McDONALD INSTITUTE CONVERSATIONS

Fierce lions, angry mice and fat-tailed sheep

Animal encounters in the ancient Near East

Edited by Laerke Recht & Christina Tsouparopoulou

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with contributions from
Francesca Alhaique, Troels Pank Arbøll, Laura Battini, Malwina Brachmańska, Franco D'Agostino, Anne Devillers, Hekmat Dirbas, Neil Erskine, Marina Fadum, Jill Goulder, Haskel J. Greenfield, Tina L. Greenfield, Ben Greet, Carina Gruber, Tuna Kalaycı, Michael Kozuh, Aren M. Maeir, Timothy Matney, Alice Mouton, Seraina Nett, Olga V. Popova, Louise Quillien, Laerke Recht, Licia Romano, Jon Ross, Szilvia Sövegjártó, Christina Tsouparopoulou, Lorenzo Verderame, Andréa Vilela, John Wainwright & Chikako E. Watanabe

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Figures

Tables

Abbreviations and sigla

ABL	Harper, R.F., 1892–1914. *Assyrian and Babylonian Letters Belonging to the Kouyunjik Collection of the British Museum*, 14 volumes. Chicago: University of Chicago Press.
AHw	von Soden, W., 1959-1981. *Akkadisches Handwörterbuch*. Wiesbaden.
AKA I	Wallis Budge, E.A. & L.W. King, 1902. *Annals of the Kings of Assyria: The Cuneiform Texts with Translations and Transliterations from the Original Documents in the British Museum*. Vol. I. London: The Trustees of the British Museum.
AMT	Campbell Thompson, R., 1923. *Assyrian Medical Texts.* Milford, Oxford: Oxford University Press.
AnOr 8	Pohl, A., 1933. *Neubabylonische Rechtsurkunden aus den Berliner staatlichen Museen.* (Analecta Orientalia 8.) Rome: Pontificium Institutum Biblicum.
AO	Siglum of objects in the Louvre Museum, Paris (Archéologie Orientale).
ARM 2	Jean, Ch.-F., 1950. *Lettres diverses.* (Archives royales de Mari 2.) Paris: Lib. Paul Geuthner.
ARM 9	Birot, M., 1958. *Textes administratifs de la Salle 5 du Palais*. (Archives royales de Mari 9.) Paris: Lib. Paul Geuthner.
ARM 10	Dossin, G., 1978. *Correspondance feminine*. (Archives royales de Mari 10.) Paris: Lib. Paul Geuthner.
ARM 14	Birot, M., 1974. *Lettres de Yaqqim-Addu, gouverneur de Sagarâtum*. (Archives royales de Mari 14.) Paris: Lib. Paul Geuthner.
ARM 15	Bottero, J. & A. Finet, 1954. *Repertoire analytique des tomes I à V.* (Archives royales de Mari 15.) Paris: Lib. Paul Geuthner.
ARM 26	Durand, J.-M. *et al*., 1988. *Archives épistolaires de Mari.* (Archives royales de Mari 26.) Paris: Lib. Paul Geuthner.
ARM 27	Birot, M., 1993. *Correspondance des gouverneurs de Qaṭṭunân*. (Archives royales de Mari 27.) Paris: Lib. Paul Geuthner.
ARM 28	Kupper, J.-R., 1998. *Lettres royales du temps de Zimri-Lim*. (Archives royales de Mari 28.) Paris: Lib. Paul Geuthner.
ARM 30	Durand, J.-M., 2009. *La nomenclature des habits et des textiles dans les textes de Mari*. (Archives royales de Mari 30.) Paris: Lib. Paul Geuthner.
AUCT 1	Sigrist, M., 1984. *Neo-Sumerian Account Texts in the Horn Archaeological Museum.* (Andrews University Cuneiform Texts 1.) Berrien Springs: Andrews University Press.
BabMed	Babylonian Medicine online [no year]: 'Corpora', https://www.geschkult.fu-berlin.de/e/babmed/Corpora/index.html
BAM	Köcher, F., 1963–1980. *Die babylonisch-assyrische Medizin in Texten und Untersuchungen*, 6 Vols. Berlin: De Gruyter.
BCT 1	Watson, P.J., 1986. *Neo-Sumerian Texts from Drehem*. (Catalogue of Cuneiform Tablets in Birmingham City Museum I.) Warminster: Aris & Phillips.
BIN 1	Keiser, C.E., 1917. *Letters and Contracts from Erech Written in the Neo-Babylonian Period*. (Babylonian Inscriptions in the Collection of James B. Nies, vol. 1.) New Haven: Yale University Press.
BIN 3	Keiser, C.E., 1971. *Neo-Sumerian Account Texts from Drehem.* (Babylonian Inscriptions in the Collection of B.J. Nies, vol. 3.) New Haven: Yale University Press.
BM	Siglum for objects in the British Museum, London.
BPOA	Biblioteca del Proximo Oriente Antiguo (Madrid: Consejo Superior de Investigaciones Científicas, 2006ff.)
BPOA 6	Sigrist, M., & T. Ozaki, 2009a. *Neo-Sumerian Administrative Tablets from the Yale Babylonian Collection. Part One* (Biblioteca del Próximo Oriente Antiguo 6.) Madrid: Consejo Superior de Investigaciones Científicas.
BPOA 7	Sigrist, M., & T. Ozaki, 2009b. *Neo-Sumerian Administrative Tablets from the Yale Babylonian Collection. Part Two* (Biblioteca del Próximo Oriente Antiguo 7.) Madrid: Consejo Superior de Investigaciones Científicas.
BRM 1	Clay, A.T., 1912. *Babylonian Business Transactions of the First Millennium B.C.* (Babylonian Records

in the Library of J. Pierpont Morgan, Part 1.) New York: Privately printed.

CAD *The Assyrian Dictionary of the Oriental Institute of the University of Chicago.* Chicago: The Oriental Institute, 1956–2010.

CBS Siglum for objects in the University Museum in Philadelphia (Catalogue of the Babylonian Section).

CDLI Cuneiform Digital Library Initiative, https://cdli.ucla.edu

CHD Goedegebuure, P.M., H.G. Güterbock, H.A. Hoffner & T.P.J. van den Hout (eds.), 1980–. *The Hittite Dictionary of the Oriental Institute of the University of Chicago*. Chicago: The Oriental Institute.

CM 26 Sharlach, T.M., 2004. *Provincial Taxation and the Ur III State.* (Cuneiform Monographs 26.) Leiden: Brill.

CT 22 Campbell Thompson, R., 1906. *Cuneiform Texts from Babylonian Tablets in British Museum*, vol. 22. London: British Museum.

CT 32 King, L.W., 1912. *Cuneiform Texts from Babylonian Tablets in British Museum*, vol. 32. London: British Museum.

CT 55 Pinches, T.G. 1982. *Cuneiform Texts from Babylonian Tablets in the British Museum Part 55. Neo-Babylonian and Achaemenid Economic Texts*. London: British Museum Publications.

CTH Laroche, E. 1971. *Catalogue des Textes Hittites*. Paris: Klincksieck.

DAS Lafont, B., 1985. *Documents Administratifs Sumériens, provenant du site de Tello et conservés au Musée du Louvre*. Paris: Editions Recherche sur les Civilisations.

DMMA Siglum for objects in the Département des Monnaies, médailles et antiques de la Bibliothèque nationale de France.

DUL Del Olmo Lete, G. & J. Sanmartín, 2015. *A Dictionary of the Ugaritic Language in the Alphabetic Tradition*. Translated and edited by W.G.E. Watson. Third revised edition. 2 vols. (Handbuch der Orientalistik 112.) Leiden: Brill.

EA Siglum for the Tell El-Amarna Letters, following the edition of Knudtzon, J. A., 1915. *Die El-Amarna-Tafeln.* Leipzig: J.C. Hinrichs'sche Buchhandlung.

ePSD Electronic version of *The Pennsylvania Sumerian Dictionary*, http://psd.museum.upenn.edu

ETCSL Black, J.A., G. Cunningham, J. Ebeling, E. Flückiger-Hawker, E. Robson, J. Taylor & G. Zólyomi (eds.), 1998–2006. *The Electronic Text Corpus of Sumerian Literature.* Oxford, http://etcsl.orinst.ox.ac.uk/

FM 2 Charpin, D. & J.-M. Durand (ed.), 1994. *Recueil d'études à la mémoire de Maurice Birot*. (Florilegium Marianum II.) Paris: Société pour l'étude du Proche-Orient ancien.

Hh *The Series HAR-ra='hubullu'*, Materials for the Sumerian lexicon (MSL), 5, 6, 7, 9, 10 & 11. Rome: Pontificium Institutum Biblicum, 1957–.

HSS 14 Lacheman, E.R., 1950. *Excavations at Nuzi V. Miscellaneous Texts from Nuzi, Part 2, The Palace and Temple Archives.* (Harvard Semitic Studies 14.) Cambridge (Mass.): Harvard Univ. Press.

HW² Friedrich, J. & A. Kammenhuber (eds.), 1975–. *Hethitisches Wörterbuch. Zweite, völlig neubearbeitete Auflage auf der Grundlage der edierten hethitischen Texte*. Heidelberg: Winter.

IB Siglum for finds from Isin (Isan Bahriyat).

IM Siglum for objects in the Iraq Museum, Baghdad.

ITT 5 de Genouillac, H., 1921. *Inventaire des Tablettes de Tello conservées au Musée Imperial Ottoman. Tome V. Époque présargonique, Époque d'Agadé, Epoque d'Ur III*. Paris: Édition Ernest Leroux.

KAH 2 Schroeder, O. 1922. *Keilschrifttexte aus Assur historischen Inhalts, Heft II*. (Wissenschaftliche Veroffentlichungen der Deutschen Orient-Gesellschaft 37.) Leipzig: J.C. Hinrichs'sche Buchhandlung.

KBo *Keilschrifttexte aus Boghazköi* (Bd. 1-22 in Wissenschaftliche Veroffentlichungen der Deutschen Orient-Gesellschaft) Leipzig/Berlin, 1916 ff.

KRI Kitchen, K.A., 1969–1990. *Ramesside Inscriptions. Historical and Biographical,* 8 vols. Oxford: Blackwell.

KUB *Keilschrifturkunden aus Boghazköi*, Berlin 1921 ff.

