Conclusion

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In reviewing a volume inspired by another archaeological luminary, Randall McGuire (2014) identifies two problems with the *Festschrift* genre. First, in attempting to reflect the interests of the individual scholar being honoured, such volumes become rather disparate collections of essays lacking thematic coherence. Second, the emotional and political implications of picking and choosing contributors and editing contributions result in a decline in overall quality. We have tried to mitigate these problems in this book by focusing on a relatively narrow topic and by inviting contributions from Tony's students and project collaborators rather than a selection of the great and the good. As a result, the volume does not do justice to the extraordinary scope of Tony's scholarship and expertise, which ranged geographically from the UK to Southern Arabia and Iran, and temporally from the Neolithic to Medieval periods. Rather, the contributors were asked to celebrate a particular aspect of Tony's work, his pioneering use of remote sensing and large-scale datasets in landscape archaeology, in the hope of producing a more useful final collection. This concluding chapter seeks to draw out some of the emergent themes of these contributions and to suggest what new agendas in remotes sensing and landscape archaeology in the ancient Near East might look like.

Prospection and site mapping

Much has changed since the early days of landscape archaeology as applied to the Near East (for a useful overview see Hritz 2014). When Tony first began to work in the field during the 1970s and 80s, the tensions resulting from the Cold War meant that it was difficult to obtain detailed maps, let alone remote sensing data such as aerial photographs. Landsat satellite data were available by the early 1970s, but offered very coarse resolution (initially over 80m (Heaslip 1977), although resolution of 30m was available by the 1980s), and were used for land cover mapping as much as the detection of individual sites and features. That said, Landsat imagery played a role in site location during Tony's North Jazira Project in the late 1980s, although this was not widely publicised at the time. The real step-change occurred in the late 1990s and early 2000s with the declassification of CORONA and the growing availability of commercial high resolution and multispectral satellite data. Increased computational capability, the availability and higher accuracy of GPS devices, and improved spatial databases and analytical software such as GIS platforms, and of affordable hand-held computers that could be taken into the field, also played an important role. Taken together these innovations served to make what were once highly technical, laboratory-based techniques accessible and affordable to archaeological field teams. Much of the initial landscape work to make use of the new remote sensing data sources was highly empirical, focusing on defining and recognising sites and features in the landscape, both as an end in itself and as a way of enhancing traditional methods of Near Eastern survey. Remote sensing also facilitated a renewed interest in off-site features, including traces of water management and route systems which were relatively easy to identify on CORONA but often ephemeral or destroyed in the field. Such methods were not new as such, having been pioneered by Adams and others using aerial photographs in Southern Mesopotamia from the late 1950s (Adams 1981), but the massive increase in coverage of the new datasets was certainly transformative. In some areas, such as the lowlands basins of Syria, it quickly became clear that almost all known types of archaeological site were visible on the imagery, meaning the search for new sites could be largely driven by prospection through remote sensing (see Philip *et al.* 2005; Casana and Wilkinson 2005; Ur and Wilkinson 2008; Ur 2010). By demonstrating that the technique was able to recover a large proportion of the ancient settlement record, these projects served to disarm a somewhat skeptical survey research community, and allowed archaeology in the Middle East to continue to pitch its landscape projects at a relatively large scale, resisting the trend in adjacent areas, such as Cyprus and the Aegean, for the ever more intense field-walking of increasingly small study units. In some respects, the emergence of remote sensing permitted Near Eastern archaeology to side-step the kind of 'small but perfectly formed' projects that both Blanton (2001) and Kowaleski (2008) viewed as having undermined the ability of researchers to address large-scale questions. More than a decade later, this methodology has become the norm in much archaeological survey work, as demonstrated by the flurry of projects currently underway in Iraqi Kurdistan.

