

PLAGUE PERSISTENCE IN WESTERN EUROPE: A HYPOTHESIS

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HUMAN PLAGUE OUTBREAKS occur after fleas infected with *Yersinia pestis* can find no other preferred hosts. Thus, plague is similar to the vector-borne infectious diseases that have been described as “spillovers,” because humans are not directly involved in the primary ecological processes that govern pathogen persistence (McMichael 2010; Ostfeld 2011; Quammen 2012). Plague persists via transmissions within a population of reservoir hosts, such as Eurasian great gerbils and marmots. This hidden, silent stage of plague transmission is now called “maintenance phase” plague,¹ and involves only burrowing rodents and their fleas. Burrows provide protected microenvironments for temporary survival of both bacteria and flea larvae (Anisimov, Lindler, and Pier 2014; Wimsatt and Biggens 2009). The precise mechanisms and ecological triggers that cause a wider, explosive “amplification phase” of plague, when highly susceptible animals begin to die, are not yet fully understood (Gage 2012). Intensive laboratory and field research projects focus on events early in a “transmission shift”: from ongoing flea-borne transmission within a maintenance host population to rapidly widening rodent die-offs, spread by many flea species (Buhnerkempe et al. 2011).

Today, several low-tech, early-alert surveillance systems teach people living near plague hotspots how to notice deaths among the rodents involved in plague amplification. Should the warning signs escape notice, laboratory and/or autopsy investigation of sudden human deaths in a plague-endemic region become the next-best alert that it is time to inter-

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I The terms “sylvatic” or “enzootic” are still used to refer to plague transmission exclusively among animals. More uncommonly, maintenance phase plague is called “primary plague,” and amplification (the spread to highly susceptible animal hosts), “secondary plague.” On the shifting scientific terminology, see Gage and Kosoy (2005).

rupt plague's spread. The remedy in both cases is the same: using pesticides to kill the fleas and flea larvae in areas near human habitation or worksites (Dennis and Staples 2009; Duplantier 2012; Stenseth et al. 2008). *Yersinia pestis* persists because it can infect a wide range of fleas, many of which do not feed on humans (Hinnebusch 2010).

Environmental conditions that favor flea activity and replication are linked to plague amplification (Wimsatt and Biggins 2009; Adjemian et al. 2007; Davis, Calvet, and Leirs 2005; Keeling and Gilligan 2000). Indeed, *Yersinia pestis* evolved from its ancestor, *Yersinia pseudotuberculosis*, through the acquisition of DNA permitting the infection of fleas. Because *Y. pseudotuberculosis* is able to live and replicate freely, typically in water, it needs genes that allow it to utilize environmental resources as nutrients. The new species *Yersinia pestis* lacks such capacity: it is an obligate pathogen. Instead, flea-borne transmission permits *Y. pestis*'s survival, as well as its capacity to survive at the body temperature of fleas (26°C/79°F), a capacity which is conferred by two unique plasmids (i.e., DNA molecules within the bacterium, but separate from the DNA chromosome of the organism). Even though slightly over 90% of the DNA is the same in both organisms, the "extra-chromosomal" or plasmid DNA is essential to the extraordinary virulence of *Yersinia pestis* (Hinnebusch 2005; Keim and Wagner 2009; Eisen and Gage 2009).² Because most fleas are able to clear *Y. pestis* infection from their gastrointestinal system relatively quickly, evolutionary pressure selects for strains of plague that overwhelm mammalian immune defenses, ensuring high concentrations of bacteria in the bloodstream. When fleas feed on an infected mammal, most of these insects can become transiently infected, able to transmit the organism to a new mammalian host (Perry and Fetherston 1997; Stenseth et al. 2008; Suntssov 2012). In sum, knowing that the evolution and survival of *Yersinia pestis* depends upon conditions favoring flea replication and dispersal changes how we historians can approach the problem of plague's four-hundred-year persistence in Western Europe.

2 Many of the genes which *Y. pestis* shares with *Y. pseudotuberculosis* became "pseudogenes" serving no known purpose. Some of the novel virulence genes that *Y. pestis* develops after the flea bite are genes that block many of the systemic immune defenses that warm-blooded mammals deploy. These genes are turned on ("upregulated") at a temperature of 37°C/98.6°F. Similar to other emergent pathogens, *Y. pestis* lost or scrambled key components of the chromosomal DNA of the ancestor organism, and it acquired the two additional plasmids unique to the killer bacterium, possibly in separate stages (Hinnebusch 2005). Many of the functions new to *Y. pestis* related to flea-borne transmission, but some included virulence factors in mammals, particularly the ability to cause an overwhelming pulmonary infection (Price, Jin, and Goldman 2012).

Bio-historical interest in European plagues typically concentrates on the origins and nature of the disease that appeared in 1347. Secondly, interdisciplinary interest once centered on the possible reasons for plague's eventual disappearance from Western Europe: a region that, for the purposes of this historical study, I will limit to medieval Christendom. Nicely summarized a generation ago by Stephen Ell (1984), plague's disappearance subsequently became a relatively less interesting locus of interdisciplinary debate. The best-supported arguments for plague's disappearance pointed to historical factors (such as modernization, change in interregional trade patterns, targeted public health measures) rather than specific identifiable biological or environmental changes in eighteenth-century Europe.

Until very recently, biologically oriented analysis of the cause, spread, and decline of plague outbreaks in Europe also focused on the habitats and habits of the genus *Rattus*, the species of rodents assumed to be fundamental to understanding medieval and early modern plague. Those who strongly supported the view that the Black Death was caused by *Yersinia pestis* (e.g., Benedictow 2004; Audoin-Rouzeau 2003), as well as those who equally vigorously opposed that view (Twigg 1984; Cohn 2002; Christakos et al. 2005), assumed that black rats and two anthropophilic fleas (*Xenopsylla cheopis* and *Pulex irritans*) were required for the spread of plague across Europe. The constraints imposed by the rat/flea model made the rapid temporal and spatial diffusion of human mortality in the Black Death epidemic of 1347–53 a site of intense historical debate. Benedictow (2004) concluded that plague could spread very quickly, “metastasizing” to settlements along rivers and roads, gradually diffusing into the agrarian spaces that surrounded towns: an argument consistent with some earlier work on British India. That is, passive redistribution of infected fleas and rats could infect sizeable populations of black rats (*Rattus rattus*) in cities, towns, and market centers.

My analysis assumes that many more mammalian and flea species were involved in plague maintenance and amplification in late medieval Europe, just as is the case today.³ Now that we are sure that the excess mortality of the great mid-fourteenth century epidemic was caused by

3 Bolton's helpful, very recent (2013) essay appeared too late to fully inform my present research. I agree with his shift in emphasis to non-*Rattus* plague host species, and will not here repeat his important summary of plague transmission by fleas that do not become “blocked,” a classic mechanism for plague described in Bacot and Martin (1914). Their work led to a long-standing assumption that one flea species, *Xenopsylla cheopis*, was the primary insect vector in plague epidemics.

Yersinia pestis, it is vitally important to understand the ecological features of areas where high levels of human mortality are discernible. Ecology is the study of interrelationships among all living organisms, as well as with their physical surroundings. This means that the anthropocentrism of familiar contagion-based diffusion analyses hinder our full understanding of the initial catastrophe. Contagion-based understanding of Black Death plague mortality tends to elide evidentiary lacunae, in order to claim that the epidemic was uniform, sparing only a few cities, towns, and regions. But given that *Y. pestis* has been identified as the primary cause of the overall pandemic, this molecular-archeological finding redraws the ecological and historical questions that we must now confront.

For example, the apparent speed of plague's spread across different European regions and within human populations has traditionally been calculated by mapping accounts that offer very little more than a brief allusion to an epidemic: these have been staple findings of the contagion-driven model of Black Death diffusion. Rethorizing and problematizing maps of Black Death mortality is therefore an important next step, as David Mengel (2011) has shown. Meanwhile, it is now evident that the initial mid-fourteenth century epidemic cannot be explained by appealing to a uniquely virulent emergent strain of *Y. pestis* at the time of the Black Death. The archaic *Y. pestis* DNA recovered from Black Death plague pits shows no significant genetic differences from bacterial strains of plague still extant today. Further study of the plague genome in its ecological contexts is consequently another important next step, as we try to understand "the genetic changes involved in [plague's] transformation from a sylvatic pathogen to one capable of pandemic human infection on the scale of the Black Death" (Bos et al. 2011: 506; and see Green 2014, in this issue).

But genomic and molecular-archeological studies cannot account for the initial demographic collapse and the lingering population stagnation that characterizes many areas of Western Europe in the century following the Black Death. We must look to other historical factors to explain mortality patterns, indeed, bringing to the foreground many that have long been a part of more complex understandings of the late medieval period. For example, DeWitte's analysis of Black Death victims buried in East Smithfield, London (2009, 2010, and 2014, in this issue), provides strong evidence that poor prior health status increased an individual's risk of dying during a plague epidemic. Recent syntheses of economic and demographic evidence suggest that the surviving population was *not* a more privileged one that escaped a Malthusian trap; epidemics and famines recurred, exacerbated by warfare in many regions. Borsch (2014, in this issue), meanwhile, analyzes the processes of social and economic

collapse, undermining the stability of crucial infrastructures supporting urban populations. I find the global framework provided by Bruce Campbell's recent synthesis of northern hemisphere climate change to be most promising (Campbell 2010, 2011, 2013). Overall, I was inspired to focus on plague outside urban centers by Campbell's suggestion that the long secular decline in population numbers and overall population health during the period 1300–1800 CE are best situated in a wider ecological and climatic context.

With the knowledge that *Yersinia pestis* accounts for the dramatic mortality levels seen in the Black Death, we should expect that different localities would have experienced mortality crises of quite different dimensions. Yet historians of European plagues have shown a strong tendency to connect only the bigger data-rich dots, remaining unimpressed by patchy and problem-ridden evidence from rural hinterlands. As a consequence, a common claim is that plague became almost exclusively an urban phenomenon in Europe by the fifteenth century. (e.g., Alfani 2013). Renewed, detailed study of the paths and timing of recurrent waves of plague in Western Europe is necessary, given what we now know of the ecology of *Y. pestis*. Plague first spills over around a limited number of maintenance reservoirs, which are “heterogeneous at global, regional, and local scales” (Eisen and Gage 2012: 63). How, then, does it travel between rural areas, small market centers, and larger cities?⁴ The papers by Nükhet Varlık (2014) and Michelle Ziegler (2014, both in this issue) offer detailed observations on amplifying rodent host species (Varlık) and the circumstances and locations in which flea “super-production” would have amplified flea-borne transmissions to susceptible mammals, including humans (Ziegler). Here I will direct attention to a remote region serving as habitat for a possible plague maintenance host.