LAPO 16 Durand, J.-M., 1997. *Les Documents épistolaires du palais de Mari, tome I.* (Littératures anciennes du Proche-Orient 16.) Paris: Éditions du cerf.

LAPO 18 Durand, J.-M., 2000. *Les Documents épistolaires du palais de Mari, tome III.* (Littératures anciennes du Proche-Orient 18.) Paris: Éditions du cerf.

LD Lepsius, C.R., 1849–59. *Denkmäler aus Aegypten und Aethiopen* (plates), 6 vols. Berlin: Nicolaische Buchhandlung.

LKU Falkenstein, A., 1931. *Literarische Keilschrifttexte aus Uruk.* Berlin: Berlin Staatliche Museen zu Berlin Vorderasiatische Abteilung.

M Siglum for texts from Mari.

Moore, Mich. Coll.
Moore, E., 1939. *Neo-Babylonian Documents in the University of Michigan Collection*. Ann Arbor: University of Michigan Press.

MSL VIII/I Landsberger, B., 1960. *The Fauna of Ancient Mesopotamia. First Part: Tablet XIII.* (Materialien zum Sumerischen Lexikon VIII/1.) Rome: Pontificium Institutum Biblicum. [with the assistance of A. Draffkorn Kilmer & E.I. Gordon].

MVN 8 Calvot, D., G. Pettinato, S.A. Picchioni & F. Reschid, 1979. *Textes économiques du Selluš-Dagan du Musée du Louvre et du College de France (D. Calvot). Testi economici dell'Iraq Museum Baghdad*. (Materiali per il Vocabolario Neosumerico 8.) Rome: Multigrafica Editrice.

MVN 11 Owen, D.I., 1982. *Selected Ur III Texts from the Harvard Semitic Museum*. (Materiali per il Vocabolario Neosumerico 11.) Rome: Multigrafica Editrice.

MZ Siglum for finds from Tell Mozan.

NBC Siglum for tablets in the Nies Babylonian Collection of the Yale Babylonian Collection.

NCBT Siglum for tablets in the Newell Collection of Babylonian Tablets, now Yale University, New Haven.

OIP 99 Biggs, R.D., 1974. *Inscriptions from Tell Abu Salabikh*. (Oriental Institute Publications 99.) Chicago: The University of Chicago Press.

OIP 115 Hilgert, M., 1998. *Cuneiform Texts from the Ur III Period in the Oriental Institute, Vol. 1: Drehem Administrative Documents from the Reign of Šulgi.* (Oriental Institute Publications 115.) Chicago: The Oriental Institute.

OIP 121 Hilgert, M., 1998. *Cuneiform Texts from the Ur III Period in the Oriental Institute, Volume 2: Drehem Administrative Documents from the Reign of Amar-Suena*. (Oriental Institute Publications 121.) Chicago: The Oriental Institute.

P CDLI (Cuneiform Digital Library Initiative) number.

PDT 1 Çig, M., H. Kizilyay & A. Salonen, 1956. *Die Puzris-Dagan-Texte der Istanbuler Archäologischen Museen Teil 1: Texts Nrr. 1-725.* (Academia Scientiarum Fennica Annales, série B, tome 92.) Helsinki: Academia Scientiarum Fennica.

PKG 18 Orthmann, W., 1985. *Der alte Orient*. (Propyläen Kunstgeschichte 18.) Berlin: Propyläen Verlag.

PTS Siglum for unpublished texts in the Princeton Theological Seminary.

RGTC *Répertoire géographique des textes cunéiformes*. (Beihefte zum Tübinger Atlas des Vorderen Orients, Reihe B.) Wiesbaden: Reichert, 1974–.

RIMA 2 Grayson, A.K., 1991. *Assyrian Rulers of the Early First Millennium BC I (1114–859 BC).* (The Royal Inscriptions of Mesopotamia, Assyrian Periods Vol. 2.) Toronto, Buffalo & London: University of Toronto Press.

RIME 1 Frayne, D., 2008. *Presargonic Period (2700–2350 BC).* (The Royal Inscriptions of Mesopotamia, Early Periods Vol. 1.) Toronto: University of Toronto Press.

RIME 4 Frayne, D., 1990. *Old Babylonian Period (2003–1595 BC)*. (The Royal Inscriptions of Mesopotamia, Early Periods Vol. 4.) Toronto: University of Toronto Press.

RINAP The Royal Inscriptions of the Neo-Assyrian Period; Open Richly Annotated Cuneiform Corpus, available at http://oracc.museum.upenn.edu/rinap/index.html

RLA *Reallexikon der Assyriologie und vorderasiatischen Archaologie.*

RS Siglum for documents from Ras Shamra (Ugarit).

SAA 2 Parpola, S. & K. Watanabe, 1988. *Neo-Assyrian Treaties and Loyalty Oaths.* (State Archives of Assyria 2.) Helsinki: Helsinki University Press.

SAA 7 Fales, F.M. & J.N. Postgate, 1992. *Imperial Administrative Records, Part I: Palace and Temple Administration*. (State Archives of Assyria 7.) Helsinki: Helsinki University Press.

SAA 10 Parpola, S. 1993. *Letters from Assyrian and Babylonian Scholars*. (State Archives of Assyria 10.) Helsinki: Helsinki University Press.

SAA 11 Fales, F.M. & J.N. Postgate, 1995. *Imperial Administrative Records, Part II: Provincial and Military Administration*. (State Archives of Assyria 11.) Helsinki: Helsinki University Press.

SAA 12 Kataja, K. & R. Whiting, 1995. *Grants, Decrees and Gifts of the Neo-Assyrian Period.* (State Archives of Assyria 12.) Helsinki: Helsinki University Press.

SAA 13 Cole, S.W. & P. Machinist, 1998. *Letters from Assyrian and Babylonian Priests to Kings Esarhaddon and Assurbanipal*. (State Archives of Assyria 13.) Helsinki: Helsinki University Press.

SAA 17 Dietrich, M., 2003. *The Neo-Babylonian Correspondence of Sargon and Sennacherib*. (State Archives of Assyria 17.) Helsinki: Helsinki University Press.

SAA 19 Luukko, M. 2012. *The Correspondence of Tiglath-pileser III and Sargon II*. (State Archives of Assyria 19.) Helsinki: The Neo-Assyrian Text Corpus Project.

SAA 20 Parpola, S. 2017. *Assyrian Royal Rituals and Cultic Texts*. (State Archives of Assyria 20.) Helsinki: The Neo-Assyrian Text Corpus Project.

SAT 2 Sigrist, M., 2000. *Sumerian Archival Texts. Texts from the Yale Babylonian Collection 2*. Bethesda: CDL Press.

SF Deimel, A., 1923. *Schultexte aus Fara*. (Wissenschaftliche Veröffentlichung der Deutschen Orientgesellschaft 43.) Leipzig: J.C. Hinrichs'sche Buchhandlung.

SP Alster, B., 1997. *Proverbs of Ancient Sumer*. Bethesda: CDL Press.

TCL 12 Conteneau, G., 1927. *Contrats Néo-Babyloniens I, de Téglath-Phalasar III à Nabonide*. (Textes cunéiformes, Musées du Louvre 12.) Paris: P. Geuthner.

TCL 13 Contenau, G., 1929. *Contrats néo-babyloniens II. Achéménides et Séleucides.* (Textes cunéiformes, Musées du Louvre 13.) Paris: P. Geuthner.

TRU Legrain, L., 1912. *Le temps des rois d'Ur: recherches sur la société antique d'après des textes nouveaux*. (Bibliothèque de l'École des Hautes Études 199.) Paris: H. Champion.

TU Thureau-Dangin, F., 1922. *Tablettes d'Uruk à l'usage des prêtres du Temple d'Anu au temps des Séleucides.* (Musée du Louvre. Département des antiquités orientales. Textes cunéiformes.) Paris: P. Geuthner.

U. Siglum for finds from Ur.

UCP 9/1,I Lutz, H.F., 1927. *Neo-Babylonian Administrative Documents from Erech: Part I.* (University of California Publications in Semitic Philology Vol. 9 no. 1/I.) Berkeley (CA): University of California Press.

UCP 9/1,II Lutz, H.F., 1927. *Neo-Babylonian Administrative Documents from Erech: Part II*. (University of California Publications in Semitic Philology Vol. 9 no. 1/II.) Berkeley (CA): University of California Press.

UDT Nies, J.B., 1920. *Ur Dynasty Tablets: Texts Chiefly from Tello and Drehem Written during the Reigns of Dungi, Bur-Sin, Gimil-Sin and Ibi-Sin*. Leipzig: J.C. Hinrichs'sche Buchhandlung.

VA Siglum for objects in the Vorderasiatisches Museum, Berlin (Vorderasiatische Abteilung).

VAT Siglum for objects/tablets in the Vorderasiatisches Museum, Berlin (Vorderasiatische Abteilung. Tontafeln).

VS 1 Ungnad, A. & L. Messerschmidt, 1907. *Vorderasiatische Schriftdenkmäler der Königlichen Museen zu Berlin*. Vol. 1, Texts 1–115, Königliche Museen zu Berlin. Sammlung der Vorderasiatischen Altertümer. Leipzig: J.C. Hinrichs'sche Buchhandlung.

VS 16 Schröder, O., 1917. *Altbabylonische Briefe*. (Vorderasiatische Schriftdenkmäler der königlichen Museen zu Berlin 16.) Leipzig: J.C. Hinrichs'sche Buchhandlung.

VS 17 van Dijk, J. 1971. *Nicht-kanonische Beschwörungen und sonstige literarische Texte*. (Vorderasiatische Schriftdenkmäler der Königlichen Museen zu Berlin 17.) Berlin: Akademie Verlag.

WB Erman, A. & H. Grapow (eds.), 1971. *Wörterbuch der ägyptischen Sprache,* 5 vols. Berlin: Akademie Verlag.

WMAH Sauren, H., 1969. *Wirtschaftsurkunden aus der Zeit der III. Dynastie von Ur im Besitz des Musée d'Art et d'Histoire in Genf*. Naples: Istituto orientale di Napoli.

YBC Siglum for tablets in the Yale Babylonian Collection.

YOS 7 Tremayne, A., 1925. *Records from Erech, Time of Cyrus and Cambyses (538-521 B.C.)*. (Yale Oriental Series, Babylonian Texts, vol. 7.) New Haven: Yale University Press.