The increasingly efficient recognition and documentation of sites is to be applauded, and represents a major contribution to landscape archaeology. Furthermore, the scope for continuing empirical work of this nature is enormous; the Near East is a vast geographical area and there are many parts which have not been sufficiently studied either in the field or remotely, for political, academic, logistical or happenstance reasons. However, there are clear areas where these sorts of approaches could be improved. It is somewhat remarkable to note that we are still not entirely sure why certain archaeological sites and features are visible on certain types of imagery, and that this fundamental subject has received relatively little attention. This is particularly true of un-mounded sites which show up as soil discolourations on the imagery and are frequently Iron Age or later in date. The few analyses which have been conducted suggest that some combination of particle size, soil moisture and mineral composition are all involved (Wilkinson *et al.* 2006; Beck *et al.* 2007) but we do not as yet have a series of general principles for understanding the causes of reflectivity in, and consequent visibility of, anthropogenic signatures. Developing such principles is vital in order to understand where different sorts of remote sensing will be most effective, assess what is missing from the record and examine the relationship between site extents in the field and on the imagery. CORONA imagery has, for example, proved relatively effective at detecting sites in upland landscapes in Syria where the building stone is predominantly volcanic (Philip *et al.* 2007) but less effective in areas where both structures and bedrock are limestone, as well as for recognising low, shallow-sided tells in Azerbaijan (Ricci *et al.* 2018) and Turkey (Lawrence 2012). This is almost certainly attributable to variations in the degree of contrast between the reflectivity of the various elements appearing in the image in different parts of the electromagnetic spectrum (Beck and Philip 2013).

Assessing the relative utility of imagery in different types of landscapes is also hampered by the absence of clear methodological descriptions of prospection techniques within publications, and the frequent identification of features through the visual inspection of imagery that has been subjected to a ‘standard’ transformation, when other methods of image manipulation might produce additional insights. Just as in archaeological survey, the amount of time and labour expended per unit area in examining an image, alongside other factors such as user experience and sampling techniques, will have a profound effect on the quality and quantity of archaeological information recovered, and yet these are rarely discussed explicitly, let alone considered from a cost-benefit perspective. Similarly, although recording the number of false positives (sites identified on imagery which when visited in the field prove not to be archaeologically relevant) is standard in predictive modelling of remote sensing datasets (Kwamme 2006), this is not the case for more qualitative interpretation methods, although these data were recorded by the Durham field team working in the Homs region of Syria (Philip *et al.* 2005). Collating this sort of information at a regional scale would give us a much better understanding of the relative effectiveness of our current approaches in different areas, allowing us to identify what may be missing from the archaeological record.

Broadening the scope of the discipline

A welcome recent trend in remote sensing and landscape archaeology in the Near East has been the willingness to move beyond simply describing the landscape and to engage with questions of interest outside the discipline. Given the bewildering array of data sources becoming available, complexity theory (Bentley and Maschner 2003; Kohler 2012) represents a promising theoretical strand because it integrates disparate data sources and examine how interactions between social and environmental variables, even at different scales, obtained from archaeological research can enhance our understanding of settlement and past land use. Beyond complexity, concepts such as human niche construction (Kendall *et al.* 2011) and resilience (Redman 2005) provide useful ways to look at human and environmental dynamics holistically and to move beyond simple deterministic hypotheses (Butzer and Endfield 2012).

Discussion around collapse and resilience brings us to palaeoclimate studies. Despite the growing wealth of data, and its obvious potential for understanding the human past, archaeologists have been rather reticent about engaging in these debates. This we attribute to the small-scale focus of most archaeological research projects which typically work on a single site or local area (for comment on a similar situation within the discipline of history, see Guldi, and Armitage 2014). However, disciplinary specialists also have a clear sense of the limitations of the archaeological evidence. Accordingly, the ‘high level’ debates have mainly been conducted by specialists in other fields, who have not always been cognisant of these issues. For example, claims that episodes of rapid climate change engendered major economic transitions and political disruptions (e.g. Staubwasser and Weiss 2006; Weniger *et al.* 2006), have not generally been borne out when the archaeological evidence is accorded detailed scrutiny (e.g. Flohr *et al.* 2015; Maher *et al.* 2011). A recent study (Clarke *et al.* 2016), has both argued that periods of high climatic variability may have been as important for driving change as unidirectional shifts, and demonstrated the degree to which local responses to just such an episode during the 4th millennium BC, differed according to their particular affordances and pre-existing social organisation.

