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A War of Mobility

Transportation, American Productive Power, and the Environment during World War II

Thomas Robertson and Christopher W. Wells

> We knew that we would have to fight a highly motorized mechanized war – or a *losing war*.
>
> – Donald Nelson, Chairman of the War Production Board[1]

World War II was a global war. It was a war of transport, mobility, and speed, fought in the far corners of the planet, across four continents and four oceans. It was also a gross national product war, fought with huge armies equipped with the fruits of modern industry – guns, artillery, tanks, trucks, airplanes, and thousands of other tools and supplies. To fight a war of men and material simultaneously on opposite sides of the earth, the United States needed weapons of speed and distance, such as the airplane, but also tools of mobile transport, such as heavy trucks – and they needed them in record numbers. The United States also required a transportation infrastructure at home (and abroad) that could deliver people and resources where needed for production and warfare.

Building hundreds of thousands of airplanes and millions of new trucks, combined with creating the substantial, far-flung transportation infrastructures to support them, spurred significant and lasting environmental changes: a new pattern of extracting resources, some of which came from the United States and some from overseas; a host of new industrial sites and expanded production capacity, which brought environmentally destructive practices; a new geography, together with an accelerated culture of mobility; and new ideas about modern life,

[1] A. J. Baime, *The Arsenal of Democracy: FDR, Detroit, and an Epic Quest to Arm an America at War* (Boston: Houghton Mifflin Harcourt, 2014), 135.

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technology, and nature – and, especially, a sense of fragility in the face of humanity's growing technological prowess. Remaking extractive and productive landscapes and the transportation systems that connected them during the war created patterns, technologies, and ideas that shaped American relationships with nature well into the future.

BUILDING AN AVIATION INDUSTRY

Many of the more distinctive environmental changes that World War II prompted in the United States – new materials, technologies, productive power, and ideas – flowed from the stunning growth, in just a few short years, of the American aviation industry. Between 1940 and 1943, the American military's air force grew from tiny to gargantuan. In September 1939, the United States possessed 2,470 aircraft; in July 1944, it had nearly 80,000. In late 1939, the United States had 17 airbases; by 1943, it possessed 345 main bases, 116 subbases, and 322 auxiliary fields – most of which had also been expanded and improved during the war. In June 1938, the General Headquarters Air Force, a predecessor to the Army Air Force (AAF), enlisted more than 20,000; in March 1945, it had almost 1.9 million men and women, roughly one in six of all military personnel.[2] Of the planes the United States had in 1939, only 23 were truly modern aircraft – B-17 bombers – which by the end of the war had been surpassed in size, speed, power, and capacity for devastation.[3]

Massive air power was not possible without industrial facilities that gobbled up massive amounts of materials and left behind a significant environmental mark. During the war, the United States possessed great productive advantages over other countries in steel, automobiles, oil, and – eventually – in aviation. But the war did not start that way. In 1938, US production of planes, including both military and civilian, totaled more than 3,600 aircraft. In May 1940, President Franklin Roosevelt shocked the nation by calling for a yearly output of 50,000 planes, an almost unimaginable number. The United States had produced only about 50,000 aircraft in its entire history until then. But one-third of those were made in World War I, so planners knew that wartime emergency

[2] David T. Courtwright, *Sky as Frontier: Adventure, Aviation, and Empire* (College Station: Texas A & M University Press, 2005), 118.

[3] D'ann Campbell and Richard Jensen, "Domestic Life, War Effort, and Economy," in *The Oxford Companion to World War II* (Oxford: Oxford University Press, 2001), 1180–1182. See also John Bell Rae, *Climb to Greatness: The American Aircraft Industry, 1920–1960* (Cambridge, MA: MIT Press, 1968).

measures could yield big results. By early 1944, the United States could produce 110,000 planes a year. In total, the United States produced 300,000 planes during the war (see Figure 1.1).[4]

The buildup began long before the United States entered the war in December 1941. In 1939, the federal government allocated $68 million for military aircraft production. At the time, only 15 plants made airframes, engines, and propellers. By 1940, 41 factories did so, and, by 1943, more than 80. More than 2.1 million American men and women worked in the aircraft industry.[5] In the run-up to American involvement in the war, the country began spending lavishly on airports, disbursing $40 million in 1939 and another $95 million in 1941.[6]

None of this would have been possible without the automobile industry. "Automotive conversion," the War Production Board's Donald Nelson wrote, "was the first and biggest item on our agenda. The story of production for war … centers around the story of conversion of our automotive industry – the most colossal aggregation of industrial might in history."[7] It was not just the size of the auto industry that mattered; more important was that no industry could match the auto industry's mastery of assembly-line mass production. Ultimately, the United States won the war, as A. J. Baime notes, with thousands of "Oldsmobile cannon shells, Packard marine and aviation engines, Buick aviation engines, Dodge gyrocompasses and ambulances, Studebaker troop transporters, Cadillac tanks and Howitzer cannons, Dodge shortwave radio sets, Chrysler field kitchens, A. C. spark plug 50 caliber Browning machine guns."[8] This was just one of many ways in which the aircraft and automobile were interlinked during the war.

Much of this prodigious production occurred in and around Detroit, as the city's automakers redirected their prowess in mass production toward establishing the United States as the "arsenal of democracy." Almost as soon as the United States entered the war, Detroit's automakers stopped building cars for civilians, shifting to a round-the-clock, seven-day-a-week schedule of war production. By war's end, only the chemical industry giant DuPont outstripped General Motors as a producer for the American military. The nation's largest automaker churned out a vast range of

[4] Roger E. Bilstein, *Flight in America: From the Wrights to the Astronauts* (Baltimore: Johns Hopkins University Press, 2001), 159–160. Also see Donald M. Pattillo, *Pushing the Envelope: The American Aircraft Industry* (Ann Arbor: University of Michigan Press, 2000).

[5] Courtwright, *Sky as Frontier*, 96–97. [6] Ibid.

[7] Baime, *The Arsenal of Democracy*, 135. [8] Ibid., 136.

FIGURE 1.1 Garrett Price, "Pour It On" (poster) (Washington, DC: War Production Board, 1942). Library of Congress Prints and Photographs Division Washington, DC, Reproduction Number: LC-USZC4-6032.
Source: Image in the public domain

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military goods, including tank and airplane engines; complete bombers and fighter planes; tanks, trucks, and armored vehicles; and an array of cannons, machine guns, carbines, and mortar and artillery shells, among other war products. Ford and Chrysler ranked eighth and ninth, respectively, in military production, making a similarly wide range of war materiel. Smaller automakers like Willys and Packard also did their part.[9] By war's end, no less than 30 percent of the nation's total military equipment was pounded, welded, and bolted together in southeastern Michigan.[10]

No better example of the auto industry's involvement in wartime airplane production – and of the new scale and intensity of interactions with nature during the war – exists than the Ford Motor Company's massive Willow Run plant, built early in the war to make B-24 Liberators. Backed with the promise of a federal contract, Edsel Ford carved out the huge industrial facility from soybean fields 25 miles west of Detroit, near Ypsilanti. The airfield emerged first, in 1941, with workers bulldozing 650,000 cubic yards of dirt, and laying down 16 miles of sewers and 58 miles of drain tile.[11] The plant was monstrous: 67 acres under one roof. The *Washington Post* called it "the greatest single manufacturing plant the world had ever seen." Inside, the *Post* reported, "All 16 major league baseball teams could play simultaneous games before crowds of 30,000 each.... And there would still be room enough left over for a full-sized football game before an additional 30,000 spectators."[12] Before the end of the war, Willow Run would be rolling out a new B-24 bomber every hour.[13]

