear on the Corona image. A large number of waypoints were taken, but they do not align with the Corona due to the distortions in the imagery, and so are not shown. The boundaries are also shown on the 2003 imagery (Figure 8-59). Figure 8-61 shows the site in 2009: the boundaries have not been included in order to demonstrate the 'invisibility' of the site without information provided by the field visits, and to enable easier threat identification in some areas.

During the initial visit in Spring 2006, the only recorded threat to the tell was looting holes, which revealed up to 2m of cultural deposits. However, a cemetery, a road, and cereal cultivation were all noted on the outer town, and the wadi was responsible for burying some parts of the site under 2-3m of gravel, as well as causing "the obliteration of parts of the industrial area" (Wilkinson et al. 2007). During a second field visit in 2010, a recent quarry was noticed near the ancient quarry (Section 8.7.6, Figure 8-45, p376).

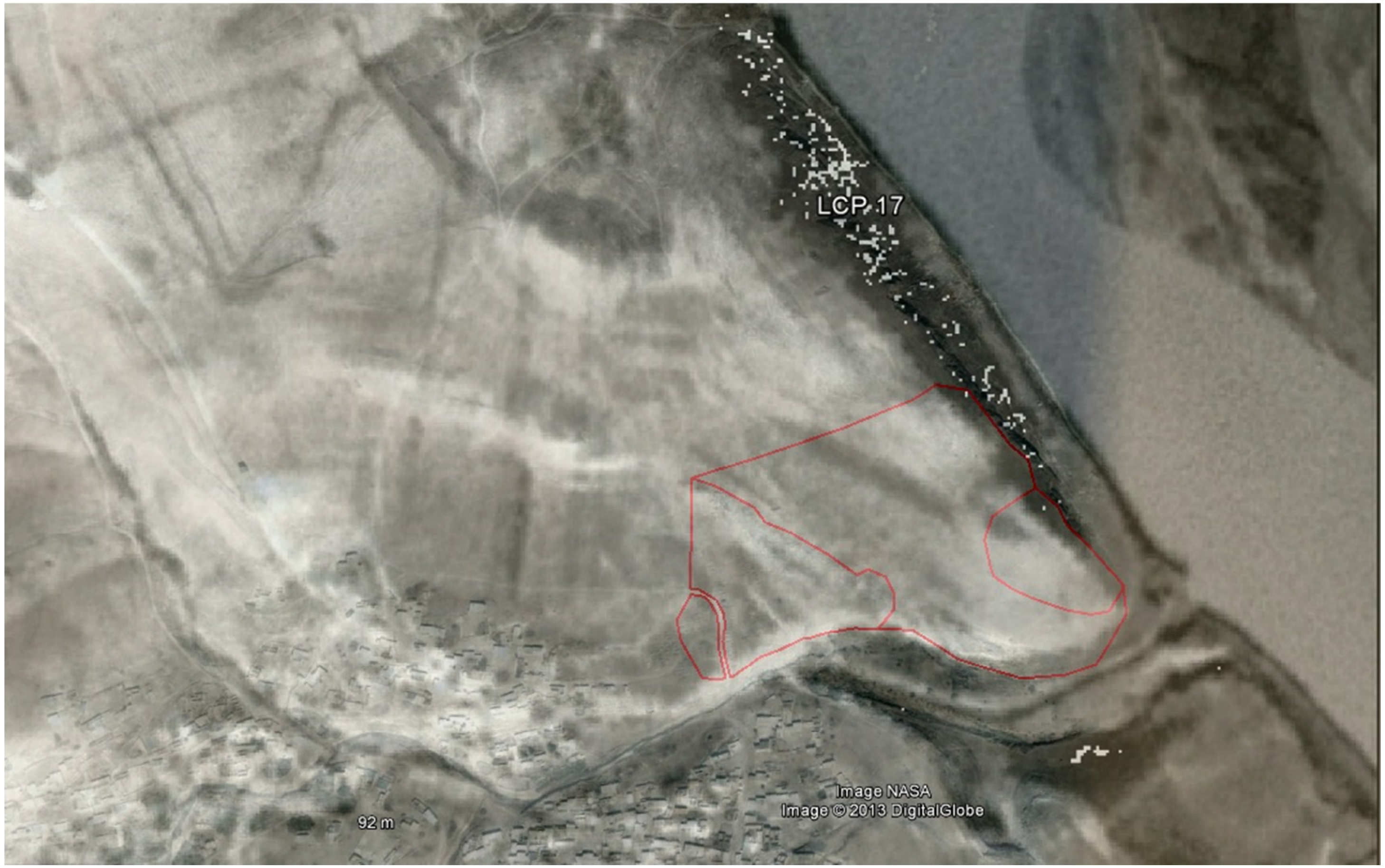


FIGURE 8-58: KHIRBET SERAISAT IN 1967[161] (BOUNDARIES TAKEN FROM THE SKETCH MAP)

[161] Corona 1038 Image, 22 January 1967, superimposed over DigitalGlobe 2003 Image, 2 September 2003. Taken from Google Earth 20 February 2013.

FIGURE 8-59: KHIRBET SERAISAT IN 2003 (BOUNDARIES TAKEN FROM THE SKETCH MAP)[162]

[162] DigitalGlobe Image, 9 September 2003. Taken from Google Earth 15 January 2013

FIGURE 8-60: KHIRBET SERAISAT IN 2004[163]

[163] SPOT Image, 31 December 2004 (?). Taken from Google Earth 15 January 2013

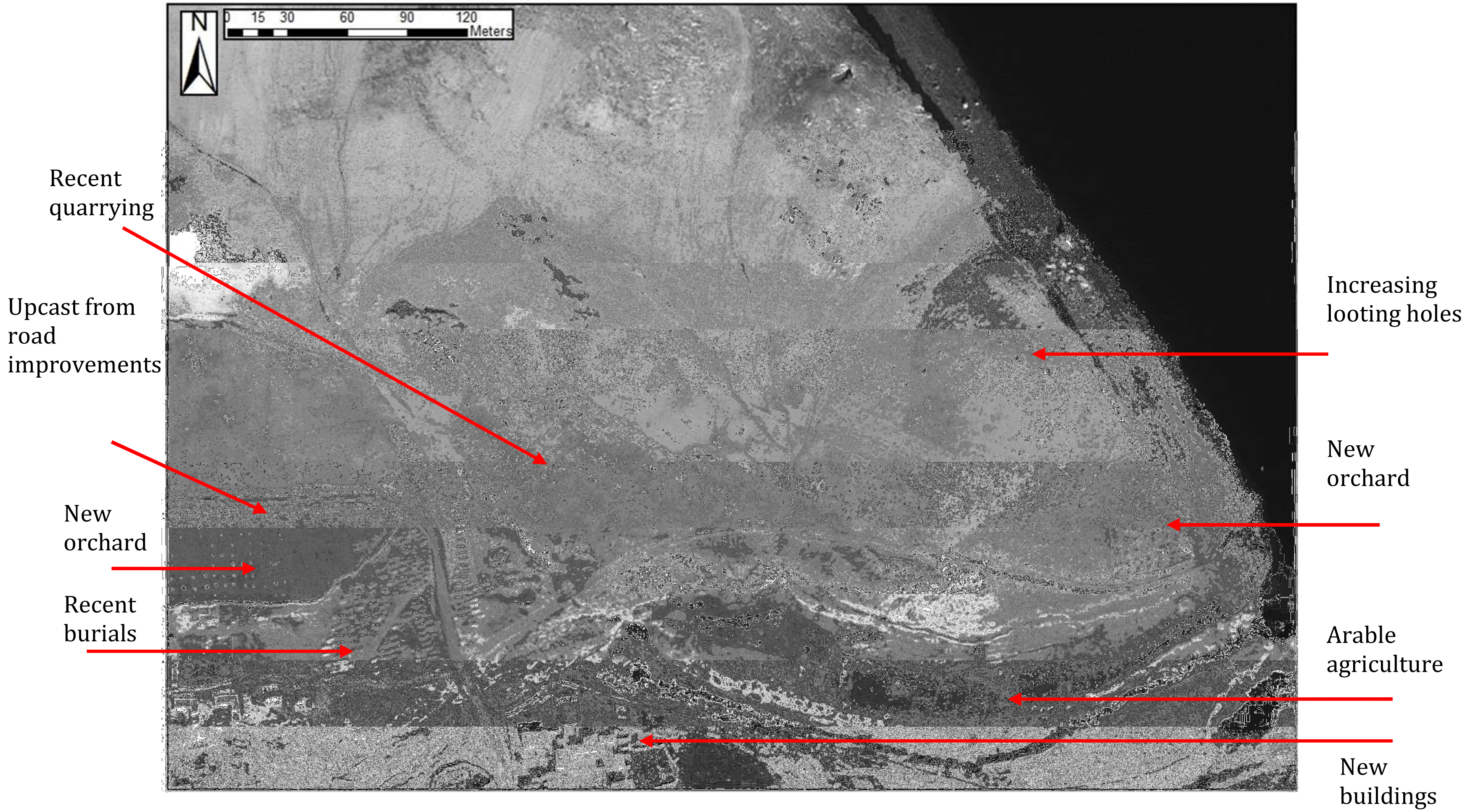


Figure 8-61: Details of Threats on Khirbet Seraisat in 2009[164]

[164] Panchromatic Geoeye image, po_3801419_pan_001, 10 November 2009

Comparing the imagery several other threats become visible (marked on Figure 8-61). There is a substantial increase in looting holes (Figure 8-53, p388). The cemetery is still in use, and the number of graves has increased (Chapter 3.5.16, Figure 3-59, p101). The road through the cemetery and outer town has also been widened and tarmacked at some point between 2003 and 2009. Upcast from this is visible on the Geoeye imagery, particularly along the edge of the new orchard which now abuts the cemetery: this was not present in 2003 or mentioned in the field visits. Another new orchard now also covers part of the tell, and can be seen in the southeast corner of the Geoeye imagery. The village of Khirbet Seraisat has also expanded. Although the cemetery and orchard prevent it encroaching onto the tell from the east, the southern houses had reached the wadi bridge by 2009. If the village continues to expand, the outer town, and ultimately the tell could be threatened like other sites in this region.

This site is at great risk from multiple threats, although relatively speaking none of them has caused significant damage to the site. However, the more the site is incorporated into the intensifying land use strategies of the local people, the greater the risk to it. It is in a marginal area, but almost all parts of the land are utilised for farming, orchards, transport, burial, and the age old use of archaeological sites – artefact acquisition.

8.10 - Key Findings

- In total, 78 sites were surveyed broken down into 100 individual units (e.g., separate areas, tombs, etc.) and 85 amalgamated sites (individual units amalgamated into types of site present on each site, for example, tells or complexes of low mounds). In this area there was very little difference between the unit analysis and the amalgamated site analysis, so results were only given in the text for the amalgamated sites, although unit analyses were included in the Appendix for comparison.

- Sites were examined on Corona imagery from the 1960s, DigitalGlobe imagery from 2003, SPOT imagery from 2004, and Geoeye imagery from 2009. DigitalGlobe only covered 61 amalgamated sites, and Geoeye only covered 75. At least two thirds of sites on each image type were identified with Definite or High certainty.

- Estimates of damage are conservative and follow the principle of least damage in which the least possible confirmed damage a threat can cause is recorded:

this ensures that the assessment will not overstate the damage. Less than 50% of the analysis was given a High certainty of correct damage identification.

- Sites were not always visible on imagery, particularly in the limestone terrain. About a quarter of sites become more visible on later higher resolution imagery, but a quarter become less visible.

- The total number of land uses on and around sites has increased significantly on two thirds of sites. The river terraces had the most intensive land use in the 1960s, and show the greatest increase in land use over time. The upland plains have the least change. Land use on the limestone hills is increasing, but sites there have the fewest land uses on and around sites. However, land use in all areas is clearly intensifying.

- Damage to sites is definitely increasing. 146 damage threats were recorded on Corona and 224 on Geoeye, despite the fact that 10 sites are not covered by Geoeye.

- Between 1967 and 2009, counts of development damage more than doubled. Almost half the sites on the plains and on the river terraces had development on them. Development increases in this area are likely to take the form of small buildings rather than settlement increase, so it is rarely a primary cause. The largest increase is on flat sites, where counts of development effectively tripled. Two fifths of development affected Sections of sites in the 1960s: this number more than doubled by 2009. Development is almost always recorded as damaging the Upper Levels of sites as without excavation it is difficult to determine the depth of building foundations or how deep the site was.

- All three forms of agricultural damage – arable agriculture, animal grazing and orchards - are visible on imagery in the Carchemish area. In total, arable agriculture was recorded on three quarters of sites over the study period. It is the most common damage, and is a third again as prevalent as the next most common threat. Today it accounts for a quarter of threats to sites. Even though many fields were converted to orchards, agriculture still increased between the 1960s and 2009, and crops were often still farmed around the trees. Where arable agriculture is recorded on Corona, in a third of cases it affected the Majority of the site and in almost a third of cases it affected the site Wholesale. In 90.5% of cases arable agriculture affects the Upper Levels of amalgamated

sites on Corona, decreasing only slightly to 85.5% on Geoeye.
There was a significant decrease in Peripheral agriculture, as improved machinery allows areas that may once have been difficult to farm to be brought into cultivation.

Grazing occurs on sites, and causes damage to the artefact assemblage, but the extent is unknown. However, as grazing land can be valuable, it may also serve to protect the land from worse damage threats.

Orchards are increasing. Only 2 were recorded on Corona, but 25 were recorded on Geoeye. They were the second most common primary and secondary damage on Geoeye, and are predominantly found on flat sites. Orchards are one of the fastest increasing threats to sites in this area. Initially most orchards were located on the upland plains: in 2003 11 orchards were on the plains, 3 were on the limestone hills and 3 were on the river terraces. By 2009, there were 13 orchards on the plains, (accounting for almost 1 in 5 threats to sites), but the number on the limestone terrain more than doubled in 6 years. Most orchards covered only a Section of the site, although a large number covered the Majority. Only one orchard covered the entirety of a site in 2003, and 2 in 2009. Orchards were most likely to damage the Upper Levels of sites, although few studies have been done into orchard damage, and like all threats it is dependent on the depth of the site. Paradoxically, on some sites the presence of the orchard acts to protect the site from more destructive threats like development.

- Irrigation channels are rare in this area: 5 were recorded on DigitalGlobe, and only 3 on Geoeye, and these were relatively small. Most irrigation water is machine pumped from rivers and wells.

- Roads take three main forms: tractor tracks, gravel tracks, and tarmac roads, which cause increasing levels of damage. 55% of amalgamated sites had a road or track on them. The number of roads and tracks increased over time, from 29 on Corona to 42 on Geoeye. Roads were the second most common damage type. By 2009, roads were equally likely to be located on any of the three land types. This is particularly interesting given the relative sizes of each land type – proportionally one would expect far more roads on the limestone hills given it is the largest area, although it has the least development (on sites). Counts of roads presumably reflect the relative concentrations of the population. There is no correlation between roads and site type. Roads and tracks in all periods were not placed to avoid sites: they were equally likely to affect the Periphery, a Fraction or a Section. Most roads on Corona were assumed to only Slightly Degrade the site (26 of 29 threats), as it was not usually possible to tell if the site was a tarmacked road or a gravel track. However, many roads were visibly improved over the study period, damaging the site. In 2009, 13 roads were tarmacked, damaging the Upper Levels of the site. 3 Heavily Degraded the site, and in 2 cases roads Destroyed the site to Ground Level.

- 3 quarries were recorded: 2 were small and local, but one was a major industrial quarry.

- Military damage was only recorded on the tell of Carchemish, which was mined. (The mines have recently been removed).

- Bulldozing is particularly difficult to identify in this area, and was usually determined from field notes. It was recorded 12 times. In most cases bulldozing was marked as a primary threat due to the severity of the damage it causes. On Geoeye, bulldozing was recorded only once on the upland plains, perhaps due to the relatively flat nature of the land, whereas it was recorded 5 times on the limestone hills, and 5 times on the river terraces (despite the fact that they cover a much smaller area). Only one site was Totally bulldozed: in most cases, Sections were affected, Bulldozing rarely destroys a site entirely: it either Heavily Degrades or Destroys a Site to Ground Level. Examination of wells and looters' holes have demonstrated that in many cases there is a significant depth of sub-surface deposit which would theoretically be preserved.

- In total, water erosion was recorded 12 times on Corona, and only 7 times on Geoeye. It is the only damage types to decrease, reflecting the decline in perennial wadis. It is equally likely to be a primary or secondary effect on Corona, and when it is recorded on Geoeye, it is almost always a primary effect. Half the Water Erosion threats to amalgamated sites on Corona and Geoeye are recorded on flat sites. All water erosion affects a Section of the site and in most cases is assumed to Heavily Degraded sites, or using the field visit notes as a guide, it in 3 cases completely Destroyed them.

- Visitor erosion damaged only one small flat site: this was not visible on imagery but was recorded on the field visit.

- Looting is an increasing problem in this area: it was recorded on 15 sites, which is almost 1 in 5. It was never recorded on Corona, perhaps due to the low resolution, but was recorded 12 times on SPOT (as a proxy for the field visits) and 12 times on Geoeye. (In three cases it was recorded on field visits (and therefore SPOT) but the site was not covered by Geoeye imagery). In half the cases, it was a primary damage cause on Geoeye. Looting clearly increased on several sites, identified during consecutive field visits, or when comparing DigitalGlobe and Geoeye imagery, so the increase is not an illusion caused by the low resolution of Corona compared to the high resolution of Geoeye. Almost all looting occurs on the limestone hills. On three quarters of sites, only a Fraction was affected, however on some sites large robber trenches have been dug. Paradoxically, concentrations of looting holes have also allowed several potential new sites to be identified.

- No mudbrick extraction pits and only 3 dumping pits of varying size were recorded.

- 10 sites had cuts into them which affected Fractions or Sections of the site. The actual affected extent would require excavation to determine. Paradoxically, some buried sites were only discovered due to cuts in the landscape.

- Cemeteries and grave pits are recorded on 11 sites. Only 1 cemetery was visible on Corona, 6 on DigitalGlobe, 10 on SPOT and 9 on Geoeye: 2 sites which were covered by SPOT were not covered by Geoeye. Cemeteries were likely to be a primary or secondary damage cause. Almost all the cemeteries were located on the limestone hills, showing they are not necessarily linked to where developments are located. There are almost no single graves in this area: most cemeteries cover Sections of sites, although 1 covered a site entirely. In general, they protect the sites from further interference, but several are still in use, causing on-going site damage, and preventing study.

- 7 sites had pits of unknown purpose or gravel extraction pits (Pits Other) on them: these were all recorded on Geoeye.

- One site – the lower town of Carchemish – had a railway destroying part of the site.

- Damage visibly increased between 1967 and 2009 in almost 30% of cases, and even between DigitalGlobe and Geoeye (2003 and 2009). 129 threats increased since the date of the Corona imagery: of these 29 worsening threats could be dated to between 1967 and 2003 DigitalGlobe, 60 to SPOT, and 40 to Geoeye. 89 threats recorded on Geoeye (the most recent source of information) had not increased, but 1 in 5 threats grew worse between the 6 year period 2003-2009. Only 4 damage threats decreased in the study period.

