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Wild wheat to productive drylands: Global scientific practice and the agroecological remaking of Palestine

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ABSTRACT

This paper traces how scientific research on wheat (*Triticum*) worked to establish Palestine as a region sought for colonization. Recent work in geography has refined our understanding of agricultural expansion as an outcome of colonization, however, this work leaves the place-making capacity of agricultural research largely unexplored. My claim is that rather than a byproduct of colonization, wheat research served to remake Palestine as a biophysical region in need of improvement and colonization. I show how a shift in the plant sciences from research in taxonomy to plant breeding corresponded to an agro-climatic shift on Palestine from an undesirable, arid region to a promising dryland agricultural region. In this way, wheat research drew Palestine and the United States into a wider effort to transform arid areas into agricultural drylands. Drawing on a previously unexplored episode of technical cooperation between researchers in the United States and Palestine, I argue that we must examine how wildness, native-ness, and agro-climatic suitability are scientifically constituted within and not apart from colonial conquest. In doing so, the paper calls for reconsideration within geography and political ecology of the place-making relationship between colonization and scientific practice.

1. Introduction

The fledgling railroad town of Billings, Montana, in 1909 is an unlikely place to begin a story about Palestinian agriculture. Just thirty years before, the area had witnessed one of the last large-scale, campaigns by Native American tribes in the American West. Indeed, the history of the West and the production of scientific knowledge cannot be seen apart from the regimes of violence that underpinned American expansion into the West (Blackhawk, 2008, p. 9). But thirty years later, Billings must have posed an attractive location on the semi-arid steppe to showcase efforts to settle the West when hundreds of agricultural officials came together for the Fourth Dry Farming Congress to discuss research on intensive production in the so-called arid and semi-arid areas. As Knobloch has shown, the renewed, turn-of-the century, settlement effort in the U.S. West was meant to make arid areas cultivable by using new technologies and by developing adapted crop varieties (Knobloch, 1996, p. 61).

One of the key figures addressing the gathering was Aaron Aaronsohn (1876–1919), an agronomist and resident of a Jewish colony in Ottoman Palestine, who claimed to have discovered the singular wild ancestor of cultivated wheat. He had been invited by the U.S. Department of Agriculture (USDA) on a sprawling tour of the United States. Aaronsohn was seeking funding to establish a research station in Palestine that he argued would also benefit U.S. agriculture. Aaronsohn must have felt a certain affinity with pioneers of the American West, whose concern with settlement and agricultural productivity he shared in Palestine. His early emphasis on botanical explorations of Palestine gave way to a new emphasis on plant breeding, especially wheat. His reorganization of plant material using the natural forces of genetics and climate through field trials and plant breeding would in turn allow him to remake the modern geographic situation of Palestine.

Indeed, plants shape our world in unexpected ways, affecting how and where we live and thereby making plant science a field that is inextricably linked to place-making. This paper traces one historical case: how scientific research on wheat (*Triticum*) worked to establish Palestine as a region sought for colonization. My claim is that rather than a byproduct of colonization, wheat research served to remake Palestine as a biophysical region in need of improvement and colonization. I show how a shift in the plant sciences from research in taxonomy to plant breeding corresponded to an agro-climatic shift on Palestine from an undesirable, arid region to a promising dryland agricultural region. I argue that as modern agro-climatic regions, drylands are arid areas that require action, development, and improvement to enable

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domination of the peoples, the living organisms, and the landscape by the settler enterprise.

The case for Palestine's promise as a geographic region was underpinned by the manipulation of the wheat plant. To illustrate this, the paper tracks research practices of Zionist, European, and American scientists on wild strains of cultivated wheat varieties. Scientific practice on plant material drove an epistemological and political turn from 'pure' scientific (botanical) practices to 'practical' scientific (agronomic) practices. The shift culminated in the establishment of the USDA-supported modern agricultural research station, which as established during Ottoman rule of Palestine. The short-lived agronomic research station sought to breed new varieties of crops to benefit Zionist and American agriculture and drive colonization of other dryland areas.

Methodologically, I draw on previously unexplored evidence through a critical analysis of published historical materials – USDA publications, conference proceedings, scientific journal articles, and published field journals from the turn of the twentieth century – to show that modern Palestine was engineered as a settler-colonial space in part through material practices of plant sciences. I show how wheat research in Palestine manifested three intertwined modes of appropriation – taxonomic, agro-climatic, and genetic – and how those research practices on wild wheat helped to draw Palestine into a wider effort to transform arid areas in the United States into agricultural drylands sought for colonization. In doing so, the paper calls for reconsideration within geography and political ecology of the place-making relation between colonization and practices of plant science.

2. Literature review

This study is located within geographical explorations of the role of science in the production of nature and space under colonialism (Smith, 2008). The relation of scientific practice and colonialism has been extensively explored. Early work Crosby (1977 [2003] and 1985 [2015]) sought to show how European conquest was enabled by not only military but also biological and ecological power. Mintz (1986) showed how the consumption of certain plants like sugar cane is implicated in a suite of social and political processes like slavery, capitalist relations, and knowledge. In the succeeding years, Grove (1995) illustrated how the roots of modern environmentalism are found in the work of European colonial scientists and imperial practices of knowledge production. Knobloch (1996) showed how knowledge production underpinned the capacity to colonize North America. More recent work by Carney (2001) has forcefully demonstrated the relation of rice cultivation and slavery helped to shape our understanding of the making of the Americas. Warman (2003) showed how maize/corn was "a settler of new lands" and how scientific knowledge about it "helped to fashion the modern world" through its relationship to colonial projects.

