Writing the Environmental History of the Yellow River Region from the Zhou to the Han: Sources and Methodological Problems

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Abstract

This thesis explores the changing environment of the middle and lower Yellow River basin from the Zhou to the reign of Han Emperor Wu (ca. 1045-87 B.C.), a period characterised by an increase of government control over the land along with an intensification and expansion of agriculture. The second chapter employs palaeoecological sources to look at the early environment of the region, arguing that the eastern plains were mixed forest-steppe, and that the regions to the west were mostly steppe. The third chapter uses archaeological sources to explore the rise of civilisation, the fauna of the region in the Shang period and the spread of iron tools. The fourth chapter is divided into two sections, the first of which looks at what can be learned from the texts of the period concerning agriculture, land clearance, deforestation, hunting, fishing and economic geography. The second half concerns the intensification of state power in regulating and transforming natural environments through legal measures and water control projects, as well as the development of a market economy.

Abstrait

Ce mémoire analyse les changements environnementaux dans la region centre et basse du bassin du Fleuve Jaune de 1045 à 87 B.C. (période correspondant aux dynasties Zhou et Qin, et le premier siècle de la dynastie Han). Durant cette période, le gouvernement intensifie son contrôle des terres, encourage l'intensification agricole ainsi que l'expansion des territoires exploités. En se basant sur des données paléoécologiques, le deuxième chapitre explorera l'environnement passé de la region et tentera de démontrer que les plaines orientales étaient constituées d'un mélange de forêt et de steppe alors que la région occidentale était constituée surtout de steppe. Le troisième chapitre présente ce que nous révèlent les sources archéologiques: la naissance d'une civilisation, les caractéristiques de la faune durant la dynastie Shang ainsi que la diffusion des outils de fer. Le quatrième chapitre est divisé en deux sections, la première se base sur des sources textuelles pour présenter les réalités agricoles, le défrichement des terres, la déforestation, la chasse, la pêche et la géographie économique. La deuxième section illustre l'intensification du pouvoir de l'état à travers une organisation et une transformation de l'environnement, ceci par des lois et des projets hydrauliques ainsi que par le développement d'une économie de marché.

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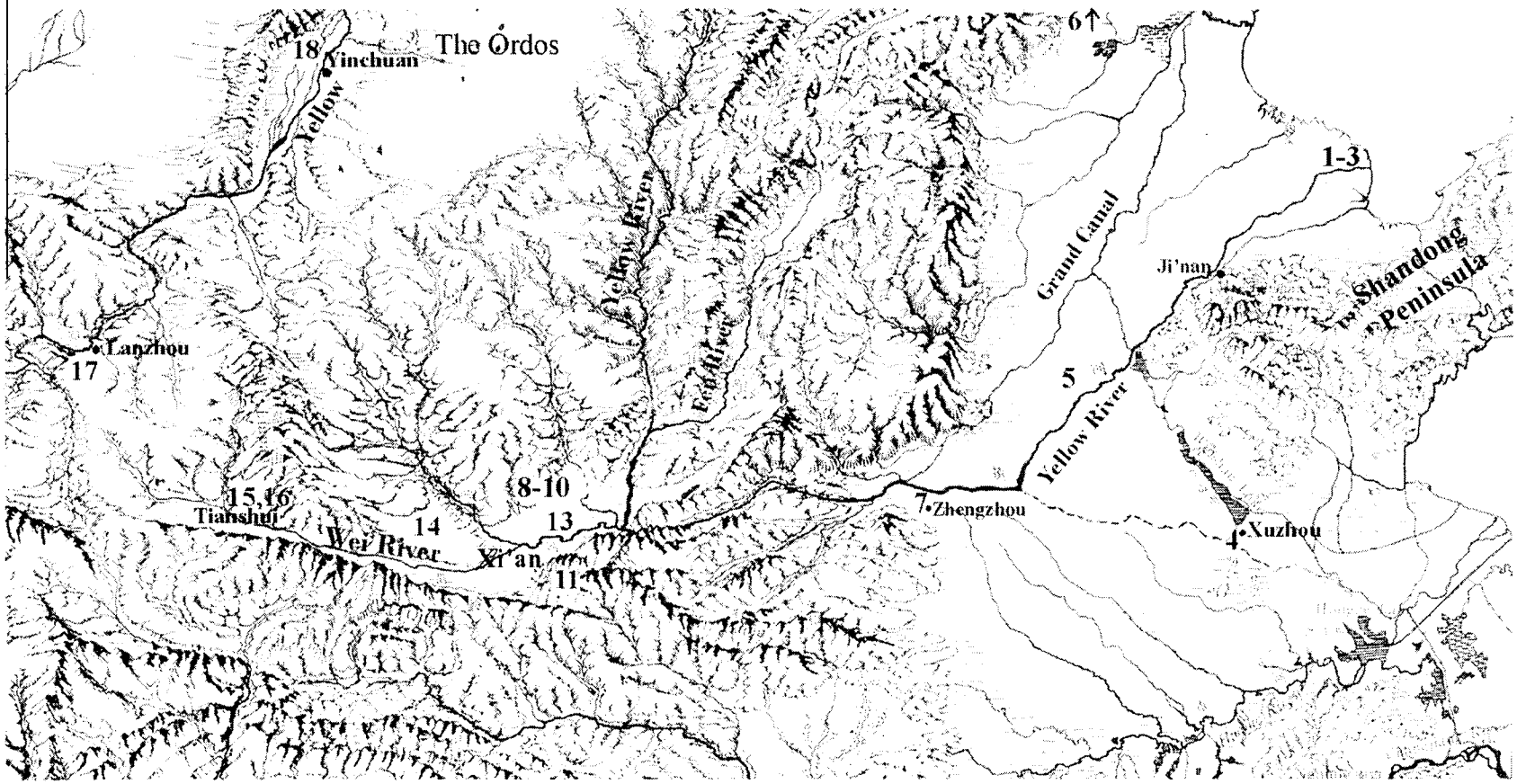
The courses and the teachers at McGill seemed perfectly suited to my project. Robin Yates' course on research methods in Chinese history was an essential, if daunting, introduction to the field. Ken Dean was an excellent and enthusiastic teacher of Classical Chinese. Griet Vankeerberghen's seminar on early Chinese texts and their interpretation was the perfect training in the study of these texts and the period. I doubt anyone could have provided me with a more creative and critical framework from which to approach early texts. Gail Chmura's willingness to offer a course to only three students and to structure it around my project was unexpected and highly appreciated. Her course, including long discussions with Florin and Marie, provided me with a perfect introduction to palynology and helped me work through the problems of my own project. The other students of the East Asian Studies department were supportive in many ways, and I learned a lot from our many calm and courteous debates. Thanks especially to Jim, Lin Fan, Margaret and Sara. I would also like to thank Lin Fan for help in interpreting difficult passages of classical Chinese. Last of all I thank my supervisor Robin Yates for his expert guidance through the study of early China and the process of writing this thesis.



This map depicts the study area, roughly 1500km from east to west. The Yellow River flows from the Tibetan plateau in the west to the northeast, then turns and flows due south until it turns sharply to the east. It flows out onto the plain around Zhengzhou, and has flowed both north and south of the Shandong Peninsula. The numbers depict core sites.

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* Chen Shupeng, ed., *Atlas of Geo-science Analyses of Landsat Imagery in China* (Beijing: Science Press, 1986), 121.

Mencius said, "the trees of Ox mountain were once beautiful. Being situated, however, in the suburbs of a large city, they were hewn down with axes and adzes; could that be considered beautiful? With the healing of the day and night and the nourishing influence of the rain and dew, they were not without buds and sprouts springing forth, but then cattle and goats again browsed upon them. To these things is owing the bare and stripped appearance of the mountain, and when people now see it, they think it never had anything growing on it. But is this the nature of the mountain?"

孟子曰:牛山之木嘗美矣. 以其郊於大國也, 斧斤伐之, 可以為美乎?是其日夜之所息, 雨露之所潤, 非無萌蘖之生焉, 牛羊又從而牧之, 是以若彼濯濯也. 人見其濯濯也以為未嘗有材焉, 此豈山之性也哉?

Mencius 11.8 [1]

Chapter 1: Introduction

This thesis explores changes in the environment of the middle and lower Yellow River drainage basin from the early Zhou period to the time of Han Emperor Wu (ca. 1045-87 B.C.). This region, stretching roughly 1200km from Lanzhou in the west to coastal Shandong in the east, formed the economic centre of the Zhou states and the early empire. Human activity has so altered the vegetation of this region that ecologists differ greatly in their imagination of what it must have looked like before it was transformed. Thus the goal of this thesis is to discover what information is available on the pre-clearance vegetation and to determine what types of ecological changes occurred during the period. The most important of these changes relate to the development of centralised states and empires whose governments exercised greater control over the environment than had their predecessors.

In terms of morphology, the region can be divided into two regions: western highlands and eastern plains. The western region is mostly composed of loess, a fertile, but easily eroded silt deposited over the past 2.5 million years by windstorms from the northwest and lying well over 200m deep in some areas. Severe erosion has dissected much of the Loess Plateau, and the rivers flow in deep gulleys and valleys, which means that little of the region is prone to flooding. Because of the thickness of the loess in this area and the natural fertility of loess, farming has been able to

[1] *Mencius* 孟子 (*Zhuzi jicheng* 諸子集成 vol.1, Beijing: Zhonghua, 1954), 11.456. James Legge, *The Chinese Classics* vol. 5 (Hong Kong: Hong Kong University Press, 1960), 407. Mod.

continue for thousands of years despite constant erosion.[2] The most important agricultural areas are the valley bottoms, particularly that of the Wei River and of other tributaries of the Yellow River to the East such as the Yiluo. The monsoon brings 80% of the year's precipitation in the three summer months, often in torrential downpours. Moreover, the differences in rainfall between years are often great and the region is prone to both droughts and floods. Because of this, much of the agriculture of this region depends on irrigation, which was first practiced on a large scale in the Warring States period (481-221 B.C.).

Of the world's rivers only the Ganges transports more sediment than the Yellow River.[3] For two million years eroded loess has flowed down the turbid Yellow River and flowed out onto the plain near Zhengzhou, Henan. The North China (or eastern) Plain is mostly composed of this alluvium, which is often harder than the highland loess and more difficult to plough. The only hills or mountains in the plains region are found in eastern Shandong. Until it was constrained by dikes, the river wandered freely across the plain, often in several separate channels; it has no "natural course." Thus it is not surprising that humans living in the area have frequently been ravaged by severe floods. There is a direct correlation between upstream erosion caused by agriculture and downstream flooding. The process whereby humans have constrained it (with varying amounts of success) to a single course began in the Warring States period.

Because it is a flat plain composed of alluvial deposits, the North China Plain was relatively easily altered by humans, who began in the Eastern Zhou period (771-221 B.C.) to alter existing waterways in order to create transport canals. A current map is of no use in understanding the hydrology of the plain 2500 years ago; human activity has completely transformed it. Perhaps because of this, there remain few areas undisturbed enough to preserve records of ecological change; and few

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[2] Loess soil is unusually fertile when irrigated as it contains most trace elements necessary for plant growth. Liu Tungsheng has shown that although it is weak in zinc (Zn), copper (Cu), and manganese (Mn), these elements accumulate over years of farming. Only molybdenum (Mo) does not accumulate, and was thus lacking, although it is unclear what effect this would have had on crop growth. Liu Tungsheng, *Loess in China* (Beijing: China Ocean Press and Berlin: Springer-Verlag, 1988), 163.

[3] John D. Milliman & Robert H. Meade, "World-wide Delivery of River Sediment to the Oceans," *The Journal of Geology* 91.1 (1983), 1-21.

palynologists (fossil pollen specialists) have studied the area. So the pre-clearance vegetation remains a mystery.

The central questions of this study arose as a result of my perspective as a student of the environmental history of the Americas where the ecological transformations effected by the first peoples and then by European colonists were so drastic that in each case the concept of "original" fauna and vegetation is useful. In China, humans have been a part of the environment for many thousands of years, and there are no such pivotal ecological events. During the past few thousand years humans have gradually gone from being one of many species in the Yellow River region's ecosystems to being the single dominant species, thoroughly modifying the environment for their own needs.[4] Because this transformation began long before the invention of writing, its history has largely remained the domain of scientists and archaeologists. By combining the findings of palaeoecology, archaeology, and text-based history, I hope to provide a more thorough picture of the changing environment in this time of great change.

Environmental historians often explore the processes by which humans destroy nature, a negative perspective. This perspective would probably have been shared by the non-human inhabitants of the area as their habitat was cleared by farmers, and is somewhat inherent in the idea of focusing on the ecosystem rather than the people. The same story could just as easily be described as a heroic process whereby humans overcame floods and wild beasts to found a lasting civilisation, as it was by Mencius.[5] Instead of focusing on destruction or celebration, I would like to base my study on the realisation that human civilisation is always inseparable from the various chemical and biological systems of the earth. Although it is necessary for analysis to separate human ideas and social systems from these others, it must be remembered that they are never separate at all. But because humans often behave in ways that make no sense from an ecological point of view, the way our societies

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[4] Although the field of environmental history was founded in the U.S. and its foremost theoreticians are still mostly American, the problems of Chinese environmental history are quite different from those in the Americas. The most insightful overview of the most recent three millennia of China's environmental history is Mark Elvin's "Three Thousand Years of Unsustainable Growth: China's Environment from Archaic Times to the Present," *East Asian History* 6 (1993), 7-46.

[5] *Mencius* (*Zhuzi jicheng* vol.1), 5.219-26, 6.263-68.

relate to their environments can only be understood by studying their internal (ideological, economic, political, etc.) logic. A focus on the fundamental inseparability of human society and ecology is useful because it allows us to study any society, whether industrial capitalist or hunter-gatherer, as an ecological system. This model has much more potential for modern history, with its abundance of sources, than for ancient history, but it is nonetheless a useful framework from which to examine relations over time between human society and the environment which it inhabits. This thesis describes a period in which human society gained more control in its relationship with the processes of the earth. As is common throughout world history, the process whereby humans expand their control over the environment is inseparable from the process whereby some humans expand their control over others.

The gradual increase in human control over the environment is often explained as a process whereby humans improve their lifestyles at the expense of other elements in the ecosystem, but this is not necessarily so. The trend towards intensive agriculture and increased population, while beneficial in the short term for states interested in military success, tended to put farmers in a much more tenuous relation with the earth than when populations were lower and there was more wild land. Forests and marshes contained resources that could be depended on when crops failed; once they were gone there was nothing to prevent famine. From a long term perspective, the enormous famines and subsequent popular uprisings so common in Chinese history were not natural events, but had their roots in the overemphasis on land clearance for agriculture. Sima Qian's descriptions of the North China Plain make clear that the area was already overpopulated in the early Han, and resources were scarce.

Although it is often assumed that human society tends to increase in knowledge as society becomes more sophisticated, understanding of natural ecosystems tends to fade as agriculture increases in importance. Hunter gatherers, who spend all of their time interacting with wild environments, have a more profound understanding of natural ecosystems than do sedentary agriculturalists who

themselves are much more aware of natural processes than urbanites. The intensification of agriculture at the expense of natural ecosystems is accompanied by increased social stratification and exploitation; a higher level of civilisation does not mean a higher standard of living for everyone. It is good to remember, when researching environmental history, that the authors of most early texts were elites and urbanites, the people most separated from the environment. By the Han, our best sources for environmental history are economic texts, because the writing classes viewed wild animals and plants as commodities.

In any case, the focus of this thesis is not on changes in human consciousness towards the environment but rather how the environment changed during this period due to changing patterns of human activity. Although there is little direct evidence of this process, its traces can be found in written texts from the period, archaeological finds, and palaeoecological evidence. Throughout the period agriculture became more intensive, and spread outwards, intensifying human pressure on wild ecosystems and gradually replacing them with farmland, orchards, fish ponds, grazing land, and human settlements.

It should be noted that I am not claiming that civilisation began in the Yellow River and spread from there, a thesis that has been discredited by archaeologists.[6] I am arguing that a previously-unknown intensity of land use was developed in the states of the Yellow river region during the Eastern Zhou, and spread outwards along with the population of the region. This process had no obvious beginning, and has continued, intermittently, to the present, but the inter-state competition of the Eastern Zhou led to an aggressive drive for increased productivity, which was then spread across a large area by the highly centralised and powerful early empires, especially under the Qin First Emperor (221-210 B.C.) and Emperor Wu of the Han (147-87 B.C.).

At the beginning of this period, human settlements were places within a wild landscape, while, by the end, the entire land was considered to belong to whatever state claimed and occupied it. In the Shang (ca 1200-1045 B.C.), for example, land

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[6] K.C. Chang, *The Archaeology of Ancient China* 4th ed. (New Haven: Yale University Press, 1986), 234-42.

was understood in terms of the clans or peoples who inhabited and exploited it, not as the territory of a specific state.[7] A thousand years later, all of the people and land inside the borders of a state were considered part of that state, which appointed officials to ensure that productive land was being exploited for state revenue.

By the time of the downfall of the Western Zhou (1045-771 B.C.), society had been socially stratified for at least two thousand years and large regions had been unified under the rule of various kinship groups, clans and dynasties. During the Eastern Zhou, this system of rulership was replaced by centralised, bureaucratic states. In a passage explaining the transformation of political power during the Eastern Zhou, Mark Edward Lewis explains that "the correlation of the concentration of power in the ruler and the central court was the extension of state control into the rural hinterlands. This extension was based on the development of a new political role, that of the dependent official who was the creature of the ruler. The ability to appoint officials, dispatch them to remote cities, maintain control over them at a distance, and remove them when necessary was essential to the creation of a territorial state. Only with such powers could the ruler impose his will across an extended realm."[8] Although the polities that Lewis describes can be considered the earliest territorial states in China, the difference between this and earlier decentralized polities was reduced by the relative autonomy of officials in distant posts. Nonetheless, the ruler now officially controlled all of his land, giving him unprecedented power to transform the environment.

The purpose of this research is to provide a basis for any other research on the environmental history in the region. I had never intended to study ancient history, but found that without the basic information on the early period it would be difficult to study the changes in the environment of any subsequent period in North China. It is also relevant to the environmental history of other regions in China at the same time, and those that were later colonised by people from the Yellow River region. Even intellectual histories of early environmental thought cannot be done in

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[7] David N. Keightley, "The Late Shang State: When, Where and What?," in *The Origins of Chinese Civilization*, ed. David N. Keightley (Berkeley: University of California Press, 1983), 527.
[8] Mark Edward Lewis, "Warring States Political History," in *The Cambridge History of Ancient China*, ed. Michael Loewe & Edward L. Shaughnessy (Cambridge: Cambridge University Press, 1999), 603.

an ecological vacuum and should pay attention to the physical environment of the author. Thus I have gone back to the beginnings of written history and beyond in order to provide a basis for future work.

Because the goal of this study is to discover changes in an environment that has long disappeared and which has left only scattered clues, the reader may find it vague and inconclusive at times. However, this is the nature of such research; to present the results in any more concrete terms would be an exercise in historical imagination. Perhaps these limitations explain why the topic has so rarely been studied. Although there are scholarly debates that will be discussed in this thesis, such as the pre-clearance vegetation of the region and the best way to characterise early polities, very few people have dealt with this subject directly and there is little academic debate on the subject as a whole.

The most significant contributions in a western language have come at the beginnings of larger studies of the period, most notably from archaeologists K.C. Chang and Li Liu,[9] as well as from Shang specialist David Keightley.[10] These are well-researched overviews of the subjects, but they are brief and are focused on the environment as it shaped human society during the entire Holocene rather than the effects humans had on the environment in any given period. Likewise, Ho Ping-ti's *The Cradle of the East* discusses palaeoenvironment and the beginnings of agriculture in some depth, but does not consider the role of humans on the environment.[11] The developing field of Chinese environmental history has produced high-quality work, most notably in the collection *Sediments of Time: Environment and Society in Chinese History*, and in Mark Elvin's *The Retreat of the Elephants: An Environmental History of*

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[9] K.C. Chang, *Shang Civilization* (New Haven: Yale University Press, 1980), 136-50; K.C. Chang, *The Archaeology of Ancient China*, 71-81; Liu Li, *The Chinese Neolithic: Trajectories to Early States* (Cambridge: Cambridge University Press, 2004), 19-32. The latter work is the most up to date, and the environment is taken into consideration in the rest of the work.

[10] David N. Keightley, "The Environment of Ancient China," in *The Cambridge History of Ancient China*, ed. Loewe & Shaughnessy, 30-36.

[11] Ping-Ti Ho, *The Cradle of the East: An Inquiry into the Indigenous Origins of Techniques and Ideas of Neolithic and Early Historic China, 5000-1000 B.C.* (Chicago: University of Chicago Press, 1975).

China.[12] Although both of these focus on later periods, they include excellent studies of water-control in North China.[13]

Far more work has been done on subjects relevant to this thesis in China than elsewhere, although virtually none of it by scholars describing themselves as environmental historians. During the course of my research, I discovered the titles of many works published recently in China on a variety of topics relevant to this thesis, but was unable to obtain the works themselves. I am hopeful that my upcoming research in China will show the comments in this thesis on the inadequacy of palaeoecological and archaeological data to be outdated.

The scholar whose works can be considered the most relevant to this thesis is Shi Nianhai 史念海, a historical geographer who specialised in the Yellow River region from the Neolithic to the Tang dynasty. The two volumes of his *Heshan ji* 河山集 (Collected works on rivers and mountains) includes studies of agriculture, economy and trade, various commodities, rivers and canals, smaller areas like the Wei valley, erosion on the Loess Plateau and the forests of the central Yellow River valley.[14] His more recent study of the Loess Plateau, although a brilliant work summarising a lifetime of study, does not consider recent scholarship.[15] His work is very useful for understanding the economy of the early period, and he is particularly strong in his familiarity with the region's local geography. However, although he uses archaeological evidence for the Neolithic period, he considers textual evidence paramount, and often gives far too much weight to ambiguous passages in ancient texts. Thus his best work is that which deals with periods for which textual evidence

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[12] *Sediments of Time: Environment and Society in Chinese History*, ed. Mark Elvin & Liu Ts'ui-jung (Cambridge: Cambridge University Press, 1998); Mark Elvin, *The Retreat of the Elephants: An Environmental History of China* (New Haven: Yale University Press, 2004).

[13] Elvin, *The Retreat of the Elephants*, 128-40; Pierre-Étienne Will, "Clear Water versus Muddy Waters: The Zheng-Bai Irrigation System of Shaanxi Province in the Late Imperial Period," in *Sediments of Time*, ed. Elvin & Liu, 283-343. Although also focused on more recent times, a Sino-French collaboration on the particularity of local customs in areas with hydraulic management systems is among the most interesting work being done on the relationship between human society and the environment in North China: Bai Erheng 白爾恒, Christian Lamoureux & Pierre-Étienne Will, *Gouxu yiwen zalu* 溝洫佚聞雜錄 (Gestion locale et modernisation hydraulique) (Beijing: Zhonghua, 2003).

[14] Shi Nianhai 史念海, *Heshan ji* 河山集 (Beijing: Sanlian, vol. 1, 1963; vol. 2, 1981).

[15] Shi Nianhai, *Huangtu gaoyuan lishi dili yanjiu* 黃土高原歷史地理研究 (Study of the historical geography of the Loess Plateau) (Zhengzhou: Huanghe shuili, 2000).

is abundant, especially from the Han to the Tang. He is also not an ecologist, listing tree species mentioned in texts rather than considering what types of plants communities may have existed. As can be seen by comparing the plants in the second chapter of this thesis (on palaeoecology) with the plants mentioned in the *Odes* (discussed in the fourth chapter), textual sources are strongly biased towards the human environment and do not represent the dominant natural ecosystems. Despite these weaknesses, Shi's work is invaluable.

Another notable work is Wang Xingguang's environmental history of the Xia dynasty, which contains a useful overview of the Neolithic and early Bronze Age environment, but does not discuss the post-Shang period.[16] However, the most important work has been done by palaeoecologists; I will not discuss it here because the next chapter of this thesis is an overview and discussion of this literature.

I have divided the body of the thesis into three chapters based on three types of sources. In the first I will use information from palaeoecological sources, especially palynology, to see what can be learned about the environment of the period. The second will analyse archaeological sources, which provide information on the development of civilisation up to the Zhou period, the animal remains found at Anyang, and the spread of iron technology and tools. The third chapter will discuss written sources, which are strongest in describing the human society of the period and its relationship with its environment. Because each source leads to the discussion of specific topics, other types of sources will occasionally be mentioned where appropriate. It will be seen that each source provides a different perspective on the process, and it is hoped that the strengths of each can make up for the weaknesses of the others. Moreover, correlations and contradictions between various sources provide a valuable perspective from which to examine each, so that the overall picture of environmental change will be more valuable than the sum of its parts.

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[16] Wang Xingguang 王星光, *Shengtai huanjing bianqian yu Xia dai de xingqi tansuo* 生態環境變遷與夏代的興起探索 (An exploration of ecological change during the Xia-dynasty period) (Bejing: Science Press, 2004).

Chapter 2: Palaeoecological Sources

Because rainfall is higher in the southeast than the northwest, the vegetation of this region has generally been interpreted as having faded from coastal forests in the east to grassland/desert in the northwest. However, human activity has so altered the vegetation of this region that it is impossible to find modern analogues of ancient landscapes, especially on the eastern plain, and a variety of environments are possible.

The objective of this chapter is to determine what information on the environment of the region can be determined from palaeobotanical, mostly palynological, sources. For reasons that will be explained below, few of the sources for the relatively short time period in question include any changes that can be equated with events identified in other sources. However, they show long-term environmental change, and, moreover, provide some information on the vegetation around the region before it was cleared for human use. It should be noted that although I will discuss climate change, I am not attempting to use pollen data to explore questions of climate change. This would require too much discussion of longer time periods, and is much better suited to areas with better depositional environments, such as northeast China.

Although we know that the south was forested, and the arid north and west were steppe and desert, it is unknown where the forest ended and the steppe began. In his description of the forest-steppe biome, Heinrich Walter provides a description that probably corresponds to what it would have once been like to travel from Shandong to Gansu. This ecological transition zone was "not a homogeneous vegetational formation like the tropical savannah, but rather a macromosaic of deciduous-forest stands and meadow-steppe. At first, the former predominate, the steppes forming scattered islands. But the more arid the climate becomes, the more the situation tends to be reversed, until finally, small islands of forest are left in a sea of steppe."[17]

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[17] Heinrich Walter, *Vegetation of the Earth and Ecological Systems of the Geo-biosphere* (Berlin: Springer-Verlag, 1984), 220.

Humans have transformed the vegetation of the entire Loess Plateau, leaving few clues as to what once grew there. Sun Xiangjun notes that "human activity has destroyed almost all the natural vegetation of the Plateau surface and mountain areas below 1000 m a.s.l. except for patches at the higher altitudes and in valleys."[18] Shi Nianhai believed that the forests extended as far as the Ordos.[19] However, this is based only on excavated charcoal and mentions of places named 林 *lin* "forest" in early texts, the former of which proves only tree presence, the latter only that there were *lin* in some areas. The term itself may not actually refer to the type of dense forest Shi is describing, and the fact that places were named something-*lin* could be interpreted as evidence that forests were uncommon rather than ubiquitous in the region. It should be noted that Shi's position had been argued by earlier textual scholars, and it remains the most common position among Chinese historians, although rarely based on any more evidence than Shi's claims.[20] It has recently been supported by He Xiubin's argument that the mid-Holocene palaeosol could only have been formed under a warm-temperate forest.[21]

On the other side, V.K. Ting, founder of the China Geological Survey, claimed in 1931 that "all geologists agree that in the loess there has never been any forestation...the loess area has always been a semi-steppe," a claim quoted by Ping-ti Ho, who held the same opinion.[22] They both note that there are wetlands in the Wei valley. This position was later affirmed by Liu Tungsheng, who based his opinion on a study of soil, phytoliths, organic carbon isotopes and pollen evidence.[23] This

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[18] Sun Xiangjun et al., "Vegetation History of the Loess Plateau of China during the Last 100,000 Years Based on Pollen Data," *Quaternary International* 37 (1997), 27.

[19] Shi Nianhai, "Lishi shiqi Huanghe zhongyou de senlin" 歷史時期黃河中游的森林 (Central Yellow River region forests in the historical period), in Shi Nianhai, *Heshan ji* vol. 2, 232-314.

[20] For example: Li Jihua 李繼華, "Shandong senlin de lishi yanbian" 山東森林的歷史演變 (Historical changes in Shandong's forests), *Nongye kaogu* 1987.1, 219-25; Zhang Junchang 張鈞長, "Shang-Yin lin kao" 商殷林考 (A study of Shang dynasty forests), *Nongye kaogu* 1985.1, 180-86; Zhang Qingtao 張靖濤, "Gansu senlin de lishi bianqian" 甘肅森林的歷史變遷 (Historical changes in Gansu's forests) *Nongye kaogu* 1986.2, 202-09. Also argued in R. Pearson, "Pollen Counts in North China," *Antiquity* 48 (1974), 226-28.

[21] He Xiubin et al., "Bio-climatic Imprints on a Holocene Loess Paleosol from China," *Journal of Asian Earth Sciences* 22 (2004), 455-64.

[22] Ping-Ti Ho, *The Cradle of the East*, 29-32.

[23] Liu Tungsheng et al., "Prehistoric Vegetation on the Loess Plateau: Steppe or Forest?," *Journal of Southeast Asian Earth Sciences* 13 (1996), 341-46.

would imply that the forest-steppe transition zone would have been in the lower Yellow Valley.

It is not only the prehistoric vegetation that is debated; even the geomorphology is in dispute. Shi Nianhai has suggested that the severely eroded Loess Plateau would have been mostly a series of interconnected plateaus in the Zhou period, having been dissected by gullies only since humans cleared the forests.[24] Timothy Quine et al. have shown that some areas have experienced significant erosion during the past 60 years.[25] However, while acknowledging that erosion rates have greatly increased under human pressure, Liu Tungsheng argues that these gullies have been forming for at least 50,000 years, and thus cannot be solely attributed to human activity. He also mentions aerial photos of the plateau which show that trees usually grow only in the gullies, the only places with adequate moisture, a situation he believes to be natural and not simply the result of human land clearance.[26]

One type of indirect evidence useful for understanding the history of erosion of loess on the plateau is the deposition rate of alluvium on the plain. The Yellow River's current annual sediment deposition between Sanmenxia, Henan, and the coast is 400,000,000 tons, in addition to the 1,080,000,000 tons which flow into the ocean. Based on dubious historical evidence, John Milliman et al. have estimated that the sediment discharge was 35% of the latter figure from 340 to 200 B.C. at which time they claim an increase in farming occurred that raised the figure to 80%.[27] Even the lower figure still represents an enormous amount of sediment, and explains how the coast has grown so much over the past few millennia. Based on analysis of sediment rather than imagined historical events, Xu Jiongxin has shown the increase in erosion rates over time:

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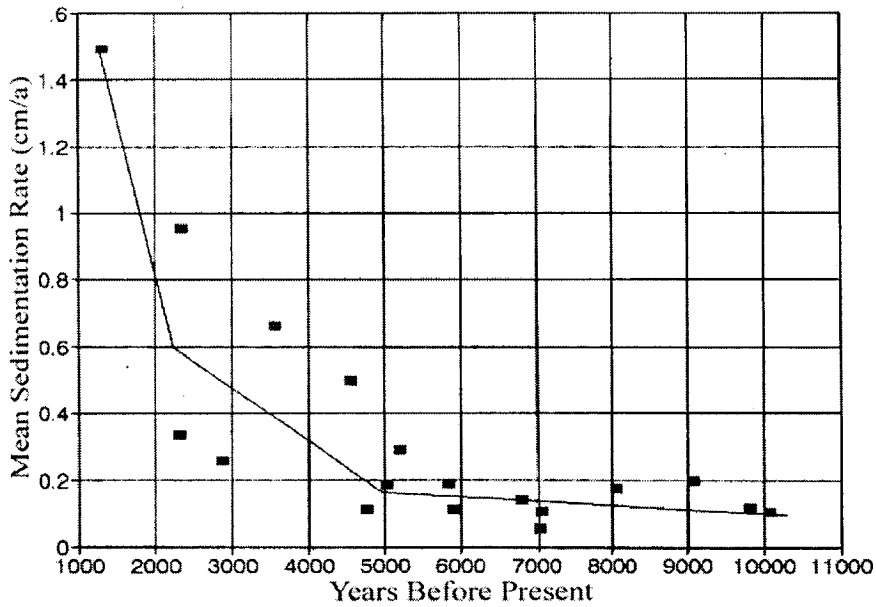
[24] Shi Nianhai, *Heshan ji* vol. 2, 1-33.
[25] T.A. Quine, D. Walling & X. Zhang, "Slope and Gully Response to Agricultural Activity in the Rolling Loess Plateau, China," in *Fluvial Processes and Environmental Change*, ed. A.G. Brown & T.A. Quine (New York: Wiley & Sons, 1999), 71-90.
[26] Liu Tungsheng, *Loess in China*, 198-99.
[27] John D. Milliman et al., "Man's Influence on the Erosion and Transport of Sediment by Asian Rivers: the Yellow River (Huanghe) Example," *The Journal of Geology* 95 (1987), 751-54.



Sedimentation in the lower Yellow River.[28]

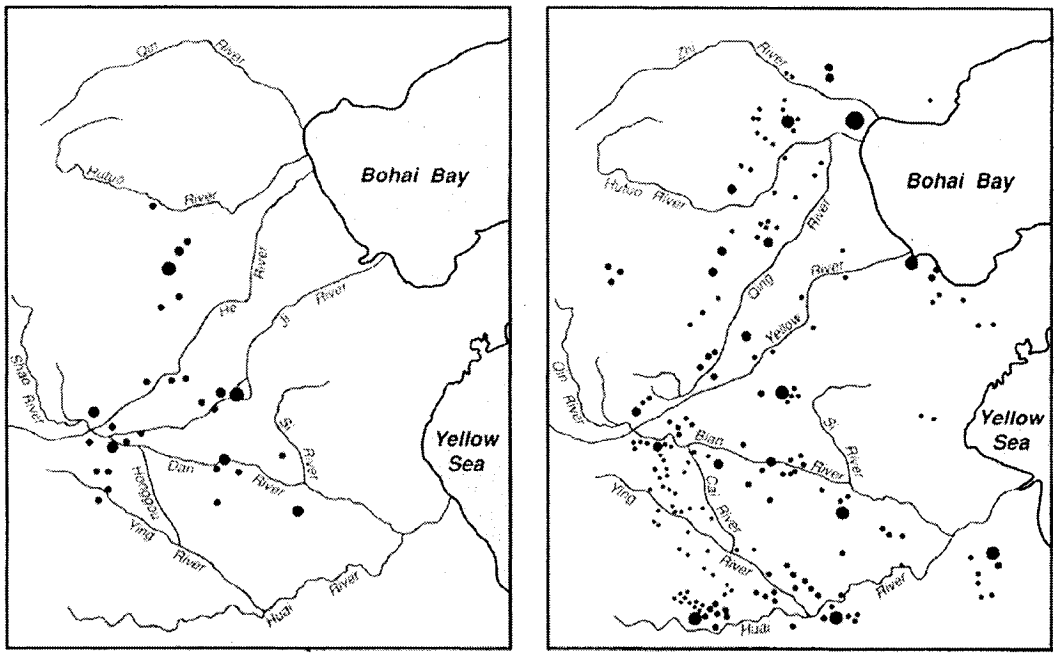
This shows clearly that sedimentation began increasing around 3000 B.C. and has increased steadily since. Xu believes that the early stages of this increase were caused by the drying of the climate. Although this may well be true, there were human settlements across the region by that period, as will be shown below, so human influence is likely.

The survival of small areas of somewhat natural vegetation on the plateau makes reconstructing ancient vegetation easier than on the plain where there are no mountains or gullies to protect relict vegetation. In his survey of China's vegetation Wang Chi-wu admits that "the original natural vegetation of the Great Plain...is a perplexing problem. Ecologists do not agree as to whether it was originally a grassland, wooded steppe, or woodland."[29] One thing that is known is that the plain was dotted with lakes and wetlands, most of which have since been filled in by alluvial sediment or human activity. The following maps show the lakes of the region. The first is based on pre-Qin texts, the second on the *Shuijing zhu*, a text written during the 5th century A.D., but probably describing lakes that existed earlier. These lakes would probably have grown significantly during the marine

[28] Xu Jiongxin, "Naturally and Anthropogenically Accelerated Sedimentation in the Lower Yellow River, China, over the Past 13,000 Years," *Geografiska Annaler. Series A, Physical Geography* 80.1 (1998), 73.

