Organizing the Terrain: The Maginot Line, 1919-1939

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Abstract:

The Maginot Line fortifications represented a hubristic attempt to harness nature to the purposes of French national defense, thus creating an "envirotechnical object." French military engineers drew on an early version of managerial science known as the "science of organization." They conceived of the Maginot Line as an integrated human, mechanical, and natural whole, in which nature was treated like a human "crowd," which they believed to be chaotic and formless absent the influence of elites. In the end, the engineers' plans were frustrated by rival organizers of nature, notably commercial interests, tourists, and the Forest and Water Authority, and by the properties of the forest, water, and air.

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It is difficult now to imagine the enormous scale of the Maginot Line fortifications. Tourists may descend thirty to eighty meters underground into carefully restored individual forts, to the hospitals, barracks, refectories, kitchens, and powerplants constructed by French military engineers. They may travel through tunnels, in some cases on electric trains, to command posts and fighting blocs up to a kilometer forward (Figure 1). They may marvel at retractable turrets weighing up to 265 tons, constructed where the ground was suitable, or casements where it was not. Tourists may also visit the locks and bunkers that controlled and covered planned flooding on the "Aquatic Maginot Line." They may chance upon some of the thousands of ruined bunkers and casements in fields and forests, but the barbed wire and

antitank rails and ditches that cut swaths hundreds of kilometers long through the landscape have long since disappeared. Tourists will probably not know, however, that the concrete works were but one element in a network of barracks for troops, housing developments for officers, military roads, narrow-gauge railways, telephone lines, command posts, planned inundations, and supply chains reaching across the world.

<<Figure 1 about here>>

Although military historians usually treat the natural environment as one element—alongside logistics, soldiers, and weapons—that generals orchestrate in the battle, they cannot usually be accused of neglecting it altogether. However, in the case of the Maginot Line, the shadow of the French defeat of May and June 1940 has obscured the significance of the natural environment in most historical accounts. Historians have attributed the German victory to their mechanized forces' ability to brush aside French fortifications and natural features, notably the Meuse River and Ardennes Forest. They have largely seen the defeat as a consequence of France's anachronistic subordination to "passive" natural and man-made defenses.[1] Military technology specialists have demonstrated the fortifications' technical sophistication and integration into the terrain, and their work is invaluable for this study.[2] Yet for them too, the natural environment has been something to be instrumentalized in pursuit of victory. Thus, historians of the Maginot Line have assumed a sharp culture/nature division.

However, the fortifications merit continued attention as one of the greatest engineering projects of their age, and also as a hubristic, impossible attempt to regulate the human/non-human divide. Like installations analyzed by Santiago Gorostiza and Chris Pearson, who have treated fortification as an element of a militarized landscape, the Maginot Line was a *de facto* synthesis of the human and the non-human.[3] Similarly, like Sara Pritchard's "envirotechnical objects," the Maginot Line was a hybrid of nature, technology, and culture, just as forests, waterways, and factories were. And as Pritchard stresses, neither

people nor the ostensibly natural world necessarily behave as predicted—something the designers of the Maginot Line discovered.[4]

The Maginot Line functioned as an envirotechnical object from three perspectives. First, from a cultural point of view, the Maginot Line illustrates the particular way in which French military engineers understood the nature/culture divide. Published and unpublished sources on military doctrine, along with fictional works dealing with warfare, usually written by soldiers or veterans, underscore the degree to which nature was seen as potentially treacherous, often comparing it to the human "crowd," as understood by the influential French polymath Gustave Le Bon (1841-1931). The army feared that the enemy might exploit nature's instability to turn it against France.

To ensure that nature served French objectives, military engineers turned to the science of organization, the precursor of modern management science, and so the Maginot Line also represents a social construct. The science of organization was a rationalized system of control from above, designed to tame nature and harmonize it with human bodies and machines in an "organized" defensive system.[5] In organizationalist terms, the "elite," equated to culture, was expected to "organize" nature, equated to the human crowd. Organizationalists also introduced the now familiar idea that managerial skills were transferable because the same principles governed all complex bodies, from armies to corporations and the household.[6] Moreover, organizationalism extended or clashed with the efforts of preceding French monarchies and republics to centralize, standardize, and rationalize forests, waterways, railways, electrical grids, and so on.[7] Rival claims on nature are followed through the archives of the army general staff and Administration des Eaux et Forêts (AEF), responsible for state forests and rivers. They show that despite its history of high-handedness, the AEF sometimes allied with collectivities and individuals to contest military objectives.[8]

The third perspective is environmental. As Bruno Latour argued, natural logics shape, enable, or block human action.[9] In practice, building fortifications deep underground, bringing in clean air and water, and evacuating poisonous fumes and human waste—all without creating vulnerabilities—proved immensely difficult. The engineers' fruitless battle against water, against the damp, and against soiled air undermined soldiers' morale, as the technical archives of the general staff and military engineers, together with commanding officers' reports on the experience of manning the fortifications, reveal.

Focusing on these perspective marginalizes other worthy stories. The article does not discuss the equally problematic use of horses, pigeons, and dogs, or the use of vegetation as camouflage, for instance. It also focuses the story on a particular part of the Maginot Line. While the fortification of the French border was first discussed in 1919, controversies over its necessity and type, delayed its approval until 1930. On January 14 of that year, the French Parliament passed a law that funded fortification along 120 miles of the nation's border, stretching from the Belgium-Luxembourg border to Switzerland (Figure 2). In doing so, it established two fortified regions (RFs). RF-Metz (Figure 3), comprised eleven artillery forts (*gros ouvrages)* and twenty-six machine-gun and mortar forts (*petits ouvrages*); RF-Lauter comprised six *gros* and eleven *petits ouvrages* (Figure 4). Between these two RFs, the Sarre Gap was defended by planned floods and blockhouses. Within RF-Lauter was another lightly fortified gap, the forested Northern Vosges hills. The Rhine was protected by machine-gun casements. The 1930 program also funded works in mountain passes and on the coastal plain along the Italian border. Four years later, another law authorized construction of *petits ouvrages* at key points on the Belgian border as a fallback. Although additional light fortifications were subsequently commissioned on the Belgian border, those constructed under the 1930 and 1934 laws are analyzed here. It was only there that engineers constructed

the huge artillery forts in which the ambition to "organize the frontier" and "organize the terrain" were fully developed.

<<Figure 2 about here>>

<<Figures 3 and 4 about here>>

Dangerous Nature

The army held that the political limits of France should coincide with militarily defensible natural features—seas, rivers, and mountains. Yet on the eastern border from the North Sea to Switzerland they did not. The attempts of regimes from Louis XIV to Napoléon I to secure the "natural" Rhine border failed. In 1815, the second Treaty of Paris allowed defeated France to retain Alsace-Lorraine, and thus the Rhine River border from Switzerland to Lauterbourg. Yet from Lauterbourg to the North Sea, the treaty deliberately traced a hard-to-defend limit.[10] There were no defensible barriers, and the French side was overlooked by observatories. It was cut by perpendicular river valleys leading to Paris through the Oise, the Sambre, and the Escaut/Scheldt valleys (Figure 5). These "invasion routes" would have been less dangerous had the centralizing administration not constructed a communication network converging on Paris, thus concentrating war industries and people within easy reach of invaders. At least, however, the Belgian and Luxembourg buffers and thick Ardennes Forest gave the French warning of a German attack via that route.

