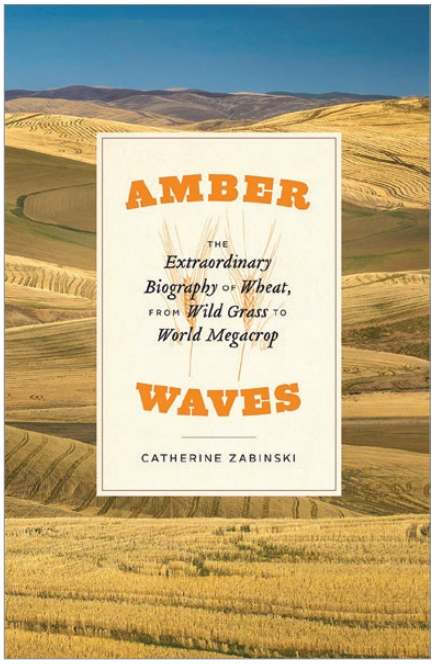
How Did Wheat Take Over the World?

CINDY SALO



Amber Waves: The Extraordinary Biography of Wheat, from Wild Grass to World Megacrop
by Catherine Zabinski. Chicago, IL: University of Chicago Press, 2020, 246 pp.

The story of wheat is inextricably linked with that of humans. Catherine Zabinski's *Amber Waves: The Extraordinary Biography of Wheat, from Wild Grass to World Megacrop* tells both. In fact, the author suggests this might be the tale of how wheat used humans to take over the world.

Zabinski describes wheat's rise from annual grass growing wild in what is now the Middle East to today's biggest crop in terms of the number of acres planted worldwide. She traces humans' relationship to wheat, starting in the era of hunter-gatherers to the current day, when less than 1% of the population of the United States works in agriculture. Her deep history extends to the future, suggesting that both humans and wheat will need ingenuity and adaptability to face increasing challenges.

A professor of soil and plant ecology at Montana State University, Zabinski is an ideal chronicler of this sweeping story about the evolution of wheat. Human domestication of grains and legumes (whose edible seeds are called pulses) helped the earliest settled societies develop by providing them nutritious foods that could be easily stored, transported, and taxed. She notes that at the dawn of agriculture, human cultivation of crops altered the landscape—a process that only increased as human settlements and their farmland expanded.

Zabinski describes farming in the Middle Ages, when European serfs grew rye and oats for themselves but tended the more finicky wheat for landowners. She details how European settlers plowed the sod of America's Great Plains to plant wheat, much of which blew away along with the unprotected soil in the 1930s. And she ends at contemporary US farms of large-scale, high-input wheat growers whose vast operations produce billions of bushels of wheat annually.

Zabinski marvels at humans' resourcefulness in recognizing that wheat seeds could be transformed into delicious foods. She traces the development of the farming methods and improved varieties that transformed wheat into a megacrop. But she also notes that as wheat became more significant to the diet of many cultures, the crop became a powerful weapon in social conflict. Governments gave away wheat to strengthen alliances, militaries burned or blockaded stores to starve opponents, and societies used forced labor to grow the crop.

Wheat has surmounted several challenges—such as its failure to thrive in Europe during the Little Ice

Age of the fourteenth through the nineteenth centuries—and it will face more in the future. Zabinski concludes by wondering how future generations of humans will feed themselves and exploring some of the technologies being developed to meet this need. She provides a comprehensible primer on molecular genetics and genetic engineering, noting the startling facts that wheat has five times as many genes as humans and that humans might share as many as one-quarter of their genes with wheat. Wheat scores high in the gene tally because it has four to five sets of chromosomes, depending on the variety; humans have just two sets, one from each parent. Wheat acquired its additional chromosomes through interspecific crosses early in its evolution. With each cross, the resulting plants incorporated all the genetic material from each parent. This feat, called polyploidy, is rare in animals but relatively common in plants. Multiple copies of genes can be an asset to a wheat plant if one copy is damaged, but can create headaches for plant breeders trying to modify wheat crops for specific traits.

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Is biotechnology the answer to continuing to increase wheat production? Could scientists use gene-editing tools to essentially cut and paste new genes into wheat plants that enable them to better tolerate heat and drought, resist pests, or use atmospheric nitrogen to produce even bigger harvests as the climate changes?

