HPLS (2018) 40:49
https://doi.org/10.1007/s40656-018-0220-3

ORIGINAL PAPER

Entangled histories of plague ecology in Russia and the USSR

Susan D. Jones[1] · **Anna A. Amramina**[1]

Received: 13 April 2017 / Accepted: 22 July 2018 / Published online: 21 August 2018

Abstract During the mid-twentieth century, Soviet scientists developed the "natural focus" theory–practice framework to explain outbreaks of diseases (such as bubonic plague) endemic to wild animals and transmitted to humans. Focusing on parasitologist-physician Evgeny N. Pavlovsky and other field scientists' work in the Soviet borderlands, this article explores how the natural focus framework's concepts and practices were entangled in political as well as material ecologies of knowledge and practice. We argue that the very definition of endemic plague incorporated both hands-on materialist experience (including the identification of microbes/pathogens, insects/vectors, and mammals/reservoirs) and ideological concepts that supported Soviet colonization ("improving" hinterlands, "controlling natural focuses of disease," and "sanitizing" landscapes). Theorizing and fighting plague assisted with the goals of controlling and improving landscapes and peoples in southern Russia and Central Asia. The history of the natural focus framework illustrates how Soviet disease ecology co-developed with the needs of local and central political powers in the Soviet borderlands.

Keywords Plague · USSR—environmental history · Pavlovsky, E.N. · Disease ecology

In 1908, the young Russian physician and zoologist Evgeny Nikanorovich Pavlovsky (1884–1965) realized a dream. He traveled from his St. Petersburg home to the wild beauty of the Tien Shan mountains, where a colleague captured an

✉ Susan D. Jones
Jone0996@umn.edu

[1] Program in History of Science and Technology, Department of Ecology, Evolution and Behavior, University of Minnesota—Twin Cities, EEB, Rm 100, 140 Gortner Lab, 1479 Gortner Ave, St Paul, MN 55108, USA

Fig. 1 "*Pavlovsky c* Мургаба *1908"* [Pavlovsky in Murghab 1908] (penciled on the back of photo in Pavlovsky's hand). Evgeny Pavlovsky gazes into the distance confidently while on expedition in the Pamir mountains, a landscape largely unexplored by scientists at the time. Fond 878, Opis 6, [folder] No. 48, Archive of the Russian Academy of Sciences, St. Petersburg Branch, St. Petersburg, Russia

image of him standing confidently on a rocky promontory (Fig. 1).[1] Pavlovsky prized this photograph highly enough to have it enlarged, framed, and mounted on his office wall for the remainder of his life—a vision not only of his career, but of the approach taken by him and fellow Russian/Soviet scientists seeking to understand the complexities of disease and the natural environment in the vast Russian borderlands. During the 1920s and 30s, Pavlovsky and other prominent Soviet scientists developed the "natural focus"[2] theory–practice framework to explain outbreaks of zoonotic diseases—those transmitted from animals to humans, such as bubonic plague, tularemia, and encephalitis—that were en-zootic or always present in Eurasian wild animals (Pavlovsky 1966). The natural focus framework guided both Soviet thinking about zoonotic diseases, and the policies designed to control them, until at least the 1980s. Using Pavlovsky and his contemporaries as a case study, we contribute to this special issue's theme of global "disease ecology" by introducing these Russian/Soviet disease ecologists and their ideas and practices. We argue that the natural focus framework was so successful because its developers entangled it with political as well as material ecologies of knowledge and practice during the chaotic early decades of the USSR (Rosenberg 1979; Shaw 2015).

[1] Evgeny Nikanorovich Pavlovsky, "*Pavlovsky v Murgabe 1908"* [Pavlovsky in Murghab 1908]. Fond 878, Opis 6, [folder] No. 48, Archive of the Russian Academy of Sciences, St. Petersburg Branch, St. Petersburg, Russia (hereafter Pavlovsky Papers). Pavlovsky transliterated his name ending in "–sky".

[2] The name of this theory is most familiar to Anglophone scholars as the "natural focus" theory of disease, thus we will use it in this article. However, according to some western scientists who met Pavlovsky in his later years, Pavlovsky himself preferred the translation "natural nidus" (see English translation of Pavlovsky (1966), *Natural Nidality of Transmissible Diseases*. Original Russian title, Природная очаговость трансмиссивных болезней).

The history of research on plague in Russia and the USSR over the past century provides a window into the natural focus framework's entanglements with specific ideas and colonial practices in Central Asia and the Eurasian borderlands during the long twentieth century. Incorporated into the Russian empire during the waning decades of the nineteenth century, these regions were rapidly transforming and were crucial to Russia's geopolitical ambitions. After the Revolution and Civil War (1917–1921), Siberia and Central Asia—what now includes Turkmenistan, Kazakhstan, Kirghizstan, Uzbekistan, and Tajikistan—represented tantalizing economic and political opportunities for the young Soviet supranational state (Demko 1969; Morrison 2017). During successive Five-Year Plans, beginning in 1928, the Soviet rapid-industrialization mandate included resettlements of large populations (even of the politically dominant ethnic group, Russians); a dramatically destructive re-engineering of vast Central Asian and Siberian landscapes; and the disruption of local cultures and lifeways for at least two dozen smaller ethnic groups. At this same time, the natural focus concept grew out of a commitment to understanding and controlling a particular disease: plague, in its bubonic and other forms. Plague has been many diseases: the displeasure of deities; the "Black Death;" and the result of "foreign" invasion, to name a few iterations.[3] Most histories of plague have analyzed human pandemics, from the time of Justinian through the Black Death to the most recent era of global plague circulations–circa 1850–1950. However, the plague that we are concerned with here was not primarily a disease of humans in transit and their associated rats and fleas (Echenberg 2007). As envisioned by Russian and Soviet scientists, plague was an ancient disease of small burrowing animals, such as marmots and gerbils, that persisted in the Soviet borderlands, spilling over into people working or living nearby. The environmental transformations associated with Russian settler societies and resource extraction regimes made the colonial landscape of the Central Asian borderlands particularly complex,

[3] The Anglophone medical historical literature on plague is vast, but some useful entry points follow. For approaches to bubonic plague and other diseases as sociocultural–biological entities with changing meanings over time, see: Charles E. Rosenberg, "Framing Disease: Illness, Society and History," pp. xiii–xxvi in Charles E. Rosenberg and Janet Golden, *Framing Disease: Studies in Cultural History* (New Brunswick, NJ: Rutgers University Press, 1992); Jon Arrizabalaga, John Henderson and R.K. French, *The Great Pox: The French Disease in Renaissance Europe* (New Haven: Yale University Press, 1997); Susan D. Jones, *Death in a Small Package: A Short History of Anthrax* (Baltimore: Johns Hopkins University Press, 2010). For analyses of plague in twentieth-century east Asia, see: Eli Chernin, "Richard Pearson Strong and the Manchurian Epidemic of Pneumonic Plague, 1910–1911," *Journal of the History of Medicine and Allied Sciences* 44 (1989): 296–319; Mary Preston Sutphen, "Imperial Hygiene in Calcutta, Cape Town and Hong Kong: The Early Career of Sir William John Ritchie Simpson (1855–1931)," Ph.D. Dissertation, Yale University, 1995; Sutphen, "Not What, but Where: Bubonic Plague and the Reception of Germ Theories in Hong Kong and Calcutta, 1894–97," *Journal of the History of Medicine and Allied Sciences* 52, 1 (1997): 81–113; David Arnold, *Colonizing the Body: State Medicine and Epidemic Disease in Nineteenth-Century India* (Berkeley: University of California Press, 1993), pp. 200–239; Myron Echenberg, *Plague Ports: The Global Urban Impact of Bubonic Plague* (New York: New York University Press, 2007); William C. Summers, *The Great Manchurian Plague of 1910–1911: The Geopolitics of an Epidemic Disease* (New Haven: Yale University Press, 2012); and Christos Lynteris, *Ethnographic Plague: Configuring Disease on the Chinese–Russian Frontier* (London: Palgrave Macmillan, 2016), pp. 49–53. For the history of bacteriological and epidemiological investigations of human plague, see: Andrew Cunningham, "Transforming Plague: The Laboratory and the Identity of Infectious Disease," pp. 209–244 in Cunningham and Perry Williams, eds., *The Laboratory Revolution in Medicine* (Cambridge: Cambridge University Press, 1992).

especially in the middle decades of the twentieth century (Brower 1997; Morrison 2013; Etkind 2011).

