Adaptive fuel procurement in nineteenth century Great Plains landscapes

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ABSTRACT

Harnessing energy for cooking, heating, eating, and travel is a fundamental human requirement, and prior to fossil fuel adoption, much energy was derived from local landscapes. In the North American Great Plains, the nineteenth century was a period of rapid social–ecological change, and adaptive fuel procurement was at its core. Here, we review nineteenth century accounts of energy acquisition and use in Great Plains landscapes, documenting the utilities, renewabilities, and geographic distributions of important organic fuels, excluding coal. Native and Euro-Americans devised and adopted diverse strategies for accessing energy stored in herbaceous biomass and woody biomass, which although variable in form, availability, specific energy, and energy density, could generally be obtained locally and regenerate relatively quickly. Three forms of herbaceous biomass—forage (undigested), buffalo chips (partially digested), and pemmican (metabolized)—were associated with ubiquity of prairie vegetation and bison, whereas woody biomass was a rarer fuel largely restricted to lowlands and decreasing from east-to-west. Amidst transformational waves of colonization in dynamic environments, seasonal strategies for securing energy locally were supplanted by strategies of fuel storage and importation. All fuel-based adaptations had social–ecological causes and consequences, and in nineteenth century plains landscapes, colonization facilitated rapid, cross-cultural exchanges of fuel sources, technologies, strategies for increasing energy access, and human environmental influences that collectively shaped regional environmental history.
INTRODUCTION

Securing energy (fuel) is a fundamental human challenge, and innovations in fuel procurement may indicate human adaptation to disturbance and change. Examples of social–ecological causes and consequences of fuel-based innovation are provided in nineteenth century landscapes of the North American Great Plains, where cultures adapted to meet their fuel requirements in dynamic environments amidst transformational waves of colonization. Native Americans actively responded to and modified landscapes as they encountered European-based colonization frontiers, including horses (*Equus caballus*), guns, and resettlement. Immigrating Euro-Americans also responded to and modified environments shaped by centuries of Native American habitation, which from their perspective, were extreme and variable in weather and resource availability. Adaptive fuel procurement was at the core of these cross-cultural influences and adaptations.¹

With the exception of coal—which is excluded here because of its widespread availability only in the late nineteenth century—plains peoples derived a large proportion of energy for accomplishing daily tasks (e.g., cooking, heating, and travel) from local landscape elements, including three forms of energy from herbaceous biomass—forage (undigested), buffalo (*Bison bison*) and cow (*Bos taurus*) chips (partially digested), and pemmican (metabolized)—as well as woody biomass, wind, and flowing water. Each of these energy sources could be traced back to the sun and their energy contents per unit mass (specific energies), differed. Excluding wind and water, specific energy was greatest in pemmican, then woody biomass, herbaceous biomass, and buffalo chips (Table 1); however, different proportions of these energies could be captured and applied to human uses. In this review of nineteenth

century organic fuels of the North American Great Plains, we assess the importance of these fuel sources, according to their utilizations, renewabilities, and geographic distributions (Figure 1). Findings demonstrate the influences of cross-cultural adaptive fuel procurement on regional environmental history.

HERBACEOUS BIOMASS

Photosynthesis allows for the capture and storage of solar energy in plant tissue, which may be converted to alternative forms via herbivory. Forage, buffalo chips, and pemmican were three important fuels derived from herbaceous biomass (grasses and other non-woody plants).

Utilization

Horse reintroduction was an initial wave of European colonization that rapidly transformed Great Plains social–ecological systems. Following the sixteenth-to-eighteenth century spread and domestication of horses throughout the plains, they, with other livestock, became prized for their utility in activities like travel, hunting, and drafting. In their energetic efficiencies (ratio of energy input to output), horses rivaled steam engines; however, the benefits associated with these animal adoptions were accompanied by a requirement to continually procure food for them. Herbaceous biomass in the form of forage was a primary food of plains horses and livestock, and as such, became an important fuel. Challenges and strategies associated with accessing forage varied among peoples and places.²

Among Native Americans, horse ownership increased the ease of travel associated with hunting and raiding, and translated into wealth. Horses provided a direct connection to the ubiquitous stores of energy housed in prairie grasses, which dogs (*Canis lupus*), the previous beast of burden, could only access indirectly via meat consumption. Although horses did not compete directly with people or dogs for food, they did compete directly with bison—another important human energy source. Horses also aided with bison hunting. By substantially increasing access to stores of energy in herbaceous biomass and bison, horse reintroduction increased the appeal of the Great Plains to immigrating Native American cultures (e.g., Lakotas, Cheyennes, and Comanches) in the seventeenth and eighteenth centuries. By the early nineteenth century, a typical family in these horse cultures owned multiple, even dozens, of horses.3

There were, however, energy-related inconveniences associated with horse ownership, one of which was an inability to congregate in one location for extended time periods, due to the outpacing of local vegetative growth by herd consumption (Figure 2). In the absence of hay storage—a practice not adopted by Native Americans until at least the 1860s—forage had to be procured from landscapes year-round. Local grass scarcities were especially problematic on the northern plains in winter because of shorter growing seasons and snow covering grass.4 One example of local forage exhaustion comes from the journals of the German explorer and naturalist, Prince Maximilian, who in 1833, described the prairie surrounding Fort McKenzie, in present-day Chouteau County, Montana, as “barren and dry, trampled down by men and horses,

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and grazed bare. Everywhere one saw Indians and bunches of grazing horses, guarded and
herded by Indian boys on horseback."\(^5\)

For semi-nomadic peoples, who farmed and hunted bison (e.g., Pawnees and Poncas),
semi-annual hunts provided a partial solution to the complication of forage exhaustion by
promoting frequent movement among hunting camps. For example, the Reverend John Dunbar, a
Presbyterian missionary to the Pawnees, accompanied the tribe on their 1834–1835 summer and
winter bison hunts, and recorded total hunt travel distances of 300–600 kilometers. In the 1830s,
the Pawnees were grazing horses—which they owned 6,000–8,000 of at that time—on mature
prairie cordgrass (\textit{Spartina pectinata}) each autumn, prior to the winter bison hunt, on Grand
Island, along the Platte River, in present-day south-central Nebraska.\(^6\)

In fully-nomadic societies (e.g., Cheyennes, Comanches, and Arapahos), who embraced
horse reintroduction to the point of abandoning farming, securing forage became a secondary,
even primary, driver of movement. The forage requirements of herds varied with season,
precipitation, and geography. For example, in western Kansas, a band of 1,000 horses required,
on average, three hectares of grass each day under normal precipitation, and as many as 17
hectares each day in drought. During winter, when people and their herds retreated to timbered
lowlands, each horse needed about 9 kilograms of forage per day, with a lowland residency of
75–150 days, depending on latitude. Accordingly, total winter forage requirements for a camp of


25 people with 38 horses in the Southern Plains was 28.5 tons, compared with 57 tons in the Northern Plains.  

Euro-Americans utilized forage for horse, mule, and oxen (cattle) fuel, as evidenced by the millions of hectares of prairie overturned by people and draft animals, beginning around 1870. Draft animals were also powered with grain that farmers raised—largely through animal labor. Besides 1–5 kilograms of grain, the average 450-kilogram draft horse required 5–6 kilograms of roughage (herbaceous biomass) each day, depending on activity. Hay and grain storage helped ensure that these demands could be met year-round. When travel was necessary in areas or seasons without sufficient forage, hay and grain were even transported with parties in wagons.