- Sites on the limestone hills were particularly hard to identify, even on higher resolution imagery. However, threats like agriculture and bulldozing have increased here more than on the upland plains, although development has not. In particular, almost all looting occurs here – a quarter of sites in the limestone terrain have been looted, and it is continuing to increase.

- Outer towns experience significantly more damage threats than other flat sites. An average of 3.4 threats per outer town was recorded in the 1960s, increasing to 5.2 threats per outer town in 2009. This is substantially higher than the damage to other flat sites, which had an average of 1.4 threats per site in the 1960s, rising to 2.1 in 2009.

8.11 – Concluding Remarks

Archaeological fieldwork in the area around Carchemish was neglected for many years in favour of the tell itself, until the implementation of dam projects on the Euphrates, when the ensuing salvage work turned international focus onto the area. That in turn led to investigation of the areas away from Carchemish and the Euphrates, resulting in the discovery of a well-populated hinterland. However, the area has undergone extensive change and modernisation, and the land is now utilised more intensively than ever before, resulting in damage to many of the sites.

Sites are clearly being degraded: a quarter of sites are less visible in 2009 than they were in 1967, despite the fact that sites in some areas were not even visible in 1967, and imagery resolution has increased significantly. No site has been completely destroyed for certain, although some sites are almost gone. Only 2 sites appeared undamaged by cultural (i.e. human) processes, and were (hopefully) undamaged by anything except natural taphonomic processes.

Even most of the more marginal land is now cultivated, and the number of threats to sites has increased significantly. Agriculture is the most common threat to sites, affecting almost all of them. Although it is a slow threat, it is a serious on-going problem. Orchards have become common, covering huge swathes of land. development has increased, and although it is not reflected in the figures, all of the towns and villages in the area have increased in size, as have the road networks to accommodate them. This will inevitably have led to an increase in infrastructure, as new building methods lead to deeper foundations, and pipes and electricity cables are laid into the ground.

The expansion of agriculture has led to an increase in secondary damage threats – bulldozing of sites to enable agricultural expansion has increased, as have roads and tractor tracks on sites. This latter may not sound threatening, and in most cases it has only slightly disturbed the site, damaging the surface pottery, but in at least one case, the bottom of a dried out wadi was bulldozed to create a tractor track, highlighting the potential risk. Many water management features have been recorded along the wadis in this area, including qanats, channels and an aqueduct. The bulldozing of wadis to create tracks, and the creation of tracks elsewhere, can have a huge impact on sites that have been recorded, and on those that have yet to be discovered. The increase in looting may also be linked to the increase in agriculture, and it is becoming a serious problem. As well as affecting many sites in the limestone hills, several concentrations of looting holes were identified outside known site boundaries, hinting at sites as yet undiscovered by survey teams.

It is clear that satellite imagery is of value in monitoring the damage which has occurred in this area. Comparative analysis of different images has revealed extensive landscape change, even in marginal areas. This is not the first time in its history that the area has experienced such intensive occupation and farming. These earlier instances, too, will have damaged the sites that went before them, just as they in their turn left the settlements that became the sites we study today. However, the destructive impact of modern urban and agricultural cultivation compared to that caused by the tools of earlier peoples cannot be understated. Damage in this region is occurring more quickly, and more destructively, than ever before. The question is, is it unique to this region? How far can this be extrapolated to the rest of the Middle East? The final chapter will examine this question by comparing the two, very different, case study areas, and drawing out general trends which can be applied to the wider region.

"Without some idea of how much of the landscape has been lost … we cannot even start to understand the landscape that survives. This issue is particularly urgent today because vast areas of the Middle Eastern landscape and its archaeological sites are being irretrievably lost as a result of flooding behind major dams, highway and urban development, and new levels of intensive agriculture. Virtually every survey or landscape project now entails some degree of salvage archaeology. Unless steps are taken to halt the destruction (or at least to record what is being destroyed), very little of the ancient landscape and archaeological sites will remains for future generations to study"

~T.J. Wilkinson (2003: 219) ~

Chapter 9:
From Beydar to Carchemish: A Comparison

9.1 - Introduction

This chapter compares the damage experienced by the two survey areas, looking for differences and commonalities in the trends identified and discussed in the earlier chapters. For ease of comparison, the analysis will follow a similar format to those of the previous chapters. Contextual information - such as visibility and certainty – does not need to be repeated, but the certainty of the results outlined in the previous chapters should be borne in mind.

This chapter will begin with a comparison of the land uses in the area in section 9.2, looking for commonalities which will allow extrapolation to the wider region. Section 9.3 covers general damage trends. Section 9.4 breaks these damage trends down by the different causes of the damage, examining the prevalence of the damage threats, the type of damage each one causes, highlighting any differences, and identifying the important considerations.

However, this study had two aims: it aimed to examine damage to sites and assess the key impacts, but also aimed to assess the viability of free and low-cost imagery as a monitoring tool for this purpose. This will be evaluated in section 9.5.

Key issues are identified and final recommendations are made in section 9.6, before general conclusions are made in 9.7.

9.2 – Changing Landscapes and Site Damage

The two case study areas present both similarities and differences, many of which were detailed in Chapters 2, 5 and 7. Both areas have a long history of occupation dating back to at least the ceramic Neolithic, with a well-documented record. A major tell site forms a focus of occupation for each area, with many supporting settlements testifying to a high degree of interaction between settlements. Intensive survey has provided a detailed record of off-site features in the form of ancient tracks and a Roman road, water management features and many others. Both areas are near to, and affected by, the creation of a major dam, and both areas stand witness to the intensive changes occurring to the landscape in the last 50 years. In particular, as discussed at the start of Chapter 5, the Khabur Basin (and thus the Tell Beydar survey region) exemplifies the environmental conditions, social processes and modern changes found in other parts of the Middle East, and so stands as an analog, (Hole 2006: 492), .

However, archaeological occupation in the Tell Beydar area was primarily tell based: 80% of sites display some form of mounding, and only 8 flat scatters were identified. Many of the mounded sites are part of complexes of low mounds, often associated with large tells. In the Carchemish area, on the other hand, settlement types are more variable, and almost half are flat scatters. This has obvious implications for how sites are affected by the various damage threats: the effect on site morphology can be compared. However, in terms of the other variables it also makes the two areas harder to compare, as the effects of site morphology cannot be discounted. There were 108 amalgamated sites around and including Tell Beydar, broken down into 194 distinct site units. 85 amalgamated sites were surveyed around Carchemish, composed of 100 distinct site units. In the Tell Beydar area, the Unit Analysis often provided additional depth to the results in the area, as grouping units together masked the damage individual areas experienced. In the Carchemish area, however, there were only 15 additional sub-units – most sites could not be subdivided further - so the results of both analyses were extremely similar. The Carchemish discussion was therefore only based on the Amalgamated site analysis, although comparative data for the Unit analysis was provided in Appendix H. Nonetheless, this makes it hard to compare the two studies directly. As a result, only general trends will be discussed here.

The Jazirah and Khabur Basin have been increasingly intensively cultivated since the resettlement programs of the 1850s. In the 8 years prior to 1950, almost 430 tractors, and 410 combine harvesters were brought in to the Jazirah and the cultivated area increased 80-fold (Lewis 1955; Nyrop 1971). In the last 25 years, steppe land has decreased, rain-fed cultivated land fluctuated but increased overall, and irrigated land has increased (NAPC 2007). In 1998 during the field visits, of the 43 sites where cultivation was recorded, 17 were unploughed and only 6 were ploughed. High resolution imagery suggests that almost all cultivated sites in this area now are ploughed, and arable agriculture is noted on or by 95% of sites. The Tell Beydar region provides quantified examples of the cumulative effects of decades of resettlement and cultivation on both archaeological sites and the wider landscape, such as the decrease in bare land, increasing reliance on irrigation. and intensive farming. Built up areas and small isolated buildings have also increased, but some small hamlets have been abandoned and their sites have been subsumed into the large open fields.

Recent landscape change as a drought response cannot be entirely discounted. The water table has been dropping, irrigation has increased and the Khabur was a trickle of its former flow even before the 2007 drought, during which cereal production was particularly badly affected (Trigo et al. 2010). Sadly, the imagery lacks the temporal resolution to date many of the irrigation channels specifically enough to see if they are related to the drought, although this would be interesting. However, over the whole study period, numerous wadis dried up and were ploughed out, and irrigation channels increased substantially: these changes are therefore not only a drought response. This process was repeatedly noted during the field visits in the late 1990s, before the drought, and has only accelerated since.

In contrast, the settlements in the Carchemish area were mostly concentrated along the river banks over the last century, and many have now been submerged by the rise in the Euphrates River resulting from the Tishrin Dam. Perhaps as a result, land use elsewhere in the region has increased dramatically, particularly over the last decade. Again cultivation and development are common, and almost no cultivated sites are unploughed. Unlike the Tell Beydar area, however, the almost industrial ploughing out of dried wadis, as part of the creation of open fields, has not occurred. However, the indentations they left in the sites were still visible in the recent field visits. Orchards have become particularly common in this area, and now cover large swathes of the area, causing extensive damage to sites with shallow stratigraphy, but offering a form of protection to sites with deeper occupation layers.

The land is "busier", and sites are a part of that: the number of land uses occurring around sites has increased dramatically. In terms of land use, both areas appeared equally utilised in the 1960s with an average of 3.4 and 3.5 land uses around the sites visible on Corona. However, by the time of the Geoeye acquisition (2009/2010), the Carchemish area was subject to far more varied land uses than the Tell Beydar area. This is contrary to expectations: the extensive resettlement and agricultural focus on the region, compared to the extremely limited information available for (and thus presumably limited interest in) the Carchemish region suggested it would be much less 'busy'. In the Tell Beydar region, in 2009 sites had an average of 3.80 land uses per site around them, whereas in Carchemish in 2010 there was an average of 4.87 land uses around each site, which is significantly more.

Of more concern is the increase in the number of land uses actually on the sites, as they become drawn into the utilisation strategies of their surroundings. New technologies and improved farming equipment means that even the highest sites are no longer exempt from the plough, as evidenced by the ploughing on the 9m high Tell Dadate (LCP 25) in the LCP area, and the 13m high Tell Farfara (TBS 52) near Tell Beydar. Sites have been absorbed into the complex land strategies around them. At Tell Beydar, an average of 2.50 land uses was identified on each site from imagery from the 1960s, and 3.44 on Geoeye. Contrastingly, in the LCP only 1.95 land uses were identified per site in the 1960s, increasing to 3.07 in 2010, demonstrating that sites have not been excluded from the rising land uses around them.

This suggests that in the 1960s, the land was similarly utilised across Syria, but that due to the more intense occupation in the Khabur Basin, sites were already a part of the land management strategies around them, whereas around Carchemish many sites were ignored. Today, however, land utilisation in the LCP area has increased greatly. Some sites are only slowly being incorporated – very few sites have become completely engulfed by the land uses around them, but equally very few have been left alone. This may be because many sites in the LCP area are located on the limestone hills, which have only been intensively exploited and re-exploited relatively recently. The river terraces and wadi banks, on the other hand, which have long been areas of intensive occupation, now also demonstrate the greatest intensification and highest rates of change. It is unknown whether this is due to a higher population, more fertile soil, or even the tendency of people in this region to live and work in the same places their ancestors did, leading to increasing use of the land. Alternatively, whilst cultivation is expanding and now covers large tracts of the area, in the Beydar area many smaller fields have now been transformed into large, open fields, which could perhaps be lowering the number of land uses around sites in those fields.

The evidence suggests that many sites were not cultivated, or were only partly cultivated, in the 1960s, and that it is only more recently that agriculture has spread onto and across them. This may be because of an increasing need for land, but it may also be partly because the machinery used by many farmers has become more accessible. This has implications for our interpretations of the effects of early farming on sites. As discussed in Chapters 2, 5, and 7, it has always been assumed that archaeological sites were farmed in antiquity much as they are today, and that at least part of the damage seen on sites today is a result of those early agricultural practices. This will be true to some extent, but it raises the question of why sites were avoided in the 1960s if they could be farmed by ancient farmers. The implication is that it is only recently that sites have been brought under cultivation and ploughed, perhaps due to the availability of modern machinery which has made it easier to plough dense mudbrick. It may be that a large proportion of the damage we see today is caused by (relatively) modern practices, and not by our ancestors as previously supposed. Due to the extensive change, and the lack of more detailed early records, it may never be possible to test this, but it should be remembered when assessment are made of how the condition of a site may have changed over time.

The land use changes have also affected the visibility of the sites on satellite imagery between the 1960s and 2009/10, despite an increase in resolution from between 2 and 4m on Corona to 0.5m on Geoeye.   Highlighting the effectiveness of using the high resolution Geoeye imagery in examining sites, and even the lower resolution SPOT and Corona imagery, a number of new sites were identified in the Tell Beydar area (although it has not been possible to confirm them in the field) (Wilkinson and Cunliffe 2012). Despite this, almost a quarter of amalgamated sites in the Carchemish area became less visible between 1960 and 2009, and in Beydar, almost as many site units have become less visible as have improved. This strongly suggests that the sites are degrading, which has obvious implications for the use of satellite imagery in site monitoring and site identification, which will be discussed in Section 9.5.

The vigorous land utilisation is occurring in both intensively cultivated areas and more marginal areas, and is therefore likely to be occurring in other regions across the Middle East, with corresponding implications for the condition of the sites.

9.3 – Comparative Damage Analysis: General Trends

This section builds on the discussions of general site condition in Sections 6.6 and 8.6 in the survey analysis chapters. As there are different numbers of sites in each analysis, and not all sites were covered by each image in the Carchemish area, as far as possible comparisons are general, or use proportions per site and area percentages.

The average number of threats recorded per site in the Tell Beydar was 1.97 in the 1960s, and 3.08 in 2010. This is higher than in Carchemish where 1.72 threats were recorded per site, rising to 2.99 threats in 2009. This reflects the differences in land use identified in each area, where sites in the Beydar area are more fully incorporated into the land use strategies around them, and thus more likely to be damaged.

Although sites in the Beydar region were already a part of the land management around them even in the 1960s, the most common threat was only to the Periphery of sites. Sites in the LCP area were less utilised: those threats that were present were most likely to be to Sections of the sites. By 2009/10, Sectional damage was the most common in both areas, affecting just over 40% of the sites. This striking similarity suggests that, if the same is true elsewhere, sections of 1 in 5 sites are being damaged.

Damage has expanded across sites in both areas over the last 50 years: small low mounds are particularly badly affected in the TBS region - many are now Totally affected by damaging activities. Tells in both areas are also increasingly damaged, despite their size. Most damage in the 1960s was to the Periphery of tells, now entire Sections are affected, and, as demonstrated by the ploughing of Tell Farfara (TBS 52), some are entirely affected. Horizontal extents of damage for most threats were found to be consistent in both survey areas by 2009.

Damage has also deepened on sites. Damage to the Upper Levels of a site is the most common depth in both areas, but in both areas the more serious vertical damage extents are gradually increasing. Sites in the Tell Beydar area, however, are generally more badly damaged with a higher proportion of deeper damage on sites.

Whilst height is a deterrent to site utilisation, it is not the barrier it used to be, as modern machinery has favoured urban and agricultural development. The following graphs of total amalgamated sites demonstrate the lack of relationship between height and damage in the survey areas in 2009/10. Figure 9-1 shows the number of threats experienced by each site plotted against their height. Figures 9-2 and 9-3 show the total horizontal damage and total vertical damage, respectively, experienced by each site, plotted against their height. This shows there is no clear relationship between site height and either number of vertical threats experiences, number of horizontal threats experienced, or total threats experienced. Higher sites are no less likely to have as many damage threats on them as lower sites.

9.4 – Comparative Damage Analysis: Analysis of Damage Sources

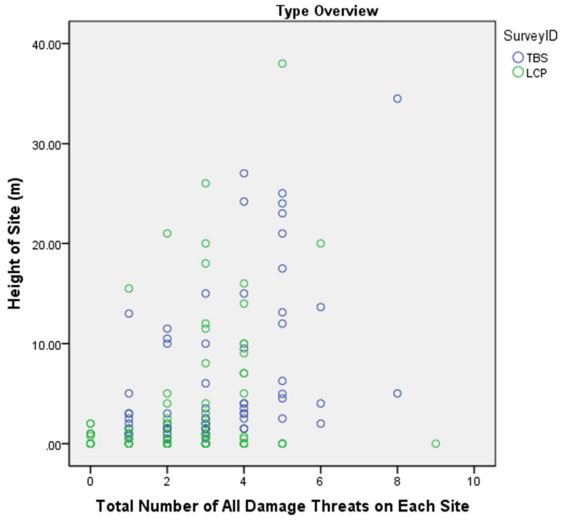
This section compares the threats discussed in the previous chapters, but endeavours not to repeat the statistics underlying each threat, which have already been discussed.

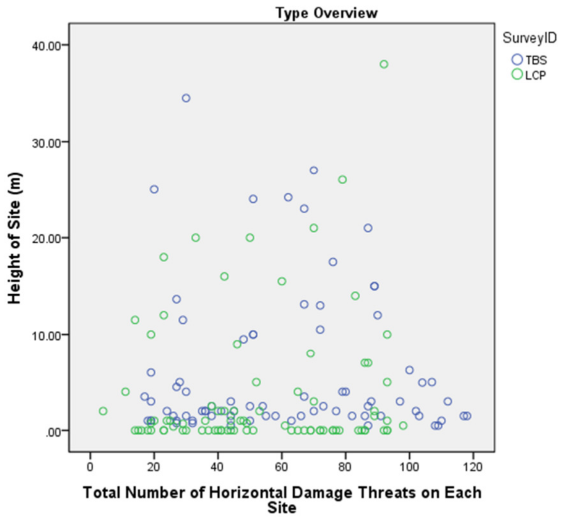
Comparative threats are visible on the graphs on the following page (Figure 9-4 and Figure 9-5). Each graph shows the percentage of amalgamated sites affected by the different threats in each survey area on Corona and Geoeye.

Development, agriculture, irrigation, roads, bulldozing, water erosion, mudbrick extraction pits, and cemeteries were more common in the Tell Beydar region.

Orchards, quarries, looting, cuts, and natural erosion were more common in the Carchemish region (as were Unknown threats on Corona due to the inability to see sites on the limestone terrain).

The threats which are more common in the Beydar region are those associated with an intensively cultivated arable landscape. The fertile, watered land is suitable for farming, so people move to the area, extracting mudbrick from the old sites to support themselves. As the wadis dry up, and the commercialisation of agriculture for cash crops intensifies the cultivation, irrigation is necessary. Sites which disrupt the farming are flattened, or land which is harder to farm (i.e. higher tell sites) is utilised for burials as it was not taxable land. Road networks improve to support the increasing population and crop transportation needs.