<<Figure 5 about here>>

The situation on the German border was more dangerous still, for it offered a direct route from Germany to Paris through the Moselle Valley. Thanks to defeat in the Franco-Prussian War of 1870-1, the French lost Alsace-Lorraine to Germany. Victory in 1918 ensured its return but the army hoped for more. It campaigned in the Versailles Peace Conference (1919) to position the "military border" on the "natural" Rhine as far as the

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Netherlands. Ignoring the principle of self-determination for which the Allies had purportedly fought, it followed leading figures of the French Revolution, such as Georges Danton, in insisting that "the limits of the Republic were set by nature."[11] However, the treaty accorded only temporary occupation of the German Rhineland. Once the Allied occupation ended in 1935, earlier if the Germans proved cooperative, the French would be left with the hard-to-defend 1815 border. As an early discussion of fortification put it in 1919, woods, swamps, and water were the best means of defense, "but it was not possible to find on the frontier continuous lines formed by end-to-end disposition of these obstacles."[12] In 1926, the Comité de défense de la frontière (CDF), which drew up the plans for fortification, used a violent organic metaphor to lament that the 1815 Treaty had "imposed on the limits of old France a series of disembowelments, often on a moderate scale but always perfectly conceived, revealing a profound knowledge of local topography and the history of wars."[13]

The barriers that existed were allegedly as unreliable as the human crowd, as understood by Gustave Le Bon. In is classic *La Psychologie des Foules* (1895), he had argued that the irrational crowd, which he associated with the working class, women, and non-European peoples, alternated between stagnation, routine, and unpredictable outbreaks. He likened, for instance, the healthy "fundamental ideas" of the crowd to "the mass of the waters of a river flowing slowly along its bed." He contrasted these deep currents with "passing ideas," which resembled "always fleeting little surface waves."[14] He explained that dangerous "agitators" misled the crowd by stirring superficial ideas, unless a rational and patriotic elite ensured that the healthy ideas in the depths prevailed. Le Bon therefore assumed division within human society between crowd/nature and elite/culture. [15] Thanks to the enormous influence of crowd psychology in press and academic circles, the circulation of concepts between understandings of nature and crowd was common by the 1920s.[16]

Thus, the army conceived the German enemy as a dangerous crowd, inferior race, and close to nature. General Pierre Klein, a fortification expert consulted by the General Staff in 1919, made this connection explicitly. He likened past and potential new German invasions to "flooding" of the South German tribes, menacing the Saint-Etienne industrial area with "inundation." He claimed that Germany and the Rhine were "liable to overflows that threatened the rich Alsatian plain; [the Alsatians] have built dikes to protect it against this invasion when the waters are inflated from upstream" [emphasis in original]. Yet, Klein warned, these dikes were cut by roads, that required blocking with guard posts. There were fissures even in the best dikes, and leaks ["infiltration" in French connotes German infantry tactics], could isolate the guard posts. If these posts were submerged, the plain would need to be defended by a second dike.[17] Klein was not alone in equating a German invasion with a natural disaster. In 1922, the novelist-veteran Maurice Genevois's *Rémi des Rauches* compared the war with a flood of the Loire, recalling accusations that German barbarians had destroyed the bucolic French landscape.[18] A journalist's likening of German bunkers to Rhine Maidens rising from the icy, smoking river as if from a legendary cauldron, underlines the association of Germany with nature and the "barbarian crowd."[19]

The army viewed forests similarly.[20] Klein remarked presciently that those of the Belgian frontier could just as easily mask the enemy's movements as defend the nation.[21] Moreover, French officers worried that forests would compromise command of the troops—regarded as a "crowd." In 1937, for instance, General Édouard Requin, commander-designate of an army on the Maginot Line, reported that discipline was problematic in casements dispersed in the Vosges Forest.[22] Positively, forests provided timber, fuel, and food for soldiers.[23] Negatively, forests connoted disease and banditry, especially those along the border. They recalled fairy tales, unnatural happenings, witchcraft, and wolves—stories in which protagonists were preyed upon and either survived (Hansel and Gretel) or died (Red

Riding Hood). The journalist André Willeman evoked a fictional Parisian conscript on leave, who told curious civilians of guarding a fortification alone in the forest at night with snow up to his neck, a fire to keep wolves away, and a dagger if the fire died.[24] These were not mere literary imaginings, for once war began, soldiers stationed in dark forests used these stereotypes to understand their experiences. To ensure that unpredictable nature served the national interest rather than the enemy's, it had to be "organized."

Organizing the Terrain

Organizationalism emerged initially in the 1900s as a way to preserve elite rule in the political, military, and social domains in the face of democratization and the rise of socialism— often rendered by critics as the age of the "crowd." As such it owed much to Le Bon's conviction that an "elite" must ensure that the crowd, like a river, was harnessed to national objectives. Organizationalism became widely known during and after the Great War. In June 1923, the first Conférence de l'organisation française met. A leading advocate of organizationalism at the gathering was André Tardieu, who went on to serve as the prime minister when fortification was approved in 1930. By then, "organization" was so routinely used in so many fields that it would be tedious to point out each recurrence.[25]

One purpose of organizational science was to justify social hierarchy as "scientific," rather than mere class privilege. Organizationalists drew on the theories of Henri Fayol, who advocated central command by a "leader" or "chief" [chef], an "elite," conceived of in opposition to the irrational mass. Also essential was F.W. Taylor's rationalization of the labor process— known in France as "organization of work." Taylorism subdivided work to facilitate standardized mass production and to ensure that only the engineer-manager understood the whole.[26] By improving productivity through rationalization, organizationalism

would increase wealth and improve workers' well-being, thus depriving "agitators" of purchase.

As in Spain and Germany, fortification was as much about political and social control as military power, for the army shared organisationalist objectives— fighting agitators though hierarchical control of the troops and by improving their comfort.[27] Since the 1900s, the left had been pressing for the democratization of the officer corps. Then, the Great War witnessed tactical democratization, in which junior officers and sergeants took command of small combat groups hidden in the terrain (trenches and dispersed posts).[28] In 1917, troops mutinied in protest at wasteful offensives and terrible material conditions. After the war, organized, centrally commanded, Taylorized forts (as opposed to small, dispersed blockhouses, preferred by the left as more "democratic") were advocated to restore discipline while improving conditions, eliminating discontent, and increasing "productivity" under fire. As its name suggests, organizationalism was central to the Comité de l'organisation de la frontière (CORF), created in 1927 to implement fortification plans. It saw fortification as a unified whole, upset by the modification of a single human or non-human element.

The Army Chief of Staff (1919-23) General Edmund Buat was the epitome of the officer-organizer. He belonged to a caste of civil and military engineers, managers, and staff officers trained in the prestigious Polytechnique in Paris, who along with graduates of institutions such as the French National School of Forestry in Nancy, played an important part in the centralized administration.[29] In 1922, Buat explained that while nations instinctively seek "natural frontiers" such as rivers and mountains, "when nature failed, military art created artificial frontiers designed to achieve the same security; ramparts were held by military colonies, and the whole constituted a coherent, organized, system."[30] Fortification was thus one element in the effort to "organize the terrain."