[29] Wang Chi-wu, *The Forests of China, with a Survey of Grassland and Desert Vegetation* (Cambridge, Mass.: Maria Moors Cabot Foundation, 1961), 85.

transgressions which peaked around 4000-3000 B.C., and were still high at 2000 B.C. The sea level only descended to modern levels on the North China coast during the



A B

Distribution of major lakes on the eastern plain according to Eastern Zhou texts (A) and the *Shui jing zhu* (B).[30]

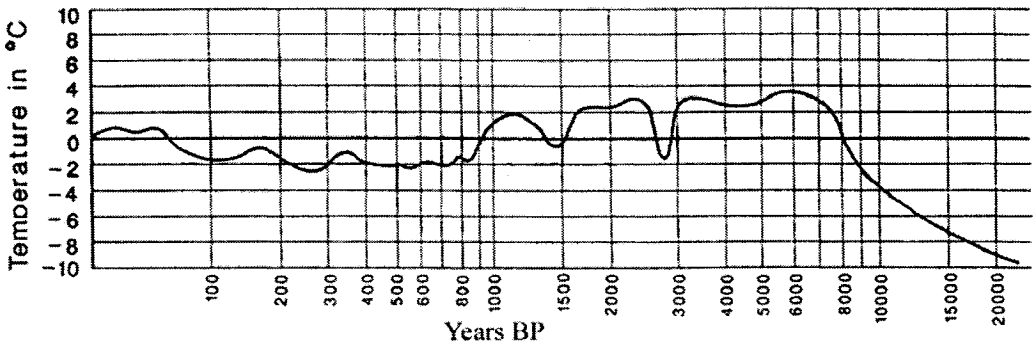
late Western Han (ca. 9 A.D.).[31] These would not only have moved the coast westward, but also slowed the flow of the rivers flowing off the plain and increased the area affected by high tides, which would tend to generally increase wetlands across such a flat area.

Unfortunately, very little palynology has been done in the plain, so we are a long way from knowing what vegetation grew in these wetlands or on the drier areas. These ancient lakes and wetlands, especially those that were filled with silt and not drained for agriculture, would be perfect coring sites, and could possibly provide the first high-quality pollen records for the plain.

Another clue that may be of use in reconstructing vegetation is climatic information, both historical and contemporary. The Holocene climatic optimum, meaning the highest temperatures in the post-glacial period, has broadly been placed

[30] Liu Li, *The Chinese Neolithic*, 22. Based on the work of Zou Yilin.
[31] Keightley, "The Environment of Ancient China," 30.

in the period 8000-3000 BP, although the temperature was still (or again) higher than at present during the Eastern Zhou. Zhu Kezhen argued that the warmer climate could be seen from the existence of bamboo in Henan, where it is currently too cold for bamboo, into the Han dynasty. The evidence for bamboo includes the bones of bamboo rat and panda (bamboo eaters), carbonized bamboo, and Neolithic pottery in the shape of bamboo. Zhu interpreted the presence of elephants, rhinoceros, and other currently southern mammals as evidence of a warmer climate, although it is likely that over-hunting and habitat loss had eliminated them from most of the region before the climate cooled. The disappearance of smaller mammals like water deer (*Hydropotes inermis*) and bamboo rat (*Rhizomys sinensis*) from the north are more likely the result of a cooling climate. Zhu argued that the existence of plums (*mei* 梅 *Prunus mume*) in the north, and the references in both *Mencius* and *Xunzi* to double-cropping, show that the period between the late tenth and the early second centuries B.C. was warmer than at present.[32] Winkler and Wang's overview of the literature twenty years later essentially agreed with Zhu, concluding that the climate was about two degrees higher throughout the Zhou and early Han period:



Changes in the Climate of China during the past 20,000 years.[33]

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[32] Zhu Kezhen 竺可楨, "Zhongguo jin wuqiannian lai qihou bianqian de chubu yanjiu" 中國近五千年來氣候變遷的初步研究 (Preliminary study of China's climate during the past 5000 years) (1973), In *Zhu Kezhen quanji* vol. 4 (Shanghai: Shanghai keji jiaoyu, 2004), 444-73. Ma Xin 馬新 has researched the Han climate in more depth and generally confirmed Zhu's opinions: Ma Xin, "Lishi qihou yu liang Han nongye de fazhan" 歷史氣候與兩漢農業的發展 (Climate history and Han dynasty agricultural development), in *Qin-Han shi luncong* 秦漢史論叢 9 (Xi'an: San Qin, 2004), 471-84.

[33] Marjorie G. Winkler & Pao K. Wang, "The Late Quaternary Vegetation and Climate of China," in *Global Climates since the Last Glacial Maximum*, ed. H.E. Wright, et al. (Minneapolis: University of Minnesota Press, 1993), 230. Chart has been modified for clarity.

Chun chang Huan et al. have shown that the Western Zhou period corresponds with a period in which the palaeosols of the Holocene Climatic Optimum were replaced by loess accumulation.[34] Although the cores were taken from the political capitals of the period, and one must wonder whether soils could possibly form in an urban (or heavily grazed) environment, the results nonetheless suggest that the period was one of increasing aridity. The authors reasonably equate this change with the southward movement of the Rong and Di, which displaced the Zhou and may have contributed to their overthrow of the Shang. Although the downfall of the Western Zhou and the Han can perhaps be correlated with significant climatic cooling, the Eastern Zhou and early Han period remained about 2° warmer than the present climate. Within this comparatively warm period, Winkler and Wang show the Warring States period as a slightly warmer period than the Han, while Zhu's results suggest the opposite.

The temperature-based interpretation of the climatic optimum has been challenged by An Zhisheng et al., who argue that "in the East Asian Monsoon Region, monsoon precipitation and effective moisture (a function of precipitation, evaporation, and temperature) are the most important factors controlling biological productivity, especially in arid, semi-arid and semi-humid areas that are sensitive to variations in the monsoon climate. As recorded by geologic and biological data, effective moisture has a strong influence on ecological environments in east-central China and determines whether the desert shrinks or advances, the level of inland lakes rises or falls, the vegetation cover becomes more or less dense, the tree limit advances or retreats, pedogenesis intensifies or weakens, and in semi-humid, lake or swamps systems develop or vanish."[35] Thus they argue that the optimum had more

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[34] C.C. Huang, Zhao S., Pang J., Zhou Q., Chen S., Li P., Mao L., Ding M., "Climatic Aridity and the Relocations of the Zhou Culture in the Southern Loess Plateau of China," *Climatic Change* 61.3 (2003), 361-78. See also C.C. Huang, J. Pang, et al., "Holocene Pedogenic Change and the Emergence and Decline of Rain-fed Cereal Agriculture on the Chinese Loess Plateau," *Quaternary Science Reviews* 23 (2004), 2525-35, and Jiang Li Pang & Chun Chang Huang, "Mid-Holocene Soil Formation and the Impact of Dust Input in the Middle Reaches of the Yellow River, Northern China, " *Soil Science* 171.7 (2006), 552-63.

[35] An Zhisheng et al., "Asynchronous Holocene Optimum of the East Asian Monsoon," *Quaternary Science Reviews* 19 (2000), 756.

to do with increased precipitation due to shifts in the monsoon than with temperature, and that we should not assume that changes in vegetation were the result of changing temperatures. The authors show that between 10,000 and 7,000 years ago lake levels were higher than at any other period in the Holocene, and have gradually decreased since then. Another method they use is stratigraphical analysis of the loess region, which is based on the assumption that soils form in wetter and possibly warmer conditions. They show that between 10,000 and 4,000 BP soils were common, but, following, this the loess accumulated with little organic matter.[36] However, it does not seem likely that the various plants and animals that previously lived farther north moved south entirely due to desiccation. High-quality pollen records from forested regions of northeast China also suggest a cooling of the climate in this period.[37]

Because we have some idea how much warmer the climate was then than now, we can infer something about the range of palaeovegetation types from the current climate. The climate of the region can be shown from the examples of seven cities which I will list from east to west followed by: 1: elevation, 2: mean annual temperature, 3: mean July and January temperatures, 4: mean July and January precipitation (mm), 5: and mean annual precipitation (mm). Most of the cores which will be discussed below were taken close to these cities.

Table 1: Modern Climate[38]

	1	2	3	4	5
Xuzhou	43m	14.0°	26.9°/-0.7°	248/13	868
Ji'nan	52m	14.2°	27.6°/-1.7°	214/6	672
Zhengzhou	110m	14.2°	27.5°/-0.3°	135/9	636
Xi'an	397m	13.3°	26.6°/-1.0°	99/8	581
Tianshui	1132m	10.8°	22.6°/-2.8°	99/4	531
Yinchuan	1112m	8.5°	23.4°/-9.0°	44/1	203
Lanzhou	1517m	9.1°	22.2°/-6.9°	64/1	326

[36] An Zhisheng et al., "Asynchronous Holocene Optimum of the East Asian Monsoon," 743-62.
[37] For example: Zhou Kunshu 周昆叔 et al., "Zhongguo beifang quanxin tong huafen fenxi yu gu huanjing" 中國北方全新統花粉分析與古環境 (Pollen analysis of the Holocene in North China and Palaeoenvironments), in *Disiji baofen fenxi yu gudai huanjing* 第四紀孢粉分析與古代環境, ed. Zhongguo kexue yuan dizhi yanjiusuo baofen fenxi zu (Beijing: Science Press, 1984), 25-54.
[38] Manfred Domros & Peng Gongbing, *The Climate of China* (Berlin: Springer-Verlag, 1988).

To make sense of the figures, we can take advantage of research done in other areas attempting to correlate precipitation, temperature and vegetation. The woodland-steppe transition of Inner Mongolia corresponds with a precipitation range of 320-450mm, which implies that the woodland-steppe transition should be between Tianshui and Lanzhou, and that the plateau and the plain would be woodland.[39] A recent biogeography textbook defines three biomes by their precipitation (mm): deserts receive between 100 and 500, grasslands receive 300-1000 and temperate forests receive between 500-2500, which puts the eastern plains in both grassland and forest, and Xi'an at the lowest end of forest, but the middle of the grassland range.[40]

The same textbook describes several models that have been created attempting to correlate climate with vegetation. If we add 2° to all of these temperatures and match them with the models, Whittaker's model would place Ji'nan, Xuzhou, Zhengzhou, Xi'an and Tianshui in the broad woodland-grassland zone, with the latter site tending towards shrubland and grassland. The Holdridge system would predict a dry forest for all of those sites. Whittaker would place Lanzhou on the border of desert and Yinchuan as desert, while Holdridge would consider them both steppe. The Troll and Paffen system predicts that much of the region would be part of the "Central and East Asian grass and dwarf shrub steppe," although Xuzhou would be in the temperate deciduous zone, and Yinchuan would be semi-desert.[41] Although the sources on climate do not include reliable evaporation information,[42] the fact that much of the precipitation falls in heavy summer rains, and the frequent summer floods, suggest that much of the water drains away before it can be absorbed by plants.

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[39] Liu Hongyan et al., "The Surface Pollen of the Woodland-Steppe Ecotone in Southeastern Inner Mongolia, China," *Review of Palaeobotany and Palynology* 105 (1999), 238.

[40] Glen MacDonald, *Biogeography: Introduction to Space, Time, and Life* (New York: John Wiley & Sons, 2003), 145-71. All of the climate models are taken from this text.

[41] Domros & Peng, *The Climate of China*, 237.

[42] Domros & Peng's *The Climate of China*, based on measurements taken in China from 1950-81, does include evaporation information for some sites, but the figures are considerably higher than the total annual precipitation. This may be because evaporation was measured without using windscreens and thus grossly overrepresents actual evaporation. The authors do not discuss evaporation at all, which suggests that they do not trust the figures either.

It should be noted that the region's precipitation is highly variable from year to year, and some years are considerably wetter or drier than the above figures would suggest. For example, at Ansai in Shaanxi the annual precipitation has ranged from 350 to 960 mm, and the single day record for precipitation is 135.5mm, of which 45mm fell in 30 minutes.[43] Because the summer rain often falls so quickly it cannot all be absorbed and much of it runs off, often carrying with it a large amount of soil.

The seasonal variation is significant because dry years would tend to harm moisture loving vegetation more than wet years would harm plants that thrive in arid climates. Thus the vegetation would tend to resemble that of a slightly drier climate. Sun Xiongjun has also suggested that the porosity of loess allows significant amounts of water to drain away unused by plants, which explains why trees would grow only in gullies.[44] This would be less relevant on the soils and alluvial deposits of the plain, where seasonal rains would more likely produce seasonal wetlands.

Pollen and Modern Vegetation

Before I begin discussing the actual pollen cores and their results, I will discuss some of the basics of palynology. To interpret fossil pollen one must attempt to understand the difference between the pollen that is deposited and preserved and the actual ecosystem that existed at the time. This involves analysis of stratigraphy in order to understand the depositional environment, and the analysis of pollen production in existing plants, to understand how certain types of pollen are over- and under-represented. Although there are no modern analogues for the environments, there are still plants growing in the region, another important clue for interpreting pollen diagrams and reconstructing past environments.

The ideal environment for the deposition and preservation of pollen are small lakes or wetlands that accumulate sediments at a similar rate for thousands of years, and thus provide a steady vegetation record. North Chinese pollen studies are almost all taken from inferior depositional environments, although it is unclear if this is because there are no undisturbed lakes or because of the focus on archaeological

[43] Quine et al., "Slope and Gully Response," 76.
[44] Sun Xiangjun et al., "Vegetation History of the Loess Plateau," 35.

sites and aeolian loess. In any case, virtually all of the cores in this study are taken from fluvial environments in which a constant deposition of sediment is unlikely and the deposition rate was probably quite varied. In several cases, the source region is the entire Yellow River drainage, which itself receives windblown pollen from the arid northwest. When combined with a lack of adequate dating, this makes it very difficult to examine pollen records in terms of events. Rather, they are more useful for determining the pre-clearance vegetation of areas long since transformed by human activity. Farmers inhabited most of the region during the Holocene, and some of the cores were taken from sites that were in or near villages at times. It is unclear what effect this may have had on the pollen record.

In general, pollen diagrams include species that depend on wind to disperse their pollen, some of which produce far more pollen than others. Insect pollinated plants produce so little pollen that they are rarely represented at all. Moreover, different types of pollen decompose at different rates. In terms of determining ancient vegetation some pollen types are more useful than others. For example, although certain types of grasses (Gramineae/Poaceae) inhabit very specific environments, all grasses produce similar pollen, so it is difficult to use grass pollen as an indicator of a specific environment. But other plants do indicate more specific environments. For example, *Ephedra* (*Ma huang* 麻黃) is a plant of arid regions and its presence indicates dryness, while *Typha* (cattails) grows only in aquatic environments.

Trees can often be differentiated to the genera, and sometimes to the species, which allows palynologists to use modern pollen production ratios to intepret those of earlier periods. In relatively open Danish forests, correction factors for various trees have been estimated at 1:4 for oak, birch and pine, 1:2 for elm and spruce, 1:1 for beech and fir and 2:1 for maple and ash. This means that pollen records show four times as many oaks as there actually were, but only half as many maples. However, research in denser Polish forests found less difference between species. In some instances pine pollen has been found to compose only a fraction of the

vegetation but dominate the pollen diagram.[45] Although pollen production may not be the same for Chinese and European species, pollen diagrams from North China do tend to have far more oak and pine pollen than other tree species, so this ratio probably applies roughly in China, but, as will be discussed below, surviving vegetation in the region suggests that oak may actually have been the dominant tree species in much of the region.

Even if we know which species are over- and under-represented, we still do not know what the landscape looked like in the period depicted by a pollen diagram because some pollen types tell us more than others. For example, a variety of trees are considered temperate deciduous species, and do not grow in arid environments. These include beech (*Fagus*), walnut (*Juglans*), chestnut (*Castanea*), hickory (*Carya*), ash (*Fraxinus*), hackberry (*Celtis*) and linden/basswood (*Tilia*). These species often increase and decrease together, and their presence is a sign of broadleaf forest, which in North China indicates relatively high precipitation. Oak (*Quercus*), elm (*Ulmus*), and poplar (*Populus*) survive in more arid climates than the deciduous trees mentioned above. Along with birch, oak is perhaps the most significant tree species of the region, including dozens of species and occupying a variety of ecological niches. Wang Chi-wu suggests that the dominance of oak forests mixed with *Celtis*, *Hovenia*, *Pistacia* and *Ulmus* on the lower slopes of the regions surrounding the plain suggests that this may have been the vegetation on the plain before it was cleared.[46] Contemporary patches of woodland in the Mongolian steppe include oak (*Quercus mongolica*), birch (*Betula platyphylla, B. dahurica*), poplar (*Populus davidiana, P. maximowiczii*), pine (*Pinus tabulaeformis*), and elm (*Ulmus pumila, U. macrocarpa*), the latter of which is the most tolerant of aridity of all deciduous trees in China.[47]

Six species of pine are found in the area (*Pinus thunbergii, P. tabulaeformis, P. bungeana, P. armandii, P. fenzeliana, P. massoniana*). Wang Chi-wu notes that *Pinus tabulaeformis* forests are found throughout the deciduous hardwood zone, although he

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[45] H.J.B. Birks & Hilary H. Birks, *Quaternary Palaeoecology* (London: Edward Allen, 1980), 196-201.
[46] Wang Chi-wu, *The Forests of China*, 81. According to Wang, the most important oak species in the region are *Quercus dentata, Q aliena, Q. variabilis* and *Q. liaotungensis*.
[47] Liu Hongyan et al., "Climatic and Anthropogenic Control of Surface Pollen Assemblages in East Asian Steppe," *Review of Palaeobotany and Palynology* (2006 in press); Wang Chi-wu, *The Forests of China*, 178-79.

does not seem to consider pine one of the most important tree genera in the region.[48] This suggests that either pine is more overrepresented than oak in the pollen diagrams or that pine has been eliminated from more areas over recent centuries than has oak.

Birch (*Betula*) is generally a hardy genus, including trees that grow in forests and forest-steppe, and shrubs that thrive in tundra and other cold environments. Both Liu and Wang Chi-wu consider birch to be among to the most common species of the forests of North China, especially in the more arid areas, where it frequently grows in pure stands, or in mixed forests with *Populus*. However birch is poorly represented in the pollen diagrams. *Populus* (poplar and aspen) produces little pollen, and its pollen decomposes quickly, so it is not represented in fossil pollen studies. However, there are trees of the genus in many regions of China, and they are currently the most common trees in much of the Yellow River plain, especially *Populus simonii*, and *P. tomentosa*. These trees, along with *Pinus tabulaeformis*, are mostly cultivated, so it is not certain whether their contemporary abundance is the result of human activity, but surrounding regions include significant numbers of these species as well as *P. davidiana* and *P. suaveolens*. The only wild trees on the plain are riparian. These include several *Populus* species and the willow trees *Salix matsudana* and *S. babylonica*.[49] Willow (*Salix*) is often riparian, although it includes shrubs and trees that grow in a variety of environments from deciduous forest to shrub tundra.

The most abundant pollen type is certainly *Artemisia*, low herbaceous plants which are usually called sagebrushes, sagewort, sage, mugwort or wormwoods in English, and which inhabit a variety of environments, but not dense forests.[50] Although we must be careful not to give too much weight to a plant just because it produces abundant pollen, the existence of *Artemisia*-dominated steppe in the Ordos and in Central and Western Asia show that it is at least possible that some of the

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[48] Wang Chi-wu, *The Forests of China*, 84.

[49] Wang Chi-wu, *The Forests of China*, 86.

[50] Common *Artemisia* species in the region include *A. capillaris, A. frigida, A. halodendron, A. sacrorum, A. siversiana, A. gmelinii, A. mongolica, A. mandshurica, A. lacinata, A. lavendulaefolia, A. eriopoda, A. palustris, A. integrifolia, A. argyi, A. sibirica,* and *A. salsoides*. See Wang Chi-wu, *The Forests of China*, 171-210, and Liu Hongyan et al., "The Surface Pollen of the Woodland-Steppe Ecotone," 242.

pollen diagrams dominated by *Artemisia* reflect real conditions.[51] On the other hand, *Artemisia* pollen has a thick exine cover, and preserves better in the alkaline loess than other pollen types.[52]

The Chenopodiaceae family are the other significant non-arboreal pollen type, and are often over-represented.[53] Chenopodiaceae mostly grow in semi arid-arid environments, and are rarely found in forests.[54] A variety of scholars from the Middle East to the steppe of Inner Mongolia have agreed that there is a direct correlation between aridity and the ratio between Chenopodiaceae and *Artemisia* (C/A), more Chenopodiaceae indicating greater aridity.[55] Liu Hongyan also notes that there is a direct correlation between increased Chenopodiaceae and human activity, while *Artemisia* ratios do not directly reflect human activity.[56] In a study attempting to identify which types of pollen rain can be used to identify the several vegetation zones from woodland to steppe in Inner Mongolia, Liu concluded that the pollen values of *Artemisia* have no correlation with their vegetation coverages."[57] He also notes that "the pollen productivity of *Artemisia* is high relative to Gramineae and steppe vegetation dominated by Gramineae normally has high percentages of *Artemisia* pollen. Consequently, high percentages of *Artemisia* pollen do not necessarily indicate *Artemisia*-dominated vegetation."[58] This suggests that cores containing significant *Artemisia* and grasses may well represent grassland.

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[51] "In the existing vegetation of the sand dunes along the Great Wall are wide stretches of *Artemisia salsoides*," Wang Chi-wu, *The Forests of China*, 191.

[52] Pearson, "Pollen Counts in North China," 227.

[53] Liu Hongyan et al., "The Surface Pollen of the Woodland-Steppe Ecotone," 243, argue that "Chenopodiaceae also has a high over-representation in the whole investigated area" occupying less than 1% of the total land but composing up to 30% of the pollen. He lists *Chenopodium album, C. urbicum, C. glaucum, C. aristatum, C. acuminatum,* and *Salsola collina* as the most common Chenopodiaceae. The genera is also discussed in Ge Yu et al., "Modern Pollen Samples from Alpine Vegetation on the Tibetan Plateau," *Global Ecology and Biogeography* 10.5 (2001), 503-20.

[54] *Flora of China* website: http://flora.huh.harvard.edu/china/. Accessed April, 2006.

[55] Ann P. El-Moslimany, "Ecological Significance of Common Nonarboreal Pollen: Examples from Drylands of the Middle East," *Review of Palaeobotany and Palynology* 64 (1990), 343-50. Her results followed similar observations in H.E. Wright et al., "Modern Pollen Rain in Western Iran and its Relation to Plant Geography and Quaternary Vegetation History," *The Journal of Ecology* 55.2 (1967), 437. Also see Caroline P. Davies & Patricia L. Fall, "Modern Pollen Precipitation from an Elevational Transect in Central Jordan and its Relationship to Vegetation," *Journal of Biogeography* 28.10 (2001), 1195-210; Liu Hongyan et al., "The Surface Pollen of the Woodland-Steppe Ecotone."

[56] Liu Hongyan et al., "Climatic and Anthropogenic Control."

[57] Liu Hongyan et al., "The Surface Pollen of the Woodland-Steppe Ecotone," 242.

[58] Liu Hongyan et al., "Climatic and Anthropogenic Control," 8.

Liu's observation that all areas have abundant *Artemisia* pollen is important for my study and seems to suggest that Ping-ti Ho's correlation of increased *Artemisia* with human land-clearance activity is incorrect.[59] However, I doubt that Liu would have found *Artemisia* equally abundant in all areas if his study area had also included dense forests. While it is true that *Artemisia* grows well in steppe and open forests, it would be unlikely to do well in dense deciduous forest. High percentages of *Artemisia* in the plain can be interpreted either as a sign that the forest was naturally more open or as a sign of human disturbance, which would be particularly likely if humans practiced swidden (slash and burn) agriculture, or if they burned land for other reasons, such as creating habitat for their favourite game species.

The existence of loess, which is composed of silt blown in from the northwest, suggests that pollen was probably also blown from the same area. We can assume that pollen from arid regions is slightly overrepresented in all of the cores because they were all taken in the loess deposition zone or from loess eroded from it. The humid, rainy summer air from the south would probably have carried less pollen.

The Cores

As mentioned above, palynologists in other areas have tended to core lakes and other wet areas which collect pollen at a fairly steady rate over millennia, and have taken advantage of modern carbon 14 dating technologies to obtain reliable dates from sediments. Of the cores on the following table, only the core from Beijing is taken from a good deposition site, and few are well-dated. Cores 1-3 come from the Yellow River delta, and thus represent the entire drainage, and possibly the pollen in the Bohai Sea. Cores 4, 5, 7 and 17 are all taken in areas where the Yellow River flowed at times and the ratio of local to river pollen is unknown. Core 8-16 and 18 are taken from smaller drainage basins on the Loess Plateau, and thus probably represent local vegetation.

The table lists the cores from east to west, providing the amounts of Arboreal (AP) and Non-Arboreal (NAP) pollen (spores are not included), and of

[59] Ping-Ti Ho, *The Cradle of the East*, 25-30.

several common genera and families presented as a percentage of the total pollen sum. I have attempted to include only the information from the period of this study, but the lack of adequate dating means that the data is often based on long periods assumed to include the period of the study, while others are based on single pollen count. Although the results are rough, they nonetheless show clearly the transition from greater abundance of trees in the east to virtual absence of trees in the west. The ratios, although equally rough, are included for reference with Liu Hongyan's pollen-type to vegetation-type ratios.

Table 2: Pollen Cores

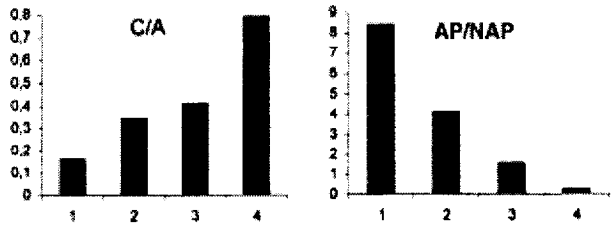
	AP	NAP	AP/NAP	Pine	Oak	Artem.	Cheno.	C/A
1-3 Yellow River delta								
1 (Yi)	30	70	0.4	0-20	10-25	10-35	15	1.5
2 (Yi)	15-30	60	0.4	10	12	30	10-20	0.5
3 (Lu)[60]	5-25	40-60	0.3	5-15	3-12	20-40	10-40	0.8
4 Xuzhou (Luo)	20-45	40-60	0.7	-	10	-	-	
5 Shandong (Liu)	25	65	0.4	15-20	5	30-45	10	0.3
6 Beijing (Zhou)[61]	50-80	40-60	1.4	10-45	10	10-40	3	0.1
7 Zhengzhou (Yan)	44	37	1.2	40	2	12	9	0.8
8-13 Wei valley. (Sun, 1991)								
8 Fuping core a	15-50	10-70	0.6	5-20	3	5-60	3	0.1
9 Fuping core b	35-40	40-55	0.8	5-20	5	20	5-10	0.4
10 Fuping core c	10-25	75-85	0.2	3-10	5	40-60	5	0.1
11 Lantian	10	85	0.1	4-8	0-5	15-50	5-10	0.2
12 Xi'an Banpo	5-10	90	0.1	5	1	60	10	0.2
13 Weinan	10	77	0.1	8	3	30	10	0.3
14 Fufeng (Wang)[62]	5-25	75-90	0.2	5	0	50	5	0.1
15 Tianshui (Zhao)	8.5	89	0.1	0	0	48	20	0.4
16 Tianshui (Zhao)	2.6	97.4	0.03	0	0	48	20	0.4
17 Lanzhou (Wang)	3	94	0.03	1	0	20	48	2.4
18 Lingwu (Sun, 1991)	5	92	0.05	1	1	0-20	20-90	5.5

[60] Lü Houyuan 呂厚遠, "Bohai nanbu wangengxinshi yilai de baofen zuhe ji gu huanjing fenxi" 渤海南部晚更新世以來的孢粉組合及古環境分析 (The Sporo-Pollen Assemblages in Southern Bohai Sediments since the Late-Pleistocene and their Palaeoenvironmental analysis), *Huang-Bohai haiyang* 7.2 (1989), 12-26. Only studies that will not be cited below are cited in the table.

[61] Zhou Kunshu et al., "Zhongguo beifang quanxin tong huafen fenxi yu gu huanjing," 25-54.

[62] Wang Shihe 王世和, "Anpi yizhi baofen fenxi" 案皮遺址孢粉分析 (Anpi site pollen analysis), in *Huanjing kaogu yanjiu* 環境考古研究, ed. Zhou Kunshu 周昆叔 & Gong Qiming 鞏啟明 (Beijing: Kexue, 1991), 56-65.

1: Woodland; 2: Woodland-grassland
3: Woodland-steppe; 4: Steppe
C/A=Chenopodiaceae/*Artemisia*
AP/NAP=Arboreal/Non-Arboreal Pollen



Pollen type ratios and corresponding biomes in southeastern Inner Mongolia.[63]

According to Liu's AP/NAP ratios all of the areas west of the middle Wei valley are steppe, and most of the rest is woodland-steppe (0.2-1.5). Only Beijing and perhaps Zhengzhou approach the woodland-grassland ratio. The C/A ratio is less simple, putting the western areas clearly in the steppe zone, but scattering the rest between steppe and woodland.

Although the Yellow River delta is difficult to interpret as a deposition site, the first core in Sangheon Yi's study[64] (1) is the most reliably dated of all the cores, and also provides a good opportunity to discuss changes in the river's course.[65] The mouth of the Yellow River, the most significant source of water and pollen, was several hundred kilometres to the north of the core site during the entire period of my study, and the pollen deposited at that time would represent more local rivers, such as the Ji 濟, and wind-blown pollen, in addition to the ocean pollen most of which would have come from the Yellow River. In the summer, when pollen is produced, the Yellow Sea Warm Current pushes the flow of northern rivers such as the Liao away from the deposition site.[66] It seems likely that the deposits mostly represent the Yellow River drainage.

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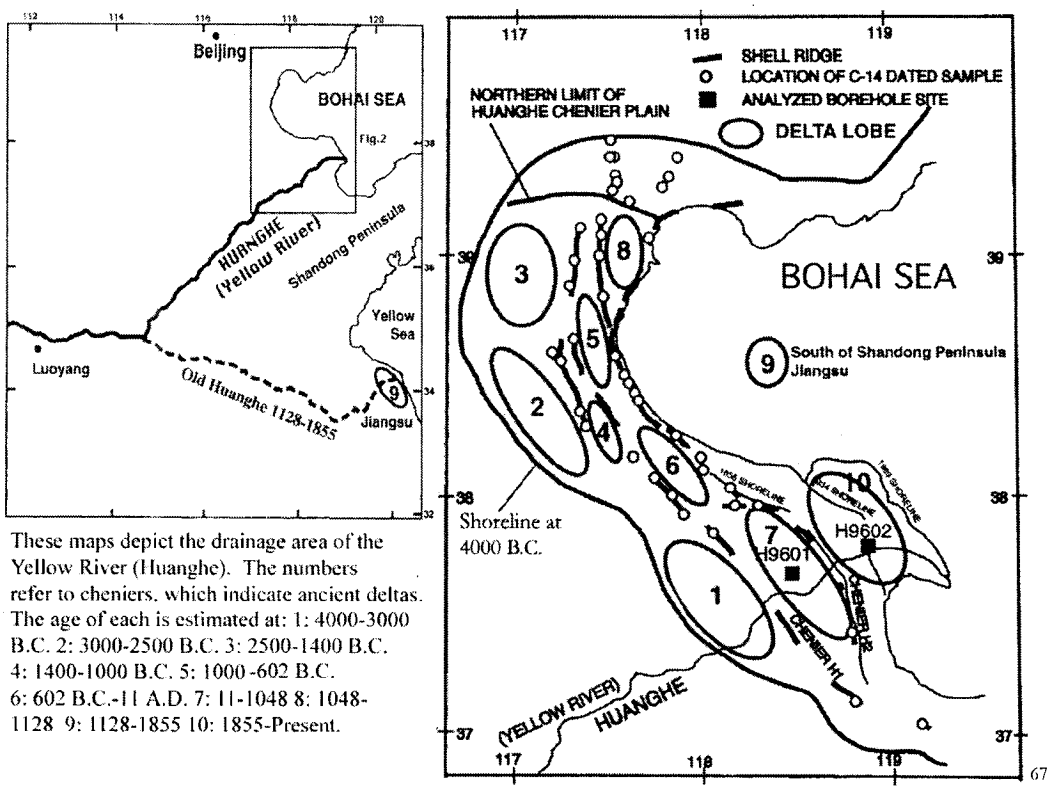
[63] Liu Hongyan et al., "The Surface Pollen of the Woodland-Steppe Ecotone," 248.

[64] Sangheon Yi et al., "Holocene Environmental History Inferred from Pollen Assemblages in the Huanghe (Yellow River) Delta, China: Climactic Change or Human Impact?," *Quaternary Science Reviews* 22 (2003), 609-28.

[65] Xue Chunting and Yoshiki Saito, among others, have shown the changes in the location of the Yellow River delta over the past 6000 or so years. Xue Chunting. "Historical Changes in the Yellow River Delta, China." *Marine Geology* 133 (1993), 321-29; Saito Yoshiki, "Delta Progradation and Chenier Formation in the Huanghe (Yellow River) Delta, China," *Journal of Asian Earth Sciences* 18 (2000), 489-97.

[66] Matthias Tomczak & J. Stuart Godfrey, *Regional Oceanography: An Introduction* (Oxford: Pergamon, 1994), 185.



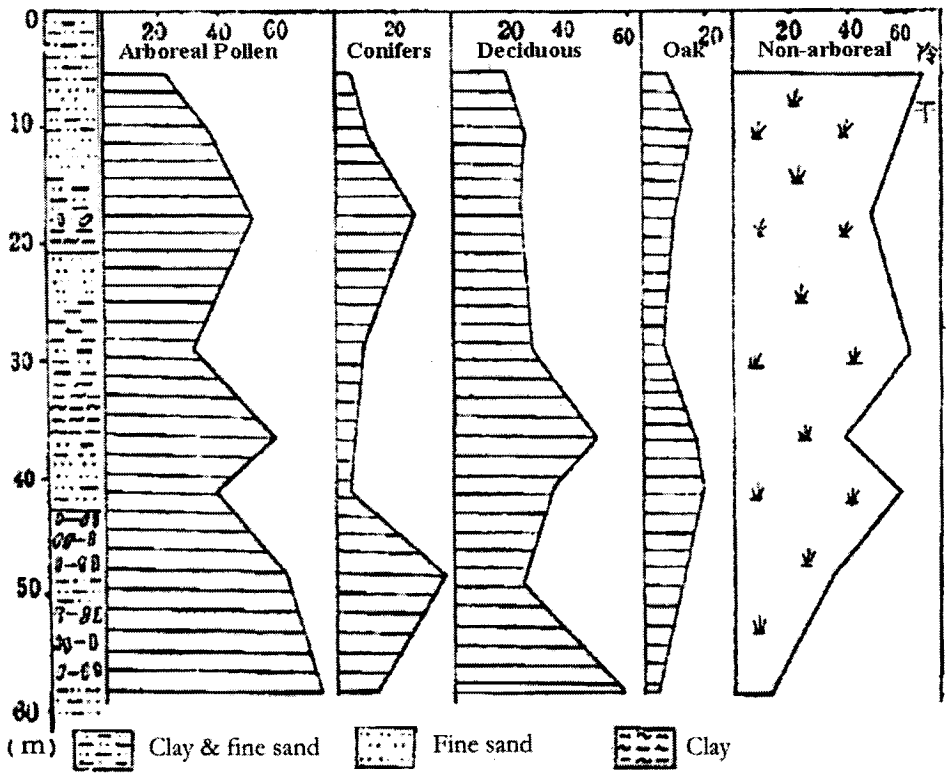
These maps depict the drainage area of the Yellow River (Huanghe). The numbers refer to cheniers, which indicate ancient deltas. The age of each is estimated at: 1: 4000-3000 B.C. 2: 3000-2500 B.C. 3: 2500-1400 B.C. 4: 1400-1000 B.C. 5: 1000-602 B.C. 6: 602 B.C.-11 A.D. 7: 11-1048 8: 1048-1128 9: 1128-1855 10: 1855-Present.