Building the B-24 – which stretched 110 feet from wingtip to wingtip and weighed 35,000 pounds – required tremendous quantities of materials from the near and far corners of the earth: aluminum, rubber, plastic, steel, and several other metals. The bomber's skin consisted of thin sheets of aluminum. Nearly 5 miles of wire and 4,000 feet of rubber and metal tubing snaked within each plane, circulating fuel, oil, oxygen, de-icing fluid, and hydraulic fluid. Eighteen self-sealing rubber fuel tanks inside the wings held 16,320 pounds (2,320 gallons) of 100-octane gasoline. Three rubber tires, each of them three feet high and capable of supporting nearly

[9] On World War II auto industry production, see Automobile Manufacturers Association, *Freedom's Arsenal: The Story of the Automotive Council for War Production* (Detroit: Automobile Manufacturers Association, 1950).
[10] Baime, *The Arsenal of Democracy*, 259. [11] Ibid., 108. [12] Ibid., 143.
[13] On Willow Run, also see David T. Courtwright, *Sky as Frontier: Adventure, Aviation, and Empire* (College Station: Texas A&M University Press, 2005), 118.

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27,000 pounds, rolled beneath the plane. Four radial engines generated the equivalent of 56 Ford V8 engines, or of a total of 4,800 horses. Four generators, each enough to power an average household, churned out electricity. Overall, aluminum made up 85 percent of the plane; steel 13 percent; brass, copper, and bronze 0.66 percent; magnesium 0.33 percent; and rubber, glass, and plastic 1.01 percent.[14] A railroad spur delivered these materials to Willow Run; four 30,000-pound cranes unloaded and distributed them.

The plant was divided into manufacturing and assembly sections. To stamp out bomber parts, metalworkers used hydraulic presses, some weighing 700,000 pounds. Welders and blacksmiths shaped sheet metal and 3,000 separate parts. Twenty-nine miles of ceiling conveyors ferried parts and materials around the plant. Machines – drills, lathes, x-ray machines, jigs, and presses – spread throughout the work areas. Pipes circulated oxygen, paraffin, machine oil, compressed air, steam, acetylene, hydrogen, oxygen, and two kinds of gasoline – 73 octane for trucks and cars, 100 octane for airplanes.[15]

From an environmental perspective, perhaps the most significant area of the factory was the metals lab, the physical location where the "age of alloys" was created. Here, to make high-performance alloys – new metallic mixtures that would remake American material culture – foundry workers mixed molten aluminum and steel with copper, chromium, molybdenum, tungsten, vanadium, and, especially, carbon.[16] They often used acid and cyanide.

Windowless because of wartime blackouts, the factory relied on 156,000 40-watt Sylvania fluorescent bulbs. Hundreds of machines generated an ear-splitting clatter and scream. One worker described the factory floor's otherworldly environment: "The roar of the machinery; the special din of the rivet guns, absolutely deafening nearby; the throbbing crash of giant metal presses; busy little service trucks rushing down endless aisles under the blue white fluorescent lights; the strange far-reaching line of half-born skyships growing wings under swarms of workers meeting deadlines."[17] (At another wartime aviation factory, one writer described the "banshee din of air-riveting hammers and the high-pitched swearing of tortured souls." It was, he said, a "nerve-shattering existence."[18])

[14] Baime, *The Arsenal of Democracy*, 90, 96, 164. [15] Ibid., 97. [16] Ibid., 146.
[17] Ibid., 18, 140.
[18] Hurd Barrett, "Bombers by the Pound," *Saturday Evening Post*, February 24, 1940.

A small army of workers, including African Americans recruited from the South and women, took turns keeping Willow Run churning around the clock. Employment peaked in the spring of 1943 at 42,331. Housing employees in the nearest hamlet, which had only 331 residents before the war, posed a particular problem. By 1942, shantytowns without clean drinking water and sewage systems sprang up.[19] Eventually the government constructed "Bomber City" for workers, a sprawling complex of one- and two-bedroom apartments. Some officials hoped to apply the latest urban planning principles to these wartime settlements to prevent problems. Their hopes were rejected. "The military's concern for delivery speed and reliability," writes Sarah Jo Peterson, "overwhelmed all other criteria."[20]

It is hard to know exactly how much factories like Willow Run contaminated the water, air, and soil. At the time, very few people gave much thought to industrial pollution, and factories kept few records. But one indication is the toxic sludge pond containing PCBs that collected some plant waste beginning in 1942 and for decades afterward.[21] Yet the pollution from a plant of this size extended beyond this. Guided by ignorance and constrained by few regulations, most American factories spewed substantial amounts of dirty air, contaminated water, and toxic solid waste. On top of this, great urgency drove all military production: "speed and more speed" according to one top planner.[22] "Facilities for production," Roosevelt announced in his 1942 State of the Union, "must be ready to turn out munitions and equipment at top speed."[23] This sense of urgency, coupled with an inexperienced workforce, pushed factories to implement many new techniques without proper testing, resulting in widespread corner-cutting, such as the dumping of chemicals.

Willow Run was only one of scores of aviation industrial sites. Similar aircraft factories remade local economies and environments in aviation production pockets scattered around the country. Aircraft factories making aircraft frames, propellers, parts and engines sprung up around

[19] Baime, *The Arsenal of Democracy*, 146–149.

[20] Sarah Jo Peterson, *Planning the Home Front: Building Bombers and Communities at Willow Run* (Chicago: University of Chicago Press, 2013), 32. Also see Douglas Karsner, "Aviation and Airports: The Impact on the Economic and Geographic Structure of American Cities, 1940s–1980s," *Journal of Urban History* 23, no. 4 (1997): 406–436.

[21] "Public Health Assessment: Willow Run Sludge Lagoon," Public Health Assessments and Health Consultations, Agency for Toxic Substances & Disease Registry, www.atsdr.cdc.gov/hac/pha/pha.asp?docid=479&pg=1 (accessed July 18, 2016).

[22] Baime, *The Arsenal of Democracy*, 85.

[23] Ibid., 69.

Detroit, New York City, Chicago, Wichita (the "air capital" of America), Seattle, and a few Sunbelt locations, such as Los Angeles and Georgia, in a process of geographic reconfiguration one scholar has called the "Military Remapping of America."[24] The Bell Aircraft Plant in Marietta, GA, which drew resources from Tennessee Valley aluminum plants, occupied a 3,000-acre plot. The biggest single factory, the Dodge plant in Chicago, which produced Wright-cyclone engines for the B-29 "Superfortress" and sat on land that in 1942 was just a grassy prairie, occupied 6.5 million square feet of work area (covering 30 city blocks), as much floor space as occupied by the entire aircraft engine industry early in 1941.[25] These factories all contaminated local ecosystems with new chemicals and byproducts. Boeing Plant 2, located along the Duwamish River in Seattle, later became a Superfund site because of PCBs and a range of other hazardous materials in its soil and groundwater, including chromium, copper, and cadmium, cyanide, petroleum products, and chlorinated solvents such as trychlorethylene.[26] Similarly, new air bases were also industrial sites that polluted local soil and water and consumed great stretches of American territory, particularly in the Sunbelt, a term coined by the AAF. By the war's end, AAF bases covered 19.7 million acres.[27] Besides the pollution, airplane factories and bases required new local infrastructure and housing. They also pulled materials from around the country and the world.