Buffalo chips

When wood was scarce, buffalo chips (dried dung) were burned by both Native and Euro-Americans, in combination with fuels like sage and corn cobs, for cooking and heating, earning it the nickname plains oak (Figure 3). Holland determined that 8.9 cubic meters of buffalo chips are required to equal the energy contained in an average cord (3.6 cubic meters) of cottonwood (Populus spp.). Because of the great volume of chips required to produce sustained heat, supplemental fuels are likely to have been especially important during winter; however,

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these were often scarce in the western plains. Major Osborne Cross wrote from near the North Platte–South Platte confluence, upriver from Fort Kearney, in 1849:

The command stood greatly in need of wood, for we had reached a region of country entirely destitute of it, where a tree might be look on as a curiosity. We were therefore compelled to resort to the *vache de bois* [buffalo chips], which is a fine substitute when you get used to it. It is always used by hunters, who never think of the scarcity of wood when this can be obtained.  

Pemmican—a sun-dried mixture of bison meat and bone fat—was an important fuel source on the northern plains. Pemmican was a traditional food among the Blackfeet and Crees, and was actively adopted by Euro-Americans as a fuel in the fur trade, where it provided food for agents and voyageurs, who paddled canoes upriver with trading supplied and downriver with bundles of furs. In addition to being an energy-rich food with a specific energy of 7,055–8,378 kilocalories (food calories) per kilogram (Table 1), pemmican could be preserved indefinitely in bison skin bags, each of which weighed approximately 41 kilograms. Through pemmican fuel, the North West Company and Hudson’s Bay Company—dominating colonial presences in the British West—became dependent on bison, with average annual pemmican consumption of the Red River Colony in portions of present-day Manitoba, Saskatchewan, Ontario, Minnesota,

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10 Raymond Settle (ed.), *The march of the mounted riflemen: From Fort Leavenworth to Fort Vancouver, May to October, 1849* (Lincoln: University of Nebraska Press, 1989), 71.
North Dakota, and South Dakota averaged 3.4–6.8 million kilograms, or 23.9–48.0 billion kilocalories.\(^{11}\)

Hunting and processing of bison for pemmican production was conducted by multi-ethnic hunting coalitions of Native and Euro-Americans, who were thoroughly tied into a global market. To meet their own needs, hunting coalitions produced around 6,800 kilograms of pemmican per year, with additional harvest for commercial production. Bison meat and fat processing took place in forts. Pemmican remained a cheap and intensively utilized fuel until the collapse of the northern bison herd in 1879.\(^{12}\)

Renewability

Forage

Prairie plants are characterized by a high degree of renewability, with the capacity to regenerate following grazing, fire, or drought in less than a decade, typically within a year. Native Americans used fire to advance the onset and increase the vigor of spring herbaceous growth in and around their villages and hunting grounds, thereby increasing their access to energy from forage the following spring.\(^{13}\) Although variable, grazed tallgrass, mixedgrass, and shortgrass prairies of the plains produce, on average, 1.66, 1.09 and 0.74 tons of live biomass per hectare per year, respectively.\(^{14}\) Thus, with a daily winter horse herd forage requirement of 0.342 tons (38 horses consuming 0.009 tons [9 kilograms] per horse per day), a winter camp could

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\(^{12}\) George Colpitts, ‘A Métis view of the summer market hunt on the northern plains’ in *Bison and people*, 202, 207–208.


consume the total annual biomass production of one hectare in less than a week, and over months of winter camp residency, dozens of hectares. In terms of energy content, given that one kilogram of tallgrass prairie hay contains 3,750 kilocalories (Table 1), the average daily horse consumption of herbaceous biomass energy (energy consumed, not digested or metabolized) in tallgrass prairie was around 33,750 kilocalories, and for a band of 38 horses, 1,282,500 kilocalories.\textsuperscript{15}

Buffalo chips

Like the forage they were derived from, buffalo chips were renewable; however, their availability and suitability as fuel were contingent on the presence of ruminants to deposit them and a drying period to prepare them for burning. Plains bison are estimated to have numbered in the tens of millions in the early nineteenth century, and given that bison cows between the ages of 3 and 18 years generally gave birth to a single calf each year, they were capable of recovering from population losses, but not quickly.\textsuperscript{16} At least partially as a result of market demand for pemmican and robes in the northern and southern plains, plains bison were overhunted, and after herds dwindled, they were replaced by the cattle of Euro-American settlers, a new energy source.\textsuperscript{17} R.S. Elliot described this impending transition in 1873, writing:

Our plains are the native land of the bovine race, and will continue to sustain it. We only make a slight change when we substitute domestic cattle for the buffalo. The latter, under the persecutions of Indians, hunters and sportsmen, will in a few years be extinct. The

\textsuperscript{17} Cunfer and Waiser, \textit{Bison and people}, xiii; Sherow, ‘Workings of the geodialectic’, 65, 67.
former will multiply indefinitely. The railway is fatal to the buffalo, but fosters the
domestic herd.\textsuperscript{18}

By the 1880s, bison were virtually extirpated from the plains, but cattle did not match their
former numbers until the early twentieth century.

Pemmican

Pemmican renewability also corresponded with the ability of northern plains bison
reproduction to keep pace with mortality. In addition to bison presence, pemmican production
required climates with sufficiently cool summer temperatures to prevent meat and fat spoilage;
therefore, pemmican production tended to occur north of the Missouri River near the 49\textsuperscript{th}
parallel.

Commercial pemmican production was unsustainable because commercial bison hunting
was unsustainable. Horse and gun adoption increased the ability of hunting coalitions to
preferentially select bison targets, which because of their superior fats, tended to be cows of
reproductive age. Commercial pemmican production was also substantially less efficient than
traditional production. To acquire the meat and fat needed to produce one 41-kilogram bag of
pemmican, commercial production used meat from three bison and fat from six, whereas
traditional production produced the same bag from a single animal. Additional factors that
contributed to collapse of the northern herd and disappearance of pemmican as a fuel were
competition with horses for forage, harsh winters, and droughts.\textsuperscript{19}

\textsuperscript{18} R.S. Elliot, 1874. ‘The Plains’, in: Kansas State Board of Agriculture. Report of the Kansas State Board of
Agriculture to the Legislature of Kansas, for the year 1873, pp. 252–258, (Topeka: State Printing Works: Geo. W.
Martin, Public Printer, 1874), 258.
\textsuperscript{19} Colpitts, \textit{Pemmican Empire}, 12–13, 17, 76; Jack Brink, ‘A hunter’s quest for fat bison’ in \textit{Bison and people}, 114;
Dan Flores, ‘Reviewing an iconic story: Environmental history and the demise of the bison’ in \textit{Bison and people},
39–43; Alwynne Beaudoin, ‘A bison’s view of landscape and the paleoenvironment’ in \textit{Bison and people}, 77–78.
Geographic distribution

Forage

Herbaceous biomass was generally ubiquitous wherever it had not been removed by grazing, fire, drought, or soil disturbance. Despite widespread availability, to be most useful to people, it was necessary for herbaceous biomass to co-occur with other resources, such as water in summer and shelter and wood in winter. Because of differences in soils and moisture availability, lowlands tended to produce more aboveground vegetation than uplands, even when trees were absent. In 1833, in the Missouri River bottomlands, near the town of Bellevue, Nebraska, Maximilian wrote, “Beautiful, low prairie hills surrounded us, and before them flat alluvial land with a beautiful growth of grass…very favorable for raising livestock.” In the same vicinity 14 years later, Andrew Dawson of the American Fur Company noted passing through an area that was “flat swampy and mostly covered with a long rank grass reaching over our heads when on horseback.” Further upriver, at Dakota City, Nebraska, in 1868, the British immigrant and Omaha businessman Joseph Barker Jr. stated that 6–8 tons of hay was required to raise a calf to four years, and that much of it could be obtained by grazing the Missouri River bottoms. Despite generally higher levels of production, increased competition for forage between horses and bison decreased its availability, especially in winter.

