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How Do Humans and Locusts Make Space in an Early Modern Chinese Grain Field?

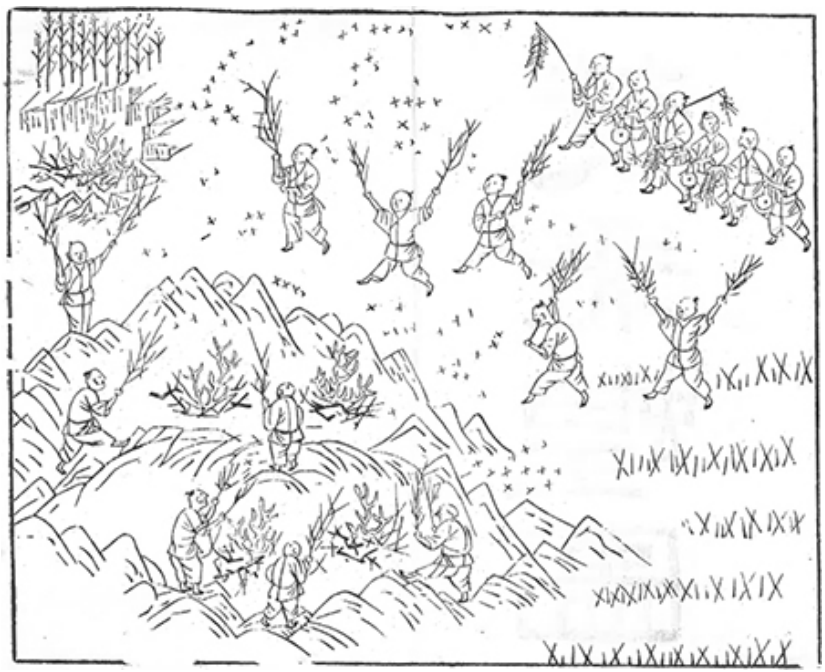

Figure 1:
Farmers attempting to burn locusts in the fields. Source: Chen Chongdi (陳崇砥), Locust Control Manual (治蝗書), Banxi zhai, (1847) 1880 ed.

For over two thousand years, under the successive supervision of 25 dynasties, farmers in China devoted themselves to creating agricultural spaces for plants such as rice, wheat, and millet. Although an excellent source of sustenance for the population, these spaces had the unintended consequence of becoming a breadbasket for pests. So began an inadvertent, grassroots, scorched-earth competition between humans and locusts for occupancy of the fields—locust swarms on the wing would threaten to devour the cereal plants down to the ground, and the farmers would then take up burning brands as a last resort—a scenario that has been captured in figure 1.

At first glance, figure 1 simply depicts an agricultural scene involving people and insects in a field, but the vertical caption on the right noting a "picture of burning flying

locusts" certainly doesn't speak for all of the actors in this scenario. It says nothing about why people need to burn locusts, and it's equally silent about the actual space: the contested niche that humans and locusts want to control but cannot simultaneously occupy. As an environmental historian, I want to keep people in the picture but without overlooking everything else around them. For me, figure 1 is a sketch of the idea that if humans had not decided to satisfy their taste for cereals by building a habitat for more of these plants than would otherwise have been able to grow, there would have been little, if any, grounds for human-locust competition. Niche construction theory makes this sort of altered perspective possible. Through it, I can form a sharper image of how humans fit into the environmental picture as part of a whole, rather than as the whole picture.

Niche construction theory defines "humans" as members of a larger constellation that includes the nonhuman environment, from which congenial spaces ("niches") are deliberately put together ("constructed") for the benefit of the builder species. Construction is the physical connection people make between the human and nonhuman worlds that is historically expressed as a niche. Their interactive collaboration merges into a landscape of mutual relationships—rather than being cropped out into individual portraits—that historians can trace through niche construction theory.