Envisioning plague in this way brings us into conversation with particular historiographical narratives. Classic environmental histories demonstrated how rapid industrialization, destructive mining practices, collective agriculture, and destroyed environments characterized the Soviet century and poignantly illustrated the overarching ideology of nature as an exploitable object to be controlled, transformed, and battled (Josephson et al. 2013; Weiner 1988). The historiography also traces profound shifts in official ideologies and political policies toward non-human nature during the Soviet century and queries how these shifts affected the work of scientists (Shaw 2015; Brain 2010, 2011). From the utopian Marxist scenarios of the early 1920s, through Stalin's "Great Break" and the intensifying objectification of nature, to the hardening vision of nature as an "enemy" of statist goals following the Great Patriotic War (World War II) (Bruno 2017; Josephson et al. 2013; Weiner 1988), Soviet policies in the borderlands were often negotiated by scientists in the field. Complex local relationships and the fates of the biomedical sciences were closely intertwined (Raleigh 2001; Michaels 2003). Recent work has argued that scientists' encounters with environmental degradation and the ill-treatment of indigenous peoples also sometimes supported environmental preservation, conservation, and attempts to protect local citizens' health and well-being, and our article aligns with this approach (Moon 2017). In contrast with the West (Anderson 2004), the ecology and landscape-based epidemiology of infectious diseases remained a central, not marginal, approach to Soviet public health policies throughout the twentieth century. We do not argue that the Russian/Soviet natural focus framework developed in isolation; on the contrary, we demonstrate a surprisingly vigorous knowledge exchange with Western ecologists and biomedical scientists even under the most difficult conditions. Even within this transnational circulation of scientific ideas, embedding research in local environments was a particularly important component of Russian and early Soviet sciences, and a defining aspect of disease ecology in the USSR (Bruno 2016).

In our case study, Evgeny Nikanorovich Pavlovsky, his colleagues, and their local collaborators speak to us today in various ways, and a word on our sources is indicated here. Although many sources are in Russian, we have indicated whenever an English translation is available for the convenience of Anglophone readers. Our analysis is anchored by archival materials, images, interviews and the grey-literature memoirs of scientists who worked on plague investigations in the USSR. During the Soviet era, much of this information was classified as secret or internally restricted, and thus was unavailable to western scholars. Pavlovsky's field notebooks and much of his correspondence are held by the Medical Military Museum, St. Petersburg, and we have not yet been given permission to access this collection. Fortunately, the Archive of the Russian Academy of Sciences in St. Petersburg holds reports and some of Pavlovsky's papers and photographs. We have been able to interview historians and scientists who worked with natural focal diseases. We also rely on grey-literature oral histories, in Russian, self-published by one of the plague researchers after the dissolution of the Soviet Union: M.I. Levi's newsletter series *Illuminating Studies of the Anti-Plague System [Занимательные очерки о*

деятельности и деятелях противочумной системы России и Совет, ского Союза] (1994–2002). Determined to reverse the decades of secrecy and to honor persecuted colleagues, Levi collected reminiscences and data from fellow "plagueologists" (*chumolog*, as they called themselves), used his meagre resources to get the narratives printed, and distributed copies to the authors. Historians can thank Raymond Zilinskas and colleagues at the James Martin Center for Non-Proliferation Studies, Monterey, CA, for preserving a rare complete run of Levi's newsletters, donating it to Stanford's Hoover Institution Library, and sponsoring an English translation of excerpts with additional commentary (Levi 1994–2002; Mahoney et al. 2013). Finally, by visiting a former anti-plague research institute and field site in Kazakhstan, we have been fortunate to meet a younger generation of *chumolog* and to participate briefly in fieldwork.

The natural focus framework depended heavily on experience in the field, and also on the developing ecological sciences during the twentieth century.[4] For Russian/Soviet scientists, ecological thinking and practices included a commitment to focusing on *interactions* between components of disease systems (human cultures, microorganisms, animals, landscapes and climate) and an explicit reliance on the developing ecological sciences—while navigating shifting political and ideological contexts. In our case study, the very definition of a disease such as plague (both conceptually and realistically) incorporated both hands-on materialist experience (including the identification of microbes/pathogens, insects/vectors, and mammals/reservoirs) and ideological concepts that supported Soviet colonization ("improving" hinterlands, "controlling natural focuses of disease," and "sanitizing" landscapes). The history of plague in Russia and the USSR is unremittingly political, and this history of how scientists envisioned plague ecology in the borderlands exposes how epistemological and practical choices were political ones.

1 Entanglements of plague and politics

What was "plague" in Russia at the turn of the twentieth century? Traditionally, there had been several different diseases that would be nosologically re-arranged to accommodate germ ideas (the bacillus thought to cause plague, *Yersinia pestis*, was not isolated until 1894). The hallmark swollen, darkened lymph nodes or "buboes" marked the body of the sufferer of [бубонная] чума ([bubonic] plague), the most well-known form of plague. A highly lethal lung sickness (referred to as легочная чума, lung/pneumonic plague), was sometimes (but not always) understood to be related to bubonic plague. Aside from the buboes, the most important designator of the illness was the victim's proximity to other sick people or to animals that appeared similarly ill. The Russian word used to unite this constellation of afflictions was чума (*chuma*, plague). At least since the visitations of the dread "Black Death," plague was also understood to be an imported "foreign" disease brought by certain groups of people (Risse 2012; Shah 2001; Chase 2003). But for

[4] See Warwick Anderson's essay in this issue for a synopsis of the scholarly discussion about disease ecology since Mendelsohn's article.

naturalists and scientists in the Russian Empire and its successor, the USSR, plague was an important domestic disease, endemic to certain places and assemblages of living creatures.

During the nineteenth century, natural historians and explorers reported *chuma* to affect animals and people in areas of the Caucasus, Mongolia, the part of Siberia around Lake Baikal and the Central Asian steppes (Minkh 1881). As Christos Lynteris has recently described, late nineteenth-century naturalists and physicians such as Mikhail Eduardovich Beliavsky linked human *chuma* outbreaks with wild burrowing animals hunted by people who then fell ill with what Beliavsky called the "marmot plague of men" (Beliavsky 1895; Lynteris 2015, 2016). Marmots or "tarbagans" (from the Mongolian name for them), along with several other species, lived in colonies on the steppes and in the mountain valleys of the South and East (Besser 1906; Skrzhivan 1901). Plague and other diseases flared up periodically in the borderlands within the Imperial Russian sphere of influence, threatening developments such as the "colonization movement" (*kolonizatsionnoe dvizhenie*), which relocated Russian and Ukranian peasants onto Kazakh and Kirghiz lands to "improve" them by developing the cotton industry (Morrison 2016). Recurrent outbreaks of plague, tick encephalitis, and relapsing fever were obstacles to these goals and large epidemics could become major geopolitical events. The most notable, the 1910–1911 Manchurian plague epidemic, was attributed to an epizootic in Siberian marmots on the border (Summers 2012). For Evgeny Pavlovsky and other young scientists trained in both medicine and zoology, successful careers could be made studying hinterland diseases. Controlling disease and improving landscapes in the borderlands served the needs of both local and central power structures, even as political configurations shifted dramatically.

During the first decades of the twentieth century, borderland field research enabled Evgeny Pavlovsky to build a career in disease ecology based on his dual training as a physician and zoologist. He graduated from the Military Medical Academy in St. Petersburg and began post-graduate research in zoology and entomology in the early 1910s. Pavlovsky's mentor was Nikolai Aleksandrovich Kholodkovsky, who taught zoology and medical entomology at the Military Medical Academy and was a member of the Zoological Institute of the Russian Academy of Sciences (Lebedenko 1961). Kholodkovsky supported Pavlovsky's early zoological expeditions to collect, classify and study the evolution of poisonous creatures, especially scorpions.[5] Pavlovsky first turned to disease ecology in 1915 while working in Uzbekistan, where he collected malaria-carrying mosquitoes in towns and villages near abandoned rice paddies and irrigation canals. Concerned with the lack of local public health infrastructure, he reportedly advocated creating posters that explained malaria epidemiology (in both Russian and the local languages) and placing them at train stations and public places (Lebedenko 1961). Pavlovsky concentrated on vector-borne diseases endemic to the Russian/Soviet borderlands for the rest of his career.

