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Perennial Plants and Wealth Inequality

Exploring the correlation between high perenniality and low wealth inequality in Çatalhöyük, Pompeii, Cahokia and Corsica

Table of Contents

Introduction

The following work is intended to serve as an exploration into the relationships between wealth inequality of societies and the degree to which their food production relies on perennial plants[1].

Considering specific traits of a group of plants under cultivation is not usually considered part of socioeconomics. However, there are different qualities that make certain plants more or less suitable to be under the cultivation of one or another social organization. One such quality is whether a plant is annual or perennial. Annual crop plants tend to demand inputs when under cultivation and only succeed in disturbed sites free from competition. Perennial plants by contrast, are only planted once, grow more productive as they mature and enrich the soils on which they grow. In order to discuss in broad terms both specific plant qualities and the economic structures of the people who are observed to take their nourishment from them, this paper will set out to analyse what forms of social organizations tend to accompany the cultivation of perennial plants. The central hypothesis is that a higher degree of perenniality[2] is correlated with a lower Gini[3] coefficient of wealth inequality. Four case studies (see Table 1) will be discussed in relation to two main theories in order to evaluate the hypothesized correlation.

Before moving on to those cases and theories it might prove useful to consider, keeping both perenniality and wealth inequality in mind, what is termed the "Neolithic revolution". The origins of sedentary grain cultivating society can be understood both as a move towards greater wealth inequality and away from reliance on perennial plants and thus provides a useful introduction to the ideas presented in this work.

Literature regarding the origins of civilization consistently fails to mention the societal implications of the transition from relying on perennial plants to the mass cultivation of annual grains. Despite there being some discussion regarding the domestication of annual grains and their suitability for mass cultivation (see for instance (Diamond, 1997; Harari, 2012; Scott, 2017)), discussion of how cultivation of annual plants compares to cultivation of perennial plants is lacking. Even though there is consistent reference to the reliance on perennial plants by hunting and foraging subsistence that preceded or lived in the hinterlands of sedentary grain cultivating communities, authors do not argue from the perspective of plant communities that the cultivation of one group of plants might be more or less complementary to one or another social organization.

One of the central arguments in this paper is that the transition from high reliance on perennial plants to relying on annual plants is non-trivial. Including

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[1] This paper works with a slightly adjusted definition of perennial plants: namely all those that are not annual plants. Common definitions usually exclude biennial and triennial plants from perennial plants as well.

[2] For lack of a better word, *perenniality* is used here to refer to 'the degree to which a society depends on perennial plants in its food production' (see **Discussion**).

[3] The Gini coefficient of wealth inequality is a standard measurement for wealth inequality. A coefficient of 1 implies all wealth is concentrated with one member and 0 implies even distribution.

the perennial-annual perspective in analysis can yield new insights regarding the maintenance of highly stratified societies as well of the ecological breakdown that seems to accompany almost all societies practicing intensive cultivation of annual plants. In a broader sense this paper rests on the notion that contemporary academics can benefit from the fusion of knowledge of ecology and socioeconomics.

Grain and hierarchal early states

In his *Against the Grain: A Deep History of the Earliest States* (2017), James C. Scott's argues that the cultivation of annual grain plants was an essential ingredient in the formation of early states. The work focuses on the earliest states in Mesopotamia where cropland was mostly devoted to the cultivation of grains. These are annual plants with qualities that make them especially suitable for a highly centralized bureaucracy. Grains tend to preserve well, opening up the possibility of a centralized location of storage. Grains grow mainly above ground as opposed to for example tuber crops, which can to some extent be hidden away. Furthermore, grains ripen all at once, at a predictable time. These qualities together make grain an excellent crop to be taxed and distributed by a centralized bureaucracy. It is hard to imagine any other plant, annual or perennial that could have replaced it as the subsistence of highly stratified sedentary (proto)-states (Scott, 2017).