MINING NATURE TO MAKE PLANES

Procuring the vast range and quantity of materials for airplane production – the total mobilization of materials required by new military strategy – also dramatically rearranged nature, often with significant environmental consequences. The many minerals and other materials demanded by an aviation-driving military strategy all came from the earth somewhere – often outside of the United States. As Brian Black also shows in Chapter 4, digging up and transporting these materials transformed not just the earth but also the lives of many people along the way.

[24] Ann R. Markusen, *The Rise of the Gunbelt: The Military Remapping of Industrial America* (New York: Oxford University Press, 1991).
[25] Rae, *Climb to Greatness*, 143.
[26] Environmental Protection Agency, "Hazardous Waste Cleanup: Boeing Plant 2, Tukwila, Washington," www.epa.gov/hwcorrectiveactionsites/hazardous-waste-cleanup-boeing-plant-2-tukwila-washington (accessed July 25, 2019).
[27] Rae, *Climb to Greatness*, 16.

At the war's outset, the United States lacked domestic sources for many materials essential for a massive military. In 1940, the United States possessed just 15 percent of the raw materials needed for even a two-year military emergency.[28] Supplies for airplanes – including rubber, copper, ferroalloys, and, especially, aluminum – particularly worried planners.[29]

Aluminum was to the mid-twentieth century what iron and steel were to the late nineteenth century: the era's defining material. Its widespread availability gave birth to spectacular innovations and yielded shiny new aesthetics. Above all, aluminum created modern airplanes, and, with them, modern warfare. "The aluminum industry helped to modernize warfare," Mimi Sheller has noted, "and warfare helped to modernize the aluminum industry."[30] As strong as iron or steel but much lighter, aluminum enabled planes to carry more, fly faster, and travel farther than ever before. Aluminum made up 60 percent of a modern heavy bomber's engines, 90 percent of its wings and fuselage, all its propellers, as well as rivets, wires, cables, rods, and electrical equipment.[31] "Aluminum," one observer noted in 1951, "has become the most important single bulk material of modern warfare. No fighting is possible, and no war can be carried to a successful conclusion today, without using and destroying vast quantities of aluminum."[32]

Between 1939 and 1943, American aluminum production multiplied sixfold, eclipsing the growth of all other essential metals.[33] At first, the United States obtained most of its bauxite – the ore in which aluminum is found – from mines in Suriname. But in 1942, despite new air bases and other heavy fortifications, German U-boats disrupted this supply. During a single three-week period in early fall, German submarines ignited a crisis by torpedoing 15 bauxite carriers and cutting deliveries by more than 75,000 tons. Launching an "all-out" program to develop domestic sources, the War Production Board turned to bauxite from Arkansas, newly useable because of a technological breakthrough called the

28 Alfred E. Eckes, *The United States and the Global Struggle for Minerals* (Austin: University of Texas Press, 1979), 94.

29 For Canadian aluminum production, see Matthew Evenden's pioneering work, "Aluminum, Commodity Chains, and the Environmental History of the Second World War," *Environmental History* 16, no. 1 (January 1, 2011): 69–93. Also see Matthew Evenden, *Allied Power: Mobilizing Hydro-Electricity during Canada's Second World War* (Toronto: University of Toronto Press, 2015).

30 Mimi Sheller, *Aluminum Dreams: The Making of Light Modernity* (Cambridge, MA: MIT Press, 2014), 62.

31 Ibid., 70. 32 Ibid., 61. 33 Ibid., 70.

lime-soda sintering process.[34] In 1941, foreign suppliers provided 54 percent of America's bauxite; in 1943, even as aluminum production increased dramatically, they supplied less than 20 percent.[35] "Had the United States not possessed a deposit of bauxite in Arkansas," a 1952 government commission explained, "it might have been forced to cut back on airplane production."[36]

Like most mining, bauxite mining came at an environmental cost. Aluminum comes from reddish bauxite ore pulled from the earth in strip mines. In these mines, workers rip away the earth's trees and other vegetation to uncover the ore mixed with soil and rock below. Bauxite mines leave behind vast pools of red mud, and often disrupt local streams and contaminate groundwater.

The ore was then transported to processing plants, which were located near massive hydroelectric dams because of the tremendous quantities of electricity needed to remove impurities. Indeed, so much electricity was needed that aluminum has been called "packaged electricity" or "solidified electricity."[37] During the war, reduction plants near Niagara Falls in New York, the Tennessee Valley in Tennessee and North Carolina, and the Bonneville Dam in Washington processed most American aluminum.[38] Without the huge amounts of power produced by New Deal dams in the Tennessee and Columbia River valleys, started during the New Deal and expanded during the war, it is unlikely that the United States could have reached the astonishing production heights it did. In the Pacific Northwest, half of the 8.5 billion kilowatt-hours of electricity produced during the war's last year went into producing more than half a billion pounds of aluminum – one-third of the nation's total. That was enough, a proud Bureau of Reclamation official pointed out, to produce 10,000 B-29s or 150,000 fighter planes.[39]

Securing the many little-known materials essential to the bauxite refining process became a top national security priority. No better example

[34] Eckes, *The United States and the Global Struggle for Minerals*, 107. [35] Ibid., 115.

[36] President's Materials Policy Commission, *Resources for Freedom, Vol. 1* (Washington, DC: US Government Printing Office, 1952), 157.

[37] Brad Barham, Stephen G. Bunker, and Denis O'Hearn, *States, Firms, and Raw Materials: The World Economy and Ecology of Aluminum* (Madison: University of Wisconsin Press, 1994), cited in Sheller, *Aluminum Dreams*, 148.

[38] National Resources Planning Board, *Industrial Location and National Resources, December, 1942* (Washington, DC: Government Printing Office, 1943), 178.

[39] Department of Interior, *Annual Report, 1945* (Washington, DC: Government Printing Office, 1945), 45.

exists than cryolite, a scarce material used as a bath in the alumina smelter pots and critical to the electrolytic process. No cryolite, no aluminum – and no American air force. In 1939, the only known accessible location of cryolite in the world lay within the Ivigtut mine on the west coast of Greenland, a Danish colony. In April 1941, after Germany took over Denmark, yet still six months before Pearl Harbor, the US Army moved in to secure the site.[40]

American airplanes also required large quantities of high-octane fuel. "Aviation," Secretary of the Interior Harold Ickes noted, "is a creature of petroleum." Planes, he said, were "oil in the air." You could imagine electric or coal automobiles, he said, but not electric or coal airplanes.[41] In particular, modern aircraft demanded special gasoline: 100-octane fuel. This new "super" fuel, which contained lots of lead, ramped up the power of engines, fueling greater speed and steeper climbs. "Without high-octane gasoline," the War Production Board noted in 1944, "the huge bombers – the B-29's, the Liberators, and the Flying Fortresses – and the fast fighter planes – the Mustangs, the Hellcats, and the Black Widows – might have been built, but they could not have been flown. It is the high-octane gasoline that makes possible the quick take-off speed, the long range, the high altitude, and the heavy loads of modern planes."[42] Fueled by oil, heavy bombers delivered destruction with greater intensity and on a broader scale than ever before.

In addition to aluminum and fuel, numerous other raw materials linked airplane production to environmental change and destruction. Take rubber, for instance. As Japan swept through the world's major rubber-producing region in Southeast Asia, including the British Malay States and the Dutch East Indies, the United States lost its chief source of rubber. In 1942, the US government created the Emergency Rubber Project, a "Manhattan Project of plant sciences" that was, according to historian Mark Finlay, comparable to some degree to the nuclear bomb project "in terms of scale, urgency, and interdisciplinary scope."[43] Rubber was needed, President Roosevelt told the nation in June 1942,

[40] Evenden, "Aluminum, Commodity Chains, and the Environmental History of the Second World War," 81–82.