A key principle was the doctrine of "compartments" [cloisonnements or compartiments], analogous to the rational layout of regularized forests and rivers. Firepower was to be concentrated in zones bounded by crests, rivers, forests, and, if necessary, fortifications. These limits were often referred to as "môles de résistance"—"breakwaters"—able to "break the impetuosity of the waves," as one general put it, again likening invasion to a flood. The expression came to refer to any military obstacle: cities, forests, river valleys, the Alps, and fortified regions, were all "môles."[31] Thus, a study of fortification advised repetitively, that "this organization will use compartments formed by the combination of organized compartments and natural obstacles, the latter covered with numerous destructions [of roads and bridges]."[32] Within compartments, the terrain was entirely covered by pre-planned fields of fire, using 75mm artillery firing directly and howitzers, bomb-throwers, and mortars firing indirectly over obstacles into dead zones.[33]

Individual forts were integrated into the terrain. In 1928, General Robert Normand (director of military engineers at the War Ministry) explained that while Louis XIV's great fortifier, Sébastien Le Prestre de Vauban, re-modelled the landscape to create fields of fire, the contemporary requirement to defend the whole frontier made that unachievable. It was therefore a "modern necessity" to integrate forts into the terrain.[34] The centralized forts of the past, including Verdun, which dominated the terrain, were outmoded. Now, little was visible above ground. Forts consisted of camouflaged, dispersed combat blocs, linked by deep galleries to services in the rear, while entrances to them were hidden in forests (Figure 1). As the fortifications of the Maginot Line were taking shape, a reporter authorized by the army to visit them described encountering a turret: "that second, I noticed a glint of steel and the black holes that cut the monstrous barrels of the guns. Another second, and the field recovered its bucolic charm."[35] Normand described "artillery firing from little invisible

orifices, real vipers' nests," an animal metaphor that underscores the integration of human and non-human.[36]

Forts integrated into the terrain were depicted as the antithesis of disorganized nature, and by extension as a guarantee of order and command in the army. Colonel Louis Chauvineau, who taught fortification to engineer cadets, stressed that even field fortification required command, for "Tactics, topography, cunning, technique, the organization of work, constitute an indissociable bloc." He likened ad hoc digging in to "spontaneous vegetation," and declared that nothing required coordination more than "organization of the terrain."[37] Likewise, in the detective novel, *Double crime sur la Ligne Maginot* (1937), written anonymously by a French officer, the Taylorised orderliness of the fort and the artificial landscape around contrasts with the border in the "dark forest," located "somewhere in the disorder." As the imminent murder victim, Major Espinac, inspects the fort, he imagines the enemy under artillery fire, fleeing to the forest, "which irresistibly attracts it in the headlong rush, more dangerous than a hurried retreat, for the men are too dispersed to remain attentive to the orders of their officers." They would, Espinac predicted, lose cohesion in the inextricable tangle of the forest.[38]

Organizationalism faced multiple challenges. Among them was the conviction of many field commanders, especially infantry officers, that command was not a mathematical science, as engineers thought, but an art requiring judgement and feeling for men and the terrain. To permanent fortification constructed in peacetime, field commanders preferred improvised field fortification, constructed under the commander's guidance in the flow of the battle. General Émile Alléhaut, a leading military thinker, warned that pre-planned works were potentially useless: "You might well have marked out in advance all possible fields of fire, taken the precaution of covering all the terrain from all angles. But during the battle churning up of soil by enemy artillery will modify your field of vision and annul all your

adjustments."[39] Critics of the engineers did not always reject organizationalism altogether—they simply argued that it was the task of field commanders to "organize the terrain" (that was Chauvineau's view). Yet nothing illustrates the hostility of infantry officers to the engineers' science than the popularity among them of radiesthesia. This pseudo-science used pendulums to detect rays purportedly emitted by humans and natural objects. It gave "scientific" backing to the intuition and feeling for the terrain that infantry officers valued. It was allegedly orthodox at the Ecole de Guerre. General André Prételat, future commander of the 2nd Army Group on the Maginot Line, persuaded the army to resume research into radiesthesia, until the Académie des Sciences objected. He nevertheless distributed the names of *radiesthésists* to his subordinates. During the Phoney War, one officer used pendulums to verify the position of machine guns from his office.[40]

The opposition of field commanders such as Prételat to the engineers' science eventually prevailed. In 1935, the CORF was wound up despite its commander insisting that its work was incomplete. No more *gros ouvrages* were funded. Instead, field commanders constructed thousands of assorted blockhouses. Many turned out to be useless, and they undermined the objective of improving troops' conditions. But their relative worthlessness notwithstanding, their construction underscores the degree to which the organizationalist ambitions of the military engineers proved tenuous and contingent. As it happened, military engineers also faced opposition from non-military organizers of nature.

The Beauty of Nature and Tourism

The Maginot Line differed from civilian infrastructure in being explicitly sacrificial. Obviously, enemy resources were to be destroyed, and ideally fighting would happen in Belgium, not France. However, in the event of invasion, the army was ready to sacrifice national resources. General Paul Maistre, Inspector of Infantry, explained that natural barriers

must be improved constructively by fortification and destructively by blowing up roads, provoking landslides, and felling trees—on the massive scale implemented by the retreating Germans in 1918.[41]

Given this ethos, one might expect fortification to have incited opposition from within the growing movement for the protection of nature. After all, in March 1930, just after approval of the fortification, parliament enacted a law for "the protection of natural monuments and sites of artistic, historical, scientific, legendary, or picturesque character."[42] Yet this law had no discernable impact on fortification. To be sure, the construction of a barracks for fortification troops in the Mormal Forest was immensely controversial, but no critic mentioned that it was the site of France's first bird protection zone. The Bird Protection League, responsible for this zone, blamed hunters, trains, and mechanized farming for the decline of birds, not the army. Perhaps the many landed aristocrats in the League favored the army and disliked the democratization of hunting.[43]

Opponents of fortification prioritized commerce and farming. The Association for the Protection of the Schwartzbach Valley, for example, was not concerned with natural beauty. Rather it complained that the antitank ditch between Windstein and Dambach disrupted irrigation and necessitated that farmers take long detours to access their fields. In this case, a complaint to Édouard Daladier, France's Prime Minister and Defense Minister, ensured that the army delayed weeding the barbed-wire barrier and unblocking the irrigation channels until winter, as the law required.[44]

While farmers largely challenged the army for commercial reasons, associations such as the Touring Club de France, mountaineering, and canoeing societies—which saw access to beautiful landscapes as desirable for the cultivated, sporting bourgeois—raised different challenges. After the First World War, bourgeois tourism became more independent thanks to the spread of the automobile. And as portable cameras became cheaper, clubs encouraged

members to send photographs of picturesque sites. With limitations on working hours in 1919 and 1936, tourism began to be democratized. Indeed, in 1936 the socialist government created a ministry for the *organization* of leisure. Just as tourists' numbers and mobility increased and cameras became more affordable, the country's fortifications ceased to be enclosed within a defined zone and were dispersed and camouflaged. Since forts were nevertheless situated on iconic rivers and heights with panoramic views, tourists were tempted to take landscape photographs from them. Moreover, fortifications and battlefields were established objects of tourist curiosity.[45]

While tourists understood that it was illegal to photograph or draw an *ouvrage* itself, they were rarely aware that with their backs to it they were photographing its field of fire. One man, for instance, was arrested near the Veckring fort for photographing the village of Monneron for an innkeeper who wanted a panorama of his premises.[46] The mountain border with Italy attracted sightseers and practitioners of winter sports. Tourists sipped tea on the balcony of the Righi hotel in the Alpine foothills, where they shared a spectacular view of the Mediterranean coast with the Sainte-Agnès fort, to which it was adjacent.[47] Even soldiers did not obey the law. Young conscripts, many of whom had left their city or village for the first time, behaved much as the tourists, and had to be warned that photography was illegal.[48] Nothing could be done about German tourists on the other bank of the Rhine, who came to bathe and watch the construction of fortifications.[49] Thus**,** while the army did not have to contend with the movement for protection of nature, it did have to reckon with commercial interests and tourism. It also had to take account of "conservationism," more broadly defined as the rational use of forests, waterways, soil, and terrain to serve human needs.