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At Cottonwood Canyon (later Fort McPherson), near the North Platte–South Platte confluence at the present-day town of North Platte, Nebraska, United States Army Captain Eugene Ware described lush grass growth on river islands in 1864: “The valley here was several miles wide. There was a large island in the river of several thousand acres, upon which grew the finest grass to be found in the country.” West of the town of North Platte, Joseph Barker recounted that the 8–10 kilometer-wide South Platte River valley was “Covered with much the same grass as arround [sic] Omaha but generally not so thick or rich – But plenty sufficient & [sic] good for all purposes.” However, Barker was unimpressed by the quality and quantity of grass outside stream valleys west of the town of Sidney or in the Sandhills ecoregion. Although the nutritional qualities of grass indeed vary among species and seasons, what Barker is likely to have observed in these uplands were shortgrass species [e.g., buffalo grass (*Buchloe dactyloides*) and blue grama (*Bouteloua gracilis*)] and blackroot sedge (*Carex elynoides*), which actually serve as excellent forage year-round, in contrast to tallgrasses, which lose more forage value late in the growing season via decreasing leaf-to-stem ratios. R.S. Elliot, an industrial agent for the Kansas Pacific Railway, expanded upon the unapparent value of buffalo grass as forage, arguing that although “to the untaught observer this is a worthless-looking grass”, it is “unsurpassed in nutritive qualities”, and “dries to a natural hay, and it retains its nutritive properties all winter.” United States Army General George Custer echoed this assertion in the late 1860s, writing:

Nearly all graminivorous animals inhabiting the Plains, except the elk and some species of the deer, prefer the buffalo grass to that of the lowland; and it is probable that even

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26 Snoddy, *Their man in Omaha*, 515.
these exceptions would not prove good if it were not for the timber on the bottom land, which affords good cover to both the elk and deer. Both are often found in large herds grazing upon the uplands, although the grass is far more luxuriant and plentiful on the lowlands. Our domestic animals invariably choose the buffalo grass, and experience demonstrates beyond question that it is the most nutritious of all varieties of wild grass.29

Shortgrasses were indeed the preferred forage of bison on the northwestern plains.30

The historian Geoff Cunfer speculates that human alteration of grazing regimes drove geographic shifts in plains grass communities, writing: “As late as 1880 there were just over 2 million cattle in the region, on land that had supported some 28 million bison. For a decade grass biomass increased dramatically across the plains. Without bison to hold them in check, midsize and tall grasses overtook short grasses.”31 Buffalo grass, in particular, thrives under moderate to heavy grazing and is capable of withstanding successive years of drought.32 It is likely that interactions among factors such as grazing, fire, weather, and soil disturbance shifted the geographic distributions of grassland species and communities.

Despite its abundance in uplands, herbaceous biomass became scant there at times too. The Baptist missionary Isaac McCoy documented dry conditions accompanied by an autumn prairie fire in present-day north-central Kansas in 1830, writing: “Grass for our horses, is every day becoming more scarce. The season is remarkably dry. The whole country around us, has burned over today,” and later, “The grass is so poor for our horses, which are fast failing for want of food, that we deemed it indispensable to move on, in hope of reaching the Republican

30 Colpitts, Pemmican Empire, 74.
31 Geoff Cunfer, On the Great Plains: Agriculture and environment (College Station: Texas A&M University Press, 2005), 49.
fork of Kanza [Kansas River], where we hope to find better food.”33 In the winter of 1846–1847, United States Army Lieutenant James Abert described a similar situation near Big Sandy Creek in now eastern Colorado, writing, “All around our camp the prairies had been burnt…no pasture, no buffalo, 3 days starved.”34

Buffalo chips and pemmican

The distribution of ruminants and the chips they deposited was influenced by various factors, two of which were winter shelter locations and quality of forage. Timbered groves that attracted bison in winter likely had high bison and chip densities, as did the northern and western plains, where there were favorable carbon-to-protein ratios in shortgrasses.35 Chips left behind by livestock were likely clustered along trails; however, the continual harvest of chips by travelers, in combination with bison exclusion, would have decreased chip abundance in these areas unless new depositions by livestock counterbalanced harvest.

Pemmican, like buffalo chips, is a product of bison. Major bison hunting locations for pemmican production were the vicinities of the Red and Saskatchewan Rivers. In commercial production, bison meat and fat from hunts were transported to centralized locations—often forts—for processing, and from there, pemmican was distributed through the vast networks of the fur trade.36

WOODY BIOMASS

34 James Abert, Western America in 1846–1847: The original travel diary of Lieutenant J.W. Abert, who mapped New Mexico for the United States Army (San Francisco, J. Howell Books, 1966), 87–89.
36 Colpitts, Pemmican Empire, 1, 12–14, 92, 261.
Another important nineteenth century plains fuel was woody biomass. Although different tree species have similar specific energies, they can have substantially different masses per unit volume, and thus, energetic densities, with high-density species tending to burn more slowly and give off more heat per cord than low-density species. Such differences in heating efficiency, along with local-to-regional availability, affected woody biomass utilization.

Utilization

Woody biomass was a fuel used to produce heat, power steam engines, and feed horses. Although rarer than herbaceous forage and buffalo chips, it was energetically denser. Most of the wood fed to horses consisted of cottonwood bark and twigs from timbered lowland camps or river islands. Wood supplemented herbaceous biomass as forage when snow covered grasses or when there were dangers (e.g., harsh weather or raids) associated with sending horses out from the camp in search of grass. General Custer penned the following concerning the use of cottonwood as horse food, “Although not affording anything like the amount of nutriment which either hay or grain does, yet our horses invariably preferred the bark to either, probably on account of its freshness.”