While some very broad connections between climate and settlement can already be delineated at a regional level (Lawrence *et al.* 2016), interpretation is complicated by spatially divergent responses to what appear to be very clear climatic signals. The contrasting settlement trends in the northern and southern Levant (Wilkinson *et al.* 2014) during the later 3rd millennium BC, contemporary with a phase of growing aridity documented at Soreq Cave (Bar-Matthews *et al.* 2011), is a case in point. Additionally, the pollen evidence from from lakes in the Rift Valley does appear to reflect a unidirectional gradient (Langgut *et al.* 2015), hinting at the protean ways in which climate change could play out at the very local level in which most human experience was shaped.

It is clear that the growing breadth and depth of settlement datasets, created by augmenting field results by remotely sensed information are allowing us to ask new questions, as seen in the contributions of Rey and Lawrence and Smith. While the creation of large datasets will require new ways of comparing and integrating data collected by projects with quite distinct aims and methodologies, the potential of a large-scale approach has recently been demonstrated by an analysis of some over 50,000 sites in China spanning 8000–500 BC (Hosner *et al.* 2016) and which brings out major regional and temporal trends in settlement intensity. Our aim should be to offer a settlement-based account of long-term developments in the ancient Near East, one that can be interrogated at both local and regional scales, and that will provide a lens through which to examine critically the reliability of reconstructions of the past which draw largely upon the extant documentary sources.

The integration of remote sensing techniques and landscape archaeology with other data types is a theme that features in a number of papers. Those by Rey and LeCompte, Rattenborg and Brown make extensive use of textual sources to address questions relating to individual sites, settlement patterns and societal organisation. While analytical approaches allow us to make sense of disparate data, the layering of information from historical sources and remote sensing provides us with a way to identify features mentioned in texts, and better understand them. Environmental techniques are also becoming increasingly relevant, and the papers by Marsh and Altaweel, Jotheri and Allen, Hritz and Pournelle and Stone combine heavy use of remote sensing with detailed geomorphological studies and even phytolith analyses, and reveal that extent to which past environments may have differed quite significantly from, and thus offered opportunities at variance with, those documented in more recent times. Environmental approaches predominate among those papers concerned with Southern Mesopotamian, perhaps because of the importance of canals and other irrigation features visible on the imagery to understanding this highly complex landscape. The recognition and interpretation of water management systems represents one of the most fruitful areas of research for remote sensing in the Near East, as is evident from the papers by Rayne and Kaptijn. The remains of canals and channels are often visible on the imagery, and mapping such systems can lead directly to quite complex questions of political economy and social organisation.

Technology

The declining costs of imagery and the automation of processes necessary to utilise it, as well as the emergence of open access software such as Google Earth, are now having a further transformative effect. We saw in this volume that multiple data sources, including CORONA, multispectral, DEM, and high-resolution imagery are consistently used to assess a variety of landscape archaeological problems. Such data sources are often used together to best leverage each platform's advantages, while also integrating information with archaeological or geoarchaeological approaches such as survey and sediment analysis. In this volume, the papers by Stone, Hritz and Pournelle, Jotheri and Allen, Rey and LeCompte, and Sauer *et al.* all demonstrate the efficacy of such an approach and the interpretive power available through integrated mapping from sources within our current satellite array. Cunliffe and de Gruchy's paper takes this one step further, using an increasingly common method of comparing 1960s CORONA photography with modern imagery to assess damage to features in the landscape of the North Jazira (see below). It is clear that we need to continue to take advantage of new technologies as they become available in this rapidly developing discipline. Advances in Digital Elevation Models through techniques such as RADAR, LiDAR and CORONA photogrammetry, for example, will enable us to 'see' more of the landscape and extract archaeologically relevant information, whilst at a smaller scale the burgeoning use of drones also holds much promise.