Plague today is found on most, but not all, continents. It was eradicated from Australia by the mid-1920s but persists in both North and South America, in many regions of Africa, and across Eurasia east of the Black Sea. On continents where plague is found, reservoirs are heterogeneously arrayed: thus, transmission hotspots are discontinuous. Were there simi-

4 Not all waves of plague in Europe would have been generated by spillovers from remote maintenance foci. In an extraordinarily valuable case study of endemic plague in London, c. 1550–1665, Cummins, Kelly, and Ó Gráda (2013), show that plague persisted for up to a century in London, without requiring reintroduction of the pathogen from rural hinterlands or maritime commerce. A city the size of London (population c. 60,000 in 1550) would have supported a heterogeneous population of *Rattus rattus* rodents, some surviving and resistant, others susceptible. When fleas could not find a nearby rodent host, however, humans would serve.

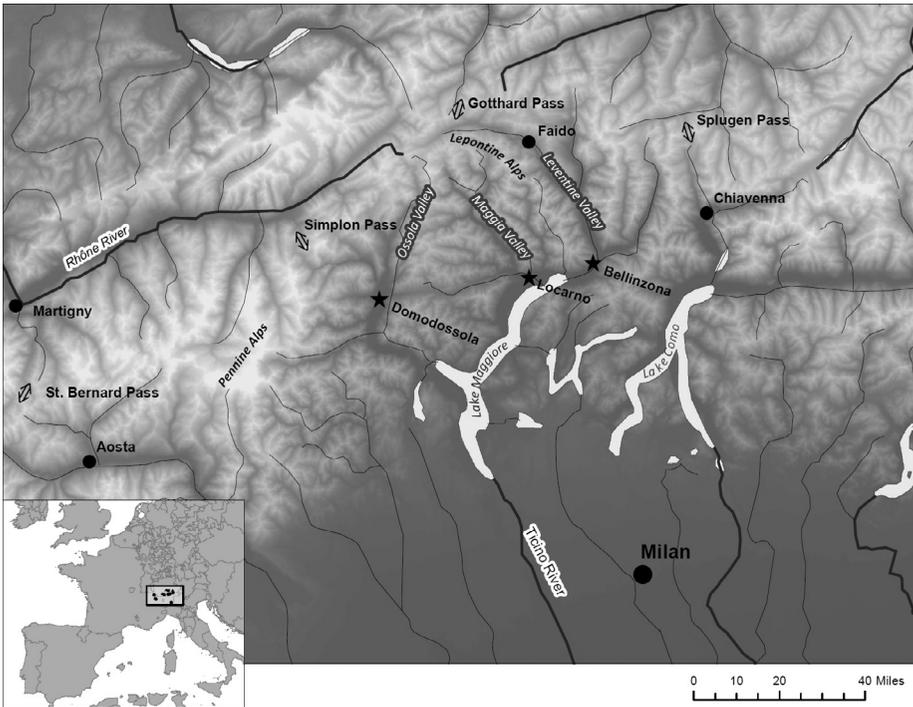
lar zones in Europe where plague could have been maintained in a reservoir host, readily amplified by fleas to involve susceptible wild rodents and lagomorphs (e.g., squirrels, voles, rabbits), and eventually extending to the infamous black rat (*Rattus rattus*) and/or human fleas (*Pulex irritans*) to cause a dramatic plague outbreak? My restudy of plague persistence in Western Europe begins with archival sources indicating that plague could have persisted in the southern Alpine region, in just such natural reservoirs. Europe's alpine zones are not often discussed in historical work on the Black Death and its recurrences, because research understandably centers on devastating late-stage zoonotic spillovers, the epidemics. Evidence nonetheless exists for plague in Europe's alpine uplands, suggesting a new approach to the larger story.

A Few Plague Deaths along High Mountain Roads, 1567

Milan's public health office, an impressive and extensive bureaucracy since the 1400s, systematically monitored plague cases on the state's northern frontier. Traditional Milanese plague surveillance evolved by concentrating on principal trade routes and nodes linked to the military boundaries of Lombardy, including those roads leading toward various Alpine passes (Pracchi 1971: 5–14 and 165–72). But surveillance over upper Lombardy collapsed during the half-century of horrors attending the “Italian Wars” (1499–1559), which subjected all of northern Italy to recurring food shortages, plagues, and pestilences (Mallet and Shaw 2012; Alfani 2013). Foreign troops repeatedly crossed the mountains into northern Italy, and often it seemed that plague came with them.

By the late winter and early spring of 1567, after hostilities had ended, public health officials in Milan resumed aggressive plague surveillance. According to a well-placed Dominican, Gasparo Bugati, they assumed that the city of Lyon presented the greatest danger of plague this particular year. Italian princes had fled Lyon after paying homage to the new Holy Roman Emperor in 1565. The following year, plague spread eastward over the Savoyard-controlled western Alps, ravaging areas involved in most transalpine commercial and communications networks. When Bugati published his massive history of Milan up to the year 1569, he believed that these heightened precautions proceeded from a constant fear of another catastrophic plague like that of 1524, the worst in living memory.⁵ In that

5 “[. . .] partì di lungo pel timor della peste già per queste parti principiata, e incrudelità poi per l’Alpi, che traversano la Savoia ne gli Suizzeri, & ne’ Grigioni: tanto che in Chiavenna, & per quei suo contorni morirono gi huomini de’ dieci gli otto: cagione



Map 4. Locomes in the Southern Alps Reporting Plague Outbreaks to Milan (Spring 1567). Map created by Theresa Quill for Indiana University Libraries, 2013.

year, almost 50,000 had died, out of a population fewer than 100,000, and economic recovery was fitful, crippled further by protracted regional warfare (Bugati 1570: 1047; d'Amico 2012: 11–13, 33; Zanetti 1977).

From more specific surviving archival documents in the health office, we know that the Milanese expected that plague would funnel through the mountains. In 1567, letters sent in early spring from local officials in three southern Alpine market towns reported recent plague cases in hamlets to their north.⁶ Although many of these Italian-speaking settlements can no

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⁶ All of the letters referenced here come from records of the Conservatori alla Sanità in the Archivio di Stato of Milan, p.a. [parte antiqua], n. 279: a box containing a bundle labeled *peste*. Unnumbered letters are cited by date. For example, a letter from Bellinzona, dated March 30, 1567, notes new plague cases in three settlements in the Leventina valley, one place named Tortengho (two deaths, two ill), another named Calpiogno (a woman died), and a third called Mairengno, where "some little children" had fallen ill.

longer be found on modern maps, the reporting centers are still important today. Domodossola, Locarno, and Bellinzona all had centuries-long ties to Milan, and informants in each town provided some details about each suspected plague case. The map locates principal places either named in these letters or relevant to itineraries by which travelers from Lyon would have reached Milan. These three mountain towns were vital to Milan's strategic and economic interests because they were situated on Ticino River tributaries that emptied into Lake Maggiore near Locarno, thirty miles west of Bellinzona. The Ticino reforms south of the lake, crossing the plains to meet the Po River.

Control of the Ticino River, which often served as a geographical boundary between Lombardy and the Italian Piedmont, was a vital economic interest to Milan during the Middle Ages. Milan's rise to power and prominence as a regional state capital was due to novel water-management strategies: because no great river ran through the city, its economic expansion depended on sustained innovative, hydrological projects, binding all these areas into a network of cities and regions with different local resources (Boucheron 2001). By the late thirteenth century, Milan became one of the richest cities in Europe, able to exploit the Alpine river tributaries within an already vast canal system. The famous *vie dei marmi*—the marble routes—brought great marble and granite stones, and the men who carved them, from the mountains to the cities (Soldi Rondinini 1989). Canals transported building supplies, meat, pelts and a steady infusion of immigrants from the Alpine regions (Grillo 1994). In the sixteenth century, migrants from the southern Alps still found work as porters and domestic servants in Milan; other hill-town people, including skilled artisans (e.g., stone masons), followed patterns established for centuries, resettling in the metropolis or living half of each year in each location (d'Amico 2012: 55). Alpine furs lined some of the Milanese gloves, bonnets, and caps which were sought after around Europe.

In 1567, plague appeared in different mountain valleys that were separated east to west by formidable peaks.⁷ Not only would it have been nearly impossible, given the season and the distances, for these sporadic cases to be transmitted by human contact, the cases of plague show no

7 Many of the tiny places named in these letters had connections to Milan stretching back many centuries. Initially, the tie was to the distinctive Ambrosian Church of the earlier Middle Ages; much of today's Swiss Canton Ticino, still Italian-speaking, was once called the *vallate ambrosiane* (Ambrosian valleys). With the Visconti and Sforza *signorie*, they each independently established pacts and agreements tying them to the regional state of the fourteenth and fifteenth centuries: see Chittolini 1985.

straightforward movement of infection along one or another route from Lyon which humans could have used. To appreciate the significance of the archival evidence, some preliminary historical and geographical background is useful.

Bellinzona and Domodossola were (and still are) Italian-speaking centers that served travelers connecting to mountain passes, but the routes northward diverged significantly. The Gotthard Pass, 45 miles northeast of Bellinzona moving up into the Leventina Valley, was more frequently used by German-speaking merchants and migrants (Racine 2004). It led into the Uri Canton and the Reuss Valley, at the headwaters of the Rhine River. Domodossola (so named because it is at the head of the Italian Ossola Valley) instead connected Lombard travelers to the French-speaking Valais Canton, through the Great St. Bernard Pass. Heavily used since the early Middle Ages, the Great St. Bernard route linked Mediterranean Italy to the Low Countries and British Isles via the Rhineland. Many of the travelers (and armies) moving through the St. Bernard Pass and the Mont Cenis Pass (further to the west and thus not on the map provided) would more easily proceed south through Ivrea and Aosta, and to Turin and Genoa. In the mid-sixteenth century these cities and lands, today part of Italy's Piedmont province, were controlled by the counts of Savoy, and were not areas the Milanese could monitor easily.

A third major Alpine pass essential to Milanese trade was the Simplon Pass, just 41 km (25 miles) away from Domodossola. While closer to the town than was the route to the Great St. Bernard Pass, reaching the Simplon involved a steep climb into the Lepontine Alps. This was the most direct route if plague were spreading between Lyon and Milan by a series of contacts. Access to the Simplon route had been created by medieval Milanese merchants eager to circumvent tolls exacted by agents of the count of Savoy, in control of the western French Alps (Bergier 1997). The Simplon route followed the upper Rhône River as it passed by Martigny. From that important medieval hub, one would continue toward Geneva and alternate routes north through the Jura Mountains, toward Burgundy, Champagne, and Paris. By comparison, it was the longer, and in several ways more rigorous journey—especially as it presented various seasonal challenges—but the Simplon route did not necessarily entail higher transport costs. The Romans had not used the Simplon, and the Gotthard Pass and the St. Bernard Pass were also used more in the medieval centuries than in antiquity. (The Romans had instead cleared and exploited passes in the far western Cottian and Graian Alps, for the conquest and administration of Gaul.) During the later Middle Ages, Milanese trade thus steadily pulled the axis of transalpine communications eastward to the Central Alps (Frangioni 1983: 18–22; Ugolini 1985; and Bergier 1997).