What Scott illustrated in his book is in effect one example of a larger idea: that the plants that humans cultivate, and the methods they use to do so, are interrelated with the way they organize relations among themselves. The earliest states where archaeologists witness the mass cultivation of grains are extremely hierarchal societies. Grain cultivation facilitated the accumulation of wealth that manifested in novel phenomena. Consider for example the erection of pyramids, the institution of debt peonage (Graeber, 2011) and the eruption of mass violence over concentrated resources. One of the most conspicuous archaeological finds in Southern Mesopotamia are small, uniform bowls, presumably to feed similarly rationed portions of grains to a large number of people (Scott, 2017).

The socio-ecology of early Mesopotamian states was riddled with problems. The onset of new strains of zoonotic diseases must have sporadically ravaged early sedentary populations. As the settlements grew, so did the demands for timber and up river deforestation. This is attested to as early as the Epic of Gilgamesh (Andrew George, 1999) and presumably lead to increasing environmental disasters as the watershed was compromised[4] (Scott, 2017). The removal of trees seemed not to have deterred the socio-ecological pattern in the long run. The mass cultivation of grains continued by replacing wheat with barley as the latter adapted better to extreme conditions and increasing salinity of the soil (Zohary et al., 2013). Barbarians[5] proved to be another threat to early states as

[4] This is a problem that will be touched upon again when discussing Cahokia. Here too the up river removal of perennial plants for construction, fuel or to make way for other crops, accompanied intense cultivation of annuals in the floodplains, eventually leading to the deterioration of the environment.

[5] The term 'Barbarian' is used provocatively by Scott in *Against the Grain* (2017) and the practice continues here. The word was used by sedentary grain cultivating communities to refer to those people living outside their immediate territory; see for instance Epic of Gilgamesh (Andrew

they often looted settlements to their own benefit (Scott, 2017). How perenniality ties into the relationship between population centres and peoples living on their periphery will be touched upon again later in this paper (See **Marginal and Hinterlands**).

Case studies

Four cases have been looked at in order to evaluate the hypothesis and discuss the relationship between perenniality and social organization generally. For three of the four cases Gini coefficients for wealth inequality have been found alongside other information on social organization. For all four cases literature was assessed regarding the cultivation of perennial crops. Here follows a brief overview of the cases before discussion of two theories pertaining to the hypothesised correlation between high perenniality and low wealth inequality.

Çatalhöyük

This case study concerns the Çatalhöyük archaeological site in Southern Anatolia. Archaeological sources for the reconstruction of a Gini coefficient date to between 6500 – 6400 BC and are based on the distribution of house sizes (Fochesato, 2018). The archaeobotanical source used in order to establish perenniality dates to between 7100 – 5500 BC. This source consists of 630 samples taken from hearths, ovens, rake outs, 'dirty' floors and burned buildings (Bogaard et al., 2017). Despite its antiquity, this archaeobotanical record offers exceptional insight into the plant uses of ancient societies.

Climatic reconstruction indicates that the site could be categorized as "humid subtropical deciduous woodland" (Bogaard et al., 2017). It was situated in a "moist and rainy" wetland crossing different zones with access to fish, birdlife, suitable cropland as well as herds of animals (*The Rise and Fall of a Neolithic Town*, n.d.).

Pompeii

Archaeological sources for the reconstruction of a Gini coefficient date to 79 AD and are based on the distribution of house sizes (Fochesato, 2018). The archaeobotanical sources are accounts by ancient authors, a pollen analysis and a survey of archaeological evidence of vegetable remains found in Pompeii and surrounding cities dating to before 79 AD (Flohr & Wilson, 2017).

Pompeii lies at the foot of the Vesuvius volcano, surrounded by fertile soils. Rainfall used to be higher than the current 550 mm/year. Agricultural production was organized by the division of land into relatively small estates, whose specific production depended on its elevation (Flohr & Wilson, 2017). The town was well connected through roads to other cities and a port near the modern day city of Naples. The case raises interesting issues when it comes to evaluating perenniality (see **Further research**).

George, 1999) and Scott (2017). It is provocative because barbarians were often much healthier than their grain-cultivating counterparts (Harari, 2012). This provocative terminology applies similarly well to meetings between chestnut eating indigenous peoples in what is now New England, and the arriving, sickly looking, Europeans (Mann, 2005).