The most notable thing about the core is that arboreal pollen decreases steadily from 5860 BP, suggesting increasing aridity and land clearance. Overall, white oaks (subgenus *Lepidobalanus*; 8-25% of AP) and pine (5-20%), trees which produce abundant pollen, dominate the arboreal pollen. Most of the species of deciduous trees mentioned in the discussion above are present in lower percentages, as are fir, hemlock and spruce, but it is notable that after 2650 BP virtually all tree species but pine and oak disappear, the only ones still seen are birch, hazel, beech and ash. This may correspond to a shift in the river's course (around 602 B.C., see above), but may also represent significant clearance of deciduous forests during the Eastern Zhou. It is also possible that the deciduous forests were most abundant on the plain, and the embankment of the river eliminated the inflow of pollen from the plains into the Yellow River. *Artemisia* (10-40% of NAP), Chenopodiaceae (10-20%) and grasses (10-40%) dominate non-arboreal pollen. Although the percentage of grasses is mostly lower than *Artemisia* and Chenopodiaceae, considering the lower

[67] Saito Yoshiki, "Delta Progradation and Chenier Formation," 490. Borehole H9601 and H9602 on the map correspond with cores 1 and 2 in the table above.

production of pollen by grasses, these percentages are very high. This shows that there were significant grasslands in some areas of, or perhaps throughout, the region.

Only two cores, one from eastern Shandong, the other from Xuzhou, Northern Jiangsu, represent the central and eastern North China Plain. The Shandong core is simple, inadequately dated, and is taken from an area which was occasionally part of the Yellow River, which means that the source of the pollen may be local or the Yellow River drainage.[68] Since the sediments are mostly alluvial it is possible that the deposit mostly represents periods in which the river flowed here. *Artemisia* averages around 20-30%, pine just under 20%, and Chenopodiaceae around 10%. Oak is less significant than in the previous studies, and arboreal pollen declines in the last two or so millennia. The constant percentage of around 10% "aquatics" (presumably mostly *Typha*) demonstrates significant wetlands.



Pollen core taken near Xuzhou, Jiangsu. [69]

[68] Kam-Biu Liu & Qiu Hong-Lie, "Late-Holocene Pollen Records of Vegetational Changes in China: Climate or Human Disturbance?," *Terrestrial, Atmospheric and Oceanic Sciences* 5.3 (1994), 398.

[69] Luo Qixiang 羅其湘 & Liu Xiangqi 劉祥琪, "Subei Xuhai pingyuan wangengxinshi yilai de gu qihou he gu dili" 蘇北徐海平原晚更新世以來的古氣候和古地理 (Paleoclimate and Paleogeography of the Xuhai plain, Northern Jiangsu, since the late Quaternary), *Haiyang dizhi yu disiji dizhi* 4.2 (1984), 111-17.

The Xuzhou core suggests that the area has never been densely forested. Although it is not dated, the core is over 60m deep, and in the upper 50m the arboreal pollen rarely exceeds 60%, and averages around 45%. In the upper 15m arboreal pollen gradually declines to about 20%, which suggests the land clearance that was necessary for the area to be an agricultural and population centre by the time of the early empire. The depth of the core suggests that the environment has been similar for thousands of years, but the article in which it is published contains no description of the depositional environment or even the exact location from which the core is taken, so it is difficult to evaluate the results, especially as the area was near (or perhaps under) the Yellow River for over seven centuries. It is quite possible that the dominance of non arboreal pollen is a sign of wetlands rather than grasslands, and the text mentions that *Typha* is a significant pollen type, but the percentages are not provided, nor do they discuss the other non-arboreal pollen types.

Yan Fuhua cored at Dahecun, in Zhengzhou, due to its importance as an archaeological site, not because it is a good depositional environment. The sediments are all alluvial loess, which suggests, as in the other Yellow River cores, that deposition was intermittent, and that the source area is ambiguous since the ratio between local sources and Yellow River floods is unknown. Nonetheless, the core is quite consistent, with Pinus comprising over 90% of the tree pollen through most of the diagram, along with a low but constant percent of *Betula.* Around the time of the only dated sample, #11 (4770-4440 B.C. cal.), a variety of deciduous trees appear, evidence of the Holocene climactic optimum.

West of Zhengzhou, several pollen studies have been done in the Wei river valley, due both to the archaeological importance of the area and to the interest of many scientists in the Loess Plateau. The most useful of these is Sun Jianzhong et al.'s *The Quaternary of the Loess Plateau*, in which the entire Quaternary is analysed by geological and palynological methods.[70] Most of these cores are taken in small drainage basins of tributaries of the Wei, and are thus much more local than cores composed of Yellow River alluvium.

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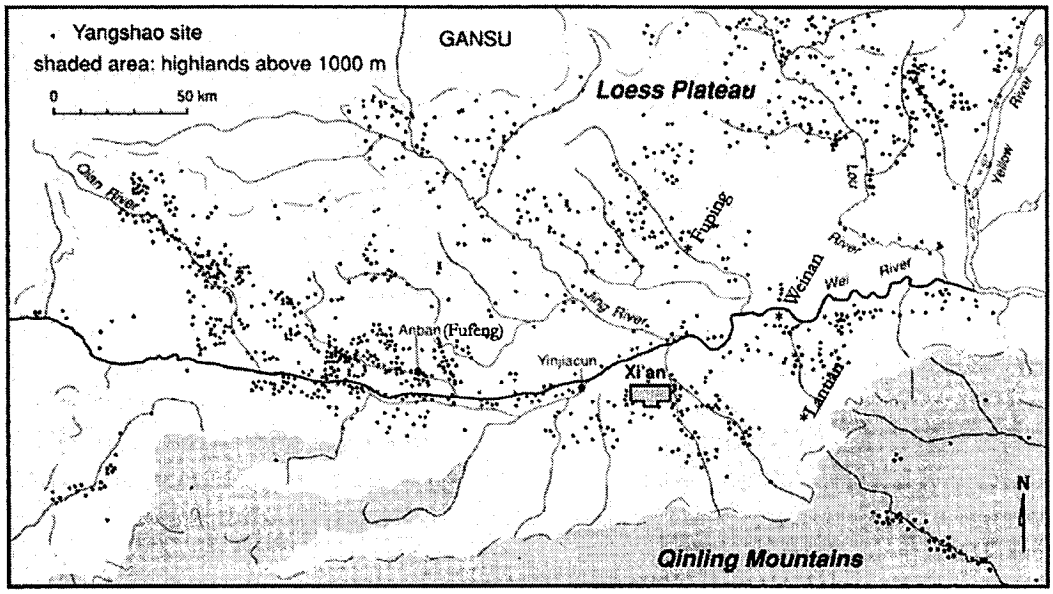
[70] Sun Jianzhong 孫建中 et al., *Huangtu gaoyuan disiji* 黃土高原第四紀 (The Quaternary of the Loess Plateau) (Beijing: Kexue, 1991).

	1		2		3		4	5		6		7		8		9		10		11		12	13		14		15		16		17		18	
	#	%	#	%	#	%	#	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	#	%	#	%	#	%	#	%	#	%	#	%
Total pollen	177	100	81	100	109	100	35	70	100	219	100	100	100	152	100	174	100	53	100	334	100	16	111	100	86	100	173	100	153	100	82	100	272	100
Arboreal pollen	91	51.4	37	45.7	39	35.8	2	27	38.6	150	68.5	50	54.1	87	57.2	129	74.1	30	56.6	147	44	13	73	65.8	52	60.5	128	74	112	73.2	69	84.2	124	45.6
Non-arboreal pollen	51	28.8	18	22.2	45	41.3	33	43	61.4	58	26.5	47	43.1	59	38.8	37	21.3	16	30.2	179	53.6	2	33	29.7	34	39.5	43	24.8	40	26.1	11	13.4	146	53.7
Spores	35	19.8	26	32.1	25	22.5				11	5.0	3	2.8	6	4.0	8	4.6	7	13.2	8	2.4	1	5	4.5			2	1.2	1	0.7	2	2.4	2	0.7
Arboreal pollen:																																		
冷杉属 *Abies*														1	1.1																			
松属 *Pinus*	90	98.9	35	94.6	36	92.3	2	21	77.8	145	96.6	50	94.0	73	83.9	116	89.9	20	66.7	139	94.6	12	71	97.2	50	96.2	122	95.3	106	94.6	64	92.8	119	96
铁杉属 *Tsuga*														4	4.6	1	0.8												2	1.8				
桦属 *Betula*	1	1.1	1	2.7	3	7.7		2	7.4	1	0.7	2	3.4	4	4.6	2	1.5	1	3.3	6	4.1		1	1.4	2	3.8	2	1.6	1	0.9	3	4.4	3	2.4
桤木属 *Alnus*																4	3.1																	
栎属 *Quercus*								3	11.1	1	0.7			3	3.5	1	0.8						1	1.4			3	2.2			1	1.4		
山毛榉属 *Fagus*										1	0.7																							
胡桃属 *Juglans*			1	2.7										1	1.1					1	0.7										1	1.4	1	0.8
榆属 *Ulmus*								1	3.5	2	1.3	1	1.7	1	1.1	4	3.1			1	0.7	1					1	0.8	3	2.7				
椴属 *Tilia*																1	0.8																	
Non-arboreal pollen:																																		
麻黄属 *Ephedra*	3	5.9	2	11.1	3	6.7						1	2.1	2	3.4			1	6.2	2	1.1				1	2.9	3	7.0	3	7.5				
藜科 Chenopodiaceae	5	9.8			20	44.4	7	13	30.2	28	48.4	12	25.5	15	25.4	9	24.3	5	31.3	98	54.7		3	9.1	8		7	16.3	15	37.5	3	27.3	33	22.6
蒿属 *Artemisia*	8	15.7	3	16.7	17	37.8	26	23	53.5	18	31	22	46.8	28	47.5	16	43.2	3	18.7	42	23.5	2	12	36.4	15	44.1	14	32.5	11	27.5	6	54.5	11	7.5
菊科 Compositae	20	39.2	9	50	3	6.7				4	6.9	1	2.1	1	1.7	3	8.1	2	12.5	6	3.4						1	2.3	2	5.0	1	9.1	1	0.7
禾本科 Gramineae	2	3.9			1	2.2		7	16.3	5	8.6			9	15.2	9	24.3	5	31.3	15	8.4		18	54.5	10	29.4	10	23.3	3	7.5	1	9.1	96	65.8
莎草科 Cyperaceae	4	7.8	4	22.2						1	1.7	1	2.1							2	1.1						1	2.3					2	1.4

Pollen counts from the Dahecun site, Zhengzhou, Henan.[71]

[71] Note that #16 is the oldest sample, #1 the most recent. Yan Fuhua 嚴富華 et al., "Ju huafen fenxi shilun Zhengzhou Dahecun yizhi de dizhi shidai xingcheng huanjing" 据花粉分析試論鄭州大河村遺址的地質時代和形成環境 (A discussion of the palynological evidence for changes in the environment of Zhengzhou Dahecun site in geological time), *Dizhen Dizhi* 8.1 (1986), 72. The following article also analyses a Zhengzhou pollen sample, but the pollen counts are so low that their results are of dubious value: Song Guoding 宋國定& Jiang Qinhua 姜欽華, "Zhengzhou Shang dai

The following map provides an indication of the human influence on the region during the Yangshao period (5000-3000 B.C.). Although this is a very long period and few of these sites would have been occupied for the entire period, we can assume that only a fraction of the agricultural settlements from the period have been preserved, discovered and excavated, so this map still may be representative of actual human distribution. This map shows that human settlements were abundant and that people may have been a dominant species in the region's ecology.



Distribution of Yangshao sites in the Wei River valley (ca. 5000-3000 B.C.).[72]

The 18m deep core from Weinan, Shaanxi is comprised of alluvial deposits from the small watershed which the river drains. It represents 30,000 years of pollen history, and shows that the dominance of non-arboreal pollen (generally over 80%) of more recent cores extends back much earlier than the Holocene. *Artemisia* dominates (20-60%), followed by Compositae (5-20%). Chenopodiaceae, *Ephedra*, *Forsythia*, Cyperaceae and Gramineae are also present through most of the core. Trees make up under 10% of the total during the last 20,000 years, and are

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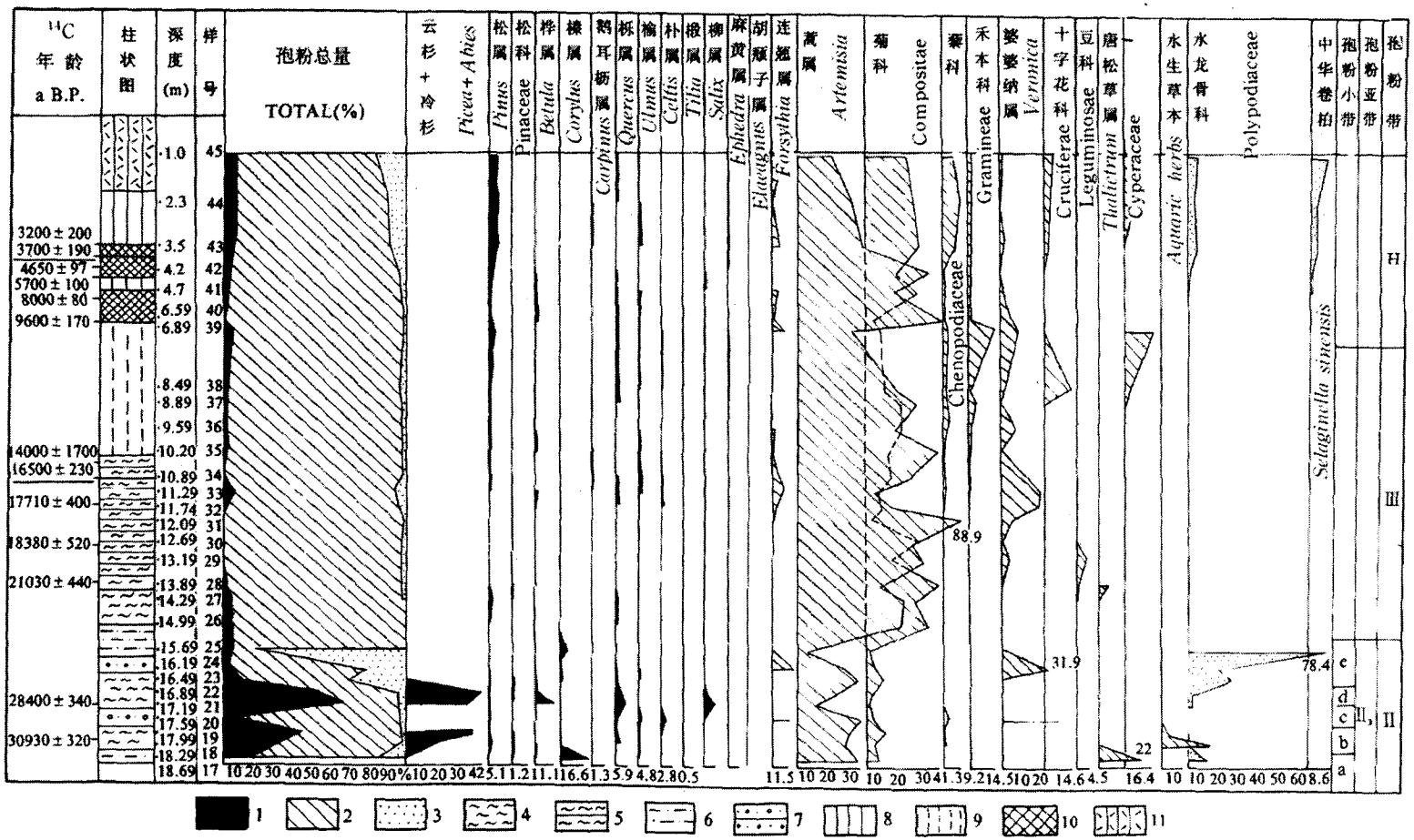
yizhi baofen yu guisuanti fenxi baogao" 鄭州商代遺址孢粉與硅酸體分析報告 (Pollen and phytolith analysis of the Zhengzhou Shang dynasty ruins) in *Huanjing kaogu yanjiu* vol. 2, ed. Zhou Kunshu 周昆叔 & Song Yuqin 宋豫秦 (Beijing: Kexue, 2000), 180-87.

[72] Li Liu, *The Chinese Neolithic*, 209. Mod.



Pollen core from Weinan, Shaanxi.

[73] Sun Jianzhong et al., *Huangtu gaoyuan dixiji*, 159.

fairly evenly composed of pine, oak, and elm, which indicates that elms were probably the most common trees. Birch and hornbeam (*Carpinus*) were also present. It seems clear that the vegetation here, just west of the confluence of the Wei and Yellow rivers was dominated by herbs, rather than trees. When one considers that pine and oak are frequently considered to produce abundant pollen and distribute it widely, their relative scarcity argues strongly against the possibility of dense forests in the area during the past 25,000 years. Based on this and other cores from the Loess Plateau, Xiangjun Sun et al. conclude that "there were no forests on the plateau during the last 100,000 years, except during some comparatively short time intervals when the climate was more suitable for forest growth."[74] However, other cores from the area suggest that trees were more abundant in some areas.

Less than 40km to the northwest, three cores were taken from a small area near Fuping, Shaanxi, have a higher percentage of arboreal pollen (10-50%) than Weinan. The two with the highest arboreal pollen percentages were taken in a lower area, a wide gully, which, as mentioned above, is where most of the trees on the plateau are found.

The Tianshui core (15 in the table) was taken from a Neolithic site and reflects the extreme west of the Wei drainage basin.[75] The site was dated by archaeological means, the last pollen count being from the Qijia culture period (ca. 2500 to 1500 B.C.), earlier than the period of this study, but close enough that it is still relevant. Of 470 grains of pollen and spores, 8.5% were Arboreal, 88.7% Non-Arboreal, 72.6% were *Artemisia*, 11% Chenopodiaceae, 1.3% Gramineae. There were 19 grains from the Oleaceae family, which includes ash trees and *Forsythia*, 10 grains of Pine, 3 of birch and walnut, and 1 each of oak, hazel and elm. It should be noted that the C/A ratio was higher earlier in the Holocene than in this last count. These figures do not only demonstrate that there was no forest cover; the presence of such low amounts of pine and oak, each of which produces abundant wind-blown pollen,

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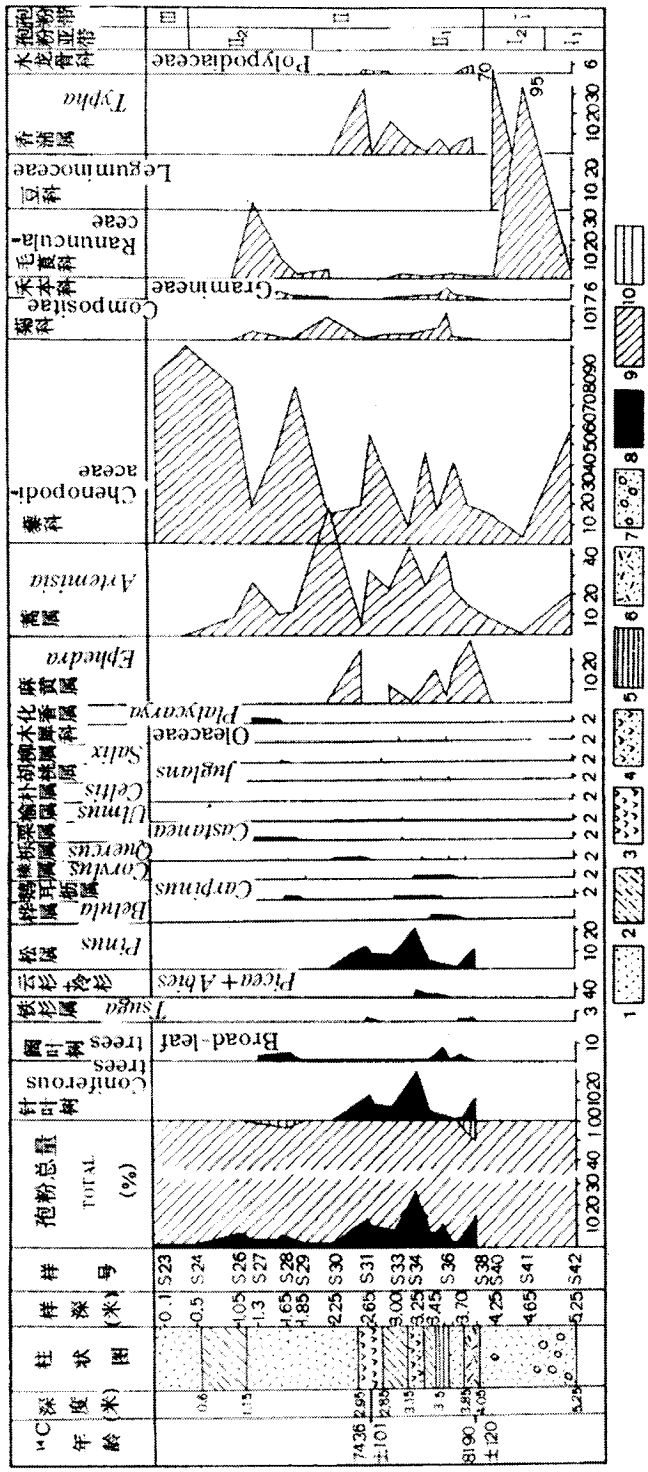
[74] Sun Xiangjun et al., "Vegetation History of the Loess Plateau," 35.

[75] Zhao Fang 趙邡, "Gansu sheng Tianshui shi liangge xinshiqi shidai yizhi de baofen fenxi" 甘肅省天水市兩個新石器時代遺址的孢粉分析 (Analysis of pollen from two Neolithic sites in Tianshui, Gansu), in *Huanjing kaogu yanjiu*, ed. Zhou & Gong, 100-4.



1. Fine sand 2. Clay and fine sand 3. Ash layer 4. Ash and fine sand 5. Clay 6. Fine sand and diatoms 7. Fine sand with gravel 8. Arboreal pollen 9. Non-arboreal pollen 10. Spores

Pollen core from Lingwu, Ningxia.

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[76] Wang Shilan 王世蘭, "Lanzhou hegu pendi 1 wannian de baofen zuhe ji qihou bianqian" 蘭州河谷盆地 1 萬年的孢粉組合及氣候變遣 (The pollen assemblages and climactic fluctuations in the Lanzhou river basin since 10,000 BP), *Bingchuan dongtu* 13.4 (1991), 307-13.

shows that there could not have been forests anywhere nearby. Further west, the core from Lanzhou shows even more arid conditions.[77]

The core taken near Yinchuan at Lingwu, Ningxia, several hundred kilometres north of Tianshui, is interesting because of the dominance in the later period of Chenopodiaceae which, as noted above, is an indicator of disturbance. This strongly suggests land clearance which is known to have taken place during the military colonisation of the region under the reigns of the First Emperor and Emperor Wu of the Han (ca. 221-87 B.C.). The area is a wide valley which is lusher than the surrounding steppe/desert due to the Yellow River, and so most of the trees would have grown on the land that was ideal for agriculture, so when it was cleared there were few surrounding forests to provide pollen, hence the dramatic change.

Conclusion

Although the pollen studies of the region come from poor depositional environments and are inadequately dated, they nonetheless provide a wealth of information on the long-term vegetation of the region. Perhaps most significant is the large percentage of non-arboreal pollen throughout the region, which makes it very difficult to believe that the eastern plain was covered in a continuous forest. More likely is that it would have contained a mix of forest, shrub, and grassland, but there is no way of knowing whether the forests and grasslands covered large areas, or whether the whole area contained mixed grassland-forest. There were also significant wetlands.

Studies of palaeovegetation in China have tended to ignore the potential impact of grazing animals, which can completely alter the ecology of an area. The presence of huge herds of elaphures (Père David's deer) could easily have maintained open environments by preventing regeneration in their favoured grazing areas, and there were several other species of grazers in the area as will be seen in the following

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[77] Sun Jianzhong et al., *Huangtu gaoyuan disiji*, 198.

chapter.[78] Likewise, herds of sheep, goats, and cattle kept by travelling herders can have an enormous impact on vegetation, maintaining open landscapes that would otherwise be forested.[79] Although there is no way of measuring numbers of herders and their herds through the Neolithic, it is possible most people kept sheep, goats, or cattle, which was more compatible with a lifestyle equally based on fishing, hunting and gathering than was cultivation. In this context, it is highly significant that both *Artemisia* and Chenopodiaceae thrive in disturbed environments.

In opposition to Shi Nianhai and others, I agree with Liu Tungsheng and Sun Jianzhong that the Loess Plateau, including the Wei valley, was not forested, but was more likely steppe with woodland in the many small valleys. As today, there were always trees in the gullies where water flowed and other wetter areas, but most of the land was dominated by grasses and herbs before it became farmland. Tianshui, Lanzhou, and Ningxia in the west of the area had very few trees at all. Thus although there was some forest from the coast into the Wei valley, none of the region was entirely forested. The vegetation of the plain included large numbers of tress, and possibly very large forests, while the percentage of trees gradually diminished westwards. It is likely that even on the Loess Plateau there would have been patches of forest, but the transition zone between dense forest and grassland occurred over the whole area, and neither dense forest nor full desert are represented in the pollen records of the region.

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[78] Frans Vera, *Grazing Ecology and Forest History* (Wallingford: CABI Publishing, 2000), argues that Western European Holocene vegetation was dominated by grazing species which prevented the regeneration of oak forests and maintained a landscape evenly mixed between grassland and patches of oak forest whose regeneration could occur only in patches of thorny shrubs avoided by grazers.

[79] For the effects of grazing on a more fragile environment see Wolfgang Holzner & Monica Kriechbaum, "Man's Impact on the Vegetation and Landscape in the Inner Himalaya and Tibet," in *Sediments of Time*, ed. Elvin & Liu, 53-106.

Chapter 3: Archaeological Sources

The strengths of archaeological sources are their ability to show physical conditions in earlier times without the mediation of texts. An excavated iron implement, pot of grain, or village, if scientifically excavated and reliably dated, is in many ways more "real" than a textual reference. Moreover, archaeology has the potential to elucidate things that texts would rarely mention, such as settlement patterns or the materials and technology of everyday utensils. Chinese studies of the Neolithic are excellent examples of how much can be learned from careful excavations of agricultural villages, and the period has also been examined using environmental archaeology methods. However, the beginnings of bronze production and the first texts seem to have distracted archaeologists from the lives of ordinary people. Few, if any, excavations have been done on agricultural sites from the Shang period or later, and the only excavations of common people have been of their tombs.[80] Environmental archaeologists likewise neglect the post-Shang period.[81]

Although many of China's excavations were done in an intellectual environment supposedly Marxist in orientation, research into the means and modes of production, which would have been so useful for the present study, were neglected as scholars focused on the ornaments of the ruling classes. As Lothar von Falkenhausen puts it, "however much Mao's slogans might tout the common people as 'the sole creators of world history,' the life of the lower classes during the historic periods remains virtually unexplored archaeologically. To an extent unparalleled in capitalist countries, research over the last 40 years has focused almost exclusively on the remains of the social elites -- the very groups that are also documented in the textual sources."[82] In the defence of Chinese archaeologists, it should be noted that

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[80] Despite the lack of contemporary evidence to suggest that Erligang and Anyang were ruled by the same family or dynasty, the Anyang period has traditionally been interpreted as being the "late Shang." Although this interpretation may well be accurate, it is based on texts written many centuries later, and I prefer to refer to the Erlitou and Erligang cultures by their archaeological names, and refer to the Anyang period as the Shang.

[81] All of the work in *Huanjing kaogu yanji*, ed. Zhou & Gong and *Huanjing kaogu yanjiu* vol. 2, ed. Zhou and Song, deals with periods before the Zhou.

[82] Lothar Von Falkenhausen, "On the Historiographical Orientation of Chinese Archaeology," *Antiquity* 67.257 (1993), 846.

the material culture of the peasants of the period is far less visible in the archaeological record than the cities, cult sites, and rich graves of the elites.[83]

Although non-elite sites are rarely excavated, plenty of material artefacts used by commoners have been excavated, most usefully early metal implements. Also, and of much wider importance, Chinese archaeologists have uncovered the general history of the development and growth of the civilisation that became China, which allows us to place the Zhou and Han periods in context, providing a much longer perspective than that provided by textual sources. Much can be inferred about the environmental situation of a society based on the sizes of its cities and levels of social differentiation.

The Neolithic societies of the Yellow River valley had probably been socially differentiated for over two millennia by the Zhou period, and the focus on cemeteries in Chinese archaeology has meant that the development of social hierarchies has been studied in depth. Although it should not be assumed that the level of wealth in a tomb corresponds to the social station of the occupant in life, the increasing opulence of the largest tombs can only reflect the growth of groups or classes of people who controlled significant resources and labour. The development of social hierarchies, specialization of tasks (including the creation of workshops and industries), the monopolisation of resources by upper classes, and the creation of classes whose labour or surplus production is controlled by others are all hallmarks of civilization, and all have their environmental consequences. These include an increased amount of energy devoted to procuring and creating luxury goods and the first possibility of large scale landscape-altering projects.

The archaeology of the Zhou period is strong in the excavation of tombs and cities, with a particular strength in the analysis of the many beautiful objects that have been excavated from these sites.[84] Comparisons of pottery and bronze vessel styles are one of the main methods of distinguishing cultures in the pre-textual

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[83] Gideon Shelach & Yuri Pines, "Secondary State Formation and the Development of Local Identity: Change and Continuity in the State of Qin (770-221 B.C.)," in *Archaeology of Asia*, ed. Miriam T. Stark (Malden: Blackwell, 2006), 207.

[84] K.C. Chang, Xu Pingfang & Sarah Allan, *The Formation of Chinese Civilization: An Archaeological Perspective* (New Haven: Yale University Press, 2005), 141-281; Gina L. Barnes, *The Rise of Civilization in East Asia: The Archaeology of China, Korea and Japan* (London: Thames and Hudson, 1999), 119-52.

periods, and inscribed vessels in tombs and hoards can sometimes be linked to textual evidence, especially if they contain inscriptions. It is significant that *The Cambridge History of Ancient China*'s chapter on the archaeology of the Warring States period was written by Wu Hung, an art historian, whose analysis neglects the rural and non-elite majority of the population, but shows how the art and architecture of the elites changed with the rise of non-aristocratic rulers.[85] City layout shows how elites displayed their power and, moreover, shows how big the cities were in given periods, which can be compared with cities of other periods to show how centres of power varied across regions over time. If many non-urban sites have been excavated, as they have for the Neolithic- Erligang periods but not for the Zhou, much can be told of the structure of society.[86] We can also assume that large cities put pressure on the environment of their regions and were a source of pollution.

The best single volume overview of the Eastern Zhou period in English is Li Xueqin's *Eastern Zhou and Qin Civilizations*.[87] Although the work is structured around information from texts, it depends mostly on the excavation of tombs and cities for its evidence, and shows how the archaeology of the period concentrates on sites occupied by elites. In the first half of this work, he outlines the history of the major states, while the second half is a description of material culture based almost entirely on relics made for, and used by, elites. However, it does contain a useful discussion of metal agricultural implements and coins.

A survey of the *Kaogu jicheng* (Collected works of Archaeology) compilations, which contain thousands of articles of Chinese archaeology from the past fifty years, shows that Chinese archaeology is rich in material objects, and that Chinese archaeologists are particularly skilled in their analysis of individual objects.[88] These

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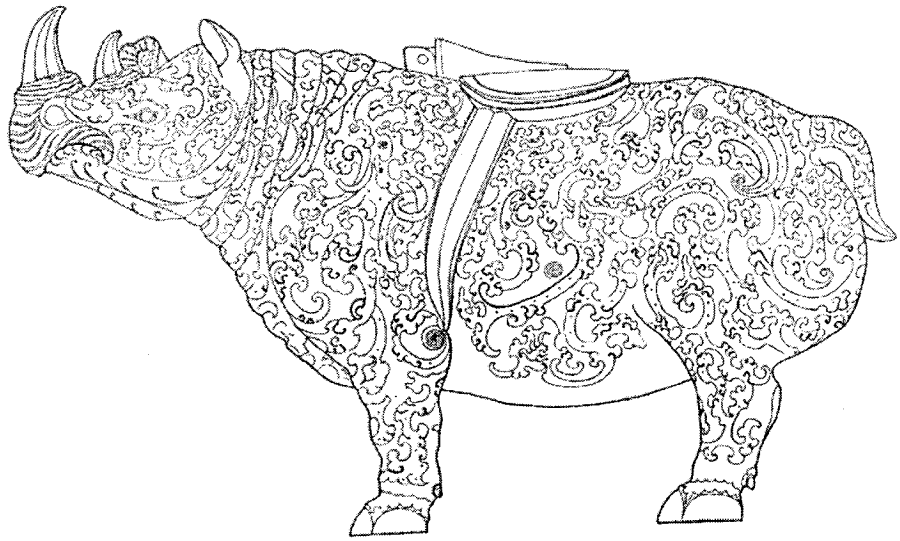
[85] Wu Hung, "The Art and Architecture of the Warring States Period," in *The Cambridge History of Ancient China*, ed. Loewe & Shaughnessy, 651-744. Robert Bagley, Jessica Rawson and Robert Thorp, three of the other leading experts in the west on the Chinese Bronze Age, are also art historians by training.

[86] See, for example, Liu & Chen, *State Formation in Early China*, and Li Liu, *The Chinese Neolithic*, esp. 159-62.

[87] Li Xueqin, *Eastern Zhou and Qin Civilizations*, tr. K.C. Chang (New Haven: Yale University Press, 1985).

[88] *Zhongguo kaogu jicheng, Huabei juan: Henan sheng, Shandong sheng* 中國考古集成,華北卷: 河南省, 山東省 (Collected Works of Chinese Archaeology: Henan, Shandong) (Zhengzhou: Zhongzhou guji, 1999), 22 vols.; *Zhongguo kaogu jicheng, Huabei juan: Beijing shi, Tianjin shi, Hebei sheng, Shanxi sheng* 中國考古集

studies often place more emphasis on how an object can be related stylistically to other similar objects unearthed elsewhere or mentioned in texts than on relating it to its position in the overall layout of the local cultural layer and site from which it was excavated. Moreover, relics of the Zhou period are often excavated in order to access older layers below, and are thus mentioned only in passing. Had this thesis been focused entirely on archaeology, a thorough survey of the published information on the thousands of objects from this period would probably have yielded much relevant information. To provide a simple example, a bronze rhinoceros excavated in Shaanxi and estimated to date from the late Warring States is realistic enough to show that its creators must have seen a rhino, although not necessarily in the wild, and may perhaps be even be accurate enough to help identify the species.



Warring States-era bronze *zun* excavated in Shaanxi.[89]

成, 華北卷: 北京市, 天津市, 河北省, 山西省 (Collected works of Chinese archaeology: Beijing, Tianjin, Hebei, Shanxi) (Harbin: Ha'erbin, 1994), 20 vols; *Zhongguo kaogu jicheng, Xibei juan: Shaanxi sheng, Ningxia Huizu zizhiqu* 中國考古集成, 西北卷: 陝西省, 宁夏回族自治區 (Collected works of Chinese archaeology: Shaanxi, Ningxia) (Zhengzhou: Zhongzhou guji, 2002), 25 vols; *Zhongguo kaogu jicheng Xibei juan: Gansu Sheng, Qinghai Sheng, Xinjiang Weiwu'er zizhiqu* 中國考古集成, 西北卷: 甘肅省, 青海省, 新疆维吾爾自治區 (Collected works of Chinese archaeology: Gansu, Qinghai, Xinjiang) (Zhengzhou: Zhongzhou guji, 2000), 20 vols.