[5] On one of these trips, Pavlovsky met Charles Nicolle at the Pasteur Institute in Tunis; see the contribution of P. O. Méthot to this special issue.

Pavlovsky thus joined the rich Russian tradition of traveling medical researchers. The eminent plagueologist Daniil Kirilovitch Zabolotny (1866–1929) preceded Pavlovsky's generation and deserves more attention than we can provide here. Zabolotny was the best-known fin de siècle Russian *chumolog* and a veteran of several anti-plague campaigns: the Russian Plague Commission to Bombay in the late 1890s; the Odessa plague epidemic (1905); and several field expeditions to the Russian–Mongolian–Chinese borderlands. He represented Russia at the International Plague Congress held in Harbin (China) in the wake of the 1911 Manchurian epidemic, and he joined Wu Lien-Teh on a cross-border expedition to find the disease in tarbagan marmots during the next summer (Lynteris 2016; Vyssokowitz and Zabolotny 1897). Although Zabolotny and Wu failed to find plague in this marmot population, a contemporary *chumolog*, Ippolit Alexandrovich Deminsky (1864–1912), succeeded in finding marmot-plague and, at great personal cost, definitively proved its transmission to humans. Deminsky was serving as deputy head of the Astrakhan microbiological laboratory in 1912 when he went on expedition near the village of Rakhinka. He was able to culture *Y. pestis* from a dead marmot he found there, and began conducting experiments. Falling severely ill with plague himself, Deminsky became a celebrated martyr of science when he left instructions for taking samples from his body after his death in order to prove the transmissibility of "marmot plague" to humans. From the storied history of the preceding generation who investigated plague and other diseases, Pavlovsky knew well the theory that marmots were a source of *chuma* in humans.[6] This history provided an important thread of continuity for Pavlovsky's generation as they sought to survive and position themselves in the years to come.

Increasingly, scientific work became entangled in the political and social upheaval of the first world war, Russian civil war, and early Bolshevik period. Like many of their contemporaries, Pavlovsky and his mentor Kholodkovsky struggled to maintain their research program despite the dangers and shortages of food and other resources. Pavlovsky's turn to disease ecology was timely. In 1915, the eminent geochemist Vladimir Ivanovich Vernadsky (1863–1945) had articulated the crucial role scientists would be expected to play in post-war recovery. Vernadsky called on scientists to investigate "the natural productive forces which Nature and History have granted to Russia" to exploit natural resources to address social problems and augment military strengths, a position later adopted by the Bolshevik government (Vernadsky 1922). By 1918, Pavlovsky prudently decided to devote his career to practical disease problems informed by entomology and parasitology, thus aligning himself with what Alexei Kojevnikov (2008) has called "the idea of science as a public profession…consciously serving social needs" under the new Bolshevik regime. Pavlovsky began teaching at the Military Medical Academy, Petrograd's major medical school and his alma mater; and when Kholodkovsky died in April

[6] Deminsky composed a final telegram containing these instructions to his supervisor, Dr. Klodnitsky, Director of the Astrakhan microbiological laboratory. The words are now inscribed on Deminsky's gravestone, located on the grounds of the Astrakhan Anti-Plague Institute. On what younger scientists knew about marmot plague, Dr. Eduard I. Korenberg told us: "Of course they [Pavlovsky's generation] were well-informed about Zabolotny's work. It cannot be otherwise. Everything starts from the Middle Ages here." Interview with Anna A. Amramina, 16 August 2016.

1921, Pavlovsky was also offered his mentor's chair in Zoology and Comparative Anatomy.[7] From this professional base, Pavlovsky enthusiastically pursued ecological and disease research on a succession of expeditions: he returned to the Pamir region in 1923, and helped organize and participated in the First Parasitological Expedition of the USSR Academy of Sciences to Central Asia in 1928.

Looking closely at the culture of these expeditions reveals the long reach of state policies into local scientific practice. Expeditions targeted the sites of disease outbreaks, and the scientists experienced the discomforts of the field and also risked infection. Usually camping and eating sparely, scientists on expeditions walked for miles swinging nets to capture hungry blood-sucking insects, offering their bodies as bait; trapped and dissected wildlife; dug out the burrows of rodents; and often provided medical care for local people. They baked in the desert and froze in the taiga. Iosif Samsonovich Tinker, stationed at a Trans-Caucasian anti-plague institute in the 1950s, remembered that the equipment was primitive and electricity only available a few hours each day. Gertruda Stepanovna Starozhitskaya recalled a visiting Iranian dignitary's shock when he realized that women worked day and night with men who were not their husbands (and had no fresh water or toilet facilities) (Tinker 1998; Starozhitskaya 1998). Igor Vasilievich Khudyakov captured the loneliness and discomforts in his poem, "The March of the Plagueologists" (1970). "No medals we received/In rain and melting ice,/For treading 'cross the flow of rivers strong!/Far off from darling eyes, from urban paradise,/Gray marmots there received us in their song…/Doctors, zoologists, where are our years of youth?!…/We lived among the mountain passageways,/Go on, ye ol' horse, take the path yet unexplored/The path of no repose—the path of plague!" (Khudyakov 1997). After a career that included organizing and participating in more than one hundred such expeditions, Pavlovsky was elected President of the Geographical Society of the Academy of Sciences in 1952 and awarded the USSR's highest distinction, the title of "Hero of Socialist Labor" (Prohorova 1972).

This could have been the stuff of heroic scientific narratives, but most of the plagueologists labored in obscurity. Scientific research and disease outbreaks in sensitive border areas—especially outbreaks of plague—were state secrets from the 1930s onward. Moreover, by the end of the 1930s the Central Committee of the Communist Party maintained a stranglehold on scientific work in the USSR (Krementsov 2002). The theme of fear ran through the accounts of Starozhitskaya, Tinker, Khudyakov and their colleagues. All had signed secrecy pledges and were constantly monitored. Starozhitskaya remembered the stress of the Iranian dignitary's visit: "We were so frightened [of] ending up at the Lubyanka Prison…because of the various secrecy pledges we had signed that I was afraid not only to speak, but to even open my mouth" (Starozhitskaya 1998). Stalin's infamous purges of the intelligentsia during the late 1930s and early 40s ensnared many scientists, including some of those working on plague and other disease

[7] St. Petersburg was renamed "Petrograd" in 1914; then "Leningrad" after Lenin's death in 1924. Pavlovsky's career is an excellent illustration of the fact that professional success under the Soviet system was measured by how many official positions and state awards an individual could accumulate, often holding several positions simultaneously.

ecology problems: Lev Aleksandrovich Zil'ber, Ilya Grigorovich Ioff, Sergei Mikhaylovich Nikanorov, and Vartan Nikitich Ter-Vartanov, among others (Mahoney et al. 2013; Belousova 1998). Moreover, several institutions attempted to control information about local plague outbreaks and laboratory accidents, placing pressure on local town councils, physicians and scientists. The Soviet People's Commissariat for Health, *Narkomzdrav* (after 1946 *Minzdrav,* Ministry of Health),[8] through its Anti-Plague Institute network, claimed jurisdiction, as did the NKVD and its successor, the KGB (secret police). I.V. Khudyakov recalled that "in Soviet times, the KGB and the USSR MOH competed to be the first to report plague outbreaks to higher authorities" and gain credit for doing so (Khudyakov and Suchkov 1999). Once reported to Moscow, plague cases and outbreaks (in animals and humans) did not appear in media reports because, as former *Minzdrav* division chief G.D. Ostrovsky remembered, "The totalitarian state was concerned about its respectable image" (Belousova 1998). After the 1956 Twentieth Congress of the Communist Party of the Soviet Union, plague outbreaks in animals (but not humans) could be reported in scientific publications for internal use only; but this knowledge was not allowed to travel either to broader media outlets (themselves state-controlled) or to the World Health Organization. Only the most general discussions from official sources reached international circulations of scientific knowledge (Mahoney et al. 2013).