Cahokia

The Gini coefficient is based on distributions of house sizes dating to between 1075 – 1300 AD (Fochesato, 2018; Kohler et al., 2017). Archaeobotanical evidence concerning perenniality consists of a fecal sample from a cave dating to between 1000 – 300 BC and a survey of vegetal remains found in a mound thought to contain the remnants of one or more feasts that took place in Cahokia. These date to between 1050 – 1100 AD and their contents are appreciated as having yielded spectacular insight (Fritz, 2019).

Cahokia is given as a name to a host of peoples who settled in the floodplain in the American Bottom, east of modern day St. Louis, along the Mississippi river. Evidence of human settlement and anthropogenic changes to the landscape are abundant before the 'big bang' during which the population in the floodplain might have spiked as high as 10,000 people in the early 12th century. Depopulation of the area followed quickly after maximum population density was reached (Fritz, 2019).

Corsica

No calculations of a Gini coefficient were found for Corsica despite substantial information on economics and social organization, going back as far as 1548. Furthermore, sources on perenniality are detailed specifically (Michon, 2011; Perry, 1967; Wilson, 1988). These are based on two agricultural surveys; *Plan Terrier* (1792) and the *Agricultural Enquiry* (1867).

Corsica is an island in the Mediterranean. Its people were under the rule of Genoa since 1284 before establishing a self-proclaimed republic in 1755. In 1768 Genoa ceded influence over the island to France who went on to violently establish its rule in 1769.

Case Name (*Space, Time*)	Evidence for Perenniality	Evidence for Social Structure	Gini	Other Sources
Çatalhöyük (*Anatolia, c. 8000-5500BC*)	(Bogaard et al., 2017) (Asouti & Hather, 2001)	**GINI:** (Fochesato, 2018), (Wright, 2014)	**0.35**	(Asouti & Hather, 2001), http://catalhoyuk.ege.edu.tr/ (Scott, 2017),
Pompeii (*Italian peninsula, 100BC – 79AD*)	(Flohr & Wilson, 2017)	**GINI**: (Milanovic et al., 2008), (Kohler et al., 2017)	**0.54**	(Murphy et al., 2013)
Cahokia, (*American Bottom, 1050-1400AD)*	(Fritz, 2019)	**GINI**: (Fochesato, 2018), (Kohler et al., 2017)	**0.34**	(Woods, 2004)
Corsica Castagnetu (*Corsica*, *16th - 19th century*)	(Perry, 1967) (Wilson, 1988) (Michon, 2011)	(Wilson, 2003)	-	(Michon, 2011), (Wolpert et al., 2020)

Table 1: Case Studies Overview. The case studies presented above have been chosen in order to substantiate analysis of the hypothesis. Applying the theories to the cases provides useful insight into the complex relationship between plant qualities and economic structures. The cases were chosen for their spatial and temporal distribution as well as the availability of a Gini coefficient for wealth inequality and evidence regarding perenniality.

Intergenerational Wealth Transmission

More research is being done recently on ancient wealth inequalities. Walter Scheidel (2017) comments that his work *The Great Leveler: Violence and the History of Inequality from the Stone Age to the Twenty-First Century* would not have been possible 10 years ago. Rising popularity in this topic is undoubtedly also due in part to Thomas Piketty whose works *Capital in the Twenty-First Century* (2014) and more recently *Captial and Ideology* (2019) have inspired many to look at historical trends of wealth inequality.