[41] Harold L. Ickes, *Fightin' Oil* (New York: A. A. Knopf, 1943), 153.

[42] US War Production Board, *War Production in 1944* (Washington, DC: Government Printing Office, 1945), 46. Also see Wright W. Gary, "Super Fuel: 100 Octane Gasoline," *Flying* 31 (July 1942): 43–44.

[43] Mark R. Finlay, *Growing American Rubber: Strategic Plants and the Politics of National Security* (New Brunswick, NJ: Rutgers University Press, 2009), 141.

to "build the planes to bomb Tokyo and Berlin" and to "build the tanks to crush the enemy wherever we may find him."[44] Copper – also crucial for planes – provides another example. "Not a ship sails, not a plane flies, and not a shot is fired but copper has somewhere entered its production," a 1944 War Production Board report noted.[45] Copper came mostly from mines in the US West and Latin America.

Ferroalloys posed particular concerns. Used in the production of high-performance steel and central to the emerging new material culture, ferroalloys typically originated overseas. The United States produced sufficient molybdenum and had a reliable source of nickel in Canada, but all other materials for alloys came from far-off lands more difficult to access during wartime. In 1942, for example, 89 percent of America's chromite came from overseas, along with 87 percent of the manganese, 78 percent of the cobalt, 64 percent of the tungsten, and 38 percent of the vanadium.[46]

Of these, chromite held particular importance for aviation and reveals the worldwide supply network on which aviation depended. Between 1940 and 1945, chromite – which produced chrome for gun barrels, naval armor, and aircraft engines – jumped in consumption by 70 percent. Chromium-bearing ore came from all over the world. As prewar Filipino sources were cut off, and numerous domestic sources in California, Montana, and Oregon proved to be too low in quality, the United States turned to Cuba, Russia, Turkey, New Caledonia, and especially Southern Rhodesia (Zimbabwe) and South Africa. Between 1940 and mid-1945, South Africa provided the United States with 680,000 tons of ore and Rhodesia more than 1 million tons. In the end, low chromite supplies created anxiety but ultimately proved sufficient; the government's reserve stockpile grew, even while meeting all military requirements.[47] Chromite became a bigger problem for Germany. In summer 1943, German supplies of chromium fell to under six months of production. If it ran out, Nazi materials expert Albert Speer warned Adolf Hitler, "the manufacture of planes, tanks, motor vehicles, tank shells, U-boats, and almost the

44 Seth Garfield, *In Search of the Amazon: Brazil, the United States, and the Nature of a Region* (Chapel Hill, NC: Duke University Press, 2013), 83.

45 US War Production Board, *War Production in 1944*, 33.

46 Elliot M. Helfgott, "The Ferro-Alloys Production and Control 1940–45," in *Industrial Mobilization for War History of the War Production Board and Predecessor Agencies, 1940–1945; Vol. II. Materials and Products* (Washington, DC: Civilian Production Administration, 1947), 2□3.

47 Ibid.

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entire gamut of artillery would have to cease."[48] Had the war continued much longer, chromite might have become the factor that tipped the fate of the war in the Allies' favor.

CARS, TRUCKS, AND HIGHWAYS: GETTING PEOPLE AND RESOURCES TO PRODUCTION SITES

In the same way that rapid wartime expansion illuminated the environmental underpinnings of the aviation industry, war also exposed how deeply the car-and-highway–based transportation system of the United States, itself so crucial to the aircraft and war production system, depended on natural systems and resources. The high priority that wartime leaders placed on getting people and resources to sites of military production helps highlight both the variety and depth of this dependence.

Almost as soon as the war began, for example, war planners launched rationing systems designed to divert the most strategically important raw materials harvested from nature from civilian to military purposes. Even the automobile, despite its prominent role in everyday American life, had to bow before military demands in the face of materials shortages. Soon after the United States entered the war, the nation's leaders determined that steel, the major component of automobiles, was too precious a military resource to use to build private vehicles. As a result, official limits on automobile construction went into effect on January 1, 1942, and on February 10 – following a short ceremony by workers at the Ford Motor Company – the last private automobile rolled off a Detroit assembly line for the remainder of the war.[49] In addition to restrictions on buying new cars, natural resource shortages made it difficult for car owners to maintain their accustomed driving habits. Fuel derived from oil, for example, became scarce on the East Coast almost as soon as the United States officially entered the war, in December 1941, when German U-boats declared open season on American oil tankers. Officials immediately instituted a program of gasoline rationing on the East Coast and expanded the practice into a national rationing system in

48 Albert Speer, *Inside the Third Reich* (New York: Simon & Schuster, 1970), 316, as quoted in Eckes, *The United States and the Global Struggle for Minerals*, 117.

49 David M. Kennedy, *Freedom from Fear: The American People in Depression and War, 1929–1945* (New York: Oxford University Press, 2001), 645; Allan Nevins and Frank Ernest Hill, *Ford: Decline and Rebirth, 1933–1962* (New York: Scribner, 1963), 198–199.

November.[50] Rubber tires, too, made from the sap of rubber trees, were in desperately short supply. After Japan occupied Southeast Asia, where vast rubber tree plantations produced a majority of the world's rubber, the federal government imposed a national 35 mph speed limit to preserve tires as long as possible.[51] Limited access to key materials also constrained highway builders: tar, asphalt, and steel shortages translated into strict limits on all nonessential highway construction, bringing the interwar highway construction boom to an end.[52]

Unable to replace aging vehicles with new ones and facing constraints on their use of gasoline and rubber, many car owners heeded the active pleas of business and government leaders to help conserve scarce resources by finding alternative means of getting around for the duration of the war. Reflecting this trend, urban public transportation systems surged to levels of popularity that they had not seen in more than a decade. After holding steady at around 10 billion rides per year between 1935 and 1941, ridership jumped after Pearl Harbor, nearly doubling to 19 billion by 1945.[53]

But growing ridership indicated more than just a practical response to wartime limits on driving. It also reflected the successful efforts of government and industry leaders to conserve a crucial natural resource: oil. Officials made a concerted attempt, for example, to cast a patriotic light on alternative forms of transportation like walking to work. In addition, to reduce congestion, conserve oil, and encourage commuting using public transportation, transportation officials coordinated with businesses to stagger their starting times with the dual aims of reducing peak demand and increasing the carrying capacity of buses and streetcars. In Atlanta, for example, officials announced that a new system of staggered work hours had increased the number of passengers that the city's

[50] "Gasoline Rationing," *New York Times*, April 27, 1942, 14. See also Daniel Yergin, *The Prize: The Epic Quest for Oil, Money, and Power* (New York: Simon & Schuster, 1991), 375; Federal Highway Administration, *America's Highways, 1776–1976: A History of the Federal-Aid Program* (Washington, DC: Government Printing Office, 1976), 145–147.

[51] "Tire Rationing," *New York Times*, December 28, 1945, 12. See also Finlay, *Growing American Rubber*.

[52] Bruce E. Seely, *Building the American Highway System: Engineers as Policy Makers* (Philadelphia: Temple University Press, 1987); Federal Highway Administration, *America's Highways*, 147.

[53] Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1957* (Washington, DC: Government Printing Office, 1960), 464.