YOS 8 Faust, D.E., 1941. *Contracts from Larsa, dated in the Reign of Rim-Sin*. (Yale Oriental Series, Babylonian Texts, vol. 8.) New Haven: Yale University Press & London: H. Milford, Oxford University Press.

YOS 11 van Dijk, J., A. Goetze & M.I. Hussey, 1985. *Early Mesopotamian Incantations and Rituals*. (Yale Oriental Series, Babylonian Texts, vol. 11.) New Haven: Yale University Press.

YOS 17 Weisberg, D.B., 1980. *Texts from the Time of Nebuchadnezzar*. (Yale Oriental Series, Babylonian Texts, vol. 17.) New Haven: Yale University Press.

YOS 19 Beaulieu, P.-A., 2000. *Legal and Administrative Texts from the Reign of Nabonidus*. (Yale Oriental Series, Babylonian Texts, vol. 19.) New Haven: Yale University Press.

Preface

Augusta McMahon

The chapters in this volume invert traditional approaches to past human-animal relationships, placing animals at the forefront of these interactions and celebrating the many ways in which animals enriched or complicated the lives of the inhabitants of the ancient Near East. The authors embrace insights from text, archaeology, art and landscape studies. The volume offers rich evidence for the concept that 'animals are good to think' (Levi-Strauss 1963), enabling humans in categorizing the world around us, evaluating our own behaviours, and providing analogies for supernatural powers that are beyond humans' control. However, totemism has never fit the ancient Near East well, because most animals had varied and endlessly complicated relationships with their human associates, as these chapters vividly describe. Taboos on eating or handling animals ebbed and flowed, and the same animal could have both positive and negative associations in omen texts. Animals were good (or bad) to eat, good (or bad) to think, good (or bad) to live with (Kirksey & Helmreich 2010) and good (or bad) to be. Through detailed, theoretically informed and well-supported case studies, this volume moves the study of human-animal-environment interactions forward, presenting animals as embedded actors in culture rather than simply objectified as human resources or symbols.

The chapters in the first section emphasize the agency of animals via their abilities to resolve crises for humans and deities and to shift between animal and human worlds. Animals have paradoxical affects: as metaphors for wilderness and chaos, or as valued companions, helpers, or votive sacrifices. The variety of interactions and assumptions cautions us to treat animals, as we do humans, as individuals. Reconstruction of animals in past rituals has a long history, usually focused on animals associated with the gods and/or animals used in formal religious sacrifice. But the chapters in the second section also examine the impact of lesser-known animals and less formal encounters, e.g., in the landscape or in funeral contexts within the home. The value and meanings of animals could vary with context.

The fascination engendered by hybrid or composite figures is also well represented. The persistence of composite figures in the Near East, from fourth millennium BC human-ibex 'shamans' on northern Mesopotamian Late Chalcolithic seals to *lamassu* and *mušhuššu* of the first millennium BC, suggests that the division and recombination of animal body elements fulfilled a human need to categorize powerful forces and create a cosmological structure. The anthropomorphizing of animals is another facet of the flexibility of animal identifications in the past. The authors here also grapple with the question of whether composite images represent ideas or costumed ritual participants.

The chapters also cover the most basic of animal–human relations, that of herd management, use in labour, and consumption, digging deeply into details of mobility, breeding and emic classifications. Economic aspects of the human-animal relationship are currently being rejuvenated through archaeological science techniques (e.g., isotopes, ZooMS), which give us unparalleled levels of detail on diet, mobility, herd management, and species. Matching these insights from science, the issues raised here include the value of individual animals versus that assigned to species, the challenges of pests, the status ascribed to and reflected by different meat cuts, animals as status and religious symbols, and animals' tertiary products or uses (e.g., transport versus traction, bile). These studies allow a more detailed reconstruction of Near Eastern economy and society, as well as emphasizing the flexibility of the relationships between animals, as well as between human and animal.

The authors implicitly advocate for a posthumanist multispecies ethnography, which incorporates

nonhumans and argues for equal care to be given to nonhumans in the realms of shared landscapes, violence, labour and especially ecology (Kirksey & Helmreich 2010; Kopnina 2017; Parathian *et al*. 2018). This approach advocates for nonhumans' agency in creating shared worlds, in contrast to the traditional approach to animals as symbols or resources in the service of humans. Going forward, the challenge will be to convert the acknowledgement of equal cultural contribution into support for nonhuman species to speak for themselves; this shift from passive subject of research inquiry to genuine active agency in academic writing does not have an easy or obvious path, and many nonhuman animals may be overlooked. Indeed, multispecies ethnography ideally seeks to incorporate plants, microbes, stones and more (Ogden *et al*. 2013; Smart 2014), many of which are ephemeral in the archaeological record and all but omitted in ancient texts. However, ancient texts do support a new approach which questions our modern boundaries between species. Our perpetual struggle to translate terms for different species of equids, to distinguish whether a word refers to rats or mice, or to link zooarchaeological remains to lexical lists, reinforces the complexity and flexibility of these concepts, and the futility of attempts at absolute categorization.

The chapters in this volume should inspire colleagues to grapple with animals, nonhumans and contexts that could not be included here. For instance, the snake has as lengthy a history of human engagement in the Near East as does the lion and had similarly unusual powers. While the lion was an icon of strength, the perfect symbol for the proximity of the emotions of awe and fear, the snake has the sneaky ability to slither between worlds, to avoid capture, and to deliver an almost imperceptible lethal injury. Fear of the snake conquers awe. Like the fox, the presence or actions of the snake, as listed in *Šumma ālu*, may be positive or negative omens. The snake was present at key moments in both Mesopotamian and Biblical literature; its actions (stealing the plant of immortality, offering the fruit of the tree of knowledge) changed the fate of humans forever. Whether represented coiled and copulating on Late Chalcolithic seals, grasped by Late Uruk 'Masters of Animals' or first millennium BC *lamaštu*, snakes and their paradoxical nature deserve deep scrutiny. There are many other nonhuman animals deserving of similar problematization and integration, and the eclectic and exciting research stream represented by this volume shows us the way.

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Chapter 12

An abstract Agent-Based Model (ABM) for herd movement in the Khabur Basin, the Jazira

Tuna Kalaycı & John Wainwright

Herd animals are significant agents of landscape transformation. Their repetitive movement may result in track formation while also reducing or completely eliminating vegetation growth along those tracks (Apollo *et al.* 2018). Herds can also drastically alter the geomorphology of a region so that new hydro-landscapes are born out of their movement (Butler 2006). In great numbers, animal droppings can introduce pathogens to the soil and adversely affect productivity and watersheds (Tate *et al.* 2003). Conversely, specific grazing patterns may result in better soil fertility (e.g. Cao *et al.* 2018). Also, the level of compaction may vary with different grazing intensities and soil types (e.g. Hiernaux *et al.* 1999). Furthermore, amounts of nutrition return to the soil in animal faeces and urine (Haynes & Williams 1993).

To balance the negative and positive impacts, the management of herding practices is a concern across the globe. In order to mitigate the adverse effects of animal movement, scholars have investigated the relationship between herding and soil-treatment practices (e.g. Franzluebbers & Stuedemann 2008), pests (e.g. Goosey *et al.* 2005), soil chemical properties (e.g. Li *et al.* 2008), and plant diversity (e.g. Ludvikova *et al.* 2014). Although seemingly a modern phenomenon, similar issues must also have been observed in the past, especially around large urban centres where humans and animals co-existed in considerable numbers (Archi 1990, 19; Sallaberger 2014, 101).

The Jazira Region of Upper Mesopotamia, and in particular its Khabur Basin, offers an ideal case study for investigating the impact of herd movement on the landscape using a quantitative approach. The evidence of movement remains visible today in the form of linear features, known as hollow ways (Wilkinson 1993), which are especially evident on aerial and satellite imagery (Ur 2003). The hollow ways have already been documented in great detail (Ur 2017) . Despite the available scholarship on the topic (Casana 2013; Wilkinson *et al.* 2010), the ways in which past societies managed herd movement and the impact of herd movement on landscape formation remains an intriguing question.

In this chapter, we investigate the herd movement around Tell Brak (ancient Nagar) and the impact of treading on the landscape using an agent-based model. Wainwright & Millington (2010) suggest that Agent Based Models (ABMs) with their bottom-up structures can be invaluable for integrating human activity into landscape studies. This is especially significant since an agent-based approach also provides the means for an empirical analysis. Therefore, an ABM can be used to explore the emergence of hollow ways and shed light on the landscape evolution of Upper Mesopotamia. The methodology to be used in this chapter includes exploring various scenarios with different levels of rainfall and moisture loss, as well as varying numbers of animal agents on a realistic landscape. The proposed methodology is expandable to other sites in the Jazira region and to other regions exhibiting similar background characteristics as the Jazira.

The Jazira

The Jazira is the vast area between the banks of the Upper Tigris and the Euphrates Rivers. It falls within the modern-day borders of Syria, Iraq, and Turkey. To the north, the region is bounded by the high-altitude Taurus-Zagros Mountains. To the south, desert conditions gradually form an arid landscape. The region is composed of low-angled slopes. Other than two major sedimentary ridges (the Jebel Abd al-Aziz and Jebel Sinjar) and numerous mounded settlements of various sizes, there are no obtrusive features in the gently undulating landscape (Wilkinson 1990) (Fig. 12.1).