Among the most pressing issues is how exactly the shift to higher degrees of wealth inequality occurred (Scheidel, 2017). Earlier hypotheses that the shift from high mobility to sedentary living necessitated a parallel shift from egalitarianism to stable hierarchies have been seriously challenged. Sedentary societies living on the interface of several different biomes predate grain cultivating societies in Mesopotamia by hundreds of years (Scott, 2017). Moreover, archaeological remains have been found of foragers buried with

elaborate relics that must have taken hundreds of man-hours to complete. In some cases, those buried were adolescents or children – pointing to substantial wealth disparities, possibly even hereditary in nature (Scheidel, 2017). Excavations of archaeological remains of sedentary peoples like those that inhabited Çatalhöyük have refuted the notion that sedentary societies are necessarily also strongly hierarchal (Bogaard et al., 2019). Most probably, peoples at Çatalhöyük practiced a mix of annual cropping, wild foraging and possibly herding yet seem to have been egalitarian in their sharing of resources (Wright, 2014). The high mobility of hunter gatherer societies does not explain their typical social organizations as it has been found they are not uniquely egalitarian among different forms of subsistence (Mulder et al., 2009).

A recent anthropological study has attempted to address these issues by redefining wealth into three types: relational, embodied and material. The authors evaluated their relative importance in four different production systems: hunter-gatherers, horticulturalists, pastoralists and agriculturalists, and to what extent they can be transmitted across generations (Smith et al., 2010). Among their findings is that the intergenerational transmissibility of wealth is a predictor of wealth inequality in societies. Also, societies that emphasize material wealth above relational or embodied wealth tend to have greater wealth inequality as this type of wealth is more easily transmitted across generations. Hunter-gatherers and horticulturalists do not show markedly different transmissibility of wealth or wealth inequalities but they are both lower than the pastoralist and agriculturalist societies (Smith et al., 2010). The authors do not mention any details regarding the plant groups associated with the different production systems and what qualities these plants might have that could have facilitated the endurance of wealth inequalities in these societies.

Transmissibility of Perennial Plants

The paper by Smith et al. (2010) can help explain why perenniality would be correlated with higher wealth inequality. In pre-industrial societies, where wealth tends to be closely defined by the access, ability and volume of food production (Piketty, 2019), the transmissibility of the means of food production is crucial in the development of wealth inequality. The case of Çatalhöyük suggests that Neolithic people were well aware of the importance of food in the development of wealth inequality. Research was done to investigate the distribution of food processing tools in Çatalhöyük and found that all households had access to them. The exception was large millstones (querns) that were harder to procure and which were possibly shared between households. The author notes that most of these seem to have been deliberately destroyed, indicating an active engagement with the idea of wealth transmission through the means of food production (Wright, 2014).

Societies with a higher perenniality tend to have lower wealth inequalities because the means of their food production is less likely to be transmitted across generations within households. This seems to be the case for both Çatalhöyük and Corsican society.

Çatalhöyük and semi-wild perennial stands

The population of Çatalhöyük might have reached somewhere in the low thousands at 6500 BC (Bogaard et al., 2017). Evidence suggests that much like

early sedentary communities in southern Mesopotamia, the Çatalhöyük community settled in an ecologically rich area with access to a wide variety of food sources. The archaeobotanical evidence suggests the inhabitants cultivated cereals and pulses and relied on a variety of perennial plants such as fruit and nut species. These perennials are often referred to as wild but were likely at least partially managed and protected (Bogaard et al., 2017). In so far as these perennial plants were not definitively within the realm of a household but somewhere in between domesticated and wild – it is reasonable to assume that these food sources were not considered the property of a single household. If this were the case then the wealth derived from semi-managed perennial plants would have fallen outside of wealth that was transmissible across generations within a household.

There is evidence that the terrestrial biome that surrounded the Çatalhöyük settlement was altered by (and to the benefit of) its inhabitants. While changes were often assumed to be the result of climate shifts, Asouti & Hather (2001) argue that the greater appearance of perennial legume (nitrogen-fixing) trees, cherry-like trees (*Prunus* spp.) and pine trees (*Pinus* spp.) could also point to anthropogenic interventions. Intervention by selection of beneficial perennial plants in surrounding terrestrial biomes will be touched upon again when discussing Cahokia (see **Cahokia: floodplain and upland communities**).