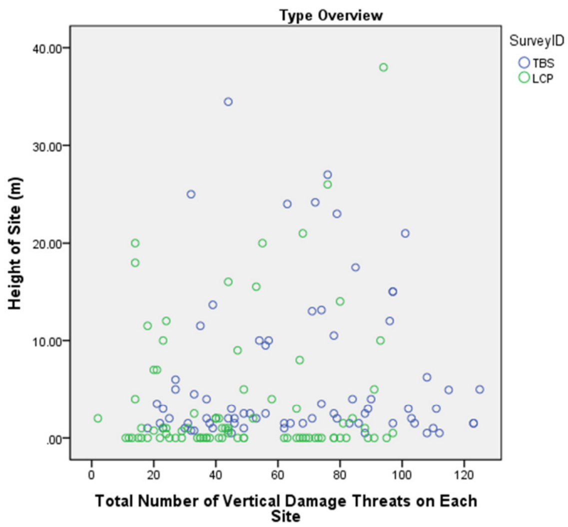


FIGURE 9-1: GRAPH OF NUMBER OF DAMAGE THREATS PER SITE AGAINST SITE HEIGHT

FIGURE 9-2: GRAPH OF TOTAL HORIZONTAL THREATS PER SITE AGAINST SITE HEIGHT

FIGURE 9-3: GRAPH OF TOTAL VERTICAL THREATS PER SITE AGAINST SITE HEIGHT

In these graphs, horizontal and vertical extents are treated as numerical ordinal categories: the ordinal values of each category are listed with the definitions in the Methodology Chapter (p147). The numerical representations of each threat category are added together, so that greater weight is given to more extensive threats. That is to say, a site with 2 Peripheral threats would have a total of 4, whilst a site with a Peripheral threat and a Sectional Threat has a total of 6. This is then displayed against the height of the site to demonstrate any relationship between height and threat extent. No relationship is evident between vertical threat extent, horizontal threat extent or total threat extent and site height.

FIGURE 9-4: GRAPH OF PERCENTAGE OF THREATS AFFECTING SITES ON CORONA

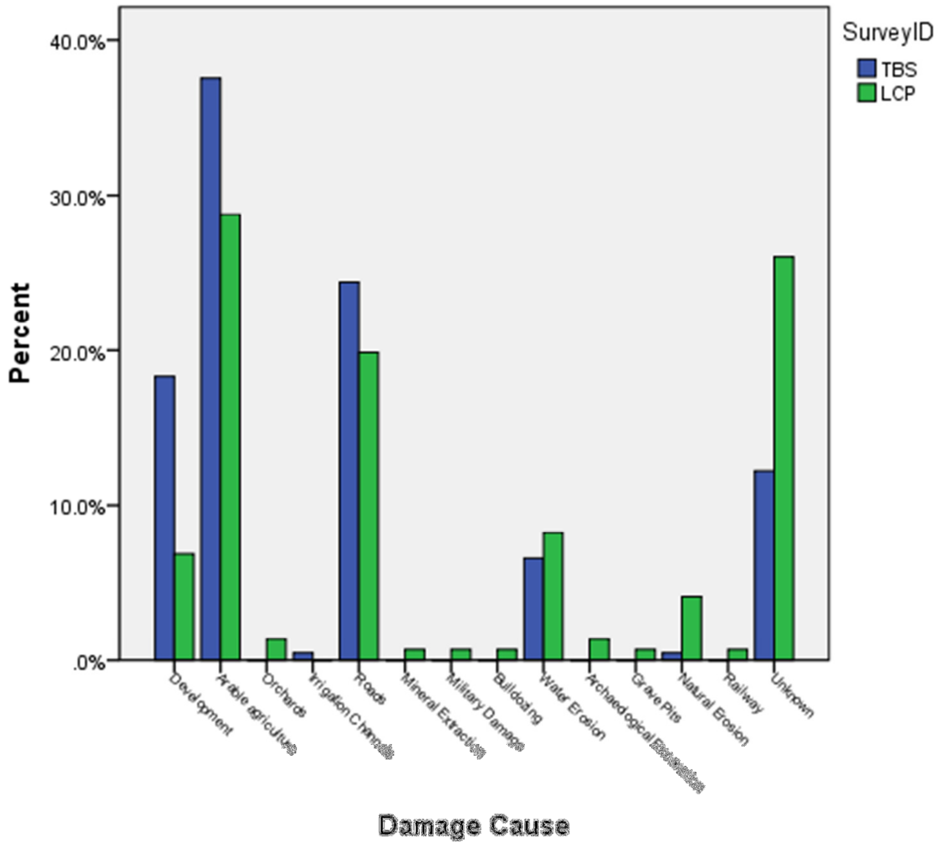
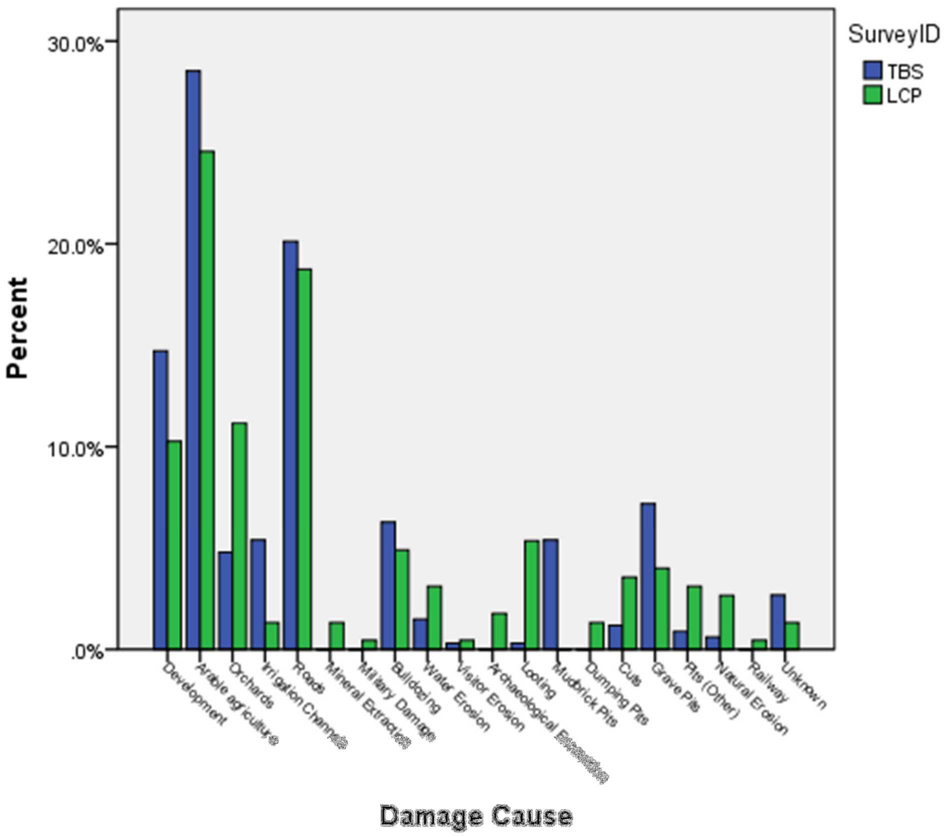


FIGURE 9-5: GRAPH OF PERCENTAGE OF THREATS AFFECTING SITES ON GEOEYE



The Carchemish region, on the other hand, demonstrates more land uses in the marginal limestone area. Orchards, a long-term strategy requiring less management, are regularly located in the marginal soils of the limestone hills, as are quarrying and looting, which is not usually carried out in highly populated areas. This is not to say the other damage threats are inconsequential. Farming was reported on 91% of sites in the Beydar region, but also on 77% of sites around Carchemish, which is more than three quarters of the sites. Other threats have also increased: 'marginal' areas are now simply areas of more recent occupation.

Many threats have consistent horizontal and vertical extents across both areas in 2009, and these affect the different site types fairly consistently. However, some exceptions and notable points are emphasised here.

As highlighted in the land use discussion, arable agriculture is the most common threat to sites and is becoming all-encompassing, subsuming sites across the landscape. Development is increasing: it is one of the most common threats to sites (3rd most common at Beydar, and 4th most common at Carchemish). Small single structures are also increasing in both areas: they were recorded on 17% of sites around Carchemish, and on 12% sites around Beydar. Modern settlements were more common on sites in the Beydar area (35% of sites were affected), but are more numerous and more extensive than in the 1960s in both areas. Where development is recorded in the LCP region, it is more likely to affect a deeper extent of the site than in the TBS region, presumably as more sites in this area are flat, and therefore proportionally more extensively damaged[165]. However, in real terms this is a difference of 4 Heavily Degraded LCP sites and 1 TBS site, so a larger sample would be required for greater accuracy.

Bulldozing is much more common on flat sites in the LCP area, and on low mounds in the Beydar area (which presumably reflects the relative frequencies of the respective site types in each area). The difficulties in identifying bulldozing on sites were discussed in Chapter 3.5.8: for example, the removal of 3 metres from the top of a site in the TBS region could not be identified in the field. Many more sites in the TBS region have probably been bulldozed, and it is tempting to wonder if some of the flat sites from the LCP region were mounds which have been bulldozed, but not identified as such during ground survey. Given the comparative pottery dating from the sites, this is

[165] 2% of TBS sites were Heavily Degraded by Development compared to 17% of LCP sites on Geoeye.

unlikely. The small low mounds which were bulldozed in the Beydar region were largely pre-Roman low tell sites, although several also showed evidence of Roman and later occupation. Most of the flat sites in the LCP region were small Roman and Islamic sites which were probably farmsteads: they will have a completely different decomposition profile, and may never have formed low mounds of the type prone to be bulldozed in the Beydar area. The loss of site elevation is more likely to be due to centuries of ploughing, and process of natural erosion.

Damage is consistently increasing from all threats in all areas with the exception of water erosion. This is decreasing as the water table lowers and wadis dry out. There have also been some decreases in development in the Beydar region which are not seen in the LCP area to the same extent. Entire hamlets have been ploughed up in the TBS region, whilst in the LCP, land is not (yet) in such short supply that abandoned houses are demolished and their locations returned to cultivation.

The comparative marginal areas are also of note. They are areas where sites are hardest to locate on imagery, which is ironic given that they are some of the areas of greatest preservation. However in the TBS region, the features which are preserved are those which cannot be seen or which are hardest to see on imagery – rock art and circular stone enclosures on the escarpment. The sites which were once well-preserved on the plateau itself are now intensively farmed, and susceptible to the same risks as other sites. Sites in the marginal limestone hills of the TBS region are similarly threatened. Whilst the history of this area, supported by archaeological survey, demonstrates only limited earlier occupation when compared to the more fertile areas nearby, it is now also extensively cultivated for crops and orchards. These marginal areas with limited modern settlements are also the locations of looting which appears to be endemic in the limestone hills of the LCP region.

The increasing intensity of land utilisation in marginal areas firstly suggests a developing land shortage in the TBS area in order to meet the needs of increasingly commercial cultivation intended to feed a rising Syrian population, to say nothing of the coping strategies to deal with the recent drought. Numerous people have also recently abandoned the area in response to the drought (Sands 2011), and headed for cities. The land on which their settlements were situated may have been bought, and converted back to arable land. In the LCP area, it is likely that the raising of the water level of the Euphrates River and inundation of the previously populated flood plains has had unintended consequences for the rest of the area, as populations who once utilised it are forced to expand elsewhere. This is seen in the concentrated intensity of land use along the rivers in 2009, and suggests these now small areas can no longer support the rising population, who are forced to look elsewhere for land.

Whilst most site types are consistently affected, the effect on lower / outer towns must also be highlighted. 16 outer towns were identified around Tell Beydar and 6 in the LCP region, of which 5 were included in the study. Despite their different forms (low mounded areas in the TBS region, and flat sites in the LCP region), all outer towns experience significantly more damage than their comparative site types. In the TBS region, on Corona the average number of threats to outer towns is 2.69, compared to only 1.88 threats to low mounds. On Geoeye this rises to an average of 4.00 threats to outer towns, compared to 2.75 to other mounds. Damage to the outer towns around Beydar was a third higher than on comparative sites.

In the LCP region, an average of 3.4 threats was recorded per outer town in the 1960s, increasing to 5.2 threats per outer town in 2009. This is substantially higher than the damage to other flat sites, which had an average of 1.4 threats per site in the 1960s, rising to 2.1 in 2009. The LCP outer towns have a very high average number of threats, as their greater size allows for multiple land uses, many of which will cause damage. Damage to outer towns was more than twice as high as that on comparative sites. This has severe implications for site identification, fieldwork, settlement patterning and archaeological research generally.

It would be useful to be able to compare the damage threats to outer towns factoring in the confounding issue of relative size. However, exemplifying the fact that most outer towns have had relatively little excavation compared to their older Bronze Age cousins, very few detailed maps of the extent of the outer towns were available, and any comparison undertaken at this point would be extremely subjective, and most likely flawed.

Highlighting the research implications, outer towns are generally of later date than their more mounded counterparts. If they are destroyed, entire periods of history will be under-represented. Of course, the Bronze Age landscape of the third millennium is not without damage – the attrition to features such as ancient road networks is catastrophic, and will affect the future of landscape research in this area. Not even the largest sites are unaffected, as the bulldozing of sections of large tells in the TBS region testifies.

9.5 – Satellite Imagery as a Monitoring Tool

The secondary aim of this work was to examine the potential of satellite imagery as a monitoring tool. Its uses in archaeological prospection are well established – given the extensive landscape attrition of recent decades, the value of the ability to see sites as they were in the 1960s (and therefore locate them) cannot be understated. However, very few studies have examined the uses of modern imagery, despite the higher resolution, as the extensive degradation has made many sites so much harder to see. One such study (Wilkinson and Cunliffe 2012) demonstrated how plough line shifts on Geoeye could be used to aid in site detection in the Tell Beydar region, but it was more effective when combined with Corona imagery.

This thesis has demonstrated the important contribution that recent satellite imagery can bring to the investigation of archaeological sites. The increased resolution allows the identification of extremely small features which can aid in the definition of site extents. In an ideal world, this would not always be necessary, as sites would only need to be located on imagery, and then they would be visited in the field to confirm their antiquity and map them. However, for a variety of reasons this is not always possible, and satellite imagery provides a viable alternative.

Traditionally if the high cost of new satellite images could be met by an organisation, the images available on Google Earth have been avoided. The coverage is not complete, the imagery is not always the most up to date, the dates of some of the images are uncertain (See Appendix A.1.2 – SPOT Imagery), the rectification process is unknown, and the imagery cannot be manipulated with GIS software. In particular, these last two points have been the ones most often cited in discussions with colleagues in this field of research. I would argue that since the goal is not to accurately represent the location of the sites within a mapped co-ordinate system, but to locate the sites on imagery, the issues surrounding georectification are of less concern. Furthermore, the error margin is within tens of metres, which still allows the accurate location of sites in the field.

The other criticisms raised all relate to the identification of sites on the imagery. As was demonstrated from the detailed discussions of visibility in the earlier chapters, site detection, and the level of feature clarity was highly variable depending on the site type, size and location. Furthermore, because of uncertainties in the definition of archaeological sites, it is difficult to make quantitative estimates of the amount of site loss. Nor were all sites covered on high resolution imagery: in some areas only SPOT imagery is available.

Many sites are detectable on SPOT imagery, and major threats can usually be identified, although not always. Interpretation was therefore informed by other imagery if the SPOT imagery wasn't clear enough. In the LCP, in particular, many sites were not visible on the SPOT mosaic; nor were important threats like looting. Although Google have expressed their intent to update their imagery every three years, large sections are still covered by the Astrium SPOT Mosaic from 2004, whilst other areas are being updated regularly. (The very southernmost parts of the Tell Beydar region were recently updated with a 10 November 2011 Geoeye image, despite the fact other parts have not been updated at all). Nonetheless, high resolution sequential imagery is becoming increasing available, offering unparalleled opportunities for site monitoring through comparison. Since this research began, several other studies located in the Middle East have been published which also demonstrate good results using Google Earth, supporting this conclusion (Hritz 2013; Kennedy and Bishop 2011; Parks 2009; Sadr and Rodier 2012). Whilst some features may not be visible, and site depth cannot be estimated, important conclusions can still be drawn.

The higher resolution imagery has been essential to accurately monitor damage to sites, and the ability to enhance the FCP Geoeye images and improve the clarity of sites in ArcGIS was extremely useful, particularly on flat sites identified through pottery concentrations and soil marks. However, whilst they stand out more clearly on enhanced imagery, they were still identifiable on the imagery available through Google Earth. It should be stressed that in order to test this, this study was conducted in Google Earth wherever possible (although figures for this text were created from enhanced imagery in ArcGIS, in order to achieve the maximum print resolution).

However, the most accurate results came from the combination of sequential imagery, interpreted using the information from field visits. Without the field visit information, many features (archaeological and otherwise) would not have been understandable, and the true extent of damage would almost certainly have been under-estimated in some cases, and over-estimated in others (particularly those where sub-surface remains were identified).

Corona imagery was also invaluable. The potential to see sites in their original context before landscape intensification accelerated has supplied extensive additional information about sites and about their condition in the modern day, providing a benchmark against which to assess them. The changing way sites have been utilised as part of surrounding land management strategies is a vital component in this study.

Despite Beck's suggestion (2004) that imagery should be acquired from the same seasons, and month if possible, it was felt that the seasonal comparisons between the images aided this work immeasurably by highlighting different features in the different seasons. Corona imagery is inexpensive, and organisations such as the University of Arkansas are working to make it freely available online. Their *Corona Atlas of the Middle East*[166], for example, provides extensive Corona coverage of the Middle East which has already been corrected for the inherent distortions and georectified, circumventing the need for complex technical abilities.

Combining multiple images from different eras and seasons provided an effective way to examine archaeological sites in Syria. Whilst the free imagery on Google Earth did not provide entirely comprehensive coverage of the region under study, in those areas where it was available, it was more than sufficient for the study, and once combined with the Corona imagery and ground survey, it provided an extremely detailed picture of the condition of the archaeological resource of Syria. The lack of coverage of some areas should not be taken as a reason to avoid this resource. Many organisations lack the funding to acquire multiple sets of high resolution imagery and the expense of covering an entire province, country or region is prohibitive. In a country which boasts many thousands of sites, the ability to monitor large numbers of them is of extreme value. Furthermore, this study has demonstrated that results from one area can be extrapolated to other areas. Whilst the condition of individual sites may not be known, the types of threats occurring can be estimated.

9.6 – Key Issues and Recommendations

The level of destruction recorded on sites, even in relatively "stable" areas like the Upper Khabur Basin, is extensive. The archaeological record is at risk from rapid changes such as widespread development, and slow attrition from threats like agriculture. Whilst not all threats affect sites to the same extent, the cumulative effect of slow threats can eventually equal the rapid devastation of others. In those areas which are actively being developed, site destruction may be total.

[166] http://corona.cast.uark.edu/index.html , accessed 20 February 2013

9.6.1 – Key Issues

The following issues have been identified:

- Sites are being discovered all the time across the Middle East, particularly with the easy availability of satellite imagery, although extensive ground survey is required to accurately assess them. Whilst the extent of the archaeological record will never be definite, it is constantly being expanded. Satellite imagery can focus the ground survey work required as currently many risk assessments which are undertaken before development work commences are inadequate.
- Comparison of field notes to satellite imagery suggests archaeologists are likely to underestimate the damage which is occurring to sites. It is infrequently recorded, and rarely included in publications except as footnotes, despite the distortion it can cause when interpreting settlement patterning. This implies it has previously been of low importance. In particular, agriculture and roads are under-reported, perhaps because their effects on sites are assumed to be inconsequential. This has been shown not to be the case.
- The different causes of site damage have been poorly researched and poorly understood, although this is starting to change as new research is being conducted. The effects of many threats are more nuanced than is often portrayed, and are dependent on multiple factors, not all of which are recorded during archaeological survey.
- Nonetheless, even when the least possible extents of damage to sites are assumed based on identified causes, the damage is extensive. Developments in this region have been focused around what are now archaeological sites for thousands of years – some loci demonstrate more than 8000 years of near-continuous occupation. The advances made in modern building techniques, the availability of earth-moving machinery, the desire for water, gas and electricity, and the need for better roads to support rising numbers of cars, all place the sites at the centre of the loci at far greater risk than ever before. Correspondingly, even in the Carchemish area, which is not a heavily agricultural area, more than 75% of sites are at least partly farmed using modern machinery, opening them to more rapid erosion than was previously likely. New irrigation methods, and the frequent abandonment of the practice

of fallow, have allowed cropping cycles to increase, so damage occurs more regularly and sites are more frequently exposed to erosion.