Geographers working in collaboration with historians of science have shown how science does not occur in a spatial vacuum, but it is practiced in places (Livingstone, 2010). Moreover the practice of field sciences like archeology, ecology, and especially agriculture is constituted by geographic context (Abu El-Haj, 2001; Kohler, 2002). Pioneering scholars like Abu El-Haj has since come to explore how a scientific practice like archeology "became constitutive not solely of the discipline itself, but, more fundamentally, of broader social and political processes as well" (Abu El-Haj, 2001, p. 7). In other words, science emerges in relation to political formations through its practices of knowing, seeing, and documenting. The separation of science and politics has been challenged in explorations of agricultural productivity and water in North Africa (Davis, 2007), Egypt (Barnes, 2014), and Israel-Palestine (Alatout, 2008). For example, Alatout (2008) demonstrated how technical surveys of annual water potential within Israel are related to political contingencies related to the capacity to resettle immigrants. This relation illustrates how scientific practice was constitutive of processes of Israeli state development among other political processes.

Within geography, one of the most sustained examinations of specific links between politics and plant science is the work of Head et al. (2012) on the "human biogeography" of wheat in Australia. The authors engage with the details of wheat's wild relatives, of its domestication, and of the biogeographic details of its reproductive functions including its ability to self-pollinate. To their credit, the authors refuse what they call the "linear and determinist way that seems to emphasize the inevitability and superiority of agriculture sweeping across human history" (Head et al., 2012, p. 23). They rightly seek to insert the human into the biogeography of wheat.

Turning their attention to Australia, the authors illustrate how European settlers brought wheat to Australia in the eighteenth century. Careful to point out that wheat originated in the Middle East, they argue, "the vernacular experiments of getting wheat to 'belong' in Europe from its semi-arid Middle Eastern origins would have been just as complicated and fraught with failure as those involved in making wheat Australian" (Head et al., 2012, p. 55). The authors use the notion of "making wheat Australian" to explain the wheat varieties and their lineages and relations to wheat varieties in Europe, India, and North America. The authors also acknowledge that the Australian "wheat belt" was predicated on the "removal of Aboriginal owners" and "broad-scale clearing of native vegetation" (Head et al., 2012, p. 79).

However, in the authors' account, the dispossession of the indigenous people of Australia is severed from the act of "making the wheat Australian". In discussing indigenous dispossession, the authors do not apply the same analytic to the understanding of processes of exploitation and uneven power relations inherent to the "mobility" of wheat and wheat science. The collection, transport, and circulation of the genetic material and knowledge of *Triticum* did not happen in a vacuum; it flowed through the uneven circuits of British colonial domination and settler-dominated power relations. Many of the lineages of wheat varieties discussed by the authors (p. 56) come from settler-colonies in North America and India but the uneven power relations of how and why those wheat varieties were deployed in Australia are overlooked in the authors' account. For example, the Federation variety, which the authors cite as "undoubtedly the most famous of the new 'Australian' wheats" (p. 56), was a cross between Fife, a wheat developed on the newly conquered prairies of what has become Canada, and Etawah, a wheat brought from British-dominated India. The authors do not explore the relations of plant breeding and colonial domination that gave rise to this circulation. Moreover, despite the "many practices through which Australian farmers and plant breeders have been in a continuous process of adapting wheat to the particular circumstances in which they find themselves", the authors overlook the cruel circumstances of Federation's deployment across newly conquered Aboriginal lands in Australia (Head et al., 2012, p. 47).

The authors do cite Aboriginal participation in growing European wheat (p. 53–55) and acknowledge evidence of Aboriginal seed-gathering before the European invasion to challenge the distinction between agriculturalist and hunter-gatherer (pp. 48–50) within the social history of wheat. However, when they turn to more technical and scientific aspects, the process of wheat "becoming Australian" loses the history of indigenous knowledge, labor, and dispossession that were its conditions of possibility. In other words, the question must be asked: on whose terms and under what conditions was wheat bred in Australia? How was wheat breeding itself a place-making exercise? This contrasts with other work in geography that holds both the technical aspects and the political aspects of seeds in tension (Kloppenburg, 2014, 2005; Mercer and Wainwright, 2008; Wainwright and Mercer, 2009).

The question of wheat transplantation and native plants is taken up within another work by some of the same authors who question the notion of "biotic nativeness" as a corollary of nationalist nativism (Atchison and Head, 2013; Atchison et al., 2010; Head and Muir, 2004; Head, 2012). It is made to seem as though, "[t]he England to Sydney leg was just another link in the chain of wheat transplantation that had been occurring for thousands of years" (Head et al., 2012, p. 47) and that this "transplantation" and naturalization of wheat across settler-contexts in the eighteenth and nineteenth centuries happened as a natural botanical unfolding within which relations of colonial domination played only a minor role. Here Mastnak et al. claim that "treating plants metaphorically as immigrants, but never as settlers, paradoxically divides the human from nature. It elides forms of displanting–of botanical colonization–that were part and parcel of the colonial encounter" (Mastnak et al., 2014, p. 374).

Recent work in geography on native and non-native plants has taken issue with the association of native plant advocacy and an anti-immigration politics. In other words, it has challenged the notion that advocating the use of native plants is related to an anti-immigration politics around immigration. In one of the most sustained engagements with the topic, Mastnak et al. (2014) show how in contrast to a reactionary politics, a "discursive field" on native plants can be part of a decolonizing politics within settler-colonial contexts like the United States (Mastnak et al., 2014). Drawing on a reading of Francis Bacon, Mastnak et al.(2014) are careful to reject anti-immigrant politics while at the same time not rejecting the value of "seeing all plants and people as place-based" (Mastnak et al., 2014, p. 375). They specifically challenge attempts to dismiss native plant advocacy as a nativist politics on issues like immigration. The authors state that in this attack on native plant advocacy, "Democratic equality is projected onto the plant world, which becomes a melting pot rather than a colonial conquest" (Mastnak et al., 2014, p. 374). Mastnak et al. (2014) confine their analysis to the "discursive field" surrounding native plants, which offers important insights into the narrative bases for native plant advocacy and nativism and its relation to colonization. However, the material epistemologies of plant life themselves and their relation to colonization are not explored.