Over the course of the nineteenth century, the fur trade, military operations, mining, and resettlement brought numerous steamboats up the Missouri River each year, distributing trade items and supplies, taking on furs, and carrying passengers (Figure 4). Wood was the primary fuel for powering steamboats, and the average daily quantity required to do so depended on boat

37 Scott DeWald, Scott Josiah, and Becky Erdkamp, Heating with wood: Producing, harvesting, and processing firewood (Lincoln: University of Nebraska-Lincoln Extension, Institute of Agriculture and Natural Resources, 2005), 1.
39 Custer, My life on the plains, 7.
size and wood properties. Because of space and weight limitations, steamboats could only carry a one-day supply of wood and typically stopped twice each day to restock.\textsuperscript{40} Lass cites an average daily (12-hour) steamboat demand of 15 cords of wood on the Upper Missouri in 1867–1868.\textsuperscript{41} When aggregated across boats and years, the quantity of wood burned by steamboats is staggering. For example, the 19 steamboats on the Upper Missouri in 1880 together burned approximately 31,394 cords of wood, which equates to 348,822 tree trunks 25 cm in diameter and 12 meters in length, or in terms of energy content, 523,334 gigajoules in dry cottonwood, 602,828 gigajoules in dry eastern redbed, and 867,807 gigajoules in dry bur oak (\textit{Quercus macrocarpa}).\textsuperscript{42} In comparison, the estimated annual wood use for all purposes in the entire United States from 1870–1879 was 140 million cords per year, the strong majority of which was for home heating. In more densely-populated Missouri River reaches, wood was piled along the river banks ahead of time, so that boats could quickly stop to purchase and load it, whereas further upriver, beyond the resettlement frontier, woodcutters left ships in search of fuel. Even abandoned trading posts were used for fuel.\textsuperscript{43} In 1856, Lieutenant G.K. Warren pinpointed the mouth of the Niobrara River as the point above which steamboat crews on the Missouri began cutting their own wood.\textsuperscript{44}

The energy density of wood varies according to tree species, tree age, and wood moisture content. Cottonwood and cedar (Juniperus spp.) were common fuels for powering steamboat engines on the Missouri, and over time, entire forested islands of these species were cleared for this purpose. It is initially unclear why denser, slower-burning species [e.g., ash (Fraxinus spp.) and oak (Quercus spp.)] were not more popular, but perhaps strong reliance on cottonwood and cedar stemmed from their greater availability along the river banks. Unlike dry cottonwood, green cottonwood was only a desirable fuel on the Upper Missouri. Maximilian relayed an interesting and apparently prevailing hypothesis for why this was so near the grave of the Omaha Chief Blackbird, in the vicinity of present-day Onowa, Iowa: “Here on the steamboats, green cottonwood is primarily burned; it gives off more heat here than farther downstream, because the ground here is far drier and the wood has less sap.” Indeed, at Morgan’s Island, five kilometers below the mouth of the Little Nemaha River in now southeast Nebraska, he had previously written, “Our woodcutters and hunters went ashore but did not bring anything back, since the forest consists of nothing but cottonwoods.” Because of its low moisture and high resin content, cedar could be burned green, although this was likely not preferable.

Wood was the primary fuel of United States railroads until 1870, and steam engines in some of the first Great Plains locomotives were wood-powered (Figure 5). In fact, roads for transporting wood between railroad stations and privately-owned timber groves along the Platte River were documented by surveyors near Fort Kearny, in present-day south-central Nebraska, in the 1860s. In several instances, this trespassing led to armed conflict between settlers and

45 Smil, Power density, 12–13, 85.
46 Witte and Gallagher, The North American Journals... Volume 2, 63, 90.
48 Schurr and Netschert, Energy in the American economy, 52.
railroad employees. Timber-related disputes also occurred between Native and Euro-
Americans. For instance, fuel-desperate settlers were on several occasions observed stealing
large quantities of timber from the reservations of the Otoe-Missourias and Pawnees during
harsh winters of the 1860s. Native Americans used different tree species for different purposes in different seasons,
according to their energy densities. For instance, the Cheyenne used poplar ($Populus$ spp.) and
cottonwood for summer cooking, but oak and other hardwoods for winter cooking and heating.
Similarly, the Hidatsa preferred species other than cottonwood for firewood; however, it was the
most abundant and available woody species.

Renewability

Woody biomass was renewable on relatively short timeframes, but could not recover as
quickly as herbaceous plants. Regenerative potential also differed among species. For example,
cycles of disturbance and recovery caused spatial differentiation in the composition of Missouri
River forests, as early successional species [e.g., cottonwood and willow ($Salix$ spp.)] were
common along river banks and later successional species [e.g., boxelder ($Acer$ negundo) and
oak] were relegated to higher terraces, due at least partly to the ability of cottonwood and willow
to quickly regrow after being sheared off by flowing water and ice. Arapahos in the western
plains even manually sheared the tops of cottonwood trees to stimulate growth of young shoots
for winter horse feed the following year. Although some willow species [e.g., peach-leaf willow

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49 Charles Richardson, 1968. ‘Early settlement of eastern Nebraska territory: A geographical study based on the
original land survey’, (Ph.D. diss., University of Nebraska-Lincoln, 1968), 63, 174–178; W.C. Johnson and S.E.
51 Moore, The Cheyenne Nation, 149; Gilbert Wilson, Uses of plants by the Hidatsas of the Northern Plains. M.
(Salix amygdaloides) could grow into relatively large trees, other shrubbier species [e.g.,
sandbar willow (Salix exigua)] could not, which likely affected their usefulness as fuel. In the
absence of fire, eastern red-cedar (Juniperus virginiana) can spread and transform open prairies
into closed-canopy forests in fewer than 50 years.52

Despite high regenerative potential and rotational harvest, mid-nineteenth century timber
depletion generally outpaced timber growth, and by 1860, many tree stands were stressed or
diminished. Factors contributing to depletion include increased horse ownership among Native
Americans, increased Euro-American travel, harsh winters, and droughts.53 Although he was
confident that sufficient wood supplies existed for the near term, Lieutenant Warren
contemplated future shortages along the Missouri, as he noted that steamboats were experiencing
greater wind interference above the town of Council Bluffs in 1856 than they had in years prior,
due to the fact that riverside timber windbreaks—which Maximilian had described two decades
earlier as “a band of tall forest”—had been severely reduced.54 Joseph Barker similarly depicted
timber as dear and scarce in Omaha in 1866. He observed high prices for hardwood, cottonwood
lumber, and imported pine (Pinus spp.) lumber, settlers scrambling westward to take out
Homestead and Preemption Act settlements in wooded valleys, and the construction of portable
sawmills for capturing and processing driftwood on the banks of the Missouri (Figure 6). Barker
noted an average of three to four steamboats in the wharf at Omaha each day in 1866, which by

52 W.C. Johnson, R.L. Burgess, and W.R. Keammerer. ‘Forest overstory vegetation and environment on the
Missouri River floodplain in North Dakota’, Ecological Monographs 46 (1976): 59–84; Sherow, ‘Workings of the
‘Assessing the potential for transitions from tallgrass prairie to woodlands: Are we operating beyond critical fire
53 West, The contested plains, 88–90.
1868, had increased to between four and five. Temporary timber shortages caused sharp price
spikes in local fuel and construction markets before railroad completion stabilized supplies.

In the late nineteenth century, Great Plains residents bought wood through large-scale
lumber distribution networks headquartered in Minneapolis and Chicago, which imported wood
into the plains from the Great Lakes region. It was common for towns to build a lumber yard
near the railroad for wood processing. This demand for wood in the Great Plains and other
regions drove the decimating harvest of white pine (Pinus strobus) forests around the Great
Lakes. At the same time, global demand for bison products pushed the ungulate—one of the
most important energy sources for human metabolism in Great Plains landscapes—to the brink
of extinction. Chicago’s role as a major hub in wood and bison imports and exports was largely
facilitated by the railroad construction in the Great Plains. Therefore, like mounted bison hunts,
the railroad increased the geographic extent of human energy access.