Technological advances in sensors and platforms can be supplemented by advances in analytical techniques. Automated multi-source data fusion, where algorithms and techniques are allowing a more sophisticated statistical approach to data representation, are of interest here. Such fusion incorporates ground-, aerial-, and satellite-based systems, whereby elevation, multispectral, and photographic data are used together to identify features of relevance (Zhang 2015). With the availability and utilisation of high performance computing (HPC; Zare *et al.* 2014) in data fusion, we expect such approaches to become increasingly available to archaeologists. Automation has its critics, with some arguing for a greater use of 'brute force methods' (Casana 2014), meaning manual classification by trained image interpreters (one might read 'graduate students' here!). It is undoubtedly true that the current capabilities of computational site identification, whilst impressive (see, for example, Menze and Ur 2012), cannot replicate the interpretive capacities of genuine human expertise in understanding complex or ephemeral sites and features.

A further issue with the manual approach is the large amount of labour involved. This highlights the importance of understanding the likely costs and benefits of different methods, an area where our understanding remains underdeveloped. Given the need for substantial computational and digital storage capacity, access to software (and types of data) which involves a steep learning curve, some mathematical understanding on the part of the users, and support for data security, management and archiving, it becomes apparent that these techniques pose problems in terms of staff training and sustainable funding, quite different from those that have traditionally applied to field-based research. It is for this reason that, as with advanced biological archaeology, work undertaken in this area has occurred within large, well-funded projects, based in institutions that can attract and support post-graduates and research assistants required to perform the tasks of image processing, rectification, analysis, and other required techniques. While this situation is unlikely to change any time soon, an alternative model is provided by crowdsourcing platforms (Estellés-Arolas and González-Ladrón-de-Guevara 2012) which are increasingly being utilised in archaeology and offer both a new source of labour and new ways of engaging with the public. In either case, a key concern must be the quality of the data produced, and the variability introduced by multiple subjective interpretations.

On the fieldwork side, there is a lot Near East archaeology can learn from work done in other regions and even other disciplines, including Geography and Earth Sciences. Much of Tony's work involved extending ideas from other disciplines into archaeology to make better archaeological inferences. At a subsurface level, we are beginning to see the study of microfossils applied to wider areas in the Near East to understanding the past environment and its relationship to human societies (Rosen 2007). Cave systems, and speleothems in particular, are plentiful in the karstic landscapes of the Near East and have been proven (Bar-Matthews *et al.* 1997; Fleitmann *et al.* 2009) to be some of the best repositories of palaeoclimate data available to us. As new work is now spreading to some of these karstic regions, one expectation is a better exploitation of these data to resolve long-standing climatic and chronological debates and how they affect key events in the Near East, including the emergence of agriculture, early urbanism, and the rise and fall of empires.

Beyond mapping: scale

A major challenge in archaeology at a general level is how to deal with issues of scale, in terms of increased geographical space and temporal breadth, but also how we conceptualise social relations. Part of this problem comes from the nature of the material record itself, as the limitations of data often mean we can only hope to obtain snapshots of society or a general period overview. Despite this, assumptions are still made across social scales, linking decisions made at a local level to enduring institutions and broader patterns. In part, there are technical approaches that can address these considerations, including complexity modelling, GIS, spatial analysis, agent-based modelling and other analytical methods (Lock and Molyneaux 2006), but data limitations remain the primary hindrance in best utilising the techniques mentioned. High precision dating techniques and Bayesian modelling help to address some of the time-dependent issues by providing greater chronological precision (Ramsey 2009), but the high costs involved mean such dating is rarely applied at large volumes of samples, let alone across multiple sites and regions.