For example, in their attention to the geographic (place-based) specificity of the local wheat strains, Zionist researchers in Palestine invoked the authority of field-based research methods for the sustenance of fledgling settlements where wheat must serve as a source of both food and income for survival. Abu El-Haj's study of archeology is particularly relevant to my focus on agricultural science because of her insight that, "unlike laboratory science, field sciences are sustained by an epistemology of temporal and spatial specificity and not (atemporal) replicability" (Abu El-Haj, 2001, p. 20). It is precisely field-based methods of scientific investigation, like the search for hyper-localized landraces, that produced territorially focused modes of knowing and legibility. Here Mastnak et al.'s call for attention to "place-based" relations between plants and people must be placed within the context of how that place and geographic specificity is constituted within settler-colonialism. I argue that land and field sciences emerge as place-specific, but the places themselves are constituted by flows of material and knowledge from wider colonial encounters and conquests. In this way, claims to native-ness of wheat to Palestine is precisely the mode by which the plant, and by extension its land, is appropriated.

Using the case study of wheat exploration and breeding in Palestine, I seek to develop a position that is distinct from both of these stances in the literature. The case of wheat in Palestine offers an incongruous situation: it is precisely the native-ness of wheat to Palestine that provides the epistemological basis for scientific practices of appropriation. When we speak of botanical decolonization, debates over native-ness or nonnative-ness are less important than examining how vegetative life is appropriated through research practices and thus harnessed for colonization. This does not deny the role of place-based practices in decolonization but rather extends the argument of Mastnak et al. by asking on whose terms and under what conditions is native-ness constituted (Mastnak et al., 2014). Moreover the case builds from Head et al. (2012) by turning attention to research practices on wheat in Palestine as practices of appropriation rather than by treating the scientific practice something that comes after conquest.

By exploring the plant science practices surrounding identification, botanizing, classification, and finally breeding of wheat in one its centers of origin, Palestine, we are able to see how Zionist scientists employed the classification of wheat's wild relatives in order to appropriate the *Triticum* germplasm, or the living genetic material such as seed or tissue, within a Western scientific grid of legibility. Rather than an outside invading force, it is precisely the native-ness of wheat to Palestine that early Zionist scientists deployed to establish Palestine as site of settlement and colonization through dryland agriculture. Rather than a byproduct, the case of wheat in Palestine raises questions within geography and political ecology about the constitution of wildness, native-ness, and agro-climatic suitability within and not apart from colonization.

3. Searching for wild wheat

Beginning in the nineteenth century, European scientists sought to explore, classify, and preserve both the local varieties and wild relatives of cereal crops of the Middle East. Germplasm was taken back to Germany, Britain, France, and other centers to be classified and housed in the collections of botanical gardens and museums.

Aaron Aaronsohn was one such scientist. Growing up in Ottoman Palestine in the 1880s, Aaron Aaronsohn[1] explored the countryside extensively and, like his generation of the earliest Zionist settlers, learned Arabic and interacted daily with the Palestinian Arab community. He grew to prominence when he returned from studies in agronomy in France to work in the Rothschild-supported Jewish plantations in Palestine (Aaronsohn, 2000; Katz, 2001a). Beginning as an assistant on survey projects led by others, he soon undertook his own agricultural and geological explorations with the help of prominent German scientists who were also conducting field research in Palestine. By his own account, on a visit to Berlin in 1902, he was asked by Paul Ascherson and fellow botanists Friedrich Schweinfurth and Otto Warburg to search for "Kotschy's wheat" near Jebel El Shaykh/Mount Hermon in the border area between Palestine, Lebanon, and Syria. The sought-after wheat was the specimen of wild wheat found by the Austrian botanist Theodor Kotschy which had been classified as *Triticum dicoccum dicoccoides*, or the wild ancestor to a hulled, tetraploid, emmer wheat (*Triticum dicoccum*).[2]

[1] Born in 1876 in what is now Romania, Aaronsohn moved as a child to Palestine, where his parents helped establish the early Zionist colony of Zichron Ya'akov (Katz, 2007). He is better known for his exploits in British espionage during the First World War, about which several laudatory accounts of Aaronsohn's activities have been written in recent years. He, his sister, and colleagues passed information on Ottoman and German positions to the British government. The Ottoman authorities discovered and dismantled the group, resulting in the destruction of the agricultural station and the arrest and death of the some members by 1917 and eventually Aaronsohn in 1919.

[2] Cultivated Emmer wheat, in contrast to Einkorn wheat, is a tetrapoloid wheat which is a cultivated wheat that was domesticated from two wild grasses. Triticum taxonomy is a complex venture has come to differentiate species on the basis of at least four factors: its status as wild or cultivated, its ploidy level (number of sets of chromosomes), genome type, and morphology. At first, scientists used morphology to establish the original ancestors of major crops as part of long-running debates around centers of origin. Later, with advances in genetics, they classified wheat in their efforts to access a more diverse genetic pool of desirable traits for plant breeding.

Classification as such meant that Kotchy's wheat was understood as the main ancestor of cultivated wheat, which crucially meant that the lineage cultivated wheat, which is hugely important as a food crop, could be mapped from its "native" Palestine. In contrast to plant life as an invading force, it was precisely the native-ness of wheat to the climate of Palestine, their diversity and specificity, its embeddedness in the microclimates of Palestine's hill country, its were harnessed by Aaronsohn's scientific research methods of taxonomy and field trials (Mastnak et al., 2014). Aaronsohn saw classification of the wild specimen as a subclass of cultivated emmer wheat as "necessary", despite how ironic it appears to have a wild ancestor classed as a subspecies of a cultivated descendant.

Aaronsohn returned to Palestine and led an unsuccessful search in 1904 near Rashiyyeh. Back in Berlin in 1905, Ascherson and Schweinfurth again approached him about finding the wild wheat. With renewed interest, Aaronsohn set out in June 1906 from Rosh Pinna, established in the northern Galilee in 1882 as one of the first Jewish settlements in Palestine. By his account, he found a single head of the wild wheat by the side of the road in Rosh Pinna on June 18, 1906. He set out the next day on horseback to Rashiyyeh, where, after searching unsuccessfully in cultivated areas of the village, he found it "in great abundance" in rocky, uncultivated areas, although, "The sample specimen from Rosh Pinar [sic], however, was the finest one" (Aaronsohn, 1910b, p. 43). The mountain samples were much taller than those found in Rosh Pinna. Aaronsohn argued that the 1906 findings established the native habitat of wild wheat and wrote to an excited Schweinfurth in Bonn. Aaronsohn coauthored a brief note on his findings with Schweinfurth immediately in 1906. In more extensive explorations in 1907, Aaronsohn set out to establish the plant's habits—its growth, preferred climate, preferred soils, and reproductive functions. Both scientists were surprised at the diversity of forms collected by Aaronsohn in the second 1907 trip.