[89]Zhu Jieyuan 朱捷元 & Hei Guang 黑光, "Shaanxi Xingping xian chutu de gudai qianjintong xizun" 陝西興平縣出土的古代嵌金銅犀尊 (A gold-inlay bronze rhinoceros *zun* from Xingping county, Shaanxi) *Zhongguo kaogu jicheng, Xibei juan* vol. 7, 4328. Originally from *Wenwu* 7 (1965).

Although I criticise Chinese archaeologists for considering written evidence superior to archaeological, I agree that by the Warring States and, especially, the Han, the growing abundance of texts covering a greater variety of subjects in more depth does reduce, but not eliminate, the importance of excavation. I am criticising Chinese scholars not so much for abandoning archaeology for texts, but for doing it too early. The textual information surviving for the Shang and much of the Zhou is inadequate for proving many of the claims that have been made on its authority, and does not cover many subjects that can be researched by archaeological methods. Neither bronze inscriptions nor the *Shi jing* 詩經 (Classic of Odes) and older sections of the *Shu Jing* 書經 (Classic of Documents) provide sufficient information on Western Zhou and Spring and Autumn (770-481 B.C.) periods to justify excavating only tombs and cities from the period, especially when excavations of Neolithic sites have shown how much can be learned about agriculturalists from archaeology. Even in the Warring States, for which texts are far more abundant, information on the lives of normal people, agriculture and the environment is sparse, as will be seen in the following chapter. Moreover, Warring States and Han texts cannot be considered a reliable record of periods centuries earlier, despite the common citation of the *Shi ji* 史記 in archaeological articles on the Shang-Zhou period. A good example of the reliance on texts is the journal *Nongye kaogu* 農業考古 (Agricultural archaeology), in which many of the articles dealing with the Zhou-Han period are entirely based on received texts, some on discussions or surveys of excavated agricultural implements, and virtually none on excavations conducted to learn about agriculture.

Despite these problems, archaeology is very important in understanding the environmental changes in the early period, and is especially relevant in three areas, which will be the focus of the rest of this chapter. The first section will review the development of Chinese civilisation up to the period of the study. The second will analyse the faunal remains found at Anyang, and the third section will explore the development of iron technology and the spread of iron tools.

The Rise of Civilisation in China

Most studies of the forest in the region seem to assume that the Zhou, or perhaps the Shang period was the beginning of large-scale human influence on the environment.[90] However, Li Liu acknowledges that early civilisation must have affected the environment, and Gina Barnes argues that "there is no doubt that the agricultural practices of the Neolithic and later historic peoples contributed to massive deforestation across the eastern loess lands and the Central Plain."[91] Very little archaeological research has been done on this subject, and palynological records do not usually indicate human land-clearance. It is clear that the levels of society reached by the late Neolithic and Shang period would have required a significant agricultural base, which must have cleared large areas of their original vegetation, perhaps beginning in the areas which were not covered by forest, which is laborious to clear with stone tools. This is one theory why agriculture and early civilisation arose in the Yellow River region: the forests farther south were too difficult to clear with stone tools.[92]

Millet agriculture seems to have been practised in the region as early as 8000 B.C., the approximate date of a site in southern Hebei from the Cishan 磁山 or Peiligang 裴李崗 cultures that contained a mortar and pestle for processing foxtail millet (*Setaria italica*).[93] The remains of farming communities from most subsequent periods have been excavated throughout the region, showing that the environmental effects of humans were always present to some degree. Over fifty walled settlements have been excavated from the Longshan period (roughly 2500-1500 B.C.), and the number of settlements of the culture (over one thousand in Henan alone) show that

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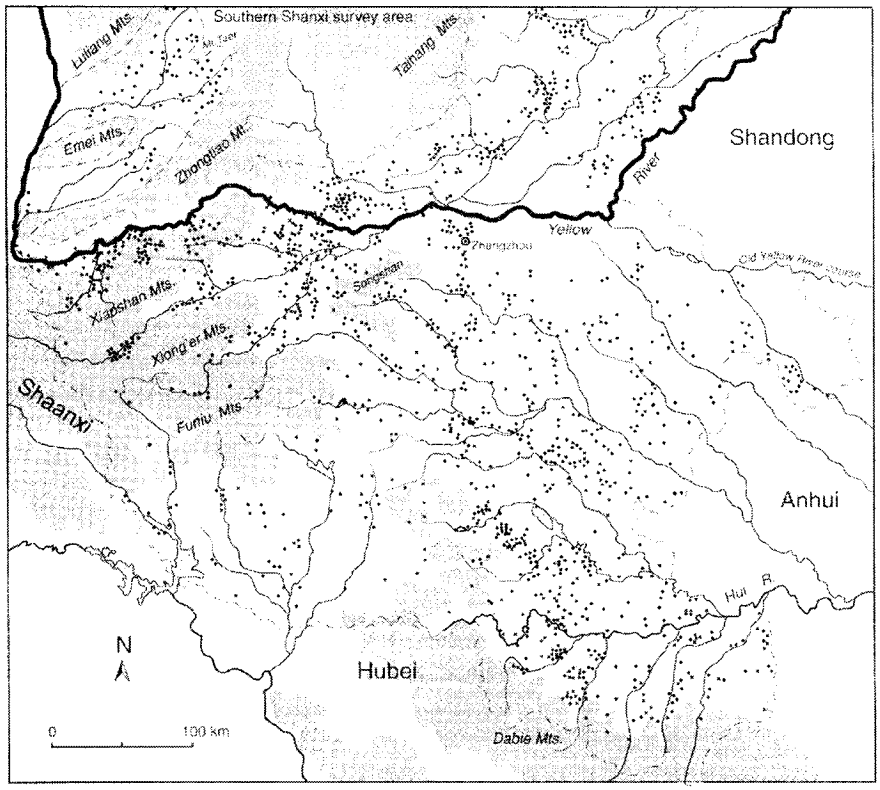
[90] For example Shi Nianhai, "Lishi shiqi Huanghe zhongyou de senlin" 歷史時期黃河中游的森林 (Central Yellow River region forests in the historical period); Li Jihua 李繼華, "Shandong senlin de lishi yanbian" 山東森林的歷史演變 (Historical changes in Shandong's forests); Zhang Junchang 張鈞長, "Shang-Yin lin kao" 商殷林考 (A study of Shang dynasty forests); Zhang Qingtao 張靖濤, "Gansu senlin de lishi bianqian" 甘肅森林的歷史變遷 (Historical changes in Gansu's forests).

[91] Gina Barnes, *The Rise of Civilization in East Asia*, 107.

[92] Ping-Ti Ho, *The Cradle of the East*, 92.

[93] K.C. Chang, "China on the Eve of the Historical Period," in *The Cambridge History of Ancient China*, ed. Loewe & Shaughnessy, 44-45.

the populations must have been considerable.[94]



Distribution of Longshan sites (ca. 3000-2000 B.C.) in southern Shanxi and Henan.[95]

Both this map and that of Yangshao sites in the Wei valley in the previous chapter show that human settlements were scattered across the landscape. Some fertile river valleys were probably quite highly populated.

Although population probably increased through much of the Neolithic, it is impossible to quantify regional population from archaeological evidence. By 1500-1700 B.C., Li Liu and Xingcan Chen have estimated the population of the largest town (Erlitou, 75km west of Zhengzhou) to be 18,000-30,000, and the population of the core area of that civilisation to have been 54,000-82,000.[96] Between 1600 and 1400 B.C., Erligang (at Zhengzhou) was the largest city and centre of ritual bronze production. It was considerably larger than Erlitou had been, and was the largest urban centre in a large region of similar culture. The trading routes and spread of

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[94] Robert L. Thorp, *China in the Early Bronze Age: Shang Civilization* (Philadelphia: University of Pennsylvania Press, 2006), 14-15.
[95] Li Liu, *The Chinese Neolithic*, 169.
[96] Li Liu & Xingcan Chen, *State Formation in Early China* (London: Duckworth, 2003), 64; Li Liu, *The Chinese Neolithic*, 240.

people from the Erligang region extended over long distances in every direction into the Yangzi region and south into Jiangxi and Hunan. In eastern Hubei, 450km south of Zhengzhou, a town with Erligang style bronzes but a different ceramic style (Panglongcheng) can be interpreted as evidence that the rulers were Erligang people and their subjects were local. The existence of Erligang-style bronzes across a large region of North China suggests that these people invaded and may have ruled over a significant area, if only briefly.[97]

There is no way of knowing what political connections existed between the Erligang rulers and the rulers of these outlying areas, or whether these areas were ever under the control of the central city. There is no reason to suppose that a single ruling culture group spread over a wide area should be interpreted as a state in which the central ruler exerted direct control over outlying areas.

The Shang dynasty is the first period for which some written evidence is available, in the form of oracle bones. The Shang directly ruled the region of northeastern Henan, southern Hebei, and western Shandong, but ruled over, or were allied with, a variety of groups over a much wider area. However, it would be anachronistic to think that they directly administered all of the land even in the core region. As David Keightley points out, "there were undoubtedly more medium- and large-sized animals than people living on the North China Plain at this time so that the rural landscape would inevitably have been regarded as the animals' domain."[98]

The Zhou came out of the Wei valley in the mid-eleventh century B.C., overthrew the Shang, and went on to conquer most of the central and lower Yellow River region. Most of this area was awarded to relatives and allies of the ruling house, and was thus never directly ruled by the central court. Although there had been extensive trade during the Neolithic, intensifying greatly during the Erlitou and, especially, the Erligang periods, most people were probably subsistence farmers who interacted little with the long-distance trade network. There was no money economy, and the most substantial movement of goods was related to tribute rather than

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[97] Robert Bagley, "Shang Archaeology," in *The Cambridge History of Ancient China*, ed. Loewe & Shaughnessy, 170.

[98] David Keightley, *The Ancestral Landscape: Time, Space, and Community in Late Shang China (ca. 1200-1045 B.C.)* (Berkeley: Institute of East Asian Studies, 2000), 107.

commerce, as will be described in the discussion of the "Yu gong" in the next chapter.

It has become common in the study of early China and in the study of early societies in general to assume that early civilisations were either city-states or territorial states. Although I believe that reliance on these concepts tends to obscure rather than enlighten, I cannot discuss this period without referring to the debate on when the first territorial states developed. Because the development of a territorial state was a transformation both in terms of political structure and in terms of the relationship between humans and their environment, my argument that the earliest territorial states appeared in the Eastern Zhou period must be understood as an argument situating an important change in human ecology over the entire middle and lower Yellow River region. Those who consider the Erligang, the Shang, and the Western Zhou to have been territorial states are claiming that the central court had far more control over the exploitation of the land within their domain than I believe it actually did.

A city-state is essentially a state in which only one settlement is large enough to qualify as a city, and that city controls the surrounding productive land and settlements, while "in territorial states a ruler governed a larger region through a multileveled hierarchy of administrative centres."[99] There were probably many small city-states in the Yellow River region during the late Longshan period, and the first undeniably territorial states were those of the Warring States period, but the situation of most of the period can be seen as a variety of forms of political organization with which the two previously mentioned ideals do not correspond exactly.

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[99] Bruce Trigger, *Understanding Early Civilizations: A Comparative Study* (Cambridge: Cambridge University Press, 2003), 92. On City-states in early China, see Robin D.S. Yates, "The City State in Ancient China," in *The Archaeology of City-States: Cross-Cultural Approaches*, ed. Deborah L. Nichols & Thomas H. Charlton (Washington, D.C.: Smithsonian, 1997), and Mark Edward Lewis, "The City-State in Spring-and-Autumn China," in *A Comparative Study of Thirty City-State Cultures*, ed. Mogens Herman Hansen (Copenhagen: C.A. Reitzels Forlag, 2000). Most of the debate around which states were territorial relates to the ambiguity of terms such as "governed" and to what type of connections between the central ruler and local rulers qualify as a "hierarchy." If one chooses to interpret these terms as compatible with what was probably a high degree of local autonomy, then the Erlitou may be considered the first territorial state, for example Liu & Chen, *State Formation in Early China.* I tend to consider a strong bureaucracy necessary for a central ruler to truly "govern" a large territory, as does Lewis, quoted on page 6.

According to Herrlee Creel's loose definition of feudalism as "a system of government in which a ruler personally delegates limited sovereignty over portions of his domain to vassals," the Western Zhou was feudal.[100] The Shang were probably less powerful than the early Western Zhou and although some of their land may have been ruled by members of the ruler's family, much of their "domain" was controlled by groups whose land was probably not given by the Shang ruler, and are better considered allies.[101] The rapid and extensive spread of the material culture of the Erligang state would suggest that the rulers were more powerful than the Shang. This state, whatever its extent, was probably administered through a decentralised system in which local rulers exerted far more power over their domain than did the central ruler. The bureaucracy was not yet developed enough for the ruler to directly govern a large region through a multileveled hierarchy of administrative centres.

Even if the early Western Zhou did have enough control over their domain to be considered a territorial state, the decentralising tendencies of such a system would quickly mean that the central ruler's power over most of the outlying territory was nominal. Robin Yates is certainly correct in arguing that feudalism does not correspond to the way Zhou people viewed their settlements, but the city-state model is also inadequate for the Eastern Zhou because the rulers of the various polities did not declare independence, but continued to acknowledge their ritual subordination to the feeble Zhou ruling house. Their worldview was one in which "all space, human and divine, secular and sacred, is incorporated into a system of

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[100] Herrlee G. Creel, "The Beginnings of Bureaucracy in China: the Origin of the *Hsien*," in Creel, *What is Taoism? and Other Studies in Chinese Cultural History* (Chicago: University of Chicago Press, 1970), 132-33. Scholars arguing against the use of the term "feudal" for the Zhou tend to do so by arguing that the term feudal refers only to medieval Europe, and imply that anyone who uses the term in reference to China is imposing a European framework on China. For example, Li Feng's comparison of medieval European feudalism and the Western Zhou shows clearly that the two were very different. Li Feng, "Feudalism and Western Zhou China: A Criticism," *Harvard Journal of Asiatic Studies* 63 (2003), 115-44. This argument is important, and serves to refute earlier tendencies to crudely equate the Western Zhou with medieval Europe. However, other terms such as "state" or "nobility," could equally be shown to have originated in a European context, and be inappropriate for discussions of the Zhou. One might as well argue that the only appropriate language for discussing early China is classical Chinese. As long as the term is defined in a technical sense to refer to a particular form of political organisation, there is no reason to avoid or replace it. "Feudalism' is not, after all, a thing; it is a term, and a term that is perhaps no older than the seventeenth century. It means what is is defined to mean." Creel, "The Beginnings of Bureaucracy in China," 132.

[101] Keightley, "The Late Shang State," 528-32.

nested hierarchies, boxes within boxes, compartmentalised and separated, yet each one being a template of the system as a whole."[102] The city-state model perfectly describes the actual situation of many Spring and Autumn-era polities, but to the degree that they were not regarded by those who lived in them as sovereign or politically independent, they cannot be considered states according to Trigger's definition.[103] On the other hand, the system can not be considered feudal because, although the rulers of the various states relied on the authority of the central ruler for legitimation, their real power depended on their own military strength. The inter-state warfare of the period led directly to the reforms whereby the various states developed the fixed jurisdictions under the control of an appointed and professional bureaucracy necessary for rule strong enough to unambiguously fit with Trigger's definition of a territorial state. These will be discussed in the following chapter.

Faunal Remains

Excavated faunal remains (non-human animal bones) have provided important information into the prehistoric fauna of North China. The faunal remains from various Neolithic sites have been studied, but none from the Zhou. The most recent site to be studied extensively in terms of faunal remains was Shang-era Anyang, which showed that a variety of animals inhabited the region in the 13th-11th centuries B.C. Because many of these animals are currently found only to the south, and because we know that the climate was warmer at the time, it is generally assumed that the existence of these species is indicative only of a warmer climate.

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[102] Yates, "The City State in Ancient China," 83. In light of this, Trigger's description of feudalism is significant: "The feudal orders of medieval Europe and premodern Japan both evolved out of the collapse of more centralized forms of government and coexisted symbiotically with international religions of foreign origin that strongly assisted their political functioning." Trigger, *Understanding Early Civilizations*, 15. Although he emphasises the foreignness of the religion in order to reduce the importance of feudalism as a model, the idea of a collapsed central power depending on religion to maintain its existence fits well with the Eastern Zhou. In the Zhou case the religion was based on the direct connections between the sky deity, the king (*tianzi* 天子), and provincial ruling families through kinship connections in both the spirit world through a pantheon of ancestors and in living kinship groups. If we choose to regard the religious system as an ideology that assisted the political functioning of the Zhou, it is part of the feudal system. However, within that worldview the political ties between the central and provincial rulers were a small part of a much broader cosmology.

[103] "A state is a politically organized society that is regarded by those who live in it as sovereign or politically independent and has leaders who control its social, political, legal, economic, and cultural activities." Trigger, *Understanding Early Civilizations*, 92.

However, just as it is not logical to assume that North China must have had tropical rain forests because the closest surviving rhinoceros live in Indonesia, it is not certain that a mammal currently found only in the Yangzi area could not live farther north if its habitat had not been eliminated. The area that has been completely cleared of its ecosystem is large enough to have had unique ecosystems that had no parallels elsewhere. For example, the large herds of elaphures that once roamed the plains are gone because their ideal habitat was also ideal for farming. Although the discussion in the first chapter of vegetation is more useful for understanding what the landscape might have resembled before humans took over, knowing what animals inhabited the region makes it easier to understand how much the environment has changed, and to imagine what it once was like. It is very difficult to imagine deer, alligators, elephants and rhinoceros in the region today.

Before discussing the Shang, there is one animal whose remains were not found at the Anyang but which is nonetheless relevant. Items made from the skin of the Chinese alligator (*Alligator sinensis*) were excavated from the Taosi (ca. 2500-1900 B.C.) site north of the Yellow river in Shanxi, although they were probably brought from the plains since no alligator remains have been found in Shanxi.[104] A.A. Faudel showed that they were once abundant from the North China Plain to the Pearl River delta.[105] Chou Pen-hsiung argued that "from the Neolithic to the historic period, the Yellow River and Huai-ho River plains were crisscrossed with rivers and densely dotted with large and small lakes and were covered with a full vegetation...furnishing a natural condition suitable for the habitation of the Yangtze alligators."[106] They have been eliminated by habitat destruction and by hunting for medicine and drum skins. There are currently fewer than 200 Chinese alligators left in the wild, all of them in Anhui.

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[104] Li Liu, *The Chinese Neolithic*, 122.
[105] A.A. Fauvel, "Alligators in China," *Journal of the North China Branch of the Royal Asiatic Society* 13 (1878), 1-36.
[106] Quoted in K.C. Chang, *The Archaeology of Ancient China*, 162.

K.C. Chang has summarised the results of de Chardin and Young's studies of Anyang's faunal remains.[107] Although the relationship between the natural fauna of the period and the bones that were buried is unknown, I will assume that the numbers of individuals has some relation to their population and a direct relation to their importance for humans. The most common animal remains at Anyang are the carapaces of turtles and the scapulae of cattle, which were used for divination, but these were not included in the study.

In the original study at Anyang, water buffalo (*Bubalus Mephistopheles*), boar (*Sus vittatus* var. *frontalis*), and elaphure (*Elaphurus davidianus*), were estimated to have amounted to over 1000 individuals. The former may have been a useful domesticate, in which case it would indicate that winters were not so cold; however, new scholarship has suggested that these were actually a wild species, and that the domestic buffalo was introduced from Southeast Asia during the Western Zhou period.[108] This is also suggested by the possibility that the character *si* 兕 referred to wild buffalo rather than rhinoceros.[109] If it turns out to be true that these remains are those of wild buffalo and that the *si* mentioned so often in early texts refers to buffalo, it will transform our understanding of the human ecology of the period, showing that the Shang were more reliant on hunting than previously thought.

Boars "live in many kinds of habitat but generally where there is some vegetation for cover. They are most plentiful in oak forests and in the reedbeds of Asia."[110] Elaphures are deer up to 120cm high and 135kg, which would naturally live in large herds in grasslands and wetlands, being very comfortable in water, which perhaps explains why they were so common on the North China Plain, which contained considerable wetlands. Their gregarious nature probably made them easier

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[107] K.C. Chang, *Shang Archaeology*, 138-40. Originally published in P.T. de Chardin & C.C. Young, "On the Mammalian Remains from the Archaeological Site of Anyang," *Paleontologia Sinica Series C: Fossil Vertebrates* 12 (1936), 1-71.

[108] Liu Li 劉莉, Yang Dongya 楊東亞, and Chen Xingcan 陳星燦, "Zhongguo jiayang shuiniu qiyuan chutan" 中國家養水牛起源初探 (Preliminary discussion on the origins of Chinese domestic buffalo), *Kaogu xuebao* (2006.2): 141-78.

[109] Jean A. Lefeuvre, "Rhinoceros and Wild Buffaloes North of the Yellow River at the End of the Shang Dynasty," *Monumenta Serica* 39 (1990-91), 131-57.

[110] Ronald M. Nowak, *Walker's Mammals of the World* 5th ed., vol. 2 (Baltimore: The Johns Hopkins University Press, 1991), 1338.

to hunt in large numbers, and they may well have been the most common victim of the royal hunting parties common from at latest the Shang well into the imperial period. Although they are extinct in the wild and currently classified as critically endangered, they were obviously very common 3200 years ago in the Anyang area.[111]

Species of which the remains of over 100 individuals were found include dog (*Canis familiaris*), domestic pig (*Sus* cf. *scrofa*), water deer (*Hydropotes inermis*), sika deer (*Cervus nippon*), Shang sheep (*Ovid shangi*) and cattle (*Bos* sp.). Both the water deer and the sika deer are solitary, which probably explains their lower numbers at Anyang The former are very small (9-14kg) and inhabit swampy, open grasslands, while the latter (25-110kg) inhabit a range of environments including forest, marshes and grassland.[112]

Eight species were estimated as comprising between 10 and 100 individuals: raccoon dog (*Nyctereutes procyonoides*), bear (*Ursus* sp.), badger (*Meles meles leucurus*), tiger (*Felis tigris*), rat (*Epimys rattus*), bamboo rat (*Rhizomys sinensis*), rabbit (*Lepus* sp.), and horse (*Equus caballus*). The presence of bears and tigers may suggest that they were plentiful, as they were certainly not hunted for food. However, given the importance of hunting as a militaristic ritual in the culture, it is likely that they were hunted for the prestige of killing them and of wearing their pelts and teeth. Eliminating animals which posed a danger to humans and livestock was also probably considered a service to the people. The smaller mammals were probably commonly hunted, snared and trapped for food.

Fewer than 10 individuals were found of the following species: fox (*Vulpes vulgaris*), Asian black bear (*Ursus thibetanus*), leopard (*Panthera pardis*), cat (*Felis* sp.), whale (*Cetacea* sp.), field rat (*Siphneus/Myospalax* sp.), tapir (*Tapirus indicus*), rhinoceros (*Rhinoceros* sp.), goat (*Capra* sp.), takin (*Budocras taxicolor*), elephant (*Elephas indicus*), and monkey (*Macaca* sp.). With such low numbers it is difficult to say what these species signified. The whale bones were probably brought to Anyang as bones. The takin, a cow or goatlike horned mountain mammal, although currently found only in the mountains of western China and the southern Himalayas, may have inhabited

[111] Nowak, *Walker's Mammals of the World*, 1383-84.
[112] Nowak, *Walker's Mammals of the World*, 1365-66, 1379-80.

mountains closer to Anyang. Tapirs are tropical mammals, and may have been brought from the south. Along with horses, monkeys, birds, and many humans buried with the primary occupants of Anyang tombs, two complete elephants with "attendants" have been found in tombs,[113] which may indicate that elephants were partly domesticated at the time. Elephants, along with rhinoceros and bears, will be discussed at more length in the following chapter.

The 1997 excavation of the Huayuanzhuang site at Anyang unearthed *Lamprotula* mussel, clam, black carp, chicken, dog, rhinoceros, domestic pig, elaphure, ox, buffalo and shhep remains. Pigs, dogs, chickens and sheep make up 93% of the total, again showing that livestock were a more important food source than wild game.[114]

The Fengxi site in Shanxi was also excavated in 1997 and yielded the bones of chicken, rabbit, dog, horse, sika deer, ox, sheep and buffalo.[115]

Although it was a sedentary, socially stratified agricultural society, deer hunting was a significant source of food, which suggests that even the city at the centre of the Shang polity was not very far from significant wild land. The textual sources discussed in the next chapter do not suggest that wild game was as significant as the Anyang numbers would suggest. They also rarely mention some mammals (i.e., boar, raccoon dog, bamboo rat) which the Anyang remains suggest were a common food source. It seems that wild animals were less common by the Warring States and Han than they had been centuries earlier. This is one of the most ecologically useful aspects of archaeological evidence.

The Beginnings of Iron Technology

> "Birds of prey and fierce beasts wounded people, and there was no way to stop them until people cast metal and forged iron to make weapons; then the birds

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[113] Bagley, "Shang Archaeology," 193.

[114] Yuan Jing 袁靖 & Tang Jigen 唐際根, "Henan Anyang shi Huan bei Huanyuanzhuang yizhi chu tu dongwu guge yanjiu baogao" 河南安陽市洹北花園莊遺址出土動物骨骼研究報告 (Report on the bones excavated from the Huanyuanzhuan site at Anyang, Henan), *Kaogu* 2000.11, 75-81.

[115] Yuan Jing 袁靖 & Xu Lianggao 徐良高, "Fengxi chutu dongwu guge yanjiu baogao" 澧西出土動物骨骼研究報告 (Report on the animal bones excavated at Fengxi), *Kaogu xuebao* 2000.2, 246-56.

and beasts could no longer do harm" 爲鷙禽猛獸之害傷人, 而無以禁御也; 而作爲之鑄金鍛鐵以爲兵刃, 猛獸不能爲害.[116]

One interesting aspect of the rise of civilisation in China is that, despite the importance of bronze vessels in rituals of rulership and in weaponry, it was still an essentially stone age society until the spread of cast iron technology in the Eastern Zhou. Bronze was considered precious, and was only rarely used for tools, which were usually made of more humble materials.[117] Francesca Bray notes that "throughout the Shang and into the Zhou dynasty most agricultural tools, including mattocks and hoes, continued to be made of shell, stone, bone and wood. They may have been mass-produced, for shell and bone workshops have been found in several Shang sites. Unfortunately, descriptions or illustrations of these humble tools are hardly ever published, for they naturally attract far less attention than the more glamorous products of the age."[118] Fortunately this is not the case for metal tools, partly because scholars, such as Joseph Needham, have been eager to prove how much earlier cast iron was invented in China than in the west.[119]

The most important reason to consider metallurgy in this context is that modifying the environment is much easier and more effective with metal than with stone, bone, or wood. We can expect that the widespread use of cast iron tools would likely increase deforestation and erosion, and greatly facilitate large-scale

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[116] *Huainanzi* 淮南子 (*Zhuzi jicheng* vol.7), 13.212; Charles LeBlanc & Rémi Mathieu, tr., *Philosophes taoïstes,* vol.2, *Huainan zi* (Paris: Gallimard, 2003), 607.

[117] Although dozens of bronze tools from the Shang have been excavated, most studies conclude that they in no way compare in number to the bronze ritual vessels from the period, and it is unlikely that all of them combined would outweigh a few of the largest Shang vessels. See Bai Yunxiang 白雲翔, "Yindai Xi-Zhou shifou daliang shiyong qingtong nongju zhi kaoguxue zai guancha" 殷代西周是否大量使用青銅農具之考古學再觀察 (Another archaeological look at whether or not the Shang and Western Zhou used many bronze agricultural tools), *Nongye kaogu* 1989.1, 194-203; Xu Xueshu 徐學書, "Shang-Zhou qingtong nongju yanjiu" 商周青銅農具研究 (Study of Shang and Zhou bronze agricultural implements), *Nongye kaogu* 1987.2, 184-94. However, the following volume describes hundreds of bronze tools of various types, and suggests that any further study of the role of metal technology in altering the early environment should also consider bronze: Chen Zhenzhong 陳振中, *Qian Qin qingtong shengchan gongju* 先秦青铜生產工具 (Pre-Qin bronze production implements), Xiamen: Xiamen Daxue, 2004.

[118] Francesca Bray, *Science and Civilisation in China* 6.2: "Agriculture" (Cambridge: Cambridge University Press, 1984), 201.

[119] Joseph Needham, *The Development of Iron and Steel Technology in China* (Cambridge: Published for the Newcomen Society by W. Heffer, 1964).

earth-altering projects like canals. William Rostoker et al. note that "white iron is exceedingly hard... its resistance to abrasive wear is superior to any ancient metal and is comparable to many contemporary metals. The cast iron of ancient China for at least the first five hundred years of production was almost exclusively white iron. For the tool applications that involved forcible penetration of hard clay and soft stone it was ideal."[120] Such hard metal is also ideal for cutting down trees, as shown by Mencius on the first page of this thesis.

Although it was never common, bronze was used in some areas for tools. For example, 35.4% of the bronze casting moulds excavated at Zhengzhou (Erligang) were tool moulds, although it is unspecified what kinds of tools or how representative surviving moulds are of actual production.[121] Li Xueqin has shown that, although a few bronze agricultural implements have been found in the North, they were only ever common in the lower Yangzi region, mostly in the Eastern Zhou state of Wu.[122] In that area, archaeologists have discovered toothed sickle blades, saw-toothed harvesting knives, and caps for digging implements, and a few other bronze agricultural implements. There have also been occasional bronze hoe-heads and hatchets excavated in the area of Chu.[123]

Although there are plenty of references to iron in early texts, enough to show that by the 3rd century B.C. it was a commonly used material, the archaeological evidence is the most reliable for tracing the beginnings of iron. Donald Wagner argues that southern bronze casters, using sophisticated bronze-casting technology developed further north, began casting iron as a cheaper replacement for bronze in implements in the 8th century B.C.[124] However, the earliest cast-iron yet found comes from the mid-8th century B.C. in Sanmenxia, Henan, and from a slightly later tomb in Gansu.[125] Regardless of when and where it began, it was only in the Warring

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[120] W. Rostoker, B. Bronson, J. Dvorak & G. Shen, "Casting Farm Implements, Comparable Tools and Hardware in Ancient China," *World Archaeology* 15.2 (1983), 208.
[121] Liu & Chen, *State Formation in Early China*, 96.
[122] Li Xueqin, *Eastern Zhou and Qin Civilizations*, 284-90.
[123] Donald B. Wagner, *Iron and Steel in Ancient China* (Leiden: Brill, 1993), 136-42; 211-15.
[124] This is the central argument of Wagner's book *Iron and Steel in Ancient China*, from which much of the information in the following paragraphs is drawn.
[125] K.C. Chang et al., *The Formation of Chinese Civilization*, 206.

States that iron tools became common.[126] Tombs excavated at Huixian county, Henan, included axe heads, ploughshares, "digging implements," hoe and mattock heads, and other potentially earth-altering tools. The widespread use of the iron ploughshare would have improved the ability of ploughs to turn soils, and may also have facilitated the working of the heavier soils, especially in the drained wetlands of the plains.

Hexagonal hoe heads were very common in the Late Zhou-Han period. Even more common were iron caps whose function is unknown, but were probably used to cap a variety of wooden tools including hoes and spades. The site of the workshops of the First Emperor's mausoleum (built around 212-209 B.C.) included such tools as hammer-heads, implement caps, spikes, chisels, chains, hooks, spades, and knives, showing the variety of iron tools that were probably available for imperial projects such as the building of the Zheng Guo canal 40 years earlier.[127] Such a project would have been virtually impossible with only stone and wooden implements, even if earlier rulers had been able to muster the many thousands of labourers required.

Iron foundries have been excavated at Xinzheng and Gaocheng in Henan and at Xinlong, Hebei, the latter of which produced mostly agricultural implements. Texts of the period such as the *Shi ji* and *Han shu* 漢書, say that Qi, Zhao, Chu, Yan, and especially Han were centres of production in the Warring States. These were large-scale operations in which vertical furnaces and bellows were used to produce continuously for long periods. A bell from the state of Qi records that there were 4000 workers in the iron foundry that produced it. From the late Warring States onwards, iron was one of the most important commodities.[128]

By the Han stacked stoneware or cast-iron moulds were used to cast agricultural implements on a huge scale. Rostoker estimates that the three main Western Han sites, possibly government monopolies, would have been capable of

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[126] Li Jianmin 李健民, "Zhanguo shiqi tie nongju de kaogu faxian yu yanjiu" 戰國時期鐵農具的考古與研究 (Study of archaeologically discovered Warring States period iron tools), *Nongye kaogu* 2005.1, 194-96.

[127] Wagner, *Iron and Steel in Ancient China*, 201-9.

[128] All information in this paragraph from K.C. Chang et al., *The Formation of Chinese Civilization*, 207.

casting 1,400 metric tons per year.[129] This must have allowed the near universal use of iron implements, a complete revolution compared with a few centuries earlier. These furnaces, and the production of charcoal to fuel them, must have created significant air pollution, and burned entire forests, as suggested by Wagner's insight that "the limiting resource in pre-modern iron productions is *wood*, not ore."[130] This was especially significant after the beginning of the state monopoly in iron in 117 B.C., after which smelters were located directly beside the cities, both polluting the air and competing with the people for wood.[131]

The spread of cast iron tools can be considered a revolution in the power of humans over the environment. It made all kinds of labour easier and more effective, especially where previous tools had been inadequate, such as in the felling large trees or breaking hard soil. Large scale projects such as canals and roads became feasible. Moreover, "since cast iron cannot be a cottage industry, it set the precedent for large central industrial sites which served the needs of a whole nation. Combining the new concentration of specialised craftsmen, the need to collect and distribute food surpluses, and the regulation of trade that is consonant with surpluses, the urban areas became a necessary consequence."[132] The wide scale production of bronze coins in this period is part of the same process.

Conclusion

Archaeology is essential for an understanding of the rise of civilisation in China, and provides material evidence for much that would otherwise remain unknown or poorly understood. The most notable of these are faunal remains and earth-altering tools, both of which provide information about subjects on which textual sources are weak. While an early textual mention of iron can perhaps be attributed to scribal error, a well-dated tool not only provides material evidence for the existence of iron tools at a specific time and place, but also shows what type of

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[129] Rostoker et al., "Casting Farm Implements," 202.
[130] Wagner, *Iron and Steel in Ancient China*, 258.
[131] Donald B. Wagner, *The State and the Iron Industry in Han China* (Copenhagen: Nordic Institute of Asian Studies, 2001), 38.
[132] Rostoker et al., "Casting Farm Implements," 209.

tools were being used. Likewise, the bones of over 1000 water buffalo at Anyang represents the existence of that many animals, which is more easily interpreted than a specific number of oak pollen which could have been produced by a single tree.

Perhaps most usefully, archaeology has illuminated the prehistory of China, so that the history previously known from texts can now be placed in a much longer context of civilisation in the region. We not only know that the region was inhabited by large numbers of humans for thousands of years, but are even able to roughly understand where the population centres were, and something of their socioeconomic characteristics. The prehistory of the region is beginning to be understood in more depth than before now that archaeologists are studying settlement patterns and trade routes in addition to the traditional methods of describing and categorising artefacts.

In terms of the Zhou period, the few texts that were once the only evidence can now be interpreted along with contemporary cities, tombs, and iron implements. The archaeological evidence provides another type of information that greatly adds to our understanding of the period by reducing the dependence on texts. Although archaeological research has tended to focus on elite culture and on clarifying what texts had left unclear, rather than on researching questions that the texts do not cover at all, much has be learned of the overall society from the material culture of the elites. Nonetheless, archaeology could be even more useful. It can only be hoped that future research will focus more closely on more prosaic areas of early Chinese history.

Chapter 3: Textual Sources

The written sources up to the end of Han emperor Wu's reign in 87 B.C. are many and varied, from the cryptic divination records on the Shang oracle bones to the detailed *Historical Records* (*Shi ji*) of Sima Qian. The *Mencius* passage on the first page of this thesis is one of very few passages that deals directly with environmental change, but many sources include passages that provide information on environmental conditions or on socio-political changes that affected the environment. Because most transmitted texts are now extant only in Song dynasty woodblock prints, validated to some degree by earlier engravings, we must accept that the version we now have may well have been modified. Although this does not apply to recently excavated sources, I have found little relevant information in them with the notable exception of the Qin law codes from Yunmeng. Another important consideration is that some texts were intended to be depictions of reality while others are completely imaginary; most lie somewhere in between. Moreover, the histories and meanings of some texts are much better known than others, and the more we know about the history of a text the more useful it is. In general, I tend to treat most textual evidence as having some weight, but place much more emphasis on subjects that occur in more than one text. Thus I have arranged this chapter thematically, rather than by source.