The salience of these complex geographical features to the Milanese plague surveillance of 1567 is their connection with routes and passes along Ticino River tributaries. However, long before this time, larger ecological and political changes to the region had affected the entire southern Alpine zone during this period: changes that (as I argue) facilitated the establishment of plague maintenance foci. An historical ecology of Alpine-region plague cannot respect the political, linguistic, and social boundaries that have hitherto shaped most historical study of the past. Essentially, we should first understand that different Alpine passes threaded north-south traffic through different Alpine valleys, thereby passing towns and hamlets that may look close to one another on some maps, but were not actually in easy trading distance one from the other.

At the beginning of February 1567, health deputies in Locarno (situated between Domodossola and Bellinzona) relayed news of suspicious deaths in the Val Maggia. Two women had died suddenly, one of them with a *bugnone* (bubo) behind one ear. The officials wrote to say that they had implemented plague controls, but did not describe their actions further. In mid-February, a frustrated health commissioner in Domodossola independently complained of costly trade and travel restrictions, claiming that he had been on the lookout for plague for the previous three years, guarding the roads day and night. He expected that travelers from Lyon or Savoy would bring plague, but had no knowledge of events in Locarno. Two months later, a more detailed letter from Bellinzona, dated April 25, reported cases near a larger settlement in the Leventina valley, halfway to the Gotthard pass:

The day before yesterday we wrote to you about some cases occurring in Faido in which we suspected plague. To be certain, we sent out one of our deputies and he provided a written report certifying that in this place of Faido a little boy died of plague, [and that he had also] discovered a man who had the disease in one armpit.⁸

Reassuring Milan's health office that they (officials in Bellinzona) had implemented appropriate procedures, they volunteered details of uncon-

⁸ Milano, Archivio di Stato, Conservatori alla Sanità, p.a., n. 279: "L'altro ieri una l[ette]ra. scrivessimo[...]le certi casi occorsi in Faido dubiosi di peste, et per sapper sicuramenti come era il fatto haveramo man[dat]ti uno de n[ost]ri Deputati al ritorno del quale fatta la sua relatione che subito ne haressemo scritto la verità a quelle. Così è gionto detto n[ost]ro Deputato certificandone ch fa esso luogho di Faido è morto uno putto di peste, et uno huomo essergli scoperto tal morbo sotto una sella. ¶ Dipui che nelle Montagne d'esso luogho di Faido à quelli luoghi dove già muolt' giorni fa la peste anchor regnava fa progresso. Il tutto si fa per riguardarsi v[ostri] s[ignori]. . ."

nected cases in three tiny settlements where they found other presumptive plague cases; they verified oral reports by undertaking direct bodily inspection of the victims; then they prepared to receive district officials, dispatched by orders from Milan, to investigate the full extent of the infected zone.

From other reports this same year, the Milanese knew that the geographical scope of the plague threat was not limited to the Canton Ticino. During the spring and early summer months, the health office and even well-informed citizens received a steady stream of similar alerts from officials in Bergamo and mountain areas as far to the east as Trent. Plague menaced the Grigioni (Grisons), a German-speaking Swiss canton much further east, in a region connecting Milan to the Splügen Pass by way of Chiavenna.⁹ Still other cases popped up along the roads that doubled back eastward into the Venetian Trentino. Plague reports coming to Milan from these areas further east included similar postmortem descriptions of confirmed plague deaths, but (with practiced facility) they blamed plague's spread preemptively on travelers or undesirable migrants, or on infractions to good order by smugglers, tax evaders, and delinquent watchers.

Thus in 1567, plague menaced Milan's Alpine fringe: west, east, and center. Yet specific trade and travel connections to the known plague in Lyon were elusive. Despite consistent and worrisome news, cities and towns of the northern Italian plains did not confront an epidemic later that year. From the end of winter into the summer, the Milanese authorities received and responded to plague reports. Spared the worst, they eventually filed away letters that required no further action. There is no evidence (at least in the box of papers now containing these letters) concerning how Milan's health office ultimately assessed these mountain-region plague threats. Considering the letters strictly as historical evidence, we know that the Milanese had mostly well-established routines of remote, rural-area surveillance in place by the mid-sixteenth century. The control that Milan could exert was impaired during the decades of war, but economic integration of upper Lombardy and the southern Alps had not been fractured either by warfare or the shift in political boundaries when the Canton Ticino became part of the Swiss Confederation. Officials

⁹ Bugati (1570: 1047): “. . . partì di lungo pel timor della peste gia per queste parti principiata, e incrudelità poi per l'Alpi, che traversano la Savoia ne gli Suizzeri, & ne' Grigioni: tanto che in Chiavena, & per quei suo contorni morirono gi huomini de' dieci gli otto: cagione che à Milano si fecero strettissime guardie, come quello che ricordavasi della infinita strage dell'anno del 1524. passato, & si per questa diligenza, come principalmente per la pieta d'Iddio conservossi intatta.”

in the hinterlands were in the habit of reporting plague to the office in Milan, regardless of their transient political allegiances.

More detail about the diffusion of sporadic plague outbreaks through the southern Alps might lead us to a better understanding of the beginnings of the great epidemic that pummeled northern Italy later, in the 1570s. The point of this preliminary excursion is, instead, to show that early spring cases could not have been connected to one another by normal channels of human communication and interaction. All these routes, through high mountains and treacherous late winter Alpine climes, seem labyrinthine paths for plague to travel from one known-infected city, Lyon, to another large and vulnerable city, Milan.

Endemic Plague in Alpine Europe during the 1560s

Sporadic Alpine plague cases in the Canton Ticino illustrate that contagion-based transmission scenarios for the spread of plague do not map onto the evidence from 1567. The zone at risk was too wide, the known cases disconnected, the terrain too difficult, the season uncooperative. Contemporary with these Milanese records, archival evidence of endemic plague in other areas of Alpine Europe actually suggests plague *persistence* in this general region during the mid-sixteenth century and for at least a century before that. In the Haute-Maurienne, this evidence is illuminated by some extraordinary dramatic and artistic artifacts.¹⁰ In 1567, a village near the northern outlet of the Mont Cenis Pass, Lanslevillard, orchestrated the performance of a traditional mystery play, the *Mystère de Saint Sébastien*, in honor of the saint frequently invoked in times of plague. This two-day dramatic event was probably based on a much older template (Symes 2011) scripted in the early fifteenth century, before the painting of the murals in Lanslevillard's chapel of Saint-Sébastien (1446–1518), which also document this village's long experience of recurrent plague outbreaks (see **Plate 2** on page 230). Other performances of plays dedicated to that saint were mounted elsewhere in the Maurienne in the mid-1560s, as they had been a generation earlier, when the plague last circulated there. Indeed, there is widespread evidence of many other artistic and theatrical responses to plague in this region (Leandri-Morin 1997). In a few instances, we have specific archival evidence to show that such performances fulfilled a community's prophylactic vow (made at a time when

10 The Maurienne follows the Arc river valley and connects Lyon to Turin across the Mont Cenis Pass, by way of Susa and the Susa Valley. Outbreaks here are typically explained by its proximity to trade.

plague raged) to honor the saint (Chocheyras 1971; Lebègue 1975). All of this evidence points to the plague's wide diffusion into the transverse Maurienne valley, as well as along the longitudinal ones of Canton Ticino.

Study of plague in an ecological zone such as the Alpine region is difficult. Historians tend to search for plague within a specific archive, a political domain, or urban setting. Many different kinds of boundaries—political, linguistic, religious, social, economic—frustrate attempts to gather and evaluate evidence from ecologically similar regions of Europe that sprawl across these boundaries. Thus, the rather limited evidence presented here can be usefully compared to that uncovered by William Naphy, mostly from Genevan archives, and by Edward Eckert, using principally south German parish records.

Naphy's research found that 1567–72 was the single worst plague interval in Geneva's history (Naphy 2002: 13–16, 18–19, 108–19, and 163). He initially wanted to understand why, from 1470 to 1530, records from the western Alps provided dramatically increasing reports of plague deliberately spread by "greasers" (*engraisseurs*). This accusation was a manifestation of the popular notion that plague could be transferred by oily substances, carried by persons who themselves did not contract plague (see also Preto 1987). Though similar fears of plague spreaders had emerged in the western Alps at the time of the Black Death (Guerchberg 1948; Arrizabalaga 1994; Cohn 2007), later medieval fear of plague-carriers in the western Alps coincided with a surge in witchcraft persecutions. Prior to Naphy's research, scholars had argued that witches and "greasers" were variant expressions of general popular anxiety during an age of rapid social and economic change to the countryside. After all, Geneva was still a small city (less than 20,000) that served as a refuge for displaced country people during the late fifteenth and early sixteenth centuries. Situated along the dangerous confessional fault lines of the Protestant Reformation, Geneva and its leaders had to discern heresy from superstition, even in plague times.

But contrary to his expectation, Naphy found that the fear of persons spreading plague was fueled by a gradual recognition that plague was endemic. Between 1470 and 1530, local plague epidemics increased, but Geneva's governing elite treated each outbreak as a new external threat. Accordingly, they applied costly reactive measures to each newly discovered case of plague. When their *de facto* approaches failed, they made little effort to stanch rumors that plague workers (nurses, launderers, gravediggers, barber-surgeons, and so on) were seeding new cases in order to hang onto their high, hazard-pay wages. By 1567–72, frustrated city managers finally adopted the more proactive, remote surveillance

approach Milan had long taken. They began to treat plague as something flowing from the countryside all around them, not something deliberately spread in the city by persons hoping to sustain the plague. Accordingly, they spent money during quiescent intervals. They funded the retention of pest-house staff over winter months and required medical certification of cause of death. They applied sustained attention to the identification of new plague cases and put brakes on commercial ties between these people and places and the general urban community. After 1572, “greasers” finally became harder to find, and the plague seemed to release its century-long grip.