4. Taxonomic practices of appropriation

Botanizing, or the taxonomic classification wild plant specimens, is a scientific practice fraught with difficulty. In his seminal study, the German agricultural scientist Friedrich Körnicke had used the dicoccum versus monococcum distinction on the basis of the presence of two seeds or a single seed in each spikelet of wild wheat. This diversity within wild wheat found by Aaronsohn clearly caused speculation as to whether the wild wheat should remain a subspecies of an emmer (*dicoccum*), be classified as its own species, or be classified as an einkorn (*monococcum*) (Aaronsohn, 1910b, p. 44). The diversity in what Aaronsohn collected troubled but did not ultimately change Schweinfurth and Aaronsohn's adherence to Körnicke's taxonomy. Aaronsohn's emphasis on the validity of the *dicoccum* taxonomy for all forms of the plant illustrates the centrality of building his structure on the scientific authority of Körnicke. Aaronsohn and colleagues clearly struggled to contain the tremendous diversity in form found in Rashiyyeh within a single subspecies—a necessary precondition to sustaining this particular wild strain as the single progenitor of wheat and establishing its importance.

The classification of the plant as *T. dicoccum dicoccoides* meant that Aaronsohn classified a wild plant, deemed as an ancestor to wheat, as the subspecies of a cultivated species. The first act of taxonomic appropriation was reverse-classification of a wild plant as a subspecies of a cultivated crop. This awkward taxonomic maneuver allowed Aaronsohn to draw the plant he found into much larger scientific debates by tying its importance to cultivated wheat varieties. From that point forward, Aaronsohn referred to the wild wheat only by the Körnicke classification, *Triticum dicoccum dicoccoides*. Later studies by O.F. Cook, an American expert dispatched to Palestine in 1911 to investigate Aaronsohn's findings, and other cereals specialists preferred to classify the wild wheat as a separate species named for Jebel El-Shaykh/Mount Hermon, *Triticum hermonis* (Buller, 1919; Cook, 1913). However, Aaronsohn international stature for having ostensibly discovered this wild relative of cultivated wheat depended on his fidelity to the Körnicke classification. By the end of 1906, his findings were published in two German and one French language publication. Schweinfurth's detailed 1908 announcement of Aaronsohn's research came in the journal of the German Botanical Society, *Berichte der Deutschen Botanischen Gesellschaft* (Schweinfurth, 1908). These articles established Aaronsohn as a global field-based authority on wild wheat: its taxonomy, morphology, habit, reproductive behaviors, and, increasingly, its potential.

Here Aaronsohn's taxonomic practices came to play a crucial role in establishing the plant he found as the sole progenitor of emmer wheat. First, Aaronsohn built from Körnicke's notion of the seed structure of the plant (one or two seeds in the spikelet) as the basis for classification as either einkorn (*monococcum*) or emmer (*dicoccum*). However, Körnicke himself oscillated in classifying some samples. Second, the *monococcum* was excluded as a candidate because of its inability to cross with other species of Triticum, unlike emmer. Third, he pointed to the wild wheat's brittle or jointed rachis, a specialized spine that allows easy kernel detachment. The move from brittle to rigid rachis is famously associated with grain domestication because easy detachment helps plant dispersal but a rigid rachis helps farmers collect grains (Zohary et al., 2012). Thus, the brittle rachis is associated with earlier, wilder wheat strains.

Aaronsohn's field-based practices of documentation, photography, cataloging, and observation authorized his expertise and enabled his appropriation of wild wheat. For Aaronsohn, cultivated wheats emerged because Arab farmers remained localized due to the "backward" circumstances they lived in that cut them off from each other. This he distinguishes from another valuable treasure trove, the physical landscape itself, which, by its varied topography produced wild varieties (Aaronsohn, 1910b, p. 33). If crops cultivated by generations of Palestinian Arab farmers could be written off as the outcome of "centuries of stagnation" and Arab backwardness and the physical geography, then the native-ness and localness of these landraces (or localized or "heirloom" crops) is made inevitable by the physical geography, and not by the expertise of Palestinian cultivators who developed them. The wealth of plant life that is valuable to Aaronsohn is only made legible, understood, and productive by an actor such as the scientist, whose taxonomic practices enable identification of crops with potential, unlike native cultivators whose crops were the inadvertent outcome of their ostensibly backward circumstances. A story recounted by Aaronsohn on the search for wild wheat relatives illustrates this:

> The habits of these two plants are so similar that the Arabs fail to distinguish them, although they are given to more or less close observation of natural phenomena. Several times I have asked the Arabs to gather for me some stools of wild Triticum like the sample which I gave them. They always brought me back Hordeum spontaneous. Nor have I been able to find any special word in their language for wild wheat. They always called it "scha'ir barri" or "scha'ir iblisse" (wild barley or devil's barley). But, when I asked if it was not wild wheat, they admitted that it was "kamh barri" (wild wheat), being eager, as the Arab always is, to agree with the opinion of a guest (Aaronsohn, 1910b, p. 45).

Paradoxically, Aaronsohn established the wild wheat as native in part via its association with Palestinian cultivators. Aaronsohn does recognize that Arab cultivators managed to produce an amazing diversity of crop landraces. However, Aaronsohn describes the process of development of landraces lasting for "ten centuries" whereby, "[a]ccess to the markets was thereby cut off, and the Arab learned to depend entirely upon the products of his own immediate district. As the same products continued to be cultivated for centuries on the same soils without outside introduction, local races were necessarily developed" (Aaronsohn, 1910b, p. 33). In this way, local crop varieties (landraces) developed by Palestinian farmers were classified as the product of an almost inadvertent process, but Aaronsohn's crops were classified as the product of scientific expertise. These practices reorganized local expertise into categories legible within Western botanic circles, which allowed wild wheat to appear as his autonomous discovery.