- As modern settlement is still concentrated around ancient tells, outer towns face far greater levels of damage than similar sites elsewhere. However, the study of these outer towns has often been neglected by archaeologists in favour of the Bronze Age settlement on the large tells.

- Site size is not an indicator of site safety: numerous large tells have been bulldozed, as earth moving machinery is more easily available. As well as severely disturbing the archaeological record, this opens tells up to potential collapse from erosive undercutting by rainwater. The damage to shallow sites and low sites is even more extensive.

- In the Carchemish area, looting has been attempted on almost 1 in 5 sites, and it continues to increase. Sites of all types have been affected, and the damage ranges from a few small holes to large trenches across a site.

- Whilst they have not been the focus of this study, given the damage to sites, features such as ancient tracks, water management techniques, relict field systems, wine presses, rock art and others, which gave evidence of the lives of ancient people outside settlements, must be facing catastrophic damage.

- Location also no longer protects sites. Marginal areas such as plateaus or hills with thin soils are now widely farmed or converted to orchards. This is not the first time in history such areas have been cultivated, but the modern machinery available today can penetrate to greater depths, destroying shallow sites, and heavily degrading deeper ones. Areas which have long been the focus of occupation, such as river terraces and around wadis are also showing rapid landscape change, and whilst it might be expected that sites have formed an equilibrium with the people around them given the extensive history of occupation, the evidence instead suggests that these are now the sites most at risk.

- This research presents a benchmark against which future site damage can be evaluated. Great change has been recorded over the study period, and even between 2003 and 2010 – the dates of the first and last images used to study change over the last decade. It is likely that if the study were repeated in another seven years, the rate of damage to sites will have increased even more rapidly.

- Whilst these results were obtained in case study areas in Syria, a comparison of the underlying variables has determined that the results can be generalised across large areas of the Middle East.

9.6.2 – Key Recommendations

Responding to what can only be called a crisis facing the archaeological resource is the responsibility of both archaeologists and state agencies. Based on the identified issues, the following recommendations are made:

- Archaeologists need to design research questions considering attrition to the archaeological record, asking questions now that may not be answerable later.
- More research is needed into the effects of different threats which are specific to site types, and the unique cultural and environmental context of each area.
- It is not possible to save every site, nor is it recommended. Modern people have just as much of a right to utilise the landscape as their ancestors did. However, certain sites of all sizes, periods and importance should be marked and given protection to ensure that a representative sample of our history is passed on to our descendants.
- Any attempt to choose sites for protection must be based on an assessment of their condition, importance, uniqueness and representivity on a local, regional and national scale. This requires a knowledge of the archaeological resource which is not currently available in Syria, or in many other countries.
- A Sites and Monuments Record (SMR) is a vital first step to protecting sites. Recognising this, many countries either possess one, or are designing one.
- Nor is it possible to control every type of land use which may threaten sites. However, recognition and encouragement should be given to those land uses which cause less damage to sites, or which act to protect them from greater damage. For example, an orchard on a site like Carchemish is more protective than low investment agriculture, which can then be invaded by the urban area.

- Future archaeological surveys should be combined with remote sensing to achieve more comprehensive investigations of the survey areas. We cannot save all the sites, but we can record them before they are destroyed. Copies of such records should be given to the governments of the respective countries.
- Such surveys should also record the condition of the sites in more detail, and with greater accuracy and consistency. Site damage must move beyond the realms of the footnote.

9.7 – Concluding Remarks

Landscape change is an on-going process, and is part of the natural cycle of the land. However, the rapid changes over the last fifty years are affecting archaeological sites at an accelerating rate. Undoubtedly not all the sites and features of the area have been discovered yet, and other areas will also have unknown pasts, waiting to be revealed. The change must be managed and the archaeology taken into account. In turn, archaeologists must factor the damage that sites, and the wider area, have experienced into their records and their analysis in order to truly understand an area.

Despite the vast area separating them – some 230 miles – damage to sites in the two case studies is remarkably similar. They both demonstrate increasing threats, regardless of whether the area is intensely agricultural with a long history of occupation, or more marginal.

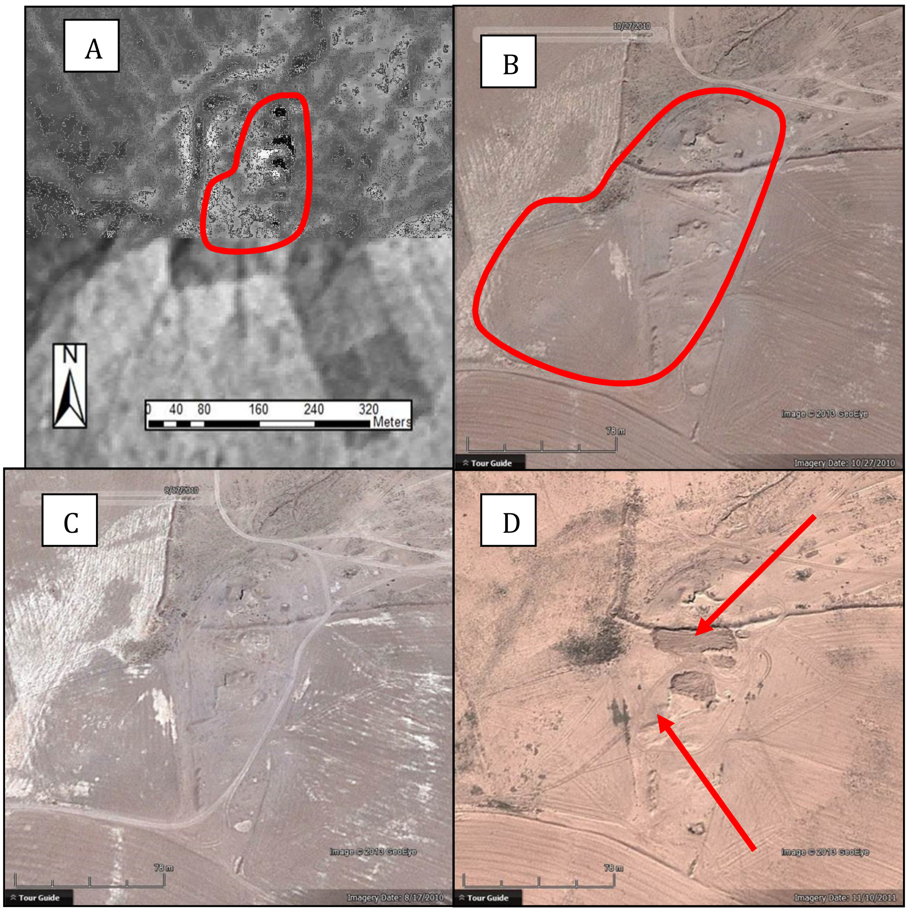
Satellite imagery, particularly the low cost Corona imagery and the free Google Earth imagery, has proved to be of immense benefit in this study, providing a comparative record of the changes to the landscape and the sites over the study period.

This study forms an essential first step in understand the attrition of the archaeological record, and provides a benchmark against which to assess future damage. New imagery is becoming available, enabling the continuation of the assessment and monitoring of sites in order to better protect them. For example, recent updates on Google Earth cover the area around the West Hasseke Dam. Since this research was conducted, further damage can be seen at the site of TBS 2. When last evaluated, this site had been partially bulldozed to create the West Hasseke Dam reservoir, although decreasing water levels meant that it has not been recently threatened by the inundation. Some tracks covered the Periphery, and the western mound was ploughed and cultivated (and possibly bulldozed). Now, just one year after the previous image was acquired, the mound has degraded further. The tracks have extended to criss-cross the mound, and large sections appeared to have been dug into (Figure 9-6).

The overall change to the landscape over the past 40 to 50 years has been extremely dramatic, and even knowing that, it has perhaps been greater than would be expected. Remote sensing is clearly a fundamental tool for the long term monitoring of damage to archaeological sites, but it should not be the only tool. As much as is possible, ground survey is necessary as well. The example of TBS 2, epitomising the work underlying this study, demonstrates the urgent need for the implementation of protective measures to manage the on-going destruction of this vital archaeological resource. However, without the initial survey, the original extent of the site and even its existence may never have been known.

Figure 9-6: TBS 2 on Corona and Comparative Geoeye Images[167]

From left to right: A –Corona 1102 (December 1967); B - Geoeye August 2010; C – Geoeye November 2010; D – Geoeye October 2011. New damage which is visible on the most recent image is indicated with the arrow.



[167] Corona Image, 1102-1025df007-1_37N, standard deviation stretch, 09 December 1967. All Geoeye images taken from Google Earth 20 February 2013.

"We were making the future, he said, and hardly any of us troubled to think what future we were making. And here it is!"

~ H. G. Wells, 1910 (1988) ~

Chapter 10:

Final Conclusions

History and archaeology sit at the meeting place of the past and the present. They are the accumulations of the actions of past people and their interactions with the natural world given physical form. They express the heritage of those peoples, and become the heritage of the people of today. Wilkinson (2003: 7) discussed the idea of signature landscapes – those landscapes which are so deeply etched that they remain throughout time. The Early Bronze Age landscapes of the Jazirah are a prime example – the road networks mapped by Ur and Wilkinson (Ur 2003; Wilkinson 1993; Wilkinson et al. 2010) were used and reused for centuries, and were still visible in the 1960s. The sites themselves are often persistent places (Hritz 2013), loci of occupation throughout different phases of history. Each period of use or reuse has, in turn, modified the inherited landscape, yet left behind something for future generations, until today. Now the needs of a rising population, coupled with the pace of modern progress, leave us facing difficult questions about how our inheritance – our heritage – is to be incorporated into our present, and whether there will be anything left for the future.

10.1 – Summary

From this question sprang this thesis. There were two main aims. The first was to examine site damage in selected areas, assessing the impacts, and the second was to examine the potential for using satellite imagery to monitor sites. In order to achieve the first of these aims, it was necessary to study damage and its causes, refining understanding of the concept. The study was limited to damage caused in peace-time, for whilst war time damage is unarguably significant, it has been the focus of much greater attention. Two case studies were chosen in Syria, a central part of the Fertile Crescent region, with the hope that through careful analysis, results could be extrapolated to the wider region. Sites within these areas were studied on sequential satellite imagery, supported by field visit data, and a large amount of quantitative data was collected and analysed.

The two studies chosen were the Tell Beydar Survey and the Land of Carchemish Project, detailed in Chapters 2, 5 and 7. These areas had enough similarities to be comparable, but enough differences that any correlations should be valid across the wider region. In total 161 sites were studied, and 19 separate causes of peace time damage identified, discussed in Chapter 3. In order to analyse the sites and the damage, and provide quantitative data on a topic which has previously been approached largely subjectively, a new methodology and database were developed, detailed in Chapter 4. Chapters 6 and 8 gave the results of the analysis of the sites in each case study area. Whilst obviously no site is in the condition it was when finally abandoned, and abandonment itself is simply another phase of the natural cycle of a site, the focus was on anthropogenic damage to sites - including natural causes that affected the interpretation of anthropogenic causes. Almost no sites were unaffected by human intervention, but equally, it appears that very few have been entirely destroyed. Many, however, have been severely damaged - some almost completely - and in numerous cases sites are preserved only through a rise in ground levels, which has denied the bulldozer total access. Many archaeologists have commented that as later settlement is often located over earlier phases of occupation (see Adams 1981; Wilkinson 2003), earlier occupation is most likely under-represented. It was hoped that the extensive destruction of those sites would at least present a silver lining in the form of access to earlier levels. Whilst there were very few sites where this was actually studied, in no cases was earlier pottery revealed.

Site damage is not new: those sites which remain are undoubtedly only a fraction of those which have been destroyed by earlier phases of occupation. Furthermore, by the time the damage is visible on satellite imagery, extensive destruction has already been done. Crucially, this study has demonstrated the increasing pace and intensity of site destruction on a scale which was never previously possible. Even marginal areas are now cultivated: something that has happened only rarely before. Modern machinery is increasingly commonly available, and is able to plough to a greater depth and up greater slopes than ever before. Government subsidies have encouraged long-term investment in orchards, which damage even as they protect sites. Advances in dams and irrigation allow multiple cropping without fallow seasons, leading to continuous soil use with no chances for cohesive plant cover to regrow, and the ensuing erosion is inevitable. Finally, of course, the rising population need homes, all with the supporting infrastructure of water and power, along with roads and railways. Intensification of land use and advances in available technology have enabled sites to become part of this utilisation, when once some may have been left separate. In these cases, sites are collateral damage, lost to the advancement of progress. In others, sites are deliberately targeted – looting is increasing, and now it is possible to detect potential new sites by the clustering of holes visible on satellite imagery. The sites studied may only be a fraction of what was present before, but they are certainly only a fraction of what will be left tomorrow.

From this analysis, key issues have been highlighted which it is hoped will assist with the development of policies of protection, as well as recommendations which are also relevant to archaeologists. The comparison of case study areas in Chapter 9 demonstrated that the damage recorded is not limited by geographical region, or by land type, or even site type, although some trends are reflective of the land use within each area. The Tell Beydar area, for example, is a predominantly agricultural area, and whilst the land use on the sites reflects that, agricultural damage is not limited only to predominantly agricultural areas. The trends observed here are widespread, supported by multiple unquantified anecdotal reports from excavations across the region. The issues recorded and recommendations made here are equally applicable across large areas of the Fertile Crescent. It is not possible to save all sites; nor is it desirable. Sites should be protected based on their local, regional and national significance, as well as the contribution they make to representing the past of all humanity – prince and peasant alike. It is therefore important that the threats to them be recognised and understood, so that more archaeological / cultural heritage surveys can be undertaken in order to record the sites and materials which cannot be saved before they are lost forever.

The second aim of this study was to examine the potential for using satellite imagery, particularly free or cheap imagery, to monitor sites. It is not possible to guard, or even to visit every site: they are too numerous. This study has demonstrated the potential for Google Earth and Corona in site monitoring, but also demonstrated their core weaknesses. These include the low resolution of some imagery, the uneven coverage of better imagery, and unequal update schedules, as well as the necessity of a field visit to act as a benchmark. It is also difficult to fully quantify site damage, as there are many problems in defining sites on satellite imagery. Nonetheless, as more and more imagery becomes available, it will become increasingly easy to utilise, and should form an essential component of regional site monitoring.

10.2 – Modifying the Framework

As a result of these findings, we must also revisit the landscape framework under which the analysis was originally conducted. In Chapter 3.3, Wilkinson's development of landscapes of destruction and survival in the Near East (2003) was used as part of a framework against which to evaluate the case study areas. Wilkinson proposed the landscape could be split into 5 zones of preservation and attrition, summarised as

> *"Landscapes with the greatest probability of feature survival occur in deserts and high mountains, whereas progressive loss of features is at its maximum in areas of long-term cultivation and rather less so in areas of marginal settlement … although it requires emphasis that the patterning of landscapes of destruction and survival can be extremely complicated"* (2003: 41).

This study demonstrates that he was correct in that it is complicated, but like all facets of the landscape, it continues to change. Studies in the Jordanian desert, a Zone of Preservation and feature survival, have shown that even there, sites are "under serious threat" (Kennedy and Bewley 2010: 198).

The recent intensification of land use and cultivation, and in particular over the last decade, also suggests that our understanding of what constitutes an area of progressive feature loss should be modified. Despite probable millennia of intensive agriculture in fertile areas such as the upland plains of the LCP region, sites are still visible there, and could still be recorded. Supported by the studies of plough-zone attrition, discussed in chapter 3.5.2, it is suggested that these sites reached a state of equilibrium. Advances in modern technology, such as the mouldboard ploughs used to break topsoil and open it for cultivation, can cause extensive damage to sites. This study has demonstrated that marginal zones have now been brought under intensive cultivation, and therefore the sites there have been exposed to these destructive cultivators which may have extensively disturbed any buried layers in the subsoil. Sites in areas of on-going cultivation, on the other hand, are exposed only to regular ploughs, and the deep soil is rarely reached. However, these sites have already faced long periods of ploughing, and have been affected by on-going erosion. As a result, Intermediate Zones, such as marginal rain-fed steppe, are now perhaps the areas of greatest destruction. However, this is not a static situation: a key feature of intermediate areas is that settlement levels fluctuate. Whilst the Jazirah and the Khabur Basin have been intensively farmed for more than fifty years, in 2010 they were being abandoned as drought forced farmers to the cities in search of work. It remains to be seen what equilibrium the sites will reach.

10.3 – Conservation Approaches: East Meets West

It is not enough just to identify damage: the next stage is - of course - what to do about it. What should be studied, what should be kept, and what should we accept as lost? Darvill (1998), in his Monuments at Risk Survey (MARS), suggested an approach where sites were assessed based on a number of criteria which would determine their significance, detailed in Chapter 3. However, this admirable study was the first and one of the only studies to attempt an evaluation of a national archaeological resource in such detail, where sites were to be compared on local, regional, national and historical scales of significance. Furthermore, although it was intended that MARS form a benchmark against which to assess future damage, it was never repeated, despite almost twenty years having passed. In the TBS area at least, where the field visits were conducted just after MARS was completed, that was enough time for a significant amount of further damage to have occurred. For many countries it would be unfeasible to attempt such a study: even the basic information is not available.

At this point, as possible ways forward are sought, the potential bias underlying this work should be noted. Although never directly stated, the conservation of some or all sites is implicitly advocated throughout this work. The principles underlying conservation theory and practice are often accused of impressing the dominance of western approaches onto wider (and often inapplicable) situations (for a summary, see Pournelle 2007). Western approaches have traditionally ascribed values such as 'inspirational', 'civilisation affirming', or 'a testament to the achievement of humanity' to historic monuments. They focus on a combination of learning and aestheticism, promoting preservation of original fabric, rather than restoration, based on concepts of the 'international importance' of heritage. Underlying these principles are broad assumed universalities, where local differences in approach are ignored and overridden. Importantly, over the last 20 years this approach has begun to change, acknowledging local differences and emphasising the importance of local consultation, local involvement, and the preservation of intangible local values as well as built monuments.

This study does not seek to preach preservation over progress, to halt the advancements that have enabled widespread access to healthcare and education in a misguided attempt to freeze an ever-changing landscape at an arbitrarily defined point in time. However, where site destruction does occur, it should be as a result of an informed choice, rather than as an unconsidered result of collateral damage, or illegal excavations to find saleable items. If sites must be destroyed to meet rising global needs, then it is hoped that they can be recognised and studied first. This may not always be possible – some sites will be so degraded they will not be worth excavating. Some are of a ubiquitous type where the information gained will not justify the expenditure of study. However, others are being destroyed before such considerations are taken into account. This study seeks to provide the context against which such decisions can be made. The damage sites are experiencing must become a relevant factor in both conservation choices and research decisions, which has not previously been the case.