In a study focused on a region just north of the Alps, epidemiologist Edward Eckert (1996) analyzed parish death records that covered an eighty-year span, from 1560 to 1640. Mapping intervals of crisis mortality at the local level, he found two distinctive pathways implicated in plague outbreaks within the region. He argued that larger-scale trade corridors transmitted plague from maritime areas to southern, German-speaking European towns and villages. But once plague reached the interior, outbreaks moved around the entire region in pathways defining a “closed system”: that is, without a new plague wave coming from the maritime epicenters. These internal cycles repeated every five to ten years. Thus, Eckert emphasized different spatial and temporal differences between local crisis mortality in the German-speaking regions north of the Alps (stretching from the Rhine river to today’s Czech Republic) and the patterns of plagues that originated in European maritime cities. He argued that we should look at regional clusters of plague rather than study only focal epidemic outbreaks, and see that plague moved by “traveling waves” from one cluster to another contiguous cluster.¹¹

Eckert parsed evidence from hundreds of parish registers, spanning a century and covering a generous portion of Central Europe, but focused entirely on Protestant records that provided no evidence of similar events in the Alps, Catholic Bavaria, or Slavic-speaking regions further east. His mapping of temporal plague patterns within larger regions is nevertheless quite valuable, because it helps us to see that plague outbreaks were neither random nor sporadic. (Lacuna-ridden documentation and uncertainties about the historical diagnosis of plague deaths can otherwise lend

11 The characterization of “traveling waves” comes from Adjemian et al. (2007): a historically interesting spatio-temporal review of the eastward expansion of plague from western coastal cities of the United States in 1900, from which it spread across the Rocky Mountains, and then extended as far east as Kansas. Within forty years, plague traversed 2250 km (nearly 1400 miles).

the impression that plagues followed no clear pattern.) Although Eckert's evidence is consistent with my hypothesis that Alpine plague foci existed, I question his assumption that plague had to be repeatedly reintroduced to the coastal cities of Western Europe in order to set these regional plague cycles in motion. In a subsequent evaluation of the factors leading to bubonic plague's retreat from Central Europe over the long eighteenth century, Eckert accordingly emphasized the decline of exogenous plague introductions to the maritime coasts in order to explain plague's eventual disappearance (Eckert 2000). Here, Nühket Varlık's recent work on plague in the Ottoman empire makes untenable Eckert's backdated assumption that trade with Anatolia could have been the proximate origin of late medieval European plagues.¹² The path of plague spread in the fifteenth and sixteenth centuries instead moved the other way, from Venice and its hinterlands eastward into the Balkans and Black Sea littoral (Varlık 2012 and 2014, in this issue).

The Western Alps and Black Death Mortality

Interdisciplinary application of recent plague ecology to historical investigations of the Black Death requires a regional focus in addition to research at the global and local levels.¹³ The southeastern region of what is now France is happily an ideal place to begin such inquiry. Those familiar with narrative histories of the Black Death—in particular, with Rosemary Horrox's collection of sources—know that striking accounts of the Black Death in Marseille and Avignon illustrate different aspects of the catastrophe than the accounts that we have from Tuscan and English sources. The magnitude of the demographic catastrophe and social disruption in Marseille has been well studied (Smail 1996; Michaud 1999). Similarly, a range of texts generated in and around the court of Pope Clement VI include staple Black Death accounts by the natural philosopher Conrad von Megenberg (Gotschall 2003); the physician Guy de Chauliac (1363/1997: 2, 119); and the musician Ludwig van Kempen, a close friend of Francesco Petrarca, writing in Avignon (trans. in Horrox 1994: 41–45). Petrarca himself had fled Avignon, taking refuge from the pestilence in the Vaucluse,

12 I am especially grateful to Nühket Varlık for correspondence with me on this point, and her ideas on how altitude and Mediterranean ecology, as environmental determinants, might support possible Alpine plague foci. See her essay (2014) in this issue.

13 Here, as elsewhere throughout this essay, I use “Black Death” with temporal specificity, to refer to the singular epidemic wave 1347–53.

right at ground zero of plague's spread into the French Alps.¹⁴ From the Provençal region broadly, including also southwestern France and northern Iberia, we possess the notorious written accounts of the early, widespread riots and massacres of Jewish communities (Cohn 2007; Foa 1992: 7–23; Nirenberg 1998: 231–49; Shatzmiller 1974; and Biraben 1975: 54–71), now further substantiated by the work of Colet and colleagues (2014, in this issue).

Plague seeped into these temperate alpine regions from early-infected Mediterranean port cities, moving toward Europe's upland interiors, high plains, and Massif Central. Alpine regions included the Pyrenees (linked to eastern Iberian ports), the Julian Alps (in Venice's hinterlands), and, above all, the maritime and western (French) Alps, where we have disproportionately more urban archival evidence of the plague's spread and social effects than elsewhere. The Apennine chain in Italy is also an alpine zone, but one characterized by a Mediterranean climate regime (Nagy, Grabherr, and Thompson 2003). I am limiting discussion here to the alpine region where we have substantial and diverse documentation about the Black Death, but Tàrrega (Colet et al. 2014, in this issue) and many other market centers in upland Iberia could illustrate a similar pattern of severe Black Death mortality in regional market centers connected to alpine zones (Emery 1967; Phillips 1998).

Historical evidence and contexts are as fundamental to the new interdisciplinary study of past plague as are the ecological and environmental determinants of regional plague amplification. Biraben's monumental plague history (1975) argued that plague's effects during the Black Death were not uniform, but instead varied according to the season during which the plague first arrived. Evidence subsequently wrested from the Savoyard archives confirms his observation. Such geographical variation in mortality experience is far more characteristic of the previous diffusion of *Yersinia pestis* than it is of human infection spread by contagion. Evidence of plague's incursions into Alpine Savoy is, for this time period, abundant, permitting some demographic study of Black Death mortality in rural hinterlands (Carrier and Mouthon 2002). At the same time, many different important social and political changes overlap the Black Death's

14 We do not know precisely when Petrarca was at his villa in Vaucluse. He was in Avignon until November 1347, when he left for Parma and Verona. He learned of the death (in Avignon) of the woman whom his love poems made famous (Laura) while he was in Verona, and was likely in the Vaucluse to finish his *Secretum* in 1349–50. That year, he went to Rome for the Jubilee and returned to the Vaucluse for the last time, 1351–53, before moving to Milan. See Kirkham and Maggi (2009: xix–xx).

diffusion through the western Alps: for example, the most brutal phase of the Hundred Years' War (Sumption 1990: 6–13) and the rising political and military career of the extraordinary young duke of Savoy, Amadeus VI, who created a transalpine feudal state (Cox 1967). From the late 1340s through the 1360s, the entire region was subjected to new stresses on local resources, primarily caused by demobilized soldiers coalescing into mercenary companies.

Given the number and variety of potential mammalian hosts for *Yersinia pestis* in these human-churned landscapes, it is reasonable to postulate the establishment of enzootic plague foci, although not with geographical precision. Thankfully, unusually detailed accounts of Savoyard district administrators allow historical reconstruction of the multi-century processes of the region's occupation, cultivation, and late medieval abandonment (Carrier and Mouthon 2010: 11–30 and 171–205). For example, we know from Savoyard archival sources that high mortality during the Black Death epidemic occurred in the *bailliages* of Chambéry, Chablais, Bugey, Bresse, the Viennois, the Maurienne, the Tarentaise, and in the Italian Piedmont, the Val d'Aosta, and the marquisate of Susa. Two especially useful social and demographic studies of localized Black Death mortality in Savoy show that plague mortality was greater in the surrounding countryside than in the towns, that the season at which the plague arrived affected the severity and duration of the epidemic interval, and that the Alpine population steadily declined in the fourteenth and fifteenth centuries. Gelting (1991) establishes that Martigny, an important market town connecting travel from either the Mont Cenis Pass or the Simplon Pass to Geneva, suffered rural population losses up to 45% during the Black Death. Andenmatten and Morerod (1987) likewise show that Black Death losses in hinterlands of larger centers—in their case, Lausanne and Geneva—were greater than within urbanized settlements. As I have already suggested, evidence from remote villages in the Maurienne indicates that these communities continued to struggle with recurrent plague outbreaks throughout the fifteenth and well into the sixteenth centuries.

A regionally integrated analysis of economic and ecological changes within the western Alps following the Black Death would be most welcome, since the many extant surveys concentrate instead on individual French *départements* or Swiss cantons. Even histories of the duchy of Savoy, which Amadeus VI transformed over the central decades of the fourteenth century into a transalpine state, are similarly fragmented along modern national divides (Vester 2013). For now, the storied version of some of the events commonly described in political and military histories of the region suggests that the Black Death accelerated a profound

reversal and deterioration of human occupation of Savoy's mountain regions, with the disappearance of cultivation and settlements fundamental to Savoy's rise as a regional power during the twelfth and thirteenth centuries. We know so much about these rural areas because the young Amadeus's advisors moved quickly to stabilize his tax base and central administration, documenting revenue collections from both autonomous and comital landholdings in each castellany. The Count himself was busy exerting military power to keep the dynastic holdings intact. During the seven years between 1348 and 1356, when he had reached twenty-two years of age and made his first important diplomatic treaty, Count Amadeus traveled tirelessly with huge entourages, entailing all the horses and all the grain required to keep these large mammals well provisioned. Meanwhile, throughout the 1350s, mountain people in his domain had to forage for survival. Neither the stranded and hungry English and French soldiers from the Provençal wars, nor Amadeus and his retinue, would have confronted the protracted subsistence crises that locals endured.

Even where the plague did not strike directly, tax burdens multiplied and local environmental conditions deteriorated in the upland communities. In both Lombardy and Savoy, the most destabilizing reflection of larger climate change was the recurrence of crippling spring flooding (Tropeano and Turconi 2004; Bravard 1989).¹⁵ Spring floods amplified the foliage of semi-arid Alpine valleys, thus feeding small rodents and providing abundant humidity for the replication and activity of their various fleas. In plague ecological field studies, this sequence is referred to as a "trophic cascade" (e.g., Salkeld et al. 2010, on changing vacillations of prairie dog populations).¹⁶ The preconditions for a rural plague epizootic were amply supplied in the years surrounding the Black Death.

The Black Death did not affect all regions of Europe equally; even neighboring, or similarly situated, towns experienced quite disparate overall mortality. In analyzing the spread of the Black Death via spotty mentions of high mortality, some scholars have inferred equally catastrophic losses from comparable places where we have no documentation. We should

15 Important recent historical studies of multi-decadal climate change includes those of McCormick et al. (2012), for late antiquity, or Campbell (2011 and 2013), for the late medieval period; but neither focuses on the Alpine regions nor the great rivers that originate there. This is surprising, because climatologists today see global alpine regions as sentinel areas of large ecological change: see Allainé and Yoccoz (2003). Squatriti (2010) usefully couples written documentation of northern Italian flooding to climate changes of late antiquity.