Timber exhaustion was a problem at Euro-American forts, where soldiers were tasked
with guarding and collecting wood from the surrounding countryside, with increasing
vulnerability to attack at greater distances from forts. The annual wood requirement for 100
soldiers corresponded with clear-cutting 3–12 hectares of deciduous woodland. At Fort Kearny
in 1848, the ethnologist George Gibbs wrote, “No wood is to be had except the soft cottonwood
found on the islands of the Platte, which is brought up with difficulty and not fit for building
when obtained.” At Fort Union, on the Missouri, near what is now the Montana–North Dakota

56 John Hudson, *Plains country towns* (Minneapolis: University of Minnesota Press, 1985), 113; William Cronon,
57 West, *The contested plains*, 276; Witte and Gallagher, *The North American Journals... Volume 3*, 2, 90, 124, 153,
58 Settle, *The march*, 299.
border, Maximilian mused that the fort’s horses were kept outside all winter, and in snowy
conditions made their way down to forested portions of the river to eat cottonwood bark.

In the years preceding resettlement, the impending mismatch between timber availability
and demand in the plains was foreseen by a number of individuals. Chief Big Elk of the Omaha
recognized the potential for discrepancies in uplands, as he professed to members of the Long
Expedition in 1820:

Some think, my father, that you have brought all these warriors here to take our land from
us, but I do not believe it. For although I am but a poor, simple Indian, yet I know that
this land will not suit your farmers; if I even thought your hearts were bad enough to take
the land, I would not fear it, as I know there is not enough wood on it for the use of
whites. You might settle along this river, where timber is to be found; but we can always
get wood enough in our country to make our little fires.  

In 1811, the Scottish botanist John Bradbury made a similar acknowledgement regarding the
inability of plains landscapes to supply the amount of timber to which Euro-American settlers
would require—yet was confident of its eventual resettlement—as he penned:

Accustomed, as they are, to a profusion of timber, for buildings, fuel, and fences, they are
not aware of the small quantity of that article that may be dispensed with, in a country
abounding in another substance for fuel…My own opinion is, that it can be cultivated;
and that, in process of time, it will not only be peopled and cultivated, but that it will be
one of the most beautiful countries in the world.  

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59 Edwin James, *An account of an expedition from Pittsburgh to the Rocky Mountains, performed in the years 1819
60 John Bradbury, *Travels in the interior of North America in the years 1809, 1810, and 1811: Including a
description of Upper Louisiana, together with the States of Ohio, Kentucky, Indiana, Tennessee, with the Illinois and
This concurs with the perspective of the historian James Malin, who saw nineteenth century Great Plains landscapes as entirely sufficient for habitation by Euro-Americans, who gradually adjusted, albeit hesitantly, to their new environments. In the context of what the historian Alfred Crosby termed ecological imperialism, European American colonists not only adapted to their environments, but shaped them into semblances of landscapes of eastern North America and Europe, to which they were accustomed. Such landscape transformations occurred in the Great Plains through activities like the suppression of fires, planting of trees, and plowing of prairies.\textsuperscript{61}

Native Americans were also prone to overusing wood resources, particularly when wintering with large horse herds in timbered refuges of the western plains. For example, the Big Timbers on the Arkansas River—near present-day La Junta, CO—which contained 97 kilometers of cottonwoods in 1805, had shrunken to half that size by the 1840s, and experienced additional depletion in subsequent decades as Native American horse herds grew, droughts occurred, and European American travel increased along the Santa Fe Trail. By 1864, timbered lowlands along the Arkansas were eliminated and per capita horse ownership among the Cheyennes, Arapahos, and others who depended on the timbers for shelter and fuel plummeted. Another example of rapid timber depletion under combined Native and Euro-American harvest is the Platte River valley, where an estimated 300,000 people and 1.5 million domesticated animals traveled the Great Platte River Road in the mid-nineteenth century, and along with the railroad, harvested trees.\textsuperscript{62}


\textsuperscript{62} Moore, \textit{The Cheyenne Nation}, 161; West, \textit{The contested plains}, 88–89, 229–230; Sherow, ‘Workings of the geodialectic’, 75–76, 80–81; Abert. \textit{Western America in 1846–1847}, 85; Stephen Hart and Archer Hulbert (eds.),
**Geographic distribution**

Except for elevated portions of the western plains, such as the Pine Ridge and Black Hills escarpments, timber was primarily restricted to river valleys and other lowlands. Timber was also more plentiful in the eastern than western plains. A description of this east-to-west gradient of timber decrease is found in the journal of General Custer, who wrote, “As you proceed west from the Missouri, the size of the trees diminishes as well as the number of kinds…the only trees to be seen being scattered along the banks of streams, these becoming smaller and more rare, finally disappearing altogether and giving place to a few scattered willows and oisers.”

According to the Kansas State Board of Agriculture’s 1874 statewide timber assessment, the Kansas counties with the greatest proportion of timbered land area were Wyandotte (25%), Doniphan (16%), and Leavenworth (16%) in the northeastern corner of the state. Meanwhile, 18 counties further southwest were only 1% timbered. Indeed, the 100th parallel was a longitudinal threshold, west of which precipitation and tree richness and abundance were observed to decrease.

Spatial settlement patterns provide additional indicators of tree distributions. To ensure consistent water and timber access, Native Americans situated villages on river terraces, periodically shifting locations as local timber supplies were exhausted. In 1811, for example, John Bradbury noticed that all the trees on one bank of the Platte River near an Otoe-Missouria

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63 Custer, My life on the plains, 6.


village had been cut, as did John Dunbar at another location in 1834.\textsuperscript{66} In 1848, Andrew Dawson documented the Hidatsas near Fort Berthold, in what is now western North Dakota, erecting winter villages upriver and downriver from their main village, in order to access timber and shelter. This is understandable, given that he went on to describe timber in the vicinity of the fort as “only of a narrow [sic] stripe along the bed of the Mo [Missouri].”\textsuperscript{67} The ethnographer Gilbert Wilson also documented the importance of wood availability in the historical siting of Hidatsa villages. Similar siting strategies were employed by the Northern Cheyennes, who in order to save wood for when they needed it most, stayed away from their winter villages during warmer months.\textsuperscript{68} Although Pawnee movements were predominantly westward, they at times traveled east to winter in the timbered bottomlands of the Missouri River. The Omahas were also wintering along the Missouri by the 1830s, in response to increasingly frequent and dangerous Dakota raids during winter bison hunts. In addition to the Big Timbers of the Arkansas River, the Big Timbers on the Republican River were described by Captain Ware in 1864 as stretching for 23 kilometers and containing only cottonwoods that averaged 0.3 meters in diameter. Other important High Plains wintering sites were situated along Lodgepole Creek, Sand Creek (Big Sandy Creek), Summit Springs, the Purgatoire River, the Upper South Platte River, the Republican River, the north side of the Cimarron River, near Freedom, Oklahoma, and along the Smoky Hill River in Kansas.\textsuperscript{69}