For example, a team from the Oriental Institute of Chicago examined several sites with the Syrian antiquities agency (DGAM) when considering their options for a new project. Of those sites examined, Tell Hamoukar in North Eastern Syria was "clearly the most threatened… the site would be lost to archaeology fairly quickly" (Gibson 2010: xxi), as it was at risk from expanding urban development and a paved road. It was also described as "one of the prime sites in Syria". Despite the obvious risks to the site, and its importance, it was not initially the top choice for the project, yet it has since provided important information on settlement patterns across the region which may have later been impossible to gain. The responsibility lies not only with the relevant authorities, but also with archaeologists. Research questions should be designed with progressive site destruction in mind. They must account not only for the damage sites have already undergone, and the effect it might have on data collection, but also consider what may not be possible in the future.

10.4 – Areas of Further Research

10.4.1 – Change Over Time

As remote sensing continues to improve, it is hoped that it will be possible to add greater depth to this study. In particular, it would be useful to be able to quantify the affected areas of sites. However, at present, there is not enough agreement on site boundaries between images to be certain if change is due to variations between imagery, such as seasonality, or due to damage. As multiple images with increasing resolution from different seasons become available, this should resolve itself and the causes of differences will become more certain, and area affected can be quantified. Elevation data collected with greater precision will also become more widely available, so it should become possible to assess the volume of site matter affected, even on very small sites. It may even become possible to provide time depth perspectives and accurate quantified rates of change over time.

10.4.2 – Extending the Study

Anecdotal evidence from other surveys suggests that the results of this study are applicable across the Fertile Crescent. In Turkey, for example, many sites in the Amuq Plain which were identified on Corona by Casana are now bulldozed for irrigation and roadways (Casana 2007: 199). In particular, small Bronze and Iron Age sites were damaged by modern construction (Casana 2007: 204). In Iraq, extensive landscape alteration caused by ploughing was noticed in a the first season of the North Jazirah survey around Tell al-Hawa – a large number of relict wadi channels were already ploughed out (Ball et al. 1989: 9). By extension, sites (particularly low or flat sites) must also have been undergoing attrition caused by ploughing. Kennedy and Bewley (2010: 198) noted the vital role aerial archaeology is playing in monitoring the condition of sites threatened by development in Jordan. Around Amman, for example, a “relatively dense hinterland” of towns, villages, farmsteads, industrial sites and roads, has largely disappeared within a 15 km radius from the city centre. Even a cursory examination of the region on Google Earth will show a landscape scarred by the multiplicity of changes. Israel, Palestine and the other countries of the Arab region are all undergoing significant population increases and extensive urban and agricultural expansion which will have a corresponding effect on their archaeological resource.

The research presented in this study is applicable beyond the borders of Syria: damage to archaeological sites has many commonalities. However, to group sites together in such a way across such a broad region denies both the uniqueness of the sites, and the unique contexts in which they can be found. This work presents a framework against which damage in these areas can be evaluated, and offers general results, but further work in each region would be needed to create site protection plans which are tailored to specific contexts.

10.4.3 – Off-site research

This research also excluded off-site features, such as hollow-ways and water management features. Considering the size and relative fragility of these features, in many ways it is astonishing that they were still visible in the 1960s on imagery, or identifiable in the field (Wilkinson et al. 2010). However, whilst no attempt has been made to gather quantifiable data as part of this study, it was quickly clear that the rate of attrition to off-site features is far greater than that of sites. In the Hamoukar survey, Ur noted:

> *"The transformation by agriculture of the off-site record is far more dramatic, although in different ways for different features. The stripping of natural vegetation and constant tilling of the landscape, and the movement of sediments that results from these activities, have obscured many landscape features with subtle topographic expression. Hollow ways and canals have especially suffered, and now must be mapped primarily from historic Corona photographs*" (Ur 2010b: 43).

It was briefly discussed in Chapter 6. 9.1, the case study of sites on the Hemma plateau around Tell Beydar, that many of the desert kites noted by van Berg et al. (2003) and Picalause (2004) were no longer visible. In his study, Picalause noted:

> *"Due to the destructive impact of agriculture on the plateau, their [the kites'] state of conservation varies greatly, and it is likely that several desert kites are no longer recognizable as such in the modern landscape"* (2004: 90-91).

If comparatively large kites are so heavily affected, one must wonder about the condition of the far more rare and fragile rock art recorded in the survey. Although it is possible to examine the broader areas they are found in, these off-site features cannot always be recorded and monitored on imagery: site visits are usually necessary. Further work is needed not only to establish the full extent and range of these features before they are lost forever, but to record the threats to them so that they can be studied and maybe preserved. The history of humanity is not only the story of cities, or even of farmsteads: Bradley's study (2011) of the uses of natural places as religious foci demonstrated there are few places we have not used for one purpose or another in the course of history. If off-site features are destroyed before we can even record them, we lose an irreplaceable piece of our past.

10.4.4 – Multispectral Imagery and Automation

Aside from a brief foray into potential uses of Landsat imagery (discussed in Chapter 4.3) the potential uses of multi-spectral imagery have not been examined. Whilst the resolution of Landsat is too low to be of use in such a detailed analysis, many other types of multispectral imagery are available for increasingly low prices. The Fragile Crescent Project obtained Geoeye imagery in 4 bands, for example, and although its inclusion was outside the scope of this study, a brief examination suggested it may reveal more information about the sites than currently known. Multispectral imagery has also been used successfully to gain additional information about sites in a number of other archaeological studies in many different areas. Most relevantly, Altaweel (2005) used ASTER and Corona in site prospection in Iraq. However, Grøn et al. (2011) used a variety of imagery in Norway; Aqdus et al. (2012) applied hyperspectral and multispectral techniques successfully in Scotland and, closer to the study area, they were used successfully in Jordan (Savage et al. 2012); and Agapiou et al. (2012) used hyperspectral spectroradiometric data in the Thessalian plains of Greece, to name but a few of the most recent examples. Although cost and lower resolution are still problematic when working with multispectral imagery, it is improving rapidly, and the cost is dropping.

Additionally, as the resolution of imagery continues to improve and the cost continues to drop, it is hoped that soon the process can be more easily automated, and thus automation can be more widely adopted (approaches are detailed in Campbell and Wynne 2011).

10.4.5 – Other Forms of Damage

This study has focused on specific types of damage, and several have been excluded, particularly military damage. The unrest in the region has seen expression in the destruction of the Bamiyan Buddhas in 2001 (O'Dell 2013), and in Iraq in two Gulf Wars (Rothfield 2008; 2009; Stone 2008; Stone and Farchakh-Bajjaly 2008). Now Syria, too, faces extensive damage to its cultural heritage as a result of the increasing conflict (Cunliffe 2012a; b; c).

Damage monitoring using satellite imagery has only been financially feasible for heritage professionals in the last decade. It was used to examine damage to archaeological sites in Iraq resulting from the 2003 invasion (Emberling et al. 2008; Ricci and Wilkinson 2009). Van Ess et al. used IKONOS (2006), and Stone used DigitalGlobe (2008) to monitor looting in Iraq after the conflict, as have the Global Heritage Fund (Cunliffe in press a). However, this study shows that other kinds of damage can be monitored on a wider scale if imagery is available. Amnesty International used DigitalGlobe imagery to examine impact craters in Syria in 2012 to evaluate the risk to civilians (Amnesty International 2012), but to date the cost of examining heritage damage on such a scale has made it prohibitive for many organisations.

However, conflict damage, perhaps due to the immense amount of destruction that can be caused in such a short time, draws what may be a disproportionate share of attention. Looking to the future, climate change will also become a major threat to sites. It is difficult to directly measure its effects in weather-related events, as it is hard to separate human-induced impacts from natural occurrences, but research is beginning. English Heritage has released two papers on the subject (English Heritage 2008a; b). They described the physical, societal and cultural impacts of climate change on the historic environment of England, as well as the potential opportunities, another under-studied area. However, they listed a number of key knowledge gaps, including hazard recognition and prioritisation, extreme weather effects, monitoring and assessment of vulnerability and performance, and indicators and standards.

Howard and Kincey et al. (2008) gave some specific examples of some of the ways sites in Britain in riverine catchment areas are likely to be affected. Examples include: increased river incision; increased erosion and sedimentation on valley floors; the lowering of groundwater through pumping for quarrying and farming intensification, which results in the oxidation and destruction of organic remains; and the intrusion of saline water as sea levels rise. Other effects include the possibilities of new crops as growing seasons and temperatures change, with changing root penetration, and changes in irrigation and tillage. They made particular note of the fact that whilst many policies to deal with climate change take account of standing architecture, many take no account of the buried archaeological record. Many policies and solutions, particularly ‘hard’ engineering solutions and water transfer initiatives, are in fact detrimental to the record. Whilst this article focused on British river catchment areas, parallels with the study areas of this thesis are clear. The TBS area in particular demonstrates increasing locally-implemented irrigation as a response to changing groundwater resulting from drought, with necessarily accounting for the buried archaeology.

Kincey furthered this work with Challis (2010) using LiDAR on an upland area of Britain which is at risk from intensive land use practices, pollution and climate change, which were potentially causing extensive erosion. Their work demonstrates the potential of remote sensing on monitoring such threats. 559 discrete erosion threats of varying depth were monitored in their study area, along with their proximity to cultural sites and trackways: erosion damage was confirmed on eight of the eighteen archaeological sites.

Climate change will becoming an increasing threat in the coming years: however much like the term ‘damage’ it runs the risk of becoming a catch all phrase which obscures the actual threats causing damage. The work already started in Britain in these two areas – upland erosion and riverine catchments - gives a foundation from which to work to begin to examine the threats climate change will bring in other areas.

10.4.6 – Prioritising Site Preservation

This work has highlighted an important gap in how sites are treated. Whilst it is not a direct extension of this research, as mentioned in Section 10.3 and discussed briefly in Chapter 3, adequately determining which sites should be marked for preservation according to existing criteria (e.g. those of English Heritage or similar large national organisations) requires extensive site details. Few Middle Eastern countries even possess Sites and Monuments Records, which is an important first step, although some are looking to create them. It is therefore becoming increasingly important to establish simple criteria for preservation which can be easily applied, even when only limited information is available regarding sites. Given the previously mentioned complexities in international attitudes, and the need to incorporate the unique features of different regions, it is unknown whether a standardised set of guidelines would be possible, although if it were, it would be unarguably useful. Furthermore, the creation of any such criteria must be developed as part of a co-operative partnership with many organisations, not least the countries responsible for their heritage.

10.5 – Concluding Remarks

This thesis has endeavoured to show that damage to archaeological sites is not simple, and nor is it static. Whilst focussing on site damage in peace time, it is part of an on-going cycle of war and peace (Figure 10-1). Certain types of damage are a direct result of conflict, and others are associated with instability, a by-product of unrest. Equally, periods of stability allow the expansion of peace-time damage threats, such as those detailed in this study.

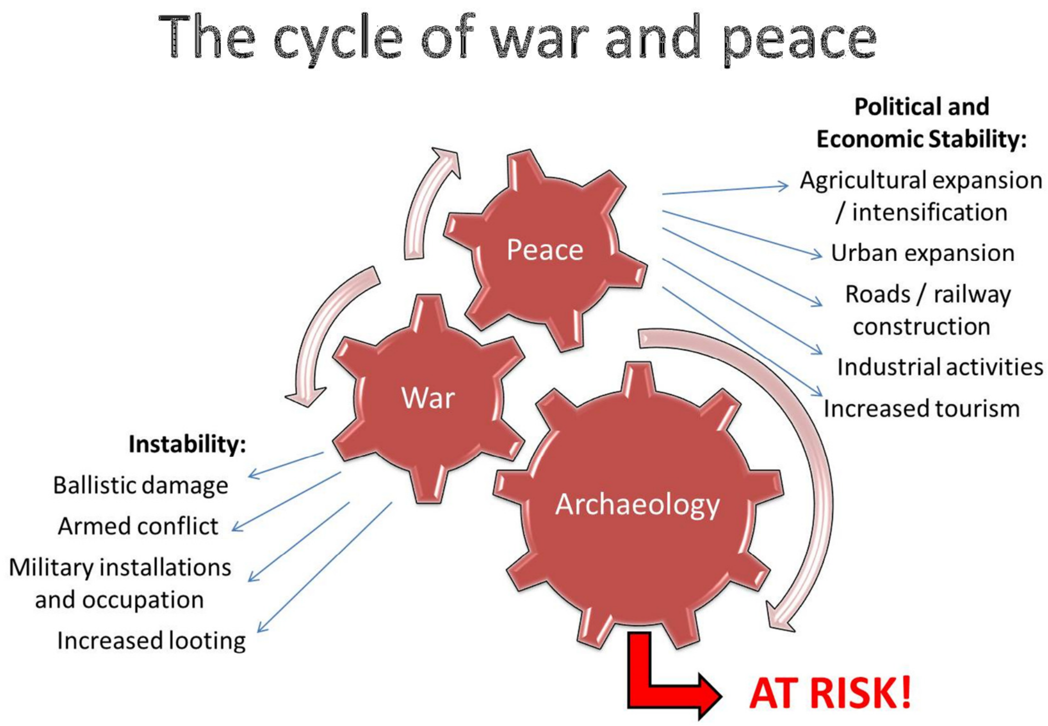


Figure 10-1: The Cycle of War and Peace

It should be stressed that these are not mutually exclusive. For example, farming occurs in war, and looting, as demonstrated, can occur in peace. Conflict in one region does not mean conflict in all areas, and widespread stability does not preclude hostilities. This thesis has deliberately excluded the recent damage done to Syria's cultural heritage in the current unrest, as the consequences are significantly beyond the scope of this study and may not be quantifiable for years to come, if ever.

Damage to archaeological sites is a thing of the past, the present, and the future. We cannot live for the past - we must acknowledge the needs of the present, whilst striving to create a future that allows both. We cannot save everything: it is hoped this thesis provides the first steps in considering what should be saved, and how.

"If there had been good prospect that the ruin should stand as it had stood for over a thousand years, uninjured save by the winter rains, it ought to have been allowed to remain intact in the rolling country to which is gave so strange an impress of delicate and fantastic beauty; but the railway has come near, and the plains will fill up, and neither Syrian fellāh nor Turkish solider can be induced to spare walls that can be turned to practical uses. Therefore let those who saw it when it yet stood unimpaired, cherish its memory with gratitude"

Gertrude Bell (1907: 45).

Bibliography

Adams, R. M. 1981. *Heartland of Cities: Surveys of Ancient Settlement and Land Use on the Central Floodplain of the Euphrates.* Chicago: The University of Chicago Press.

Agapiou, A., Hadjimitsis, D. G., Alexakis, D. and Sarris, A. 2012. Observatory Validation of Neolithic Tells ("Magoules") in the Thessalian Plain, Central Greece, Using Hyperspectral Spectroradiometric Data. *Journal of Archaeological Science* 39 (5), 1499-1512.

Akkermans, P. and Schwarz, G. 2003. *The Archaeology of Syria: From Complex Hunter-Gatherers to Early Urban Societies.* Cambridge: Cambridge University Press.

Allen, M. J. 1991. Analysing the Landscape: A Geographical Approach to Archaeological Problems. *In:* Schofield, A. J. (ed.) *Interpreting Artefact Scatters: Contributions to Ploughzone Archaeology.* 4. Oxford: Oxbow, 39-57.

Altaweel, M. 2005. The Use of Aster Satellite Imagery in Archaeological Contexts. *Archaeological Prospection* 12 (3), 151-166.

Ammerman, A. J. 1985. Plow-Zone Experiments in Calabria, Italy. *Journal of Field Archaeology* 12 (1), 33-40.

Ammerman, A. J. and Feldman, M. W. 1978. Replicated Collection of Site Surfaces. *American Antiquity* 43 (4), 734-740.

Amnesty International. 2012. *Syria: Satellite Images from Aleppo Raise Concerns over Risk to Civilians* [Online]. Amnesty International. Available: http://www.amnesty.org/en/news/syria-satellite-images-aleppo-raise-concerns-over-risk-civilians-2012-08-07 [Accessed 10 August 2012].

Anderson, J. R. 1976. *A Land Use and Land Cover Classification System for Use with Remote Sensor Data.* Washington: U.S. Government Print. Office.

Aqdus, S. A., Hanson, W. S. and Drummond, J. 2012. The Potential of Hyperspectral and Multi-Spectral Imagery to Enhance Archaeological Cropmark Detection: A Comparative Study. *Journal of Archaeological Science* 39 (7), 1915-1924.

Aston, M. 1985. *Interpreting the Landscape: Landscape Archaeology and Local History.* London and New York: Routledge.

Astrium GEO-Information Services. 2008. Spot Image Introduces New Services for Google Earth Users. Available: http://www.spotimage.co.jp/web/en/805-spot-image-introduces-new-services-for-google-earth-users.php [Accessed 02 February 2009].

Astrium GEO-Information Services. 2012a. Preprocessing Levels and Location Accuracy. Available: http://www.astrium-geo.com/en/195-preprocessing-levels-and-location-accuracy [Accessed 26 June 2012].

Astrium GEO-Information Services. 2012b. *Spotcatalog* [Online]. Spot Image S. A. Available: http://catalog.spotimage.com/PageSearch.aspx [Accessed 26 June 2012].

Ball, W. 2000. *Rome in the East: The Transformation of an Empire.* London and New York: Routledge.

Ball, W., Tucker, D. and Wilkinson, T. J. 1989. The Tell Al-Hawa Project: Archaeological Investigations in the North Jazira 1986-87. *Iraq* 51, 1-66.

Beck, A. 2004. *The Evaluation of Corona and Ikonos Satellite Imagery for Archaeological Applications in a Semi-Arid Environment.* Ph.D. Thesis, Durham University.