Both visible and invisible within the USSR, plague came into being when physicians and scientists recorded its land- and body-borne signs: the buboes of animal and human sufferers; the bacilli found in fleas; and the conditions of soil and climate. But defining an outbreak of plague also created a type of political currency that could be spent or reserved. An impediment to settlement, a threat to secure borders, and a black mark on the record of a region's governing officials, plague may have been reported to the KGB or *Minzdrav,* recorded as a "mysterious disease," or not reported at all. Landscape-based diseases, such as plague, circulated constantly and persisted in endemic forms among communities of animals and insects, an ever-present danger to humans. Endemic diseases were forces of nature seen as resistant to human control, as we discuss in the next sections. These recalcitrant, persistent diseases hindered the "improvement" of the Soviet borderlands, and scientists such as Pavlovsky found safe niches during the dangerous decades of Stalin's regime by theorizing, investigating, and attempting to control endemic zoonotic diseases.

[8] The Soviet Ministry of Public Health has existed in three major forms: in 1918, it began as the People's Commissariat for Health of the Russian Soviet Federative Socialist Republic; in 1936, it was reorganized as the People's Commissariat for Health of the USSR (commonly known by its acronym, Narkomzdrav (*Nar(odny)-Kom(missariat)-Zdrav(ookhraneniya)*). In 1946, it was transformed into the Ministry of Health of the USSR and acquired a new acronym, Minzdrav (*Min(isterstvo) Zdrav(ookhraneniya)*), as it is still known today.

2 Theorizing natural foci of disease

In the steppes and arid lands of the south, and the forests of the northeast, Pavlovsky and his colleagues crafted the natural focus theory–practice framework to explain endemic diseases during the 1920s and 30s. Expeditions, as we have seen, fulfilled many functions for these scientists; but perhaps most importantly for our purposes, they shaped the natural focus framework differently from traditional Western notions of medical geography (Rupke 2000). While medical geography relied on two-dimensional mapping of disease ranges onto places (and tended to concentrate on humans), the natural focus framework located disease explicitly in spaces of interaction between the components of non-human assemblages in nature. It was, in other words, a system that considered the ontological category-analysis of the constituent parts (rodents, microorganisms, fleas, bounded regions on a map) to be of secondary concern to their mutual influences. The natural focus framework also did not situate humans at the center of natural foci of plague and other diseases. On the contrary, "natural" foci emerged independently of human activities, however, natural foci became visible and known primarily when humans made incursions into them. Although the natural focus theory developed dynamically over time, the founding concepts articulated by Pavlovsky and his colleagues endured. We have space to analyze only two of the most important concepts here: natural foci operated at multiple, interrelated scales; and the interactions between components of the focus were characterized by ecological notions of population-level parasitism—what Pavlovsky called the "parasitocenoses" (Korenberg 1989).

Pavlovsky has been given credit for these ideas, but it is important to recognize that he functioned as a collector, synthesizer and popularizer of knowledge emanating from many sources. Based in Moscow and Leningrad, he used expeditions to gather not only biological material, but also information from colleagues stationed in the borderlands. In 1933, for example, Pavlovsky visited the malaria station in Kara Kala while on expedition in Turkmenia and met Polina Andreevna Petrishcheva (1899–1973) (Fig. 2). Petrishcheva was interested in the ecology of insect vectors in the region, and she had gathered large amounts of data on mosquitoes, fleas, and ticks by collecting material in "places where you least expect it," such as caves uninhabited by warm-blooded animals and people (Petrishcheva 1960, 1962). In 1931, Petrishcheva and her Turkmen assistant, Mengli Davletov, looked for and found complex communities of blood-sucking insects and hibernating animals in caves, grottoes and cracks in rocks. These communities also harbored microorganisms: bacteria, spirochetes, and trypanosomes associated with diseases such as plague and tick-borne relapsing fever (which became apparent when Davletov fell ill). Petrishcheva had found "vectors of human diseases in an uninhabited area"—the "nests" and "shelters" in which animals and their insect parasites interacted and preserved the microorganisms' life cycles (Petrishcheva 1960). Pavlovsky quickly saw the similarities in their approaches to disease ecology and offered her an internship at his Zoological Institute in Leningrad. This boosted Petrishcheva's career (Kryuchechnikov 2000) but also helped Pavlovsky. As we will see, his exposure to her experience and approach to disease problems came at

Fig. 2 "*E.N. Pavlovsky and Group, Parasitological Expedition, 1931.*" Pavlovsky is standing at right; P.A. Petrishcheva is seated center; and the man seated at left is probably her local collaborator, Mengli Davletov. Turkmenia. Photograph no. 66244, Archive of the Military Medical Museum, St. Petersburg, Russia

the right time to influence his first major contribution to the natural focus framework: his 1934 article entitled "The Organism as a Habitat" (Pavlovsky 1934).

This article, published in the widely popular scientific journal *Priroda* (*Nature*),[9] creatively envisioned multiple scales of ecological interactions and reflected Pavlovsky's familiarity with both Russian and western scientific ideas (most of the references cited American and European authors). In the article, Pavlovsky argued that disease and parasitism were comprised of multiple, interrelated levels of ecological interactions. Taking the vantage point of a parasite, Pavlovsky explained that its "primary environment" was within the body of its host (the "organism"). The "secondary environment" encompassed the experiences of the host body in its external environment. The whole system consisted of these layered interactions between parasites, the primary environment and the secondary environment (Pavlovsky 1934; Korenberg 1989). This analysis drew on Vladimir Ivanovich Vernadsky's theory of the "biosphere," the global-scale living world (this was the same Vernadsky who had urged scientists to explore Russia's natural resources in 1915). Vernadsky's biosphere was comprised of two levels or "worlds": living things, and the abiotic environment with which they interacted (Sokolov and Shilov 1989; Levit 2000). For Pavlovsky, the host body ("organism") was loosely analogous to the living world, and distinguishable from the external environment.

[9] This journal, which survived throughout the twentieth century, has a fascinating history. Run by successive consortia of scientists, *Priroda* was (and is) a prestigious, peer reviewed journal that also has had a wide popular audience. It has included contributions from many scientific disciplines. See A. F. Andreev, "The Journal *Priroda*—100 Years Old," *Physics—Uspekhi* 55 (2012): 96–102.

He went a step further, however. The organism (host body), he explained, functioned as its own little world: an ecological "habitat" for external and internal parasitic organisms, including those causing diseases such as plague, malaria, and others (Pavlovsky 1934). Disease systems were comprised of multiple organisms, each its own site of interactions, at multiple levels. Infected organisms, Pavlovsky implied, functioned like infected landscapes. Petrishcheva's "nests"—caves and grottoes in Turkmenia—were natural laboratories that confirmed and, in her assessment, "extended" Pavlovsky's theory (Petrishcheva 1960). Each cave was a habitat: the secondary environment for hordes of hungry parasitic insects. Each insect body, the primary environment, housed parasitic microorganisms. "The Organism as Habitat" thus formalized the notion of interactions within interactions, applying finer levels of resolution to Vernadsky's global-scale biosphere theory.

Influenced directly by Russian ecologists of the 1920s and 30s, Pavlovsky next developed the concept of the "parasitocenose" by merging the "organism as habitat" with the notion of a "biocenose" (Pavlovsky 1937). In an influential article published in 1937, Pavlovsky originally defined a parasitocenose as the "community" of parasites inhabiting the body of a host, which was their "habitat" (Pavlovsky 1937). The parasitocenose was a complex community characterized by the interactions between the parasites themselves, and the community of parasites with the environment of the host body.[10] The "biocenose," an idea originally traceable to the German natural philosopher Karl Möbius, gained popularity after World War I among Russian ecologists seeking to define communities according to the interactions between plant and animal components (Mobius 1880; Weiner 1988). The first journal of ecology in the USSR, launched in 1931, was titled *Zhurnal ekologii i biotsenologii* (*Journal of Ecology and Biocenology*), indicating the importance of this concept to Soviet ecology. For Russian ecologists, the biocenose concept closely paralleled European and American ecologists' thinking about biological communities. During the 1920s, Soviet ecology grew dramatically, and several Soviet scientists spent time working in Western universities and institutes (Josephson et al. 2013).[11] The most important influence on Pavlovsky's "parasitocenose" idea was Daniil Nikolaevich Kashkarov (1878–1941), an animal ecologist who had studied in the United States (1928) with the sponsorship of the Rockefeller Foundation's International Education Board and collaborated with American ecologist C.C. Adams (Weiner 1988). Like Pavlovsky, Kashkarov was a veteran of ecological surveying in Central Asia and he served as director of vertebrate zoology at the Turkestan (later Central Asian State) University, living in Tashkent during the 1920s (Rakhimbekov 1990). Kashkarov began teaching courses in ecology there in 1924 (Weiner 1988), and relocated to Leningrad State University in 1934, where he perished in 1941 while being evacuated during the blockade of Leningrad. Kashkarov began editing the journal *Zhurnal ekologii i biotsenologii* (he

[10] Pavlovsky's notion of the parasitocenose also influenced French thinkers such as Hervé Harant; see Pierre-Olivier Méthot's contribution to this issue.