\textsuperscript{66} Bradbury, \textit{Travels in the interior}, 54, 201; Richard Jensen (ed.), \textit{The Pawnee mission letters, 1834–1851} (Lincoln: University of Nebraska Press, 2010), 121–122, 146.
\textsuperscript{67} Wischmann and Dawson, \textit{This far-off wild land}, 200.
\textsuperscript{68} Wilson, \textit{Uses of plants}, 7; Moore, “The dynamics of scale”, 229–230.
\textsuperscript{69} James, \textit{An account of an expedition}, 446; Wishart, \textit{An unspeakable sadness}, 77; William Emory, \textit{Notes of a military reconnaissance from Fort Leavenworth, in Missouri, to San Diego, in California, including parts of the Arkansas, Del Norte, and Gila Rivers} (Washington, D.C.: United States Army Corps of Topographical Engineers, Wendell and Benthuysen, Printers, 1848), 13; Ware, \textit{The Indian War}, 47, 341–342; Moore, \textit{The Cheyenne Nation}, 162; West, \textit{The contested plains}, 229–230.
Changes in human occupancy and activity are hypothesized to have contributed to short- and long-term fluctuations in timber availability. Before resettlement, Native American timber harvest and prairie fires restricted tree distributions. Maximilian described the aftermath of a fire near Mill Creek, in present-day Omaha: “One saw whole stretches of black, dead cottonwoods; the Indians set fire to the prairie and in this way also burn the trees. The dark spots of the hills were also burned forest… The burned forest had tall, completely black trees; here and there individual trees were a most beautiful green.”70 Just a few years earlier, in the midst of an 1830 autumn prairie fire in present-day north-central Kansas, Isaac McCoy had mused: In a day the whole country put on its black and dismal dress…The fires around us were sublime—the long lines and the flame ascending ten, fifteen, and sometimes twenty feet high. On seeing these prairies on fire in such a dry time as this we cease to wonder that the wood does not increase faster—we only wonder what a vestige of wood is left.”71 Finally, along the South Platte in 1842, United States Army Captain John C. Fremont penned the following east of the mouth of Lodgepole Creek, in now western Nebraska: “There were but few trees, a kind of long-leaved willow, standing; and numerous trunks of large trees were scattered about on the ground. In many similar places I had occasion to remark an apparent progressive decay in the timber.”72

Through frequent fire, Native Americans promoted increases in prairie throughout North America, whereas Euro-American fire suppression and tree planting facilitated increases in forest cover. It is plausible that the cessation of tree harvest and burning that accompanied Native American dispossession allowed timber in some areas to increase temporarily, after which it was reduced by incoming Euro-American settlers until tree-planting and fire suppression increased it

again. By 1895, there were approximately 81,000 hectares of artificial forest in Kansas, much of which can be attributed to the implementation of the Timber-Culture Act of 1873, the purpose of which was to increase timber on the Great Plains, and in doing so—it was believed—alter the climate. In summary, timber was a rare, valuable, and variable fuel. For illustrative purposes, we provide additional details on timber distributions in the Missouri and Platte River valleys, sorting observations by upstream movement (mouth-to-headwater).

The Missouri River

Nineteenth century timber distributions in the Missouri River valley were spatially and temporally heterogeneous. Although observations from before 1800 are limited, records rapidly accumulated as the river became a major transportation route. Tree abundance and species richness appear to have decreased with upstream movement and over time.

Maximilian paid careful attention to riverine forests, or the lack thereof, while traveling the Missouri by steamboat in 1833–1834. At McKissock Island, in present-day Nemaha County, Nebraska, and with the disclaimer that “the number of species of trees that make up the forests on the bank in this region of the Missouri has already greatly decreased”, he documented the presence of the following species: black oak (*Quercus velutina*), black walnut (*Juglans nigra*), boxelder, cottonwood, hackberry (*Celtis occidentalis*), hickory (*Carya* spp.), honey locust (*Gleditsia triacanthos*), ironwood (*Ostrya virginiana*), pawpaw (*Asimina triloba*), red elm (*Ulmus rubra*), red mulberry (*Morus rubra*), red oak (*Quercus rubra*), redbud (*Cercis*...
canadensis), American sycamore (*Platanus occidentalis*), and willow. Further upriver, in now Otoe County, Nebraska, where Weeping Water Creek empties into the Missouri, he noted “very tall, luxurious forest with dense understory.”

Above the Platte’s mouth, Maximilian’s Missouri River timber descriptions were increasingly dominated by stands of cottonwood and willow that were “in some places also mixed with other forest trees.” In 1811, John Bradbury had described this stretch of the river valley as “partly prairie, but interspersed with clumps of the finest trees, through the intervals of which could be seen the majestic but muddy Missouri.” By the early 1850s, the eastern side of the river below Council Bluffs was intensively settled and deforested, to the point that settlers were constructing dwellings from prairie sod. Fifty years earlier, William Clark had described the riverine forest at Council Bluffs as containing “tall timber, principally Willow Cottonwood some Mulberry elm Sycamore & ash…walnut [*Walnut*] coffenut [*Kentucky coffeetree*] & Oake [sic] in addition & [sic] Hickory & Lynn [*Linden*].”

Above the Missouri–Vermillion River confluence, near present-day Vermillion, South Dakota, Maximilian began to document less forest and more prairie, which “extended endlessly” beyond his river valley view. On his return, he reiterated the significance of the mouth of the Vermillion as where “the tall forests, so characteristic of the lower Missouri, begin.”

Maximilian used the grave of Chief Blackbird, near present-day Onowa, Iowa, as a landmark for where he first observed deciduous and coniferous trees co-occurring. Further

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76 Bradbury, *Travels in the interior*, 50.
77 Gottlieb Oehler and David Smith. *Description of a journey and visit to the Pawnee Indians who live on the Platte River, a tributary to the Missouri, 70 miles from its mouth* (New York: Moravian Church Miscellany, 1914), 32 pp.
upriver, in 1856, Lieutenant Warren documented tall cedars growing in the Missouri bottomlands at 43°N latitude, north of present-day Lynch, Nebraska, noting that they tended to decrease in size and frequency in uplands and at more northern latitudes. Maximilian had previously observed 12–15 meter cedars and 12 meter oaks in the same vicinity, and from there upriver, increasingly noted the use of cedar for steamboat fuel. Little Cedar Island, in present-day Charles Mix County, South Dakota, was covered at its tips with cottonwoods and at its center with slender cedars of height 18 meters or greater. Approximately two decades earlier, Little Cedar Island and Great Cedar Island (American Island) had been described by John Bradbury as being “covered with the finest cedar.” Upstream, in present-day Lyman County, South Dakota, there was another cedar-, cottonwood-, and willow-covered island by the name of Cedar Island, also known as Dorion Island Number 1. From here and a neighboring island, Dorion Island Number 2, traders Edward T. Latta and F.W. Johnson sold wood to passing steamboats.

At Fort Pierre, in present-day central South Dakota, Maximilian stated that timber was rare and had to be imported from 64–97 kilometers upriver; however, on his return trip, he somewhat confusingly described “a beautiful, wild forest of one-and-a-half-foot-thick cedars growing in wild disorder” 10 kilometers below the fort. The Lewis and Clark Expedition spent the winter of 1804–1805 at Fort Mandan, in present-day central North Dakota, where isolated groves of cottonwood, cedar, and ash were among the few trees dotting the grass-dominated river valley. At an Arikara village on the Upper Missouri in 1795, the explorer Jean Baptiste Truteau

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80 Warren, *Explorer on the Northern Plains*, 34.
82 Bradbury, *Travels in the interior*, 79.
83 Lass, ‘Dakota Resources’.
and his crew searched 15 days for a large enough tree from which to construct a boat, but were unsuccessful, as only sparsely distributed stands of small cottonwood and willow were available on the river for some 200 kilometers above or below the village. This assessment coincides with one offered by Maximilian some 30 years later, where he wrote that although thickets of willow, cottonwood, dogwood (*Cornus* spp.), ash, and elm were present in a far-extending forest, “There was little old wood left.” He also noticed that the wood being fed into the fire by Hidatsa children at their Great Buffalo Medicine Festival consisted primarily of small willow branches, that the nearby forest was “very much culled out, and there are only a few big trees left.”