Beck, A. 2007. Archaeological Site Detection: The Importance of Constrast. Paper given at: *RSPSoc*, 2007, Newcastle-Upon-Tyne, England. [Unpublished]. Available: http://leeds.academia.edu/AnthonyBeck/Papers/98725/Archaeological_site_detection_the_importance_of_contrast [Accessed 18 June 2010].
Beck, A., Philip, G., Abdulkarim, M. and Donoghue, D. 2007. Evaluation of Corona and Ikonos High Resolution Satellite Imagery for Archaeological Prospection in Western Syria. *Antiquity* 81 (1)**,** 161-175.
Bell, G. 1907. *The Desert and the Sown.* London: Heinemann.
Bintliff, J. and Snodgrass, A. 1988. Off-Site Pottery Distributions: A Regional and Interregional Perspective. *Current Anthropology* 29 (3)**,** 506-513.
Bintliff, J. L. 2000. The Concepts of 'Site' and 'Offsite' Archaeology in Surface Artefact Survey. *In:* Pasquinucci, M. & Trement, F. (eds.) *Non-Destructive Techniques Applied to Landscape Archaeology.* Oxford: Oxbow Books, 200-215.
Bintliff, J. L., Sbonias, K. and Populus Project (eds.) 1999. *Reconstructing Past Population Trends in Mediterranean Europe (3000 Bc - Ad 1800),* Oxford and Oakville: Oxbow Books.
Blasco, R., Rosell, J., Fernández Peris, J., Cáceres, I. and Vergès, J. M. 2008. A New Element of Trampling: An Experimental Application on the Level Xii Faunal Record of Bolomor Cave (Valencia, Spain). *Journal of Archaeological Science* 35 (6)**,** 1605-1618.
Boismier, W. A. 1997. *Modelling the Effects of Tillage Processes on Artefact Distributions in the Ploughzone : A Simulation Study of Tillage Induced Pattern Formation.* B.A.R. International Series 259. Oxford: Archaeopress.
Bonney, D. J. 1980. Damage by Medieval and Later Cultivation in Wessex. *In:* Hinchliffe, J. & Schadla-Hall, R. T. (eds.) *The Past under the Plough.* Directorate of Ancient Monuments and Historic Buildings – Occasional Paper No. 3. London: Department of the Environment, 41-48.
Bowden, M. and Royal Commission on Historical Monuments 1999. *Unravelling the Landscape: An Inquisitive Approach to Archaeology.* Stroud, Gloucestershire and Charleston, SC: Tempus.
Bowden, M. B. C., Ford, S., Gaffney, V. L. and Tingle, M. 1991. Skimming the Surface or Scraping the Barrel: A Few Observations of the Nature of Surface and Sub-Surface Archaeology. *In:* Schofield, A. J. (ed.) *Interpreting Artefact Scatters: Contributions to Ploughzone Archaeology.* 4. Oxford: Oxbow, 108-113.
Bradley, R. 2000. *An Archaeology of Natural Places.* London and New York: Routledge.
Brusasco, P. 2012. *Looting the Past. Syria's Cultural Heritage under Attack: Another Iraq? .* Adobe Digital Editions: libreriauniversitaria.it. E-book.
Burl, A. and Mortimer, N. 2005. *Stukeley's 'Stonehenge': An Unpublished Manuscript 1721-1724.* Yale: Yale University Press.
Burrows, W. E. 2006. *The Survival Imperative.* New York: Forge Books.
Butzer, K. W. 1982. *Archaeology as Human Ecology: Method and Theory for a Contextual Approach.* Cambridge: Cambridge University Press.
Butzer, K. W. and Freeman, L. G. 1986. Series Editors Foreward. *In:* Rosen, A. M. (ed.) *Cities of Clay.* Prehistoric Archaeology and Ecology. Chicago and London: The University of Chicago Press.
Butzer, K. W., Miralles, I. and Mateu, J. F. 1983. Urban Geo-Archaeology in Medieval Alzira (Prov. Valencia, Spain). *Journal of Archaeological Science* 10**,** 333-49.
Campbell, J., and Wynne, R. 2011. Introduction to Remote Sensing. Fifth Edition. New York: The Guildford Press
Casana, J. 2007. Structural Transformations in Settlement Systems of the Northern Levant. *American Journal of Archaeology* 111 (2)**,** 195-221.
Casana, J. 2008. Mediterranean Valleys Revisited: Linking Soil Erosion, Land Use and Climate Variability in the Northern Levant. *Geomorphology* 101 (3)**,** 429-442.

Casana, J., Cothren, J. and Kalayci, T. 2012. Swords into Ploughshares: Archaeological Applications of Corona Satellite Imagery in the near East. *Internet Archaeology* [Online]. Available: http://intarch.ac.uk/journal/issue32/casana_toc.html [Accessed 03 February 2013].
Clark, R. H. and Schofield, A. J. 1991. By Experiment and Calibration: An Integrated Approach to the Archaeology of the Ploughsoil. *In:* Schofield, A. J. (ed.) *Interpreting Artefact Scatters: Contributions to Ploughzone Archaeology.* 4. Oxford: Oxbow, 93-107.
Cooke, L. 2010. *Conservation Approaches to Earthen Architecture in Archaeological Contexts.* Oxford: Archaeopress.
Courty, M. A. 1994. Le Cadre Paléogéographique Des Occupations Humaines Dans Le Bassin Du Haut-Khabur (Syrie Du Nord-Est). Premiers Résultats. *PaleOrient* 20 (1)**,** 21-59.
Crawford, O. G. S. 1924. *Air Survey and Archaeology.* Southampton: His Majesty's Stationery Office at the Ordnance Survey.
Crawford, O. G. S. 1929a. *Air-Photography for Archaeologists.* London: His Majesty's Stationery Office at the Ordnance Survey.
Crawford, O. G. S. 1929b. Air Photographs of the Middle East. *Geographical Journal* 73**,** 497-512.
Crewe, L. and Hill, I. 2012. Finding Beer in the Archaeological Record: A Case Study from Kissonerga-Skalia on Bronze Age Cyprus. *Levant* 44 (2)**,** 205-237.
Crowther, D. 1983. Old Land Surfaces and Modern Ploughsoil: Implications of Recent Work at Maxey, Cambs. *Scottish Archaeological Review* 2**,** 31-44.
Crowther, D. and Pryor, F. 1985. The Surface (Fieldwalking) Survey. *In:* Pryor, F. & French, C. A. (eds.) *The Fenland Project. No. 1, Archaeology and Environment in the Lower Welland Valley.* East Anglian Archaeology 1. Cambridge: Cambridgeshire Archaeological Committee, 44-53.
Cruells, W. 2004. Area L: The Soundings. In: Tunca, Ö. & Molist, M. (eds.) *Tell Amarna (Syrie) I: La Période De Halaf.* Louvain and Dudley (MA): Peeters, 15-36.
Cunliffe, E. 2012a. Damage to the Soul: Syria's Cultural Heritage in Conflict. Palo Alto: Global Heritage Fund. Available: http://ghn.globalheritagefund.com/uploads/documents/document_2107.pdf [Accessed 22 May 2012].
Cunliffe, E. 2012b. No World Heritage Site Safe in Syria. *Global Heritage Network Blog* [Online]. Available: http://globalheritagenetwork.ning.com/profiles/blogs/no-world-heritage-site-safe-in-syria [Accessed 01 December 2012].
Cunliffe, E. 2012c. Syria: Destroying the Past for the Future. *Antiquity* [Online], 86. Available: http://antiquity.ac.uk/projgall/cunliffe333/ [Accessed 01 November 2012].
Cunliffe, E. in press (a). "The Ways of Living". Syria's Past in an Uncertain Future. Paper given at: *ArcheoMed: Mediterranean Archaeology between Crisis and Conflicts*, in press, Chianciano Terme, Italy.
Cunliffe, E. in press (b). The Archaeological Landscape of the Tell Beydar Region: Satellite Imagery and its Implications for Settlement Patterning. In: Milano, L., and Lebeau, M. (ed). *Subartu XXXIII: Tell Beydar Environmental and Technical Studies Volume II*. Brepols: Turnhout, 89-108.
CZAP. n.d. *Shimshara*. The Central Zagros Archaeological Project [Online]. Available: http://www.czap.org/shimshara [Accessed 25 September 2013].
Darvill, T. and Fulton, A. K. (eds.) 1998. *Mars: The Monuments at Risk Survey of England, 1995,* Bournemouth: School of Conservation Sciences, Bournemouth University/English Heritage.
Darvill, T., Saunders, A. and Startin, B. 1987. A Question of National Importance: Approaches to the Evaluation of Ancient Monuments for the Monuments Protection Programme in England. *Antiquity* 61 (3)**,** 393 – 408.

Davis, M. J., Gdaniec, K. L. A., Brice, M., White, L. and English Heritage 2004. *Mitigation of Construction Impact on Archaeological Remains.* London: Museum of London Archaeology Service for English Heritage.
de Alba, S. D., Borselli, L., Torri, D., Pellegrini, S. and Bazzoffi, P. 2006. Assessment of Tillage Erosion by Mouldboard Plough in Tuscany (Italy). *Soil & Tillage Research* 85 (1-2), 123-142.
de Vaumas, É. 1956. La Djézireh. *Annales de Géographie* 65 (64-80).
del Olmo Lete, G. and Montero Fenollos, J.-L. (eds.) 1999. *Archaeology of the Upper Syrian Euphrates: The Tishrin Dam Area,* Barcelona: AUSA.
Devlin, J. F. 1983. *Syria: Modern State in an Ancient Land.* Boulder (Colo) and London: Westview Press.
Di Gregorio, A. and Food and Agriculture Organization of the United Nations 2005. *Land Cover Classification System: Classification Concepts and User Manual.* Environment and Natural Resources Series 8. Rome: Food and Agriculture Organization of the United Nations.
Diez-Martin, F. 2010. Evaluating the Effect of Ploughing on the Archaeological Record: The Early Middle Palaeolithic in the River Duero Basin Plateaus (North-Central Spain). *Quaternary International* 214 (1-2), 30-43.
DigitalGlobe News Room. 2012. Digitalglobe and Geoeye Agree to Combine to Create a Global Leader in Earth Imagery and Geospatial Analysis. *DigitalGlobe News Room* [Online]. Available: http://media.digitalglobe.com/press-releases/digitalglobe-and-geoeye-agree-to-combine-to-create-nyse-dgi-0911703 [Accessed 25 December 2012].
Donoghue, D., Galiatsatos, N., Philip, G. and Beck, A. 2002. Satellite Imagery for Archaeological Applications: A Case Study from the Orontes Valley, Syria. *In:* Bewley, R. & Raczkowski, W. (eds.) *Aerial Archaeology: Developing Future Practice.* Leszno, Poland: IOS Press, 211-223.
Donoghue, D. N. M. 2001. Remote Sensing. *In:* Brothwell, D. R. & Pollard, A. M. (eds.) *Handbook of Archaeological Sciences.* Chichester: J. Wiley & Sons Ltd, 551-560.
Drewett, P. L. 1980. The Sussex Plough Damage Survey. *In:* Hinchliffe, J. & Schadla-Hall, R. T. (eds.) *The Past under the Plough.* Directorate of Ancient Monuments and Historic Buildings – Occasional Paper No. 3. London: Department of the Environment, 69-77.
Dunnell, R. C. and Simek, J. F. 1995. Artifact Size and Plowzone Processes. *Journal of Field Archaeology* 22 (3), 305-319.
Emberling, G., Hanson, K. and Gibson, M. (eds.) 2008. *Catastrophe! : The Looting and Destruction of Iraq's Past,* Chicago, IL: Oriental Institute of the University of Chicago.
English Heritage 2008a. *Climate Change and the Historic Environment.* English Heritage.
English Heritage 2008b. Conservation Bulletin: Adapting to a Changing Climate. *A Bulletin of the Historic Environment* 57 (Spring), 1-11.
Eren, M. I., Durant, A., Neudorf, C., Haslam, M., Shipton, C., Bora, J., Korisettar, R. and Petraglia, M. 2010. Experimental Examination of Animal Trampling Effects on Artifact Movement in Dry and Water Saturated Substrates: A Test Case from South India. *Journal of Archaeological Science* 37 (12), 3010-3021.
Ergenzinger, P. J., Frey, W., Kuhne, H. and Kurschner, H. 1988. Reconstruction of Environment, Irrigation and Development of Settlement on the Habur in North-East Syria. *In:* Bintliff, J. L., Davidson, D. A. & Grant, E. G. (eds.) *Conceptual Issues in Environmental Archaeology.* Edinburgh: Edinburgh University Press, 108-128.
Everson, P. and Williamson, T. (eds.) 1998. *The Archaeology of Landscape: Studies Presented to Christopher Taylor,* Manchester: Manchester University Press.

FAO Statistics Division. 2013. *Faostat: Land*. Dataset: FAOSTAT: Land Use Database. Food and Agriculture Organization of the United Nations. Available: http://faostat.fao.org/site/291/default.aspx [Accessed 17 April 2013].

Fielding, J. L. and Gilbert, G. N. 2006. *Understanding Social Statistics.* London: Sage.

Finlayson, B. and Dennis, S. 2002. Landscape, Archaeology and Heritage. *Levant* 34**,** 219-227.

Fragile Crescent Project. 2010. *Satellite Imagery Analysis* [Online]. Durham: Durham University. Available: http://www.dur.ac.uk/fragile_crescent_project/satellite_imagery_analysis/ [Accessed 17 April 2013].

Francovich, R., Patterson, H. and Barker, G. (eds.) 2000. *Extracting Meaning from Ploughsoil Assemblages,* Oxford: Oxbow.

Frink, D. S. 1984. Artifact Behavior within the Plow Zone (News and Short Contributions). *Journal of Field Archaeology* 11 (3)**,** 356-363.

Galiatsatos, N. 2004. *Assessment of the Corona Series of Satellite Imagery for Landscape Archaeology: A Case Study from the Orontes Calley, Syria.* Ph.D. Thesis, University of Durham.

Galiatsatos, N., Wilkinson, T. J., Donoghue, D. N. M. and Philip, G. 2009. The Fragile Crescent Project (Fcp): Analysis of Settlement Landscapes Using Satellite Imagery. Paper given at: *Computer Applications to Archaeology, 2009*, 2009, Williamsburg, Virginia, USA. Available: http://www.caa2009.org/articles/Galiatsatos_Contribution365c.pdf. [Accessed 17 April 2013].

Gallant, T. W. 1986. "Background Noise" and Site Definition: A Contribution to Survey Methodology. *Journal of Field Archaeology* 13 (4)**,** 403-418.

Gerrard, C. M., Aston, M., Gidney, L., Gutierrez, A. and King, A. 2007. Fieldwalking. *In:* Gerrard, C. M. & Aston, M. (eds.) *The Shapwick Project, Somerset: A Rural Landscape Explored.* Society for Medieval Archaeology Monograph 25. London: Society for Medieval Archaeology and English Heritage.

Gibson, M. 2010. Series Editor's Preface. *In:* Gibson, M. (ed.) *Urbanism and Cultural Landscapes in Northeastern Syria: Tell Hamoukar Series.* Chicago: Oriental Institute Publications, xxi-xxiv.

Gill, D. 2008. Iraq: The Scale of Looting. In: *Looting Matters: Discussion of the archaeological ethics surrounding the collecting of antiquities.* [Online]. Available from: http://lootingmatters.blogspot.co.uk/2008/03/iraq-scale-of-looting.html [Accessed 20 April 2012].

Gillings, M., Mattingley, D. and van Dalen, J. (eds.) 1999. *Geographical Information Systems and Landscape Archaeology,* Oxford: Oxbow Books.

Göyünç, N. and Hütteroth, W. D. 1997. *Land an Der Grenze: Osmanische Verwaltung Im Heutigen Türkisch-Syrisch-Irakischen Grenzgebiet Im 16. Jahrhundert.* Istanbul: Eren.

Grøn, O., Palmér, S., Stylegar, F.-A., Esbensen, K., Kucheryavski, S. and Aase, S. 2011. Interpretation of Archaeological Small-Scale Features in Spectral Images. *Journal of Archaeological Science* 38 (9)**,** 2024-2030.

Hammond, A. A. 1973. Prolonging the Life of Earth Buildings in the Tropics. *Building Research & Practice* 19**,** 154-163.

Hayajneh, H. and McQuitty, A. 2012. Fawwaz Al-Khraysheh, 1955-2011. *Levant* 44 (2)**,** 137-138.

Hinchliffe, J. 1980. Effects of Ploughing on Archaeological Sites: Assessment of the Problem and Some Suggested Approaches. *In:* Hinchliffe, J. & Schadla-Hall, R. T. (eds.) *The Past under the Plough.* Directorate of Ancient Monuments and Historic Buildings – Occasional Paper No. 3. London: Department of the Environment, 11-17.

Hogarth, D. G. 1914. *Carchemish. Part I: Introductory.* London: The British Museum.

Hole, F. 2002-3. Khabur Basin Project, 1986-2001. *Les Annales Archéologiques Arabes Syriennes* 45-46, 11-20.
Hole, F. 2006. Agricultural Sustainability in the Semi-Arid near East. *Climate of the Past Discussions* 2 (4), 485-518.
Homer, C., Dewitz, J., Fry, J., Coan, M., Hossain, N., Larson, C., Herold, N., McKerrow, A., VanDriel, J. N. and Wickham, J. 2007. Completion of the 2001 National Land Cover Database for the Conterminous United States. *Photogrammetric Engineering and Remote Sensing* 37 (4), 337-341.
Houben, H. and Guillaud, H. 1994. *Earth Construction: A Comprehensive Guide.* London: Intermediate Technology Publications.
Howard, A. J., Challis, K., Holden, J., Kincey, M. and Passmore, D. G. 2008. The Impact of Climate Change on Archaeological Resources in Britain: A Catchment Scale Assessment. *Climatic Change* 91 (2), 405-422.
Hritz, C. 2010. Tracing Settlement Patterns and Channel Systems in Southern Mesopotamia Using Remote Sensing. *Journal of Field Archaeology* 35 (2), 184-203.
Hritz, C. 2013. A Malarial-Ridden Swamp: Using Google Earth Pro and Corona to Access the Southern Balikh Valley, Syria. *Journal of Archaeological Science* 40 (4), 1975-1987.
Hritz, C. and Wilkinson, T. J. 2006. Using Shuttle Radar Topography to Map Ancient Water Channels in Mesopotamia. *Antiquity* 80, 415-424.
Huisman, D. J. 2012. Deep Impact: What Happens When Archaeological Sites Are Built On? *Conservation and Management of Archaeological Sites* 14 (1-4), 60-71.
Huisman, D. J., Müller, A. and van Doesburg, J. 2011. Investigating the Impact of Concrete Driven Piles on the Archaeological Record Using Soil Micromorphology: Three Case Studies from the Netherlands. *Conservation and Management of Archaeological Sites* 13 (1), 8-30.
Hurtado, V. 2000. Surface Analysis of the Copper Age Settlement of La Pijotilla (Spain). *In:* Francovich, R., Patterson, H. & Barker, G. (eds.) *Extracting Meaning from Ploughsoil Assemblages.* The Archaeology of Mediterranean Landscapes Series 5. 3rd ed. Oxford: Oxbow, 121-131.
Hütteroth, W.-D. 1990. Villages and Tribes of the Gezira under Early Ottoman Administration (16th Century): A Preliminary Report. *Berytus* 38, 179-184.
Hütteroth, W.-D. 1992. Settlement Desertion in the Gezira between the 16th and 19th Century. *In:* Philipp, T. (ed.) *The Syrian Land in the 18th and 19th Century: The Common and the Specific in the Historical Experience.* Stuttgart: F. Steiner, 285-291.
Hütteroth, W.-D. and Abdulfattah, K. 1977. *Historical Geography of Palestine, Transjordan and Southern Syria in the Late 16th [Sixteenth] Century.* Erlangen: Fränkische Geographische Ges. Palm und Enke [in Komm.].
ICOMOS 1964. *The Venice Charter.* Paris: ICOMOS.
ICOMOS 1999. *The Burra Charter.* Paris: ICOMOS.
IFAD. 2008. *Rural Poverty Portal: Syria (2008)*. Dataset: Statistics. Version: 2008. International Fund for Agricultural Development. Available: http://www.ruralpovertyportal.org/country/statistics/tags/syria [Accessed 28 January 2010].
IFAD. 2010. *Rural Poverty Portal: Syria (2010)*. Dataset: Statistics. Version: 2010. International Fund for Agricultural Development. Available: http://www.ruralpovertyportal.org/country/statistics/tags/syria [Accessed 19 February 2012].
İnalcık, H. 1978. *The Ottoman Empire: Conquest, Organization and Economy.* London: Variorum Reprints.
İnalcık, H. 1993. *The Middle East and the Balkans under the Ottoman Empire: Essays on Economy and Society.* Bloomington: Indiana University Turkish Studies.