After establishing the native-ness of the wild wheat to Palestine, Aaronsohn needed to show that this precious native wheat was in need of rescue and improvement. Here the native-ness of wheat to Palestine or its place-based relation to Palestine cultivators did not pose problems to Aaronsohn's political framework of settling Palestine. Rather Aaronsohn's problem lay in the loss of the genetic material. After all, the adoption of modern agricultural methods had greatly limited the suite of crop varieties:

> From a human point of view we have every reason to rejoice at the pacification of the Orient, because of the greater safety to life and property and the better intercourse it has brought about; but from the standpoint of the cultivation of plants we are losing ground, for it is a natural tendency to reject all of the old habits and in so doing to annihilate many of these local races which have been in process of development for so many centuries (Aaronsohn, 1910b, p. 33).

Here 'pacification' stands in for various militarized modernization efforts of colonial powers in the region. He believed that the only way to ensure the future use of this unique genetic pool was through research into existing peasant practices and seed stocks. He called for an "exhaustive investigation into the local forms of agriculture, however backward they may be from the modern standpoint" (Aaronsohn, 1910b, p. 33). By registering the diversity, native-ness, and importance of local landraces, Aaronsohn's taxonomic practices mobilize those factors to forcefully argue for their protection.

Aaronsohn's entire framework hinged on the wild wheat he found on a hillside being classified as the subspecies of a cultivated wheat, the emmer wheat, so he could establish its importance for wheat production writ large. For Aaronsohn, scientific practice meant being able to tell Arab Palestinians with whom he interacted that they had incorrectly identified a strain and to look again. This epistemology of taxonomic practice let the scientist reorganize local expertise for redistribution to other sites such as in the United States. Precisely in this way, Aaronsohn had to reengineer what came to be considered native or nonnative, wild or cultivated. Aaronsohn's wheat could then go to the United States as an isolated, self-formed technical achievement, a valuable genetic resource rescued from an environment of Oriental backwardness, rather than as the product of a local plant-human spatiality produced by the accumulated expertise of Palestinian cultivators. This appropriation through taxonomy allowed Aaronsohn to decide which wild grasses growing in the hills of Palestine came to be counted as wild wheat and under which circumstances. The research also allowed him to then take the next step, arguing that the genetic resources must be protected under botanic grids of scientific legibility. However, in order for his taxonomic regime to travel it needed to establish that the new host sites for deployment of improved wheat varieties had similar agro-climatic circumstances. This allowed him to sustain the taxonomic framework around micro-adaptations of local wheat varieties. The task at hand then became field-testing these plants systematically so that the newly classified plant genetic resources could be reorganized for redistribution amongst concerned scientists and farmers in varied locales.

5. Agro-climatic matching as a practice of appropriation

In a second mode of appropriation, Aaronsohn had to establish that Palestinian wild and cultivated wheat varieties could be grown in other sites. However, in order to sustain his argument about the specificity and diversity of wheat in Palestine, the new site had to be a similar agro-climatic situation. To this end, Aaronsohn deployed his measurements and records from field research in Palestine for the purpose of drawing comparisons with other parts of the world. This agro-climatic matching was a crucial pillar of his case to the USDA that Palestine was a valuable site of interest and potential. For Aaronsohn, plants had to be understood as part of the micro-climates that help to produce them through a host of factors including moisture, temperature, disease pressure, weed pressure, and elevation. As he put it in his 1910 pamphlet published by the USDA:

> When the Jewish colony of Yemma was established at Dalaika, the colonists, who had no feeling of prejudice or hostility toward the Arabs of Nursy and Zeriin, thought it would be an improvement to give up the small-grained Dalaika wheat and to introduce the fine, large-grained wheat from Zeriin. The result, of course, was a failure, because, the wheat introduced was not adapted to local climatic conditions. Instead, however, of correctly interpreting their failure, some of the colonists attributed it to the use of European plows, and others to American harrows, both of which had been recently imported.
>
> [Aaronsohn (1910b), p. 33]

Aaronsohn sought to link Palestine to other sites of intervention through their agro-climatic conditions. In order to do so, he had to bring his extensive fieldwork on climatic conditions in Palestine into conversation with agro-climatic research being conducted outside of the European continent. His chance came with invitation from the United States Department of Agriculture (USDA) to visit the drylands of the American West that were under colonization.

Taking wheat specimens from Palestine and from the first generation of experimental plots in Germany with him, Aaronsohn traveled the United States from June to October 1909 at the invitation of David Fairchild, the noted USDA official in charge of plant exploration. He met with potential benefactors and inspected agricultural development initiatives with stops at the University of Arizona, the University of California, and the Dry Farming Congress in Billings, among others. He so impressed faculty at the University of California, Berkeley that he was offered a post to replace the well-known faculty member E.W. Hilgard, an offer he declined in order to return to Palestine. His focus was on the establishment of an American agricultural station in Palestine. In his report for the USDA, he argued that agricultural research in Palestine was part of the same effort to secure and hold arid areas under colonization:

> The economic and agricultural importance of the Orient is beginning to be appreciated in the United States more than anywhere else…They have learned in the Orient that there is every reason to hope that the vast arid and semiarid regions of America can be rendered productive, although from the point of view of the European agronomist they would appear as worthless deserts.
>
> [Aaronsohn (1910b), p. 7]

Notable in this statement is that Aaronsohn registered "uncultivated" or "wild" spaces as "unproductive" and said only American, not European, scientists understood the value of making these lands "productive." Despite his longstanding relationships to European institutions, Aaronsohn made it clear that American agricultural research offered the best way forward. Speaking to his audience in Billings about the need for more research in Palestine, he stated, "Europeans, being afraid of new ideas, will never furnish these means and will never carry on these researches" (Aaronsohn, 1910a, p. 171). Aaronsohn believed that the settlement project within the United States afforded its scientists a more useful vision than did his European counterparts who explored distant lands for colonial extraction. Aaronsohn clearly saw projects of scientific inquiry designed to work in the service of settlement, something that resonated deeply with his own vision for the Zionist settlement of Palestine. Having sought to establish the wild wheat from Jebel El-Shaykh as the wild progenitor of Emmer wheat, the case for Palestine as a site of colonization was to be built through agro-climatic comparison.

