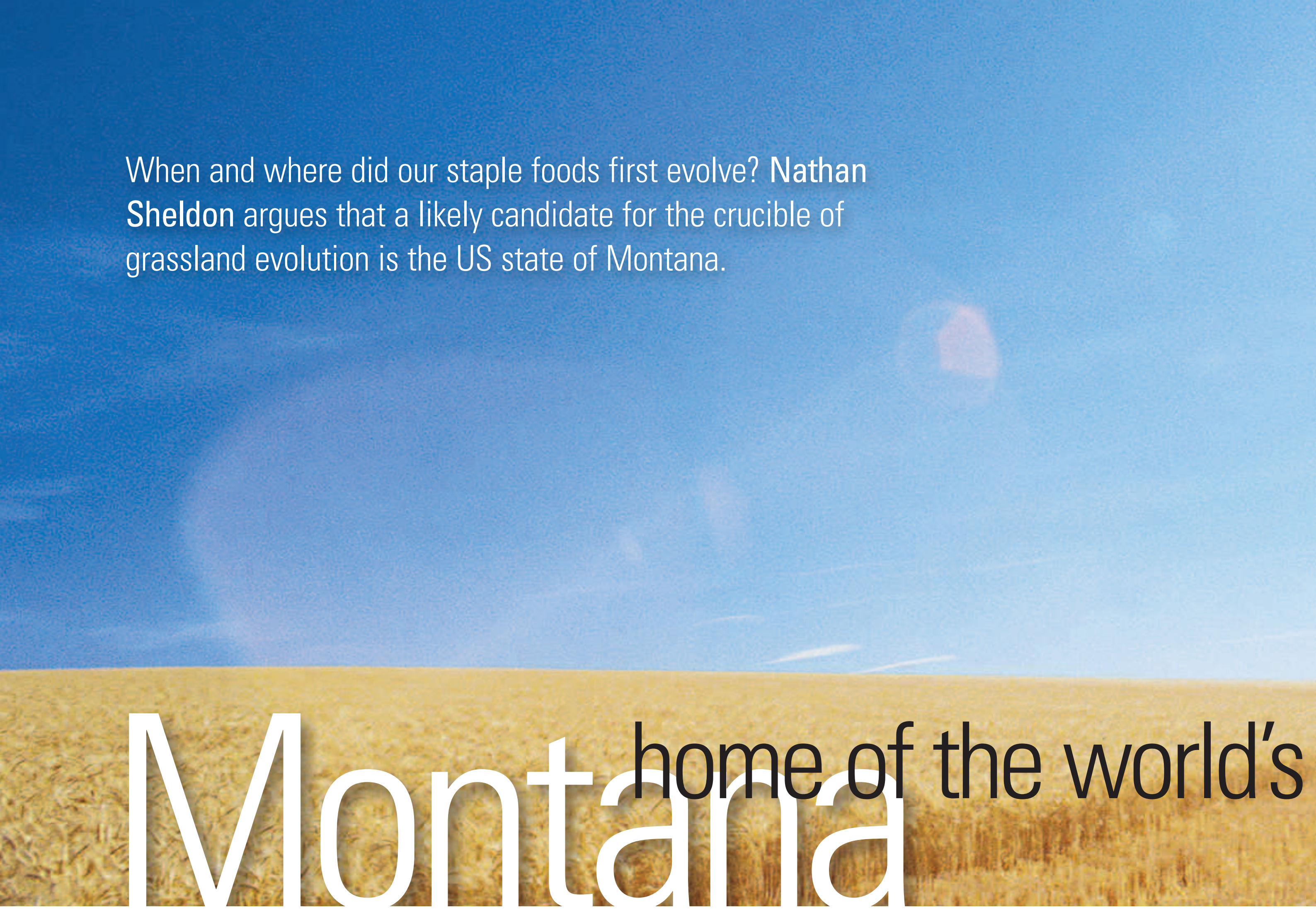

When and where did our staple foods first evolve? **Nathan Sheldon** argues that a likely candidate for the crucible of grassland evolution is the US state of Montana.