Although some cottonwood, elm, boxelder, and ash were present several miles upriver at Fort Clark in the mid-1800s, wood was especially scarce during the winter of 1833–1834, when the fort’s woodcutters only brought in driftwood. Throughout the winter, Mandan women were continually observed by Maximilian carrying and dragging firewood across the frozen river—even breaking the ice and wading—back to their dwellings. Likewise, fort employees pulled timber across the river on sleds. When river ice broke the following April, an ice drift carried tree trunks downriver, which the Mandans advantageously harvested for days.

Further upriver from the Mandan villages, the most commonly-observed conifers transitioned from eastern redcedar to Rocky Mountain juniper (*Juniperus scopulorum*) and prostrate juniper (*Juniperus horizontalis*). At Fort Union, near the Yellowstone–Missouri River confluence, in present-day western North Dakota, Maximilian stated that the only timber available for use as construction material was cottonwood. Both Maximilian and Truteau

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88 Wischmann and Dawson, *This far-off wild land*, 88.
observed the Upper Cheyenne and Lower Yellowstone Rivers to be well-wooded.\textsuperscript{89} In a portion of present-day Phillips County, Montana that is now likely inundated by Fort Peck Reservoir, Maximilian noted 9–12-meter-tall Ponderosa pine (\textit{Pinus ponderosa}) trees in the ravines and uplands along the river. Substantial stands of timber, including cottonwood and boxelder, appear to have been present on islands near Fort McKenzie in what is currently Chouteau County, Montana. Although sufficient wood for constructing the fort was apparently available in 1832, by the time of Maximilian’s 1833 visit, there was not even enough hardwood for the construction of an ax handle, an assertion supported by the fact that the hickory oars of his party’s keelboat were sawed up for that purpose.\textsuperscript{90} Just upriver, at Fort Benton, the last steamboat stop on the Upper Missouri, Andrew Dawson and his American Fur Company colleagues stockpiled wood from nearby forests in preparation for winter, and even transported it 16 kilometers downriver for steamboats.\textsuperscript{91}

\textbf{The Platte River}

The historical distribution of timber in the Platte River valley has been the subject of debate. The perception of the Platte as having nearly treeless banks with cottonwood and willow covered islands is supported by: Garnett Williams, who relays several hypotheses for the scarcity of trees on the river banks; Thomas Eschner et al., who emphasize the roles of water availability and human harvest in shaping timber distributions; and Carter Johnson and Susan Boettcher, who cite numerous early accounts of the banks and islands of the Platte being initially wooded and subsequently deforested by the hundreds of thousands of travelers, settlers, and railroad workers.

\textsuperscript{89} Truteau, \textit{Journal of Truteau}, 379, 381.
\textsuperscript{91} Wischmann and Dawson. This far-off wild land. Pages 116–117.
In a counter-argument, Paul Currier and Craig Davis use many of the same historical references as Johnson and Boettcher, along with historical species occurrence data, to characterize the Platte as a sparsely-wooded, prairie river, without heavily-wooded banks or islands. In the context of rapid regional social–ecological change, it is possible—even likely—that Platte River timber distributions were temporally and spatially variable. For instance, Carter Johnson, referencing the notes of the General Land Survey, suggests that trees grew on both the banks and islands of the Platte River east of present-day Kearney, Nebraska; that they were primarily restricted to islands on the Platte west of Kearney; and that they became extremely sparse or absent west of the South Platte–North Platte confluence. The most frequently observed tree species in the survey were cottonwood, willow, and elm.

In the 1830s, the banks of the Platte were described by John Dunbar as relatively treeless, although he did note robust stands of timber on river islands. In 1835, near the eastern end of Grand Island, in present-day south-central Nebraska, United States Army Captain Lemuel Ford stated:

The fact that all these islands are covered with a thick and heavy growth of timber, is a conclusive proof that nothing but the annual fires, which sweep over these immense prairies prevents them from being timbered also. It is nonsense to suppose, as some have asserted, that timber cannot be made to grow on land like this. Prevent the fire from

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running over these prairies but for twenty years, and instead of millions and millions of
acres of rich land without a stick of timber large enough for a riding switch, you would
see one dense and beautiful forest of oak, hickory and ash, upon the highlands, and the
majestic cotton-wood, and evergreen cedar upon the bottom lands, bordering on the great
rivers.95
The Platte was also described as treeless—with the exception of wooded islands—by Captain
Fremont in 1842 and the Moravian missionaries Gottlieb Oehler and David Smith in 1851.96 As
settlers filed into the river valley during the 1850s, the geologist Ferdinand Vandeever Hayden
stated that the river valley contained “sufficient timber for all economic purposes,” and what
Lieutenant Warren described as “fine cottonwoods” were present along the banks of the Platte
between its mouth and Fort Kearny.97
In 1864, Lieutenant Ware offered the following description of the Platte River valley,
upstream from Fort Kearny:
Beautiful valleys were seen, narrow and deep, full of enormous cedar trees, box elders,
hackberry, plum trees, and shrubbery…We rode along this plain, over these beautiful
valleys, for fully ten miles…There had never been an axe put into these canyons, except a
little at their openings near the river. The cedar trees were as straight as arrows, very
numerous, and all sizes up to two feet in diameter. They grew mostly from the bottom of
the canyon, yet no tree-tops were seen rising above the level of the plain.98

95 Lemuel Ford, ‘A summer upon the prairie by “F” [Captain Lemuel Ford]’, in Archer Hulbert (ed.), pp. 227–
305, Overland to the Pacific, volume 4. The call of the Columbia; iron men and saints take the Oregon Trail, edited,
with bibliographical resume, 1830–1835 (Denver: The Stewart Commission of Colorado College and T Denver
Public Library, 1934), 250.
96 Fremont, Report of the exploring expedition, 16, 21; Oehler and Smith, Description of a journey, 13.
98 Ware, The Indian War, 41–42.
Lieutenant Warren also noted cedars in ravines near the confluence of the North and South Platte. At Brady’s Island, not far from the confluence, Captain Fremont observed, “some timber, apparently pine” growing in the ravines, although it is reasonable to assume that these too were cedars.\footnote{Fremont, \textit{Report of the exploring expedition}, 21.} Another description of timber near the confluence was provided by Major Osborne Cross in 1849, who wrote, “The river here is nearly three miles wide [and] interspersed with islands, some of which are thinly covered with very small cottonwood and willow. In many instances they are entirely bare.”\footnote{Settle, \textit{The march}, 67.} Nearby Moran Canyon was filled with cedar trees in 1864.\footnote{Ware, \textit{The Indian War}, 70.}

In fact, there were five cedar-filled canyons near Fort McPherson, from which a local settler, Jack Morrow, cut and sold 5,000 trees. Alternatively, near the town of North Platte, in the late 1860s, Joseph Barker characterized the river bluffs as “generally treeless” and noted that the river itself contained “numerous sandbars but no timber.”\footnote{Snoddy, \textit{Their man in Omaha}, 515.}

Captain Fremont described a large driftwood deposit in the valley of the North Platte River in 1843, stating, “The plain between Scott’s Bluffs and Chimney Rock was almost entirely covered with drift wood, consisting principally of cedar, which, we were informed, had been supplied from the Black Hills, in a flood five or six years since.”\footnote{John Fremont, \textit{A report on an exploration of the country lying between the Missouri River and the Rocky Mountains, on the line of the Kansas and Great Platte Rivers} (Washington, D.C., United States Senate, 1843), 36.} Although the origin of this wood in the Black Hills was unlikely, the account highlights the potential for woody fuels to be deposited far downstream of their origin in what were called “big drifts”—piles of trees killed by fire and then carried downstream and deposited by erosion and flooding.\footnote{Moore, ‘The dynamics of scale’, 235–236.} An alternative source of this timber could have been the Wildcat Hills escarpment, south of Scott’s Bluff. The diary of United States Army Major Osborne Cross in 1849 includes another description of a wood deposit.