In terms of ecology, the major weakness of written sources is that we cannot be sure to which plant, animal, or landscape specific words refer. Folk classifications frequently group together several of what modern biologists would consider separate species, and sometimes distinguish several varieties where modern biology assigns only one name. Allyn Rickett points out that "the early Chinese had no systematic method for identifying plants. Names tended to differ from area to area and period to period. Even those names that achieved general acceptance frequently lacked standard characters, thereby resulting in the unsystematic use of phonetic loans. Moreover, throughout history the meaning of even some well-established names underwent a process of change, thus creating even more ambiguity. To make matters worse, later scribes tended to be ignorant of such subjects as soil types and

plant life so that the names and technical terms involved were especially prone to corruption."[133] Although scholars have studied and clarified early plant and animal names, early texts are not as useful as the sources on modern and ancient vegetation discussed in the second chapter. Although texts are the most useful source on the human ecology of the period, they are much less useful as a source on the natural environment, a subject that consequently will rarely be discussed in this chapter.

The problem of interpreting general landscape terms in premodern texts has been discussed in studies of European environmental history. For example, Frans Vera has shown that although the belief that the medieval European landscape was densely forested has been justified by citing the frequent use of terms like "forest" in early texts, actually our interpretation of these terms is itself based on our idea of what medieval Europe looked like. If the landscape had actually been dominated by a mixed forest/grassland, then the "forest" would have referred to that landscape, and our interpretation suffers from interpreting the linguistic evidence to show the expected conclusion.[134] Derk Bodde has similarly shown that, although the term *ze* 澤 has traditionally been translated 'marsh', it in fact refers to a range of environments, some of which were not necessarily very wet.[135] Shi Nianhai's analyses of North China suffers the same way with regards to the word *lin* 林, which he interprets as evidence for large dense forests.[136] Despite their weaknesses, written sources provide a wealth of information on the early environment, its human inhabitants, and their relationship. Because I will cite freely from a variety of sources, I will begin by briefly discussing some of them.

The Shang oracle bones provide an idea of the geographical and political situation of the late Shang, and body counts from the royal hunting expeditions give us an idea of what types of large mammals lived wild in the area 3200 years ago. An adequate study of the oracle bones would require a thesis on its own; I will only refer to oracle bones cited in secondary literature. The *Shi jing* (hereafter, the *Odes*)

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[133] W. Allyn Rickett, *Guanzi: Political, Economic, and Philosophical Essays from Early China* vol. 2 (Princeton: Princeton University Press, 1998), 254-55.
[134] Vera, *Grazing Ecology and Forest History*, 102-19.
[135] Derk Bodde, "Marshes in Mencius and Elsewhere: A Lexicographical Note," in Derk Bodde, *Essays in Chinese Civilization* (Princeton: Princeton University Press, 1981), 416-26.
[136] Shi Nianhai, *Heshan ji* vol. 2, 232-314.

contains plenty of ecological knowledge, and will be discussed in depth in the following section. Although I have decided to focus on the *Odes*, which are earlier and representative of a larger region, it should be noted that the "Di yuan" 地員 chapter of the *Guanzi* 管子 is almost as rich in plant names and ecological knowledge as the entire *Odes* collection.

Warring States texts such as the *Zuo Zhuan* 左傳, *Analects* 論語, *Mozi* 墨子, *Guanzi*, *Mencius* 孟子 *Zhanguo ce* 戰國策, *Xunzi* 荀子, *Shangjun shu* 商君書, *Lüshi chunqiu* 呂氏春秋 and the *Zhuangzi* 莊子 are all the products of several hands, sometimes writing centuries apart. All contain scattered pieces of information relevant to environmental conditions, and describe in more detail the revolutionary changes in the political economy of the period which transformed the relationship between people and the environment. Each of these texts employs different rhetorical strategies, such as description of events, rhetorical use of metaphor, or description of imagined ideal situations (often described as past events). The *Zuo Zhuan* is written as a chronicle of events. The *Mencius* passage which opened this thesis is a good example of the rhetorical mention of nature, as the denudation of a hill is paralleled with the degradation of the inherently moral nature of man. This type of metaphor was very important in early argumentation and logic, and is extremely common in early texts. I generally assume that a subject used as a metaphor must have been common knowledge if was to have rhetorical impact, and is thus a representation of perceived reality. Conversely, many of the texts describe conditions during the age of the sage rulers, which are better understood as descriptions of the author's political ideas than as reflections of reality.

The *Zhou li* 周禮 describes an idealised bureaucracy, listing hundreds of positions and their duties, some of which concern the regulation of the environment. Information on such environmental regulation is found in a variety of early texts, most importantly the Qin legal codes unearthed at Yunmeng, the only excavated texts used in this thesis.[137]

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[137] Another excavated text, the Han era *Hedi Jian* 河隄簡, contains a list of various plots of land along the Yangzi that had been drained and diked for agriculture and their sizes. It provides important information on the extent of land being taken from the river at that time, but the Yangzi is too far

The *Huainanzi* 淮南子 (ca. 123 B.C.) contains many references to environmental phenomena of all sorts. However, these are usually in metaphors, parables, or fantastical stories, and are often more useful as sources on perceptions of animals, plants, and ecological processes than on the physical environment.[138] Although the work incorporates texts from various times and places, it is nonetheless possible that one reason it mentions so many plants and animals is that the fief of Huainan (in modern central Anhui) contained far more wild land than the densely populated regions to the north. Another Han text, Jia Yi's 賈誼 (ca. 200-168 B.C.) *Xin yu* 新語, contains a good description of contemporary logging practices. The *Shi ji* contains a chapter on water works, another on trade and economy, and generally includes an enormous amount of useful information on the period. The "Huo zhi" 貨殖 chapter 129 on trade and economy includes a description of the various regions of the empire and their products (or lack thereof), and will be discussed along with the "Yu gong" 禹貢 chapter of the *Shu jing* 書經, in the last section. The *Discourses of Salt and Iron*, or *Yantie lun* 鹽鐵論, written around 80 B.C., shows that the economy was very well developed by this period and that natural resources or wild animals were virtually absent from large areas of North China.

I have made no systematic study of any individual text except the poems collected in the *Odes*, nor have I attempted to compare or contrast references to any subject or individual words in different texts. In discussing a subject I refer to any text pertaining to the subject under discussion. Although it would be interesting to study individual texts in more depth, these studies would tell us more about the texts than about the environment of the time.

Although it was done over a century later than the period of this study, the census of 2 A.D. was the first to show the population of the empire, and I have included it here to give the reader an idea of which areas were the most densely populated in the period. It roughly depicts the population centres in earlier periods,

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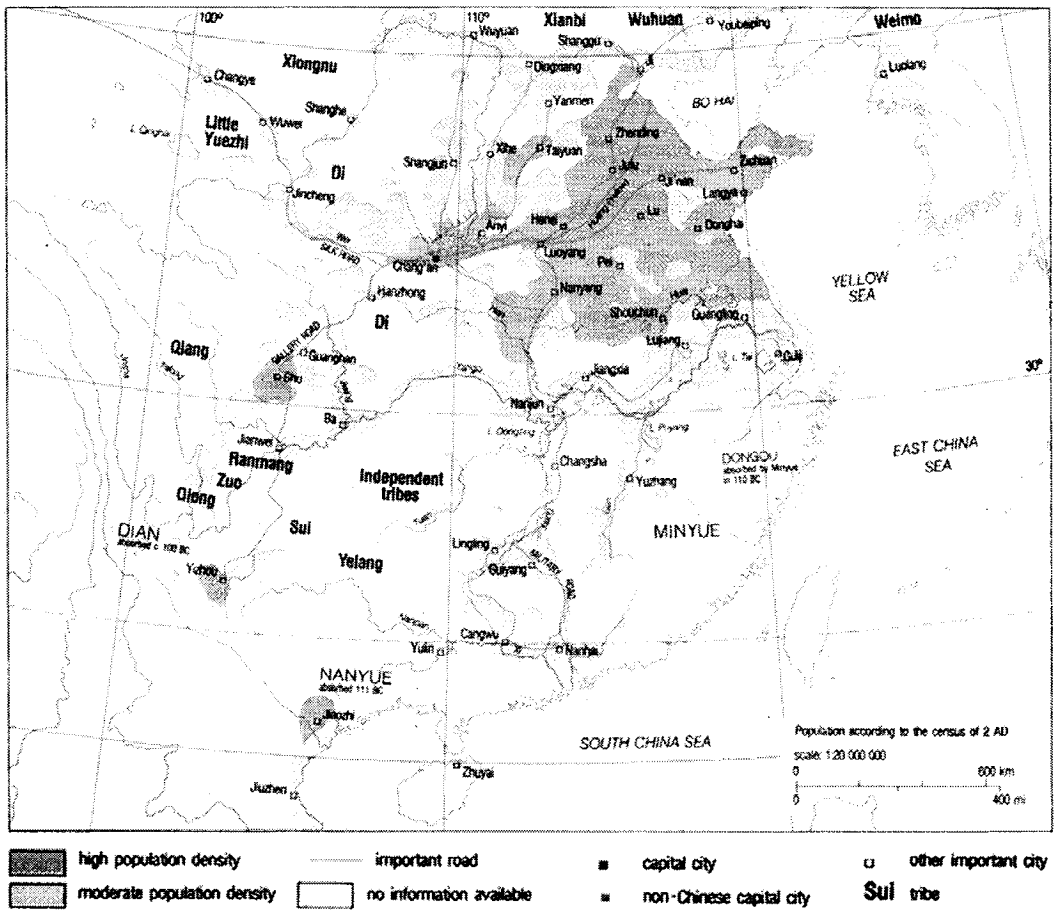
south to be relevant to this study. Peng Hao 彭浩, "'Hedi jian' jiaodu" '河隄簡'校讀 (Deciphering the "Slips on river embankments"), *Kaogu* 2005.11, 71-75.

[138] On the cultural perception of animals in early Chinese intellectual history, see Roel Sterckx, *The Animal and the Daemon in Early China* (Albany: SUNY Press, 2002).

showing that the Yellow River valley and the North China Plain, the political and economic centre of the region, was also by far the most densely populated. During the early Han the population was spreading outwards, especially to the south. If there had been a census a few centuries earlier the population density of the Yellow River region would have been even more notable in comparison to that of the Yangzi valley and other outlying areas.



Population distribution according to the imperial census of 2 A.D.[139]

This chapter is divided into two sections, the first on the human ecology/economy of the period, the second on the political transformations of the period and their effect on the environment. The first half begins with an exploration of agriculture and the environment of the *Odes*, followed by sections on livestock and herding, opening new land, deforestation, hunting and fishing. The second half concerns the increasing control of the government(s) over peripheral areas and over

[139] Caroline Blunden & Mark Elvin, *A Cultural Atlas of China* (New York: Checkmark Books, 1998), 30.

the common people, which had a direct impact on the way people interacted with the environment. This control will be examined in sections on large-scale water control works and on the bureaucratic control of the exploitation of wild land. The last section concerns the economic geography of the period and the developments of a market economy.

I: The Human Ecosystem

Agriculture

A passage from the *Huainanzi* gives an idea of the ecosystem that was built by humans in China, arguing that the ruler "should teach the people to raise the six domestic animals, to plant trees at proper times, to labour diligently in the cultivation of the fields, to plant mulberry bushes and hemp widely, and to use each type of terrain and soil to its best advantage, growing bamboo and wood on the hills and slopes which will not produce the five grains" 教民養育六畜，以時種樹， 務修田疇，滋植桑麻，肥墝□高下，各因其宜，丘陵阪險不生五穀者，以樹竹木.[140] This passage shows the importance of trees in Chinese agriculture and, moreover, advocates an intensive agriculture in which no land is left unused. This intensive form of agriculture was developed during the Eastern Zhou period.

Replacing natural vegetation and the animals that inhabit it with agriculture entails an ecological simplification, especially in a fairly biodiverse area. The more intensive the agriculture, the simpler the ecosystem. Large mammals, such as elephants, rhinoceros and brown bears, require large ranges and are incompatible with agriculture and are therefore eliminated quickly from agricultural areas. Plants which grow only in land that is suitable for farming could suffer the same fate, although they would leave no historical record. It is likely that some plant species once endemic to the region were wiped out long ago. On the other hand, some species thrive in agricultural environments, such as "weeds" and other disturbance plants, small mammals like mice and rats, and some birds. Viruses also thrive in sedentary populations, especially when various species such as chickens, humans and

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[140] *Huainanzi* (*Zhuzi jicheng* vol.7), 9.147; Roger Ames, *The Art of Rulership: A Study in Ancient Chinese Political Thought* (Honolulu: University of Hawaii Press), 200-1.

pigs live in close proximity. Indeed, despite our traditional agricultural bias, ethnographic research has shown that hunter/fisher/gatherer societies are often healthier, and require much less work to survive, than do those of agriculturalists.[141]

In terms of soil, the clearance of the original vegetation and subsequent hoeing and ploughing reduces the top layers of humus and soil to a single layer that is lighter in colour, lower in humus and weaker in soil structure. This facilitates erosion, especially in loess soils, as do the use of the plough and, to a lesser degree, the ard, which break up soil more thoroughly than tools like hoes. Francesca Bray has convincingly argued that the plough was in use as early as the Shang, which means that most agriculture of the period was done with ox-, buffalo-, and occasionally human-drawn ploughs or ards.[142] Whether the plough was in use so early may not be as important as design improvements and iron ploughshares: "we would suggest that the rapid expansion of the Chinese population and economy that began at the end of the Spring and Autumn period was facilitated by the development of a square-framed plough with an iron share, heavier and more efficient than the bow-ard, and permitting the expansion of the cultivated area into heavy and waterlogged soils that previously had not been farmed."[143] The most extensive of these heavy and waterlogged soils were probably in the eastern regions of the North China Plain.

Land clearance and agriculture often lead to soil erosion, especially noticeable in the Loess Plateau. However, in many areas "the influence of man has been the opposite of erosion; the practice of adding turf, earth and mud fertiliser, marl and sand or silt to improve texture or chemical fertility over very long periods of time has locally produced great thicknesses of man-made topsoil."[144] This is especially true in valley bottoms and near cities, where abundant night soil results in the accumulation of nutrients. Although we have no information on when the use of night soil began, Hsu Cho-yun notes that same character meant both dung and fertiliser, and assumes

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[141] For example, Marshall Sahlins, *Stone Age Economics* (Chicago: Aldine, 1974).
[142] Bray, *Science and Civilisation* 6.2, 138-96.
[143] Bray, *Science and Civilisation* 6.2, 168.
[144] Joseph Needham, Gwei-Djen Lu, & Hsing-Tsung Huang, *Science and Civilisation in China* 6.1, "Botany" (Cambridge: Cambridge University Press, 1986), 73.

that refers to both animal and human night-soil.[145] There is no reason to think the Chinese ever shared the western practice of wasting valuable fecal nutrients by dumping them in rivers or waste places. It can be assumed that the practice developed over centuries, along with the intensification of agriculture.

The most useful sources on the human environment of the early period are the poems of the *Odes*, which include mention of dozens of plants, domesticated, wild, or in-between. While most early sources refer to plants, animals, and environments, they do so mostly in terms of use; the *Odes* are one of the few sources describing natural conditions seemingly for their own sake. Although these plants and animals are mentioned in rhetorical contexts, the variety of species mentioned, and the obvious familiarity of the authors with the growth conditions and behaviour of the species described show that the authors lived in a society which was still closely surrounded by wild plants and animals. Later works tend to mention plants and animals either as commodities or as simple rhetorical tropes, much like the animals in European fairy tales. Although many of the poems in the collection are attributed to specific areas, it is impossible to tell whether this is accurate, and I prefer to analyse the entire collection as a single text referring to the whole region.

The *Odes* are among the oldest of the transmitted texts (ca. 1000-600 B.C.)[146] and among the few that remain from the Western Zhou period. They come from a period in which wild nature still existed in the central and lower Yellow River area and fishing, gathering and hunting were far more important than they would be a few centuries later. Agriculture was certainly the most important food source, but wild food was also widely available. To take a longer perspective, the traditional ecological knowledge necessary for successful fishing, hunting, and gathering was still strong in this stone-age agricultural society, but would gradually fade as more land was cleared for farming.

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[145] Hsu Cho-yun, *Han Agriculture: The Formation of Early Chinese Agrarian Economy (206 B.C.-A.D. 220)* (Seattle: University of Washington Press, 1980), 6-7.

[146] *Early Chinese Texts: A Bibliographic Guide*, ed. Michael Loewe (Berkeley: The Society for the Study of Early China, 1993), 415-23. I have followed the dates and information given in this work for all texts discussed.

As noted by Confucius, the *Odes* contain many plant and animal names, and "will widen your acquaintance with the names of birds, beasts, plants and trees" 多識于鳥獸草木之名.[147] Although not all of the plants can be identified with certainty, almost all of them have been identified to some degree. Therefore, by looking at all of them we get some idea of the human ecology of the period. What follows is a list of plants mentioned in the *Odes*, followed by the number of the times they appear in the collection, potential scientific names, and any other useful information. The picture that emerges is of a sedentary agricultural society in which a variety of wild (or semi-domesticated) plants are commonly used.

Much of the species information from the following table comes from Hsuan Keng's article "Economic Plants of Ancient North China as Mentioned in *Shih Ching*,"[148] although he discusses fewer than half of the following species. Scientific names which have the unitalicised botanist's initial after the Latin come from Keng, and have therefore been researched in depth, while the others come from a variety of other dictionaries and may not be accurate. Some of these plants are also discussed in Needham's work on botany.[149]

Table 3: Plants in the *Odes*

Herbaceous plants		
稷 *ji*	27	(*Panicum miliaceum* L.) Broomcorn or hog millet.
黍 *shu*	25	(*Panicum miliaceum* L.) Sticky broomcorn or hog millet.
葛 *ge*	22	(*Pueria lobata* Ohwi) Arrowroot, dolichos, kudzu vine; a creeping edible bean whose fibers can be made into linen-like cloth and whose roots are used for herbal medicine.
薇 *wei*	12	(*Osmunda regalis*) Bracken, fernbreak, a leguminous plant whose root is used for food.
菽 *shu*	10	Bean(s) (豆), probably (*Glycene max* Merr.) Soybean.

[147] *Lun yu* 論語 17.9 (*Zhuzi jicheng* vol.1), 374; Arthur Waley, tr., *The Analects* (Beijing: Waiyu jiaoxue yu yanjiu, 2003), 232-33.
[148] Keng Hsuan, "Economic Plants of Ancient North China as Mentioned in Shih Ching (Book of Poetry)," *Economic Botany* 28.4 (1974), 391-410. This article is a summery of Keng Hsuan's 耿煊 book *Shijing zhong de jingji zhiwu* 詩經中的經濟植物 (Economic Plants in the *Shi jing*) (Taipei: Taiwan shang wu,1974), to which I have not had access.
[149] Needham, *Science and Civilisation* 6.1.

荼 *tu*	10	(1) A bitter-leaf lettuce. (2) The ear of a reed or cogongrass. Some believe it refers to rice.[150]
瓜 *gu*	7	(*Cucumis melo* var. *conomon* Makino) Melon.
藻 *zao*	7	An aquatic plant.
竹 *zhu*	7	Bamboo.
麥 *mai*	7	(*Hordeum Vulgare* L.) Wheat, barley.
麻 *ma*	7	(*Cannabis sativa*) Hemp. Fibres used for making cloth, rope, etc. Seeds used for food and for making oils. Also medicinal.
芣苡 *fuyi*	7	(*Plantago major* L. var. *asiatica* Dcne.) medicinal plantain.
蒲 *pu*	6	(*Acorus gramineus* Ait.) Grass-leaved sweet flag (but possibly *Typha latifolia* L.) Aquatic.
葭 *jia*	6	A kind of reed.
芑 *qi*	6	(*Sonchus oleraceus* L.).
蓬 *peng*	6	Mugwort (*Artemisia*) found growing sporadically among hemp and used for making lattice or basket-work gates and fences.
茅 *mao*	5	(3 are 白茅) Cogongrass, *Eularia*, and other wild grasses.
蘩 *fan*	5	(*Artemisia vulgaris* L.) Mugwort. May have been eaten.
匏 *pao*	5	A gourd, a calabash.
苓 *ling*	5	A fungus or tuber which is used as a medicinal herb.
葑 *feng*	5	(*Brassica rapa*) The rape-turnip.
稻 *dao*	5	(*Oryza sativa* L.) Rice.
瓠,壺 *hu*	4,2	(*Lagenaria siceraria* Standl.) Bottle gourd, one variety as a vegetable, one for water containers, etc.
薽 *tui*	4	(*Leonurus sibiricus* L.) Motherwort.
梁 *liang*	4	(*Setaria italica* Beauv.) Foxtail millet.
粟 *su*	3	(*Setaria italica* Beauv. Var. *stramineofructa*) Foxtail millet.
芃/芃蘭 *penglan*	3	(*Metaplexis stautoni* R. & S.) Sparrow's ladle.
薺(稊) *ti/yi*	3	The ears of a reed or a kind of barley or millet.
荇 *xing*	3	A type of river grass: water fringe; floating heart.
菜 *cai*	3	Vegetables whose green leaves are used as food.
薿 *zi*	3	A kind of grass.
葵 *kui*	3	(*Malva verticillata* L.) Mallow.
蒿 *hao*	3	(*Artemisia* spp.) Sages and/or wormwoods.
蕨 *jue*	2	Bracken, fernbreak, the root of which is used for food.
蘋(苹) *ping/pin*	2	(*Marsilea quadrifolia* L.) Clover fern; duckweed (aquatic).
茹藘 *rulu*	2	(*Rubia cordiflora*) Chinese madder, used as a red dye.
菲 *fei*	2	A kind of radish.
穋 *lu*	2	Rice.
蔞(婁) *lou*	1	(*Artemisia stelleriana*).
韭 *jiu*	1	(*Allium odorum* L.) Chinese leek. Had religious significance.

[150] Keng Hsuan, "Economic Plants of Ancient North China," 399.

苕 *tiao*		(*Campsis grandiflora* Loisel.) Chinese trumpet-creeper.
諼草 *huancao*	1	(*Hemerocallis flava* L.) Yellow day-lily.
苧 *zhu*	1	(*Boehmeria nivea*) ramie, textile plant .
葍 *fu*	1	(*Phytolacca acinosa* Roxb. var. *esculenta Maxim.*).
藿 *huo*	1	(*Rhynchosia volubilis* Lour.)
薺 *qi*	1	(*Capsella bursa-pastoris* Moench.) Shepherd's purse.
蓍 *shi*	1	(*Achillea sibirica* Ledeb.) Siberian yarrow, possibly eaten or used medicinally.
芍藥 *shaoyao*	1	(*Paeonia lactiflora* Pall.) White peony.
藚 *xu*	1	(*Alisma plantago* L.) Water-plantain (aquatic).
茆 *mao*	1	(*Brasenia schreberi* J.F. Gmel.) Water-shield (aquatic).
藍 *lan*	1	(*Polygonum tinctorium* Lour.) Indigo, a blue dye.
芹 *jin*	1	(*Oenanthe javanica* or *Cryptotaenia canadensis*).
Trees		
桑 *sang*	40	(*Morus alba* L.) Mulberry.
棘 *ji*	22	(*Zizyphus jujuba* Mill.) Jujube, Chinese date.
棗 *zao*	1	(*Zizyphus jujuba* Mill.) Jujube, Chinese date.
松 *song*	11	(*Pinus* spp.) Pines (*P. bungeana, P. armandii, P. tabulaformis*).
柏 *bai, bo*	10	(Cupressaceae)(*Thuja* spp., *Juniperus* spp., *Cupressus, etc.*).
松柏		Keng believes that when used together these two characters refer generally to conifers.[151]
栗 *li*	10	(*Castanea mollissima* Bl.) Chinese chestnut.
楊 *yang*	9	*Liu* and *yang* refer generally to poplar and willow (i.e.,
柳 *liu*	6	*Populus hopeiensis, P. laurifolia, P. simonii, P. tomentosa; Salix matsudana, S. caprea.* Fast growing trees whose branches were used for weaving baskets, etc.
桃 *tao*	9	(*Prunus persica* Batsch.) Peach.
梅 *mei*	8	(*Prunus mume* Sieb. & Zucc.) Plum; Japanese apricot. May also include Common apricot (*xing* 杏) (*Prunus armeniaca*).
棣 *di*	8	Flowering almond tree.
檀 *tan*	7	(*Pteroceltis tatarinowii* Maxim.).
柞 *zuo*	7	Probably (*Quercus* spp.) A type of oak.
杞 *qi*	7	(*Salix sinopurpurea*).
椒 *jiao*	7	(*Zanthoxylum* spp.) Chinese prickly ash.
李 *li*	6	(*Prunus salicina* Lindl.) Chinese plum.
漆 *qi*	6	(*Rhus verniciflua* Stokes) Lacquer.
棣 *di*	6	Possibly (*Kerria* spp.), a deciduous shrub.
榛 *zhen*	6	(*Corylus* spp.) Hazel.
棫 *yu*	5	Thorny shrub with yellow flowers.

[151] Keng Hsuan, "Economic Plants of Ancient North China," 406.

樛 *jiu*	5	Zelkova tree.
栩 *xu*	4	(*Quercus* spp.) A type of oak.
甘棠 *gantang*	4	A peach-like, seedless wild fruit, perhaps crabapple, Wild plum, (杜) Mountain pear or birchleaf pear.
樞 *ou*	2	(*Hemiptelea davidii* Planch.) Spiny shrub with strong wood used for making implements.
椅 *yi*	2	(*Catalpa bungei* C.A. Mey.).
梓 *zi*	2	(*Catalpa ovata* Don.) Chinese catalpa.
栲 *kao*	2	(*Quercus* spp.) A type of oak.
杻 *niu*	2	(*Quercus* spp.) A type of oak.
櫟 *li*	1	(*Quercus* spp.) A type of oak.
檖 *sui*	1	Wild pear tree.
駮 *bo*	1	Spindle tree.
檉 *cheng*	1	(*Tamarix* spp.) Tamarisks. (i.e., *T. chinensis*, *T. pentandra*).
椐 *ju*	1	A type of wild mulberry used for making walking sticks.
榆 *yu*	1	(*Ulmus* spp.) Elm.
枸 *ju*	1	(*Hovenia dulcis* Thunb.) Chinese raisin tree.
柘 *zhe*	1	(*Cudrania* sp.) Leaves used for feeding silk worms, wood contains yellow dye.
樗 *chu*	1	(*Ailanthus altissima* Swingle) Tree of heaven.
竹 *zhu*	7	Bamboo.
薪 *xin*	20	Firewood.

By far the most common plants are agricultural: mulberry, millet, chestnut, peach, jujube, kudzu vine, etc. The prominence of mulberry shows the importance of silk in this period, although a metaphorical association with femininity may also account for its popularity. Many of the others were wild plants, but the division between domesticates and wild species was probably vague in many cases. The list shows clearly that people were aware of a variety of plants, and the relative importance to their lives can to some degree be inferred from the number of times each is mentioned.

Thus the *Odes* provide a vague but important source for the human ecology of the Yellow River area at the beginning of the historical period. The difference between this list and the species discussed in the first chapter shows that physical human environments are considerably different than wild ecosystems, and emphasises the difference in the perception of the environment between a person depending on the landscape to feed themself and an ecologist who perceives the

environment as a study object. The plants which dominated the pollen studies are all apparent, but none seems dominant, although pine and oak do seem to be the most common tree genera. The presence of several *Artemisia* species corresponds with the abundance of that genus in the pollen record.

Although it was an agricultural society, the variety of species and the absence of firm divisions between cultivated and wild plants suggests an economy in which the gathering of wild plants remained important. The prominence of hunting and fishing in the *Odes* show that these were also significant food sources. In the coming centuries, these characteristics were to disappear in the population centres, but the development of markets meant that plants and animals in distant hinterlands became commodities to be traded and taxed, as will be discussed below.

Millet was the staple crop across the region. The two kinds of broom-corn millet (*Panicum miliaceum*), *shu* 黍 (var. *glutinosum*) and *ji* 稷 (var. *effusum*) occur a combined total of 52 times in the *Odes*, while foxtail millet (*Setaria italica*), *liang* 粱 and *su* 粟 only occur seven times.[152] The fact that these plants are all called millet in English, divided into two species in Latin and three in Chinese is a good example of the problems faced when attempting to interpret written descriptions of plants across languages. Despite the dominance of broom-corn millet in the *Odes*, foxtail millet has been excavated at Cishan and Yangshao sites, which suggests that it was the most widely distributed, and the oracle bones do not mention *ji* 稷 at all.[153]

Wheat and barley, as well as sheep/goats, cattle, and horses had already arrived from the west of the continent and been adopted. The term *yang* 羊 refers to both goats and sheep, which were apparently considered the same kind of animal. Other species arrived during the period of this study, including the broad bean *can dou* 蠶豆 (*Vicia faba*) and the pea *wan dou* 豌豆 (*Pisum sativum*), both of which were also called *hu dou* 胡豆. New species that arrived during the Han include watermelon (*Citrullus lanatus*), cucumber (*Cucumis sativus*), shallot (*Allium sp.*), garlic (*Allium sativum*),

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[152] Li Hui-lin, "The Domestication of Plants in China," in *The Origins of Chinese Civilization*, ed. Keightley (Berkeley: University of California Press, 1983), 29-30.
[153] David Keightley, "Ping-ti Ho and the Origins of Chinese Civilization," *Harvard Journal of Asiatic Studies* 37 (1977), 392-93.

sesame (*Sesamum indicum*), grape (*Vitis vinifera*) and alfalfa (*Medicago sativa*).[154] Although wheat and barley arrived in China in the late Neolithic, they only became the dominant crop of north China in modern times.[155]

Rice *dao* 稻 (*Oryza sativa*) had long been a main grain crop farther south, but was not as suited to the drier north. Nonetheless, it was grown in wetter areas, and Ode 229 "Bai hua" 白華 mentions watered rice paddies (浸彼稻田), evidence for early irrigation, the technology of which was probably more advanced in the south where rice was the staple crop.

Li Hui-lin[156] lists the following vegetables as domesticates of North China: mallow *kui* 葵 (*Malva verticillata*), Chinese cabbage *ganlan* 甘藍(*Brassica campestris*), radish *fei* 菲 (*Raphanus sativus*), turnip *feng* 葑 (*Brassica rapa*), Chinese chive *qiu* 韭 (*Allium odorum*), Welsh onion *cong* 葱 (*Allium fistulosum*), scallion *xie* 薤 (*Allium bakeri*), melon *gua* 瓜 (*Cucumis melo*), the blue dye Chinese indigo *liaolan* 蓼藍 (*Polygonum tinctorium*), and the red dye Chinese madder (*Rubia cordiflora*) which is now called *qian* 茜, but was referred to as *rulu* 茹蘆 in *Odes* 89 "Che men zhi shan" 車門之墠 and 93 "Chu qi dong men" 出其東門. According to Bray, soybeans *shu* 叔 (*Glycine max*) were somewhat novel in 700 B.C. but were common in the north three centuries later.[157] Hemp *ma* 麻 (*Cannabis sativa*) was widely used for fibres, oil, and medicine.

Mallow *kui* 葵 (*Malva verticillata* L.) was one of the main vegetable crops in early times, but was gradually replaced by other crops. Likewise, common smartweed *liao* 蓼 (*Polygonum hydropiper*), wild lettuce *ju* 柜 (*Lactuca denticulata*) and cocklebur *juaner* 卷耳(*Xanthium strumarium*) are mentioned in the *Shi jing* as food plants, but were all eventually abandoned, and are now considered weeds, although still edible in times of famine.

The agriculture of North China includes many indigenously domesticated and unusually nutritious types of fruit and nut trees, which, along with the importance of mulberry *sang* 桑(*Morus nigra*) and lacquer *qi* 漆 (*Rhus verniciflua*),

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[154] Hsu Cho-yun, *Han Agriculture*, 89.
[155] Bray, *Science and Civilisation* 6.2, broad bean, 516; wheat and barley, 459-64.
[156] Most of the information in the following three paragraphs comes from: Li Hui-lin, "The Domestication of Plants in China," 21-63.
[157] Bray, *Science and Civilisation* 6.2, 511-12.

explains why trees were such an important part of Chinese agriculture. Many of these trees are mentioned in the *Odes* and later classics, the most common being jujube *zhi* 棘 or *zao* 棗 (*Zizyphus jujuba*), peach *tao* 桃 (*Prunus persica*), apricot *xing* 杏 (*Prunus armeniaca*), persimmon *shi* 柿 (*Diospyros kaki*), chestnut *li* 栗 (*Castanea mollissima*), and hazelnut *zhen* 榛 (*Corylus heterophylla*). The *Huainanzi* describes arboriculturers irrigating and fertilising their trees 樹木者,灌以濼水,疇以肥壤.[158]

The phrase *geng jia shu yi* 耕稼樹藝 (the arts of tillage, harvesting and planting [trees]) appears 18 times in the *Mozi* and the four character phrase *jia se shu yi* 稼穡樹藝 (the arts of sowing grain, harvesting and planting [trees]) is found in the *Zhou li* and *Mencius*. Because one meaning of the character *shu* 樹 is simply "to plant," these phrases could be considered to refer to growing grains, but *shu* also means 'tree,' which suggests that the word refers to arboriculture. The *Shuowen jiezi* 說文解字 defines *shu* as "a general name for growing plants" 生植之總名,[159] but also defines it as a combination of the characters for "stand" and "tree". The *Hanyu da cidian* 漢語大詞典 also defines *shu* without the wood radical as the original character.[160] The addition of the tree radical, rather than a grain radical, suggests that the growing being done was that of trees, and that arboriculture was considered a fundamental part of agriculture.

Other fruit trees include the Chinese plum *li* 李 (*Prunus salicina* or *Prunus trifolia*), Chinese cherry *yingtao* 櫻桃 (*Prunus pseudocerasus*), sand pear *shali* 沙梨 (*Pyrus serotina*), white pear *baili* 百梨 (*Pyrus bretschneideri*), Chinese apple *linqin* 林檎 (*Malus asiatica*), Chinese crab apple *haitang* 海棠 (*Malus spectabilis*), Chinese hawthorne *shanzha* 山楂 (*Crataegus pinnatifida*), large hawthorn *shanli hong* 山里紅 (*Crataegus pinnatifida* var. *major*), Chinese quince *mugua* 木瓜 (*Chaenomeles sinensis*), Japanese apricot *mei* 梅 (*Prunus mume*), Chinese prickly ash *jiao* 椒 (*Zanthoxylum simulans*), and the raisin tree *zhiju* 枳椇 (*Hovenia dulcis*).[161] Even intensively farmed areas would have had lots of scattered trees and orchards, and any area too steep for tilling could have

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158 *Huainanzi* (*Zhuzi jicheng* vol.7), 2.31; LeBlanc, *Huainan zi*, 79.

159 Xu Shen 許慎, *Shuowen jiezi xinding* 說文解字新訂 (Beijing: Zhonghua, 2002), 372.

160 *Hanyu da cidian* 漢語大詞典 (3 volume small-print edition 縮印本) (Shanghai: Hanyu da cidian, 2002), 2696.

161 Li Hui-Lin, "The Domestication of Plants in China," 21-63.

been planted with trees. Nuts, fruit species which dry well, and other transportable tree products could potentially have been grown in large orchards far from population centres, to which they were later transported and sold. Chapter 91 of the *Han shu* mentions jujubes, chestnuts, timber, bamboo, catalpa, hemp, jujubes and lacquer as products with which one could make large profits, but does not specify whether or not these were produced in plantations and on large estates, or whether merchants just bought from small scale farmers and sold in the cities.[162] Likely both.