The drainage system of the Jazira includes ephemeral wadis and perennial streams, the most prominent of which are the Balikh and Khabur Rivers (tributaries

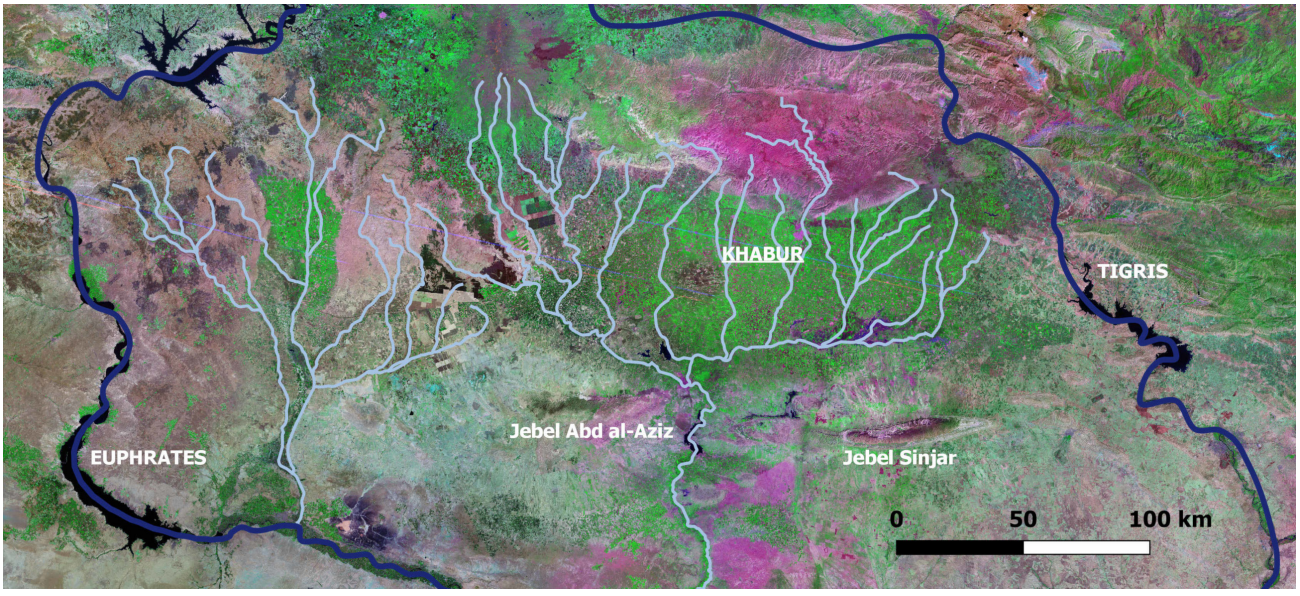

Figure 12.1. *Upper Mesopotamia lies between Tigris and Euphrates Rivers. The Khabur Basin is part of the Euphrates River. The intensification of agricultural production is visible on Landsat TM Mosaic.*

of the Euphrates) (Wilkinson 1990). Springs in the area provide water for perennial flow. The Khabur River is mainly fed by the karstic springs of Ras al-Ain (average discharge of 40 m^3 s^1) while the Balikh River gets most of its water from the spring at Ain al-Arus (average discharge of 6 m^3 s^1) (Llamas & Custodio 2003, 361). The flow increases after the winter rains (Wirth 1971, 110), but is without high floods.

Soil types vary. Matar (1980, 72) suggested two major categories in the wider region: soils which originate from hard limestones are red to reddish brown and have clayey to clayey-loam textures, while soils derived from softer limestones are lighter in colour and usually have a higher lime content. Matar's other classification is related to the climatic pattern: soils in the wetter region are dark brown with a clayey texture, while those in drier areas are yellowish brown with a silty texture.

The region has a dry climate. Today, the majority of the precipitation falls between September and May, and summers are hot with little to no rainfall. Due to this aridity, streams and wadis must have played significant roles in human occupation (Deckers & Riehl 2007). The aridity increases north to south; the 300 mm isohyet sets the critical threshold for rainfed agriculture (Wilkinson 1994). This threshold roughly matches with the alignment of the Jebel Abd al-Aziz and Jebel Sinjar.

There has been a significant amount of recent land-use transformation in the Khabur. Hole & Smith (2004) state that only a century ago the Khabur was home to migratory herders and that the basin only recently became one of the most intensively cultivated regions in the area. Nevertheless, starting in 2006 and continuing for more than half a decade, Syria experienced multi-season, multi-year droughts. In 2008, rainfall in eastern Syria dropped to 30 per cent of the annual average. Wheat production based on water sources other than irrigation dropped by 82 per cent. Overgrazing, coupled with extreme dry conditions, depleted animal food stocks and the herding economy was drastically damaged (ASCAD 2011). Since then, the civil war which began in Syria in March 2011 has been further devastating the people and the land.

Herding practices: Some historical corollaries

During the 1980s, Gallacher (1980, 52) observed that herds were brought from the Syrian steppes after the cereal harvest and that animals were kept in the area until the stubbles were ploughed. In the same time period, but describing the wider Near East, Huss (1980, 269) stated that herding was practised by nomads or transhumant herders. In 1947, Rowlands extensively wrote about the nomadic lifestyle in the Khabur. In 1853, Austen Henry Layard noted the Khabur for 'its rich pastures [that] are the resort of wandering tribes of Arabs' (p. 195). In Ottoman Syria (sixteenth to twentieth centuries), herders had a dynamic socio-political character, and the division between sheep tenders and villagers was not that clear. In fact, individuals and small groups opportunistically shifted between sedentism and migratory

herding, which in return created the conditions of reciprocity between the sedentary and nomadic groups (Douwes 2000, 22–3). In the eighteenth century BC, large parts of the Khabur were controlled by the nomadic population (Sallaberger 2007, 418). The Khabur was also occupied by sheep herders in the first millennium BC (Hole & Smith 2004, 212).

In this condensed and considerably naive linear historical narrative, the availability of grazing land is the common denominator for a herding system to survive and flourish. According to Smith (1980, 143), grazing land is the land that is not suitable or not required for agricultural production. Following this definition, one can further claim – albeit with a simplistic assumption – that suitability for grazing provides clues about environmental conditions and that production requirements point to socio-economic and political considerations.

As for the environmental conditions, Smith (1980) drew a somewhat sharp line by suggesting that fodder production is possible in areas where precipitation is more than 350 to 400 mm per annum. Therefore, large herds can be maintained only when there is enough crop surplus. Herd maintenance is also possible when there are crop by-products which are suitable for livestock feeding and/or when ley farming is required to ensure soil fertility. Finally, herd animals also can be kept in order to mitigate climatic variations, especially when precipitation levels drop below a critical threshold.

The socio-economic and political preconditions of herd movement and control also are worth noting. The *hema* (pl. *ahmia*) was one of the earliest forms of land grazing systems. The Near Eastern *hema* imposed grazing prohibitions during the wet season in order to establish a reserve for the exclusive use of certain groups during the dry season. Draz (1980, 295–6) classified the *ahmia* into three types: full prohibition, seasonal prohibition, and restricted grazing (in which the number and types of animals are specified). The *hema* was also imposed for beekeeping, and the grazing restrictions were removed when the flowering season was over. Finally, the *hema* was used to protect forest trees. In Syria, Draz reported a large number of *hema*-like reservations with the local name *mahmia*. *Koze*, the Kurdish word for *Hema*, has been also traced along the Syrian-Turkish-Iraqi borders (1980, 296).

Herding practices during the Bronze Age

The Jazira witnessed significant cultural developments during the Bronze Age. Especially during the second half of the third millennium BC (mid-to-late Early Bronze Age), rapid urbanization and the intensification of agricultural production shaped a completely new landscape. A distinct hierarchical settlement pattern was born in this period which suggests a dichotomy between the urban and the rural. The new urban economy needed large quantities of surplus staples (Kalaycı 2013). The change must also have necessitated the disciplining of the settlement hinterlands. The delicate balance between the large number of herd animals – in particular the sheep, which were kept primarily for their wool – and the calorific needs of humans and animals (which were mainly satisfied through rain-fed agricultural production) created a unique movement landscape in Upper Mesopotamia (Fig. 12.2).

In this archaeological setting, two groups of hollow ways were formed: (i) those radiating from the settlements and abruptly terminating after running for two to three kilometres, and (ii) longer hollow ways connecting various Early Bronze Age settlements together. Wilkinson (1993) suggested that the first group of hollow ways were used for controlled transportation of flocks from settlements to open pasture land. While moving, livestock was kept together to minimize crop damage, and when the production boundary was passed, flocks were allowed to disperse in open pastureland. As a result of their continuous use by herd animals – but also by farmers and carts – linear depressions were formed around the settlements. The second group of hollow ways must have been used for the transportation of agricultural surplus, other commodities, and gift animals from one settlement to another.

Hollow ways around Tell Brak

Tell Brak is one of the most prominent settlements in the Khabur Basin. Occupation at the site began as early as the Halaf Period (mid-seventh millennium BC), and with some ebb and flow it continued until the Late Islamic/Ottoman Period. The total occupation area is around 300 hectares, but it appears that the site was never settled in its entirety at a single point in time (Ur *et al*. 2011, 3). During the mid-to-late third millennium BC, the epoch of urbanization in Upper Mesopotamia also affected the settlement. The intensification of agriculture, alongside the controlled movement of flocks, formed the signature off-site features, the hollow ways. The lower town may have been abandoned at the end of the Akkadian period and the area of occupation reduced in size, based on the lack of diagnostic post-Akkadian ceramics in this area (Ur *et al*. 2011, 12). The site (especially its lower town) attracted residents once again in the Late Bronze Age.

Based on the assessment of historical CORONA imagery, Ur (2003, 110) identified 48 hollow-way