While such interventions must often have improved the terrestrial biome in favour of human food production (for example by propagation of edible species), there is evidence that negative consequences of such interventions coincided with a changing social dynamic. The record suggests that inhabitants shifted from oak (*Quercus* spp.) wood to juniper (*Juniperus* spp.) wood for fuel use (Asouti & Hather, 2001; Styring et al., 2017). This could have lead to gradual acidification of the biome and decreased drought tolerance. Furthermore, as acorns also provided a source of nutrition for the people of Çatalhöyük (Bogaard et al., 2017) this shift entails a decrease in their perenniality and a move away from Bogaard's (2009) description of the site as horticultural. This shift corresponded with Wright's (2014) observation that towards the more recent archaeological layers, there are indications of a newly emerging, less egalitarian social complexity.

Corsican land and tree rights

The people of Corsica have a long history of cultivating chestnut trees (*Castanea sativa).* Its uses include the production of nuts (for human consumption as well as fodder for livestock), the production of tannins, timber and fuel. Chestnut cultivation in Corsica expanded in the first half of the 19th century, peaking somewhere towards the end of the century. Chestnut cultivation was abandoned for much of the 20th century until a renaissance in the 1980's (Wolpert et al., 2020). The history of chestnut cultivation is embedded in the Corsicans' cultural identity by maintaining it in rejection of external pressures. At a time when 88% of village lands were under chestnut cultivation, Louis XV's restricts the planting of new plantations saying the chestnut "deprives the island from the enormous

advantages it could draw from the cultivation of wheat and all sort of grains"[6] (Michon, 2011).
In 1792, in one region of Corsica, no commune had less than 50% of its cultivable land dedicated to chestnuts while many had dedicated more than 95% (Perry, 1967). Despite the French authorities claiming that the chestnut was the food of the laziness because it does not require any cultivation, chestnut cultivation expanded in the half century afterwards (Michon, 2011). Namely, in 1846, 300 out of 355 villages on Corsica cultivated chestnut trees (Wilson, 1988).
Corsica, as a society as a whole, had a high perenniality but the land and tree ownership rules ensured that the wealth derived from chestnut trees did not lead to the concentration of wealth in the hands of a few. Although individual chestnut trees were usually privately owned, they were often planted on land in collective ownership. Most households in Corsica had access to some land and large-scale property did not exist. In 1867, 93% of properties were less than 15 hectares and in one specific region, only 2 out of 151 estates were bigger than 7 hectares. Even on private lands there were regulations. Probably the most important of these was that private land was also open to communal village flocks of sheep. Hereby communal flocks would be released into private and common property after the chestnut harvest (Wilson, 1988). The system seems to have ensured that even small landowners had some private land besides access to common land. In the 1850's, traveller Gregorovius wrote that "Perhaps there is nowhere in the world such democratic uniformity of life as in this island, where differences of rank are scarcely perceptible" – a view echoed by many visitors (Wilson, 1988).

Corsica differs from Çatalhöyük in that the perennial plants they harvested from were explicitly considered to be under management. However, in both cases cultural norms regarding ownership of the perennial plants, or the land they stood on, ensured that the wealth derived from perennial plants was not transmitted across generations within households. In both cases a high perenniality concurred with social organizations that prevented perennial plants from contributing to the establishment of wealth inequalities.

Marginal and Hinterlands

Perennial plants tend to be less demanding than annual plants. This was a characteristic noted by French authorities with respect to the Corsican chestnut tree (See **Corsican land and tree rights**) and tends to be true for most cropping woody plants. Once they are established they need little if any maintenance to produce. They are also less demanding of soil fertility and more resilient to climatic extremes such as strong winds and drought. Perennial plants can thus ensure a production on those lands that are less suitable to the energy intensive cultivation of annual plants, which is preferably done on flat and fertile terrain.
The second theory that sheds light on why perenniality could be correlated with lower wealth inequalities rests on the idea that populations with high perenniality live in the hinterlands of political centres where production is

[6] This quote is taken from Michon (2011); "(as stated in Louis XV's ordinance of June 22nd, 1771, restricting new plantations: Arch. 1771, as cited in Pitte 1986:117)".

dominated by annual plants. Correlated with this imbalance in the production of perennials versus annual plants is that the hinterland populations tend to have lower levels of wealth inequalities than their counterparts living in the political centres. The relationship between hinterland and central populations can be one of active cooperation, by trade and exchange of ideas, or of resistance to one another, where the hinterland population is resisting authority from the centre in order to maintain autonomy. In either case, the different qualities of the plants cultivated by the hinterland and the central populations are associated with social organizations that differ in their wealth inequalities.