Forests

Arguably the champion of the nation's conservation movement was the AEF, which believed that to serve commercial and national purposes, nature required the guiding hands of expert foresters and hydrologists. To facilitate the sale of high-quality timber and firewood, they laid out forests in squares, paralleling military compartments and regularized the courses of rivers to facilitate navigation. Since the AEF also preserved forests as military obstacles, it was not unsympathetic to military demands.[50] While in peacetime it was subject to the Agriculture Ministry, many officials were reserve officers, and in wartime, foresters were mobilized as "forest sappers" [*sapeurs forestiers*].The army was not immune to the conservationists' long-term view. Yet since it was prepared to destroy forests for immediate purposes, it sometimes clashed with the AEF, which criticized military demands as short-term, excessive, and damaging. Historically, the AEF had dismissed individual and local interests, but its opposition to huge military demands encouraged alliance with them.[51]

Forests in the fortified zones were vital to military calculation. So-called "improved forests" [*forêts aménagés*], with roads, pathways, and clearings, were fortified and/or used for training and camouflaging troop movements.[52] To slow the progress of the enemy, the army reinforced dense forests with blockhouses and felled swaths of trees, cratered paths, and constructed barbed-wire barriers. For instance, in 1936, 250,000 francs were allocated for this purpose in the Haguenau Forest, so that it could fulfil its role as the grandly named Môle de Résistance de Bas-Alsace.[53] General Maxime Weygand, then head of the army, cheekily asked the government whether money earned from selling felled timber could be spent on fortification, implicitly acknowledging that forests were managed for economic as well as military reasons.[54]

These priorities often conflicted. Units felled trees without permission either from their superiors or the AEF. The commander of the Vosges sector scolded subordinates for constructing a relief trench through the domain forest to the Rothenbourg casement without

informing the AEF.[55] In June 1939, an AEF inspector protested that fortification troops had felled fifteen oaks and thirty beeches in Rayerswiller Forest, costing the commune 1,556 francs.[56] The commander of the Bitche sector reminded regiments that felling must never be carried out without AEF authorization.[57]

Thanks to the AEF, the Mormal Forest partially frustrated military plans. Guarding the southern flank of the Escaut/Scheldt invasion route, it had long been valued as a military strongpoint. As construction began on the Maginot Line, the forest was far from pristine. It was cut by clearings, paths, and pastures, overexploited for game, firewood, pitprops, and clog-making. It was degraded by cattle and fires sparked by trains. Unlike most forests in the fortified zone, it had been damaged in the Great War. The occupying Germans had installed sawmills, cleared two-thirds of it, and machine-gunned trees they had not felled, making the timber unusable. In 1930, there was still considerable unemployment in the timber and clog-making industries, and the hunting on which poor families relied to supplement to meager incomes was still not restored. However, its status as a national domain forest ensured at least some degree of regeneration, and nature proved resilient. White oaks re-seeded themselves, and the AEF, which favored deciduous trees, encouraged them with planting and thinning. By 1930, the forest was reconstituting, but not yet productive.[58]

In February, the General Staff asked the CORF to draw up plans for thirteen casements on the forest's northern limit. The AEF had no legal grounds for objection, but did manage to reduce the army's demand from five hundred hectares to 226.[59] The AEF focused rather on a request, also in February, to re-site an existing small firing range so that it could accommodate a shooting range for new light machine guns and a training camp covering 1,850 hectares in the western part of the forest—around one fifth of the forest's area. After much argument, the AEF conceded construction of the firing range, but resisted—with the support of its national director and the agriculture minister—the ceding of 1,850 hectares for

the barracks. It objected on the grounds that while only 277 hectares of this area were currently productive, some 394 young trees and 650,000 seedlings were growing on it that would eventually bring in sixty thousand francs annually. Clearing the land would upset the water regimes of the Escaut/Scheldt and the Sambre, jeopardize navigation, and cause flooding. Seeking to leverage commercial concerns and enlist local support, the AEF also predicted that clog-makers would protest loss of raw materials. Nevertheless, in December, the AEF ceded 650 hectares and allowed judicious thinning.[60]

The AEF's justified suspicion that the army still coveted the whole 1,850 hectares continued to poison relations. The AEF Conservateur-en-chef at Lille warned that the proposed camp would frighten game and that spent ammunition and incursions by soldiers would damage trees. The finance ministry objected to the potential loss of revenue at a time when the state was spending huge sums reconstituting war-damaged forests. In response, the army reiterated the priority of defending the national frontier. Some local elected officials backed the army, for they were pressing for completion of military works to defend the region and relieve unemployment.[61]

In June 1934, the proposed construction of a *petit ouvrage* at Eth to the northwest of the forest made building a barracks for two thousand fortress troops more urgent. In 1936, the mayor of Locquignol in the middle of the forest expressed his concern about the long-term consequences for the forest of constructing the barracks, only to be told by a military engineer that the camp would be built "come what may." Socialists protested on behalf of clog makers. The local deputy did not oppose the plan in principle but objected to the scale of the expropriation. On May 10, the army at last gained the whole 1,850 hectares. The AEF was reduced to hoping that the agreement would preserve as much of the forest as possible.[62]

Opponents nonetheless succeeded in delaying construction to a time when the army prioritized tanks and aircraft rather than fortification. Work on the barracks began in 1938,

but only some access roads, light training facilities, and a water tower without a pump were ever built. The forest could not have stymied military plans without the AEF and local communities, but its capacity for regeneration had helped the AEF's case. The intrinsic properties of water were harder to contain.

Water and Air

Like forestry, military hydrology was a its core Renaissance and Enlightenment science, based on mathematical calculation of water flows, regularity, and straight lines. Anticipating organizationalism, hydrologists aimed to "tame" rivers, making them more like canals. Hydrological projects were integral to the power of the developing absolutist state of Louis XIV and his army, and Vauban was an expert in the subject.[63] However, France was no exception to the rule that "improving" a river on one stretch often entailed negative consequences elsewhere, including for the military. On the Rhine, the army's ability to impose its will was complicated by international control.