[11] British and American ecologists also knew about the Russian ecological literature through the 1930s because of the comprehensive bibliography published in Charles Elton's *Journal of Animal Ecology*: J. Richard Carpenter, "Recent Russian Work on Community Ecology," *Journal of Animal Ecology*, 8, 2 (November 1939): 354–378.

renamed it *Voprosy*, or "Issues," instead of *Zhurnal*) in 1934 and published the USSR's first textbook of community ecology, *Среда и Сообщество (Environment and Community)*, in 1933, both familiar to Pavlovsky (Weiner 1988).

Pavlovsky synthesized the theories, the "organism as habitat" and the "parasitocenose," with his experiences in the field in the late 1930s to create the "natural focality of transmissible diseases" framework ("*prirodnaya ochagovost transmissivnykh bolezney"*). He published two important articles introducing the theory, in 1939 and 1946, and continued to develop the details of the natural focus framework for the rest of his career (Pavlovsky 1939, 1946). One point illustrates the entanglements of the field with theory particularly well: the meaning of *ochag* (astute readers will notice the derivation *ochagovost* above). The Russian word *ochag*, translated to English, means "hearth," "home," or "nest" (of a disease, in this case). Like Petrishcheva did with her caves, Pavlovsky envisioned endemic diseases as ecological interactions between microorganisms, insects, and warm-blooded animals; the disease's home was located wherever the ecological interactions maintained it. The usual English translation of *ochag* is "focus" or "nidus" of disease, most often noted geographically as a bounded area on a map. But Pavlovsky's use of *ochag* was far subtler. *Ochagi* could exist only with particular configurations of ecological interactions; they could, and did, shift with time but only with the right combination of climate, microorganisms, and hosts. Pavlovsky had ample opportunity to study natural *ochagi* of diseases during annual expeditions to the Soviet borderlands (expeditions whose purposes were often as much political as scientific).[12]

These expeditions existed within the framework of state-mandated surveying for economic development in border areas, such as the Pamir mountain region Pavlovsky first visited in 1908 (in what later became Tajikistan). After the delimitation of the Tajik SSR in 1929, this region was expected to participate in 'modernization,' including collectivization and the forced relocation of non-native peoples. Relocated people, however, fell victim to diseases that flared up when land was plowed or settlements were built. By 1933, the Council of People's Commissars (*Sovnarkom*) of the Tajik SSR was concerned enough with this problem to fund a series of costly expeditions for Pavlovsky and his colleagues. They detailed a newly-described disease system, tick encephalitis, whose crucial components were viruses, rodents, insects, and encroaching human populations. While a major scientific discovery, the value of this research was characterized by Pavlovsky in his official report as "the unity of theory and practice:…the main objective of parasitology at this stage [is] to give assistance to collective farm development."[13] Pavlovsky's reports thus carefully articulated what he thought officials of the *Sovnarkom* and the *Narkomzdrav* (central ministry of health) wanted to hear, while establishing scientific priority for elucidating disease systems.

Finally, as E.I. Korenberg has pointed out, Pavlovsky and the other ecological parasitologists envisioned parasitism as a "form of symbiosis" rather than a more

[12] The derivation of *ochag* and its complex meanings deserve more attention than we can provide here.

[13] E.N. Pavlovsky, [*The Pamir expedition, the biological station of the Central Asian State University, and their works*], Fond 878, Opis 3, No. 59, Pavlovsky Papers.

specifically-defined predator–prey relationship. Parasites (whether microorganisms or macroparasites) could circulate; could function as mutualists, commensals or 'true' parasites; and—crucially for Pavlovsky and Kashkarov—could co-evolve with the other members of the parasitocenoses (Korenberg 1989). Pavlovsky, Kashkarov and their contemporaries in ecology and parasitology were Darwinists; that is, their conceptual thinking proceeded from viewing members of the parasitocenose as shaped by variation, adaptation, and natural selection. As Eduard N. Mirzoian has argued, for ecologists and ecological parasitologists "the theory of evolution constituted the foundation of ecology" (Mirzoian 1995). From his 1939 article through his final book, Pavlovsky referred to "evolution" and described co-evolution as a necessary condition for the persistence of an *ochag*. In his final book, Pavlovsky wrote: "All relationships…between the agent, its donors, its vectors, and its recipients have combined in a process of organic evolution and interspecies relationships against a definite background of the exterior environment" (Pavlovsky 1966).

We now must ask how Pavlovsky and the natural focus framework were able to survive, and even thrive, especially during the dangerous 1930s and 40s. After all, Pavlovsky was a physician–biologist, trained under the old Russian imperial regime. He had worked closely with and cited the work of several denounced scientists: Lev Zil'ber, who hand-picked Pavlovsky for a 1937 expedition (Kisselev et al. 1992); the ecological parasitologist Vladimir Dogel'; and the ecologist Daniil Kashkarov. Pavlovsky discussed evolution (although not genetics) in his writings, and biology was a broad target for state censure in the 1930s and during the long tenure of Lysenkoism. As Eduard Mirzoian has written, "the criticism of genetics became a launching pad for a much broader assault…against all theoretical biology" (Mirzoian 1995). Ecology and conservation were also early targets in part, Douglas Weiner has pointed out, because "many politically active Soviets viewed nature as an obstacle to socialist construction," and a problem for the "improvement" of wild landscapes through agricultural production (Weiner 1984). Despite these potential liabilities, Pavlovsky proved fortunate, politically adept, and elusive—he managed to be in the field at the right times. First of all, Pavlovsky's natural focus framework supported agricultural "improvement" and incorporated it as a "treatment" for disease-infested landscapes. Moreover, according to historian Eduard Kolchinsky and biographer N. P. Prohorova, Pavlovsky "knew what to say" when questioned, to avoid political trouble; his reports to Soviet officials were carefully crafted and always used party-line rhetoric (Prohorova 1972). Perhaps just as fortuitously, the natural focus framework proved to be a powerful tool for Pavlovsky. Like a newly developed vaccine or anti-microbial, the natural focus framework could be deployed to protect human health and it gained fame as a type of "prophylaxis" against diseases that threatened centrally-planned development in the hinterlands.[14] Pavlovsky and his contemporary Soviet disease ecologists effectively argued that

[14] As in the West, Russian and Soviet physicians and scientists developed therapeutic biologicals (serum), anti-microbials (sulfonamides and antibiotics), and anti-plague vaccines for humans living or working in endemic plague regions. See Robert Pollitzer, *Plague and plague control in the Soviet Union: History and bibliography through 1964* (New York: Institute of Contemporary Russian Studies, Fordham University, 1966).

knowledge of natural focal diseases facilitated settlement and agricultural development in the southern and eastern borderlands. Their timing could not have been more propitious.

3 Sanitizing landscapes

In Central Asia, the "improvement" of people and landscapes were closely interconnected in Soviet policies, particularly after the inception of Stalin's Five-Year Plans, which set mandatory goals for productivity and agricultural development from the late 1920s onward (Josephson et al. 2013). Scientific expeditions had already scouted the eastern and southern steppes, mountains and deserts; now they searched with more urgency for "what agricultural possibilities exist in the area" (Kashkarov and Kurbatov 1930). As Douglas Weiner has argued, Soviet biologists in the 1930s and 40s had to frame their work within "the voluntaristic spirit of the Five-Year Plans," adhering to "the pronouncements and policies of the…political leadership," and above all, producing results that had "material utility" (Weiner 1984). The natural focus framework, applied to endemic foci of plague, justified all three aims: it enlisted newly settled people in working to reshape their environment; it theorized a disease system of ancient origin that required human-directed control as agricultural modernization progressed into the borderlands (a favorite theme of the "utopian" Stalinist era) (Weiner 1984); and it promised to decrease human outbreaks of plague. Disease ecology provided logical scientific guidance for the rhetoric of disease eradication: "sanitizing" landscapes by "liquidating" the components, especially animals and insects, of the *ochag*.