Montana home of the world's

What do we have in common with cows and sheep? Both people and livestock get most of their food from grasses. Rice is the staple food for billions of humans, we use barley to make beer, we feed corn to our livestock, we use wheat for bread...the list goes on. In addition, we also use grasses as building materials (bamboo), as fuel (biodiesel), for sewage treatment, and for water conservation (parks). Without cultivated grasses, many of the things that we take for granted in modern life would be impossible.

Grasses are relatively recent evolutionary invention, with the oldest fossils found so far dating to the late Eocene, about 35-40 million years ago, though there is some suggestion from dinosaur coprolites (fossil faecal pellets) and studies of evolutionary rates among plants that a few grass-like plants may have been around for 30 million years before that. In contrast, ferns have been around for hundreds of millions of years, and flowering plants, like the kinds that fill our gardens, since dinosaurs roamed the Earth.

The uncertainty in when grasses emerged stems from the fact that, except for rare, small hard silica pieces, they resist fossilisation. This is because most of their biomass lies underground rather than in leaves or woody stems. Until recently, researchers inferred much of their palaeontological record from changes in mammals such as horses. During the Cenozoic period – the past 65 million years – plant-eating mammals have evolved from eating by browsing to eating by intensive grazing, a change evidenced by lengthening limbs to escape predators in open habitats, and high-crowned teeth that could withstand grinding down tough, silica-rich plants like grasses. To protect themselves, grasses co-evolved to become more silica-rich and harder to chew (see 'Grasses bite back', page 24). The past 8-10 million years has witnessed the most rapid evolutionary changes to mammals so scientists have inferred that grasslands, which now cover a quarter of Earth's land surface, only became widespread during this interval. Our research, though, casts doubt on this interpretation and suggests that grasslands are much older.

We are moving away from the optimum conditions for growing our staple foods.

In contrast to trees and flowers, grasses are most energy efficient at higher light levels, lower atmospheric carbon dioxide (CO_2) levels, and at higher temperatures. This is because grasses have evolved a different type of photosynthesis to trees that requires less water and that temporarily stores carbon to make energy at the most efficient times of the day.

The different photosynthetic mechanisms are known as C_3 and C_4. The former is the most common, but most grasses use the latter. A significant difference is that C_4 plants have a secondary set of chloroplasts (photosynthetic organs) that convert CO_2 to a four carbon acid, an intermediate step in photosynthesis. This adaptation means that grasses survive better in dry conditions because they can reduce the size of their stomata – the small holes on their leaves used for drawing in CO_2 – during the day, preventing evaporation, but still use the same amount of CO_2.

staple foods

Swards of bear grass *Xerophyllum tenax*, Glacier National Park, Montana.

David Woodfall/Woodfall Wild Images

There have been grasslands in Montana a full 15 million years earlier than previously thought.

C_4 photosynthesis also leaves a different carbon isotopic signature than C_3 photosynthesis because it is less discriminatory against heavier carbon (^{13}C versus ^{12}C) than the C_3 photosynthesis favoured by most woodland plants. Thus, by studying fossilised organic matter it is possible to determine the balance between C_3 and C_4 plants – woodlands and grasslands – even if there are no recognisable fossils.

Our recent carbon isotopic results have turned up two surprises. First, there have been grasslands in the US state of Montana for at least the past 24 million years – a full 15 million years earlier than previously thought. Researchers from the University of Minnesota and the University of California-Santa Cruz have found a similar result in Kansas and Nebraska, both south-east of Montana. Secondly, though both Kansas and Nebraska show an increase in the proportion of grasses from less than 5 percent up to 80 percent coverage during the past 24 million years, the proportion of grasses in Montana has remained steady at about 30 percent. During this period, the climate of Kansas and Nebraska became drier and moved towards semi-arid conditions favoured by grasses. But Montana has always been that dry, suggesting that it may be the crucible for grassland evolution, with the grasses spreading south-east.

Though these results are of palaeontological and evolutionary interest, they are also potentially of great economic importance, because this earlier emergence time for grasslands was during a cool, low CO_2 period. With increasing CO_2 levels and global warming a clear and present danger, we are moving away from the optimum conditions for growing our staple foods. Understanding their history may prove to be an important tool in ensuring their continued health and productivity for our future. ■

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Nathan used NERC's Inductively Coupled Plasma Facility for some of the analyses.