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existing fleet of 455 buses could handle by an amount equivalent to introducing 90 new buses to the system.[54]

Despite the resurgence of urban public transportation systems and the limits on driving that came with rationing oil and rubber, the steady spread of car-dependent landscapes in the United States during the interwar decades – marked especially by the movement of industrial factories toward the urban periphery, and amplified by a shift in the demographics of factory workers – meant that most American defense workers commuted by automobile.[55] In Kansas, for example, one study revealed that 93 percent of an airplane manufacturing facility's workers arrived at work in a car. Yet inadequate public transportation was not to blame. More important was the fact that factory workers, who before World War I had tended to concentrate in dense working-class neighborhoods that were easy to serve with streetcar lines, had begun during the interwar years to disperse into neighborhoods scattered across broad metropolitan regions much too extensive for public transportation to get them to work efficiently. According to the Kansas study, 81 percent of workers lived at least five miles away from work, and 17 percent lived more than 10 miles away. This reality prompted Thomas MacDonald, the longtime chief of the Public Roads Administration, to conclude early in the war that it was unrealistic to think that public transportation alone could meet the needs of anything more than a small proportion of the nation's 10 million defense plant workers.[56]

Concluding that only private automobiles could do the job, government efforts focused on reducing overall oil consumption by encouraging workers to carpool. With lone drivers stigmatized as unpatriotic, the number of riders per car swelled from a prewar average of less than two to a wartime average closer to four.[57] Yet even carpooling's most ardent advocates never presented it as anything other than a temporary, short-term "sacrifice" borne of wartime necessity to conserve oil. War may have

[54] J. T. Thompson, "Wartime Highway Transportation Problems," *Convention Group Meetings 1942* (Washington, DC: American Association of State Highway Officials, 1943), 114–124, as cited in Federal Highway Administration, *America's Highways*, 148.

[55] For an extended argument about the spread of car-dependent landscapes, see Christopher W. Wells, *Car Country: An Environmental History* (Seattle: University of Washington Press, 2012).

[56] Thompson, "Wartime Highway Transportation Problems," 114–124, as cited in Federal Highway Administration, *America's Highways*, 148.

[57] Ibid.

shrunk the rates at which American motorists consumed natural resources like oil and rubber, but motorists changed their behavior with the clear understanding that they would revert back to "normal" patterns of resource consumption after the war.

At the same time that natural resource shortages forced automakers, highway builders, and motorists to reorient their accustomed behaviors, the strategic demands of war introduced a new set of priorities for highway maintenance and construction. Rather than spreading available money around over a huge national system, as had happened during the interwar years, highway builders concentrated their investments in strategic priorities.

Before World War II, American highway policy had focused on reshaping the country's landscapes by bringing the extensive national road system up to basic minimum standards. Early in the century, the vast majority of highways were rural routes that served predominantly local traffic, and most states devoted the few resources they had to bringing the more heavily traveled routes up to basic minimum standards of passability. Even after the watershed Federal Highway Act of 1921, federal highway policy focused on creating a coordinated national system of highways built with an eye on meeting only the needs of existing traffic, which over much of the system was quite light by today's standards. Because highway builders only built the biggest, sturdiest, most advanced highways in areas with heavy traffic – often settling for thin pavements, steeper grades, and narrow widths in less-trafficked portions – the system's highways formed more of an erratic patchwork than a consistent, coordinated system. The highway system "is narrow where it should be wide, and sometimes wide where it could be narrow," declared *Fortune* in June 1941. "The system suggests exactly what it has been: the result of years and years of improvisations ... subject to local and state and federal authority, which do not necessarily work together."[58]

As the war in Europe grew ever more ominous, the nation took faltering but important steps to address the highway system's strategic deficiencies. In June 1940, President Roosevelt ordered the Federal Works Administrator to assess the national highway system from the perspective of national defense. The Public Roads Administration's resulting report in February 1941, *Highways for the National Defense*, identified a range of

[58] "The US Highway System," *Fortune* 23 (June 1941): 91–95, 91 (quotation).

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pressing needs. Defense operations would require efforts in three areas: first, constructing a range of new roads on military reservations; second, making significant improvements to roads providing access to military facilities and defense industries; and third, building "tactical roads" that would give the military easier "access to more or less isolated points of strategic importance." In addition to these direct defense needs, the report also found significant deficiencies in the trunk highway system, especially in the form of bridges and long stretches of highway incapable of carrying heavy trucks loaded with war materiel.[59] The Defense Highway Act of 1941 allocated the relatively small amount of $150 million "for the correction of critical deficiencies in highways and bridges essential to the national defense."[60]

Reshaping the environments around defense facilities by improving their "access roads" became critical to an all-out war effort. For example, the construction of the world's largest office building – the Pentagon – also required reshaping the surrounding environment with a completely new network of highways to serve its 54,000 defense workers. The system of roads serving the three bridges over the Potomac also got a makeover to relieve their regular traffic jams.[61] Factories, too, needed new facilities to make it easier for the daily crush of defense workers arriving at factory gates in automobiles. In addition to building "Bomber City" to accommodate the crush of workers at Ford's giant Willow Run facility, for example, the state built a $9.5 million high-speed, limited-access highway – still a design novelty at the time – complete with double- and triple-level crossings in and out of the facility's gargantuan parking areas, to accommodate workers during shift changes.[62] In addition to the obvious local environmental consequences of building this new infrastructure, the new highway, interchange, and parking lots reified the site's dependence on automobile-based transportation, which had its own environmental implications. As was typical of so many other defense industry workers, most Willow Run workers commuted by car, despite scarcities of gasoline and rubber; also,

59 US Bureau of Public Roads, *Highways for the National Defense* (Washington, DC: Government Printing Office, 1941), esp. 8–14.

60 "Defense Highway Bill Enacted," *American City* 56 (December 1941): 105. On the process for identifying "essential" projects, see "Programming Federal Aid Projects Essential to the National Defense," *Roads and Streets* 85 (February 1942): 42–43.

61 Joseph Barnett, "The New War Department Building Road Network," *Civil Engineering* 13 (March 1943): 127–130.

62 Curtis Fuller, "Moving Workers to Willow Run," *Flying* 33 (August 1943): 79.

typically, most drivers carpooled, with each automobile carrying on average 3.1 workers.[63]

But rebuilding the environment around factories was important for reasons beyond just giving workers better access; the wartime focus on building better access roads also presaged the growing, environmentally significant role of big trucks in the American transportation system generally and within defense industries specifically. In Michigan, for example, studies of defense plants revealed that the vast majority of factories trucked in at least half of their materials over highways and trucked out over half of their products. Of these, 13 percent depended entirely on trucks to supply their operations.[64] The growing reliance on trucks rather than railroads reflected both improvements in truck design, which allowed them to carry heavier loads more reliably, and the flexibility of operation that they offered compared to railroads for industrial operations that were increasingly spread widely over metropolitan regions.[65]

Although useful, heavy trucks were also destructive, pounding highways – and especially the lightly traveled rural portions of the nation's highway system that were not designed to carry heavy loads – which made maintaining key supply routes a strategically vital investment. In the American countryside, beyond the high-quality highways that provided direct access to specific defense plants, the expanded use of heavy trucks exposed the inadequacies of the interwar period's inconsistent highway design standards. Setting aside other deficiencies of the highway system, like limited sight distances, hazardously sharp curves, and dangerously narrow widths, *Highways for the National Defense* identified roughly 14,000 miles of paved primary route highways that could not handle 9,000-pound wheel loads, as well as 2,436 bridges that it deemed "substandard in their capacity to carry the heaviest equipment and ordnance."[66] Given wartime rationing and limited access to funds, it was nearly impossible even to maintain the nation's highways in the face of wartime demands, much less to improve them to the consistently high standards that extensive use of heavy trucks for long-distance