\footnotetext[99]{Fremont, \textit{Report of the exploring expedition}, 21.}
\footnotetext[100]{Settle, \textit{The march}, 67.}
\footnotetext[101]{Ware, \textit{The Indian War}, 70.}
\footnotetext[102]{Snoddy, \textit{Their man in Omaha}, 515.}
\footnotetext[103]{John Fremont, \textit{A report on an exploration of the country lying between the Missouri River and the Rocky Mountains, on the line of the Kansas and Great Platte Rivers} (Washington, D.C., United States Senate, 1843), 36.}
\footnotetext[104]{Moore, ‘The dynamics of scale’, 235–236.}
at Scott’s Bluff: “Wood as usual was very scarce, but we obtained enough in the valley for our use. It had been swept from the hills by the heavy rains which frequently fall during the summer. What was found consisted principally of dwarf cedar and pine.”

Further northwest, at Fort Laramie, which was situated at the confluence of the Laramie and North Platte Rivers, Major Cross noted in 1849, “Wood is scarce immediately in the vicinity of the fort, but pine and cedar may be procured on the hills across the Platte about eight miles above here.” Cross went on to describe the scarcity of wood over the entire High Plains, writing, “Wood is not to be procured from the time you leave Fort Kearny until you arrive at this place. Nothing is to be seen but the naked valley and boundless prairies in whatever direction the eye is turned.”

Indeed, in 1864, the nearest trees to Julesburg, in present-day northeast Colorado, were purported to be at Ash Hollow, near now Lewellen, Nebraska, a straight-line distance of 48 kilometers.

CONCLUSION

The nineteenth century was a period of rapid social–ecological change in the Great Plains. In transformational waves of colonization, horse herds were acquired and lost, disturbance regimes were upended, bison herds collapsed, forests waxed and waned, and prairie sod was tilled and cropped. Cross-cultural adaptive fuel procurement was at the heart of these changes, as Native American and Euro-American cultures simultaneously responded to and shaped plains landscapes through the harnessing of energy for cooking, heating, eating, and traveling.

105 Settle, The march of the mounted riflemen, 93, 98–99.
106 Ware, The Indian War, 230–231.
Two important organic fuels with different forms, availabilities, specific energies, and energy densities were herbaceous biomass and woody biomass, both of which could generally be derived locally and regenerate quickly. Herbaceous biomass—in the forms of forage, buffalo chips, and pemmican—fueled horse herds, trade networks, and fires for heating and cooking. Herbaceous biomass and bison were ubiquitous, as tallgrass and shortgrass prairie dominated vegetation in the eastern and western plains. Woody biomass supplemented herbaceous forage as winter horse food, powered steam engines in locomotives and steamboats, and fed fires for heating and cooking. Woody biomass was rarer than herbaceous biomass, was largely restricted to lowlands, and decreased from east-to-west.

Utilization of fuels was affected by their energy contents and densities. Of the fuels evaluated here, pemmican had the greatest specific energy, and was followed by woody biomass, herbaceous forage, and buffalo chips (Table 1). Although the specific energies of different tree species were similar, their energy densities were not, as illustrated by interspecific differences in energy content per cord of wood. Not all the energy in fuels could be captured and applied to human uses. For example, although the mean gross specific energy of tallgrass prairie hay is 3,750 kilocalories per kilogram, its metabolizable energy in cattle—which accounts for energy lost in feces, urine, and gasses—is 1,600 kilocalories per kilogram. Beyond energy content, additional fuel characteristics (e.g., moisture content) made them more-or-less desirable for certain purposes in certain seasons.

Although herbaceous and woody biomass were renewable over relatively short timeframes, the combined effects of environmental fluctuations, local disturbances, and human harvest caused local-to-regional shortages. Over the nineteenth century, seasonal strategies for

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107 DeWald et al., *Heating with wood*, 2
108 Olson et al., ‘Prediction of the energy content of tallgrass prairie hay’, 1373, 1376.
conserving fuel and increasing access to it were supplanted by strategies of resource storage and importation. For instance, as Native American horse herds grew and Euro-American overland travel increased, the effectiveness of lowland wintering as a strategy for meeting winter fuel and resource needs decreased, and many riverine forests were eliminated. Alternative strategies adopted for meeting winter fuel needs included fuel storage, transportation, importation, and ultimately, replacement with energetically denser fossil fuels. Horses and guns increased human efficiency in accessing energy stored in bison herds; however, the combination of sustained commercial and subsistence hunting, competition with horses for forage, and environmental fluctuations drove once-ubiquitous bison to the brink of extinction, albeit along unique trajectories in the northern and southern plains.

Although effective at meeting resource needs in the short-term, nineteenth century adaptations in fuel procurement failed to ultimately resolve the permanent human challenge of securing sufficient energy, at least amidst waves of colonization in dynamic environments. In many instances, increases in the efficiency of fuel procurement contributed to local-to-regional fuel depletion. All fuel-based adaptations have social–ecological causes and consequences, and in nineteenth century plains landscapes, colonization facilitated rapid, cross-cultural exchanges of fuel sources, technologies, strategies for increasing energy access, and human environmental influences that collectively shaped regional environmental history.

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### TABLES

Table 1: Specific energies of selected organic fuels, in kilocalories and gigajoules per kilogram.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>kcal kg(^{-1})</th>
<th>gJ kg(^{-1})</th>
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<tbody>
<tr>
<td>Pemmican</td>
<td>7,055</td>
<td>0.02951812</td>
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<tr>
<td>Cottonwood</td>
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<td>0.01617534</td>
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<tr>
<td>Bur oak</td>
<td>3,866</td>
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<td>Green ash</td>
<td>3,861</td>
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<td>Eastern redcedar</td>
<td>3,844</td>
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<tr>
<td>Tallgrass prairie hay</td>
<td>3,750</td>
<td>0.01569000</td>
</tr>
<tr>
<td>Buffalo chips</td>
<td>3,117</td>
<td>0.01304153</td>
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Figure 1: Approximate locations of in-text observations.
Figure 2: Omaha village with earth lodges and tipis, surrounded by depleted herbaceous vegetation. Credit: Nebraska State Historical Society.
Figure 3: Polly Ann McColl collecting buffalo chips in 1893, in Kearny County, Kansas. Credit: Kansas State Historical Society.
Figure 4: The steamboat Montana, which operated on the Missouri River in the late nineteenth century. Credit: Nebraska State Historical Society.
Figure 5: Men sitting on a wood pile used to fuel a Union Pacific locomotive. Credit: Nebraska State Historical Society.
Figure 6: Andy Owens with his family and sawmill along Plum Creek, east of present-day Pine Canyon Dam, in Brown County, Nebraska. Used with permission from the Brown County Museum in Ainsworth, Nebraska.