In addition to the above-mentioned trees, there were probably also fast growing species of trees planted for timber and firewood, likely poplar and pine, and high quality timber grown for specific uses. A Qin dynasty carving depicts a crew planting trees along the side of a newly-built road.[163] Throughout this period, the forests south and southwest of the Yellow River region were logged for high quality timber, but we can assume that this wood was expensive and the common people used wood grown closer to home. As with the development fish farming, the transition from logging wild forest to planting and maintaining trees for lumber was probably a gradual one. The highly developed silviculture of north China noted by W.C. Lowdermilk in the 1930s probably had its genesis in the overpopulation and lack of trees during the Warring States period.[164]

Few sources bother to give names of what plants were considered weeds, although the *Lüshi chunqiu* describes 藜 *li* (*Chenopodium*), 莠 *you* (Green Bristlegrass), and 蓬蒿 *penghao* (a kind of *Artemisia*) as weeds.[165] Apart from the silkworm (*Bombyx mori*), insects were not raised intentionally. However, the opening of land and planting of grains are beneficial for some kinds of insects, such as *ming* 螟, mentioned in the *Lüshi chunqiu* as a common parasite.[166] It is also mentioned in *Ode*

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[162] Nancy Lee Swann, *Food and Money in Ancient China* (Princeton: Princeton University Press, 1950), 432-36; *Han shu* 漢書 (Beijing: Zhonghua, 1975) 91.3686-89.

[163] Peng Wei 彭衛, "Wenwu suo jian Qin dai Guanzhong de shumu" 文物所見秦代關中的樹木 (What can be seen from cultural relics concerning Qin dynasty silviculture 'Within the Passes') *Nongye kaogu* 1987.1, 227.

[164] W.C. Lowdermilk, *Forestry in Denuded China* (Philadelphia: American Academy of Political and Social Science, 1930).

[165] Jeffrey Riegel & John Knoblock, *The Annals of Lü Buwei: A Complete Translation and Study* (Stanford: Stanford University Press. 2000), 63 ("Meng chun" 孟春 1.1).

[166] Riegel & Knoblock, tr., *The Annals of Lü Buwei*, 79 ("Zhong chun" 仲春 2.1).

196 "Xiao wan" 小宛 as *mingling* 螟蛉, which may be the corn earworm (*Heliothis zea*). *Ode* 5 "Zhong si" 螽斯 seems to celebrate *zhong* 螽, which are grasshoppers or katydids or locusts, although the praise of the insect may be ironic.

Improvements in technology were more important than plant species in the intensification of agriculture and population in this period. The adoption of iron implements, as described above, must have greatly increased the power of people to alter the earth and its vegetation. The trace harness (4th century B.C.) and the collar harness, invented in the following centuries, greatly improved the efficiency of horses, allowing them to pull heavier loads, and to plough more easily. The seed drill, invented sometime in the Eastern Han, made the sowing of grain both quicker and more efficient.[167]

The intensification of agriculture also involved an increased government presence in agricultural production. The government may have established hereditary officials in charge of improving production as early as the Shang or Western Zhou.[168] The writers of the early period all acknowledge agriculture as the basis of the state economy, and often emphasise the importance of increasing production. Thus, although few of the details are known, it is clear that this period saw an intensification of agricultural production in traditional farming areas and a constant increase in cultivated land. Francesca Bray concludes that "by the Warring States period several states appear to have been so thickly populated that cultivation was continuous and fallowing was no longer practiced, while double-cropping was even found in some areas. This was the time when the use of green manures and other fertilisers first became common, large-scale irrigation works were undertaken, and a free market in land grew up."[169] Farmers moving north and south from the central agricultural regions brought with them a far more intensive agriculture than existed elsewhere. However, although intensive agriculture could be practiced

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[167] Joseph Needham & Wang Ling, *Science and Civilisation in China* 4.2, "Mechanical Engineering" (Cambridge: Cambridge University Press, 1965), 303-33.
[168] Fan Zhimin 樊志民, "Zhanguo Qin Han nongguan zhidu yanjiu" 戰國秦漢農官制研究 (The Agricultural Official System in the Warring States, Qin and Han), *Shixue yuekan* 2003.5, 13-20.
[169] Bray, *Science and Civilisation* 6.2, 162.

throughout the south, it was limited in the north and west by aridity. In these areas the herding of sheep, goats, horses and cattle remained a common way of life.

Herding and Livestock

Herding, usually somewhat nomadic, is a common subsistence strategy on lands that are too dry for agriculture but vegetated enough to support herds of grazers. Farming in China was never as dependent on livestock as was western farming, but the regions to the west and north of the agricultural regions were ideal for herding. It is clear from textual records of nomadic people living in the Yellow River valley that herding was practiced throughout the region in the Zhou period. *Ode* 236 "Da ming" 大明 describes a broad plain used for herding (牧野洋洋) which, because the poem describes the Zhou conquest of Shang and Zhou, we can assume it was in the lower Wei valley or the Yellow River valley to the east, all of which was to become dense farmland.

Although cattle, sheep and goats do not necessarily have very different eating habits than the native grazers, large herds of livestock can nonetheless completely alter the ecology of an area, destroying native vegetation, replacing the native grazers, and maintaining a grass-dominated landscape Sheep and goats, especially, are capable of eating a wide variety of plants, and can denude marginal land, causing desertification. We know from the *Mencius* passage quoted on the first page that overgrazing was a problem near human settlements. However there is no textual record of environmental change in the northern areas during the period of this study.

Ode 190, "Wu yang" 無羊, describes a herd of 90 cattle and 300 sheep/goats grazing and being herded. The same poem mentions herders coming back with the animals they have hunted, a reminder that the divisions adopted in this thesis between hunters, farmers, and herders should not be considered to represent completely separate groups of people, but rather useful categories of analysis. There was no firm divide between farming people with livestock and herding people with gardens, and anyone could go fishing, gathering wild plants, at least until wild animals became scarce and governments began regulating the products of the wilds.

Herding was probably the lifestyle of many of the Rong, Yi, and other outside peoples frequently mentioned in early texts. Sima Qian mentions that in Yang and Pingyang in the Fen river valley, "the inhabitants have mingled with the barbarians, and their customs are by no means uniform" 其民羯狄不均.[170] This process is shown also in a *Zuo zhuan* passage (discussed below) in which the Rong leader describes how his people first settled down and cleared land, a process which eventually resulted in their assimilation by the dominant, sedentary culture. By the Han, the Rong and Di, once enemies of the central states, had been incorporated into the Han empire: "To the north [of the capital] are the herds of the Rong and Di, which are one of the riches of the world" 北有戎翟之畜， 畜牧為天下饒.[171]

Shi ji 129 also says that the area "north of Longmen and Jieshi is rich in horses, cattle, sheep, felt, furs, tendons, and horns" 龍門碣石北多馬牛羊旃裘筋角.[172] Longmen is in the area where the Fen River enters the Yellow and Jieshi is to the northeast of present-day Tianjin. Although these areas probably had some agriculture, large areas still supported herds of cattle, sheep, goats, and horses. The horses of the imperial armies, especially under Han emperor Wu would have occupied extensive areas of the north and west. There must also have been some land set aside in more populated areas to feed horses, most notably imperial lands, and a market in horse-feed in the cities.

Apart from the herded animals, dogs, chickens and pigs fit best into a densely populated agricultural regime. Although the dog declined in importance, the chicken and pig have been an essential part of village life from the early Neolithic until the present. Cattle declined in importance in the fertile areas of the Yellow River region due to the spread of intensive agriculture, as did sheep/goats, but the *Mencius* passage which opened this thesis reminds us that they were still grazing the marginal land surrounding the farming areas. Nonetheless, the growing population and the government emphasis on grain production gradually reduced the numbers of

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[170] Sima Qian, *Shi ji* 史記 (Beijing: Zhonghua, 1972) 128.3263; Burton Watson, tr., *Records of the Grand Historian: Han II* (New York: Columbia University Press, 1993), 442.
[171] Sima Qian, *Shi ji* 128.3262; Watson, *Records of the Grand Historian: Han* II, 441.
[172] Sima Qian, *Shi ji* 128.3254; Watson, *Records of the Grand Historian: Han* II, 434.

livestock in the farming areas. This transition probably reduced the overall amount of meat in people's diets, and what meat they did eat was more likely pork and chicken. However, along with improvements in transportation and the growth of a widespread market economy, the people in the valleys and plains were increasingly able to buy the products of herded animals from the north, and thus to affect the environment of distant semi-arid regions.

By the early Han, grazing land in the crowded agricultural areas was so scarce that people had to pull ploughs. While describing agricultural reforms around 100 B.C. the *Han shu* explains that, despite the absence of oxen, the policy of teaching people to pull ploughs nonetheless resulted in the opening of much new agricultural land 民或苦少牛亡以趨澤,故平都令光教過以人輓犁…田多墾闢.[173] Although it was probably considered temporary at the time, replacing oxen with people reduced the amount of land needed for grazing, thus allowing even more land to be cultivated. By reducing both non-cultivated land and potential famine food (oxen), the increasing population further reduced its own ecological safety net, and had to work harder to maintain itself at the same productivity level as before. Where a drought year would once have meant hunger and foraging in uncultivated lands for food, the replacement of these lands with farm fields left the people at the mercy of a few grain crops for survival. The simpler the ecosystem the more thoroughly it can fail.

Opening New Land

The clearance of land for agriculture is usually a practice whereby existing farmland is extended into adjacent previously unfarmed land, but can also occur during colonisation of new areas. The earliest written evidence for a group of people opening new land comes from the Shang oracle bones, which show that the king concerned himself with clearing new land and developing new fields, and appointed officials to oversee it. There was a close connection between royal hunts, military

[173] Swann, *Food and Money in Ancient China,* 189; *Han Shu* 24.1137.

activity, and the colonisation of new land.[174] The clearance of new land is also mentioned in *Odes* 227 "Shu miao" 黍苗, 237 "Mian" 綿, 241 "Huang yi" 皇矣 and 250 "Gong liu" 公劉. *Ode* 241 celebrates the beginnings of the Zhou state, the period in which the Zhou moved into the Wei river valley and cleared land for farming:

> They cleared them away, they removed them, the standing dead trees, the (fallen) dead trees; they dressed them, leveled them, the bushy clumps, the *li* trees; they opened them up, they cleared them, the tamarisks, the *ju* trees; they cleared them away, they cut them the wild mulberry trees, the *zhe* trees...God examined the mountains: oaks were thinned, the pines and cypresses were cleared; God made a state" 作之屏之，其菑其翳。脩之平之，其灌其栵。啓之辟之，其檉其椐。攘之剔之，其檿其柘。帝遷明德，串夷載路。天子厥配，受命既固。帝省其山：柞棫斯拔，松柏斯兌。帝作邦作對.[175]

Ode 250 also celebrates the move of the Zhou people into the Wei valley. It describes the preparation, the voyage, the duke surveying the land and choosing a site in the Wei valley, and the Zhou people building their new homes. It then describes how they measured the land and cleared it for farming, and how the area became densely populated.

Although most accounts of land clearance describe clearing dry land by cutting, the *Lüshi chunqiu*'s prohibition for the second month of spring provide an idea of some other methods: "do not dry up stream and marshes, do not drain dammed-up ponds, and do not burn mountain forests" 無竭川澤,無漉陂池,無焚山林.[176] There are few accounts of forest fires in early texts, but the banning of fires in the spring, which was presumably before the rains and thus a very dry time of year, must have been intended to prevent fires getting out of control, as suggested by an account in the *Han Feizi* of a fire set in a *ze* (wetland or wasteland) that got out of control.[177] The ban may also have been intended to curb swidden agriculture.

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[174] David N. Keightley, "The Shang: China's First Historical Dynasty," in *The Cambridge History of Ancient China*, ed. Loewe & Shaughnessy, 279-80.

[175] Bernhard Karlgren, *The Book of Odes* (Stockholm: Museum of Far Eastern Antiquities, 1950), 194; Ruan Yuan 阮元, *Shisan jing zhushu fujiao kanji* 十三經注疏：附校勘記 (The thirteen classics with commentary: revised and corrected) (Beijing: Zhonghua, 1980), 519.

[176] Riegel & Knoblock, tr., *The Annals of Lü Buwei*, 79 ("Zhong chun" 仲春 2.1).

[177] 魯人燒積澤, 天北風, 火南倚, 恐燒國. *Han Feizi* 韓非子 (*Zhuzi jicheng* vol. 5), 30.168; W.K. Liao, tr., *The Complete Works of Han Fei Tzu: A Classic of Chinese Political Science* vol. 1 (London: Probsthain, 1959), 296.

Wetlands are important for a variety of species. Draining them for agriculture is an important step in the replacement of a wild ecosystem with a human one and it is important to note that this prohibition applied only during a certain season. As with fires, it was presumably legal to drain wetlands at other times of year.

Apart from the removal of unwanted vegetation or water, *Ode* 237 "Mian" 綿 celebrates the removal of the *Yi* 夷 people from the Wei valley, showing that humans were also displaced. When insulted by the duke of Jin, the leader of the Rong people defended himself by arguing that, although the Rong speak a different language and wear different clothes, they have always been loyal to Jin. Duke Hui 惠 of Qin (r.391-378 B.C.) "gave us fields in the Southern borders, where the jackals lived and the wolves howled. We, the Rong people, cleared the thorny thickets, chased away the foxes and wolves" 賜我南鄙之田，狐狸所居，豺狼所嗥. 我諸戎除荊棘，驅其狐狸豺狼.[178] The clearance of land is cited to show that they are civilised people. The Rong, who may have been herders, were forced from their homeland by an expanding Qin, and were settled and gradually assimilated.

A thorough examination of the environmental history of the period should consider the differences in land use between various culture groups and the history of the relations between those groups.[179] This applies especially to the spread of agriculturists and removal or assimilation of herders, hunters and fishers, but also to the contributions of these people, during their assimilation, to what became China. These relations must be studied by archaeological, linguistic, and textual methods. The domination of certain groups over others (identifiable by cultural assemblages) began before the earliest texts were written. The Yellow River region was once inhabited by a variety of peoples, and the creation of the present more homogeneous culture group involved significant intermingling of cultures. Although the Chinese written language came from a specific area and culture group, nonetheless many

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[178] Hu Zhihui, tr., *Zuo zhuan* 左傳 (Bilingual Edition) (Changsha: Hunan Remin, 1996), 762-63 (Xiang 14); Ruan Yuan, *Shisan jing*, 1956.

[179] The differences between indigenous land use and that of colonisers is a common theme of environmental history in the Americas and other colonised areas, but less so in Eurasia, where the colonisation process has not been so sudden or so obvious. The best such study for China is Mark Elvin's study of the Miao in *The Retreat of the Elephants*, 216-72.

important technologies and customs (including those concerning agriculture and husbandry) came from people other than the people who left written records. Just as Chinese archaeologists have begun to emphasise the different cultures during the Neolithic, the histories of the various culture groups should be traced as long as possible to see whether their assimilation was accompanied by a change in environmental use. The exploitation of the environment is often accompanied by the exploitation of people.

One area that seems to have been widely colonised and cleared in this period is the North China Plain. The ruler of Zheng recounts in the *Zuo zhuan* that "formerly, our ruler Duke Huan and these Shang people all came from the Zhou realm. Thus they were associated in clearing this piece of wild land, cutting away the mugwort, sage, *Chenopodium*, and *Rhynchosia*" 昔我先君桓公,與商人皆出自周,庸次比耦以艾殺此地,斬之蓬蒿藜藿而共處之.[180] This passage shows that they were colonising land (eastern Henan) just south of the former Shang heartland with some people who, coincidentally or not, were called the Shang people. The two first species which they were clearing are both *Artemisia*, the third (*li* 藜) is Chenopodium, although it is possible that the latter two (*lihuo* 藜藿) are just a term for rough non-arboreal vegetation. This passage is very significant in light of the discussion in the first chapter, and suggests that the dominance of those two pollen types in the cores taken from the plains may accurately represent actual vegetation. Whether or not the passage describes actual ecosystems, it is evidence that in the Warring States the pre-clearance vegetation of the plains was not understood as a forest.

The same is suggested by a passage in the *Discourses on Salt and Iron*, which, in a discussion of a period many centuries earlier, recounts that "formerly, when Duke Tai was enfeoffed at Ying Qiu [probably Linzi, capital of Qi], he had to clear away the grass and Chenopodium/weeds before settling down." 希太公封於营丘辟草莢而居焉.[181] Again, the word for Chenopodium (*jia* 莢), may also mean simply weeds,

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[180] Hu Zhihui, tr., *Zuo zhuan*, 1214-17, mod. (Zheng 16); Ruan Yuan, *Shisan jing*, 2080.

[181] *Yantie lun jiaozhu* 鹽鐵論校注, ed. Wang Liqi 王利器 (Beijing: Zhonghua, 1992), 14.178; Esson M. Gale, tr., *Discourses on Salt and Iron: A Debate on State Control of Commerce and Industry in Ancient China* (Leiden: Brill, 1931), 85.

although it suggests that the Chenopodium were the most common weeds. These passages are the only two descriptions I have found of the colonisation of the eastern plains, and both mention the same species whose abundance seems so anomalous on the pollen diagrams. They are also significant as evidence that the Western and early Eastern Zhou saw the clearing of the plain. Needham notes that the "Yu gong" describes the soil between the Ji and the Yellow River as black, which tells us that in that period the land had recently been cleared and still had forest humus in the soil.[182] The "Yu gong" also says that the people came out of the uplands to live in the plains once Yu had regulated the waterways, which suggests drainage of soggy land for agriculture. The alluvial soil of the plain would have been harder than the upland loess, and thus the inventions of iron tools and ox- or buffalo-drawn ploughs were more important in that area than on the Loess Plateau.

Mozi encouraged rulers to promote clearing grassland and trees.[183] The *Book of Lord Shang* likewise argues that "if the population exceeds the territory, then one should pay attention to opening up new land; if the territory exceeds the population, then one should set about calling in colonists" 有地狹而民眾者,民勝其地.地廣而民少者,地勝其民.民勝其地務開.地胜其民者事徠.[184] Both options involve intensified use of the land for farming. The work also includes an ideal land-use ratio: "A tenth should be occupied by mountains and hills, a tenth by valleys, dales, and running water, a tenth by cities, towns, and highways, two tenths by barren fields, and four-tenths by fertile fields" 山陵處什一,藪澤處什一,勃谿谷流水處什一,都邑蹊道處什一,惡田處什二,良田處什四.[185] Despite the emphasis on agricultural land, the author recognises the importance of wilder land to provide other resources.

The practice of sending people to colonise new land was taken to new levels by the First Emperor, who moved tens of thousands of people. Although they cannot be considered accurate figures, Sima Qian tells us that the emperor sent 30,000 households to Langya in the south coastal area of Shandong, groups of

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[182] Needham, *Science and Civilisation* 6.1, 96.

[183] 辟草木. *Mozi* 墨子 (*Zhuzi jicheng* vol.4), 6.108.

[184] *Shangjun shu* 商君書 (*Zhuzi jicheng* vol.5), 6.12; J.J.L. Duyvendak, tr., *The Book of Lord Shang* (Ware: Wordsworth Classics, 1998), 172.

[185] *Shangjun shu* (*Zhuzi jicheng* vol.5), 7.16; *The Book of Lord Shang*, 201.

lawbreakers south to colonise parts of Guangxi, Vietnam, the Guangzhou area, as well as the northern frontier. He also conquered the Ordos, and established military colonies along the north- and northeast-flowing section of the Yellow River, and sent 30,000 to the central Ordos area (Yuzhong 榆中) and the north bend of the river (Beihai 北海). He also moved 50,000 households to Yunyang 雲陽, which is either the site of the Qin summer palace, or a region east of present-day Nanjing.[186]

The northwest was further developed under Han emperor Wu, especially after the peace treaty with the Xiongnu in 127 B.C. Large irrigation works were built along the Yellow River in Shuofang 朔方 and Xihe 西河, Inner Mongolia, and Hexi 河西 and Jiuquan 酒泉, Gansu.[187] The *Han shu* reports that in 119 B.C., following a severe flood of the Yellow River on the North China Plain, over 700,000 people were moved to the northwest.[188] If this number is anywhere near accurate it must have represented a huge population increase in areas of the upper Yellow River valley in modern Gansu and Ningxia. The only way such an arid region could support a large population was with irrigation from the Yellow River.

Aside from large-scale organised migrations, people were always migrating towards less densely populated areas. During the Warring States and early imperial periods, intensive agriculture spread southwards and eastwards from the Yellow and Wei river regions into eastern Shandong, then into the Huai and Yangzi areas and Sichuan. This did not necessarily include the spread of crops or technologies, but rather the spread of political pressures and economic opportunities encouraging increases in agricultural production, as well as the constant exodus of surplus population from the Yellow River region. In contrast, the northwestern agricultural frontier is directly related with rainfall, and thus only areas which could be irrigated, generally by the Yellow River, could support large populations.

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[186] Sima Qian, *Shi ji* 6.244-61; Burton Watson, tr., *Records of the Grand Historian: Qin* (New York: Columbia University Press, 1993), 47-59.
[187] Sima Qian, *Shi ji* 29.1414; Watson, *Records of the Grand Historian: Han* II, 59.

Deforestation

Several early texts mention that much of the North China Plain was lacking in timber. It is difficult to tell whether there had ever been many timber-quality trees in the north, but it is clear that, by the late Warring States, the south was the source of good wood. The *Zhanguo ce* and the *Mozi* include a passage in which Mozi attempts to convince the ruler of Chu not to attack Song:

> Jing [Chu] has Yunmeng, filled with buffalo, rhinoceros, buffalo, elaphures, and deer, and the Yangzi and the Han are full of fish, tortoise, giant turtles and alligators – enough to feed the empire. Song, on the other hand, is known as a land that even lacks pheasants, rabbits, and foxes. So this is like exchanging meat and millet for dregs and lees. Jing has tall pines and beautiful catalpa, *pien-jan* and *yü-chang* trees while Song has no timber 荆有雲夢，犀兕麋鹿滿之，江漢之魚鼈黿爲天下富。宋所爲無雉兔狐狸者也，此猶粱肉之與糠糟也。荆有長松文梓，楩柟豫章，宋無長木.[189]

Sima Qian likewise cites Zou, Lu, Song, Liang, and eastern Chu as lacking timber.[190]

The *Discourses on Salt and Iron* make it clear that the middle and lower Yellow River region was poor in resources, but that areas to the south were still forested:

> Shu 蜀 and Long 隴 [Sichuan, southeastern Gansu and southwestern Shaanxi] have famous and precious forests. The supply of bamboo in Wu 吳 and Yue 越 [lower Yangzi area], and the timber in Sui 隨 and Tang 唐 [both in north-central modern Hubei] is more than can be used while in Cao 曹, Wei 衛, Liang 梁 and Song 宋 [northern Henan and western Shandong] they are forced to use coffins over again for the dead. The fish of the regions of the great river and the globe fish of Lai 萊 [northern Shandong peninsula] and Huang 黃 [southern Henan/northern Hubei] are too many for local consumption, while in Zou 鄒, Lu 魯, Zhou 周 and Han 韓 [Henan and Shandong Yellow River region] they have only vegetable fare 蜀,隴有名材之林…今吳,越南之竹,隋,唐之材,不可勝用,而曹，衛,梁,宋,材棺轉尸;江,湖之魚;萊,黃之鮐,不可勝食,而鄒魯周韓,藜霍蔬食. [191]

Sima Qian also tells us that the timber for the construction of the Qin First Emperor's tomb came from the south. "Stone was quarried in the northern hills and

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[188] Swann, *Food and Money in Ancient China*, 263-64; *Han shu* 24.1162.

[189] J.J. Crump, *Chan-kuo ts'e* (Ann Arbor: Center for Chinese Studies, The University of Michigan, 1996), 563; *Zhanguo ce* 戰國策(Hong Kong: Shangwu yinshu guan, 1962), 279; Also in *Mozi* (*Zhuzi jicheng* vol. 4), 13.294.

[190] Sima Qian, *Shi ji* 129.3266; Watson, *Records of the Grand Historian: Han* II, 444.

[191] *Yantie lun jiaozhu*, ed. Wang Liqi, 3.42; Gale, *Discourses on Salt and Iron*, 20.

timber transported from the regions of Shu 蜀 [Sichuan] and Jing 荆 [Central Hubei], all being brought to the site" 發北山石椁,乃寫蜀,荆地財皆至.[192]

The reasons for this scarcity are made clear in a passage from the *Huainanzi*, which lists the various misuses of fire: cooking, hunting by burning the forest, smelting metal, and making charcoal from wood and ashes from grasses. This passage is also notable for describing the barren ground and criticising the blocking of the sun's light by the smoke and the destruction of the earth's resources.[193] Although the expression "burning the forest to hunt" became an expression indicating any self-defeating activity, the critical tone of this passage suggests that the phrase is being used literally, and that hunting was actually done with fire.

Luckily, we have a few sources that describe contemporary logging practices. *Ode* 112 "Fa tan" 伐檀 is usually assumed to be a lumberman's work song.[194] It discusses felling *tan* 檀 trees, making them into spokes and wheels. Its lyrics critique a lazy lord, and give the impression that logging was one form of corvée labour at the time. In his *Xin yu*, Jia Yi tells us that the *piannan* 楩柟 and *yuzhang* 豫章 trees are the most valuable, and describes how trees are cut in the mountains and floated down to metropolitan areas. He goes on to describe the trees of the natural forest as being wasted wood unless cut and used by people "When the *piannan* is growing in its native place it possesses less value than a drying willow" 處地楩楠賤於枯楊.[195] Although this is a metaphor for unused talent, he must have considered it a relevant example for it to hold rhetorical weight. Cutting remote trees and floating them" downstream was a common practice in Canada, and Jia Yi's belief that uncut trees are wasted wood also resembles that of early Canadian loggers.

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[192] Sima Qian, *Shi ji* 6.256; Watson, *Records of the Grand Historian: Qin*, 56.

[193] 野莽白素,不得其時.上掩天光,下殄地財. *Huainanzi* (*Zhuzi jicheng* vol.7), 8.122; Wagner, *The State and the Iron Industry in Han China*, 62.

[194] Ode 165 "Fa mu" 伐木 is also a lumbering song, and Odes 300 "Bi gong" 閟宮 and 305 殷武 "Yin wu" also mention logging.

[195] *Xin yu* 新語 (*Zhuzi jicheng* vol. 7), 7.11-12; *A Chinese Mirror for Magistrates: The* Hsin-yü *of Lu Chia* (Canberra: Australian National University, 1988), 101-4.

Huainanzi chapter 18 describes people who cut trees in the winter and in the spring float them down the river and sell them.[196] Although income from this region (Wei 魏?) had tripled, the text says that the ruler considered it harmful since the winter should be a time to relax rather than because of wastage of wood.

Another major use of wood was for burning, and the necessity for fuel would have kept a strain on the forests surrounding all populated areas. Firewood must have been one of the most important of the frequently mentioned products of the mountains, marshes, forests, etc., as suggested by *Ode* 218 "Che xia" 車舝 "I ascend that lofty ridge, And split the branches of the oaks for firewood" 陟彼高岡、析其柞薪.[197] When one imagines a densely populated farming area with little wooded land it becomes easy to understand the importance with which early thinkers viewed regulating wood.

The *Huainanzi* chapter 8 mentions the impact of metal production on forests.[198] Although the impact would be felt only in the vicinity of smelters, unlike the ubiquitous scrounging for firewood, it would nonetheless be immense locally. The need for wood was so large that smelters and salt makers established themselves in remote areas where they had little competition for the forest. The *Discourses on Salt and Iron* notes that "the places where salt is crystallised and iron smelted are in most cases in mountains and on rivers near to iron and (char)coal." 鹽冶之處，大（敖>校）皆依山川,近鐵炭.[199] This may refer to coal or charcoal. If the former, it would be an early usage of fossil fuels, but charcoal is more likely.[200]

The cutting of forests eliminated the habitat of various animals, and can probably be considered at least as important as overhunting in the gradual elimination of wild animals from the Yellow River region.

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196 *Huainanzi* (*Zhuzi jicheng* vol.7), 18. 314; "En hiver, les habitants de ces régions abattent des arbres et les entassent. Au printemps, par le flottage des bois, ils les transportent pour les vendre," LeBlanc, *Huainan zi*, 352.

197 *Shi jing*, (Shandong Friendship Press), 627; Ruan Yuan, *Shisan jing* 1.482.

198 See Joseph Needham, Wang Ling, & Lu Gwei-Djen, *Science and Civilisation in China* 4.3, "Civil Engineering and Nautics" (Cambridge: Cambridge University Press, 1971), 245.

199 *Yantie lun jiaozhu*, ed. Wang Liqi, 5.68; Gale, *Discourses on Salt and Iron*, 33.

200 Peter Golas interprets a passage found in the 1st century A.D. *Lun heng*論衡 and *Shi ji* as a reference to the mining of coal in the mountains, and notes that coal was being used for smelting in Henan by the Eastern Han, so it is not impossible that this passage refers to coal. Peter Golas, *Science and Civilisation in China* 5.13: "Mining" (Cambridge: Cambridge University Press, 1984), 190-94.

Hunting

Although the tendency in ecology is to describe environments in terms of plants, animals also play an important role in their ecosystems. To give two simple examples, grizzly bears bringing salmon into Pacific forests provide vital nitrogen for tree growth, while several African savannah plants have evolved seeds that can only be dispersed by elephants. Most ecological relationships are not so easy to discover and understand, and those that occurred in a landscape that has since been completely transformed by human activity will never be understood. If any plants existed in China that depended on elephants to spread their seeds, they may have disappeared along with the elephant. Despite this limitation, our understanding of the roles animals play in their ecosystems allow us to study the changes in animal populations (in this context the replacement of wild species by domesticates) with an awareness that the changes would have transformed entire ecosystems.

Written sources mention various species that were hunted, including deer *lu* 鹿, elaphure *mi* 麋 (*Elaphurus davidianus*), boar *shi* 豕, Chinese river deer *zhang* 獐 (*Hydropotes inermis*), fox *hu* 狐, rhinoceros *xi* 犀, elephant *xiang* 象, leopard *bao* 豹, tigers *hu* 虎, otter *ta* 獭, pheasant *zhi* ,雉 black bear *xiong* 熊, brown bear *pa* 羆, sable *diao* 貂 (*Martes zibellina*), rabbit *tu* 兔, alligator *tuo* 鼉, and others.[201]

The Shang oracle bones contain records of royal hunts, although it is unclear whether the scale of their hunts was exceptional or whether rulers of other areas would also have killed hundreds of animals in a single hunt. It is quite possible that the connection between organised hunts and political authority was already an ancient tradition in the Shang period. Although I tend to believe that these hunts would not have had nearly as large an impact as everyday hunting by normal people, they were often mass slaughters, and would have had a significant impact locally. For example, K.C. Chang cites an oracle bone record of a single hunt in which one tiger, 40 deer, 164 foxes and 159 "hornless deer" were caught, and another

[201] Unfortunately I discovered Magnus Fiskesjö's "Rising from Blood-Stained Fields: Royal Hunting and State Formation in Shang China," *Bulletin of the Museum of Far Eastern Antiquities* 73 (2001), 48-191, too late to include its findings in this thesis.

expedition which killed 348 elaphures.[202] The largest number of animals recorded caught come from a record translated as "On the Yihai day, traps (were laid), 700 deer were caught."[203] The Shang Oracle bones mention the hunting of buffalo even more than of elephants.[204] Shaughnessy shows that the Shang hunted deer, horses, and buffalo from chariots.[205] The reasons for the hunts were complex, and can be simply summarised as a combination of acquiring sacrificial animals, killing animals that competed with agriculture, displaying royal presence, and war games, all connected to ritual activity and ancestor worship.[206] It is also possible that the Shang court derived relatively little income from taxing peasants, and relied on the hunts for meat and other resources.[207]

Ode 180, "Ji ri" 吉日, provides perhaps the best early account of a royal hunting expedition. It describes the chariot preparations, sacrifices before the hunt, the large herds of deer, and the hunt. This poem shows that the Zhouyuan region of the Wei valley included significant areas of grassy plain:

> ...we selected our horses there where the animals assemble, the does and stags were in great numbers; by the Qi and the Ju we pursued them, the grounds of the Son of Heaven. Look at that middle of the plain! It is extensive and rich in game; they rush, they move on, some are in herds, some are in pairs; we led on all the attendants, in order to please the Son of Heaven. We drew our bows, we grasped our arrows, we shot at the small boar, we killed this big rhinoceros (or buffalo) 既差我馬。獸之所同、麀鹿麌麌。 漆沮子從、天子之所。瞻彼中原、其祁孔有。儦儦俟俟、或群或友。悉率左右、以燕天子。既張我弓、既挾我矢。發彼小豝、殪此大兕.[208]

As this valley was soon to be the densely populated economic and political centre of Qin and then of the early empire, it is significant that the early Zhou found it inhabited by large herds of deer. This passage provides important evidence that

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[202] K.C. Chang, *Shang Civilization*, 142.
[203] K.C. Chang et al., *The Formation of Chinese Civilization*, 170.
[204] Wen Huanran, *Zhongguo lishi shiqi zhiwu yu dongwu bianqian yanjiu*, 223. Assuming that the character *si* 兕 refers to buffalo and not rhinoceros.
[205] Edward L Shaughnessy, "Historical Perspectives on the Introduction of the Chariot into China," *Harvard Journal of Asiatic Studies* 48.1 (1988), 213-16.
[206] Mark Edward Lewis, *Sanctioned Violence in Early China* (Albany: SUNY Press, 1990), 24.
[207] Lewis, "The City-State in Spring-and-Autumn China," 360.
[208] Karlgren, *The Book of Odes*, 124; Ruan Yuan, *Shisan jing* 429.

despite millennia of occupation by farmers, this region was sparsely populated as late as the early-mid Zhou. The stone drums of Qin also depict royal hunts in the Wei region, in one of which they hunted elaphures, boar, male and female deer (*youlu* 麋鹿), pheasant, and hare.[209] Several of the other drums, although fragmentary, mention these animals. It is unclear to what species of deer the *youlu* 麋鹿 refers, although these terms are used frequently in various early texts on hunting.

According to the *Zuo Zhuan*, when the Duke of Lu was spending too much time hunting and fishing, one of his advisors attempted to convince him that royal hunts were very different from any normal subsistence activity:

> An ancient precept forbids the ruler to shoot any bird or animal whose flesh is unsuitable for offering at the ancestral altar, and whose flesh, teeth, bones, skin, or feathers may not be used for the making of ritual vessels or weapons of war. And this applies to most products of the mountains, woods, rivers and marshes. These are the affairs of the common people and their gathering is supervised by the relevant officials 鳥獸之肉不登于俎,皮革,齒牙,骨角,毛羽不登于器,則公不射,古之制也.若夫山林,川澤之實 ,器用之資,皂隸之事,官司之守,非君所及也.[210]

Although it is difficult to assess how accurately this statement reflects actual opinions of the Spring and Autumn period, it should be noted that the culture of hunting among the nobility did result in the preservation of large royal parks with preserved some wild species.[211] For example, the *Han Feizi* mentions attendants feeding rabbits to the tigers in the park of the king of Zhao.[212] The Qin park, in the Wei valley, was copied by later emperors, and by the Qing the imperial park was home to the last population of elaphures.[213]

Dozens of well-armed nobles in chariots may have successfully caught animals, but ordinary people would not have had the resources for such active hunting. They were more likely to use nets, snares and traps. The *Zhanguo ce* provides one description of hunting methods: "The craftiest animal of the mountains is the elaphure. He knows that hunters spread nets in his path to drive

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[209] Gilbert L. Mattos, *The Stone Drums of Ch'in.* (Nettetal: Steyler, 1988), 220.
[210] Hu Zhihui, tr., *Zuo zhuan*, 24-5 (Yin 5); Ruan Yuan, *Shisan jing*, 1727.
[211] Edward H. Schafer describes these in his "Hunting Parks and Animal Enclosures in Ancient China," *Journal of the Economic and Social History of the Orient* 9.3 (1968), 318-43.
[212] *Han Feizi* (*Zhuzi jicheng* vol. 5), 35.258; Liao, tr., *The Complete Works of Han Fei Tzu* vol. 2, 297.
[213] Nowak, *Walker's Mammals of the World*, 1383-84.

him into them, so he turns about and rushes the beaters. But those who have hunted often know the beast's craft and deception. They advance on him with the nets held up in front of them and in this way capture the creature as he rushes them" 今山澤之獸無黠於麋;麋知獵者張罔,前而驅己也,因還走而冒人,至數.獵者知其詐,僞舉罔而進之,麋因得矣.[214] This tells us that relatively large animals were caught with nets, and that people hunted in teams. Another passage from the *Zhanguo ce* shows that snares were used to catch tigers.[215] Rabbits were also caught in nets, as in *Ode* 7 "Tu ju" 兔罝, as were birds: "when there is a bird about to arrive one spreads out the net and waits for it. What catches the bird is one string of the net, but with a net made of only one string one would never catch birds" 有鳥將來,張羅而待之.得鳥者,羅之一目也.今爲一目之羅,則無時得鳥矣.[216] *Ode* 216 "Yuan yang" 鴛鴦 also mentions catching ducks with nets.[217]

But birds were also hunted in the air: "with powerful crossbows and darts they shoot high birds, their running dogs chase clever hares" 强弩弋高鳥.走犬逐狡兔.[218] Another passage discusses the use of dogs in hunting: "this is a good dog. His mind is set on roebucks, elaphures, boars, and deer" 此良狗也,其志在獐麋豕鹿.[219]

The use of snares, a common technique in much of the world, is rarely mentioned, although the *ti* 蹄 is mentioned as a snare for rabbits in the *Zhuangzi*.[220] Two passages in the *Huainanzi* explain that it is possible to hunt using fire, but both suggest that it is, like draining a pond to catch the fish, a short-sighted thing to do.[221]

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214 Crump, *Chan-kuo ts'e*, 253; Liu Dianjue & Chen Fangzheng, *A Concordance to the* Zhanguo ce (Hong Kong: Shang wu, 1992), 96.