The introduction of his 1910 USDA bulletin "Agricultural and Botanical Explorations in Palestine" was dedicated to drawing an agro-climatic analogue between California and Palestine. He announced, "Palestine is more like the State of California than any other in the Union in everything except size" (Aaronsohn, 1910b, p. 8). This fixation on California as Palestine in terms of geology and climate drove specific comparisons: "The same forms of vegetation, often the same genera, are found on Mount Tamalpais, California, and on Mount Carmel, Palestine; the maqui formation of Palestine is to be compared to the chaparral and chamiso of California, and the forms of vegetation of the Lebanon and the Hermon mountains are much the same as those of the western slope of the Sierras" (Aaronsohn, 1910b, p. 11). "It is practically a California reduced to about one-twentieth in size, bur markedly similar in general topography, climate, vegetation, and agricultural and economic possibilities" (Aaronsohn, 1910a,b, p. 8). He discusses the general topography, climate and rainfall, and vegetation of Palestine in order to show the adaptability of Palestinian plants for the United States. In the bulk of the report, Aaronsohn details the plant species from Palestine as "Economic Plants Worthy of Introduction to the United States". He begins with plants useful as stocks for grafting, including *Zizyphus*, *Pistachia*, *Amygdalus*, and *Prunus* species. Moving on to fruits, he discusses apricots, quinces, pomegranates, olives, figs, and grapes. He briefly discusses forage plants, then moves to field crops including chick pea, sesame, barley, wheat, and some medicinal plants. In the final section of the report, he discusses his research into wild wheat, barley, and rye in Palestine and Syria. His field methods include constant reference to elevation and rainfall statistics, supported by photographs, both landscape level and specimen level for the relation between topography and plant species.

Aaronsohn's research sought to show that if the native plants of Palestine are most successful in the arid Mediterranean agro-climatic conditions and the diversity and origin of major crop plants is found native to Palestine, then their deployment in areas of similar climate will be met with success. He stated, "The plants of Palestine are, so to speak, homologues of those of California, and, a priori, their success seems assured" (Aaronsohn, 1910b, p. 12). Drawing plant "homologies" between the United States and Palestine was intimately related to the project of American colonization of the arid regions of the West. Employing topographical and agro-ecological evidence, Aaronsohn sought to make disparate environmental spheres amenable to modern dryland agriculture and settlement.

Aaronsohn had arrived in the U.S. in the midst of a decades-long, frenetic effort to secure the Great Plains agro-ecosystem under commercial agriculture, underpinned by scientific expertise in transferring crops from humid regions into conquered lands. According to Aaronsohn, the most striking feature of his tour of arid and semi-arid regions of the fledgling United States was the American investment of so much military-economic-scientific muscle to secure an ostensibly undesirable area. Tillage and crop agriculture through dry-farming was the biophysical answer to the challenge posed by the biogeographic context of the U.S. West, where its status as rangeland was unacceptable because it did not allow transformation and domination of the landscape (Knobloch, 1996). Bringing it under control, the story goes, meant plowing, taming the grassland, and growing field crops. Contemporary writings make clear that the settlement apparatus of science, technology, economy, and violence depended on a reordering of the landscape that only crop agriculture could bring (Knobloch, 1996; Tesdell, 2015). The presence of modern crop agriculture on the landscape, in contrast to other forms of foraging, gathering, hunting and cultivation helped to secure the sustenance, economy, and domination of the settler population.

Aaronsohn most richly articulates the connections between Palestine and the United States in his Billings speech. For Aaronsohn, the United States had "a geographical situation which enables the people of this country to understand and make use of all that is best in the East and West" (Aaronsohn, 1910a, p. 171). This telling statement reveals his understanding of the uneven terrain of knowledge and power required to drive settlement in Palestine. It is precisely the "geographical situation" of the United States, the agro-climatic spatiality, that helps Americans understand the importance of practical research driving *settlement*, as compared with European research that supports *extraction*. Aaronsohn told his American audience that research should have a "practical, economic importance, an importance which I dare to call social" (Aaronsohn, 1910a, p. 171). European colonial scientific institutions apparently did not fully understand the stakes of his scientific research in Palestine, whereas scientific endeavors in settler-colonial contexts such as the United States sought an understanding of the land that would be the basis of a new society. This settler-society must attract, establish, and sustain a settler population for the long term. In other words, "geographic situations" like Palestine and North America require a different kind of research and knowledge, one that can sustain settlements. By drawing Palestine and North America into the same "geographic situation," Aaronsohn appropriated the agro-climatic features of Palestine in the service of land settlement and colonization.

This "geographic situation" names the uneven agro-ecological terrain of plant material, knowledge, financing, and natural forces that is at once place-specific and multiple in its spatiality (Mastnak et al., 2014). The colonizer's exclusive ability to make the land productive is tied inextricably to the "practical," "economic," and "social" importance of scientific discovery. In the next section, I explore Aaronsohn's research initiative, the Jewish Agricultural Experiment Station near Haifa, which was the first overseas U.S. agricultural research station. The station reorganized reproductive behaviors of wheat and other plants, isolating them in field trials. This research station lasted only five years until the First World War when a lack of support caused it to close, but the circumstances of its establishment and the technical details of its research practices reveal the remaking of Palestine as a sphere of drylands science intervention through the breeding of wheat. The wild wheat plant was taken from Jebel El Shaykh in northern Palestine/Syria in 1906 to the banks of the Rhine in Bonn, Germany, where in 1908 it was grown in 36 experimental plots. The shared spatiality was not only an idea but also the product of the iterative plant-breeding practice that manufactured it. Aaronsohn harnessed the genetic material of the wild wheat by reorganizing its reproduction in experimental plots and on that basis working to establish Palestine as geographic region of technical intervention and colonization.