Although an important military defense, the Rhine had been crossed many times in the past. Moreover, the unforeseen consequences of interventions by German engineers during the annexation of Alsace-Lorraine posed significant problems to the army. Regularization above Strasbourg began in the nineteenth century under the Baden engineer, Johann Gottfried Tulla. Having trained in Paris at the Polytechnique, he brought the desire for mathematical regulation of nature to the German states. He is famous for the maxim that "No stream or river, the Rhine included, needs more than one bed."[64] His works, completed in 1876, well after his death, eliminated shifting meanders and islands, and gave the river a single course, with two dikes on each bank to contain flooding. Unintentionally, Tulla's works sped both the river's flow and increased erosion, forming alluvial bars, exposing rocks, and creating rapids at Istein. The river became unnavigable from Strasbourg to Basel, and a

potential crossing point at Saint-Louis emerged. At the turn of the century, the Alsatians and Swiss proposed a lateral canal to resolve the problem, but Baden blocked a project that competed with its railways and threatened to harm agriculture by lowering the water table. Instead, from 1906, engineers constructed dikes and groynes and reinforced the banks.[65] At Versailles, the French gained the sole right to develop the river, and to dilute German influence, they added the Netherlands, Belgium, Britain, and Italy to the Rhine navigation commission. The French rejected the German-Swiss preference for further works on the river in favor of the Grand Canal d'Alsace on French soil under French control. The first stage was a dam, canal pound, and hydro-electric station at Kembs, constructed from 1928-31, with locks at Istein to bypass the rapids.[66] While the priorities driving the alteration had been navigation and commerce, the German press portrayed the canal as an effort to turn Baden into steppe and to integrate the river into the French fortifications.[67]

In fact, the canal did not please the French army, but it had to defend the river as the navigation authorities and civil engineers made it. It complained that the construction of the canal had substituted the "real and indestructible barrier of the Rhine [for] an obstacle of less value and essentially vulnerable," for it would drain water from the river. Another difficulty for the army was that the Kembs installations, which controlled the level of the river, lay just outside a zone in which fortification was forbidden under the 1815 Treaty of Paris. The army ensured that points for explosives would be built into the bridge over the dam so that it could be blown if necessary and the full flow of the Rhine restored. Even then, officers worried that it would take thirty-six hours to restore the river to its former flow. At least fear that shellfire could destroy the canal banks and cause flooding proved to be unfounded.[68] Using the lateral canal to flood the Alsatian plain was dismissed because of likely opposition from the navigation authority, the cost of building sluices in the wide dikes, and the permeability of the Alsatian soil.[69]

On the Rhine itself, the army abandoned a plan to disguise casements with embankments and trees because officials in the Navigation Department believed that summer floods would eventually alter the course of the river. Doubtless the army accepted the advice because that would have rendered the blockhouses useless. Instead, its engineers modified the (already artificial) banks upstream and downstream. The blockhouses resembled bridge piers and were more visible than ever.[70] Moreover, casements were uncomfortable. Seasonal flooding meant that they could not be heated electrically. Lack of money meant that construction of guard posts to provide warmth and refuge from flooding was possible only where salvaged materials could be found.[71]

There were some examples of cooperation between the AEF and army in developing water defenses. The AEF regarded small hydrological works in the two RFs positively, probably because it approved of regularization. Those works included defensive flooding at various points on the Franco-German border, notably in the Haguenau and Vosges forests in RF-Lauter, and in the Boulay and Saint-Avold sector of RF-Metz. In the latter, work was carried out on the Nied Allemande River, but its flow was too feeble to be trustworthy. Military engineers installed concrete weirs, but soon removed them because they caused silting; they then deepened the bed between the villages of Biding and Folschviller and at Grossberg to make an antitank barrier.[72]

The most important example of civil-military cooperation was in the planned flooding of the twenty-kilometer Sarre Gap (Figure 4). The zone was hard to defend because it was dominated by heights on the German side and the surface clay made the ground too prone to flooding for deep *ouvrages*. Moreover, until 1935, French control of the Saarland made fortification impolitic. The flooding project originated with a 1927 study by Monsieur Pariset, a military engineer turned chief civil engineer of the Moselle department, who proposed taking advantage of the clay soil. He proposed small structures which could quickly dam the

Sarre and its left tributaries, the Moderbach and Albe.[73] Disguised as roadworks and fishing improvements, beds were deepened, banks strengthened, and because flow varied, rivers were linked to three modified natural lakes and six artificial pools. The army had little confidence in this work. Even if the installations were not destroyed by a surprise attack, releasing water too quickly would destroy the dikes, so it would take up to two days to complete flooding. In 1936, the high command initiated a plan to protect the area with thirty-one casements, twelve of which were constructed by December 1938.[74]

Keeping water out of the *ouvrages* was challenging, thanks first to geological conditions. To simplify, the border coincides with the rim of the Paris Basin, where its layers from bottom to top of limestones, marls, and sandstones turn upwards to the surface. Consequently, tectonic folding, some volcanic events, and differential erosion created varied hydrological conditions. Deep works are best in the impermeable marls, and these were found half the time on the right bank of the Moselle and more often on the left bank.[75] But if marls are overlain by easily waterlogged permeable sandstones, fighting blocks close to the surface could not be constructed. Such was the case north of Lens, where it had been impossible during the Great War to prevent trenches from flooding.[76] The same was true of the Northern Vosges Forest, where a red sandstone layer is covered by sandy soil. Depending on the weather, ground there was too marshy or too unstable to dig reliable trenches. There was no money to concrete them, so wattle was substituted or camouflaged pathways used instead.[77]

Although *ouvrages* were rarely constructed within the water table, that did not seal them. Infiltration derived from two sources. First, surface water ran into the *ouvrages*, especially in Southeast France, where they crossed fault lines in the limestone, and in the impermeable clay soil of Anzeling on the aforementioned right bank of the Moselle. In certain conditions, water could penetrate the masonry galleries (concrete was more expensive). Indeed, construction shortcomings could complicate the issue, as they did at the

Einseling fort, where concrete had been poured in two stages, creating a crack through which rainwater poured.[78] Infiltration could be combated by applying a waterproof coating in galleries, but that often proved prohibitively expensive. Grassing the embankments of fortification to bind the surface soil so that surface water did not create channels offered a promising solution, the more so as vegetation was necessary for camouflage. Often the results were disappointing, however, not least because contractors had not foreseen that soil excavated for the fortifications would have to cover the *ouvrages.* Channeling resulted nevertheless.[79] A second problem was condensation. In winter, warm damp air brought in from outside by ventilators condensed on colder surfaces inside. Condensation could be prevented by cooling the air as it entered. Yet warm air in the depths of the *ouvrage* also condensed as it rose into cooler fighting blocs nearer the surface.