16 One of the earliest mentions of Alpine marmots is in 1339, by a Benedictine prior imposing restrictions on peasants' hunting (Carrier and Mouthon 2010: 141).

resist this temptation. Filling in the map between localities where some evidence of plague exists is not without foundation when estimating the true costs of the Black Death pandemic in Europe, but we do need to exercise considerable caution when drawing conclusions about the in-between areas of these maps (Mengel 2011). Not unreasonably, tracing the path of plague in 1347–53 typically inspires careful researchers to follow waterborne and overland routes of human communications. Indeed, historians must usually follow human-generated sources, as I did in describing sinuous mountain back roads where the plague cases of early 1567 were located. But diffusion of *Yersinia pestis*, spreading via rodents and their fleas, does not replicate human itineraries.

The “Second Pestilence” of 1359–63

The lack of evidence for some places, such as Bohemia (which Mengel 2011 has studied), may not be evidence for the absence of plague during the 1347–53 epidemic. However, the dearth of Black Death evidence from urbanized Lombardy and especially from Milan, its capital, is differently problematic. We know from the famous account of Gabriel dei Mussis (trans. in Horrox 1994: 14–26) that Piacenza was severely infected, most likely as plague spread inland along the Po River. Piacenza was fewer than 42 miles south of Milan, a city of nearly 100,000 people. And yet secure contemporary evidence of the Black Death in Lombardy is almost nonexistent (Albini 1982: 14–17). Why would Milan and many other towns and cities to the north of the Po River, all of which were larger than most rural market centers anywhere in Europe and Britain, be spared a disease supposedly spread by contagion? Oddly, many historians accept the claim by a Florentine plague survivor, Matteo Villani, that Milan escaped catastrophic mortality in 1348–49 because its ruler took cruel and aggressive isolationist measures to board up infected houses when the first cases of the new disease appeared (e.g., Benedictow 2004: 95; Christakos et al. 2005: 215). While a few places in Milanese suburban districts reported epidemic outbreaks in 1350, during the high traffic caused by pilgrims to Rome this Jubilee year, no evidence of these outbreaks is unambiguously plague-related (Albini 1982: 15–16; Michaud 1998).

Instead, the first devastating plague in Milan and the major cities of Lombardy occurred in 1361–63 (Del Panta 1982: 118). Francesco Petrarca fled Milan in the late spring of 1361, as the city faced its initial experience with the catastrophic new epidemic. His son remained behind. Long disappointed by the young man’s adolescent choices and limited achievements, Petrarca consigned his nuanced remorse to pages of a precious manuscript copy of Virgil which his own father had given him:

Our Giovanni, born to my toiling and my sorrow, brought me heavy and constant cares while he lived, and bitter grief when he died. He had known few happy days. He died in the year of our Lord 1361, in the 25th year of his age, in the night between Friday and Saturday the 9th and 10th of July. The news of his death reached me in Padua late on the afternoon of the 14th. He died in Milan in the unexampled general devastation wrought by the plague, which hitherto had left that city immune from such evils, but now has found it and has invaded it. (Kirkham 2009: 5).

The other deaths Petrarca recorded in this manuscript are of those he loved most: Laura (in Avignon, April 1348, of plague); his closest friend, Ludwig van Kempen, also called Louis Heiligen (in Avignon, 1361, of plague), and his grandson Francesco, aged 2 years, 4 months (in Pavia, 1363, toward the end of a plague). Writing to Francesco Nelli, a favorite correspondent and a former tutor of his son, while he was still grieving for Ludwig, Petrarca dedicated his *Letters of Old Age* to his friend's memory:

[T]his year [1361/62] has not only equaled but even surpassed the earlier one in many regions, especially here in Cisalpine Gaul, and has almost completely emptied along with many other cities the most flourishing and populous Milan, untouched until now by these disasters. (Petrarca 1361–73/1992: 1).

Many of Petrarca's other correspondents survived the initial wave of plague, only to die in the next epidemic. Francesco Nelli subsequently died of plague, in Avignon, in 1363.

Seen from the perspective of England or Florence, this "second plague" is often called the "plague of children," likely because a very large baby-boom generation dominated the population at risk a decade after the first epidemic, in those places where it had caused substantial mortality.¹⁷ Otherwise, occurrences of the "second plague," and the places where it was severe, have received the muted acclaim consonant with its "second" sobriquet. Glénisson long ago observed that some areas in France's Massif Central were far more devastated during the 1360s plague than they had been at the time of the Black Death. Moreover, he traced the north-to-south overland itinerary of the second epidemic's spread, noting the substantially different pattern from the Black Death (Glénisson 1968; see also Albin 1982: 14–18 and 82). Plague's initial spread from the alpine and high upland communities of the western Alps, down to great metropolitan

17 New perspectives on population immunity, as discussed by Crespo and Lawrenz (2014, in this issue), are likely to change our understanding of how human populations adapt when living near plague enzootic foci.

centers such as Milan, seems most likely to have occurred during the second wave of plague, not the first, and this anomalous temporal-geographical evidence led me to locate persisting plague foci in a way consistent with modern plague ecology. This second wave of plague in Europe, as well as the even more neglected later European plague recurrences over the following centuries, may claim a greater importance in plague history generally if we reposition plague within larger ecological and environmental contexts.

The Alpine Marmot: A Potential Host for Persisting Plague in Europe

The western Eurasian alpine system is vast, and its temperate-zone mountains include the Pyrenees, the alpine groups variously referred to as maritime, western, south-central (or Italian), Julian, Dinaric and Carpathian, and the Apennines (Nagy, Grabherr, and Thompson 2003). All these mountain regions are connected to the Mediterranean climate zone, where undershrubs are prominent and winters are mild and wet. Undershrub vegetation survives better than forests in these fire-prone regions, and provides habitats for many nesting and burrowing rodents. Mild, wet winters support year-round flea activity, and all the way up to the high mountain pastures the fleas would have found a great variety of indigenous rodent and lagomorph hosts for plague.¹⁸ The French Alps have a now-dwindling variety of likely plague-susceptible species, including lagomorphs (hares), sciuridae (squirrels), mice, dormouse species, voles, and both *Rattus rattus* and *Rattus norvegicus* (Ariagno 1976). Many other mammalian genera and species implicated in maintaining plague elsewhere also inhabit, or once inhabited, the southern and western European Alps (Armitage 2013).

Alpine regions linked to Mediterranean plague ports were therefore, I contend, ecologically ideal homes for the introduction and propagation of the plague bacillus. At the time of the Black Death, moreover, all these upland zones were under considerable ecological stress, both chronically (following centuries of intensive development of the uplands and alpine pastures) and acutely (due to destabilizing flooding events). The longer-

18 Generally, I rely here on a model for the spatial diffusion of plague epizootics offered by Davis et al. (2008). Full elaboration of the hypothesized movement of plague from coastal regions into the Mediterranean and western alpine hinterlands would require a separate study. Varlık (2014, in this issue) provides illustrative detail of the rodents inhabiting zones from the mountains to the great city of Istanbul.

term anthropogenic changes to land use and settlement are important to fold into our understanding of medieval history (Hoffmann 2014). Nicholas Carrier and Fabrice Mouthon (2010) have summarized ecological transformations in the French and Italian Alps during the medieval era, describing how these different, contiguous ecological regions became fundamentally connected through human activities. Beginning in the eleventh century, communities of monks vied with local lords and autonomous civilian communities for control of the use and access to high alpine pastures. Alpine meadows were given over to pastoral farming, not only to exploitation by transhumance, but (by the mid- to late thirteenth century) to the multiplication of permanent settlements in the high pastures and more extensive forest-clearing on slopes leading up to these pastures. Where pastoral activity was not easy, the peaks attracted new mining investments. Mountain peoples who once farmed lived much of the year very close to famine, scratching their meals from the ground.

Once these alpine communities were linked to the grain-rich plains, the extraction of mountain resources intensified; even more uplands were exploited for products which the plainsmen wanted in return. As beneficiaries of economic trade integration, people in the mountainous areas of Europe became ecologically bound to urban regions outside these zones, and cereals were staple imports to the region during the seasons when travel was easier. Over the colder months, the hunting of larger rodents and carnivore competitors (both for food and pelts or fur) had been common across the region since early Neolithic times, but remodeling the flora and fauna of the entire European Alpine region occurred only during the last millennium. Medieval monastic documents occasionally mention marmots (von Tschudi 1870: 750–69; Shopkow 2010: 242), which is significant (see below). As early as the 1330s, edicts indirectly refer to pressure on larger fauna of the region, when great feudal lords feared that the peasants could compromise their sport hunting (Blache 1922). Even more spectacular changes to the Alpine region's ecology and human settlement patterns occurred over the fourteenth through seventeenth centuries (Carrier and Mouthon 2010; Viazzo 1989).

In sum, diverse regional stressors and the creation of vital economic ties and new demands on high mountain pastures made an easier entry for *Yersinia pestis* at the time of the Black Death. The upland landscapes were fragmented by human occupation and early commercialized livestock rearing, here and there connecting commensal rodents to the fleas of a great many other plague-susceptible mammals. The precise mechanisms for a very rapid wave of epizootic die-offs during the Black Death epidemic remain elusive, requiring further research if the primary

hypothesis presented in this paper—the existence of a suitable reservoir host for plague—offers a plausible model for plague persistence in Continental Western Europe more generally. If plague were well established in Europe's southern alpine region, the circumstances under which occasional early spring plague cases would occur—such as those suggested in the letters to the Milanese health office in 1567—can be readily imagined. Tilling and/or living in Alpine valleys might have brought the occasional subsistence farmer into contact with burrowing rodents, and if those hosts maintained plague infection, sporadic human plague outbreaks would have occurred (Ariagno 1976).

One candidate species for plague maintenance in the uplands would be the Alpine marmot (*Marmota marmota*), a highly social, burrowing, hibernating species that is a favorite of tourists in Switzerland today (Tomé and Chaix 2003). The species is closely related to rodent hosts of plague elsewhere in Eurasia (Allainé and Yoccoz 2003). For example, *M. marmota* is morphologically similar to the *M. bobac* species common in Kazakhstan, and to the Manchurian marmots (*M. sibirica*) made famous by Wu Lien-Teh's investigations of plague in Manchuria during 1910–11 (Summers 2011: 107–29). Marmot populations expanded during the last glaciation across the temperate Alpine zone (Zimina and Gerasimov 1973), but did not survive unmolested thereafter. Between 10,000 and 7000 BCE, early hunters rid the upper Rhone area of the western Alps (e.g., the Jura mountains) of marmots, ibex, and chamois. At the same time, intensified pasturage and resource extraction during the medieval era created new habitats for marmots within higher elevation forest clearings. Because the roots of trees make burrow-formation quite difficult, potential new marmot habitats were created when trees were felled or burned for increasing pasturage (Armitage 2013). Surviving alpine marmot colonies today inhabit the region above the treeline (altitude varies by Alpine location) along with two species of voles, but their steady disappearance is a much more recent process, further threatened today by global warming and by competition for the highest alpine pastures and slopes.