215 Crump, *Chan-kuo ts'e*, 358; Liu & Chen, *A Concordance to the* Zhanguo ce, 130.

216 *Huainanzi* (*Zhuzi jicheng* vol.7), 16.282; LeBlanc, *Huainan zi*, 786.

217鴛鴦于飛、畢之羅之. Ruan Yuan, *Shisan jing*, 480.

218 *Huainanzi* (*Zhuzi jicheng* vol.7), 3.37. Although it is not mentioned which birds are hunted, the following birds are mentioned in the *Odes*. The number indicates how many times they are found in the collection: 燕 *yan* 55 Swallow (also has various other meanings), 雉 *zhi* 14 Pheasant, 鴈 *yan* 9 Wild goose [雁], 鴻 *hong* 9 Wild swan or goose, 鷺 *lu* 8 Egret or heron, 鵲 *que* 8 Magpie, 鳩 *jiu* 8 Pigeon, turtle dove or cuckoo, 桑扈 *sanghu* 4 Green bird?, 鴟鴞 *chixiao* 3 Owl, 脊令 *jiling* 2 Wagtail, 雀 *qiao*, *que* 1 Sparrow. David Keightley estimates that there were over 200 species of birds in the Anyang region during the Shang period. For a partial list see Keightley, *The Ancestral Landscape*, 107.

219 Riegel & Knoblock, tr., *The Annals of Lü Buwei*, 644 ("Shi rong" 士容 26.1).

220 *Zhuangzi* 莊子 (*Zhuzi jicheng* vol.3), 26.407; Burton Watson, tr., *The Complete Works of Chuang Tzu* (New York: Columbia University Press, 1968), 302.

221 *Huainanzi* (*Zhuzi jicheng* vol.7), 13.223, 18.313; LeBlanc *Huainan zi* , 333, 868.

Although it was common in many parts of the world to use fire to modify the environment in order to create grazing land for prey, there seems to be no textual evidence that this was practiced in China.

It is clear that most mammals of any size were eliminated long ago from most of North China. I will briefly discuss two species were eliminated so long ago that it is difficult to imagine them in that region: bears and rhinoceros.

Bears are often mentioned in early texts, most famously in Mencius' moral discourse in which he states his preference for bear paw over fish.[222] Several sources mention *xiongpi* 熊羆, which is a general term for bears that combines the names of two bear species.[223] *Xiong* 熊 are Asian black bears (*Ursus torquatus* or *Ursus thibetanus*), which still inhabit remote areas of East Asia, although the majority now live in bile farms in northeast China. *Pi* 羆 are *Ursus arctos*, brown bears, which are called grizzly in North America, but were originally a Eurasian species. Brown bears do not cohabitate well with humans, which is why they have been wiped out of most of their former range in western North America and China. They still inhabit a large area from Western North America to Eastern Europe. Panda bears once lived in a much wider areas than at present, although they never lived north of the Qinling.[224] There seems to be no mention of them in early texts.

There are currently three species of rhinoceros in Asia, although it is unknown whether those which lived in China were the same, as they have only been examined based on size. Wen Huanran mentions that the bones of either Javan (*Rhinoceros sondaicus*) or Sumatran rhinoceros (*Dicerorhinus sumatrensis*), or both, were found at Anyang. Considering that both of these species now live very far from North China and in much warmer places than North China was then, it is quite possible that the (sub)species whose bones were found at Anyang is now extinct.

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[222] *Mencius* (*Zhuzi jicheng* vol.1), 11.461.

[223] For example: Bernhard Karlgren, "The Book of Documents," *Bulletin of the Museum of Far Eastern Antiquities* 22 (1950), 15; Ruan Yuan, *Shisan jing*, 150; *Ode* 261 "Han yi" 韓奕, and *Huainanzi* (*Zhuzi jicheng* vol.7), 6.93, 16.287; LeBlanc, *Huainan zi*, 145, 796.

[224] Wen Huanran 文焕然 et al., *Zhongguo lishi shiqi zhiwu yu dongwu bianqian yanjiu* 中國歷史時期植物與動物變遷研究 (A study of changes in plants and animals in Chinese history), Chongqing: Chongqing, 1995), 232-40.

There does not seem to be any mention of using rhinoceros horn for medicine (currently the main killer of rhinoceros) in the early texts, but the *Odes* contain several mentions of cups made from rhinoceros (or buffalo) horn, and they continued to be carved into cups and other objects for many centuries.[225] Rhinoceros skins were used as armour during the Warring States. Duke Huan of Qi made fines payable in armour, the most expensive of which were those of rhinoceros skin, which suggests there were still rhinoceros in the Shandong area in the seventh century B.C., but that they were scarce enough to be expensive.[226]

Although Zhou texts frequently mention wild animals seemingly as everyday sightings, as humans took up more and more of the land, other animals became rarer and rarer. By the Han, many beasts are mentioned only metaphorically in fables and stories, and elephants and rhinoceros are no longer mentioned as live animals, only as exotic products.[227] Jia Yi associates them with donkeys and camels, recent arrivals from Central Asia, seemingly not aware that they had lived all over North China a few centuries earlier.[228] The commodification of animals was very advanced in this period, as will be shown in the section on geography and trade below.

It would seem that people who hunted, fished and gathered were numerous enough in the Han to be considered worthy of taxation. The *Han shu* recommends taxing "all those who gathered articles of any kind, birds and beasts, fish and turtles, the "hundred" (all kinds of) insects and reptiles, from mountains and woods, streams and marshes, and well as those who reared and pastured domestic animals" 諸取眾物鳥獸魚鱉百蟲於山林水澤及畜牧者.[229] This taxation was both for revenue and to encourage people to pursue the fundamental occupation, agriculture. Although it may not reflect actual taxation, it does show that a significant number of people were engaged in gathering, hunting and fishing.

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[225] Rhinoceros (or buffalo) horn cups (*sigong* 兕觥) are mentioned in Odes 3 "Juan er" 卷耳 , 154 "Qi yue" 七月, 180 "Ji ri" 吉日, and 215 "Sang hu" 桑扈.
[226] *Huainanzi* (*Zhuzi jicheng* vol.7), 13.229; LeBlanc, *Huainan zi*, 643.
[227] For example: *Huainanzi* (*Zhuzi jicheng* vol.7), 11.186; LeBlanc, *Huainan zi*, 510; *Yantie lun jiaozhu*, ed. Wang Liqi, 7.42; Gale, *Discourses on Salt and Iron*, 21.
[228] *Xin yu* (*Zhuzi jicheng* vol.7), 1.2, 10.17; Ku Mei-kao, tr., *A Chinese Mirror for Magistrates*, 68.
[229] Swann, *Food and Money in Ancient China*, 339; *Han shu* 24.1180-81.

Fishing

The frequent use of fish designs on Neolithic pottery and the many mentions of fishing in early texts attest to the importance of fishing in the early period. The intensification of fishing that must have occurred in some areas alongside population increases must have dramatically altered the ecology of many freshwater ecosystems in the Yellow river drainage. Fish bones are not as durable as the bones of mammals or birds, and few have been excavated, although many fishhooks have been excavated, including several made from bronze at Zhengzhou.[230] However, the *Odes* (esp. 170 "Yu li" 魚麗, 226 "Cai lu" 采綠 and 281 "Qian" 潛) frequently mention fishing and fishing materials, and the names of at least eleven kinds of fish.[231]

Gilbert Mattos' study of the fish names on the stone drums of Qin suggests that there were various local forms of fish names, which helps explain why these identifications are so tenuous. The "Qian yi" stone concerns fishing in the Qian 汧 river, a tributary of the Wei, and mentions fishing *yan* 鰋, *li* 鯉 , *fang* 魴, and *xu* 鱮, "small fish" and "white fish," and putting them in (probably baskets made from) poplar and willow, which presumably grew along the river.[232]

Along with fish, a variety of other water animals were consumed, most commonly the soft-shelled turtle *bie* 鱉 (*Pelochelys bibroni*). Others include the "giant sea turtles, alligators, fish, freshwater turtles, loach, and eels [or sturgeon]" 黿鼉魚鱉鰍鱣 mentioned by Xunzi in an argument against Mozi's belief that the world's natural resources were prone to scarcity.[233] This argument is very similar to contemporary environmental debates, in which one side warns of impending scarcity while the other denies the problem entirely. Although I tend to regard political and economic systems as more important than ideology in altering the environment,

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[230] Liu & Chen, *State Formation in Early China*, 98.

[231] The following fish are found in the *Odes*. Identifications are speculative, and the numbers indicate how many times the word appears in the collection. 魴 *fang* 9 Triangular bream; 鱮 *xu* 4 Tench, silver carp (*Hypophtalmichtys molitrix*); 鯉 *li* 4 Carp (*Cyprinus carpio*); 鱣 *zhan* 3 Sturgeon; 鮪 *shu* 3 Type of sturgeon; 鰥 *guan* 2; 鯧 *chang* 2 Yellow-jaw; 鰋 *yan* 2 Sheat, catfish; 鰷 *tiao* 1 minnow/whitefish (*Hemiculter leucisculus*); 鯊 *sha* 1 Sand-blower; 鱧 *li* 1 Murrel. On fishing see *Odes* 24, 35, 43, 57, 59, 104, 138, 149, 159, 170, 171, 178, 190, 199, 226, 233, and 281.

[232] Mattos, *The Stone Drums of Ch'in*, 167-96.

[233] *Xunzi* 荀子 (Bilingual Edition) John Knoblock, tr. (Changsha: Hunan Renmin, 1999), 10.283. Mod.; On fish and turtle species, see also *Xunzi*, Knoblock, tr., 9.241, 30.961.

Xunzi's attitude emphasising efficient management and production is clearly significant considering the influence he and his students had on the political thought and policies of the early empires.

Several methods were used for fishing, as this passage from the *Huainanzi* shows: "Those who fish with a line are peaceful, those who fish with a net bang on the boat, those who fish with a basket push it underwater, those whose fishing line has many hooks must wait; various methods, all in order to catch fish."
釣者靜之,　者扣舟,罩者抑之罣者與之,為之異得魚一也.[234]

As with amateur fishing today, bait was used when fishing with hooks.[235] *Ode* 24 "He bi nong yi" 何彼襛矣 suggest that the fishing line was often made of silk,[236] which may have also been attached to darts used for shooting birds: "Those who like to dart birds must first prepare their cords and darts, those who like to fish must first prepare their fine-netted and their large nets." 好弋者先具繳與矰,好魚者先具罟與罛.[237] Nets of various kinds were used, which we know only from the names *wang* 網, *gu* 罛 large nets, *gu* 罟 fine-meshed net, and *gua* 罣, which is sometimes translated as snare, although it seems unlikely that people snared fish. Three different terms sometimes translated "basket," *zhao* 罩, *gou* 笱 and *liu* 罶, were likely fish traps placed in weirs, eddies or small streams which allowed fish to swim in, but not out. The *Zhuangzi* mentions a *quan* 荃 (same as *quan* 筌), which Cheng Xuanying 成玄英 (a Tang commentator) explained as being the same as *gou* 笱, bamboo fish traps.[238]

Weirs (梁 *liang*) seem to have been widely used for fishing. A weir can be either a dam which forces all the water through one passage or simply a line of sticks close enough together to prevent a certain size of fish from passing through anywhere but the main opening, which is then an excellent place to catch fish in a trap. A weir can potentially trap all fish in a waterway, a case of "draining the pond

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[234] *Huainanzi* (*Zhuzi jicheng* vol.7), 17.296; "Qui pêche à la ligne patiente sereinement, qui pêche à la bastude frappe la coque du bateau; qui pêche à la nasse l'immerge; qui pêche à la palangre la relève: autant de procédés differents qui tous permettent d'attraper du poisson." LeBlanc, *Huainan zi*, 822.
[235] "You can't catch fish without bait" 魚不可以無餌釣也 *Huainanzi* (*Zhuzi jicheng* vol.7), 16.275; LeBlanc, *Huainan zi*, 772.
[236]其釣維何,維絲伊緡 . Ruan Yuan, *Shisan jing* 1.293.
[237] *Huainanzi* (*Zhuzi jicheng* vol.7), 16.283; LeBlanc, *Huainan zi*, 788; *Huainanzi* (*Zhuzi jicheng* vol.7), 36 mentions that people in Chu fish with arrows.
[238] *Zhuangzi* (*Zhuzi jicheng* vol.3), 27.407; Watson, tr., *The Complete Works of Chuang Tzu*, 303.

to catch the fish," so, although people resented government controls, it is easy to see why, as the population increased, a need was felt to regulate the use of weirs.

Another story which concerns regulations is found in both the *Lüshi chunqiu* and the *Huainanzi*. A man visiting a region under the control of a respected administrator sees a man catching fish and letting them go. Upon asking why, he is astounded to hear the fisherman say that he is releasing them because the master does not want people keeping small fish.[239] His surprise to see someone following the law of their own free will suggests that the laws regulating resources were often ignored. But the existence of catch and release laws similar to modern ones suggests a developed management program. Confucius already had his own rules about ethical angling and fowling centuries earlier: "The master fished with a line but not with a net; when fowling he did not aim at a roosting bird" 子釣而不綱,弋不射宿.[240]

By the Han dynasty the agricultural areas of the Yellow River region were densely populated, and the government instituted many rules to ensure the sustainability of fish. "The government of these past centuries has increased taxes on hunting and fishing, rapidly raised outpost and market duties, instituted regulations on the weirs of the marshes, and prevented the spreading of fishing nets" 末世之政, 田漁重税, 關市急征, 澤梁華禁, 網罟無所布.[241] This intensive management of fish probably developed over the years for state profit and to prevent local overfishing, and gradually evolved into pisciculture as people concerned themselves more and more with the production of fish. A passage from *Zhuangzi* which mentions a dried fish market (枯魚之肆), demonstrates that fish were a major commodity by the late Warring States.[242]

Once people are raising fish, rather than just catching them, questions arise concerning ownership of the fish themselves, rather than just control of the catch-

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[239]見得魚釋之巫馬斯問焉曰凡子所爲魚者, 欲得也今得而釋之, 何也? 漁者對曰: 季子不欲人取小魚也. 所得者小魚是以釋之" *Huainanzi* (*Zhuzi jicheng* vol.7), 12.205; LeBlanc, *Huainan zi*, 573-74; also in Riegel & Knoblock, tr., *The Annals of Lü Buwei*, 471 ("Ju bei" 具備 18.8).

[240] *Lun yu* 7.26 (*Zhuzi jicheng* vol.1), 148; Waley, tr., *The Analects*, 88-89.

[241] *Huainanzi* (*Zhuzi jicheng* vol.7), 8.123; LeBlanc, *Huainan zi*, 352.

[242] *Zhuangzi* (*Zhuzi jicheng* vol.3), 26.399. Watson, tr., *The Complete Works of Chuang Tzu*, 295.

site. And once fish have become property, their owners will defend them, hence the saying "those who raise fish in ponds must drive away the otters; those who raise fowl and livestock must drive away jackals and wolves" 畜池漁者必去猵獭養禽獸者必去豺狼.[243] This is a reminder that the human adoption of agri- or pisci-culture affects other animals just as much as hunting. By monopolising land or water humans eliminate other carnivores by competition rather than hunting.

II Transformation of the Political Economy

The Expansion of State Power

The political transformation that occurred in the Eastern Zhou allowed the ruler for the first time to directly affect local subsistence activity, and was thus also an ecological transformation. The drive for military success engendered a more aggressive relationship with all potentially productive ecosystems and an ideology which viewed a higher human population as the measure of a state's success.[244] This transformation led to a much more rigorous exploitation of both agricultural and non-agricultural land. An empire as large and complex as the Han could not have been supported by the relatively low level of production of the early Eastern Zhou. The huge armies of the Warring States were achieved at the expense of the environment and of the peasants, who provided the surplus production to support the armies and fought in them. Even after unification the emphasis on increasing production continued as expensive wars were fought along the borders, especially under the First Emperor and Han Emperor Wu. The most important step in this transformation was the replacement of a decentralised system of hereditary fiefdoms with one based on fixed jurisdictions under the control of a single ruler and governed by an appointed and professional bureaucracy.

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[243] *Huainanzi* (*Zhuzi jicheng* vol.7), 15.252; LeBlanc, *Huainan zi*, 710. A similar passage is found in *Yantie lun jiaozhu*, ed. Wang Liqi, 14.179; Gale, *Discourses on Salt and Iron*, 87. There are no jackals in China today, so *chai* 豺 may refer to feral dogs, or to the golden jackal (*Canis aureus*), which can be found in Southeast Asia and the former Soviet Union. Nowak, *Walker's Mammals of the* World, 1067-68.

[244] Mark Elvin's argument that warfare was the driving force that transformed early societies into more complex and ecologically destructive states is convincing, and I tend to follow it in this thesis. However, such a complex process can never be satisfactorily attributed to a single cause. Mark Elvin, *The Retreat of the Elephants*, 86-115.

Based on Shang oracle bones, Keightley notes that "rudimentary conceptions of territorial jurisdiction did exist, but...no evidence that a conception of state territory, as opposed to group or clan or tribe territory, existed."[245] The oracle bones indicate that various officials were appointed in the capital by the king, which may be considered the beginnings of bureaucracy. The state controlled groups of soldiers/labourers who cleared land, a function related to invading new territory.[246] Nonetheless, the Shang ruler probably had little influence over the way most land was exploited in his domain.

Like the Shang, most of the land nominally ruled by the Western Zhou rulers was actually under the control of kinship groups and allies. Even at the height of its power the Western Zhou was composed of various fiefs with their own rulers, courts, and ancestral temples.[247] The conquest of the Western Zhou in 771 B.C. by the Quan Rong consolidated the already apparent decline in the central power, leaving various nominally vassal states more powerful than the Zhou. Although each of these states had a hereditary ruler, power was distributed among a group of noble families whose offices were hereditary, which "led to a collegial mode of authority in which the ruler was first among equals, but actual decisions would require a consensus."[248] Central rulers gradually replaced these nobles with appointed officials and replaced their hereditary fiefs with jurisdictions administered by these officials. The relatively small sizes of the states allowed the rulers to gradually extend control over their entire realms, an important step in reducing the power of the hereditary landed nobles.

One of the first steps in this process was the extension of military service in Qi to the men of the capital and the surrounding rural area. This occurred in the seventh century B.C., and was accompanied by the replacement of hereditary fiefs by 15 territorial jurisdictions known as *xiang* 鄉. This gave the ruler more direct control over the land, and provided the central court with its own armed force, the

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[245] Keightley, "The Late Shang State: When, Where and What?," 527.
[246] Keightley, "The Shang: China's First Historical Dynasty," 279-88.
[247] Edward L. Shaughnessy, "Western Zhou History," in *The Cambridge History of Ancient China*, ed. Loewe & Shaughnessy, 311-13; Lewis, "The City-State in Spring-and-Autumn China," 368.
[248] Both quotes from Lewis, "The City-State in Spring-and-Autumn China," 369.

beginnings of the great armies of the Warring States. The need for infantry was the first incentive for the ruler to extend his reach directly into the homes of the populace, and would eventually lead to the organizing of the population to ensure universal military service. Other incentives included increased taxation revenue and the greater central control made possible by the elimination of potential rival power sources in both rural areas and the central court.

At the same time Qi was reorganising, the state of Chu established *xian* 縣, usually translated as "county," in border areas, which was copied by other states and was followed by the creation of *jun* 郡, larger units which encompassed several *xian*.[249] In all of these new jurisdictions and the capital (*guo* 國), nobles were replaced by officials whose duties combined civil and military functions, and who reported to their direct superiors and eventually to the ruler, a bureaucracy. By the late Warring States there remained few hereditary fiefs within the states, although the officials in charge of *jun*, *xian*, and *xiang* often treated them as fiefs.[250]

In 594 B.C., the state of Lu began to collect taxes according to the amount of cultivated land (初稅畝), a policy that was copied by the other states.[251] Cho-yun Hsu writes that "a tax based on production from land held by the peasant was tacit recognition that the farmer was entitled to use the particular piece of land...the status of the people likewise changed to that of subjects of the state."[252] This probably overstates the evidence, but nonetheless highlights the way in which the relationship between state and peasant was changing.

In 548, Wei Yan 蔿掩 was appointed minister of war in Chu, and immediately calculated the entire resources of the state:

> He recorded the ground and arable land, estimated timber on the mountains, added up the wastes and marshes, distinguished the hills from the tombs, noted saline ground and flooded districts, calculated areas with soil too hard to plough, regulated embankments, put livestock to graze in marshy places, divided fertile land into grids of nine, and then adjusted the *fu* tax based on the income of each

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[249] Creel, "The Beginnings of Bureaucracy in China."
[250] This paragraph, and the previous, are based on Hsu Cho-yun, "The Spring and Autumn Period," and Lewis, "Warring States: Political History," in *The Cambridge History of Ancient China*, ed. Loewe & Shaughnessy, 545-650.
[251] Hu Zhihui, tr., *Zuo zhuan*, 519 (Xuan 15); Ruan Yuan, *Shisan jing*, 1888.
[252] Hsu Cho-yun, "The Spring and Autumn Period," 577.

area 鳶掩書土田，度山林，鳩藪澤，辨京陵，表淳鹵，数疆潦，規偃豬(瀦)，町原防，牧隰皋，井衍沃．量入修賦.[253]

This is the first indication of the state attempting to assess *all* of the land in its domain and make it as productive as possible. The fact that this was the initiative of the minister of war demonstrates the close connection between warfare and the intensification of land use.

At the same time, officials were appointed to increase production, as shown in the *Lüshi chunqiu*'s description of the duties of field inspectors (*tian she* 田舍), who "are to ensure that everyone keeps boundaries and borders in good repair and that care is taken as to the straightness of the small pathways between the fields. They are skillfully to survey the mounds, slopes, ravines, plains, and marshes to determine which have soil and landforms suitable to grow each of the five grains" 皆修封疆，審端徑術，善相丘陵坂險原隰，土地所宜，五穀所殖.[254] They survey land both to encourage the clearing of new agricultural land and to determine land quality in order to optimise production and tax revenue. The increasing bureaucratic regulation of wild land will be discussed below.

In Qin, the state which was to make these reforms the policies of the first empire, reforms began later than many states. Qin instituted a land tax paid in grain in 408 B.C., which was followed in the reign of Duke Xian 獻公 (384-362) by the registration of households in units of five, and by the establishment of *xian* districts which were administered directly by the central government.[255] In 348, Qin minister Shang Yang created the *fu* 賦 military service, and he was later noted for having collected taxes on the mountains and marshes.[256] Both of these taxes indicate a greater pressure from the state on the people and the land. The Qin legal documents unearthed at Yunmeng show "that a substantial part of the land was exploited directly by the state, using slave and convict labour."[257]

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[253] Hu Zhihui, tr., *Zuo zhuan*, 879 (Xiang 25); Ruan Yuan, *Shisan jing*, 1985.
[254] Riegel & Knoblock, tr., *The Annals of Lü Buwei*, 62-63 ("Meng chun" 孟春 1.1).
[255] Lewis, "Warring States Political History," 602.
[256]收山澤之税. *Yantie lun jiaozhu*, ed. Wang Liqi, 7.93; Gale, *Discourses on Salt and Iron*, 40.
[257] Robin D.S. Yates, "Slavery in Early China: A Socio-Cultural Approach," *Journal of East Asian Archaeology* 3.1–2 (2001), 294-95.

Even before they conquered the other states the bureaucracy of Qin was already highly developed. Indeed, "one of the main reasons why the Qin were able to unify the empire and found the imperial system was because of the[ir] bureaucratic procedures and techniques."[258] Creel notes that all of the attributes that Max Weber considered characteristic of modern bureaucracy existed in Han China, the first of which is "fixed and official jurisdictional areas, which are generally ordered by rules, that is, by laws or administrative regulations." These areas (in China the *xian*, *jun*, *xiang*, and *guo*) are administered by a system that includes the following three characteristics: "1. The regular activities required for the purposes of the bureaucratically governed structure are distributed in a fixed way as official duties. 2. The authority to give the commands required for the discharge of these duties is distributed in a stable way and is strictly delimited by rules concerning the coercive means...which may be placed at the disposal of officials. 3. Methodical provision is made for the regular and continuous fulfilment of these duties and for the execution of the corresponding rights; only persons who have the generally regulated qualifications to serve are employed." [259] This bureaucracy augmented the government's capability to regulate and alter the environment and its use throughout the empire.

In the following sections I will examine three areas in which this intensified political control affected the environment: large-scale water control works, the bureaucratic regulation of wild land, and the creation on a region wide commercial trade in agricultural products and luxury goods.

Large-Scale Water Control Projects

Much has been made of the importance of water control in the development of the early Chinese state. Karl August Wittfogel argued that the geography and climate of North China required large-scale public water works to prevent the

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[258] Robin D.S. Yates, "State Control of Bureaucrats under the Qin: Techniques and Procedures," *Early China* 20 (1995), 364.

[259] Max Weber quoted in Creel, "The Beginnings of Bureaucracy in China," 126. As Yates points out in his analysis of Qin bureaucracy, the correspondence between Weber's ideas of bureaucracy and early Chinese practice should not be overstated as they were conceptualised very differently. Yates, "State Control of Bureaucrats," 363-64.

Yellow River from flooding and to irrigate during frequent droughts. These projects required a centralised bureaucratic state, and led to the unification of China.[260] Although this idea has largely been discredited, there is nonetheless a strong connection between the development of water control and the intensification of state control over both people and the environment. The necessity of regulating water on the North China Plain forced its people to develop advanced hydraulic engineering skills and fostered an ideology in which such transformations were (and are) equated with a strong and able government. In addition to the controlling of the Yellow River, these projects included transport canals on the plains and in valley bottoms, and river-diversion irrigation projects elsewhere.

The prominence of flood myths among the people of early China is not surprising considering they lived on an active alluvial plain.[261] The legend of Yu the Great, tamer of the floods, may well have its roots in a real person who fought floods. The legend of Yu can be considered a kind of geographical creation myth, since it explains the origin of much of the geography of the region as the work of Yu. Or, to put it another way, the legend of Yu allowed early people to claim the landscape as their own, since much of it was actually created by one of their leaders. It also required political leaders to demonstrate similar water-controlling abilities. It is interesting to note that these early people had a more developed mythology surrounding the creation of their landscape (imbedded in the story of the rise of their civilisation), than they did of the origins of humans or other animals. The prominence of large scale landscape altering projects in the mythology/religion of early China is as striking as the actual number and scale of such projects that have been, and continue to be, carried out by its rulers.[262]

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[260] For one version of this thesis, see Needham et al., *Science and Civilisation* 4.3, 263. The idea was originally presented in Karl Wittfogel, *Wirtschaft und Gesellschaft Chinas* (Leipzig: Hirschfeld, 1931), which I have not read, and its Cold War reincarnation *Oriental Despotism: A Comparative Study of Total Power* (New Haven: Yale University Press, 1957).

[261] Flood myths can be found, among many other places, in Ode 304 "Chang fa" 長發 and in *Mencius* (*Zhuzi jicheng* vol.1), 5.219-26, 6.263-68. See Mark Edward Lewis, *The Flood Myths of Early China* (Albany: SUNY Press, 2006).

[262] Environmental philosophers often cite early Chinese thought (especially Zhuangzi and Laozi) as being more ecologically sound than western philosophies. However, those who seek to find in Chinese thought an alternative to the ecologically unsustainable ways of the west must first deal with Yu the Great. The water projects of the last 60 years on the Yellow, Huai, and Yangzi rivers must be

The beginning of large scale projects may have been related to the elimination of the feudal nobility, which resulted in the transfer of corvée obligations of peasants from their local lords to the central ruler, who could then employ thousands of people for a project. It is also possible that corvée obligations simply became military obligations, and peasants recruited for military service ended up digging instead of fighting. However, the importance of the labour of prisoners and convicts in the state of Qin suggests that other states may also have depended on prisoners for the construction of large public works.[263] It is also no coincidence that the beginning of large-scale public works occurred at the same time as the spread of iron tools.

As explained in the introduction, the Yellow River once wandered freely over the North China Plain, constantly threatening human settlements. Thus the great hydraulic battle has been to maintain the river in a single course. Because the Yellow river tends to rise in elevation due to siltation, the artificial maintenance of a single course causes the river to rise higher than its former tributaries and become a drainage divide in the North China Plain. Thus maintaining a stable river required also dealing with water that had previously flowed into the Yellow river.

Of the most powerful warring states it was Qi, Zheng and Wei which were beside the lower Yellow River. Qi, lying lowest of the three, first built dikes to protect itself from the river, with the result that high water flooded Zheng and Wei, who then built their own dikes.[264] According to Yang Kuan, many defensive walls between states were built on dikes, thus showing an obvious correlation between warfare and water control. He points out that the large amount of dike work done in the Warring States, both in competition with other states and to protect against deliberate flooding, drove water engineering to higher levels.[265] Given the amount of

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understood as continuing an ancient tradition in Chinese political culture. Hu Jintao, the current president of China, is a hydrological engineer by training. The use of flood myths and the regulation of water as sanctions of political authority is a central theme of Lewis' *The Flood Myths of Early China.*

[263] For the importance of convict labour in Qin see Yates, "Slavery in Early China."

[264] Yang Kuan 楊寬, "Zhanguo shidai shuili gongcheng de chengjiu" 戰國時代水利工程的成就 (Warring States-era hydraulic engineering achievements) in *Zhongguo kexue jishu faming he kexue jishu renwu lunji* 中國科學技術發明和科學技術人物論集, ed. Li Guangbi 李光璧 & Qian Junye 錢君曄 (Beijing: Sanlian, 1955), 103.

[265] Yang Kuan 楊寬, "Zhanguo shidai shuili gongcheng de chengjiu," 104-5.

information we have on the political and military activity of this period, the scarcity of intentional dike breaking mentioned in texts suggests it was not common. More important than intentional flooding was the building of transportation canals to facilitate, among other things, the transportation of troops and military supplies. The waterworks built in the 480s south of the Huai by the state of Wu for military transport were the earliest large-scale canals, although parts of the Hong canal system were older.[266]

Sima Qian considered the Hong canal the oldest waterworks constructed after those of Yu, which suggests that its oldest sections were very old, although the system as a whole was constantly being improved. Shi Nianhai has shown that it was not one, but actually a series of transport canals which connected the Yellow and Yangzi rivers and formed a network of waterways by connecting the rivers on the plain that separated the two.[267] Some of these canals were built along routes that had been important for the transport of goods for over one thousand years by that point, and may have been modified to some degree during that period.[268] The system included the Ji 濟, Ru 汝, Si 泗, and Ying 潁 rivers as well as many lakes and smaller rivers which were transformed during the making of the canal system. Most of the lakes and wetlands have been drained, and none of the rivers flow in the same courses they did 2500 years ago. Information on what exactly was done in the early period is scarce, so it is not even known whether modern waterways such as the Guo 過 follow natural courses or are the remnants of waterways that were later replaced.

The maps on page 15 give an idea of the changes in the waterways during the period. The Ji River originally flowed out of the Yellow River at Shi Men (Stone Gate) but eventually disappeared. The lake and wetlands (*Xingze* 滎澤) that the Ji once flowed through, and which provided an outlet for the Yellow River when it ran high, silted in and were drained for agriculture. This indicates the wider tendency of

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[266] 吳城邗, 溝通江淮. Hu Zhihui, tr., *Zuo zhuan*, 1516-7 (Ai 9); Ruan Yuan, *Shisan jing*, 2165.

[267] Shi Nianhai, "Lun Jishui he Honggou" 論濟水和鴻溝 (A discussion of the Ji river and the Hong canal), in 3 parts (*Zhongguo kaogu jicheng. Huabei juan, Henan and Shandong,* Zhongzhou guji, 1995), 276-98. Most of the information in this and the following paragraph is taken from this article.

[268] On these early transportation routes, see Liu & Chen, *State Formation in Early China*, 50-54. They were combined into the Grand Canal during the Sui.

land clearing and draining to eliminate land whose ecological function (in this case absorbing high water) were beneficial to humans. It also replaces fish, a nutritious and potential famine food, with more cropland. The short term gain of such a move would be gone once the population increased, and their lives would be more precarious. As Mark Elvin has shown, a similar logic applies to irrigation systems, which initially increase production, but then become burdens as labour is required merely to maintain the status-quo.[269]

The first mention of state irrigation comes from 563 B.C. when Zi Si created irrigation or drainage ditches in Zheng, which caused powerful families to lose land, so they had him assassinated.[270] Zi Chan renewed these irrigation works twenty years later as part of his reform program, converting previously brackish land into productive farmland. Although the people initially complained, they later recognised the value of drainage canals.[271] The canals built by the state of Wei 魏 during the 430s are the earliest-recorded large-scale irrigation project, the whole project being twenty li, roughly five miles, in length.[272] This project brought water from the Zhang 漳 River to Ye 鄴 for irrigation, transforming mediocre land into some of Wei's most productive.[273] The people made a song: "Ye had a sage commandant, this was Sir Shi. He channeled the river Zhang to irrigate the lands round Ye. What had been a salty waste now produces rice and grain" 鄴有聖令是爲史公.决漳水灌鄴旁.終古斥鹵生之稻梁.[274]

The most famous irrigation canal was the Zheng Guo canal, which diverted water from the Jing River to irrigate land in the Wei River. It was built by Qin in the late Warring States. It irrigated previously brackish land, and "as a result the area Within the Pass [Wei valley] was converted into fertile fields and no longer suffered

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269 Elvin, *The Retreat of the Elephants*, 115-64.
270 Hu Zhihui. tr., *Zuo zhuan*, 740-41 (Xiang 10); Ruan Yuan, *Shisan jing*, 1948.
271 使田有封洫. Hu Zhihui. tr., *Zuo zhuan*, 976-79 (Xiang 30); Ruan Yuan, *Shisan jing*, 2013. Also in Riegel & Knoblock, tr., *The Annals of Lü Buwei*, 389-90 ("Yue cheng" 樂成" 16.5).
272 Ping-Ti Ho, *The Cradle of the East*, 47.
273 西門豹引漳水溉鄴以富魏之河内. Sima Qian, *Shi ji* 29.1408; Watson, *Records of the Grand Historian: Han* II, 54; Also in Riegel & Knoblock, tr., *The Annals of Lü Buwei*, 388 ("Yue cheng" 樂成 16.5).
274 Riegel & Knoblock, tr., *The Annals of Lü Buwei*, 392-93 ("Yue cheng" 樂成 16.5).

from lean years; Qin became rich and powerful and eventually was able to conquer all the other feudal lords and unite the empire" 於是關中爲沃野,無凶年秦以富彊,卒并諸侯.[275] The Zheng Guo canal shows clearly the link between the harnessing of natural processes and increasing military and political power.