Cahokia: floodplain and upland communities

Before the 'Big Bang' of population density in the floodplain of what is now called Cahokia, the peoples inhabiting the American Bottom ate from and cultivated stands of perennial plants. Similar to Çatalhöyük, researchers believe the harvesting of perennial plants went hand in hand with forms of management that blur the lines drawn between wild and domesticated.

Fire was probably used to suppress growth under favourable plants as early as 3000 BC (Fritz, 2019). Evidence from an archaeological site dating to 1800 – 1700 BC demonstrates peoples' dependence on a host of perennial plants: black walnut (*Juglans nigra*), butternut (*Juglans cinerea*), hickory nuts (*Carya* spp.), acorns (*Quercus* spp.), persimmons (*Dyospyrus* spp.), elderberry (*Sambucus* spp.), and hazelnuts (*Corylus* spp.). In a fecal sample dating to 1000 – 300 BC, at least 20% of the fecal bulk can be attributed to nuts (mostly hickory) and fruit seeds (Fritz, 2019).

The evidence suggests that besides cultivating annual crops and hunting a variety of animals, the populations inhabiting the American Bottom strongly depended on perennial plants. This dependency persisted even until up to 10,000 people settled in the Cahokia floodplain in the 11th and 12th centuries. Nut trees were probably removed from the floodplain in the early phase of expansion to make way for annual croplands and to harvest fuel and timber (Fritz, 2019; Woods, 2004). However, hickory nut oil still served as the cooking oil in which many foods were prepared (Fritz, 2019). This suggests that a trading network arose between floodplain and upland communities where perennial plants such as hickory nuts and a variety of fruits were traded for items with floodplain communities. Along with the influence that might have spread hundreds of kilometres up and down the Mississippi river, networks of trade developed so that perennial plants were still widely used despite the felling of trees and the focus on intense annual cultivation in the floodplain.

Most researchers believe that Cahokia served as a cultural hub and religious centre for people inhabiting the American Bottom and long stretches along the Mississippi river. Archaeobotanical evidence from what has been interpreted to be the remains of several large feasts dating to 1000 – 1200 BC suggest an on-going dependency on perennial plants. Along with the species mentioned earlier, traces of a variety of fruits were found: plum/cherry (*Prunus* spp.), bramble berry (*Rubus* spp.), grape (*Vitis* spp.), mulberry (*Morus* spp.) and more (Fritz, 2019).

The floodplain society of Cahokia went through substantial changes during the 'Big Bang' to become the 'first North American city' (Fritz, 2019). The Cahokia settlement is believed to have been an ethnically and linguistically diverse place

and that at times of ceremony, tens of thousands of people from the hinterlands would have gathered in the city. The social organization that dominated in Cahokia is largely unclear despite some researchers having suggested that there were definitely elite people with hereditary positions of authority (Fritz, 2019). If this was the case, it is reasonable to suggest that such authority would have had modest influence in the periphery of the political centre. Namely, the subsistence of hinterland people seems not to have changed substantially with the advent of a high population density in the floodplain (Fritz, 2019). It is plausible that if the 'Big Bang' was followed by the development of an elite hereditary class and associated skew of wealth distribution, this novel social structure could only have had limited effects on the less densely populated hinterlands, despite frequent interaction.