Human uses of Alpine marmots can only be documented over the last half-millennium. Beginning with the sixteenth-century naturalists, we have direct testimony of marmots being captured and kept as pets. Felix Platter, the famous Protestant Swiss printer of the early sixteenth century, briefly had a captive Valais marmot in his collections, as we learn from his daybook entries of the early 1560s (Katritzky 2012: 20). Tourists and travelers encountered marmot pelts, used for luxury bedding in nineteenth-century chalets (Raverat 1872: 14–20; Gayot 1889). Outside the mountain region, the rodent had already become a familiar performer

in French cities. During the eighteenth and nineteenth centuries, mountain people from the one-time kingdom of Savoy migrated seasonally to France's cities and towns, desperately poor and eking out a winter living by offering services that lowlanders found either necessary or amusing—for example, sweeping chimneys, killing rats, or begging for pittances by entertaining passersby with trained ferrets and marmots, memorialized as the “marmotte en vie.”¹⁹ Because these economic migrants returned to the high meadows come spring, they were not seen as intrinsically dangerous, in contrast to feared, rootless vagabonds of the pre-Revolutionary period. Poster illustrations captured the quaint dress and humble activities of the Savoyards (Hufton 1972). European naturalists of the nineteenth century became fascinated with marmots as a hibernating species, reporting local knowledge of their habitats and the ease of extracting animals from their burrows soon after the first snowfall. Species-targeted exploitation accelerated on the eve of the so-called “Third Pandemic” of plague.

Epilogue: Global and Historical Perspectives on Ecological Change and Plague Persistence in Europe

The Alpine marmot was not necessarily uniquely responsible for plague maintenance in that region, as seems to have been the case with the Siberian marmot during the pneumonic plague catastrophe of 1910–11 in Manchuria. In most of today's permanent plague foci, *Yersinia pestis* can infect a local array of small mammals and their fleas. Although Sunstov (2012) argues that Eurasian marmot species, generally, were the original maintenance host for plague's evolution as a species, the burrow structure of great gerbils (*Rhombomys opimus*) has also made them candidates (Randall et al. 2005; Wilschut et al., 2013). As in regions of the globe where plague was newly introduced during the “Third Pandemic,” a variety of amplifying hosts and their fleas would have promoted plague persistence in the Mediterranean and temperate Alpine zones during the second pandemic. Rather than focusing entirely on *M. marmota*, we should note the general characteristics of Alpine zones and the high meadowlands that marmots favor. Thus equally important would be the wide range of potential amplifying hosts common throughout the Alpine foothills and high massif regions of Western Eurasia, species that Varlık details in her dis-

19 For an eighteenth-century image of a young man with a trained marmot and what appears to be a street organ, see Claude-Louis Desrais, designer, “Petits métiers, cris de Paris,” available online at <<http://catalogue.bnf.fr/ark:/12148/cb40312379s>> [accessed September 18, 2014].

cussion of rural plague transmissions (Varlık 2014, in this issue; specifically for the western Alps, see Allainé and Yoccoz 2003). In particular, the southern face of the Eurasian Alpine system, linked to Mediterranean climates and ecology, bears important ecological similarities to modern areas where newly introduced plague persisted. Grove and Rackham (2001: 11–65) emphasize common characteristics of “mediterraneoid” zones across the globe: a mosaic of landscapes, predominant undershrubs and savanna, steppes with more grasses than woody plants, warm wet winters, hot dry summers. Almost all of California, Chile, and, to a lesser extent, South Africa have regions comparable to Mediterranean uplands, and all became areas where plague established new, permanent maintenance foci during the late nineteenth and early twentieth century.

Temperate-climate alpine rodents better survive occasional bitter winters because snowfall is heavy, protecting the ground from sheet ice that impairs their survival. But whether many colonies could have survived the aggressive and prolonged winters during the Little Ice Age (roughly 1550–1830; see Parker 2013) is difficult to say. Early and late snowfalls could have shortened the reproductive season of most burrowing rodents, especially marmots, but the species could have survived and thrived if it were not targeted by hunters and hungry mountain dwellers. The historical evidence at present offers greater support for sustained habitat destruction and/or human-driven landscape alteration, profound since 1700 throughout Europe.

With or without northern hemispheric cooling during the Little Ice Age, the fauna and flora biodiversity of the Alpine and Mediterranean upland regions steadily declined, processes that continue today. By the time French and English investigators rushed to East, West, and South Asia to investigate outbreaks of plague in the 1890s, a world of plants and animals once commonly known in earlier centuries had disappeared. Europeans, including scientists, found the natural and human environments of the strikingly “other” colonial metropolises utterly foreign spaces a century ago. Was it also difficult for them to imagine that the humble black house rat—much less the ibex, chamois, badger, and bear of the western Alps—had once been fairly ubiquitous around European human settlements? In Britain, the aggressive use of rat poisons, from the 1680s on, may have cleared the way for the rat species dominant there today, *Rattus norvegicus* (Konkola 1992). At least as early as 1800, a few British zoologists had noted the disappearance of the “old English rat,” which we now know was *Rattus rattus* (Burt 2006). But most plague observers in British India had no knowledge that the Indian or “tropical plague rat” was once a domestic species back home. A flea that renowned ento-

mologist N. Charles Rothschild named *Pulex cheopis* in 1903, for the great Egyptian pyramids where he found it, became *Xenopsylla cheopis* within five years, its Greek-derived prefix (*xeno*) capturing its “foreign” status as an “Indian rat flea” ([U.S.] *Public Health Reports* 1907). But both *R. rattus* and *X. cheopis* once had a cosmopolitan distribution across Eurasia (McCormick 2003).

Today, the single most active plague maintenance focus causing human deaths is in the uplands of subtropical Madagascar, where a different flea genus (*Synopsyllus*) spreads plague continually among highland rodents (800 meters or more above sea level). *R. rattus* is the dominant species there, “found everywhere: in houses, villages, fields, and also in the forests,” but hedgehogs, insectivores, and small mammals such as shrews and tenrecs help to amplify plague (Andrianaivoriamana et al. 2013: quotation at e2382; see also Rahelinirina et al. 2010, and Vogler et al. 2013). High degrees of poverty, the difficulty of recognizing atypical human plague infection, and insufficient governmental resources to apply to surveillance lead to high and persisting plague in Madagascar today: the consequences of which Michelle Ziegler’s (2014) contribution to this issue makes clear. In other words, the famous British Commission for the Investigation of Plague in India (1906/07), used by many different historians of the Black Death (e.g., Cohn 2002; Benedictow 2004) might better reflect its imperial (European) historical context than the ecology of plague in the early twentieth century (e.g., Chandavarkar 1992; for French Indochina, see Latour 1988: 59–110; and recently Au 2011: 29–49).²⁰ Katherine Royer (2014) has shown how the observations of colonial physicians and surgeons (who had long lived and served in British India) were rejected or discarded by Bombay-based scientists from London. Hence, actual plague experience throughout the northern Indian subcontinent may need to be reconstructed historically, based on her work.

The historical moment of the Black Death introduced a highly virulent flea-borne pathogen to densely settled regions crippled by multiple economic and ecological stressors. A wide variety of potential plague hosts and vectors intrinsic to the Alpine regions faced a combination of climate-driven and anthropogenic destabilization in the years surrounding the beginnings of the great plague: massive spring flooding events, intermittent droughts, and high traffic of demobilized soldiers and camp supporters after the English victory at Crécy (1346). All were likely factors in the

20 Mathematician Nicolas Bacaër (2012) has even shown how the plague data generated by the 1906/07 Commission provides a misleading picture of the magnitude and temporal progression of the human epidemic on Bombay Island.

devastating and uncharacteristically rapid spread of plague between 1347 and 1349. Now that we know that mortality in this great, catastrophic epidemic was at least partly caused by *Yersinia pestis*, the study of plague history is not at an end; only a narrow and protracted debate about the presence of the plague pathogen has been resolved. An altogether different set of historical questions, prompted by the findings of modern plague ecology, must begin to bridge the local, the regional, and the global. Interdisciplinary historical study of evidence for prior global climate change, exemplified by Campbell (2010, 2011, 2013) and McCormick et al. (2012), seems to point a way forward.

Bibliography

- Adjemian, J. Z., P. Foley, K. L. Gage, and J. Foley. 2007. "Initiation and Spread of Traveling Waves of Plague, *Yersinia pestis*, in the Western United States," *American Journal of Tropical Medicine and Hygiene* 76, no. 2: 365–75
- Albini, Giuliana. 1982. *Guerra, fame, peste: crisi di mortalità e sistema sanitario nella Lombardia tardomedioevale* (Bologna: Cappelli)
- Alfani, Guido. 2013. *Calamities and the Economy in Renaissance Italy: The Grand Tour of the Horsemen of the Apocalypse* (New York: Palgrave Macmillan)
- Allainé, D., and N. G. Yoccoz. 2003. "Rodents in the European Alps: Population Ecology and Potential Impacts on Ecosystems," in *Alpine Biodiversity in Europe*, ed. L. Nagy, G. Grabherr, C. Körner, and D. B. A. Thompson, 339–50 (Berlin: Springer)
- Andenmatten, Bernard, and Jean-Daniel Morerod. 1987. "La peste à Lausanne au XIVE siècle (1348/49, 1360)," *Étude de Lettres* 2–3: 19–49
- Andrianaivoarimanana, V., K. Kreppel, N. Elissa, J.-M. Duplantier, et al. 2013. "Understanding the Persistence of Plague Foci in Madagascar," *PLoS Neglected Tropical Diseases* 7, no. 11: e2382
- Anisimov, A. P., L. E. Lindler, and G. B. Pier. 2004. "Intraspecific diversity of *Yersinia pestis*," *Clinical Microbiology Review* 17, no. 2: 434–64
- Ariagno, D. 1976. "Essai de synthèse sur les mammifères sauvages de la région Rhône-Alpes," *Mammalia* 40: 125–60
- Armitage, K. B. 2013. "Climate Change and the Conservation of Marmots," *Natural Science* 5, no. 5A: 36–43
- Arrizabalaga, J. 1994. "Facing the Black Death: Perceptions and Reactions of University Medical Practitioners," in *Practical Medicine from Salerno to the Black Death*, ed. L. García Ballester et al., 237–88 (Cambridge: Cambridge University Press)
- Au, S. 2011. *Mixed Medicines: Health and Culture in French Colonial Cambodia* (Chicago: University of Chicago Press)
- Audoin-Rouzeau, F. 2003. *Les Chemins de la peste: le rat, la puce et l'homme* (Rennes: Presses universitaires de Rennes)
- Bacaër, N. 2012. "The Model of Kermack and McKendrick for the Plague Epidemic in Bombay and the Type Reproduction Number with Seasonality," *Journal of Mathematical Biology* 64, no. 3: 403–22