[63] Peterson, *Planning the Home Front*, 200.
[64] Thompson, "Wartime Highway Transportation Problems," 114–124, as cited in Federal Highway Administration, *America's Highways*, 148.
[65] Robert J. Gordon, *The Rise and Fall of American Growth: The US Standard of Living since the Civil War* (Princeton, NJ: Princeton University Press, 2016), 561. William E. Rudolph, "Strategic Roads of the World: Notes on Recent Developments," *Geographical Review* 33, no. 1 (January 1, 1943): 110.
[66] *Highways for the National Defense*, 42, 26 (quotation).

transportation required. Some states attempted to preserve their roads by enforcing weight limits, but political pressure to sacrifice the long-term integrity of highways on behalf of wartime exigencies won the day.[67] Remaking the American landscape with a new national system of highways that could cater to heavy trucks would have to wait until after the war – but wartime experiences would eventually factor heavily into the final form of the postwar Interstate system.

STRATEGIC HIGHWAYS IN LATIN AMERICA AND ALASKA

As a window onto the ways that wartime imperatives for transportation infrastructure shaped landscapes and American relationships with nature, no highway projects were more important than the two major "tactical" roads that the United States prioritized during the war – the Alaskan-Canadian Military Highway (known as the "Alcan" highway), and the Pan-American Highway. First, both highways demonstrate the nation's commitment to using transportation infrastructure to assert control over valuable natural resources and strategically important areas, even when they were remote, difficult to access, and located outside the boundaries of the United States. Using transportation infrastructure to exert such control opened sizable territories to new efforts to extract natural resources. Second, both highway-building efforts embodied important ideas about the interrelationships among nature, construction technologies such as bulldozers and aerial surveys, and progress as they evolved against the backdrop of an ongoing war, setting the stage for postwar relationships.

Though plans for the Alcan and Pan-American highway projects originated in the interwar decades, both took on new strategic significance during the war, which prompted the US government to prioritize immediate construction. This required the United States to assume the lion's share of construction costs and to send American construction crews into the field. The Pan-American Highway, the planned route for which ran from the US border town of Laredo, Texas, through Central America and on to Buenos Aires and Rio de Janeiro, represented a potential supply line more secure from U-boat attack than traditional shipping lanes. "Ships still are the principal means of moving commodities in inter-American trade," explained an American official in *Scientific American* about the new importance of highways. "It is the long sea distance which makes this

[67] Federal Highway Administration, *America's Highways*, 145–147.

menace to our shipping so crucial. If transportation between the Americas over the long sea routes can be sharply reduced and if, at the same time, a continuous flow of essential supplies can be maintained, we are on the way to a solution of the problem."[68] Providing overland routes for the flow of strategic materials, including copper, bauxite, and rubber for airplanes, would directly serve military priorities.

The Alcan Highway gave the United States a safe overland alternative to shipping to and from Alaska, and beyond that to Asia. Even more importantly, it supported a reliable air route to what one geographer described as "the most strategic area on the continent."[69] "[T]he road now being shoved through the British Columbia and Yukon fastness is more than a highway," a *Saturday Evening Post* article explained. "It is the land counterpart of an air route which ranks in importance with those our fighting planes travel to the Near East and South Pacific." Before the highway went through, the "route" was little more than an unconnected string of landing strips newly carved out of the otherwise continuous forests of the region, which gave Alaska-bound planes places to stop and refuel. These were much easier to supply by truck than by plane, and the highway helped transform the isolated landing strips into what the *Post* described as a full-fledged "wilderness airway."[70] In addition, as Col. J. K. Tully explained, the highway made navigating the route much safer, giving pilots access to emergency landing strips and providing "a trace for our airmen to fly along."[71] Airplanes, at the same time, used new aerial surveying methods that made it easier to map out where the highway should go in rough, remote, and poorly mapped regions.

In addition to creating more secure transportation links to distant but strategically important areas, both highway projects improved the ability of the United States to assert control over valuable natural resources like oil and rubber in South America and timber and minerals in Canada. "The universal shortage of ship transportation has increased the importance of the Pan-American Highway as a potentially vital factor, not only

[68] Edwin W. James, "Highways to Strategic Materials," *Scientific American* 168 (March 1943): 110. On the failure to fully achieve an entirely overland connection, see Shawn W. Miller, "Minding the Gap: Pan-Americanisms's Highway, American Environmentalism, and Remembering the Failure to Close the Darién Gap," *Environmental History* 19 (April 2014): 189–216.

[69] S. C. Ells, "Alaska Highway," *Canadian Geographical Journal* 28 (March 1944): 105.

[70] V. H. Jorgensen Jr., "Our New Land and Air Route to Alaska," *Saturday Evening Post*, November 7, 1942, 16.

[71] Ibid., 105.

in the 'Battle of Supply Lines,' but also in the 'Battle for Raw Materials,'" an American official explained in *Scientific American*. "South America is veritably a storehouse of strategic materials for the great munition industries of the Arsenal of Democracy, and is now more important than ever before as a source of strategic materials formerly obtained from the Far East."[72] In the case of the Alcan Highway, the transportation functions clearly outweighed immediate access to natural resources, but its builders nonetheless extolled the ways that the road would open the area to "mining, lumbering, agricultural production ... and the development of such hydro-power as may be required."[73]

Both highway projects also illustrate evolving wartime ideas about nature, technology, and progress, as well as the ways that the patterns of the natural world affected the contours of the war effort. The formidable natural obstacles confronting road builders permeated press accounts of both highways. Writers characterized portions of the Pan-American route as impenetrable "uncharted jungle" that "had not even been surveyed," noting that the pass over the Andes outside Santiago was "closed by snow from seven to nine months of the year."[74] Other sections traversed "a great diversity of terrain and climate, arid desert country, tropical rain forest, and alpine scenery."[75] For the Alcan Highway, descriptions reached almost poetic heights:

> Mud so deep that even tractors were swallowed up, dust ankle high which rose in clouds like a dense fog so that a convoy of trucks could be spotted from many miles away, jellylike muskeg which had to be bridged with corduroy, cold, drizzling rain, frigid nights, vicious black flies, and ravenous gnats – all these now are part of the epic of the road.... There were only three points of access in Alaska, Yukon Territory, and British Columbia and only one settlement which could be called a town on the entire route. The country was a wilderness and some of it was barely explored. There were no adequate maps and, of course, no detailed survey for the route.[76]

The *Rotarian* ran a photo essay on the highway's construction featuring packhorses, mules, and dogsleds hauling supplies, rugged campsites, and

[72] James, "Highways to Strategic Materials," 110. [73] Ells, "Alaska Highway," 118.

[74] Richard Tewkesbury, "Jungle Journey for a Hemisphere Highway," *Scholastic* 40 (May 18, 1942): 28 (first quotation); Walter Holbrook, "The Pan-American Highway Nears Completion," *Popular Science* 139 (August 1941): 33 (second quotation), 35 (third quotation).

[75] Herbert Charles Lanks, "The Pan-American Highway," *Canadian Geographical Journal* 26 (April 1943): 162.