In contrast with its settlement, the reasons for the depopulation of Cahokia are much clearer. Similar to early Mesopotamian states, unsustainable felling of perennial plants in the watershed led to environmental degradation. Unseasonable flooding during the summer period probably harmed annual crops in the floodplain. Increased rates of sedimentation would have created further problems of standing water and subsequent suffocation of annual plants (Woods, 2004). The presence of a darkening soil horizon points to the recovery of vegetation on slopes in the watershed. These correspond to the time of depopulation of the Cahokia settlement – suggesting the primacy of tree felling among the reasons for its decline (Woods, 2004). The fact that the floodplain communities disappeared over time is non-trivial and intimately related to the plants they cultivated. Those communities that cultivated perennial plants in the uplands presumably continued subsisting.

Corsican chestnut resistance

The case of Corsica is different in that the relationship between the islanders and the French political centre was characterized by imposing authority on one side and conscious resistance on the other. The higher perenniality of the hinterland Corsicans coincided with an active struggle to maintain a more egalitarian autonomy in the face of the French political centre which in turn was characterized by steep wealth inequalities (Piketty, 2019).

Michon (2011) writes that "successive chestnut policies largely relied on the perception of native Corsicans as backward, amoral, and violent salvages reluctant to adopt civilized agriculture and modern social institutions such as land property, wage labor, or capital accumulation." In 1854, France passed a law aimed to abolish the practice of communal land use (See **Corsican land and tree rights**) and encourage partitioning of common land. This law had some effect in the coastal areas but barely so in the less accessible interior.

The maintenance of an egalitarian autonomy in the face of French authorities was facilitated by the cultivation of chestnut trees. One of the reasons why France had difficulty imposing their authority beyond the coastal areas was because Corsican dissidents were able to retreat into the marginal hill lands where they were still able to produce abundant chestnuts. The chestnut tree allowed Corsicans to produce what is often called the 'bread of the poor' on lands that are unsuitable to the cultivation of most annual crops.

In the cases of Corsica, and possibly Cahokia, the higher perenniality of hinterland populations with respect to those living in the political centres coincided with a more even distribution of wealth. That perennial plants can produce crops in marginal lands, which are sometimes populated by more egalitarian societies than those living in political centres, can help explain why perenniality would be inversely correlated with wealth inequality.

Discussion

The data collected as part of this research was too meagre to meaningfully test for correlation between high perenniality and low Gini coefficients of wealth inequality. A dataset would have to be compiled containing a more extensive set of data points with perenniality and Gini coefficients for wealth inequality.

Such an undertaking would also necessitate the formulation of a conceptual framework to translate varied sources of evidence on perenniality (see **Case Studies**) into a standardized metric. This metric could consist of the percentage of perennial plant species cultivated, area of cropland dedicated to perennial plants, portion of diet coming from perennial plants, etc. The benefits and drawbacks of possible metrics warrant further discussion. Data collection on wealth inequality also poses challenges, especially for pre-industrial societies, but in general, research concerning data collection and calculation of Gini coefficients is much more advanced.

Further research

Despite not having yielded an answer, the hypothesis put forward in this research has the potential to host interesting discussions. These regard the origins of institutionalized wealth inequality, plant characteristics and their implications for the organization of labour and the distribution of wealth, the relations between political centres and hinterlands and more.

One case that has not been touched upon is that of Pompeii. This is because the case of Pompeii raises unique problems for evaluating this hypothesis. The hypothesis rests implicitly on the assumption that a society is isolated such that its perenniality and Gini coefficient for wealth inequality can be assembled as a data point without it being contingent upon the perenniality and wealth inequality of another society. Pompeii is more difficult to analyse in isolation than the other cases described in this study because Pompeian society was deeply embedded in a regional and intercontinental network of exchange. Agricultural production was organized by specialization among neighbouring towns and trade took place over long distances by sea (Flohr & Wilson, 2017). This makes defining perenniality difficult.

In addition, the methods of cultivation of perennial plants here take on forms similar to the cultivation methods used for annual plants. For instance, evidence suggests perennials like grape vines (*Vitis* spp.) were managed in plantation monocultures and that cultivation was labour intensive (Flohr & Wilson, 2017). Although their cultivation is still typical of perennial plants in that they only need to be planted once and are resilient to climatic extremes, such combinations of crop and method make the analysis of this hypothesis with respect to Pompeii more complicated.