Engineers responded with informed trial and error. In March 1932, the Service technique du Génie (STG) set up a commission presided by General Charles Belhague (head of the CORF) to disseminate best practice. Its first notice recognized the difficulty of preventing water infiltration and suggested that local knowledge must be respected regarding the precise combination of pressurized cementation, coatings, and drainage. The STG established rules that waterproofing needed to be complete in all shafts, galleries and underground installations except for latrines, washrooms, and galleries and shafts not containing machinery, where "slight seepage" could be tolerated on grounds of "cost." The note does not explicitly mention sleeping quarters and dining areas, but the implication is that damp was tolerable there.[80]

Damp became a pressing problem once forts were occupied. In June 1935, the Senate Army Commission urged the army to solve the problem and minimize fluctuations in temperature.[81] The Minister of War Colonel Jean Fabry reminded the military governor of Metz that damp had already caused considerable damage to equipment.[82] A few months later,

an inspection of the Anzeling *ouvrage* found that sleeping conditions were acceptable in the underground barracks, but "mediocre or frankly bad" in the fighting blocs, thanks to condensation. The crew was reminded to close the airtight doors. At Soetrich, on the drier left bank of the Moselle, the inspector reported that everything was perfectly clean, and the impression was of "comfort and even luxury." Even there, however, food had to be protected from condensation, and stored clothing and mattresses rotted.[83]

Those charged with finding solutions were not optimistic. General Joseph Alleau, Director of Engineers in the War Ministry, told Belhague that sealing the ouvrages would "never be complete," while Commander-in-Chief General Maurice Gamelin was informed that "whatever measures were implemented previously, we will always be obliged to implement new ones to ensure that *ouvrages* are watertight," and that the ability to do so depends on funds.[84] The Médecin-Général reported on the eve of war that damp continued to impair occupants' health.[85] So much for the army's choice of large forts to improve habitability and make soldiers more "productive" under fire.

Circulation of fresh air, which could help with the damp, was difficult because cost and military considerations dictated that underground works were as small as possible. Circulation was further reduced by compartmentalization to protect against gas attack and prevent the spread of gasses produced by the *ouvrage*'s own kitchens and artillery. Air was renewed by electrical ventilation to expel noxious fumes and to pump air in from the surface. Incoming air was filtered in the event of gas attack. Air intakes were potential weaknesses of the *ouvrage*, and had to be protected by armored "mushroom cloches."

The problem of damp air and condensation was also tackled by pumping fresher air from underground into the surface fighting blocs, by mixing the air within the different parts of the ouvrage, and by installing central heating and air conditioning. Troops were protected from the cold and damp by periodic rest periods in camp and by taking the air when possible,

just as off duty sailors had the right to come on deck.[86] Officers on site improvised solutions. At Hackenberg fort, they installed airshafts outside the dressing station and operating theatre to improve air circulation.[87]

Air conditioning—not to be confused with ventilation—entailed maintaining constant air temperature and humidity. That was more difficult to achieve, partly thanks to the need for ventilation. Cold was another issue, especially in the deeper forts. The temperature was usually 13 degrees Celsius, often lower—at which point bodies do not function to full capacity. Conditions were worse still in the Alps, where generators caused deafening vibration of the mountain rock. In casements and blockhouses everywhere, frigid winter drafts penetrated through the apertures (through which poison gas and flamethrowers could enter too).[88] The 1933-4, winter was so cold that occupation was often impossible. Under pressure from parliamentary inspections, Gamelin ordered that in winter blockhouses should be left unoccupied and visited by patrols, or guarded by one or two soldiers in rudimentary posts outside the entrances.[89] However, as the international situation deteriorated, the requirement for permanent lookout overrode concern for the troops.

Conclusion

Understanding the Maginot Line as an envirotechnical object offers fresh insights into the engineering efforts that produced it, underscoring the ways in which they were intended to "organize," under elite guidance, advanced engineering, the machine-regulated actions of the troops (and animals), wood, water, and air, while preventing the enemy from using nature, machines, and men to their own advantage. Yet military objectives were often countered by foresters and hydrologists, business interests, local collectivities, ordinary individuals, and nature. In the Mormal Forest and on the Rhine, powerful social and natural

agencies together compromised military planning. But those compromises didn't determine its fate in the war.

The Battle of France is, after all, another story. Suffice it to say that Maginot Line was not designed for occupation during the eight months of the Phony War. In the *ouvrages*, the deleterious effects of poor air quality and damp were multiplied by overcrowding. One soldier ironically contrasted press reports of the "comfortable" lives of soldiers on the Maginot Line, who benefit from all sorts of material advantages such as elevators and showers, with reality: "Our room? Four concrete walls covered with lime-based paint that was once white, running with rivulets of shiny condensation. Big drops of water stagnate on the ceiling, which, thanks to the light, resemble shing pearls. … Number one enemy is water. The other is cold."[90] In forest advance posts, morale suffered from another exceptionally cold winter. Soldiers' letters home showed how terrified they were on freezing, stormy nights, as largely imaginary Germans prowled, hooting like owls and yelping like dogs—once more equating the enemy with animal nature.[91]

Little fighting took place on the Maginot Line, for whatever its weaknesses, its achieved its objective of forcing the Germans to take the militarily and politically riskier route through the Low Countries into France. Yet that which did happen proved Alléhaut's skeptical view of organizing the terrain half right. Interlocking fields of fire did protect larger works from determined assault. But the Germans captured a handful of smaller works, not by bombarding them directly, but, as Alléhaut predicted, by shelling the terrain to alter it, masking defenders' vision and creating cover for troops to approach. The Rhine fortifications proved ineffective, for their visibility made them an easy target. Flooding the Sarre Gap contributed on June 14, 1940, to a rare French victory. But by then, the Germans were already in Paris. After the war, the Maginot Line undeservedly became the quintessential example of military miscalculation and outdated doctrine. Consequently, its origins as an

envirotechnical object rooted in organizationalist thought were quickly forgotten and remained largely obscured.

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Notes

[1] See Robert Doughty, *The Seeds of Disaster: The Development of French Army Doctrine 1919-1939* (Hamden, Conn: Archen, 1985), 43–73; Pierre Rocolle, *La Guerre de 1940*, vol. 1: L'Illusion (Paris: Armand Colin, 1990), 94–101; and Karl-Heinz Frieser, *Blitzkrieg-Legende: der Westfeldzug 1940* (München: de Gruyter, 1996). ; Revisionists' view that in reality the French actually relied as much on armor as on fortification, does not challenge the nature/culture opposition. See Martin S. Alexander, *The Republic in Danger: General Maurice Gamelin and the Politics of French Defence, 1933-1940* (Cambridge: Cambridge University Press, 1992); Julian Jackson, *The Fall of France: The Nazi Invasion of 1940* (Oxford: Oxford University Press, 2003); Philip Nord, *France 1940: Defending the Republic* (New Haven: Yale University Press, 2015).

[2] Jean-Yves Mary and Alain Hohnadel, *Hommes et ouvrages de la ligne Maginot*, 5 vols. (Paris: Histoire et collections, 2001).

[3] Chris Pearson, *Mobilizing Nature: The Environmental History of War and Militarization in Modern France* (Manchester: Manchester University Press, 2012), 148–50; Santiago Gorostiza, "Fortifying the Nation in Francoist Spain," *Environmental History* 23 (2018): 797–823; For miltiarized landscapes, see Peter Coates et al., "Defending Nation, Defending Nature? Militarized Landscapes and Military

Environmentalism in Britain, France, and the United States," *Environmental History* 16 (July 2011): 456–91.

[4] Sara B. Pritchard, *Confluence the Nature of Technology and the Remaking of the Rhône* (Cambridge, Mass: Harvard University Press, 2011); My approach also has affinities with the concept of the city as a combination of physical environment, technology, and human beings, as explained in Simo Laakkonen, "Environmental History, the Second World War, and Urban Resilience," in *The Resilient City in World War II: Urban Environmental Histories*, ed. Simo Laakkonen et al. (Cham: Springer International Publishing, 2019), 3–19.