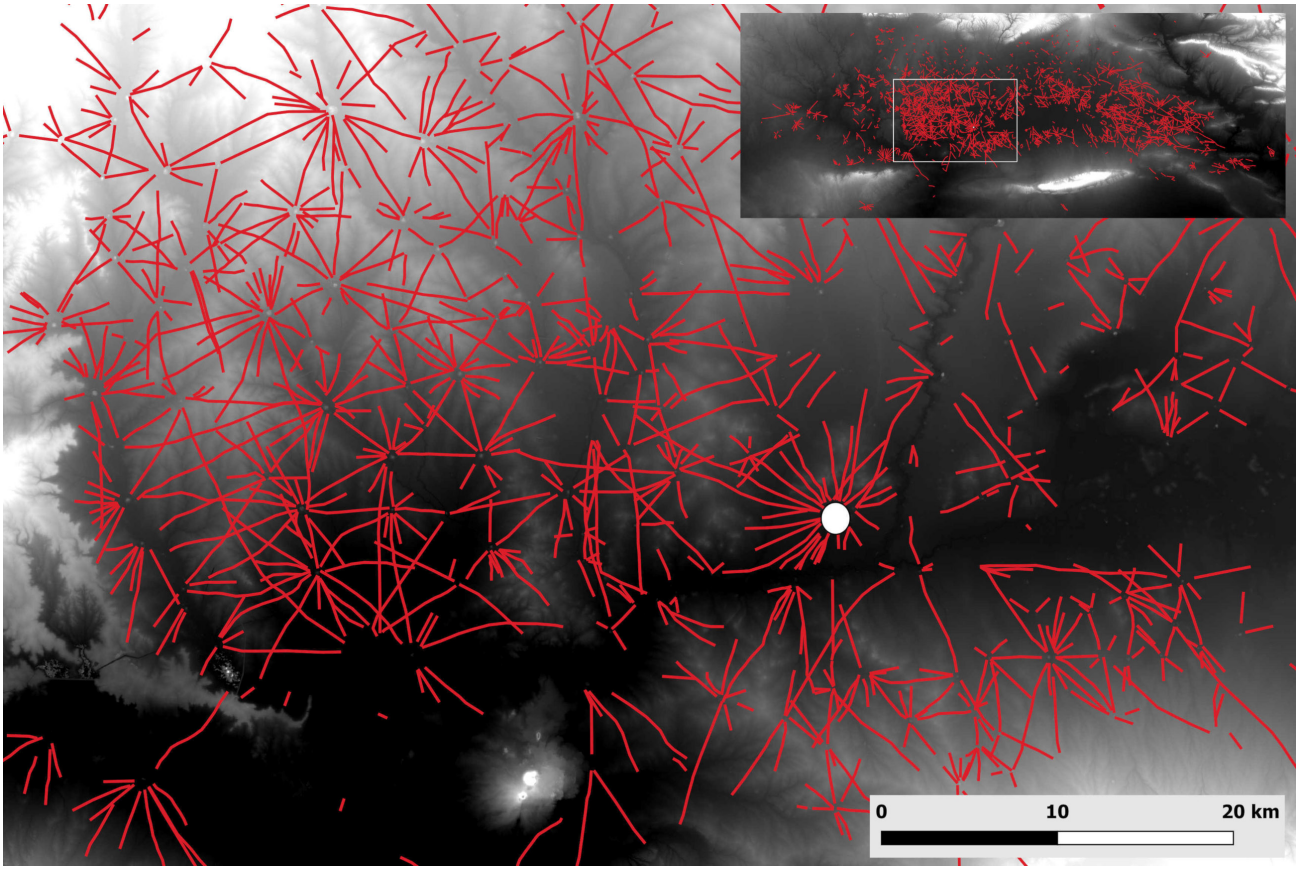

Figure 12.2. *The Khabur Basin was criss-crossed by a dense network of hollow ways. The white dot marks the location of Tell Brak.*

segments with a total length of 67.1 km and an average length of *c*. 1.4 km. The radial pattern is evenly distributed except in the site's southeastern catchment (Fig. 12.3). The absence in this area is attributed to the impact of irrigation during the Abbasid Period (*c*. AD 600–1000) (Ur *et al.* 2011, 16). The geoarchaeological study by Wilkinson *et al.* (2010) shows that the hollow ways started to form in the landscape in the Early Bronze Age (or slightly earlier) where their fills also indicate low-energy sediment movement accompanied by weak soil formation.

Herd animals as geo-agents of landscape transformation

Herd animals apply pressure on the ground and deform soils. The deformation process generally leads to a reduction in soil porosity and an increase in soil bulk density (Drewry & Paton 2005). In return, the infiltration capacity of the soil decreases a (Mulholland & Fullen 1991) and surface runoff shapes a new physical environment (Di *et al*. 2001). The process also results in increased wind erosion, especially after a new plasticity level is reached when the soil dries out.

The pressure exerted on soils depend on two variables: the weight of the animal, and the contact area between the hoof and the soil surface (Fig. 12.4). In mathematical terms, the pressure is defined as:

$$p = F / A;$$

where p is the pressure (Pa), F is the magnitude of the normal force (N), and A is the area of surface contact (sq. m). This relationship suggests that the pressure increases as the animal weight increases, or as the hoof area decreases. Therefore, it can be deduced that different species exert different pressure on the ground. Furthermore, the sex and age of an animal determine its weight as well as its hoof area, such that applied pressure can be variable even within the same species.

For instance, the Awassi sheep, which is the most common species in Iraq and Syria, weighs around 4 kg at birth and can reach up to 70 kg as an adult.

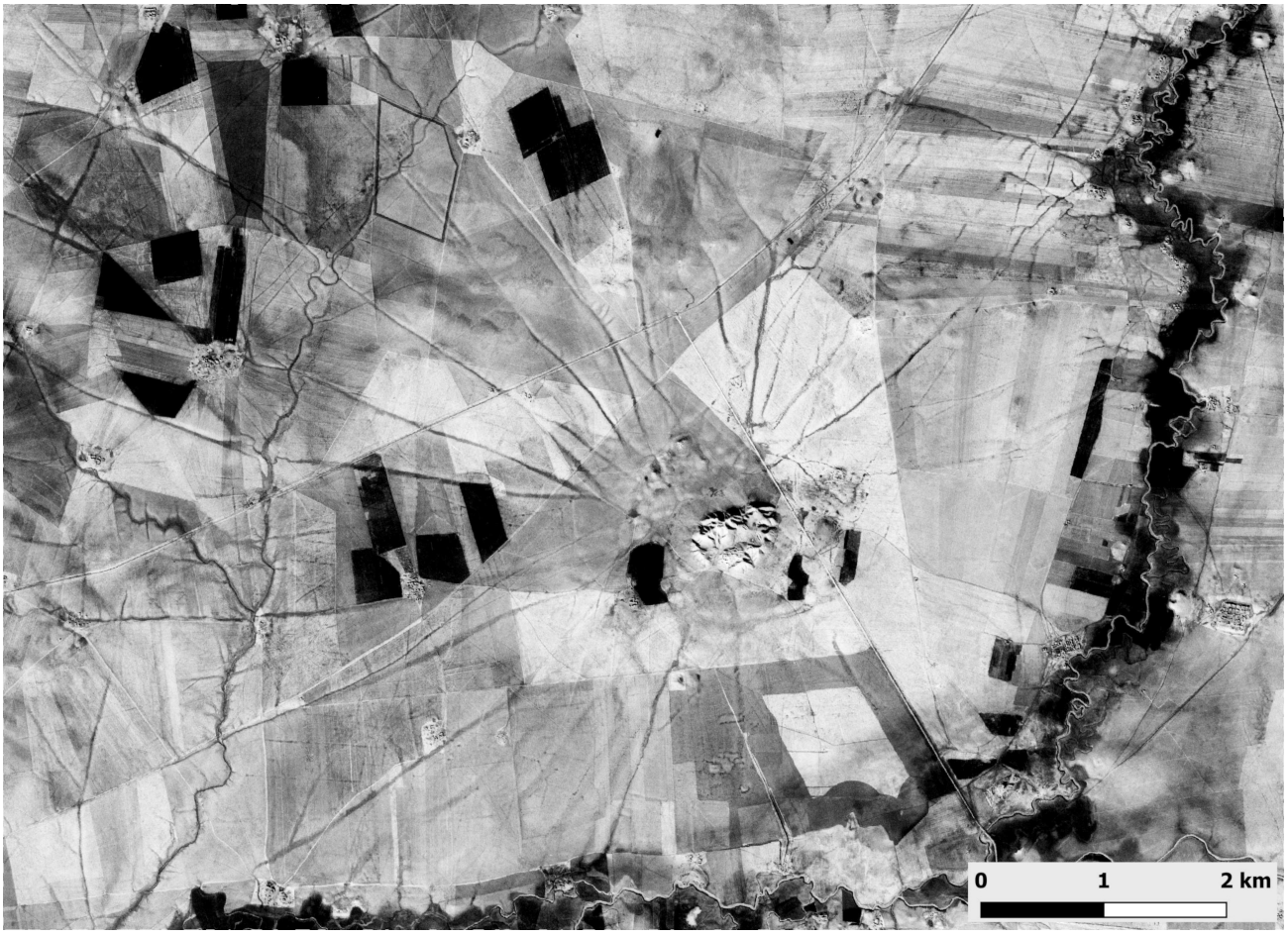

Figure 12.3 *(above). A scene from a CORONA historical satellite image (DS1102-1025DA013) preserves the details of the radial route system around Tell Brak. The layout of the system is clear. Notably, hollow ways appear to be missing southeast of the site.*

Figure 12.4 *(left). Variable herd movement strategies differentially alter landscapes. Animals walking in a straight line (below) tend to form paths relatively quickly. When scattered, the impact of treading is less visible (above).*

If one assumes a 2,000 sq. mm hoof area, then an Awassi would exert around 90 kPa of pressure per hoof. South Anatolian red cattle are around 25 kg at birth, and as adults, males can reach 600 kg and females up to 450 kg. If one assumes a 10,000 sq. mm hoof area for the South Anatolian, then the pressure exerted per hoof is around 150 kPa for males and 110 kPa for females.

When a healthy animal is standing, the weight is equally distributed among the four hoof areas. The total pressure increases when the animal begins walking and contact with the ground occurs between only two to three hooves at any given time. The pressure is further increased when the hoof is not in full contact with the soil surface due to microtopographic variations (Di *et al*. 2001). Therefore, the actual pressure metrics are much more variable than the abovementioned algebraic formula, which represents estimates of the minimum pressures involved.

The species and the age of the animal also determine its shoulder height and, in return, its stride length. The stride length, which is the distance between each step, dictates the number of steps an animal must take to travel a given unit of distance. Thus, the cumulative impact of movement on soils is not only determined by the number of animals, but also their stepping frequencies. At the same time, stepping frequency is a function of herd size above a threshold; for large herds the movement of one animal affects the trajectory and speed of another.

The mechanics of soil deformation

Soil deformation is determined not only by hoof pressure, but also by the texture of soil and its moisture content. The size and arrangement of soil particles determine the volume and configuration of pores in the soil. Essentially, the force under the hoof area changes the porosity and, thus, determines the water-holding capacity of the soil (Houlbrooke & Laurenson 2013).