Agri-niches: Chinese Empire's Natural Habitat

The landscape I focus on in my work is that of China during its last dynasty, the Qing, from the mid-seventeenth through to the mid-nineteenth centuries. At this time, China rapidly integrated substantial new territories, expanding into Manchuria, Mongolia, Tibet, and Turkestan (or "Xinjiang"), to reach the largest territorial extent of any Chinese empire. Part of the reason for this achievement is that the Qing founders were not ethnic Chinese ("Han") but Manchus, formed from diverse groups mainly indigenous to Eurasia's forested seacoasts on the northeastern frontier of China proper. For nearly a century and a half from 1644, the Manchus used their multiethnic experience, which combined Inner Asian mounted military power and Chinese bureaucratic institutions, to extend and consolidate their control of these vast and very different territories under a single imperial state.

Different Qing subjects used their ecological surroundings in different ways, including herding, foraging, and agro-pastoralism across Inner Asia. The vast Han Chinese majority, however, mainly relied on a particular sort of rather intensive agriculture that not only fed most of the empire, but also paid for its bureaucracy. This was possible in many parts of China proper thanks to the congenial soil and climate, as well as to the vast river systems—especially the Yellow and Yangzi—that China's extensive irrigation and flood control system had been developed over centuries to exploit. The imperial administration spent a great deal of its energy maintaining the stability of this agricultural core, which emerged from a combination of natural conditions and human actions that affirmed the Qing identity of the people and kept them fed and taxed as Qing citizens.

Indeed, agriculture was so important that imperial administrators sent in a constant stream of reports, or "memorials," to the throne in Beijing about how to keep farming sustainable under constantly changing environmental conditions. One of the most visible and dramatic results of centuries of the intersection of human action and natural change is the Pearl River delta, an area that now includes the major Chinese cities of Canton (Guangzhou), Macao, and Hong Kong. From the end of the thirteenth to the end of the sixteenth centuries, the delta's natural silt build-up was accelerated and concentrated by dikes and polders (low-lying tracts of land enclosed by dikes) to produce rich fields of a quality second only to those of the Yangzi River delta further north. The "construction" of the Pearl River delta "niche" was a creative long-term human response to flooding and erosion, which, along with drought, were the most serious challenges to Chinese agriculture.

Other niche threats, however, were more difficult to convert into an advantage no matter how much time was spent working on them. Locusts were among the most persistent of such difficulties, as outlined by one official, named Shi Mao, in 1759. In a memorial to his ruler, the Qianlong Emperor (r. 1736–95), entitled "A Memorial That Respectfully Lays Out the Circumstances of Locust Catching," Shi Mao stressed that "the capture of locusts" by otherwise busy Han farmers "cannot be done in a perfunctory or crude manner." He was worried that these distracted, part-time bug catchers might not realize that there was a critical time to strike: the grasshoppers were much easier to contain early in their lifecycle, before they had sprouted wings. Shi's memorial explained how necessary it was to exploit opportunities that would allow farmers to avoid disruptive overlaps between cereal and locust reproductive cycles.

Shi Mao was attempting to deal with a human niche construction phenomenon: conflicting human and locust behaviors, which were complex responses to the surrounding ecology and to each other. The initial complex human action, cultivation of agri-niches, had created the right conditions for a corresponding response from the grasshoppers. As humans labored to grow food, they were also, inadvertently, raising a crop of hungry locusts in the same tasty niche.

Genetic Significance of Agri-niche Construction

Human niche construction theory suggests that people tend to behave in ways that modify their surroundings to reduce survival pressures—such as competition, disease, or predation—influencing the course of their own evolution, as well as that of other species. While such behavior is partly hereditary, this very complicated process involves more than just flipping a genetic switch. There is also a cultural component that includes socially learned behaviors, which may depend in part on how genetic makeup is expressed under various ecological and social circumstances. Niche construction theory explains how organisms leave niches behind as an inheritance that continues to shape the physical and cultural expressions of their descendants' genetic code in a way that is as definitive as the wings of a locust.