Beginning in the 1930s, the natural focus framework bore fruit as the blueprint for scorched-earth anti-plague campaigns that would "sanitize" landscapes meant for agricultural development. The ecological understanding of plague meant that eradicating the disease depended on removing one or more components of the disease's *ochag*: "liquidating" the wild animals that harbored it, or the parasites that transmitted it. Led by the Anti-Plague Institute at Saratov, Soviet scientists began by presiding over the most extensive killing campaigns against burrowing rodents ever conducted. Adopting the language of public health, they called these campaigns "disinfection" of the rodents' native landscape (Fenyuk 1948, 1960). Focusing on the wild rodents' burrows, workers spread poison to kill the mammals and chemicals such as DDT (dichlorodiphenyltrichloroethane) to kill all insects. The final step in "sanitation" of a natural focus was the application of herbicides and fires to remove all vegetation, i.e. the rodents' food (Pavlovsky 1966; Naumov 1951; Naiden and Diatlov 1964).

Pavlovsky argued that the ultimate control of natural foci of disease was agricultural development, and he cited the example of an earlier anti-plague campaign. "We can assume that in the distant past the nidus of plague was much larger" in the area around the Caspian Sea, he wrote. Soviet agricultural development following landscape "sanitation" had successfully disrupted the disease's ecology. "Increased farming efforts…ploughing up areas of virgin land, the appearance of villages, and elimination of marmots," the latter under

supervision of ecologist N.I. Kalabukhov, had significantly decreased plague outbreaks (Pavlovsky 1966). Although outbreaks and most scientific research about plague officially remained state secrets (even more so as some of the Anti-Plague Institutes became sites of biological weapons research from the 1960s onward), Josef Stalin's death in 1953 opened a window of opportunity for Soviet scientists to exchange ideas with their western colleagues and to publicize the successes of plague foci "sanitation" (Mahoney et al. 2013).

In 1956, with state-sanctioned US–USSR scientific exchanges during Khrushchev's "thaw," Pavlovsky and his colleagues invited their American counterparts to visit carefully controlled locations and see the results of the landscape sanitation efforts. Since the U.S. had its own endemic plague problem in western prairie dog populations, Americans were keen to learn Soviet techniques for plague control.[15] By the early 1960s, Soviet and Western scientists interested in plague and other natural focal diseases converged at conferences, debated standard terminology, and published (by Pavlovsky's count) more than 2500 works in various languages "devoted…to natural-nidal diseases" (Pavlovsky 1966). The World Health Organization requested the Soviet government to organize a course on the "natural focality" of diseases in the USSR in 1960 and again in 1962 for specialists from various countries (WHO 1960). Pavlovsky published his final and most mature statement of the natural focus framework in his book-length treatise prepared for the Twenty-Second Congress of the Communist Party of the Soviet Union (October 1961), *Prirodnaya Ochagvost Transmissivnykh Bolezney* (*Natural Nidality [Focality] of Transmissible Diseases*). Determined to bring to Western scientists the "definitive exposition of [Pavlovsky's] ideas and those of his many followers," American parasitologist Norman Levine acquired copies of Pavlovsky's book published in Moscow in 1964.[16] Pavlovsky sent Levine originals of the photos and illustrations, and Levine secured funding from the U.S. Centers for Disease Control to pay for the book's translation and printing. The result was *Natural Nidality of Transmissible Diseases* (1966), which revealed the extent of the Soviet school of disease ecology for Western scientists. Here, Pavlovsky and the natural focus framework controlled the narrative received by Western scientists. In the preface, Levine highlighted the iconic natural focal disease: "Russia is the ancient home of plague, the most dramatic, the most extensive, and the most feared killer of mankind in all history" (Levine 1966).

Analyzing the history of plague and the natural focus framework allows us to capture some important historical and conceptual implications of Soviet disease ecology during the twentieth century.

First, "plague" and other natural focal diseases were comprised of imbricated material, political and cultural components, all interacting in the *ochag*. The important scientific visual representation was not a bacillus under a microscope, but the linkages between insect-infested burrows of wild rodents and their contacts with

[15] American visitors included virologist Richard E. Shope and veterinary disease ecologist Karl F. Meyer.

[16] Levine was a Professor of Parasitology at the University of Illinois, 1946–1983, and he worked on malaria and other vector-borne diseases. Levine depended on Frederick K. Plous, Jr., to translate scientific articles from Russian to English.

humans (Fig. 3). Envisioning endemic diseases as natural foci validated colonial practices by responding to disease problems in settlements and reinforcing the agricultural goals of the Soviet state (Meyer 1957; Josephson et al. 2013). *Ochagi* became visible when characterized as parasitocenoses that impeded these steps toward developing productive hinterlands and securing borders; and *ochagi* needed to be "disinfected" and "sanitized." In a convenient form of circular logic, the agricultural development and settlement associated with colonization were both the means and the goal of landscape sanitation. For Pavlovsky and his contemporaries, reading the sanitized landscape backward in time naturalized the processes of theorizing and attacking natural focal diseases by improving and internally colonizing the borderlands. Soviet scientists' official reports, and Pavlovsky's book translated for Anglophone readers, prominently featured the classic colonizer's 'empty lands' justification. As Norman Levine put it in his preface to *Natural Nidality of Transissible Diseases*, "zoonoses were encountered when the Russians extended their agricultural operations to uninhabited regions" (Levine 1966). Of course, these regions were *not* "uninhabited;" but for the purposes of colonizing the borderlands, this narrative rendered the indigenous nomadic peoples *invisible* in the process of making plague *visible*.

Second, by thinking of the natural focus framework as an entanglement of the material, cultural and political, we also problematize the notion that Soviet scientists had little intellectual freedom or autonomy while still acknowledging the difficulties they faced. The natural focus framework demonstrates what Jonathon Oldfield and Denis J.B. Shaw called a "subtle and two-way relationship…between Soviet scientists and the Stalinist state, with the former often seeking patrons among Party and State officials, and political ideology being a flexible rather than rigid instrument of control" (Shaw and Oldfield 2015). Pavlovsky's career, briefly introduced here, provides an instructive case. Not only was he successful in gaining patronage for expensive expeditions and institutional units, he felt secure enough to take risks–such as maintaining close professional relationships with ostracized colleagues. In December 1948, Pavlovsky even succeeded in hiring the anti-Lysenkoist, Academician Ivan Schmalhausen, for his staff at the Zoological Institute. Others he tried to hire included Professor Strelkov and Professor Polyansky, both of whom had lost their jobs for opposing Lysenkoism (Birstein 2009). Such a level of confidence reflected a secure political position, and for Pavlovsky that position arose in part from the political utility of disease ecology and the natural focus theory–practice framework. It provided the scientific justification for landscape sanitation campaigns and reinforced the ability of the Stalinist and post-Stalin regimes to exert power over vast landscapes and biological and human communities. Landscape sanitation campaigns boosted the political reputations of local and regional officials and served as a propaganda triumph for Soviet science on the international stage.

Pavlovsky's strategies thus included developing tools that would serve both science and the state, cultivating patronage and building an epistemic community around himself. Pavlovsky was a long-lived scientist whose charisma inspired a large and devoted following, including Polina Petrishcheva, who one contemporary called a "fanatically devoted disciple" of Pavlovsky (Diatlov 1996). His Russian ethnicity helped, as did his willingness to choose his words (written and spoken)