Soil deformation is usually limited to the upper 50–150 mm layer of soils. Once the compaction takes place, it is only a slowly reversible process, for instance, due to the reduced activity of microfauna in the soil (Drewry 2006; Greenwood & McKenzie 2001) or the effect of wetting/drying or freezing/thawing. Deformation causes variations in the physical properties of soils which, in turn, affect vegetation growth and productivity (Bell *et al.* 2011). Based on the level of water content in a given area, soil deformation can follow three different paths: compaction, pugging, and poaching. Any of these processes can occur in the area depending on the season and timing of the herding event, relative to precipitation events.

a) Compaction

Compaction is the compression of unsaturated soils which results in the reduction of the unit volume. (Canillas & Salokhe 2001). When an animal exerts pressure, the soil particles under the hoof area are pushed closer to each other. Repetition of this event eventually results in increased soil bulk density (Di *et al.* 2001). For some disturbances, the soil shear strength decreases when the surface is disturbed by animals (see Table II in Parsons & Wainwright 2006)

b) Pugging

Pugging is the process by which the animal hoof leaves a deep print in wet soil (Drewry 2006). When the hoof leaves the soil, the imprint remains intact, resulting in rough and uneven soil surfaces. However, it is not only the water content but also the texture of the soils which determine the level of pugging. Soils with higher clay levels are more plastic than other types and, thus, more susceptible to pugging (Kellett 1978 in Bilotta *et al.* 2007)

c) Poaching

Poaching is the deformation which occurs when the hoof penetrates the (over-)saturated soil surface as well as the soil below (Drewry 2006). Since the soil is slurry, there is considerable structural recovery at the end. Nevertheless, poaching tends to reconfigure fine soil particles and may result in the formation of surface pans as the soil dries out.

Methodology

Agent-Based Modelling

Agent-Based Modelling (ABM) is a computational technique within which a group of decision-making entities (called 'agents') interact with each other and/or with other types of entities in a synthetic environment. The interaction is based on a set of explicitly defined rules, which may range from simple decisions to complex spatio-temporal phenomena. What is especially compelling with ABM is its potential for capturing emerging processes from the bottom up (Bonabeau 2002).

An ABM is also useful when there are little or no available empirical data. Simulated agents and their synthetic interactions with the landscape – and each other – may generate patterns which then can be cross-examined with other observed proxy variables. Therefore, an agent-based model can be used to build numerous scenarios and then investigate their viabilities. ABMs can be extremely beneficial tools in modelling dynamic feedbacks on landscape (Wainwright 2008; Wainwright & Millington 2010),

but in most current examples the agents operate in a static landscape and their feedbacks are thus limited.

As a spatio-temporal discipline, archaeology has greatly benefited from the scalar flexibility and modelling benefits of ABMs (e.g. Premo 2006; Kohler *et al.* 2008; Janssen 2009; Chliaoutakis & Chalkiadakis 2016). In particular, the integration of ABMs with Geographic Information Systems (GIS) (e.g. Brown *et al.* 2005; O'Sullivan 2008; Davies *et al.* 2019) appears to be a path forward, as these two computational environments complement each other in multiple respects.

An Agent-Based Model for Tell Brak

The ABM was built using NetLogo 6.0.4 with the Cf extension (Wilensky 1999). It is an abstract model with agents walking on actual terrain. Abstraction is due to the fact that physical laws which determine pressure, compaction, and erosion are not directly simulated in this first approximation. Rather, the model is built using a series of parameters. The model mainly aims to investigate:

- the role of herd animals as geomorphic agents,
- the impact of rainfall variation on the formation of hollow ways, and
- the impact of hollow ways on the geohydrological landscape of the Khabur Basin.

Terrain

The background terrain of the ABM was built using the TanDEM-X Digital Elevation Model (Figs. 12.5 and 12.6). The pixel spacing of the TanDEM-X DEM depends on the latitude of observation. For the Tell Brak area, the spatial resolution is *c*. 11.25 m.

In order to ensure a smoother terrain (and to compensate for the DEM generation defects) a Gaussian Filter was applied to the DEM using QGIS (Search Mode: Square, Search Radius: 3 pixels, Standard Deviation: 1 pixel) (Fig. 12.7a). For the second step of DEM processing, a sink fill algorithm was used using SAGA in order to approximate the terrain prior to landscape deformation due to herd movement and other hydrological processes (Qm of Esp, Fill Increment: 0.2 m) (Fig. 12.7b). The final DEM was fed to the ABM after converting the data type from floating point to integer.

(Modified) Hollow ways

The radial configuration of the hollow ways around Tell Brak is complex. In order to give herd animals an equal chance of picking a hollow way at random, a buffer was set around the site and the hollow ways were clipped out from this zone (Fig. 12.8). Therefore, animals starting their journey from the centre of the settlement have equal distances to travel until reaching any predesignated road. Once an animal starts walking on a hollow way (which is the action that is considered to be the prime driver of hollow way formation), the surface erosion starts.

Agents

In the abstract ABM, there are four types of agent: two related to herd animals and two for the background setting. Herd animals are represented as 'sheep' and 'cow' agents. Due to their differential weights and hoof areas, they exert different pressure levels on soils. The third agent is the 'raindrop'. As previously discussed, soil moisture is one of the main determinants of soil erosion resulting from herd movement. Therefore, in order to investigate various precipitation scenarios and to explore the potential impact of soil-moisture variations on surface erosion, raindrops populate the model. The fourth and last agent is the hollow way. These agents act only to guide the others' movement and help calculate erosion levels for given agent locations, but they do not have an impact on the calculations themselves.

Parameters and rulesets

For the sake of simplicity and in order to reach a solution faster, animal agents are considered to apply differential pressure based on multipliers rather than specific pressure estimates detailed above. Using pressure estimates would have resulted in longer model-run times since hollow ways were actually formed by daily movement of animals which lasted for centuries. Unrealistically increasing the pressure levels using multipliers shortened the development of hollow ways. In this way, it was also possible to use smaller numbers of animal agents (hundreds instead of thousands) which reduced the number of agents at a given step of a run. However, it is important to note that increased modelling efficiency comes at the expense of obtaining realistic surface erosion estimates. In other words, the final level of erosion after each model run is only evaluated qualitatively.

The intensity and duration of rainfall can be adjusted so that different climatic scenarios can be explored. When the 'raindrop' agent falls on the ground, it wets soil with a certain parameter value and it reflects the infiltration process and is based on soil formation. The 'raindrop' agent also wets patches around the initial location with a second user-defined parameter reflecting the runoff process. In order to represent soil-moisture loss due to evapotranspiration and drainage, the soil dries at a rate determined by a third parameter. The boundary patches of the model are set as the outlets where excess water drains. The

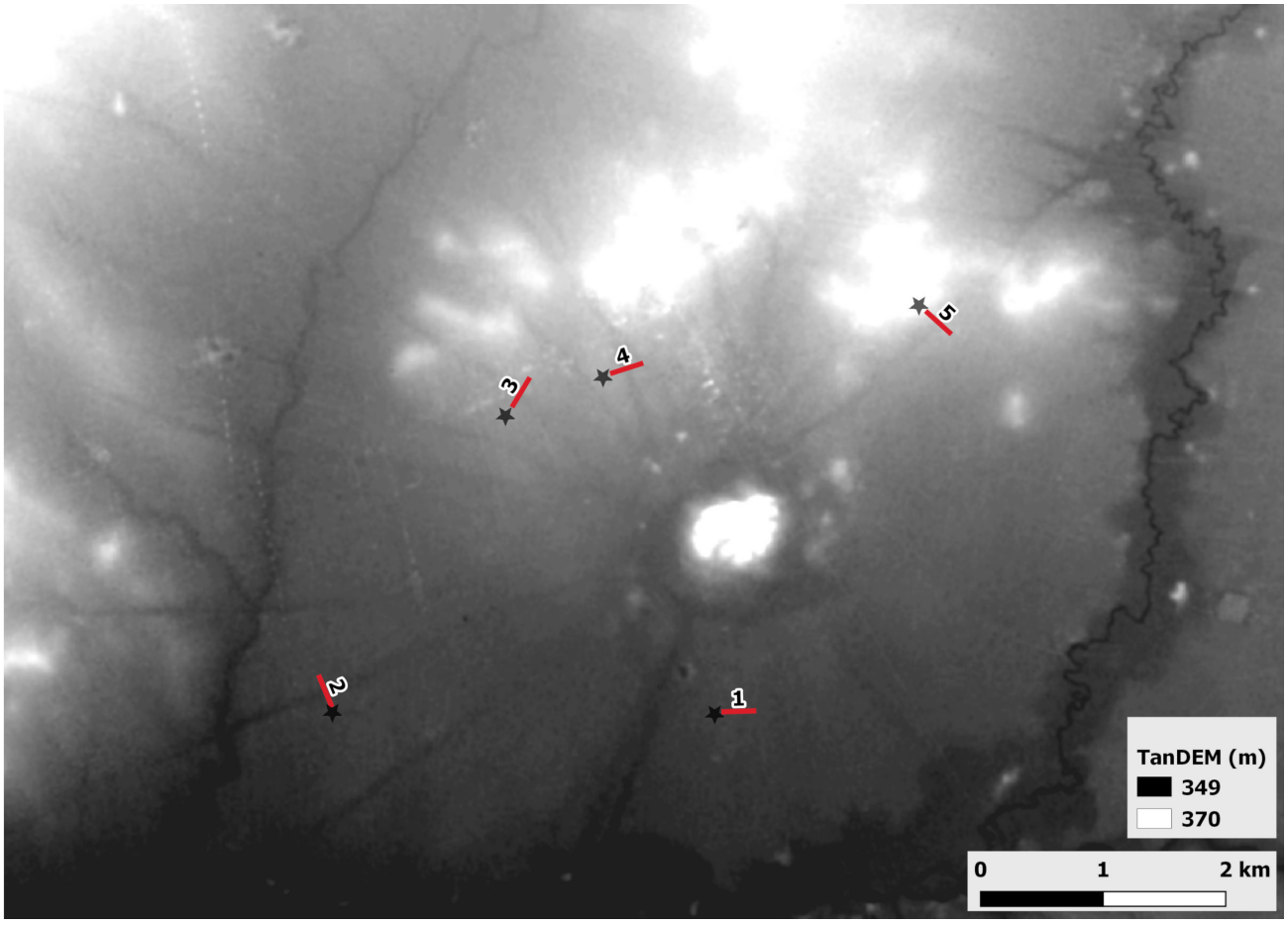

Figure 12.5 *(above). Hollow ways (as depressed linear features) are also visible on the TanDEM-X Digital Elevation Model (DEM).*