There are theories I have not been able to discuss in this paper but that warrant future research. The first of these rests on a paper by Bogaard et al. (2019) positing that the transition from labour-limited farming to land-limited farming facilitated the appearance of sustained wealth inequalities in ancient agricultural societies. An argument could be made that food systems with a high perenniality tend to be labour-limited farming systems and that the transition from cultivation of perennial to annual crops facilitated the onset of wealth inequalities.
Secondly, research could be done into the possible connections between short versus long-term subsistence strategies and level of wealth inequalities. Societies with high wealth inequalities could be more likely to focus on short-term strategies of production while societies that emphasize democratic deliberation among members might be more inclined to secure subsistence in the long-term.

Conclusion

Contemporary debates about the future of sustainable agriculture are dominated by recognition of problems regarding fossil fuel consumption, pesticides, herbicides, eutrophication, waste streams, etc. and responses such as sustainable energy use, organic inputs or system circularity. Surprisingly little discussion concerns the type of plants we should be cultivating.
Much of the environmental degradation the Earth and its inhabitants face today bears similarity to those faced by ancient Southern Mesopotamians and floodplain Cahokians in that the demands of annual crops for tillage and irrigation ultimately lead to the degradation of the ecosystem services on which humans ultimately depend. All annual grain cultivating societies ended up compromising the rich environmental conditions that initially facilitated their development, thereby effectively committing ecocide (Shepard, 2013)[7].
In today's discussion, shifting the focus away from fertilizers, chemicals, organic or circularity, towards whether the plants cultivated are perennial or annual, could go a long way towards solving many of the fundamental problems of agriculture. Perennial plants such as nut and fruit trees produce abundantly besides offering many additional resources and services. This, despite not needing any tillage or chemical inputs. They produce medicine, fuel and timber, they hold soils in the face of erosion, they hold water for times of drought and all the while they store carbon in their roots and branches.

A silent revolution is taking place among small farmers around the world commonly referred to as the agro-ecological movement. These farmers take a different approach to agriculture. Namely, agro-ecology rests on the idea that the natural world is inherently a productive place and that natural ecosystems produce an abundance of resources. Agro-ecological food systems are those that mimic these ecosystems in function but are optimized for the production of resources that are valuable to humans. Mimicking ecosystems in large parts of

[7] This does not prevent those societies from building colossal structures while their ecosystem functions are not yet severely degraded. For an insight into the irony of this contradiction see for instance Percy Bysshe Shelley's poem 'Ozymandias' (1818) in which he writes of a traveller describing a statue half sunk in an empty desert, with the pedestal reading: "My name is Ozymandias, king of kings; look on my works ye Mighty, and despair!".

the world will automatically lead to the inclusion of trees in agro-ecological food systems, simply because most of the plant species in terrestrial biomes are perennial plants (Cox et al., 2006).

There is a tendency among the leading actors of the agro-ecological movement to connect the need for ecological restoration with a call to greater social justice (Shiva, 2015). Many often argue that the horrible consequences of today's conventional agriculture (with its heavy reliance on artificial fertilizers and synthetic pest and herbicides) on the world's biodiversity, is reflected in what some call hypercapitalism (Piketty, 2019) or neo-liberalism (Chomsky & Pollin, 2020; Graeber, 2011) – a systematic drive towards economic growth whereby the gap between the rich and poor is growing so large that it is beginning to seriously compromise the democratic institutions people have come to take for granted[8].

This work is intended as an exploration into the relationships between perennial plants and wealth inequalities. In a broader sense, this work can contribute to our contextual understanding of today's agro-ecological movement.

[8] Wealth inequality has surged during the Covid-19 pandemic (*Covid-19 and Inequality*, n.d.). Also, the Bulletin of Atomic Scientists have recently multiplied the global threats due to the existence of nuclear bombs and worsening catastrophic climate change with a component they describe as the undermining of democracy. The Doomsday Clock is now at 100 seconds to midnight (*2021 Doomsday Clock Statement*, n.d.).

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