The growing availability of imagery, in combination with advances in computational power and storage, has led to a step-change in the scale of analysis being undertaken, exemplified in this volume in the papers by Casana, Lawrence and Rey, Iamoni, Smith, and Bradbury and Philip. Here, satellite imagery is being used to examine trends in the settlement of the living, and the disposal of the dead over very large regions, crossing national boundaries and traditional scholarly divisions such as that between northern Mesopotamia and the Levant. The production of such large datasets requires scholars to consider the quality and comparability of the underlying data, and to think about ways of capturing variations in recording techniques, chronological sequences and field methods (Alcock and Cherry 2004: 4). Finding ways to organise, display and interpret data at this expanded scale without becoming reductive is a further challenge. Chronological sensitivity is perhaps the most pressing of these challenges, and the time block approach developed for the Fragile Crescent Project in Durham to work around the issue of conflicting local periodisation schemes (Lawrence *et al.* 2012; Wilkinson *et al.* 2014) and used here by Bradbury and Philip, along with morphological interpretations used by Lawrence and Rey, and Casana, represent novel approaches in this area.

More generally, new theoretical concepts are required to articulate the relationships between individuals and societies, and to examine the material culture and landscape signatures visible in the archaeological record in this light (see papers in Robb and Pauketat 2012). The very broad scales at which landscape archaeology is now able to operate, particularly through the use of remote sensing approaches, can provide information on trends which are unrecognisable through other means. Recent work by the Fragile Crescent Project, for example, has demonstrated the presence of a range of trajectories of settlement in advance of the so-called 'second urban revolution' in Northern Mesopotamia and the Levant (Wilkinson *et al.* 2014; Lawrence and Wilkinson 2015). Certain kinds of social phenomena, such as empires, can have an impact over vast areas, and it is only by examining and combining data from multiple local sources that these effects can be discerned. We see the possibility of investigating empires at a scale which is consistent with, or even greater than, their actual physical footprint as an exciting new area of study.

Future developments: heritage

Whilst fieldwork across the Middle East may be curtailed by political events which render certain countries or regions inaccessible to archaeologists, particularly from the West, remote sensing can play a vital role in continuing research. Even more importantly, the ability of satellites to revisit specified locations on a regular basis provides an effective means of monitoring change — in particular site-damage through looting, deliberate destruction or opportunist activity such as uncontrolled development. It seems increasingly likely that when linked to appropriate database software, the large settlement datasets, created by research projects will make an important contribution to the creation of regional or national historic environment records, of a kind that will be vital for heritage organisations in the Near East and wider region. Steps in this direction are already being taken by projects such as the American Schools of Oriental Research Cultural Heritage Initiatives (http://www.asor-syrianheritage.org/) and Endangered Archaeology in the Middle East and North Africa (http://eamena.arch.ox.ac.uk/).

However, the growing dependence on large repositories of digital information highlights the need for capacity building within these bodies, and the development of retention strategies that recognise the attractiveness of personnel with good IT skills to a wide range of alternative employers. In terms of technical matters, the cost and licensing issues that attach to much commercial software mean that there may be an important role for free-to-use open source products. Furthermore, many of the issues of data quality, security and organisational sustainability that arise in the case of Western research institutions are likely to be even more acute in under-resourced regional antiquities offices; the potentially profound impact that the growth of non-Western modes of heritage governance (Winter 2014) might have upon the situation remains another imponderable.

Conclusion

As discussed in Gibson's introductory chapter, remote sensing has a long history in Near Eastern archaeology. A combination of factors, including the prevailing land cover and climate types, long term forms of settlement leaving marked archaeological traces and the recent geopolitical importance of the region, have led to a unique situation for archaeologists. There is arguably nowhere else in the world where such a large proportion of the material record is detectable from space and at the same time remote sensing sources through time are so plentiful. The importance of the region as an arena for the 'pristine' development of agriculture, social complexity, urbanism, and empires coupled with the current political conditions preventing or severely curtailing fieldwork in certain areas only adds to the importance of the remote sensing record. Historically, Near Eastern archaeologists have been relatively quick to adopt new technologies, at least in comparison with those working in many other areas of the world. Where we have been less successful is in integrating our results into broader theoretical and interpretive frameworks, and it is here that we see significant room for improvement.

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