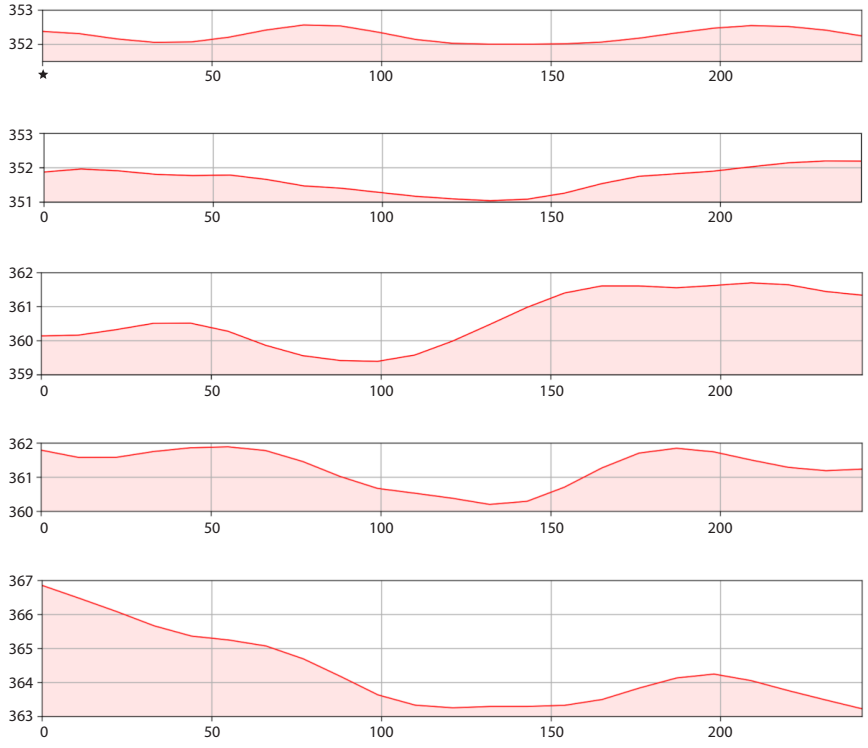

Figure 12.6 *(left). Variations in profiles may indicate differential traffic, hydrological systems, and/or preservation conditions.*

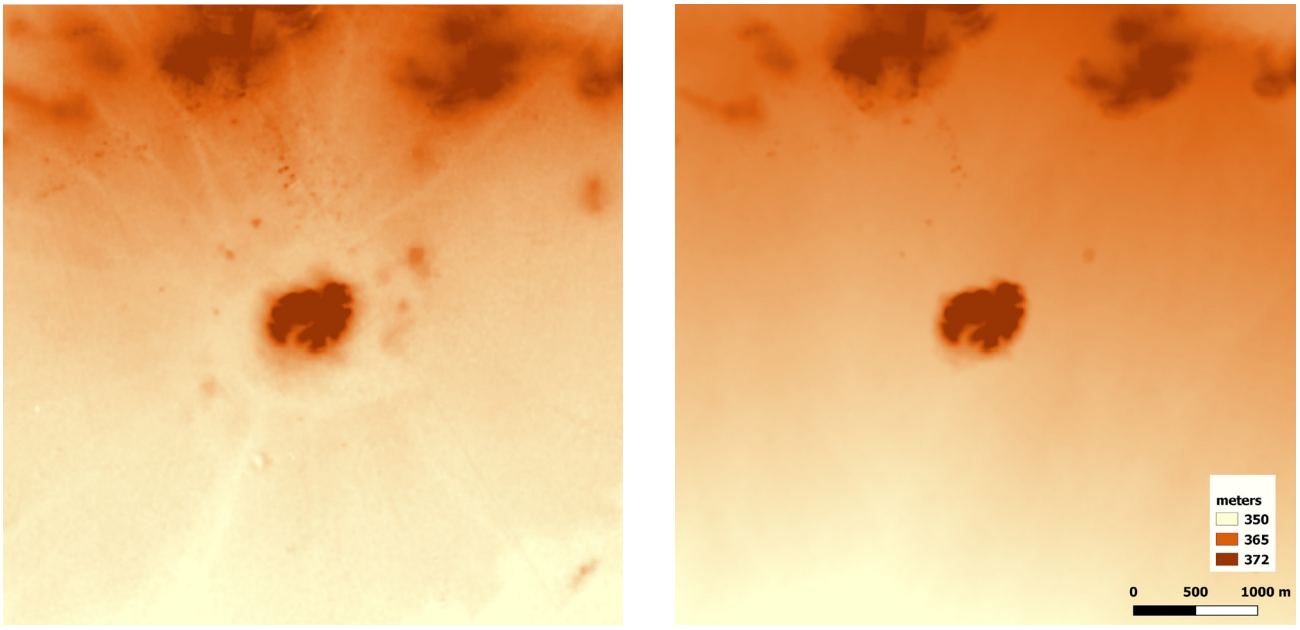

Figure 12.7. *(a) TanDEM-X DEM around Tell Brak; (b) the DEM after Gaussian Filtering and Sink Filling in order to 'approximate' the terrain prior to incision due to herd movement. After the sink filling operation, the hollow ways disappear while changing the original elevation values.*

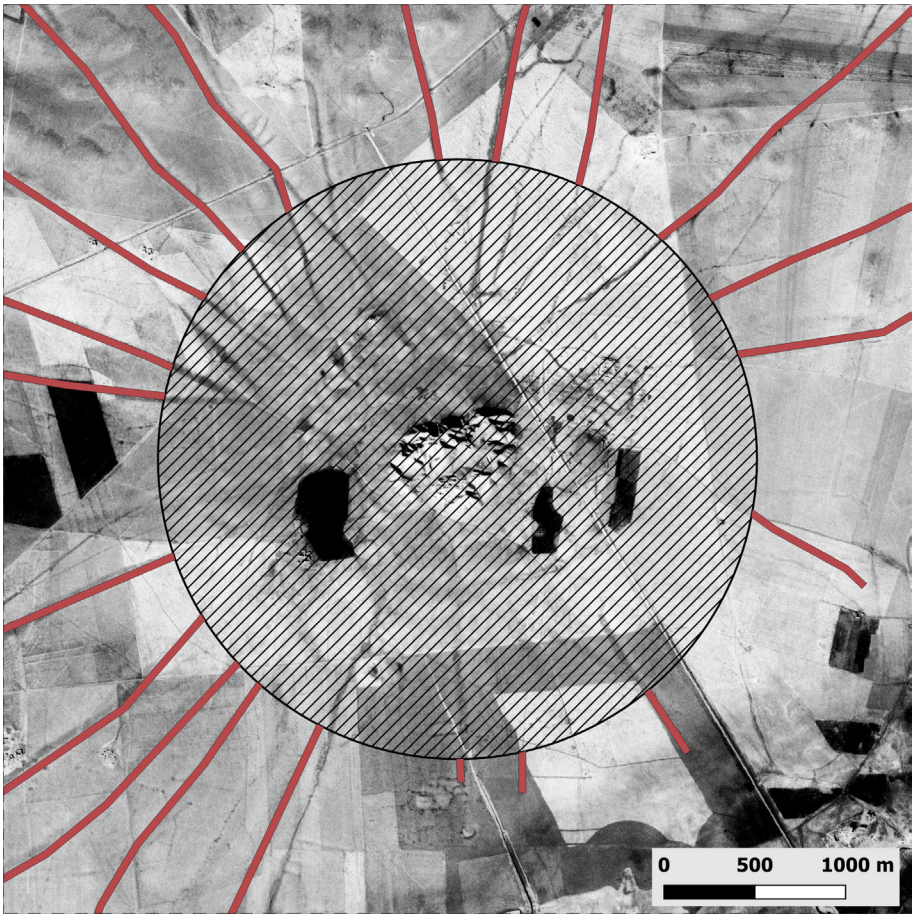

Figure 12.8. *Since there is little knowledge as to where the herd animals began branching out when outside of the city, the ABM gives herd animals an equal chance of picking any given hollow way. To accomplish this, a circular zone is set around Tell Brak and the hollow ways are removed to ensure equal distance between the initial location of an animal agent and the starting point of the hollow way.*

inclusion of surface runoff in the model is inspired by the erosion model of NetLogo (Dunham *et al.* 2004).

Three hierarchical soil-moisture classes are defined to determine if moving animal agents cause soil compaction, pugging or poaching. The levels of erosion are different for each of these classes. To reduce computational cost, and thus, to decrease the model run-time, erosion due to animal treading is set to zero around the site (Fig. 12.8, hatched area). The erosion initializes when an animal agent sets foot on a hollow way.

Initialization and model run

The herd animals' journeys start from the centre of Tell Brak rather than from the city gates since the exact locations of the city gates are not known (Ur *et al.* 2011). The animal agent randomly sets a heading and begins walking outwards. When the no-erosion zone is passed, it redirects itself towards the closest hollow way. Once on a hollow way, the agent variably erodes the patch (i.e. lowers its elevation) depending on the breed of the agent (sheep or cow). When an agent reaches the terminal point of a hollow way, it is removed from the model domain.

The water level of a patch at the time of treading also determines different levels of erosion. Surface runoff occurs when the water amount (plus the elevation of the patch) exceeds the elevation of neighbouring patches; that is the water spills out towards the lowest elevation around it. Therefore, the combination of animal movement and surface runoff governs the development of the hollow ways.

Results

The abstracted ABM for the herd movement around Tell Brak reveals clues about the emergence of hollow ways and their intrinsic relationship with rainfall, soil moisture, and hydrogeomorphology. Thanks to the flexibility of ABMs, it is possible to explore how the landscape around Tell Brak might have co-evolved due to cultural and natural processes. As anticipated, the ABM unearths more questions than answers due to its heuristic and dialogic properties (Millington & Wainwright 2017).

Under conditions of no precipitation, the animal agents remain the sole landscape modifiers. While this is an unrealistic scenario, it is used to evaluate the behaviour of the model. Their constant movement within the predefined bounds of the hollow ways erode the soil and the model converges to the expected radial pattern (Fig. 12.9a). Despite the fact that the hollow ways were initially assigned equal probabilities of being selected, some were 'chosen' more frequently than others even after many model-runs. However, the abstracted ABM uses a modified (i.e. clipped) version of hollow way topology and ignores intentionality in route selection. Therefore, this preferential routing is most probably due to modelling bias, for instance due to a specific sequence of random numbers being used by the ABM.

To give a specific example, one of the hollow ways (see the dashed box in Figure 12.9a) was rarely picked by the animal agents for each ABM run. It is likely that the initial heading of an animal had a narrow window walking towards this hollow way and a slight change in the angle resulted in picking the neighbouring routes. This outcome should be considered as an artefact of the model rather than an actual condition for Tell Brak. This is especially true since the hollow ways were clipped and they lost their original spatial configurations. Nevertheless, it throws some questions on the topological relations of radial hollow ways around settlements, and the issue on intentionality on route selection.