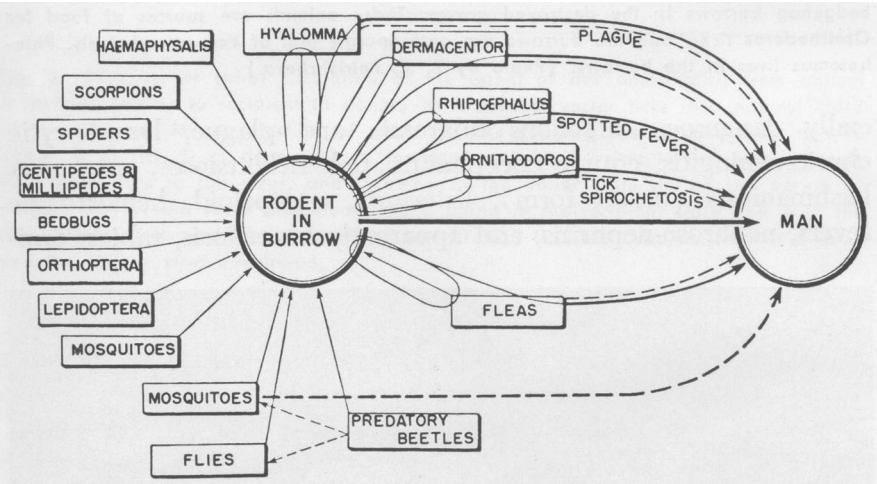

Fig. 3 "*From the Burrow to Man.*" Pavlovsky created this figure of a Central Asian rodent burrow to illustrate the concept of a rodent burrow as biocenose for human and animal diseases. From E.N. Pavlovsky, *The Natural Nidality of Transmissible Diseases* (University of Illinois Press, 1966), p. 12

very carefully. However, Pavlovsky's natural focus framework also enlisted adherents because it emerged from the intellectual traditions of the Russian biological sciences, including V.I. Vernadsky's "biocenose" theory, and enabled scientists to obliquely discuss sensitive topics (such as plague outbreaks and evolutionary theory). Most importantly, the natural focus framework developed at the time the Soviet state needed it: it provided scientific validation and guidance for Stalinist-era colonization and development projects, promising to help transform 'unproductive' peoples and landscapes and police the contested Soviet borders. Following Pavlovsky into this colonial terrain, even if very briefly, highlights a Russian-inflected view of the "environment" in sympathy with Warwick Anderson's characterization of it as "a far more animated…concept than the older notions of place and milieu that had prevailed in medical geography" (Anderson 2006). The multi-dimensional disease ecology of plague and other natural focal diseases flexibly helped to shape (and was shaped by) Russian and Soviet colonialisms.

Today, plague and other natural focal diseases still cause sporadic animal outbreaks and human cases in the former Soviet borderlands. Interviewed in 2016, eminent Russian parasitologist Eduard I. Korenberg pinned the importance of disease ecology to ongoing cycles of interaction between settler societies and natural foci of diseases. Scientists would always need to return to the field to conduct basic research, he acknowledged; but more crucially, disease ecology was entangled with a continuing human process of migration and settlement within Russia and its post-Soviet neighbors (Kazakhstan, Tajikistan, Kyrgyzstan, Turkistan, and Uzbekistan). "Builders will come tomorrow, they will set up a settlement—and what is in store for them tomorrow? A nidus is constant, people are more mobile," he explained.[17] In this simple assessment, Korenberg recalled

[17] Anna A. Amramina, Interview with Eduard Isaevitch Korenberg, 16 August 2016.

decades of human attempts to control the ecologies of the steppe, taiga and mountainous regions that Pavlovsky first entered over a century ago—ecologies that have persisted in the homelands of plague.

Acknowledgements For archival assistance, we thank Irina Vladimirovna Tunkina and Elena Annenkova, Archive of the Russian Academy of Sciences (St. Petersburg), and the staffs of the Bancroft Library (University of California—Berkeley, USA) and Bodleian Library (Oxford University, UK). Dr. Eduard Kolchinsky (St. Petersburg) and Dr. Eduard Korenberg (Moscow) provided valuable insights in interviews with the authors. We thank Bakhyt Atshabar, Director; Nailya Kabysheva; and Gulmira Utesheva of M. Aikimbayev's Kazakh Scientific Centre for Quarantine and Zoonotic Diseases; and Aidar Alikbayev and Aidyn Yeszhanov of the Bakanas field site. Two anonymous reviewers and the editors have made helpful suggestions, and we thank them and the participants at the "Making Microbes Complex" workshop, Queen Mary University (London), organized by Mark Honigsbaum and Pierre-Olivier Méthot.

Funding Funding was provided by National Science Foundation (Grant No. 1126923) and NOCC-Norwegian Centennial Chair/University of Minnesota Foundation Collaborative Grant.

References

Anderson, W. (2004). Natural histories of infectious disease: Ecological vision in twentieth-century biomedical science. *Osiris, 19,* 39–61.

Anderson, W. (2006). *Colonial pathologies: American tropical medicine, race, and hygiene in the Philippines*. Durham, NC: Duke University Press.

Beliavsky, M. E. (1895). O chumy tarbaganov [On tarbagan plague]. *Vestnik obshchestvennoi gigienui, sudebnoi I prakticheskoi meditsinui, 23*(2), 1–6.

Belousova, T. (1998). Чума [The plague]. *Sovershenno Sekretno, 10,* 18–19.

Besser, L. V. (1906). Kratkaya zapiska o tarbaganyei chumy na lyudyakh, nablyudavsheisya v Mongolii I zabaikalye v 1888–1897 godakh [Brief note on the marmot plague of men, observed in Mongolia and beyond Baikal in 1888–1897]. *Voyenno-med. J.,* ccxv, med-spec. pt., 279–293.

Birstein, V. J. (2009). *The perversion of knowledge: The true story of Soviet science*. New York: Basic Books.

Brain, S. (2010). The great Stalin plan for the transformation of nature. *Environmental History, 15,* 1–31.

Brain, S. (2011). *Song of the forest: Russian forestry and Stalinist environmentalism, 1095–1953* (p. 2011). Pittsburgh: University of Pittsburgh Press.

Brower, D. (1997). Islam and ethnicity: Russian colonial policy in Turkestan. In D. R. Brower & E. J. Lazzerini (Eds.), *Russia's Orient: Imperial borderlands and peoples* (pp. 1700–1917). Bloomington and Indianapolis: Indiana University Press.

Bruno, A. (2016). A Eurasian mineralogy: Aleksandr Fersman's conception of the natural world. *Isis, 107*(3), 518–539.

Bruno, A. (2017). *The nature of Soviet power: An Arctic environmental history*. Cambridge: Cambridge University Press.

Chase, M. (2003). *The barbary plague: The Black Death in Victorian San Francisco*. New York: Random House.

Demko, G. J. (1969). *The Russian colonization of Kazakhstan, 1896–1916*. Bloomington: Indiana University Press.

Diatlov, A. I. (1996). Tracking down the answer to the riddle of plague enzoonosis. *In Levi, Illuminating Studies, 4,* 11–20.

Echenberg, M. (2007). *Plague ports: The global urban impact of bubonic plague*. New York: New York University Press.

Etkind, A. (2011). *Internal colonization: Russia's imperial experience*. Cambridge: Polity.

Fenyuk, B. K. (1948). Ecological factors in the focality and epizootiology of rodent plague. Report III. Rodent control as an anti-plague measure (**in Russian**). *Trudy Nauchn. Konf. Posviashch. 25-Letnemu Iubileiu Institut "Mikrob," 1944.* Saratov: Nauka.