6. Plant breeding practices of appropriation

When Aaronsohn first stood before his audience at the Dry Farming Congress in Billings in 1909, he argued that his research was not only integral to his project of agricultural research in

Palestine but also central to transforming U.S and other drylands. He argued that the two areas shared a common biophysical context, which required an intervention to find mutually adapted plants for the land to be "rendered productive" (Aaronsohn, 1910b, p. 7). However, his speech did not depend on his words and argument alone. As he spoke, he displayed the wheat plant that embodied his project of expansion and adaptation through its re-domestication. He stated forcefully:

> A proof of the great adaptability of this plant is found in the following fact: Transported from Palestine to the shores of the Rhine, my species of wheat has given in the first generation the excellent spikes which are presented to you here.
>
> [(Aaronsohn (1910a), p. 170]

It was the materiality of the wild wheat plant, its embodied potential as the raw genetic material for drought and disease resistance, that gave Aaronsohn's case its force. Aaronsohn did not rely on words alone to make the case to the assembled Americans, but used his systematic manipulation of the plant life itself (appropriated by him as "my species") to give force to his argument. The crucial distinction between cultivated and wild wheat for Aaronsohn was that cultivated wheat was understood to be self-pollinating, a trait developed in Europe. This feature makes it easier to select for certain traits and cross. Wild wheat was understood to be cross-pollinating, making it more vigorous and resistant but also harder to select in breeding and harder to make into a commercial crop because of its brittle rachis, which shatters and does not hold its seed. Aaronsohn's reorganization of the wild wheat's reproductive functions in experimental plots in Germany allowed him to appropriate the plant as his own creation, and by extension underpin his argument with evidence of the plant's viability based on field trials.

Aaronsohn had given Schweinfurth seeds to begin experimentation in Germany. His U.S. tour was built on two seasons of successful growing in Germany, 1908 and 1909. To further prove his point in Billings, he noted that Schweinfurth said, "Out of the 36 plots sown, 35 came to fruition, and the 'seed were larger than those in the cultivated wheat' and this is in spite of a humid, cloudy, and cold summer" (Aaronsohn, 1910a, p. 170).

Aaronsohn understood the centrality of plant life for his project of fashioning Palestine as a site of intervention through dryland agriculture. He argued that Palestine was thought to be "exhausted" and neglected but he believed that it held great potential. This potential had to be unlocked through plant breeding:

> The rediscovery of wild wheat has opened up an extensive field, and we have only recently drawn the attention of competent authorities to a whole series of new cultures or to the new adaptations of old cultures.
>
> [Aaronsohn (1911), p. 118]

It is clear that, precisely through practices of plant breeding, the very material of the plant and the reorganization of its reproductive and resistant properties through crossing and selection opens the field of intervention, the sphere of action.

For his part, O.F. Cook, the USDA expert sent in 1911 to Palestine to evaluate Aaronsohn's claims, sought to understand from early U.S. experiments the potential for crossing and hybridization of the wheat plant brought from Palestine. The first U.S. trials of the wild wheat were held at a station near San Antonio, Texas, in spring 1911. Cook was interested in the development of seeds in the spikelets and weight of the kernels, which he compared in detail with seed imported from al-Ḥaḏr. However, crucially, he notes that the Texas trials of the wheat showed that it did not have complete immunity to wheat rust, because it had been "severely attacked" and had "scanty" growth (Cook, 1913, pp. 40, 45). The next round of experiments in November 1911 were in the arid Colorado River Valley near Bard in southern California. Here the wild wheat grew well, showing a much wider range of individual diversity (heterism) in height and leaf size (Cook, 1913, p. 45). In the California experiments, Cook illustrated a "loss or reduction" in the jointed structure of the rachis, which was a potentially significant development to keep the seed from scattering at maturity, making it commercially viable. As he states, "If the plant represents a definite variation a few more changes of similar magnitude would mean the production of a cereal of agricultural value. But there can be no assurance regarding the behavior of the variation until further generations have been grown" (Cook, 1913, p. 48). Cook believed that it would take two or three years for Aaronsohn's hybridization research program in Palestine, where crosses of the wild wheat with domesticated wheats were being done (Cook, 1913, p. 52). In addition, two projects with wild wheat from Palestine were implemented in Canada. Reporting on the discovery and research on the wheat's potential for the industry in Canada, wheat breeder Buller wrote of his encounter with the plant. Like Cook, he concurred the plant should be considered as a separate species and insisted on classifying it *Triticum hermonis*, as Cook had done. He noted that the plant was under study at the Agricultural College in Winnipeg and the University of Saskatchewan in Saskatoon in 1918, but little is known about those experiments (Buller 1919).

On Aaronsohn's tour of the United States, the wheat plant from Palestine found itself suddenly enrolled in a project not only to test its viability outside Palestine, as with Schweinfurth in Bonn and the early experiments in California and Texas, but to breed it into existing cultivated strains. Aaronsohn acknowledged that Schweinfurth accepted the notion of breeding for desirable traits at least in principle (Aaronsohn, 1910b, p. 51). In particular, plant scientists sought to select for two traits of interest to U.S. scientists, drought resistance and resistance to the Puccinia leaf-rust fungus that threatened U.S. and Canadian production. The rediscovery of Mendelian genetics informed this effort (Bowler, 2000). Fairchild, the USDA botanist, argued for the value of Aaronsohn's experiment station on this basis from an early stage: "His discoveries in Palestine of drought-resistant stocks and dry land grains and forage plants, as well as the possibilities of American breeders utilizing his wild wheat" (Fairchild, 1910, p. 377). This genetic potential for Fairchild sparked U.S. interest in the breeding potential of the plant and the importance of his report "giving in some detail the bearing of his studies in Palestine on the many agricultural problems of the United States" (Fairchild, 1910, p. 377).