In the second scenario (Fig. 12.9b), rainfall takes place with a duration predefined by a parameter. This scenario does not include moving animal agents. As in the case of the previous scenario, the simplistic agent set is used to evaluate model behaviour and to converge to a solution faster. The ruleset causes erosion only due to surface runoff. In this setup, when it stops raining the moisture levels remain the same since there is also no parameter representing evapotranspiration or drainage event. Even though this is an unrealistic scenario, it also rapidly approximates how the landscape around Tell Brak could have evolved under solely natural causes. The locations of documented hollow ways (in transparent red) do not align with emerging water channels, This observation fits well with Wilkinson's argument on the lack of relationship between local topography and the locations of hollow ways (Wilkinson 1993, 548).

In the third scenario (Fig. 12.9c), it again rains with a predefined duration, but animal agents are introduced. As anticipated, treading causes most of the erosion within the bounds of the hollow ways. Furthermore, the hollow ways also facilitate surface runoff, contributing to deeper hollowing. The emerging channel system bifurcates to the greatest degree at cardinal directions. Moreover, water channels usually meet up with hollow ways not at terminal points but rather at their mid-sections. Further modelling is required in order to understand this behaviour.

In the fourth scenario (Fig. 12.9d), water loss is introduced to make the ABM much more realistic. When it stops raining, the water content is also reduced due to evapotranspiration and drainage. This last

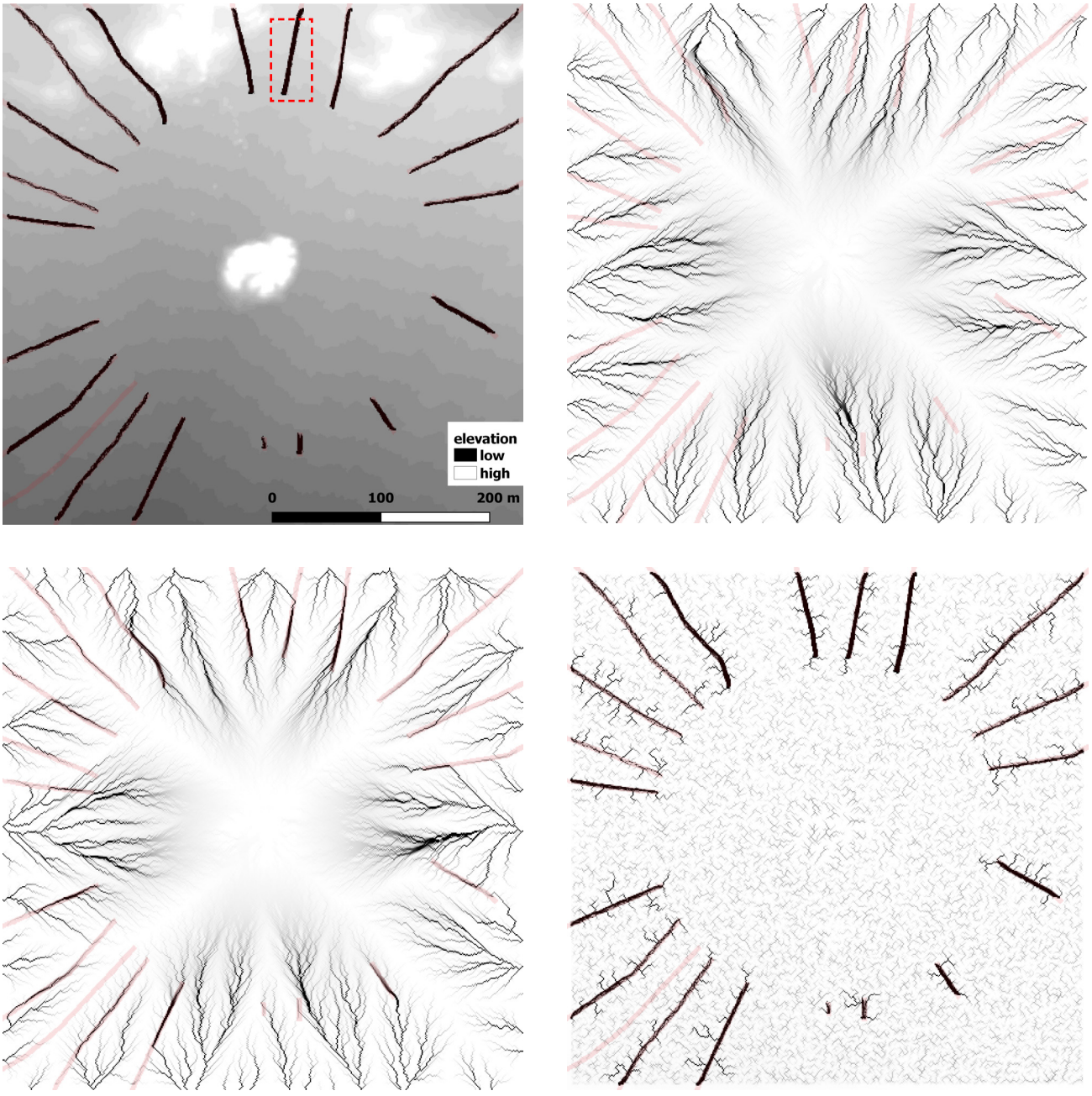

Figure 12.9. *The results of the ABM from four main scenarios. The hollow way in the red rectangle appears separately in Fig. 12.10. The transparent red features indicate the original locations of hollow ways. (a) Hollow way formation with no rain. (b) Landscape incision due to surface runoff and without animal movement. (c) Hollow way formation with rainfall event. (d) Hollow way formation due to animal movement with even rainfall, but also with high evapotranspiration.*

variable drastically alters the model landscape and we observe the hollow ways acting as local water collectors, which further contributed to pugging and poaching processes. A closer look (Fig. 12.10) at one of the hollow ways (rectangle in Fig. 12.9) clearly shows the spatial details of three rainfall scenarios.

Conclusions

This study aimed 'to determine quantitatively how hollow ways contributed to the extension of regional hydraulic systems' (Wilkinson *et al.* 2010, 768). We followed an agent-based modelling approach due

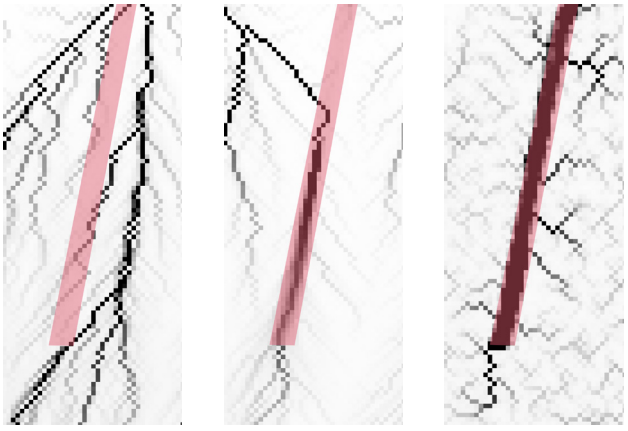

Figure 12.10. *A close-up view of one of the hollow ways (rectangle in Fig 9.) around Tell Brak. (a) Surface runoff creates a hydrological landscape in the absence of animal movement. (b) Hollow ways further facilitate surface runoff when it rains. (c) Integrating water loss into the ABM reveals a more realistic model for the hydrogeomorphology around Tell Brak.*

to the lack of empirical data concerning the hollow ways. While doing so we also hoped to highlight the significance of herd animals in the formation of landscapes. Humans not only shape their environment with structures, such as irrigation canals, reservoirs, and qanats, but also indirectly change it through disciplining nature (e.g. the *hema*).

Despite the level of abstraction in the model, it is capable of capturing details of geomorphological evolution. The model shows the herding power of animals and how they are capable of shifting the water channels and creating new ones. If the hollow way in Figure 12.9c is an indication of this process, managing agricultural fields around these radial route systems must have been a concern in the Khabur Basin. This is also to say that hollow ways may have been emergent phenomena, but they also required external management.

The mechanisms of formation of hollow ways are truly complex (Wilkinson 1993, 556–8). The abstracted ABM we propose here only catches a glimpse of the real-world problem. Still, it is a clear path forward. As the first step, we will carry our model into Python computational environment which will provide more coding flexibility. In doing so, it will be also possible to integrate realistic environmental simulations to our work so that we can transition from an abstract ABM towards more realistic scenarios. Replacing agent multipliers with the specific hoof pressure estimates will also contribute to this transition. Finally, we will cross-compare the results of ABM with our work focusing on satellite remote sensing (Kalaycı *et al.* 2019).

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Fierce lions, angry mice and fat-tailed sheep

Animals have always been an integral part of human existence. In the ancient Near East, this is evident in the record of excavated assemblages of faunal remains, iconography and – for the later historical periods – texts. Animals have predominantly been examined as part of consumption and economy, and while these are important aspects of society in the ancient Near East, the relationships between humans and animals were extremely varied and complex.

Domesticated animals had great impact on social, political and economic structures – for example cattle in agriculture and diet, or donkeys and horses in transport, trade and war. Fantastic mythological beasts such as lion-headed eagles or Anzu-birds in Mesopotamia or Egyptian deities such as the falcon-headed god Horus were part of religious beliefs and myths, while exotic creatures such as lions were part of elite symbolling from the fourth millennium BC onward. In some cases, animals also intruded on human lives in unwanted ways by scavenging or entering the household; this especially applies to small or wild animals. But animals were also attributed agency with the ability to solve problems; the distinction between humans and other animals often blurs in ritual, personal and place names, fables and royal ideology. They were helpers, pets and companions in life and death, peace and war. An association with cult and mortuary practices involves sacrifice and feasting, while some animals held special symbolic significance.

This volume is a tribute to the animals of the ancient Near East (including Mesopotamia, Anatolia, the Levant and Egypt), from the fourth through first millennia BC, and their complex relationship with the environment and other human and nonhuman animals. Offering faunal, textual and iconographic studies, the contributions present a fascinating array of the many ways in which animals influence human life and death, and explore new perspectives in the exciting field of human-animal studies as applied to this part of the world.

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