Fenyuk, B. K. (1960). Experience in the eradication of enzootic plague in the Northwest part of the Caspian Region of the USSR. *WHO Bulletin, 23,* 263–273.
Josephson, P., Dronin, N., Cherp, A., et al. (2013). *An environmental history of Russia*. Cambridge: Cambridge University Press.
Kashkarov, D., & Kurbatov, V. (1930). Preliminary ecological survey of the vertebrate fauna of the Central Kara-Kum Desert in West Turkestan. *Ecology, 11*(1), 35–60.
Khudyakov, I. V. (1997). The march of the plagueologists. In M. I. Levi (Ed.), *Illuminating studies of the Soviet anti-plague system* (Vol. 5, p. 245). Self-published.
Khudyakov, I. V., & Suchkov, Y. G. (1999). On the anniversary of Klavdiya Aleksandrovna Kuznetsova. In M. I. Levi (Ed.), *Illuminating studies of the Soviet anti-plague system* (Vol. 9, pp. 4–13). Self-published.
Kisselev, L. L., Abelev, G. I., & Kisselijov, F. (1992). Lev Zilber, the personality and the scientist. *Advances in Cancer Research, 59,* 1–40.
Kojevnikov, A. (2008). The phenomenon of Soviet science. *Osiris, 23,* 115–135.
Korenberg, E. I. (1989). Population principles in research into natural focality of zoonoses. In A. V. Iablokov (Ed.), *Soviet scientific reviews* (*physiology and general biology*), part 5 (Vol. 3, pp. 303–354). London: Harwood Academic Publishers.
Krementsov, N. (2002). *The cure: A story of cancer and politics from the annals of the Cold War*. Chicago: University of Chicago Press.
Kryuchechnikov, V. N. (2000). Полина Андреевна Петришева (к 100-летию со дня рождения) [Polina Andreevna Petrishcheva (to the 100th birthday anniversary)]. *Zoologicheskii Zhurnal, 79*(7), 876–880.
Lebedenko, A. (1961). *Война с невидимым врагом [The war against the invisible enemy]*. Leningrad: Lenizdat.
Levi, M. I. ed. (1994–2002). *Illuminating studies of the Soviet Anti-plague system.* 12 volumes. (**in Russian**). Self-published.
Levine, N. (1966). Editor's preface. In Pavlovsky, *Natural nidality of transmissible diseases*. Levine, N. Ed., and Plous, F. K. Trans. Urbana and London: University of Illinois Press.
Levit, G. S. (2000). The Biosphere and noosphere, theories of V.I. Vernadsky and P. Tielhard de Chardin: A Methodological essay. *Archives Internationales d'Histoire des Sciences, 50,* 160–176.
Lynteris, C. (2015). Ignoring native ignorance: Epidemiological enclosures of not-knowing plague in Inner Asia. In Roy Dilley & Thomas G. Kirsch (Eds.), *Regimes of ignorance: Anthropological perspectives on the production and reproduction of non-knowledge* (pp. 50–69). Oxford: Berghahn Press.
Lynteris, C. (2016). *Ethnographic plague: Configuring disease on the Chinese–Russian frontier*. London: Palgrave Macmillan.
Mahoney, C., Toppin, J., & Zilinskas, R. (2013). Stories of the Soviet anti-plague system, *CNS Occasional Paper* No. 18, Monterey Institute of International Studies. http://www.nonproliferation.org/wp-content/themes/pitch_premium/pdfs/130904_soviet_antiplague.pdf. Accessed 10 July 2018.
Meyer, K. F. (1957). Some observations on infective diseases in Russia. *American Journal of Public Health, 47*(9), 1083–1092.
Michaels, P. (2003). *Curative powers: Medicine and empire in Stalin's Central Asia*. Pittsburgh: University of Pittsburgh Press.
Minkh, G. N. (1881). *Отчет об астраханской эпидемии [Report of the Astrakhan epidemic]: Otdiel I: Vetlianskaia Epidemiia* (p. 1881). Moscow: M.P. Shchepkina.
Mirzoian, E. N. (1995). From the history of Soviet ecology: The evolutionary views of D.N. Kashkarov. *Russian Studies in History, 34*(2), 7–23.
Mobius, K. R. (1880). The oyster and oyster culture. In *Report of the U.S. Fish and Wildlife Commission* (Washington, D.C.: Government Printing Office, 1883), 41–45 (originally published in German in 1877).
Moon, D. (2017). The curious case of the marginalisation or distortion of Russian and Soviet environmental history in global environmental histories. *International Journal of Environmental History, 3*(2), 31–50.
Morrison, A. (2013). Review of Alexander Etkind. *Internal colonization. Ab Imperio, 3,* 445–457.
Morrison, A. (2016). Russia's colonial allergy. *EurasiaNet.org*. http://www.eurasianet.org. Accessed 2 March 2017.
Morrison, A. (2017). Stalin's giant pencil: Debunking a myth about Central Asia's borders. *EurasiaNet.org*. http://www.eurasianet.org/node/82376. Accessed 25 Feb 2017.

Naiden, P. E., & Diatlov, A. I. (1964). Prospects of the sanitation of the epizootic plague focus in the Kyzyl-Kums. In A. A. Volkova (Ed.), *Prirodnaya Ochagovost Bolezhny i Voprosy Parazitology* (No. 4, pp. 86–87). Frunze: Izdsvo an Kirgizskoi SSR.

Naumov, N. P. (1951). New methods in the fight against *Microtus arvalis*. *Zoologicheskii Zhurnal, 30*(5), 466–476.

Pavlovsky, E. N. (1934). Организм как среда обитания [The organism as a habitat]. *Priroda, 1,* 80–91.

Pavlovsky, E. N. (1937). Teaching about biocenoses as applied to certain problems of parasitology. *Izvestyia Akademii Nauk SSSR Ser Biol, 4,* 1385–1422.

Pavlovsky, E. N. (1939). The natural focality of infectious and parasitic diseases. *Vestnik Akademii Nauk SSSR, 10,* 98–108.

Pavlovsky, E. N. (1946). Fundamentals of the theory of natural focality of human transmissive diseases. *Zhurnal Obshchei Biologii, 67,* 3–83.

Pavlovsky, E. N. (1966). *Natural nidality of transmissible diseases*. Levine, N. Ed., and Plous, F. K. Trans. Urbana and London: University of Illinois Press.

Petrishcheva, P.A. (1960). *Разгаданная опасность* [A danger solved] (n.p., 1960). In English: Petrishcheva, P.A., Myshne, D., Trans. (1962) *Forewarned is Forearmed*. Moscow: Foreign Languages Publishing House.

Petrishcheva, P. A. (1962). *Perenochiki vozbuditelei prirodnoochagovykh boleznei*. Moscow:Gosudarstvennoe Izdatel 'tstvo Meditsinskoi Literatury.

Prohorova, N.P. (1972). *Академик Е.Н. Павловский* [Academician E. N. Pavlovsky]. Moscow: Meditsina.

Rakhimbekov, R. U. (1990). *Даниил Николаевич Кашкаров: 1878–1941 [Daniil Nikolaevich Kashkarov: 1878–1941]*. Moscow: Nauka.

Raleigh, D. (Ed.). (2001). *Provincial landscapes: Local dimensions of Soviet power, 1917–1953*. Pittsburgh: University of Pittsburgh Press.

Risse, G. (2012). *Plague, fear and politics in San Francisco's Chinatown*. Baltimore, MD: Johns Hopkins University Press.

Rosenberg, Charles E. (1979). Toward an ecology of knowledge: On discipline, context and history. In Alexandra Oleson & John Voss (Eds.), *The organization of knowledge in modern America* (pp. 440–455). Baltimore: The Johns Hopkins University Press.

Rupke, N. A. (Ed.) (2000). *Medical geography in historical perspective*. London: Wellcome Trust Centre for the History of Medicine at University College London.

Shah, N. (2001). *Contagious divides: Epidemics and race in San Francisco's Chinatown*. Berkeley: University of California Press.

Shaw, Denis J. B. (2015). Mastering nature through science: Soviet geographers and the great Stalin plan for the transformation of nature, 1948-53. *The Slavonic and East European Review, 93*(1), 120–146.

Shaw, Denis J. B., & Oldfield, J. (2015). Soviet geographers and the Great Patriotic War, 1941–1945: Lev Berg and Andrei Grigor'ev. *Journal of Historical Geography, 47,* 40–49.

Skrzhivan, F. (1901). Nashi svedieniya o tarabaganyci chumie [What we know about the plague among marmots]. *Russk. Arch. Patol., lin. Med., I bakteriol*, xi, 603–612.

Sokolov, V. E., & Shilov, I. A. (1989). Razvitie idei V.I. Vernadskogo v sovremennoi ekologii. *Vestnik AN SSSR, 7,* 91–95.

Starozhitskaya, G. S. (1998). What Mr. Karimi saw and should have seen when examining the work of the zooparasitology brigade in the territory of the Turkmen AP station. In M. I. Levi (Ed.), *Illuminating studies of the Soviet anti-plague system* (Vol. 8, pp. 141–150). Self-published.

Summers, William C. (2012). *The great Manchurian plague of 1910-1911: The geopolitics of an epidemic disease*. New Haven: Yale University Press.

Tinker, A. I. (1998). Reminiscences of working in the Budennovsk AP division. In M. I. Levi (Ed.), *Illuminating studies of the Soviet anti-plague system* (Vol. 8, pp. 68–87). Self-published.

Vernadsky, V. I. (1922). *Очерки и речи [Essays and public talks]* (Vol. 1). Petrograd: Nauch. khimiko-tekh. izd-vo.

Vyssokowitz, V. K., & Zabolotny, D. K. (1897). *Recherches sur la peste bubonique* (p. 7). No: Annales de l'Institut Pasteur.

Weiner, D. (1984). Community ecology in Stalin's Russia: "socialist" and "bourgeois" science. *Isis, 75*(4), 684–696.

Weiner, D. (1988). *Models of nature: Ecology, conservation, and cultural revolution in Soviet Russia*. Bloomington: Indiana University Press.

WHO [World Health Organization]. (1960). *Bulletin No. 2 and No. 3*. Geneva: WHO.