Zabinski concludes that biotechnology is unlikely to realize increases in food production similar to those achieved in the past. Rather, she proposes that growers and policy-makers focus on strengthening agroecosystems by ameliorating the environmental effects of farming. Early wheat farmers rotated nitrogen-fixing legumes with grains. Today's growers could tap organic sources of nitrogen to reduce their reliance on inorganic fertilizers, which are produced with fossil fuel-intensive methods. This, in combination with other soil management practices, could reduce fertilizer runoff and limit the role these nutrients play in the creation of dead zones in the Gulf of Mexico. But the current economics of wheat growing in the United States mean that most growers keep using fertilizers made with fossil fuels.

Other techniques and practices can also mitigate the environmental impacts of growing this staple crop. Stands of perennial flowering plants embedded within crop monocultures could provide habitat for beneficial insects and important pollinators. This could reduce the need for insecticides while providing pollination services. And growing perennial versions of wheat, such as Kernza, developed by the nonprofit Land Institute, would better protect soil from erosion, add to it deeper organic matter, and sequester more atmospheric carbon than annual crops do.

Zabinski's warm, down-to-earth style and whimsical analogies are so engaging that readers might not notice how much archeology, soil chemistry, and molecular genetics they are absorbing. Biology students who found photosynthesis boring didn't have Zabinski as their instructor. She likens the electron chain unleashed as a plant transforms sunlight into chemical energy to "when you drag your stockinged feet across the carpet." She compares the energy compound adenosine triphosphate to "the emergency granola bar you keep in the bottom of your backpack." The cell walls of plants are composed of cellulose fibers, "arranged with an obsessive-compulsive attention to order," while the lignin that lines the xylem vessels that move water and nutrients in plants has a more varied composition, "like making soup with whatever is in your refrigerator."

Zabinski tosses delicious tidbits into her literary soup, such as origin stories for Turkey Red and Red Fife, formerly the dominant types of wheat grown in the United States and Canada, respectively. Both have been replaced by improved varieties, but are now making comebacks as organically grown heirloom grains for use in artisanal breads. Zabinski also mixes in details such as the number of tractors and implements used in the first large-scale industrial wheat farming in the United States—on Native American lands in Montana.

Even the endnotes serve up intriguing anecdotes. In 1935, the pioneering soil conservationist Hugh Bennett timed his congressional testimony in support of the Soil Conservation Service to coincide with a dust storm rolling into Washington, DC. This lobbying led to the formation of the agency now called the Natural Resources Conservation Service. Another note describes how the Black Death spread in fourteenth-century Europe through disease-carrying rodents seeking out ships stocked with wheat.

A few quibbles: As I read about the evolution of wheat, I wished for a diagram with both the common and scientific names of species as well as chromosome numbers. A diagram could help readers track the process. Several drawings by Angela Mele and one photograph illustrate the text but lack captions. Which

kinds of wheat and their ancestors are depicted? When and where did farmers use the implements shown?

Still, I was delighted to find an illustration of a grass flower—a glorious and underappreciated creation. (The next time the grasses in your area burst into full bloom, grab a hand lens and admire the feathery stigmas and grooved anthers. Then imagine removing the anthers and dusting pollen on the stigma by hand to develop new wheat varieties.)

Zabinski does a good job of injecting a sense of urgency into her call to reform intensive agricultural practices. With so few Americans working in agriculture today, the environmental effects of crop production can be easy to overlook. Although the economic threshold (the point at which a profit can be made) for cropping systems can be calculated, the environmental threshold (the point at which an ecosystem has been irreversibly damaged) is harder to determine, especially if ecological costs are externalized.

Amber Waves would make a good text for an introductory agriculture course—and for anyone who wants to understand how today's food is grown. Zabinski does not rail against current agricultural systems; nor does she give checklists of actions for readers to follow to become better food citizens. Instead, she starts at the beginnings of agriculture to explain why contemporary wheat has turned out the way it has, why humans now grow it as they do, and why these methods might not work so well in the future. She suggests that readers listen to the story carried in the whisper of the wheat stalks and think hard about how to make food systems more sustainable and equitable.

Cindy Salo *is an independent plant ecologist who writes about agriculture and natural resources from rural Idaho and Arizona.*