İnalcık, H. 1995. *From Empire to Republic: Essays on Ottoman and Turkish Social History.* Istanbul: Isis Press.
İnalcık, H. 2000. *The Ottoman Empire: The Classical Age 1300-1600.* London: Phoenix Press.
İnalcık, H. 2006. *Turkey and Europe in History.* Istanbul: Eren.
İnalcık, H. and Quataert, D. (eds.) 2004. *An Economic and Social History of the Ottoman Empire,* Cambridge: Cambridge University Press.
Irin and sb/at/cb. 2010. Syria: Drought Pushing Millions into Poverty. *IRIN*, 9 September 2010, Available: http://www.irinnews.org/Report/90442/SYRIA-Drought-pushing-millions-into-poverty [Accessed].
Jaquin, P. and Augarde, C. 2012. *Earth Building : History, Science and Conservation.* Bracknell: IHS BRE Press.
Jaquin, P. A. 2008. *Analysis of Historic Rammed Earth Construction.* Ph.D. Thesis, Durham University.
Keable, J. 1996. *Rammed Earth Structures: A Code of Practice.* London: Intermediate Technology.
Kennedy, D. 1998a. Declassified Satellite Photographs and Archaeology in the Middle East: Case Studies from Turkey. *Antiquity* 72, 553-61.
Kennedy, D. and Bewley, R. 2008. Aerial Archaeology in Jordan Project. *Bulletin of the Council for British Research in the Levant* 3 (1), 52-54.
Kennedy, D. and Bewley, R. 2009. Flying Past: Jordan's Changing Landscapes from the Air. *Bulletin of the Council for British Research in the Levant* 4 (1), 11-18.
Kennedy, D. and Bishop, M. C. 2011. Google Earth and the Archaeology of Saudi Arabia : A Case Study from the Jeddah Area. *Journal of Archaeological Science* 38 (6), 1284-1293.
Kennedy, D. L. 1982. *Archaeological Explorations on the Roman Frontier in North-East Jordan: The Roman and Byzantine Military Installations and Road Network on the Ground and from the Air* B.A.R. International Series 132. Oxford, England: B.A.R.
Kennedy, D. L. 1998b. Aerial Archaeology in Jordan. *Levant* 30, 91-96.
Kennedy, D. L. 2012. Pioneers above Jordan: Revealing a Prehistoric Landscape. *Antiquity* 86 (332), 471-491.
Kennedy, D. L. and Bewley, R. 2010. Archives and Aerial Imagery in Jordan. Rescuing the Archaeology of Greater Amman from Rapid Urban Sprawl. *In:* Cowley, D., Standring, R. A. & Abicht, M. J. (eds.) *Landscapes through the Lens : Aerial Photographs and Historic Environment.* Oxford: Oxbow Books, 193-206.
Kennedy, D. L. and Riley, D. N. 1990. *Rome's Desert Frontier from the Air.* Austin: University of Texas Press.
Kila, J. D. 2012. *Heritage under Seige: Military Implementation of Cultural Property Protection Following the 1954 Hague Convention.* Heritage and Identity. Leiden: Brill.
Kincey, M. and Challis, K. 2010. Monitoring Fragile Upland Landscapes: The Application of Airborne Lidar. *Journal for Nature Conservation* 18 (2), 126-134.
Kirby, A. and Kirkby, M. J. 1976. Geomorphic Process and the Surface Survey of Archaeological Sites in Semi-Arid Areas. *In:* Davidson, D. A. & Shackley, M. L. (eds.) *Geoarchaeology: Earth Science and the Past.* London: Duckworth, 229-253.
Kouchoukos, N. 1998. *Landscape and Social Change in Late Prehistoric Mesopotamia.* Ph.D. Thesis, Yale University.
Kouchoukos, N. 2001. Satellite Images and near Eastern Landscapes. *Near Eastern Archaeology* 64 (1/2), 80-91.
Kühne, H. Year. The Effects of Irrigation Agriculture on Bronze Age & Iron Age Habitation Along the Khabur, Eastern Syria. *In:* Bottema, S., Entjes-Nieborg, G. & Zeist, W. V., eds. *Man's role in the shaping of the eastern Mediterranean*

landscape: INQUA/BAI Symposium on the Impact of Ancient Man on the Landscape of the Eastern Mediterranean Region and the Near East. Rotterdam, Netherlands; Brookfield, VT: A.A. Balkema, 15-30.

Kuzucuoğlu, C. 2007. Climatic and Environmental Trends During the Third Millennium Bc in Upper Mesopotamia Paper given at: *Sociétés humaines et changement climatique à la fin du troisième millénaire : une crise a-t-elle eu lieu en haute Mésopotamie? : actes du colloque de Lyon, 5-8 décembre 2005*, 2007, Istanbul. De Boccard and Institut français d'études anatolienne Georges-Dumézil, 459-80.

Lambrick, G. 1980. Effects of Modern Cultivation Equipment on Archaeological Sites. *In:* Hinchliffe, J. & Schadla-Hall, R. T. (eds.) *The Past under the Plough.* Directorate of Ancient Monuments and Historic Buildings – Occasional Paper No. 3. London: Department of the Environment, 18-21.

Lasaponara, R. and Masini, N. 2010. Facing the Archaeological Looting in Peru by Using Very High Resolution Satellite Imagery and Local Spatial Autocorrelation Statistics. *In:* Tania, D., Gervasi, O., Murgante, B., Pardede, E. & Apduhan, B. O. (eds.) *Computational Science and Its Applications - Iccsa 2010. International Conference Fukuoka, Japan, March 2010 Proceedings.* Part 1. Berlin and Heidelberg: Springer, 254-261.

Lawrence, D. 2012. *Early Urbanism in the Northern Fertile Crescent: A Comparison of Regional Settlement Trajectories and Millennial Landscape Change.* Ph.D. Thesis, Durham University.

Lebeau, M. 2006. Nabada (Tell Beydar), an Early Bronze Age City in the Syrian Jezirah. 2006, Tübingen. [Online]. Available: http://beydar.com/pdf/nabada-conf-en.pdf [Accessed 15 October 2012].

Lebeau, M. and Suleiman, A. (eds.) 1997. *Tell Beydar, Three Seasons of Excavations (1992-1994). A Preliminary Report,* Turnhout: Brepols.

Lebeau, M. and Suleiman, A. (eds.) 2003. *Tell Beydar, the 1995 to 1999 Seasons of Excavations. A Preliminary Report Tell Beydar, Rapport Préliminaire Sur Les Campagnes De Fouilles De 1995 À 1997,* Turnhout: Brepols.

Lebeau, M. and Suleiman, A. (eds.) 2007. *Tell Beydar: The 2000-2002 Seasons of Excavations, the 2003-2004 Seasons of Architectural Restoration : A Preliminary Report,* Turnhout: Brepols.

Lenihan, D. 1981. *The Final Report of the National Reservoir Inundation Study.* 1. Santa Fe: U.S. Dept. of the Interior, National Park Service, Southwest Cultural Resources Center.

Leveau, P. and Populus Project (eds.) 1999. *Environmental Reconstruction in Mediterranean Landscape Archaeology,* Oxford and Oakville: Oxbow Books.

Lewarch, D. E. and O'Brien, M. J. 1981a. Effect of Short-Term Tillage on Aggregate Provenence Surface Pattern. *In:* O'brien, M. J. & Lewarch, D. E. (eds.) *Plowzone Archeology: Contributions to Theory and Technique.* Publications in Anthropology no. 27. Nashville: Vanderbilt University, 7-49.

Lewarch, D. E. and O'Brien, M. J. 1981b. The Expanding Role of Surface Assemblages in Archaeological Research. *Advances in Archaeological Method and Theory* 4**,** 297-342.

Lewis, N. N. 1955. The Frontier of Settlement in Syria, 1800-1950. *International Affairs (Royal Institute of International Affairs 1944-)* 31 (1)**,** 48-60.

Lillesand, T. M., Kiefer, R. W. and Chipman, J. W. 2008. *Remote Sensing and Image Interpretation.* New York: John Wiley and Sons.

Lyonnet, B. 1996. La Prospection Archaeologique De La Partie Occidentale Du Haut Khabur (Syrie Du Nord-Est): Methodes, Resultats Et Questions Autour De L'occupation Aux Iiie Et Iie Millenaires Av. N. E. *Amurru* 1**,** 363-376.

Lyonnet, B. 2000. *Prospection Archéologique Du Haut-Khabur Occidental : Syrie Du N.E. Volume I.* Beirut; Paris: Institut français d'archéologie du Proche-Orient, Ma`had al-atar al-faransi li-l-Sarq al-Adná.

Mallowan, M. 1936. Excavations at Tell Chagar Bazar and an Archaeological Survey of the Habur Region. *Iraq* 3, 1-86.
Marchetti, N. 2012. Karkemish on the Euphrates: Excavating a City's History. *Near Eastern Archaeology* 75 (3), 132-147.
Marro, C. 2007. The Carchemish Region in the Early Bronze Age. *In:* Peltenburg, E. J. (ed.) *Euphrates River Valley Settlement.* Levant Supplementary Series 5. Oxford: Oxbow Books, 222-237.
Mattingly, D. 2000. Methods of Collection, Recording and Quantification. *In:* Francovich, R. & Patterson, H. (eds.) *Extracting Meaning from Ploughsoil Assemblages Archaeology of Mediterranean Landscapes 5.* Oxford: Oxbow, 5-15.
McDonald, J. H. 2009. *Handbook of Biological Statistics.* Baltimore, Maryland: Sparky House Publishing.
Menze, B. and Ur, J. A. 2007. Classification of Multispectral Aster Imagery in the Archaeological Survey for Settlement Sites in the near East. *Proc 10th International Symposium on Physical Measurements and Signatures in Remote Sensing (Ispmrs 07).* Davos: Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences.
Menze, B. H. and Ur, J. A. 2012. Mapping Patterns of Long-Term Settlement in Northern Mesopotamia at a Large Scale. *Proceedings of the National Academy of Sciences* 109 (12), 1-10.
Miles, D. 1980. Some Comments on the Effects of Agriculture in the Upper Thames Valley. *In:* Hinchliffe, J. & Schadla-Hall, R. T. (eds.) *The Past under the Plough.* Directorate of Ancient Monuments and Historic Buildings – Occasional Paper No. 3. London: Department of the Environment, 78-81.
Mittmann, S. and Schmitt, G. 2001. *Tübinger Bibelatlas : Auf Der Grundlage Des Tübinger Atlas Des Vorderen Orients (Tavo)*. Stuttgart: Deutsche Bibelgesellschaft.
Morgan, R. P. C. 2005. *Soil Erosion and Conservation.* Oxford: Blackwell.
Muir, R. 1999. *Approaches to Landscape.* Basingstoke: Macmillan.
Muir, R. 2000. *The New Reading the Landscape: Fieldwork in Landscape History.* Exeter: University of Exeter Press.
Munsell Color Company 1975. *Munsell Soil Color Charts.* Baltimore: Munsell Color.
NAPC. 2007. *Syria Agricultural Database*. National Agricultural Policy Centre. Available: http://www.napcsyr.org/sadb.htm [Accessed 28 January 2010].
Nicholson, R. J. 1980. Modern Ploughing Techniques. *In:* Hinchliffe, J. & Schadla-Hall, R. T. (eds.) *The Past under the Plough.* Directorate of Ancient Monuments and Historic Buildings – Occasional Paper No. 3. London: Department of the Environment, 21-25.
Nieuwenhuyse, O. and Wilkinson, T. J. 2008. Late Neolithic Settlement in the Area of Tell Beydar (Ne Syria). *In:* Lebeau, M. & Suleiman, A. (eds.) *Subartu 21: Beydar Studies 1* 21. Turnhout: Brepols, 268-303.
Nishiaki, Y. 1992. Preliminary Results of the Prehistoric Survey in the Khabur Basin, Syria: 1990-1991. *Paleorient* 18 (1), 97-102.
Nixon, T. 1998. Practically Preserved: Observations on the Impact of Construction on Urban Archaeological Deposits. *In:* Cornfield, M., Hinton, P., Nixon, T. & Pollard, M. (eds.) *Preserving Archaeological Remains in Situ? Proceedings of the Conference of 1st-3rd April, 1996.* Bradford: Museum of London Archaeology Service ; University of Bradford, Dept. of Archaeological Sciences, 39-46.
Nyrop, R. F. 1971. *Area Handbook for Syria.* Washington: American University Foreign Area Studies Division.
O'Dell, E. 2013. Slaying Saints and Torching Texts. *Jadaliyya* [Online]. Available: http://www.jadaliyya.com/pages/index/9915/slaying-saints-and-torching-texts [Accessed 20 March 2013].
Oates, J. 1982. Archaeological Evidence for Settlement Patterns in Mesopotamia and Eastern Arabia in Relation to Possible Environmental Conditions. *In:* Bintliff, J.

L. & Zeist, W. V. (eds.) *Palaeoclimates, Palaeoenvironments and Human Communities in the Eastern Mediterranean Region in Later Prehistory.* B.A.R. International Series 133. Oxford: B.A.R., 359-398.

Odell, G. H. and Cowan, F. 1987. Estimating Tillage Effects on Artifact Distributions. *American Antiquity* 52 (3), 456-484.

Ordnance Survey n.d. Map Reading: From the Beginner to the Advanced Map Reader. *In:* Ordnance Survey (ed.). Southampton: Ordnance Survey.

Osborn, A., Vetter, S., Hartley, R., Walsh, L. and Brown, J. 1987. Adverse Effects of Domestic Livestock Grazing on the Archaeological Resources of Capitol Reef National Park, Utah. *In:* Center, M. A. (ed.) *Midwest Archeological Center Occasional Studies in Anthropology.* 20. Lincoln: National Park Service, Midwest Archaeology Center, 136-153.

Palmer, C. 1999. Whose Land Is It Anyway? An Historical Examination of Land Tenure and Agriculture in Northern Jordan. *In:* Gosden, C. & Hather, J. G. (eds.) *The Prehistory of Food: Appetites for Change.* London, New York: Routledge, 288-305.

Parcak, S. 2007. Satellite Remote Sensing Methods for Monitoring Archaeological Tells in the Middle East. *Journal of Field Archaeology* 32 (1), 65-81.

Parcak, S. H. 2009. *Satellite Remote Sensing for Archaeology.* New York: Routledge.

Parks, L. 2009. Digging into Google Earth: An Analysis of "Crisis in Darfur". *Geoforum* 40 (4), 535-545.

Pasquinucci, M., Trément, F. and Populus Project (eds.) 2000. *Non-Destructive Techniques Applied to Landscape Archaeology,* Oxford: Oxbow.

Peddle, D. R., Peter White, H., Soffer, R. J., Miller, J. R. and LeDrew, E. F. 2001. Reflectance Processing of Remote Sensing Spectroradiometer Data. *Computers & Geosciences* 27 (2), 203-213.

Peltenburg, E. 2000. From Nucleation to Dispersal: Late Third Millennium Bc Settlement Pattern Transformations in the near East and Aegean. *In:* Studies, E. C. F. U. M., Rouault, O. & Wäfler, M. (eds.) *Subartu. 7: La Djéziré Et L'euphrate Syriens : De La Protohistoire À La Fin Du Iie Millénaire Av. J.-C. : Tendances Dans L'interprétation Historique Des Données Nouvelles.* VII. Brepols: Turnhout, 183-206.

Peltenburg, E. 1999. Tell Jerablus Tahtani 1992 - 1996: A Summary. *In:* Del Olmo Lete, G. & Montero Fenollos, J.-L. (eds.) *Archaeology of the Upper Syrian Euphrates: The Tishrin Dam Area.* Barcelona: AUSA, 97-105.

Peltenburg, E. 2006. Rescue Archaeology in the Middle Euphrates Valley. *Bulletin of the Council for British Research in the Levant* 1 (1), 18-21.

Peltenburg, E. (ed.) 2007a. *Euphrates River Valley Settlement,* Oxford: Oxbow Books.

Peltenburg, E. 2007b. New Perspectives on the Carchemish Sector of the Carchemish River Valley in the 3rd Millennium Bc. *In:* Peltenburg, E. (ed.) *Euphrates River Valley Settlement.* Levant Supplemetary Series 5. Oxford: Oxbow Books, 3-24.

Peltenburg, E. and Wilkinson, T. J. 2008. Jerablus and the Land of Carchemish. *Current Archaeology* [Online]. Available: http://www.archaeology.co.uk/cwa/world-news/jerablus-and-the-land-of-carchemish.htm [Accessed 17 February 2013].

Peltenburg, E. J., Campbell, S., Carter, S., Stephen, F., M, K and Tipping, R. 1997. Jerablus-Tahtani, Syria, 1996: Preliminary Report. *Levant* 29, 1-18.

Perthes, V. 1995. *The Political Economy of Syria under Asad.* London: Tauris.

Philip, G., Donoghue, D., Beck, A. and Galiatsatos, N. 2002. Corona Satellite Photography: An Archaeological Application from the Middle East. *Antiquity* 76 (1), 109-118.

Philip, G. and Dunford, R. 2013. *Research Projects. Vanishing Landscape of Syria: Ground and Space Mapping of a Diverse World* [Online]. Durham: Durham University. Available: http://www.dur.ac.uk/archaeology/research/projects/?mode=project&id=362 [Accessed 17 April 2013].

Philip, G., Lawrence, D. and Dunford, R. 2012. Issues of Confidence around Site Recognition and Definition as Addressed through High Resolution Remote-Sensing: Results from the Fragile Crescent Project. Paper given at: *Hi-res Workshop*, 2012, Bern, Germany. [Unpublished].

Picalause, V. C., N.; Lemaitre, S.; Vander Linden, M.; Van Berg, P. 2004. Desert-Kites of the Hemma Plateau (Hassake, Syria). *Paleorient* 20 (1), 89-99.

Poidebard, A. 1930. *Mission Archéologique En Haute Djéziré, 1928.* Paris: P. Geuthner.

Poidebard, A. 1934. *La Trace De Rome Dans Le Désert De Syrie; Le Limes De Trajan À La Conquête Arabe; Recherches Aériennes (1925-1932).* Paris: P. Geuthner.

Poidebard, A. 1938. *Il Limes Romano in Syria.* Roma: Ist.

Poidebard, A., Denise, F., Nordiguian, L. and Musée de l'Arles, a. 2004. *Une Aventure Archéologique : Antoine Poidebard, Photographe Et Aviateur.* Marseille, Arles and Beyrouth: Parenthèses, Musée de l'Arles et de la Provence antiques, and Presses de l'université Saint-Joseph.

Poidebard, A. and Mouterde, R. 1939. *Le Limes' De Chalcis Et La Route D'antioche À Palmyre.* Beyrouth: Impr. Cath.

Poidebard, A., Nordiguian, L., Salles, J.-F., Maison de l'Orient, m., Université, S.-J. and Fonds, P. 2000. *Aux Origines De L'archéologie Aérienne : A. Poidebard (1878-1955).* Beyrouth: Presses de l'Université Saint-Joseph.

Porter, A. 2004. The Urban Nomad: Counter the Old Clichés *In:* Nicolle, C. (ed.) *Nomades Et Sédentaires Dans Le Proche-Orient Ancient.* Amurru. Paris: Editions Recherche sur les Civilisations, 69-74.