- Bacot, A. W., and C. J. Martin. 1914. "Observations on the Mechanism of the Transmission of Plague by Fleas," *Journal of Hygiene*, Plague Supplement, 3: 423–39
- Benedictow Ole J. 2004. *The Black Death, 1346–1353: The Complete History* (Woodbridge: Boydell)
- Bergier, Jean-François. 1988. "Territorio, economia e società nella storia delle Alpi," in *Le Alpi per l'Europa: una proposta politica*, ed. Edoardo Martinengo, 25–54 (Lugano: Jaca)
- Bergier, Jean-François. 1997. "Le trafic à travers les Alpes et les liaisons transalpine," in *Pour une histoire des Alpes: Moyen Age et temps modernes*, section II, 1–72 (Aldershot: Ashgate)
- Biraben, Jean-Noël. 1975. *Les hommes et la peste en France et dans les pays européens et méditerranéens*, vol. 1 (Paris: Mouton)
- Blache, Jules. 1922. "Les trappeurs du Vercors au Moyen-Âge," *Revue de géographie Alpine* 10, no. 2: 305–10
- Bolton, J. L. 2013. "Looking for *Yersinia pestis*: Scientists, Historians and the Black Death," in *The Fifteenth Century, XII: Society in an Age of Plague*, ed. C. Rawcliffe, 15–38 (Woodbridge: Boydell)
- Borsch, Stuart. 2014. "Plague Depopulation and Irrigation Decay in Medieval Egypt," *The Medieval Globe* 1: 125–156
- Boucheron, Patrick. 2001. "Water and Power in Milan, c. 1200–1500," *Urban History* 28: 180–93
- Bouquet, Jean-Jacques. 1963. "Quelques remarques sur la population du comté de Savoie au XIVe siècle d'après les comptes de subsides," *Revue historique vaudoise* 71: 49–80
- Bravard, J. P. 1989. "La Metamorphose des rivières des Alpes françaises à la fin du Moyen Âge et à l'époque moderne," *Bulletin de la Société Géographie de Liège* 25: 145–57
- Bugati, Gasparo. 1570. *Historia universale [...] dal principio del mondo fino all'anno 1569* (Venice: Gabriel Giolito)
- Buhnerkempe, M. G., R. J. Eisen, B. Goodell, K. L. Gage, et al. 2011. "Transmission Shifts Underlie Variability in Population Responses to *Yersinia pestis* Infection," *PLoS One* 6, no. 7: e22498
- Burt, Jonathan. 2006. *Rat* (London: Reaktion)
- Campbell, Bruce M.S. 2010. "Physical Shocks, Biological Hazards, and Human Impacts: The Crisis of the Fourteenth Century Revisited," in *Economic and Biological Interactions in Pre-Industrial Europe, from the 13th to the 18th Centuries*, ed. S. Cavaciocchi, 13–32 (Florence: Firenze University Press)
- Campbell, Bruce M.S. 2011. "Panzootics, Pandemics and Climate Anomalies in the Fourteenth Century," in *Beiträge zum Göttinger Umwelthistorischen Kolloquium, 2010–2011*, ed. B. Hermann, 177–216 (Göttingen: Universitätsverlag)
- Campbell, Bruce M. S. 2013. "The Great Transition: Climate, Disease and Society in the 13th and 14th Centuries," The Ellen McArthur Lectures, University of Cambridge <<http://www.econsoc.hist.cam.ac.uk/podcast-campbell.html>> [accessed January 9, 2014]
- Carrier, Nicolas, and Fabrice Mouthon. 2002. "Extent et reconnaissance de la principauté savoyarde: une source sur les structures agraires des Alpes de

- la Nord (fin XIIIe–fin XVe siècle),” in *Terriers et plans-terriers du XIII^e au XVIII^e siècle*, ed. Ghislan Brunel, Olivier Guyotjeannin and Jean-Marc Monceau, 217–40 (Rennes: Association d’histoire des sciences rurales)
- Carrier, Nicolas, and Fabrice Mouthon. 2010. *Paysans des Alpes: les communautés montagnardes au Moyen Âge* (Rennes: Presses universitaires de Rennes)
- Castelnuovo, Guido. 2000. “Centri urbani, organizzazione del territorio e vie di traffico nell’area alpina occidentale: Chambéry, Torino e le loro montagne (X–XV secolo),” *Histoire des Alpes* 5: 109–23
- Chandavarkar, R. 1992. “Plague, Panic and Epidemic Politics in India, 1896–1914,” in *Epidemics and Ideas: Essays on the Historical Perception of Pestilence*, ed. Paul Slack, 203–40 (Cambridge: Cambridge University Press)
- Chevé, D., and G. Boëtsch, 2007. “Image-source: un préalable iconographique à l’étude de toute représentation de la peste à l’époque moderne,” in *Peste entre épidémies et sociétés*, ed. M. Signoli, 331–44 (Florence: Firenze University Press)
- Chittolini, Giorgio. 1985. “Principe e comunità alpina in area lombarda alla fine del medio evo,” in *Le Alpi per l’Europa: una proposta politica*, ed. Edoardo Martinengo, 219–36 (Lugano: Jaca)
- Christakos, G., et al. 2005. *Interdisciplinary Public Health Reasoning and Epidemic Modelling: The Case of Black Death* (New York: Springer)
- Chocheyras, Jacques. 1971. *Le théâtre religieux en Savoie au XVI^e siècle: avec des fragments inédits* (Geneva: Droz)
- Cohn, Samuel Kline, Jr. 2002. *The Black Death Transformed: Disease and Culture in Early Renaissance Europe* (London: Arnold)
- Cohn, Samuel Kline, Jr. 2007. “Black Death and the Burning of Jews,” *Past and Present* 196: 3–36
- Cohn, Samuel Kline, Jr., and Guido Alfani. 2007. “Households and Plague in Early Modern Italy,” *Journal of Interdisciplinary History* 38: 177–205
- Colet, Anna, Josep Xavier Muntané i Santiveri, Jordi Ruíz Ventura, Oriol Saula, et al. 2014. “The Black Death and its Consequences for the Jewish Community in Tàrrrega: Lessons from History and Archeology,” *The Medieval Globe* 1: 63–96
- Cox, Eugene L. 1967. *The Green Count of Savoy: Amadeus VI and Transalpine Savoy in the Fourteenth Century* (Princeton, NJ: Princeton University Press)
- Crespo, Fabian, and Matthew B. Lawrenz. 2014. “Heterogeneous Immunological Landscape and Medieval Plague: An Invitation to a New Dialogue between Historians and Immunologists,” *The Medieval Globe* 1: 229–257
- Cummins, N., M. Kelly, and C. Ó Gráda. 2013. “Living Standards and Plague in London, 1560–1665,” *Social Science Research Network* <<http://ssrn.com/abstract=2289094>> [accessed September 10, 2014]
- d’Amico, Stefano. 2012. *Spanish Milan: A City within the Empire, 1535–1706* (New York: Palgrave Macmillan)
- Davis, S., E. Calvet, and H. Leirs. 2005. “Fluctuating Rodent Populations and Risks to Humans from Rodent-Borne Zoonoses,” *Vector-Borne and Zoonotic Diseases* 5, no. 4: 305–14
- Davis, S., et al. 2007. “Plague Metapopulation Dynamics in a Natural Reservoir: The Burrow System as the Unit of Study,” *Epidemiology and Infection* 135, no. 5: 740–48

- Davis, S., et al. 2008. "The Abundance Threshold for Plague as a Critical Percolation Phenomenon," *Nature* 454, no. 7204: 634–37
- Del Panta, Lorenzo. 1982. *Le epidemie nella storia demografica italiana (secoli XIV-XIX)* (Turino: Loescher)
- Dennis, D. T., and J. E. Staples. 2009. "Plague," in *Bacterial Infections of Humans: Epidemiology and Control*, ed. Philip S. Brachman and Elias Abrutyn, 597–612 (New York: Springer)
- DeWitte, Sharon N. 2009. "The Effect of Sex on Risk of Mortality during the Black Death in London, A.D. 1349-1350," *American Journal of Physical Anthropology* 139, no. 2: 222–34
- DeWitte, Sharon N. 2010. "Age Patterns of Mortality during the Black Death in London, A.D. 1349–1350," *Journal of Archaeological Science* 37, no. 12: 3394–3400
- DeWitte, Sharon N. 2014. "The Anthropology of Plague: Insights from Bioarcheological Analyses of Epidemic Cemeteries," *The Medieval Globe* 1: 97–123
- Duplantier, J.-M. 2012. "Surveillance and Control of Plague," in *Yersinia: Systems Biology and Control*, ed. Elisabeth Carniel and B. Joseph Hinnebusch, 183–200 (Norfolk, UK: Caister Academic Press)
- Eckert, Edward A. 1996. *The Structure of Plagues and Pestilences in Early Modern Europe: Central Europe, 1560–1640* (Basel: Karger)
- Eckert, E. A. 2000. "The Retreat of Plague from Central Europe, 1640–1720: A Geomedical Approach," *Bulletin of the History of Medicine* 74, no. 1: 1–28
- Eisen, R. J., et al. 2008. "Persistence of *Yersinia pestis* in Soil under Natural Conditions," *Emerging Infectious Diseases* 14, no. 6: 941–43
- Eisen, R. J., and K. L. Gage. 2009. "Adaptive Strategies of *Yersinia pestis* to Persist during Inter-Epizootic and Epizootic Periods," *Veterinary Research* 4: 14
- Eisen, R. J., and K. L. Gage. 2012. "Transmission of Flea-Borne Zoonotic Agents," *Annual Review of Entomology* 57, no. 1: 61–82
- Ell, S. R. 1984. "Immunity as a Factor in the Epidemiology of Medieval Plague," *Reviews of Infectious Diseases* 6, no. 6: 866–79
- Emery, Richard W. 1967. "The Black Death of 1348 in Perpignan," *Speculum* 42: 611–23
- Foa, Anna. 1992. *The Jews of Europe after the Black Death* (Berkeley: University of California Press)
- Frangioni, Luciana. 1983. *Milano e le sue strade: costi di trasporto e vie di commercio dei prodotti milanesi alla fine del Trecento* (Capelli: Bologna)
- Gage, K. L. 2012. "Factors Affecting the Spread and Maintenance of Plague," in *Advances in Yersinia Research*, ed. Alzira Maria Paiva de Almeida and Nilma Cintra Leal, special issue, *Advances in Experimental Medicine and Biology* 954, no. 1: 79–94
- Gage, K. L., and M. Y. Koysoy. 2005. "Natural History of Plague: Perspectives from More than a Century of Research," *Annual Review of Entomology* 50: 505–28
- Gayot, Eugène. 1889. *La marmotte* (Paris: Firmin-Didot)
- Gelting, M. H. 1991. "The Mountains and the Plague: Maurienne, 1348," *Collegium Medievale* 4: 7–45
- Getting, Robert McC. 1981. *Balancing on an Alp: Ecological Change and Continuity in a Swiss Mountain Community* (Cambridge: Cambridge University Press)