[5] This top-down doctrine contrasts with the devolved "mission-oriented" doctrine of the German army, which allowed more room for initiative from below. See Marco Sigg, *Der Unterführer als Feldherr im Taschenformat: Theorie und Praxis der Auftragstaktik im deutschen Heer 1869 bis 1945*, Zeitalter der Weltkriege (Paderborn: Schöningh, 2014) Arguably, this division runs through management science to the present.

[6] Of course, organized defensive systems date back at least to the Roman Limes Germanicus. In France, Vauban constructed an equally complex system.

[7] Cecil O. Smith, "The Longest Run: Public Engineers and Planning in France," *The American Historical Review* 95 (1990): 657–92.

[8] Smith; Tamara L. Whited, *Forests and Peasant Politics in Modern France* (New Haven: Yale University Press, 2000).

[9] Bruno Latour, Reassembling the Social: An Introduction to Actor-Network-Theory (Oxford: Oxford University Press, 2005); Pritchard, Confluence the Nature of Technology and the Remaking of the Rhône, 17; Chris Pearson, "Beyond 'Resistance': Rethinking Nonhuman Agency for a 'More-than-Human' World," European Review of History 22 (2015): 709–25.

[10] Lieutenant-Colonel Christophe Gué, "Héritage et conséquences du traité de Paris (1815): le cas de la frontière de l'Ardenne en 1914 et en 1940," in *Frontières en Europe depuis le congrès de Vienne, 1815: enjeux diplomatiques, stratégiques, militaires et économiques*, by Ludovic Laloux, Frédéric Dessberg, and Stéphane Palaude (Valenciennes: Presses universitaires de Valenciennes, 2020), 23–42.

[11] SHD [Service historique de la défense] 7/N/3764 S-D 1, Note, April 1919, 'Le Rhin, frontière militaire de la France ; Peter Jackson, *Beyond the Balance of Power: France and the Politics of National Security in the Era of the First World War* (Cambridge University Press, 2013), 277–81..

[12] SHD 7/N/3674/2, "Exposé d'une organisation des frontières," c. 1919-1920.

[13] SHD 1/N/28/8, CDF, Rapport au ministre, 26 November 1926.

[14] Gustave Le Bon, *La psychologie des foules* Paris: Alcan, 1895), 34, 74.

[15] In the interwar years, "Chef" in French could mean "manager" or the "leader" of an authoritarian party.

[16] Gustave Le Bon, *La Psychologie Des Foules* (Paris: Alcan, 1895), 25; On the international preoccupation with command, see Yves Cohen, *Le siècle des chefs : Une histoire transnationale du commandement et de l'autorité* (Amsterdam, 2013).

[17] SHD 7/N/3674/1, General Klein, "Étude sur l'organization de la frontière," March 31, 1919, pp. 9-10.

[18] Pearson, Mobilizing Nature, 91.

[19] *L'Illustration*, 5001, January 7, 1939, p. 6.

[20] Robert Pogue Harrison, *Forests: The Shadow of Civilization* (Chicago: University of Chicago Press, 1992).

[21] SHD 7/N/3674/1, Klein, "Étude…", p. 11.

[22] SHD 7/N/3822/5, Requin to ministry, July 19, 1937.

[23] J. R. McNeill, "Woods and Warfare in World History," *Environmental History* 9 (July 2004): 388–410.

[24] *L'Intransigeant*, June 3, 1938.

[25] On the pervasiveness of crowd psychology and organizationalism in French politics and social science, see Kevin Passmore, *The Right in France from the Third Republic to Vichy* (Oxford: Oxford University Press, 2013), 151–347.

[26] On organizationalism, Philip G. Nord, "Social Defence and Conservative Regeneration: The National Revival, 1900-14," in *Nationhood and Nationalism in France: From Boulangism to the Great War*, ed. Robert Tombs (London: HarperCollins, 1991), 211–28; Stéphane Rials, *Administration et organisation: De l'organisation de la bataille à la bataille de l'organisation dans l'administration française* (Paris: Beauchesne, 1977); Yves Cohen, "Fayol, Un Instituteur de l'ordre Industriel," *Entreprises et Histoire* 34 (2003): 29–67; Jackie Clarke, *France in the Age of Organization: Factory, Home and Nation from the 1920s to Vichy* (Berghahn Books, 2011)..

[27] Gorostiza, "'There Are the Pyrenees!,'" 804, shows that Spanish fortification entailed control of the unreliable border population; Andreas Dix, "Der Westwall im Rahmen von Raumplanung und Strukturpolitik in der NS-Zeit," in *Zukunftsprojekt Westwall: Wege zu einem verantwortungsbewussten Umgang mit den Überresten der NS-Anlage*, ed. Karola Fings and Frank Möller, Materialien zur Bodendenkmalpflege im Rheinland (Weilerswist: Landschaftsverbandes Rheinland, 2008), shows that German fortification was part of planned ethnic re-structuring of Europe.

[28] Michel Goya, La Chair et l'acier. L'armée française et l'invention de la guerre moderne (1914-1918) (Paris: Tallandier, 2004).

[29] Smith, "The Longest Run."

[30] SHD 7/N/3763/3 and 1/N/27/7, "Organization défensive du territoire," March 16, 1923, p.6. Gorostiza, "'There Are the Pyrenees!,'" 798, 802 shows that Spanish engineers also endeavored to "perfect nature."

[31] General Clément-Grandcourt, *La France militaire*, January 7-8, 1934; SHD 7/N/3673/1, Pétain note,?1920; 7/N/3765, Note, December 1, 1934 ; Maurice Gamelin, *Servir*, vol. 1: Les armées françaises de 1940 (Paris: Plon, 1946), 43–44; Général Edmond Ruby, *Sedan, terre d'épreuve, avec la 2e Armée, mai-juin 1940* (Paris: Flammarion, 1948), 19–21; Ladislas Mysyrowicz, *Autopsie d'une Défaite. Origines de l'effondrement Militaire Français de 1940.* (Lausanne: L'Âge d'homme, 1973), 43–44.

[32] SHD 7/N/3764/2, Exposé, and 1/N/28/8, CDF, Rapport, November 6, 1926, e.g. p. 28.

[33] SHD 7/N/3781/10&11, Normand, "Les fortifications," July 25, 1928.

[34] SHD 7/N/3781/1/10&11, Normand, "Les fortifications"; AN Fonds Painlevé 313/AP/230, Painlevé note, January 7, 1929.

[35] *Le Matin*, April 8, 1936.

[36] SHD 7/N/3781/10&11, Normand, "Les fortifications."

[37] Colonel Chauvineau, "L'organisation du terrain et ses conséquences," *La Revue militaire française* 35 (January 1930): 246–73: at 258.

[38] Pierre Nord, *Double Crime Sur La Ligne Maginot* (Paris: Le Masque, 1936), 22, 53-4.

[39] Emile Alléhaut, *Etre prêts. Puissance aérienne, forces de terre.* (Paris: Berger-Levrault, 1935).

[40] SHD 28/N/15, correspondence Prételat–Georges October-November 1939; Entretiens avec François Le Lionnais, Oulipo, Un certain disparate, accessed June 6, 2022; Jean-Paul Sartre, *Carnets de la drôle de guerre: septembre 1939-mars 1940*, ed. Arlette Elkaïm-Sartre (Paris: Gallimard, 1995), 428–29.