Agriculture illustrates the transmission and inheritance of genetic and cultural traits; however, though it might seem like a human creation, agriculture is not at all exclusive to our species. Leaf-cutter ants are probably the best example of an insect that lives off farming. The ants cultivate fungus from leaf mulch, which is then processed and spread to create a habitat that would not exist without their behavior. Indeed, certain species of cultivating ants have evolved to live off a single kind of fungus that grows in their underground gardens and nowhere else. The cultivation behavior and the fungus itself are exclusively passed down through the generations of these species to constitute a distinctive "culture," which also leaves particular physiological marks. Leaf-cutter ant exoskeletons, for example, have evolved to house a beneficial bacterium—which seems to have developed alongside the ants' cultivation of the fungus—that acts as a kind of antibiotic against the main infection that uniquely infests the ants' fungal habitat. In this respect, leaf-cutter ants have literally been shaped by their niches even as they construct them. Ethnic Chinese may have been similarly shaped by eating cereal products of their agri-niches to the near

exclusion of other food staples like dairy products, leaving the current population of China with a genetic legacy unusually rich in lactose intolerance.

Grasshoppers aren't farming insects, but their behavior and development can likewise be profoundly altered by human farming. Some species of normally solitary grasshoppers are attracted by high concentrations of cultivated cereals—like the sorghum grown in north China, for example—because these plants lack natural chemical deterrents to repel them. As the grasshoppers crowd together, they rub against each other to activate touch-sensitive chemical receptors on the insects' hind legs. These receptors produce a neurotransmitter, serotonin, which induces behavioral changes like swarming. The grasshoppers also undergo physiological changes to develop wings. So, human construction of an agricultural niche produces not just cereals, but also locusts.

Locusts, however, do not stop there, but generally move on to niche destruction, which is mainly why they are historically significant. The empire's human-built agrarian niches had room for *either* cereals or locusts, but no capacity for full double occupancy. In this way agri-niches were both too limited and too accommodating. They could not feed every hungry mouth, but could easily fill the stomachs of either crowd depending on which one could get there first. Unless humans changed their own behavior, the natural advantages of locusts would likely ensure that the insects would catastrophically fill agri-niches long before people could reap their benefits.

Qing Agri-niche Competition

The insect lifecycle set the pace of the race between humans and locusts to occupy agri-niche turf. As emphasized in a locust control manual published by Chen Chongdi in 1874, farmers had to adapt their defensive measures to stages of locust development:

> All methods of controlling [locusts] must be divided into three stages: when they have not yet spawned, [when] they emerge as juvenile locusts [and when] they grow wings to become locusts. To control adult locusts is not as easy as controlling juvenile locusts, which are, in turn, not as easy to control as the spawn . . . Those who are concerned about dealing with this distress of the people should do so in its early stages.

Locusts were most vulnerable as eggs and hatchlings during sowing season—one of the busiest times of the year for farmers—and then rapidly underwent a series of physical transformations culminating in winged swarms that were far more difficult to contain. By the time grasshoppers had sprouted wings between the sowing and harvesting seasons, farmers already had their hands full with maintaining the agri-niches that they had constructed. People who studied the problem came up with many elaborate proposals to solve it. One 1760 plan required the mobilization of what a critic estimated as more than 7,500 people in just two districts to maintain an early warning and eradication system that could deal with the dispersed and rapid nature of locust reproduction and development across agri-niches. Implementation of such a system, which probably never happened, would take up an impractical six months annually. Figure 2 nevertheless gives some idea of what the 1760 plan, or any other kind of organized eradication effort, may have looked like:

Figure 2: An eradication effort in which farmers would sweep the fields for locust eggs. Source: Chen Chongdi (陳崇砥), Locust Control Manual (治蝗書), Banxi zhai, (1847) 1880 ed.

From a traditional Chinese agrarian viewpoint, this is an image from a nineteenth-century locust manual depicting farmers digging eggs out of the fields, as Chen envisioned. From a niche construction point of view, it is a very human scene—partly genetic, partly cultural—of an attempt to make human surroundings more inhabitable than if things were left to nature alone. From where I sit as an environmental historian, both blend together to afford a view of people who, because they depend on growing plants, must observe how insects develop if they wish to maintain relationships with those who need their crops for food and revenue.

I can also see, from the relations between Chinese farmers and their preferred cereal crops, that species' need for space is not always competitive. It is, however, generally transformative as niches are constructed, dismantled, and reconfigured, intentionally or otherwise. Niche change and species change are mutually conditioning, in some cases even down to the genetic level. Humans cannot be excluded from this picture any more than they can live without habitats. Ideas like niche construction theory make it plain to see that ecology and society are always part of the same environmental space.

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