During his time in the United States, Aaronsohn garnered institutional and financial support to establish the first agricultural experiment station in Palestine and the first American agricultural research center outside of the United States. The "Jewish Agricultural Experiment Station at Haifa" was chartered in New York State in February 1910 and consisted of a board of leading American Jewish personalities, some of whom were not involved in the Zionist movement. The station was founded with a $20,000 start-up budget, a $10,000 yearly budget guaranteed for five years (Fairchild, 1910, p. 51; Katz, 2001b, p. S–14), and a massive collection of materials that Aaronsohn had obtained during his U.S. tour. Namely, Aaronsohn acquired "the most complete" set of USDA technical bulletins outside the United States. He bought the collection of 24,000 fungi of the late Professor W.A. Kellerman, a precious acquisition for any research center, much less one outside the United States. He also assembled a library of about 27,000 volumes and purchased equipment for a small station laboratory (Davidson and Kohler, 1928, p. 205). Aaronsohn believed that the station's site posed tremendous challenges because of the poor state of the soil, making his results all the more convincing. A collection of 260 varieties of grapes was grown at the station in addition to other commercially valuable crops such as dates

(Davidson and Kohler, 1928, p. 205). A sub-station was established near Hadera, as well.

The station was considered by all to be an American agricultural research station in Palestine. Aaronsohn described it in 1913 as "an American institution supported by American money" (Aaronsohn, 1913, pp. 174–175). Aaronsohn was brought on as a technical adviser to the USDA at a salary of $1 per year. In his laudatory announcement of the station in *Science* in 1910, David Fairchild described the still-nascent project's affiliation in no uncertain terms:

> As an American institution in the Levant and carrying the American experiment station idea abroad, this newly incorporated institution cannot fail to interest American experiment station workers, since its purposes are the scientific study and development of the agricultural resources of one of the oldest parts of the old world, as rich in latent wealth as it is in historical and religious interest.
>
> [Fairchild (1910), p. 376]

In less than four years, from his claim to have discovered the wild wheat in 1906 to a short trip to the United States in 1909, Aaronsohn had morphed from a local botanist and research assistant into a major scientist introduced in the pages of *Science* by a leading U.S. agronomist as the director of an American research station abroad. In his account of Aaronsohn's transformation, Katz (2001b) describes the transition in focus from Europe to America as the logical outcome of the relationship between Aaronsohn and USDA scientists rather than a material remaking of the landscape.

From the outset, Aaronsohn began breeding programs at the Haifa research station to cross the wild wheat with domesticated species in order to select for drought and disease resistance. In a 1911 letter to a Swiss botanist describing his experiments in June 1910, he said he had produced a wheat with a non-articulated rachis, something important for commercial production, through a cross between wild and cultivated wheat (Chodat, 1913, p. 41). He also noted that the wild-cultivated crosses had resisted rust for three or four years in his station's experimental plots, while the control plots had not. For his American colleagues, the applicability of such findings was immediately clear. Citing the Mendelian advances transforming scientific understanding of genetics to select individually for this trait, he argued for the practical significance of his research to his European colleague: "You will at once realize the practical significance and the economic value of this character" (Chodat, 1913, p. 41).

The most important wager for Aaronsohn based on this plant breeding work was that the potential for breeding new races was tied to extending the cultivation of wheat into previously uncultivated areas to be colonized. He stated his plant breeding goals in a 1910 report to the USDA, "By the selection and crossing of this wild cereal...we should be able to produce new races...In this way we can extend the cultivation of wheat to regions where it is at present impossible..." (p. 51). His plant breeding practices and his interest in extending wheat cultivation to other dryland areas spoke to the prospects for widening – and further justifying – the project of settling historic Palestine.

7. Conclusion

The research station founded by Aaronsohn did not ultimately succeed in demonstrating the potential of bringing wild wheat traits into cultivated wheats during his lifetime. Aaronsohn's ties with espionage projects and his death at a young age did not allow him to complete field research. Moreover, the American scientists at the time doubted the value of the wild wheat genetics to their breeding programs. Cook concluded that the "direct agricultural value" of the wild wheat was "doubtful," even saying the plant might cause damage as an "invasive species" (Cook, 1913, p. 49). The only other instance of systematic crossing of the wild wheat from Palestine in the United States took place at Cornell University by plant breeders H.H. Love and W.T. Craig. Their research, published in 1919 and 1924, suggested that features thought to be exclusive to the wild wheat could be produced "synthetically" through selection and crossing for those features, casting doubt on the value of wild wheat as the source of desirable traits (Love and Craig, 1924, 1919).

Sustained interest in the genetic traits of wild crop relatives for breeding programs however, shows the foresight of Aaronsohn's general research thrust (Hunter and Heywood, 2010). While his scientific pursuits were not directly successful in the field trials, Aaronsohn's research on wheat in its wild and cultivated forms did transform the geographic understanding of Palestine. I have shown how three scientific practices of appropriation (taxonomic, agro-climatic, and genetic) enabled consideration of Palestine as a site of "latent possibility" for the exploitation of its plant genetic material. Aaronsohn and his colleagues did this by engineering a shared agro-climatic linkage between Palestine and the United States. This bond was enabled in part through the manipulation of the wheat plant that would provide specially-adapted crop agriculture for settlement projects in dryland areas.

The case of Palestine's geographic remaking through scientific research on wheat (*Triticum*) poses three questions about the current understanding in geography about of the relation of plants and colonization. First, in contrast to representing a byproduct of colonization (Head et al., 2012), how do the research practices on wheat participate in the processes of colonization? Second, how do the taxonomic politics of plant native-ness contribute to our understanding of what Mastnak et al. (2014) have called a need for "botanical decolonization"? Third, and most importantly, if "seeing all plants and people place-based" is a decolonizing practice as Mastnak et al. (2014) argue, how might we interrogate the constitution of agro-ecological places within, and not outside, the logic of colonization? In order to address these questions, I argue that scholars must examine how wildness, native-ness, and agro-climatic suitability are scientifically constituted within and not apart from colonial conquest. Scientific practice gave these concepts technical but also political force. By consequence, the practices explored above were integral to remaking places – in this case Palestine – as sites for colonization.

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