Porter, A. 2012. *Mobile Pastoralism and the Formation of near Eastern Civilizations: Weaving Together Society.* Cambridge: Cambridge University Press.

Pournelle, J. 2007. Klm to Corona: A Bird's Eye View of the Cutural Ecology and Early Mesopotamian Urbanization. *In:* Stone, E. C. (ed.) *Settlement and Society: Essays Dedicated to Robert Mccormick Adams.* Los Angeles: Cotsen Institute of Archaeology, University of California, 29-61.

Pryor, F. 2008. *Seahenge : A Quest for Life and Death in Bronze Age Britain.* London: Harper Collins.

Redman, C. L. and Watson, P. J. 1970. Systematic, Intensive Surface Collection. *American Antiquity* 35 (3), 279-291.

Reynolds, P. J. 1982. The Ploughzone. *Festschriftzen 100 Jahrigen Jubitaunder Abteilung Vorgenschichteder Naturhisteorischen Gesellschaft [Festschriftzum 100 Jahrigen Bestehen Der Abteilung Für Vorgeschichte]* 315-341.

Reynolds, P. J. 1988. Sherd Movement in the Ploughzone – Physical Database into Computer Simulation. *In:* Ruggles, C. L. N. & Rahtz, S. P. Q. (eds.) *Computer and Quantitative Methods in Archaeology 1987.* B.A.R. International Series 446(i). Oxford: B.A.R., 201-221.

Reynolds, P. J. and Schadla-Hall, R. T. 1980. Measurement of Plough Damage and the Effects of Ploughing on Archaeological Material. *In:* Hinchliffe, J. & Schadla-Hall, R. T. (eds.) *The Past under the Plough.* Directorate of Ancient Monuments and Historic Buildings – Occasional Paper No. 3. London: Department of the Environment,, 114-122.

Ricci, A. and Wilkinson, T. J. 2009. War & Peace in Northern Iraq: A Perspective from Space. Paper given at: *BANEA*, 2009, Durham University, Durham. Unpublished.

Rick, J. W. 1976. Downslope Movement and Archaeological Intrasite Spatial Analysis. *American Antiquity* 41 (2), 133-144.

Robinson, S. A., Black, S., Sellwood, B. W. and Valdes, P. J. 2006. A Review of Palaeoclimates and Palaeoenvironments in the Levant and Eastern Mediterranean from 25,000 to 5000 Years Bp: Setting the Environmental Background for the Evolution of Human Civilisation. *Quaternary Science Reviews* 25 (13–14), 1517-1541.

Roper, D. C. 1976. Lateral Displacement of Artifacts Due to Plowing. *American Antiquity* 41 (3), 372-375.
Rosen, A. M. 1986. *Cities of Clay: The Geoarcheology of Tells.* Chicago: University of Chicago Press.
Rossignol, J. and Wandsnider, L. 1992. Space, Time, and Archaeological Landscapes: Introduction. *In:* Rossignol, J. & Wandsnider, L. (eds.) *Space, Time, and Archaeological Landscapes.* New York: Plenum Press, 3-16.
Rothfield, L. 2008. *Antiquities under Siege : Cultural Heritage Protection after the Iraq War.* Lanham, MD: AltaMira Press.
Rothfield, L. 2009. *The Rape of Mesopotamia : Behind the Looting of the Iraq Museum.* Chicago: University of Chicago Press.
Sabins, F. F. 1996. *Remote Sensing: Principles and Interpretation.* New York: W. H. Freeman and Co.
Sadr, K. and Rodier, X. 2012. Google Earth, Gis and Stone-Walled Structures in Southern Gauteng, South Africa. *Journal of Archaeological Science* 39 (4), 1034-1042.
Sai, B., Morrow, P. and van Genderen, P. Year. Limits of Detection of Buried Landmines Based on Local Echo Contrasts. *In: Workshop Proceedings of the 28th European Microwave Conference (EuMc) 9 October 1998: Workshop on High-Frequency Measurement Techniques for Interconnections and IC Packages used in Telecommunication and Computer Systems*, Amsterdam, The Netherlands. 121-125.
Sands, P. 2011. Un Extends Emergency Aid to Drought-Hit Syria. *The National*, 11 February 2011, Available: http://www.thenational.ae/news/world/middle-east/un-extends-emergency-aid-to-drought-hit-syria [Accessed].
Savage, S. H., Levy, T. E. and Jones, I. W. 2012. Prospects and Problems in the Use of Hyperspectral Imagery for Archaeological Remote Sensing: A Case Study from the Faynan Copper Mining District, Jordan. *Journal of Archaeological Science* 39 (2), 407-420.
Schiffer, M. B. 1983. Towards the Identification of Formation Processes. *American Antiquity* 48 (4), 675 - 706.
Schiffer, M. B. 1987. *Formation Processes of the Archaeological Record.* Albuquerque, NM: University of New Mexico Press.
Schofield, A. J. 1991. Interpreting Artefact Studies: An Introduction. *In:* Schofield, A. J. (ed.) *Interpreting Artefact Scatters: Contributions to Ploughzone Archaeology.* 4. Oxford: Oxbow, 3-8.
Shott, M. J. 1995. Reliability of Archaeological Records on Cultivated Surfaces: A Michigan Case Study. *Journal of Field Archaeology* 22 (4), 475-490.
Siegel, S. and Castellan, N. J. 1988. *Non Parametric Statistics for the Behavioral Sciences.* New York: McGraw-Hill.
Stone, E. C. 2008. Patterns of Looting in Southern Iraq. *Antiquity* 82 (1), 125-138.
Stone, P. and Farchakh-Bajjaly, J. (eds.) 2008. *The Destruction of Cultural Heritage in Iraq,* Woodbridge, Suffolk: Boydell Press.
Stronach, D. 1961. Excavations at Ras Al 'Amiya. *Iraq* 23 (2), 95-137.
Taylor, C. 1972. Man, Settlement and Urbanism. *In:* Ucko, P. J., Tringham, R. & Dimbleby, G. W. (eds.) *Man, Settlement and Urbanism : Proceedings of a Meeting of the Research Seminar in Archaeology and Related Subjects Held at the Institute of Archaeology, London University.* London: Duckworth, 109-114.
Taylor, J. 2000. Cultural Depositional Processes and Post-Depositional Problems. *In:* Francovich, R., Patterson, H. & Barker, G. (eds.) *Extracting Meaning from Ploughsoil Assemblages.* The Archaeology of Mediterranean Landscapes Series 5. 3rd ed. Oxford: Oxbow, 16-26.
Terrenato, N. 2000. The Visibility of Sites and the Interpretation of Field Survey Results: Towards an Analysis of Incomplete Distributions. *In:* Francovich, R. P., Helen; Barker, Graeme (ed.) *Extracting Meaning from Ploughsoil Assemblages.*

The Archaeology of Mediterranean Landscapes Series 5. 3rd ed. Oxford: Oxbow, 60-71.
The Open University 2009. *M248 Analysing Data: Block C.* Analysing Data Block C. Milton Keynes: Open University.
The World Bank 1955. *The Economic Development of Syria : Report of a Mission Organized by the International Bank for Reconstruction and Development at the Request of the Government of Syria.* Baltimore: Johns Hopkins Press.
The World Bank Group. 2009. *Data Profile: Syrian Arab Republic*. Dataset: World Development Indicators Database. Version: September 2009. The World Bank Group. Available: http://ddp-ext.worldbank.org/ext/ddpreports/ViewSharedReport?&CF=&REPORT_ID=9147&REQUEST_TYPE=VIEWADVANCED [Accessed 18 February 2010].
Trigo, R. M., Gouveia, C. M. and Barriopedro, D. 2010. The Intense 2007–2009 Drought in the Fertile Crescent: Impacts and Associated Atmospheric Circulation. *Agricultural and Forest Meteorology* 150 (9), 1245-1257.
Trubowitz, N. L. 1978. The Persistence of Settlement Pattern in a Cultivated Field. *In:* Engelbrecht, W. E. & Grayson, D. K. (eds.) *Essays in Northeastern Anthropology in Memory of Marian E. White.* Rindge, NH: Dept. of Anthropology, Franklin Pierce College, 41-66.
Tunca, Ö. 1999. Tell Amarna. Présentation Sommaire De Sept Campagnes De Fouilles (1991-7). *In:* Del Olmo Lete, G. & Montero Fenollos, J.-L. (eds.) *Archaeology of the Upper Syrian Euphrates: The Tishrin Dam Area.* Barcelona: AUSA, 129-36.
Tunca, Ö. and Molist, M. (eds.) 2004. *Tell Amarna (Syrie) I: La Période De Halaf,* Louvain and Dudley (MA): Peeters.
Turner, B. L., II, Hanham, R. Q. and Portararo, A. V. 1977. Population Pressure and Agricultural Intensity. *Annals of the Association of American Geographers* 67 (3), 384-396.
United States Geological Survey. 2009. *Earth Explorer* [Online]. U.S. Department of the Interior and U.S. Geological Survey Available: http://earthexplorer.usgs.gov/ [Accessed 19 November 2012].
United States Geolological Survey. 2012. *Land Cover Institute: Land Cover Data* [Online]. Available: http://landcover.usgs.gov/landcoverdata.php [Accessed 05 December 2012].
Ur, J. 2003. Corona Satellite Photography and Ancient Road Networks: A Northern Mesopotamian Case Study. *Antiquity* 77 (1), 102-115.
Ur, J. 2010a. *Landscapes of Settlement and Movement in Northeastern Syria*. Version: 1. Harvard University. Available: http://hdl.handle.net/1902.1/14011 [Accessed 19 July 2010].
Ur, J. 2010b. *Urbanism and Cultural Landscapes in Northeastern Syria.* Tell Hamoukar Series. Chicago: Oriental Institute Publications.
Ur, J. and Hammer, E. L. 2009. Pastoral Nomads of the Second and Third Millennia A.D. On the Upper Tigris River, Se Turkey: Archaeological Evidence from the Hirbemerdon Tepe Survey. *Journal of Field Archaeology* 34 (1), 37-56.
Ur, J., Karsgaard, P. and Oates, J. 2011. The Spatial Dimensions of Early Mesopotamian Urbanism: The Tell Brak Suburban Survey, 2003–2006. *Iraq* 73, 1-19.
Ur, J. and Wilkinson, T. J. 2008. Settlement and Economic Landscapes of Tell Beydar and Its Hinterland. *In:* Lebeau, M. & Suleiman, A. (eds.) *Subartu 21: Beydar Studies 1* 21. Turnhout: Brepols, 305-327.
Valdés Pereiro, C. Year. Tell Amarna on the Euphrates: New Archaeological Research. *In:* Matthiae, P., Romano, L. & Icaane, eds. *6th International Congress on the Archaeology of the Ancient Near East*, 2010, Rome. Wiesbaden: Harrassowitz, 743-754.

van Berg, P.-L., Cauwe, N., Hénin, J.-P., Lemaitre, S., Picalause, V. and Vander Linden, M. 2003. Fieldwork at the Archaeological and Rock Art Sites of the Hemma Plateau (Hassake, Syria): Season 2002. *Adumatu* 8**,** 7-20.

Van Ess, M., Becker, H., Fassbinder, J., Kiefl, R., Lingenfelder, I., Schreier, G. and Zevenbergen, A. 2006. Detection of Looting Activities at Archaeological Sites in Iraq Using Ikonos Imagery. Paper given at: *Beiträge zum 18. AGIT-Symposium, Salzburg,*, 2006, Heidelberg. Wiechmann-Verlag, 668-678.

van Liére, W. J. and Lauffray, J. 1954. Nouvelle Prospection Archeologique Dans La Haute Jezireh Syrienne. *Les Annales Archéologiques de Syrie* 4-5**,** 129-148.

Villeneuve, F. (ed.) 1985. *L'economie Rurale Et La Vie Des Campagnes Dans Le Hauran Antique (Ier Siècle Av. J.-C. –Viic Siècle Ap. . J.-C.) Une Approche,* Paris: Paul Geuthner.

Wagstaff, M. 1991. An Archaeological "Site" from a Geographical Perspective. *In:* Schofield, A. J. (ed.) *Interpreting Artefact Scatters: Contributions to Ploughzone Archaeology.* 4. Oxford: Oxbow, 9-10.

Wagstaff, M., J 1985. *The Evolution of Middle Eastern Landscapes: An Outline to Ad 1840.* London: Croom Helm.

Walker, P., Keable, R., Martin, J. and Maniatidis, V. 2005. *Rammed Earth: Design and Construction Guidelines.* Watford: BRE Bookshop.

Warren, J., ICOMOS and Sri Lanka National Committee 1993. *Earthen Architecture: The Conservation of Brick and Earth Structures. A Handbook.* Columbo, Sri Lanka: Sri Lanka National Committee of ICOMOS for the International Council of Monuments and Sites,.

Well, H. G. 1988. *When the Sleeper Wakes.* London: Macmillon.

Wilkinson, E. B., Wilkinson, T. J. and Peltenburg, E. J. 2011. Revisiting Carchemish: The Land of Carchemish Project in Syria, 2009 & 2010. *Antiquity* [Online], 85. Available: http://www.antiquity.ac.uk/projgall/wilkinson329/ [Accessed 09 January 2013].

Wilkinson, K., Philip, G. and Beck, A. 2006. Satellite Imagery as a Resource in the Prospection for Archaeological Sites in Central Syria. *Geoarchaeology* 21 (7)**,** 735-750.

Wilkinson, T., J. and Rayne, L. 2010. Hydraulic Landscapes and Imperial Power in the near East. *Water History* 2**,** 115-144.

Wilkinson, T. J. 1982. The Definition of Ancient Manured Zones by Means of Extensive Sherd-Sampling Techniques. *Journal of Field Archaeology* 9 (3)**,** 323-333.

Wilkinson, T. J. 1989. Extensive Sherd Scatters and Land-Use Intensity: Some Recent Results. *Journal of Field Archaeology* 16 (1)**,** 31-46.

Wilkinson, T. J. 1993. Linear Hollows in the Jazira, Upper Mesopotamia. *Antiquity* 67 (256)**,** 548.

Wilkinson, T. J. 2000. Archaeological Survey of the Tell Beydar Region, Syria 1997. *In:* Van Lerberghe, K., Voet, G. & Studies, E. C. F. U. M. (eds.) *Subartu 6: Tell Beydar: Environmental and Technical Studies.* 6. Brepols: Turnhout, 1-37.

Wilkinson, T. J. 2003. *Archaeological Landscapes of the near East.* Tucson: University of Arizona Press.

Wilkinson, T. J. 2007a. Archaeological Regions in the Neighborhood of Carchemish. *In:* Peltenburg, E. J. (ed.) *Euphrates River Valley Settlement : The Carchemish Sector in the Third Millennium BC.* Oxford: Oxbow Books.

Wilkinson, T. J. 2007b. Research Reports from Syria: The Land of Carchemish Project. *Bulletin of the Council for British Research in the Levant* 2 (1)**,** 72-75.

Wilkinson, T. J. and Cunliffe, E. 2012. The Archaeological Landscape of the Tell Beydar Region: An Update Using Satellite Imagery. *In:* Boiy, T., Bretschneider, J., Goddeeris, A., Hameeuw, H., Jans, G. & Tavernier, J. (eds.) *The Ancient near East, a Life! Festschrift Karel Van Lerberghe* Orientalia Lovaniensia Analecta 220. Leuven: Uitgeverij Peeters En Departement Oosterse Studies, 665 – 679.

Wilkinson, T. J., French, C., Ur, J. A. and Semple, M. 2010. The Geoarchaeology of Route Systems in Northern Syria. *Geoarchaeology* 25 (6), 745-771.
Wilkinson, T. J., Galiatsatos, N., Lawrence, D., Ricci, A., Dunford, R. and Philip, G. 2012. Late Chalcolithic and Early Bronze Age Landscapes of Settlement and Mobility in the Middle Euphrates: A Reassessment. *Levant* 44 (2), 139-185.
Wilkinson, T. J. and Peltenburg, E. 2009. Long-Term Landscape and Settlement Studies: Archaeological Surveys in the Land of Carchemish, Syria: 2008. *Bulletin of the Council for British Research in the Levant* 4 (1), 33-38.
Wilkinson, T. J. and Peltenburg, E. 2010. Feature Articles Carchemish in Context: Surveys in the Hinterland of a Major Iron Age City. *Bulletin of the Council for British Research in the Levant* 5 (1), 11-20.
Wilkinson, T. J., Peltenburg, E. J., McCarthy, A., Wilkinson, E. B. and Brown, M. 2007. Archaeology in the Land of Carchemish: Landscape Surveys in the Area of Jerablus Tahtani, 2006. *Levant* 39, 213-247.
Wilkinson, T. J., Rekavandi, H. O., Hopper, K., Priestman, S., Roustaei, K. and Galiatsatos, N. 2013. The Landscapes of the Gorgān Wall. *In:* Sauer, E. W., Rekavandi, H. O., Wilkinson, T. J. & Nokandeh, J. (eds.) *Persia's Imperial Power in Late Antiquity: Sasanian Frontier Walls, Forts and Landscapes of Northern Iran (the Joint Fieldwork Project on the Great Wall of Gorgān, the Wall of Tammīsheh and Other Sites in the Frontier Zone: 2005-2009).* British Institute of Persian Studies Monograph. Oxford: Oxbow Books, 25-132.
Wilkinson, T. J. and Tucker, D. J. 1995. *Settlement Development in the North Jazira, Iraq: A Study of the Archaeological Landscape.* Warminster, England: Aris & Phillips.
Wilkinson, T. J., Ur, J. and Casana, J. 2004. Wider Perspectives. From Nucleation to Dispersal : Trends in Settlement Pattern in the Northern Fertile Crescent *In:* Alcock, S. E. & Cherry, J. F. (eds.) *Side-by-Side Survey: Comparative Regional Studies in the Mediterranean World.* Oxford: Oxbow Books, 180-203.
Wilkinson, T. J. and Wilkinson, E. B. 2010. Carchemish Outer Town Survey and Conservation Report: 2010. Report to the Global Heritage Fund. Unpublished: Durham University.
Williams, J., Sidell, J. and Panter, I. 2007. *Piling and Archaeology : An English Heritage Guidance Note.* Swindon: English Heritage.
Williamson, T. 1998. Questions of Preservation and Destruction. *In:* Everson, P. & Williamson, T. (eds.) *The Archaeology of Landscape: Studies Presented to Christopher Taylor.* Manchester: Manchester University Press, 1-24.
Woolley, C. L. 1921. *Carchemish. Report on the Excavations at Jerablus on Behalf of the British Museum. Part Ii: The Town Defences.* London: The British Museum.
Wossink, A. 2009. *Challenging Climate Change. Competition and Cooperation among Pastoralists and Agriculturalists in Northern Mesopotamia (C. 3000-1600 Bc).* Leiden: Sidestone Press.
Wright, H. T., Wilkinson, T. J., Gibson, M. and Stone, E. C. 2003. The National Geographic Society's Cultural Assessment of Iraq. *National Geographic* 2003 (May).
Yorston, R. M. 1990. Comment on Estimating Tillage Effects on Artifact Distributions. *American Antiquity* 55 (3), 594-598.
Yorston, R. M., Gaffney, V. L. and Reynolds, P. J. 1990. Simulation of Artefact Movement Due to Cultivation. *Journal of Archaeological Science* 17 (1), 67-83.