[76] Froelich Rainey, "Alaskan Highway an Engineering Epic," *National Geographic* 83 (February 1943): 143.

a variety of wild animals, including wolves, grizzly bears, and mountain sheep.[77] *Reader's Digest* dubbed the highway "one of the great wilderness undertakings of American history."[78]

Yet the descriptions of quaking muskeg bogs and impenetrable jungles, extreme heat and numbing cold, dangerous wild animals and swarming insects always provided a backdrop for the more important story: the victories over nature achieved by American ingenuity, hard work, and technological prowess.[79] Heavy earth-moving machinery conjured descriptions nearly as poetic as those of the wilderness. According to *National Geographic:*

> Giant lumbering 20-ton caterpillar tractors led the attack on the forest. Equipped with broad cutting blades or bulldozers, they advanced into standing timber and simply pushed it aside, trunks, stumps, and all. Working back and forth across a blazed right-of-way, they mowed down the thick timber as if it were no more than a field of cornstalks. The machines were like wild boars rooting and snorting in the jungle.[80]

Not to be outdone, *Life* also conjured images of a technological sublime overcoming an equally sublime nature, describing the highway as "a raw streak of sodden earth punched through the wilderness with roaring bulldozers and power shovels. The highway is the greatest achievement of the Engineers' history, surpassing even the construction of the Panama Canal in sheer efficiency of subduing Nature."[81] As in the struggle against the Axis, American technological might would triumph, even against the powerful forces of nature.

In these projects as well as building projects in the main theaters of war, the United States developed technologies and ideas about nature that profoundly shaped postwar highway building and other construction. As Francesca Ammon has pointed out, the massive earthmoving equipment that became widespread during the war and that was portrayed in heroic terms fueled a revolution in large scale, no-holds-barred construction

77 Alfred Milotte and Elma Milotte, "That Highway to Alaska," *Rotarian* 59 (November 1941): 21–26.

78 Richard Lewis Neuberger, "Our Battlefront in the Wilderness," *Reader's Digest* 41 (August 1942): 48.

79 For broader discussions about using big technological systems and infrastructure networks to dominate and control the unruly forces of nature, see David E. Nye, *American Technological Sublime* (Cambridge, MA: MIT Press, 1994) and Maria Kaika, *City of Flows: Modernity, Nature, and the City* (New York: Routledge, 2005).

80 Rainey, "Alaskan Highway an Engineering Epic," 154.

81 "Alaska Highway: Army Engineers Punch It through the Wilderness," *Life*, September 14, 1942, 45.

thinking best described by a 1954 *Time* article: "Today, there is almost no project too big to tackle, no reasonable limit to reshaping the earth to make it more productive."[82]

The postwar Interstate system was planned during the war years, in part because domestic construction was so limited. The system appeared in its broad outlines in the 1939 *Toll Roads and Free Roads* report, and in its more specific form in the 1944 report, *Interregional Highways*, which Congress approved by legislation in 1944 without any dedicated funding, setting up over a decade of political wrangling that ended with the creation of a dedicated funding system in 1956.

Despite their wartime plans, though, highway planners failed to anticipate the major environmental consequences that the Interstate system would have: restructuring cities and creating car dependence by further decentralizing the urban economy; making long-distance travel more comfortable and economically efficient; and the rise of heavy trucking, including long-distance trucking, which required much higher highway construction standards than wartime planners anticipated. Wartime planners combined the planning mindset of the interwar period with the reality of new wartime needs, new technologies, and new ideas about conquering nature to advance the idea and the routes of the Interstates.

WORLD WAR II AND PERCEPTIONS OF NATURE

As with the strategic highways and changes in the highway system, the wartime revolution in air power and air transport created new links between humans, technology, and nature. Beyond expanding productive capacity and rearranging landscapes through new patterns of resource use, pollution, and transportation, aviation also began to alter how Americans perceived geography and nature. "More than anything except the telephone," Harold Ickes wrote in 1943, "aviation is cutting down time and space."[83] A 1941 Mid-Continent Airlines advertisement summed up the war's effect: "The times call for speed."[84]

Within the United States, faster, more frequent, and more reliable air service linked countryside with city, state with state, and region with region, forging the modern system of air transportation. Direct intercity

[82] Francesca Ammon, *Bulldozer: Demolition and Clearance of the Postwar Landscape* (New Haven, CT: Yale University Press, 2016), 60.
[83] Ickes, *Fightin' Oil*, 154.
[84] Mid-Continent Airlines Ad, 1941, Zawasky Scrapbook, Minnesota Historical Society.

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flights became more common. Minneapolis, for instance, gained fast direct service to New York, Washington, Detroit, and Cleveland.[85] City officials began to see air service as not just useful but essential. "Good airline service is necessary to the commercial life of a city," a Detroit city official argued in 1944. "Wartime has emphasized that fact in a most convincing manner."[86]

Because of aviation and the war, Americans learned more about other countries and their connections to those countries and gained a new understanding of the earth. "The modern airplane," the Republican leader Wendell Wilkie wrote in 1943, "creates a new geographical dimension.… A navigable ocean of air blankets the whole surface of the globe. There are no distant places any longer."[87] The war, Ickes added, is "a world war in every sense of the word, and nothing but petroleum, plus aviation, has made it so."[88]

Aerial interconnection made many Americans feel increasingly vulnerable. The Pearl Harbor attacks shattered a sense of safety; the bombing of cities heightened anxieties. Alexander de Seversky's *Victory through Air Power*, a 1943 Book of the Month Club selection, stressed an America prone to aerial attack.[89] "Everybody," another observer wrote, "is being put in the front lines."[90]

For some, greater interconnection meant that the United States had no choice but to engage more internationally. "The world is small and the world is one," Willkie wrote, rejecting the isolationist leanings of many within his party. "The American people must grasp these new realities if they are to play their essential part in winning the war and building a world of peace and freedom."[91]

Five aerial supply routes linked the United States to the war's main arenas: across the North Atlantic to Great Britain, across the mid-Atlantic to North Africa via the Azores, across the south Atlantic from Brazil to central Africa and the Middle East, northwest from Minneapolis and

85 *Minneapolis Daily Times*, September 30, 1943, Curry Scrapbook, Northwest Airlines Collection, Box 54, Minnesota Historical Society.
86 Karsner, "Aviation and Airports," 412.
87 Sam Howe Verhovek, *Jet Age: The Comet, the 707, and the Race to Shrink the World* (London: Portfolio, 2011), 98.
88 Ickes, *Fightin' Oil*, 153.
89 Susan Schulten, *The Geographical Imagination in America, 1880–1950* (Chicago: University of Chicago Press, 2001).
90 John Hamilton Jouett, "Aviation after the War," *Flying* 31 (July 1942): 24.
91 Verhovek, *Jet Age*, 98.

Seattle through Alaska to northeast Asia, and across the south Pacific from Hawaii to Australia.[92] US-built airfields around the world, from the Caribbean to the North Atlantic, from the South Pacific to China and Northeast India increased capacity and encouraged new routes after the war. New wartime airports at Gander in Newfoundland and Shannon in Ireland, built to enable four-engine bombers and transports to fly from the United States to Britain, eventually reduced peacetime flying time for commercial flights from New York to London to 15 hours.[93] All these new routes added to Americans' knowledge of different places and shrank their conceptions of space.