As a part of the general effort to increase agricultural revenue, the reign of Han emperor Wu saw the building of several large scale irrigation and water transport works. One of these was the plan of Pan Xi who in 124 B.C. had two irrigation canals built by the mouth of the Fen 汾 river in order to provide grain for the capital, but the river shifted and ruined the whole project. Five years later Zheng Tangshi had a canal cut between Chang'an and the Yellow river on the south side of the Wei River in order to facilitate the transport of grain to the capital. This project also irrigated land beside the canal. Another large irrigation project occurred in Shuofang, the military/agricultural colony established by the first Qin emperor in present-day Ningxia on the Yellow river.[276]

According to Bray, "Wu Di was the first emperor of unified China to realise the importance of water control, and he carried out an enormous programme of canal building in Henan and Shaanxi that irrigated over a million acres of arable land, while lesser projects were realised in Northwest China and the Wei and Huai valleys. By the middle of Wu Di's reign the lower Yellow River valley was producing six million bushels of grain to the exchequer in place of the few hundred thousand it had sent in the first years of the Han, and productivity in the arid Northwest had been raised considerably."[277] Emperor Wu's reign also saw one of the first large-scale imperial projects to maintain the single course of the Yellow River, which broke out of the dikes in 132 B.C. and flowed south into the Huai river for the first time in recorded history, Although certainly not the first time ever. The break was only repaired twenty-three years later by a force of 20,000 or 30,000 workers.[278]

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[275] Sima Qian, *Shi ji* 29.1408; Watson, *Records of the Grand Historian: Han* II, 55. On the Zheng Guo canal in later periods see Pierre-Étienne Will, "Clear Water versus Muddy Waters."
[276] Swann, *Food and Money in Ancient China,* 260-61; *Han shu* 24.1163; Needham *Science and Civilisation* 4.3, 273-75.
[277] Bray, *Science and Civilisation* 6.2, 588.
[278] Sima Qian, *Shi ji* 29.1412-14; Watson, *Records of the Grand Historian: Han* II, 57-59.

Now that we have looked at the history of water control projects it seems necessary to look at the types of works that were undertaken. Although the works of Yu the Great can largely be considered mythical, descriptions of his works can nonetheless give some idea of contemporary water works. Mozi tells us that: "in the north he built a dam across the Yuan and Gu rivers in order to fill the Hou Zhi Di (basin) and the Hu Zhi River....in the east he drained the great plain and built dykes along the Meng Zhu River. The watercourse was divided into nine canals in order to regulate the water in the east and in order to benefit the people of the district of Ji" 北為防原泒，注後之邸，嘑池之竇…東 為漏大陸, 防孟諸之澤, 灑為九澮, 以楗東土之水, 以利冀州之民.[279] In the fourth or fifth century B.C., people were already familiar with dams, reservoirs, dykes, and canals.

A century or two later, Xunzi described the type of work involved in the maintenance of these systems: "the official duties of the director of public works comprise repairing dikes and bridges, keeping open irrigation channels and ditches, draining off overflow waters, and storing up water in reservoirs to maintain the water level according to the season so that even in bad weather, in times of flood or drought, the people will have something to plant and weed" 脩隄梁，通溝澮，行水潦，安水臧，以時決塞；歲雖凶敗水旱，使民有所耘艾，司空之事也.[280]

From this we can see that the transformation of the waterways was in many areas quite thorough even before the large projects of Qin and Han. The most advanced work on water control from this period is the "Du di" 度地 chapter of the *Guanzi*, which Rickett dates to the Qin or early Han.[281] It not only discusses dams, reservoirs, irrigation, dykes and flood prevention, but also displays a sophisticated understanding of the movement of water, explaining such things as different ways in which water currents cause erosion and the relation between flow rates and silt deposition. It also explains the importance of counting and organising the population into groups responsible for maintaining the dykes and channels, which

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[279] Yi-Pao Mei, tr., *The Ethical and Political Works of Motse* (London: Probsthain, 1929),85; *Mozi* (*Zhuzi jicheng* vol.4), 4.68.
[280] *Xunzi*, Knoblock tr., 9.242-45.
[281] *Guanzi* 管子 (*Zhuzi jicheng* vol.5), 57.303-6; Rickett, *Guanzi* vol. 2, 240-53.

illustrates the increasing labour and organisation necessary to maintain the increasingly artificial landscape.

Because of the political nature of these water works, as well as their large scale, the early sources provide an unusually rich record of the way in which waterways were reorganised. Wetlands were drained in some places, while reservoirs were built elsewhere. Water was diverted from streams and rivers to irrigate previously arid land, sometimes opening entirely new areas to human settlement. Reservoirs and irrigated fields increased evaporation and reduced the amount of water flowing into rivers. Irrigation raised the water table in some areas, potentially leading to salinisation, while drainage canals lowered it in others. The courses of streams and rivers were altered and previously separate watersheds were connected by canals. The normally dynamic Yellow River was fixed into a single course, dividing in two the drainage of the North China Plain. In short, the transformation of freshwater ecosystems and waterways was one of the most significant environmental changes during the period.

Legal Regulation of Resources

The establishment of fixed legal regulations was an essential part of the process whereby hereditary nobles were replaced by appointed officials. A.F.P. Hulsewé notes that the Qin laws "show that in the 3rd century B.C. the state of Qin aimed at extending its influence over all spheres of life of its inhabitants."[282] This meant extending its influence over all land which was of any use, as shown in the regulation on the use of wild or uncultivated land in the "Statutes on Agriculture:" "In the second month one should not venture to cut timber in the forests or block water courses. Except in the months of summer one should not venture to burn weeds to make ashes, to collect [indigo], young animals, eggs, or fledglings. One

[282] A.F.P. Hulsewé, *Remnants of Ch'in Law: An Annotated Translation of the Ch'in Legal and Administrative Rules of the 3rd Century B.C. Discovered in Yün-meng Prefecture, Hu-pei Province, in 1975* (Leiden: Brill, 1985), 13.

should not....poison fish or turtles or arrange pitfalls and nets" 春二月,毋敢伐材木山林及雍(壅)隄水.不夏月,毋敢夜草爲灰,敢生荔麛𣏌, 毋…毒魚鱉,置穽罔.[283]

Just as the state gradually assumed ever increasing control over the lives of individuals, it also assumed increasing control over the land. Although the focus was on agriculture, the products of the mountains and marshes, such as wood and fish, were also important. The strict control exercised by the state over wild land not only guaranteed the state what it needed, but was also intended to ensure the dependence of peasants on agriculture.

The Shang had officials responsible for farming, but probably not for forests or other wild lands, which were not taxed. Mark Edward Lewis notes that Shun 舜, one of the mythical early rulers, was called *yu* 虞, a term that was later used for officers who supervised forests, and that Shun was commonly associated with forests.[284] This suggests that by the Warring States the position was already considered ancient. By that period the population in core areas was large enough that regulation of resources was necessary. The *Zhou li* describes officers in charge of mountains (*shan yu* 山虞), forests (*lin heng* 林衡), rivers (*chuan heng* 川衡), and wetlands (*ze yu* 澤虞), who were in charge of regulating all hunting and fishing and providing animals and fish for sacrifices.[285] Likewise, the *Lüshi chunqiu* decrees that in the spring "the foresters [*yu* 虞] enter the mountains and make a tour of inspection to see that the trees have not been felled or trimmed" 虞人入山行木,無或斬伐.[286] Xunzi likewise explains that "the duties of the master of forests and game [*yu* 虞] are to prepare rules for burning, to care for the resources of the mountain forests, the lakes, and the marshes, such as the grasses and the trees, the fish and the turtles, and the hundred other edibles, opening and closing them according to the season so the state will have enough to satisfy its needs and raw materials and resources will not be

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[283] Hulsewé, *Remnants of Ch'in Law*, 22; Yunmeng Qin mu zhujian zhengli xiaozu, "Yunmeng Qin jian shiwen" 雲夢秦简釋文, *Wenwu* 7(1976), 1.
[284] Lewis, *The Flood Myths of Early China*, 35.
[285] Edouard Biot, *Le Tcheou-Li ou Rites des Tcheou* (Paris, Imprimerie nationale, 1851), 105-6.
[286] Riegel & Knoblock, tr., *The Annals of Lü Buwei*, 155 ("Ji xia" 季夏 6.1).

depleted" 脩火憲, 養山林, 藪澤, 草木, 魚鱉, 百索(素), 以時禁發, 使國家足用而財物不屈, 虞帥之事也.[287]

Han shu 24 provides some interesting details on the way these lands and products were taxed in the Han dynasty: "As to mountains and forests, swamps and marshes, plains and hills, barren and brackish land, all according to the degree of richness and poverty were allotted to the people in varying amounts. There were *fu* military taxes and *shui* taxes on products. The latter consisted of a one-tenth tax on royal fields as well as taxes paid by craftsmen, merchants and *Heng* and *Yu*" 若山林藪澤原陵淳鹵之地, 各以肥磽多少為差. 有賦有稅. 稅謂公田什一及工商衡虞之入也.[288] A passage from the *Lüshi chunqiu* shows that the *yu* also collected *fu* military taxes on the products of the waterways, springs, ponds, and marshes 命水虞漁師收水泉池澤之 賦.[289]

In the *Zhou li*, *heng* and *yu* were officials in charge of mountains, forests, streams, and marshes. As Swann explains, "each forest and each stream, each mountain and each marsh was under the charge of a forester or warden, a *heng* or a *yu*, under whom, according to its size and importance, a certain number of conscripted men brought forth products in which they paid taxes-in-kind or money equivalent to these government foresters, the *heng* of forest and of stream, the *yu* of mountain and of marsh. So many and so widespread were those engaged in this service that they formed the third of the nine occupational categories among the common people."[290] Thus even non-agricultural land was heavily used. Just as Qin had directly overseen the farming of its land, Swann suggests that many of the people exploiting the wilder land were also virtually government employees. Surveys begun in the pre-imperial states to determine productivity for military advantage coalesced into an empire-wide system of controlled and organised exploitation. The land was graded according to productivity, its products counted and taxed.

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[287] *Xunzi*, Knoblock, tr., 9.245.
[288] Swann, *Food and Money in Ancient China*, 120, mod.; *Han shu* 24.1120.
[289] Riegel & Knoblock, tr., *The Annals of Lü Buwei*, 226. ("Meng dong" 孟冬 10.1).
[290] Swann, *Food and Money in Ancient China*, 121.

This was certainly not popular, but the following passage from *Xunzi* shows that the ecological basis for sustainable management was well understood; the government considered itself, or at least claimed, to be exerting its control over the land in the interests of sustainability:

> If it is the season when the grasses and trees are in the splendour of their flowering and sprouting new leaves, axes and adzes are not permitted in the mountain forest so as to not end their lives prematurely or to interrupt their maturation. If it is the season when the giant sea turtles, alligators, fish, freshwater turtles, loach, and eels are depositing their eggs, nets and poisons are not permitted in the marshes so as to prematurely end their lives or interrupt their maturation ....The ponds, lakes, pools, streams, and marshes being strictly closed during the proper season is the reason that fish and turtles are in plentiful abundance and the hundred clans have surplus for other uses. The cutting and pruning, the growing and planting, not being out of season is the reason the mountain forests are not denuded and the hundred clans have more than enough timber 草木榮華滋碩之時，則斧斤不入山林，不夭其生，不絕其長也；黿鼉、魚鱉、鰍鱣孕別之時，罔罟毒藥不入澤，不夭其生，不絕其長也；春耕、夏耘、秋收、冬藏，四者不失時，故五穀不絕而百姓有餘食也；汙池、淵沼、川澤，謹其時禁，故魚鱉優多而百姓有餘用也；斬伐養長不失其時，故山林不童而百姓有餘材也.[291]

Despite these lofty goals, people in power tended to take advantage of these controls for their own profit, which is implied by Mencius' comment that in the days of Zhou King Wen there were no government controls on the weirs, implying that he considered the rulers of his day to be interfering with the people's livelihood by regulating fishing.[292] The *Xin yu* criticises Duke Zhuang of Lu 魯莊公, who "was greedy for the profit from the mountains, forests, grasslands and marshes. He competed with the people in gaining the wealth from the fields, fisheries, firewood and edible plants" 規固山林草澤之利,與民爭田漁薪菜之饒.[293] The scholars of the Western Han had no ideals of leaving the mountains and marshes to the people, but were concerned only to which government department they belonged:

> In ancient times the famous mountains and great marshes were not given as fiefs to be the monopolized profit of inferiors, because the profit of the mountains and the sea and the produce of the broad marshes are the stored up wealth of the Empire and by rights ought to belong to the privy coffers of the crown; but your

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[291] *Xunzi*, Knoblock, tr., 9.241; see also *Mencius* (*Zhuzi jicheng* vol.1), 1.32-35.
[292] 澤梁無禁. *Mencius* (*Zhuzi jicheng* vol.1), 2.79.
[293] *Xin yu* (*Zhuzi jicheng* vol. 7), 9.14; Ku Mei-kao, tr., *A Chinese Mirror for Magistrates*, 110.

majesty has unselfishly assigned them to the State Treasurer to assist and succor the people. Ne'er-do-wells and upstarts desiring to appropriate the produce of the mountains and the seas as their own rich inheritance, exploit the common people 古者,名山大澤不以封,爲下之專利也.山海之利,廣澤之备,天地之藏也,皆宜属少府;陛下不私,以属大司農,以佐助百姓.浮食奇民,好欲擅山海之貨,以致富業,役利細民."[294]

The speakers in this passage take a practice that had originated a few centuries earlier in Qin as a custom of antiquity. Their comments suggest that, as with the taxes from farmland, the income from mountain and marsh was being appropriated by the elite at the expense of the court and government. It is unclear whether this type of land could be bought and sold. Certainly much of this revenue was diverted from the government and was sold in the markets. As the products of the wilds became scarcer, a market grew up in animal products, medicinal plants, fish, and other such products, and the markets reached farther and farther into the hinterlands for materials.

Economic Geography and the Development of Markets

Although the early states and empires never officially promoted commerce, they nonetheless provided the security, currency, and financial organisation necessary for large-scale commerce, and their efforts to curb mercantile activity were rarely very determined. As Robin Yates has shown, the Qin rulers recognised the importance of markets in their economy and in supplying their war machine, and were themselves active in the production of leather, pottery, cloth, transport vehicles, iron, and lacquer, in addition to their agricultural activities.[295] This is a reminder that, although some have likened this period to a proto-capitalist economy, attempting to identify it with a specific European economic system is not especially helpful.[296] States also built roads and canals which greatly facilitated transportation of goods, and made it possible to move large quantities of low and medium priced goods, not just luxury goods.

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[294] *Yantie lun jiaozhu*, ed. Wang Liqi, 6.78; Gale, *Discourses on Salt and Iron*, 34.
[295] Yates, "Slavery in Early China," 314.
[296] For example, Hsu Cho-yun, *Ancient China in Transition: an Analysis of Social Mobility, 722-222 B.C.* (Stanford: Stanford University Press, 1965).

Xunzi recognised this and celebrated the benefits of long-distance trade:

> It is by the Northern Sea that there are fast horses and barking dogs; nonetheless the Central States acquire them, breed them, and put them to use. It is by the Southern Sea that there are feathers and plumes, elephant tusks, rhinoceros hides, copper ores, and cinnabar; still the Central States obtain and process them. It is by the Eastern Sea that there are purple-dye plants, fine white silks, salt, and fish; nonetheless the Central States acquire and use them for food and clothing. It is by the Western Sea that there are skins and hides and multicoloured yak tails; still the Central States acquire them and put them to use. Hence those who dwell near the marshes have adequate supplies of timber and those who live near the mountains have adequate supplies of fish... even though the tiger and leopard are ferocious beasts, the gentleman can have them skinned for his own use 北海則有走馬吠犬焉,然而中國得而畜使之;南海則有羽翮,齒革,曾青,丹干焉,然而中國得而財之;東海則有紫紵(綌),魚,鹽焉，然而中國得而衣食之;西海則有皮革,文旄焉，然而中國得而用之。故澤人足乎木，山人足乎魚…虎豹爲猛矣然君子剝而用之.[297]

This passage shows clearly that the tentacles of commerce were reaching far in every direction to provide both basic commodities and luxury items to the Central States.

Apart from its effects on faraway places, the increase in commerce, especially the growth of a market in grain, had an effect on agricultural production. The relation between farmers growing crops for food and their environment is much different than that between farmers producing saleable commodities and their environment. The impact of subsistence farming is local; nutrients stay nearby and only surrounding areas are affected. Once agricultural goods are exported over long distances the areas of production and consumption are linked, and local ecologies are influenced by distant appetites. Also, once food is a widely available commodity it becomes easier for people, such as the above mentioned *yu* and *heng*, to live in wilder areas and exploit them for sale or trade: "People who live in the mountains and marshes, or on moors and sterile uplands, depend on the effective circulation of goods to satisfy their wants" 山居澤處,蓬蒿磽埆, 財物流通,有以均之.[298]

This long-distance trade extended the environmental impact of consumers far beyond their local areas. The people of the Yellow River area had a much greater

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[297] *Xunzi*, Knoblock tr., 9.232-33.
[298] *Yantie lun jiaozhu*, ed. Wang Liqi, 3.42; Gale, *Discourses on Salt and Iron*, 23.

choice of consumer goods in the early Han dynasty than they had had a few centuries earlier. The products listed in the *Han shu* as being able to make a merchant very rich include liquor, pickles, sauces, syrups, slaughtered livestock, grain, underbrush and stalks of grain for fuel, timber, bamboo, lacquer and lacquered vessels, horses, silk, vegetable fabrics, dried fish, jujubes, fox and sable fur, and chestnuts.[299] At least some of these were probably produced in plantations, orchards and commercial farms. Iron and salt were the most lucrative. Enough so that the Han government made them a government monopoly for several decades beginning in 117 B.C.

Several early texts contain descriptions of the various known regions and their products such as that from the *Xunzi* quoted above. These texts tell us not only where various products were produced, but also what products were lacking in certain areas, and the extent of trade in the period. The longest of these early geographies texts is the *Shanhai jing* 山海經, the *Classic of Mountains and Seas*, a compilation of various texts, which describes hundreds of places, their (usually fantastical) inhabitants, and their products. Although some of these are likely based on real places, the text is important as a source on the way the world was understood at the time rather than a description of reality.[300] The same can be said for *Huainanzi* chapter 4, much of which seems to have been taken from the *Shanhai jing*.[301] Another such text is the *Mu tianzi zhuan* 穆天子傳, which describes the travels of Zhou king Mu through various landscapes. Although much effort has been devoted to identifying the exact locations of the places mentioned in the text, Rémi Mathieu has concluded that the travels should be considered entirely imaginary.[302]

I will focus mainly on the "Yu gong" chapter of the *Shu jing*, the Classic of Documents and Chapter 129 of the *Shi ji*. The former is a description of the nine

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[299] Swann, *Food and Money in Ancient China*, 434-36; *Han shu* 91.3687-89.
[300] Mark Edward Lewis, *The Construction of Space in Early China* (Albany: SUNY Press, 2006), 284-303; Richard Strassberg, tr., *A Chinese Bestiary: Strange Creatures from the Guideways through Mountains and Seas* (Berkeley: University of California Press, 2002).
[301] John S. Major, *Heaven and Earth in Early Han Thought: Chapters Three, Four, and Five of the* Huainanzi (Albany: SUNY Press, 1993), 141-216.
[302] Rémi Mathieu, tr., *Le Mu tianzi zhuan: Traduction annotée, Étude critique* (Paris: Mémoires de l'Institut des Hautes Études Chinoises 9, 1978).

provinces laid out by Yu the Great, which is usually interpreted as referring to real places. Sima Qian's chapter contains a description of various regions of the empire and their marketable goods. It is notable that the first text is several centuries older than the second, and its goods are described in terms of tribute, not commerce, a good example of the transformation in the political economy during those centuries.

I will follow Needham's interpretation of the nine provinces of the "Yu gong," as depicted in his map, below. Although there are other interpretations, it is unlikely that the text refers to much larger areas, or only to the Wei valley, because the products listed from each area generally correspond to those of each region as shown in archaeological and later textual sources.[303] Nonetheless, the borders of his map are speculative. The text was written in the mid-late Eastern Zhou, and the archaic language suggests the earlier part of this period. I will outline some of the tribute goods, which provide information on the economy of each region at the time.

Ji paid tribute in skins. Yan had mulberries and silkworms, and gave lacquer, silk, and patterned fabrics in baskets as tribute. As mentioned above, the black soil of this area suggests recent land clearance. The people of coastal Qing (the Shandong peninsula) gave salt, cloth made of grasses or hemp, and sea products as tribute, while the people of the Tai mountain area gave silk, tin, hemp, pine wood, and strange stones. Xu, just south of Tai mountain, presented earth of five colours, feathers of the variegated pheasant, paulownia trees (*tong* 桐), floating musical stones, oyster pearls, fish, and thin silk tissue. Further south, Yang produced three metals,[304] precious stones, bamboo, ivory, rhinoceros hides, feathers, hair, timber, textiles, and pomelos and other citrus. Inland, Jing gave feathers, hair, rhinoceros skins, ivory, toona mahogany, mulberry wood for bows, juniper (*gua* 栝), arbor vitae (*bo* 柏), grindstones and whetstones, flint arrowheads, cinnabar, bamboos, wood of the arrowthorn shrub (for making arrows), sedge for filtering wine, silk, and big turtles. Yu provided lacquer, hemp cloth, vine cloth, ramie grass cloth, thin silk tissue, floss

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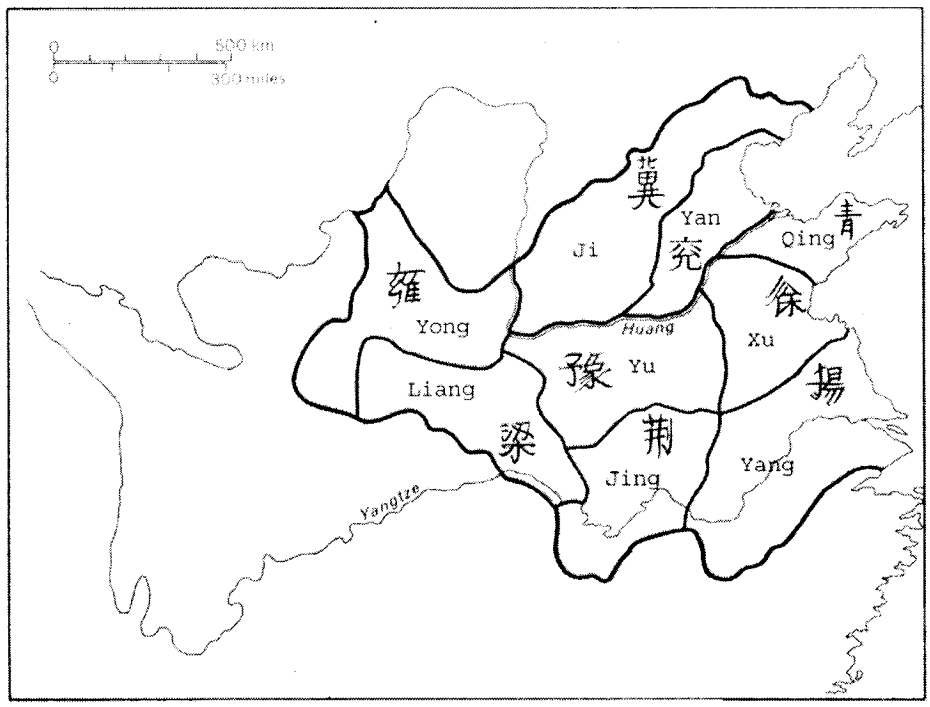
[303] Needham, *Science and Civilisation* 6.1, 77-98; Karlgren, "The Book of Documents," 13-18; Ruan Yuan, *Shisan jing* 1.146-55 Both the *Zhou li* chapter "Zhi fangshi " 職方氏 and Chapter 13 of the *Lüshi chunqiu* include geographies based on nines, but neither are as developed as the "Yu gong."

[304] Needham *Science and Civilisation* 6.1, 88, believes these to be gold, silver, and iron, while Karlgren, "The Book of Documents," 16-17, calls them "three qualities of bronze."



Provinces of the "Yu gong" according to Joseph Needham.[305]

silk for padding clothes and abrasive sand and stones for working hard stones. Liang sent jade, iron, silver, inlaid metal work, flint arrow heads, chime stones, and the hides of black and brown bears, foxes and wild cats. Yong's tribute was jade and other precious stones, and the western tribes provided furs or felt.

The northeastern frontier (Shanxi-SE Liaoning) regions provided skins, showing that the people of the region were herders, while the western frontier provided hides of wild animals. The central region (Yu and Yan) corresponds with the plains, and was weak in resources but strong in craftsmanship, and thus provided textiles and lacquer. Shandong and Jiangsu (Qing and Xu) were not as populated as regions to the east, and provided raw materials from the ocean, including salt, and from the land. The western edge of Qing, which included the state of Lu, was more developed and probably provided the silk, but the mountainous region of Shandong was still forested, and thus provided pine wood. The areas south of the Yellow river (Yang, Jing, Liang), including the Huai, Yangzi and Han river areas, provided a variety of exotic materials, products of the still abundant wild areas, Although its land was considered poor for farming. Apart from the contributions of the western

[305] Needham, *Science and Civilisation* 6.1, 84.

tribes, Yong, which included the Wei valley, provided only precious stones. But its soil was rated as highest quality, so its taxes, along with those of other central regions, were probably paid mostly in grain.

How had things changed a few centuries later when Sima Qian similarly listed the products of the empire?[306] One noticeable difference is that the imperial domain had grown. The "Yu gong" describes areas of Shandong and Shaanxi as inhabited by other ethnic groups, and does not describe Sichuan or anywhere south of the Yangzi. By the early Han, Shandong has been fully assimilated, parts of Sichuan have been incorporated, and areas far south of the Yangzi are known.

In Sima Qian's time most areas were still described using the names they had had during the Warring States. The Yan area, around Beijing, produced fish, salt, jujubes and chestnuts. Just west, Zhongshan produced no commodities; the soil was poor and the population large 中山地薄人聚.[307] Further west, and north, the Rong and Di's herds are described as "one of the riches of the empire." South of Yan, Qi is a large and fertile area that produces fish, salt and fine silks and other textiles. The regions of Zou and Lu are overpopulated and, although they make silk and hemp, "no resources are to be gained from forests or lakes. Land is scarce and population numerous, so the people are very frugal" 無林澤之饒. 地小人聚, 儉嗇." West of this, in Liang and Song, although "there are no riches to be gained from the mountains and rivers, the people are willing to put up with poor clothing and food, and even manage to save up a surplus" 雖無山川之饒, 能惡衣食, 致其蓄藏.

Things are even worse to the south in western Chu (Anhui/Henan/Hubei border area), where "the land is barren and there is little surplus to be stored up" 地薄, 寡於積聚. Farther east, "the region north of the Yi and Si rivers is suitable for growing the five types of grain, mulberries, and hemp, and for raising the six kinds of domestic animals. Land is scarce and the population dense, and the area often suffers from floods and drought. The people therefore take good care to lay away stores of food" 沂, 泗水以北, 宜五穀桑麻六畜, 地小人聚, 數被水旱之害, 民

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[306] Sima Qian, *Shi ji* 129.3253-83; Watson, *Records of the Grand Historian: Han II*, 441-46; Also partly translated and discussed in Swann, *Food and Money in Ancient China*, 437-48.

[307] All quotes from Sima Qian, *Shi ji* 129.3270, 3263-67; Watson, *Records of the Grand Historian: Han II*, 442-46.

好畜藏. The area within the pass is strong in agriculture, but overpopulated, so people also depend on trade. The three areas of Henei, Hedong and Henan, roughly the area between the eastward bend of the Yellow River and Zhengzhou, are described as the heartland of the earlier dynasties, inhabited for thousands of years and densely populated. Farther south, southern Chu produces hides, dried fish, and lumber, and areas south of the Yangzi, although unhealthy, produce bamboo, timber, and some gold and lead. Farther south yet, pearls, rhinoceros horn, tortoise shell, fruit and cloth are produced. By this time, the Sichuan basin was also a source of materials such as ginger, cinnabar, copper, iron, bamboo and wooden implements.

Thus we can see that at this time the Wei and Yellow River valleys and the North China Plain were crowded, and the plain was overpopulated to the point of poverty. This corresponds well with the most densely populated areas according to the census of 2 A.D., as shown on page 61. It is significant that the North China Plain was the poorest. Although the valleys to the west were also densely populated, they were closer to the products of the mountains and the marshes than were the people of the plain, which had probably been completely cleared.

It can be imagined that the density of population must have created problems of water pollution in the region, especially around cities. Although this thesis has focused on the great majority of the land that was rural and agricultural, increasing urbanisation had its own effects on the environment. Like the iron smelters mentioned above, cities tend to pollute and overexploit their surroundings. However, cities consumed food from a much wider area than they deposited night soil, collecting rather than depleting nutrients.

The texts discussed in this section show which areas were providing raw materials, and that the overpopulated central states were drawing on the resources of all the surrounding regions. The difference between the "Yu gong" and the *Shi ji* likewise illustrates a political transformation: during the Zhou political control was regional, and the tribute relationship was a way of demonstrating membership in the Zhou polity, while by Han emperor Wu's time all these areas were firmly under

centralised political control and the commodities were all traded and taxed within the single empire.

Conclusion

In general, written sources provide information on the relationship between humans and the environment, but are weak on ecological information. They are particularly rich in information on the policies and logic of higher levels of government, which became much more important as their power extended over more and more land, a process described in several texts. Many economic activities are covered by texts, most notably agriculture, but also herding, fishing, hunting, logging, and trade. Although textual evidence is usually the more important source on these subjects, archaeology also provides information, especially on tools, that helps with the interpretation of texts.

Textual information on the political and economic transformation of the period is the biggest strength of the written sources, most of which are connected with politics in some way. Texts also associate the changes with stories and with individual actions, a much more human way of understanding environmental change than that provided by palynology and archaeology. For example, instead of just describing the Zheng Guo canal in terms of its economic importance, Sima Qian tells how the Zheng Guo canal was originally a plot conceived by enemies to waste Qin resources, but eventually contributed to the Qin victory. The story of water control projects is known almost entirely through textual sources, and some areas have been transformed so thoroughly that only textual sources, by detailing all the various building and digging projects, can help reconstruct earlier waterways. But these do not tell us, for example, what plants grew and what animals inhabited the brackish land that was cleared by irrigation projects, only that land previously useless to humans was made agriculturally productive.

From a scientific point of view, textual sources are not very helpful in understanding the ecology of the region, but are quite useful in illuminating the human ecosystem, as shown in the overview of plants mentioned in the *Odes*. However, the ambiguities that become obvious when interpreting the same list also

highlight the weaknesses of textual sources for ecological history. Although textual sources can be used to outline changes in taxation and in administrative boundaries during the period, they do not tell us whether there were forests or grasslands on Loess Plateau. Only with the economic tracts of the Han do we start to have information directly relevant to those questions, and even then all we know is which areas were overpopulated, which were barren, and what products each region produced for export.

As is obvious from the above chapter, many of the environmental changes that occurred during the period are known only from the mechanism that caused them, such as colonisation, state expansion, and increased exploitation of forests. We can only guess at what the ecological changes were. However, when we compare this to the vagueness of pollen studies or even archaeological excavations that depend entirely on comparing city wall construction or pottery styles across large regions, textual sources seem coherent and human.

Chapter 5: Conclusion

Despite several thousand of years of agricultural society, wild animals and ecosystems could still be found through most of the Yellow River region in the early centuries of the Zhou. The most densely populated area was the lowlands between the lower Wei valley and the eastern plains, but even there enough hunting occurred to show that wild animals were plentiful, and there was still land to be colonised.

The archaeological record shows clearly that the region had been full of human settlements for thousands of years before the first extant inscriptions were written in the Shang. These settlements gradually increased in size and complexity, with evidence of warfare by the Longshan period and military colonisation with the Erlitou and Erligang cultures. But written evidence from the Shang and Western Zhou shows that rulership was still based largely on kinship ties, with only the central region being ruled directly by the ruler. The decline of the power of the central power during the late Western and Eastern Zhou left its previous fiefs effectively independent. The smaller size of these polities allowed the central rulers to gradually assume control over their entire territory by means of an appointed bureaucracy, a change that was necessary in order to orient the economy of the states towards production for the support of constant military campaigns. Although families continued to play an important role in rulership, the bureaucratic system eliminated the legal autonomy of regional lords and replaced them with administrators, allowed the ruler more direct control over his domain. One of these states, Qin, implemented this centralised system across a vast area following its conquest of the other states which was completed in 221 B.C. The early Han period was less centralised, major regions being ruled by relatives of the emperor, but Han emperor Wu returned to the strong centralisation of the Qin, as have strong rulers throughout Chinese history.

The militaristic nature of the large Eastern Zhou states and the early empires meant that their unprecedented power over their entire domain was exercised with the intention of increasing population and production, using as much land as they could for production, agricultural or otherwise. Where once the ruler had been

entitled to corvée labour and a percentage of crops, he was now theoretically entitled to a percentage of everything that was produced or harvested in his entire domain Even the exploitation of the products of wild land was organised and controlled by government officials. Two of the most environmentally significant actions of the government were the building of large canals for irrigation and transport, and the creation of the Han state iron works, which produced enormous amounts of high-quality iron implements. The archaeological record makes clear that iron tools became extremely common in the Warring States and were being mass-produced by the Han, a development that multiplied considerably the power of individual peasants or labourers to modify the environment.

In terms of ecology, the region was large enough that it must have had a variety of distinctive environments and inhabitants that we can know only vaguely. All of the evidence suggests that while the plain would have had significant forests and the Loess Plateau was dominated by steppe, the former would have contained extensive grassland and wetlands, and the wetter areas of the plateau were forested. Although much more work could be done on this subject, the complete transformation of the area, especially the removal of most of its natural animals, means that reconstructing the ecology of the early period will always require a mixture of ecological insight and imagination. The elaphure provides an example of just how much the area's ecology has changed.

The elaphure is now extinct in the wild, but was once one of the most common mammals in the region. Its ideal habitat seems to have been the mixed forest-grassland-wetland of the plain and valleys, also the best land for agriculture. The remains of over 1000 elaphures unearthed at Anyang, as well as the herds of deer described in the *Odes* and the frequent references to hunting elaphures in other texts show that they were probably one of the dominant animals of the region during the Neolithic. At one time large herds of these deer would have roamed the North China Plain, probably maintaining open areas that would otherwise have been forested. By the Han, elaphures were discussed as animals found in the mountains because the large herds were gone, and remaining elaphures could only survive in

land unsuitable for agriculture. This example could be multiplied, although some animals are more visible in the textual and archaeological records than others. Many of the species of birds, amphibians, mammals, reptiles, and insects that inhabited the region have been displaced or eliminated, and the ecosystems in which they lived can be reconstructed only imprecisely.

Sima Qian's description of the numerous areas that were densely populated in the early Han shows that by his time much of the region had been entirely humanised. The environment of much of the plain and the lower Yellow River valley would have been more similar to the present environment than to that of one thousand years earlier. However, the lands on the periphery of the agricultural centres were still quite wild, in marked contrast to the present. Another major difference with the present is that the Yellow River region was at that period by far the most densely populated region in East Asia. This was the region in which the environmental problems based on overpopulation were first encountered, and the region from which these types of problems spread.

With this we can return to Mencius' point: if we have seen a mountain long after it has been deforested and constantly overgrazed it is very difficult to imagine that it was once covered in beautiful forest. This is very much the case with North China, where the current overpopulated and humanised environment has existed since the earliest histories were written. The only reference many people in the region could make with elephants and large herds of deer wandering through forests and grasslands would be from nature programs on television. Very few people in East China have ever visited environments that are not thoroughly dominated by human activity. The current environmental problems of the region are severe enough to threaten human health and survival; we can only dream of the time when environmental problems, like the destruction of natural vegetation and large mammals, still existed. The barren state of the region is often stated as fact, and few people understand the extent to which the environment of the area has changed. It is hoped that a description, however vague, of this environment and its transformation in the early period will make clear that it has not always been thus.

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