[41] SHD 7/N/3764/1, Maistre, 21 March 1919; 1/N/50/2, Hellot, "Note sur l'organization défensive," March 29, 1919.

[42] Caroline Ford, "Nature, Culture and Conservation in France and Her Colonies 1840–1940," *Past & Present* 183, (2004): 173–98.

[43] Adrien Legros, "L'organisation des refuges d'oiseaux," *Bulletin-LPO*, 8-9, August-September 1921; *Revue des Eaux et Forêts* (1929), 398-412; Henri Jenn, "La LPO et Ses Réfuges," *L'Oiseau Magazine*, 2011.

[44] SHD 33/N/108/4, Daladier to commander 20th Region, May 21, 1938 and replies.

[45] Gary Cross, "Vacations for All: The Leisure Question in the Era of the Popular Front," *Journal of Contemporary History* 24, no. 4 (1989): 599–621; Bertram M. Gordon, *War Tourism: Second World War France from Defeat and Occupation to the Creation of Heritage* (Ithaca: Cornell University Press, 2018).

[46] AN BB18 6095/20/BL/428, October 1933

[47] AD Alpes-Maritimes 193504M 1355, Commissaire spécial to Prefect, June 6, 1934; Commissaire spécial report, January 26, 1935.

[48] SHD 7/N/3822/4, 2e Bureau to Commander 20th Region, May 1930; AN BB18 6097/20/BL/530, January-February 1935.

[49] AD Bas-Rhin 286/D/100, CS to Prefect, June 25, 1931.

[50] Jean-Paul Amat, "L'arbre et la forêt, témoins du champ de bataille," in *Memoire de la Grande guerre*, ed. Gérard Canini (Nancy: Presses universitaires de Nancy, 1989), 222.

[51] Smith, "The Longest Run"; Pearson, *Mobilizing Nature*, 132; Benoît Boutefeu, "L'aménagement forestier en France : à la recherche d'une gestion durable à travers l'histoire," *Vertigo* 6, (2005): 1–8.

[52] SHD 7/N/3766/3, Avis du général Besson, September 2, 1937.

[53] SHD 7/N/3770/5, Note pour l'EMA, March 5, 1936; and 3770/8, "Commandement et encadrement," undated; 3770/10, "Importance des déboisments à faire," April 26, 1933.

[54] SHD 1/N/54/1/4, Weygand to Gamelin, July 3, 1933.

[55] SHD 33/N/108/3, Colonel Creskens, Note de Service, June 1, 1937.

[56] A commune is an administrative unit. Most comprised a village and a few hamlets, but towns and cities were also communes.

[57] SHD 33/N/108/4, Combet, Commander SS-Bitche to colonel 37 RIF, July 25, 1939.

[58] JOCD, November, 20 1928, p. 2715; Jean-Jacques Dubois, "Influences humaines sur l'évolution des paysages et des limites de la Forêt de Mormal," *Hommes et Terres du Nord* 2, (1973): 73–106; Amat, "L'arbre et la forêt": 230.

[59] AN 199803378-14 55 DF 14, Valenciennes "Rapport fortifications," November 6, 1931.

[60] SHD 7/N/3770/4 "Note pour Belhague," February 19, 1930; AN 199803378-14 55 DF 14, directeur Génie to agriculture ministry, March 11, 1930 and Serot (Agriculture) to war ministry, June 28, 1930; Amiens to DG Jan 30, 1931. This concern for the poor confirms Tamara Whited's finding that in the interwar years, the AEF became less authoritarian and more mindful of local interests. See her *Forests,* 175–79.

[61] AN 199803378-14 55 DF 14, Ministère du Budget to Guerre, December 22, 1931, and reply Tardieu, January 23, 1932; Ministère de la guerre (4e Direction) to DG AEF, April 12, 1932**;** AD Nord, 2/R/43, Ministère de la guerre to Préfet du Nord, August 19, 1935; Pierre Rocolle, *Le Béton a-t-il trahi ? Historique de la ligne Maginot et de la ligne Mareth* (Paris: Mirambeau, 1950), 9.

[62] SHD 7/N/3771/1, "Réponse," April 3, 1936; 7/N/3675/2/2, April 23, 1936, Pouille to mayor, April 23, 1936 and Direction Génie to DG EAF, June 17, 1936; 7/N/3770/6, General Mussel, "Visite de la Commission de l'Armée," March 19-20, 1936.

[63] Chandra Mukerji, Impossible Engineering: Technology and Territoriality on the Canal Du Midi (Princeton, NJ: Princeton University Press, 2009).

[64] Cioc, *The Rhine*, 3.

[65] Albert Demangeon and Lucien Febvre, *Le Rhin. Problèmes d'histoire et d'economie* (Paris: Armand Colin, 1935), 151, 164–65, 172; Mark Cioc, *The Rhine: An Eco-Biography, 1815-2000* (Seattle: University of Washington Press, 2003), 48–67.

[66] A. Desaunais, "Le bief de Kembs, premier tronçon du grand canal d'Alsace," *Géocarrefour* 9, (1933): 143–48; Mark Cioc, *The Rhine: An Eco-Biography, 1815-2000* (Seattle: University of Washington Press, 2003), 51–54; Christoph Bernhardt, *Im Spiegel des Wassers: Eine transnationale Umweltgeschichte des Oberrheins* (Köln: Böhlau Köln, 2016), 375–87.

[67] ADBR 98/AL/244, dossier presse, *Rhein-Westfalen Zeitung*, July 6, 1933.

[68] SHD 1/N/28, CSG December 17, 1926; 7/N/3769, 2e Bureau Note, December 26, 1929 and Brécard to war minister, February 16, 1931; various correspondence, 1937-8.

[69] SHD 7/N/3679, correspondence, 1925, notably "Pièce soumise à l'examen du Maréchal Pétain," May 26, 1925.

[70] 1/N/54/1, Belhague to ministry/EMA, March 20, 1930.

[71] SHD 7/N/3822/5, Requin to ministry, July 19, 1937.

[72] Paul Marque, *La Ligne Maginot aquatique* (Sarreguemines: Pierron, 1989), 13–18; Jean-Yves Mary and Alain Hohnadel, *Hommes et ouvrages de la Ligne Maginot*, vol. 3 (Paris: Histoire et collections, 2003), 116–21; Emmanuel Chiffre, Denis Mathis, and Grégory Weimerskich, "Les hydrosystèmes défensifs : des paysages militaires atypiques de la Ligne Maginot," *Géographie historique des guerres*, (2017): 13.

[73] SHD 1/N/54/1/1, Pétain, Note, November 7, 1930.

[74] SHD 7/N/3770/8, Inspection, undated 1936; 33/N/108/4, Note, General Vielliard, Dec 24, 1938.

[75] SHD 1/N/29/3, CDF, Note pour le CSG, Mai 16, 1927.

[76] Peter Doyle, "Geology and the War on the Western Front, 1914-1918," *Geology Today* 30, (2014): 183–91.

[77] SHD 33/N/108, 37 RIF, "Compte rendu," April 15, 1937; Creskens to Génie, undated ?August 1937.

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