A shrinking planet also encouraged "one-world" thinking, an emphasis on universality and open borders. "In the air," wrote Adolf Berle, a Roosevelt advisor and State Department official in charge of aviation, "there is no excuse for an attempt to revive the 16th-and 17th-century conceptions for a modern British East India Company or Portuguese trading monopoly or Spanish Main conception."[94]

The war also gave rise to new cartographic visions that shifted the focus from the "seaman's view" focused on oceans to the "airman's view."[95] In *Human Geography for the Air Age* (1942) and *Global Geography* (1944), George Renner called for new maps and a new geography. The oversized oceans of the traditional Mercator projection had given Americans an exaggerated sense of protective distance from Europe and Asia. Renner's "World Map for the Air Age," which centered on the North Pole and showed US proximity to Russia and northern Europe, sold more in its first year than any other map in Rand McNally's history.[96]

Many maps began to provide an airplane pilot's view of the earth, elevated and integrative. Calling himself an artist and publishing in *Fortune*, Richard Edes Harrison made maps that, according to Susan Schulten, "resemble a photograph of the earth from a distance." They showed relationships "left hidden on more traditional maps" and through this perspective "silently – yet insistently – forced the reader to conclude that

[92] Wesley Frank Craven and James Lea Cate, *The Army Air Forces in World War II, Volume I* (Chicago: University of Chicago Press, 1958), 312.

[93] Peter J. Hugill, *World Trade since 1431: Geography, Technology, and Capitalism* (Baltimore: Johns Hopkins University Press, 1993), 282.

[94] Verhovek, *Jet Age*, 98.

[95] Alan K. Henrikson, "The Map as an 'Idea': The Role of Cartographic Imagery during the Second World War," *Cartography and Geographic Information Science* 2, no. 1 (1975): 19–53.

[96] Schulten, *The Geographical Imagination in America, 1880–1950*, 138.

the world had been reshaped through the advent of aviation."[97] Making maps for the *Los Angeles Times*, Charles Owens also presented scenes of the earth from an elevated oblique angle.[98]

One interesting wartime map from Rand McNally – a 12-inch translucent "air globe" – gave the names of a few crucial places but left out all factors made seemingly irrelevant by air travel, including oceans, mountains, and national borders. Rand McNally and American Airlines marketed it to teach, in their words, "the concept of freedom of the air and the universality of air transportation."[99]

Airplanes brought about another important change in perspective. Airplanes and aerial bombardment of cities became a prime example of modern technology gone awry, fueling an antimodernism that brought with it a reevaluation and celebration of nature. As technological civilization seemed more and more violent and depraved, nature emerged as more and more pure, peaceful, and restorative.

No one shows this shift better than Charles Lindbergh, the famous pilot who symbolized technological optimism during the 1920s and who became a vocal and influential environmentalist during the 1960s and 1970s. World War II dramatically transformed Lindbergh's thinking. As part of the "America First" movement, Lindbergh had at first opposed US involvement in the war but after Pearl Harbor found several ways to contribute, including as a test pilot at the Willow Run plant, a War Department advisor, and even as a combat pilot in the Pacific War. One day at Willow Run changed his life forever. On a test run at 43,000 feet in the skies above the massive factory, a faulty oxygen gauge caused Lindbergh to black out. By the narrowest of margins, he made it back to earth safely, but walked away from his plane with an altered view of technology, the war, and the earth. Approaching the huge Willow Run factory that day, he felt different. Whereas once he had seen the factory's bomber production line as "a marvelous feat of engineering," he now saw it, as he recounted in a 1948 book, as "a terrible giant's womb, growling, clanging, giving birth to robots which were killing people by the thousands each day as they destroyed the culture of Europe.... Only two years before on this same spot, I would've been surrounded by hickories, maples, and oaks. Scientific man could now touch a forest in Michigan with his wand, and by so doing wipe out

97 Ibid., 214–218, quotations from 215, 214, 215.

98 Denis E. Cosgrove and William L. Fox, *Photography and Flight* (London: Reaktion, 2010), 57.

99 Schulten, *The Geographical Imagination in America, 1880–1950*, 139.

European cities.... Here I watched a steel door lift and an airplane roll outside; while, in reality, the walls of the cathedral fell and children died."[100]

Flying into Munich in 1945, Lindbergh saw the devastation that aerial bombing had wrought:

> As human death pierces through a room, that city pierced the sky. I forgot farms and villages, trenches and tank tracks. I could no longer see the beauty of the earth or experience the joy of flight. As we drew closer, the features of death emerged – troubled streets, gutted buildings, ragged walls. *This* had been a city inhabited by men! Street after street lined with blasted factories, offices, and homes – open roofs and fallen floors, smudged by fire, deserted by life. And this was only one of the bombed cities of Europe; there were scores of them.... How fragile civilization had become, viewed through the lens of modern science; how vulnerable to the eye of the bombardier.[101]

Lindbergh filled his 1948 book "Of Flight and Life" with similar observations. A profound shift to a more "environmental" approach to modern life was underway.

CONCLUSION

Lindbergh's ruminations on the growing capacity of technology to wreak havoc on the environment and on human communities, developed in part from the cockpit of an airplane, focused on the awesome devastation of modern war and particularly on ruin rained down from the sky. Yet Lindbergh's reflections also contained the seed of a more ecological worldview, prompted by the destructive violence of war, which stressed both the fragility and the interconnectedness of nature. If the shambles of European cities pointed backward toward military bases launching massive bombing runs, they also pointed backward toward industrial landscapes of production like Willow Run, where workers hammered and riveted together the modern instruments of war, and then even further backward toward landscapes of extraction, where workers drilled, dug, grew, and collected the dizzying array of raw materials that made up the modern airplane.

Paying attention to these landscapes of production and extraction thus helps bring the environmental footprint of World War II – and the new relationships with nature that it created – into sharper focus. The mass production of "flying resources" like airplanes meant solidifying control over rare raw materials, wherever they were found around the globe, and

100 Charles A. Lindbergh, *Of Flight and Life* (New York: Scribner's Sons, 1948), 9.
101 Ibid., 16–17.

then shepherding them securely during wartime conditions toward American assembly lines. It meant turning former potato fields into vast new aviation facilities while repurposing the productive capacity of the already massive automotive industry, replacing the mass production of private automobiles with that of airplanes (while also churning out a stunning range of armaments and heavy trucks) under conditions that favored speed and quantity at all costs. And it meant thinking strategically about where to allocate limited home front resources, even when that meant redirecting valuable resources from dominant peacetime industries, encouraging people to abandon aging automobiles for busses and streetcars, and redirecting highway investments toward industrial access roads and strategic highways outside the United States. In the process, the nation remade both extractive and productive landscapes – at home and abroad – along with the transportation systems that connected them.

The crucible of war fostered a range of environmentally significant ideas as well. To exert control over strategically vital resources, the United States created a range of more secure transportation routes – both on the ground and in the air – that highlighted its growing capacity to direct its technological prowess toward subduing even the wildest, most distant environments. Airplanes gave surveyors a tool that helped them reduce even the most remote landscapes to detailed technical drawings, while bulldozers made it possible to transform even the most rugged landscapes with unprecedented ease and speed. In addition to making wild nature seem less forbidding, and somewhat more vulnerable, in the face of advanced technology, airplanes and trucks also changed the ways that people perceived geography and geographical relationships, shrinking space, strengthening knowledge of (and connections to) a greater number of places, and encouraging more ambitious planning for new transportation infrastructure, such as the Interstate highway system and a truly national system of commercial airports.

Thus, the United States left the war on a kind of environmental collision course. On the one hand, there was tremendous expanded productive capacity, technological development, and faith in heroic technologies to transform nature for the benefit of humanity. Mobile technologies accelerated, and with them the pace of life. But on the other hand, the war also brought greater pollution, violence, death, and the seeds of antimodernist ideologies that grew stronger over time. Together these new forces shaped American relationships with nature well into the future.

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