- Glénisson, Jean. 1968. "La Second peste: l'épidémie de 1360–1362 en France et en Europe," *Bulletin de la Société de l'histoire de France, Annuaire*: 27–38
- Gottschall, Dagmar. 2003. "Scienza in volgare: Corrado di Megenberg e la peste del 1348," in *Filosofia in volgare nel medioevo*, ed. Nadia Bray and Loris Sturlese, 107–31 (Louvain-la-Neuve: Fédération internationale des instituts d'études médiévales)
- Green, Monica H. 2014. "Taking 'Pandemic' Seriously: Making the Black Death Global," *The Medieval Globe* 1: 27–61
- Grillo, Paolo. 1994. "Il richiamo della metropolis: immigrazione e crescita demografica a Milano nel XIII secolo," in *Demografia e società nell'Italia medievale: secoli IX–XIV*, ed. R. Comba and I. Naso, 441–45 (Cuneo Società per gli studi storici, archeologici ed artistici della provincia di Cuneo; Società italiana di demografia storica)
- Grove, A. T., and Oliver Rackham. 2001. *The Nature of Mediterranean Europe: An Ecological History* (New Haven: Yale University Press)
- Guerchberg, Seraphine. 1948. "La controverse sur les prétendus semeurs de la Peste Noire d'après les traits de peste de l'époque," *Revue des études juives*, 108, no. 1: 3–40
- Guy de Chauliac. 1363/1997. *Guy de Chauliac: Inventarium sive chirurgia magna*, ed. Michael McVaugh (Leiden: Brill)
- Hinnebusch, B. J. 1997. "Bubonic Plague: A Molecular Genetic Case History of the Emergence of an Infectious Disease," *Journal of Molecular Medicine* 75, no. 9: 645–52
- Hinnebusch, B. J. 2005. "The Evolution of Flea-Borne Transmission in *Yersinia pestis*," *Current Issues in Molecular Biology* 7, no. 2: 197–212
- Hinnebusch, B. J. 2010. "Plague in the 21st Century: Global Public Health Challenges and Goals," in *National Institutes of Allergy and Infectious Diseases vol. 3: Intramural Research*, ed. Vassil St. Georgiev, 87–94 (New York: Springer)
- Hoffmann, Richard C. 2014. *An Environmental History of Medieval Europe* (Cambridge: Cambridge University Press)
- Horrox, Rosemary (ed. and trans.). 1994. *The Black Death* (Manchester: Manchester University Press)
- Huften, Olwen. 1972. "Begging, Vagrancy, Vagabondage and the Law: An Aspect of the Problem of Poverty in Eighteenth-Century France," *European History Quarterly* 2: 97–123
- Kacki, S., and D. Castex. 2012. "Réflexions sur la variété des modalités funéraires en temps d'épidémie: l'exemple de la Peste Noire en contextes urbain et rural," *Archéologie Médiévale* 42, no. 1: 1–21
- Katritzky, M. A. 2012. *Healing, Performance and Ceremony in the Writings of Three Early Modern Physicians* (Farnham: Ashgate)
- Keeling, M. J., and C. A. Gilligan. 2000. "Bubonic Plague: A Metapopulation Model of a Zoonosis," *Proceedings of the Royal Society of London, B* 267, no. 1458: 2219–30
- Keim, P. S., and D. M. Wagner. 2009. "Humans and Evolutionary and Ecological Forces Shaped the Phylogeography of Recently Emerged Diseases," *Nature Reviews Microbiology* 7, no. 11: 813–21

- Kirkham, Victoria. 2009. "Introduction: A Life's Work," in *Petrarch: A Critical Guide to the Complete Works*, ed. Victoria Kirkham and Armando Maggi, 1–31 (Chicago: University of Chicago Press)
- Kirkham, Victoria, and Armando Maggi, eds. 2009. *Petrarch: A Critical Guide to the Complete Works* (Chicago: University of Chicago Press)
- Konkola, K. 1992. "More Than a Coincidence? The Arrival of Arsenic and the Disappearance of Plague in Early Modern Europe," *Journal of the History of Medicine and Allied Sciences* 47, no. 2: 186–209
- Latour, Bruno. 1988. *The Pasteurization of France* (Cambridge, MA: Harvard University Press)
- Leandri-Morin, Marie-Pierre. 1997. "Représentations provençales et piémontaises de la vie de saint Sébastien : procédés narratifs et sources textuelles," *Mélanges de l'École française de Rome. Moyen-Age, Temps modernes* 109, no. 2: 569–601
- Lebègue, Raymond. 1975. "L'ancien théâtre religieux dans les Alpes françaises," *Journal des savants* 3–4: 213–24
- Little, Lester K. 2011. "Plague Historians in Lab Coats," *Past and Present* 213: 267–90
- Lucenet, Monique. 1986. "La peste inspiratrice," *Bulletins de la Société française d'histoire de la médecine*, [proceedings of the meeting held on 25 January 1986], 49–50
- Mallet, Michael, and Christine Shaw. 2012. *The Italian Wars, 1494–1559* (Harlow, UK: Pearson)
- Malou, N., et al. 2012. "Immuno-PCR: A New Tool for Paleomicrobiology; The Plague Paradigm," *PLoS One* 7, no. 2: e0031744
- McCormick, Michael. 1998. "Bateaux de vie, bateaux de mort," *Settimane di studio-centro italiano di studi alto medioevo* 45: 35–118
- McCormick, Michael. 2001. *Origins of the European Economy: Communications and Commerce, AD 300–900* (Cambridge: Cambridge University Press)
- McCormick, Michael. 2003. "Rats, Communications and Plague: Towards an Ancient and Medieval Ecology," *Journal of Interdisciplinary History* 34: 1–25
- McCormick, Michael, et al. 2012. "Climate Change during and after the Roman Empire: Reconstructing the Past from Scientific and Historical Evidence," *Journal of Interdisciplinary History* 43: 169–220
- McMichael, A. J. 2010. "Paleoclimate and Bubonic Plague: A Forewarning of Future Risk?" *BioMed Central Biology* 8, no. 1: 108
- Mengel, David. 2011. "A Plague on Bohemia? Mapping the Black Death," *Past and Present* 211: 3–34
- Michaud, Francine. 1998. "La peste, la peur et l'espoir: le pèlerinage jubilaire de romeux marseillais en 1350," *Le Moyen Âge* 104: 399–434
- Michaud, Francine. 1999. "Travail et mouvements migratoires avant et après la Peste Noire à Marseille," *Provence historique* 49: 367–83
- Milano, Archivio di Stato, Conservatori alla Sanità, p.a. [parte antiqua], n. 279
- Naphy, William G. 2002. *Plagues, Poisons and Potions: Plague-Spreading Conspiracies in the Western Alps, c. 1530–1640* (Manchester: Manchester University Press)
- Naphy, W. G. 2002. "An Outline of Europe's Alpine areas," in *Alpine Biodiversity in Europe*, ed. L. Nagu, G. Grabherr, and D. B. A. Thompson, 3–12 (Berlin: Springer)

- Nirenberg, David. 1998. *Communities of Violence: Persecution of Minorities in the Middle Ages* (Princeton, NJ: Princeton University Press)
- Ostfield, R. S. 2011. *Lyme Disease: The Ecology of a Complex System* (Oxford: Oxford University Press)
- Parker, Geoffrey. 2013. *Global Crisis: War, Climate Change, and Catastrophe in the Seventeenth Century* (New Haven, CT: Yale University Press)
- Perry, R. D., and J. D. Fetherston. 1997. "Yersinia pestis: Etiologic Agent of Plague," *Clinical Microbiology Reviews* 10, no. 1: 35–66
- Petrarca, Francesco. 1361–73/1992. *Letters of Old Age, vol. I*, trans. Aldo S. Bernardo, Saul Levin, and Reta A. Bernardo (Baltimore: Johns Hopkins University Press)
- Phillips, William D. 1998. "Peste Negra: The Fourteenth-Century Plague Epidemics in Iberia," in *On the Social Origins of Medieval Institutions: Essays in Honor of Joseph F. O'Callaghan*, ed. Donald J. Kagay and Theresa M. Vann, 47–62 (Brill: Leiden)
- Pollitzer, Robert. 1954. *Plague* (Geneva: World Health Organization)
- Pracchi, Roberto. 1971. *Lombardia* (Turino: Unione Tipografico)
- Prentice, Michael B., and Lila Rahalison. 2007. "Plague," *Lancet* 369, no. 9568: 1196–207
- Preto, Paolo. 1987. *Epidemia, paura e politica nell'Italia moderna* (Bari: Editori Laterza)
- Price, P. A., J. Jin, and W. E. Goldman. 2012. "Pulmonary Infection by Yersinia pestis Rapidly Establishes a Permissive Environment for Microbial Proliferation," *Proceedings of the National Academy of Sciences* 109, no. 8: 3083–88
- Quammen, D. 2012. *Spillover: Animal Infections and the Next Human Pandemic* (New York: Norton)
- Rabut, François. 1872. *Le mystère de Monseigneur Saint Sébastien, première journée*. Extract published in Chambéry, *Mémoires et Documents*, 13: 259–452
- Racine, Pierre. 2004. "Le col du Saint-Gothard, maillon du grand commerce international (1260–1320)," in *Montagnes médiévales: XXXIV^e Congrès de la SHMES, Chambéry, 23–25 May 2003*, 63–82 (Paris: Publications de la Sorbonne)
- Rahelinirina, S., J. M. Duplantier, J. Ratovonjato, O. Ramilijaona, et al. 2010. "Study on the Movement of Rattus rattus and Evaluation of the Plague Dispersion in Madagascar," *Vector-Borne and Zoonotic Diseases* 10, no. 1: 77–84
- Randall, J. A., et al. 2005. "Flexible Social Structure of a Desert Rodent, Rhombomys opimus: Philopatry, Kinship, and Ecological Constraints," *Behavioral Ecology* 16, no. 6: 961–73
- Raverat, Achile. 1872. *Haute Savoie: Genevois, Sémine, Faucigny et Chablais* (Lyons: Meton)
- Royer, Katherine. 2014. "The Blind Men and the Elephant: Imperial Medicine, Medieval Historians, and the Role of Rats in the Historiography of Plague," in *Medicine and Colonialism: Historical Perspectives in India and South Africa*, ed. Poonam Bala, 99–110 (London: Pickering & Chatto)
- Salkeld, D., M. Salathé, P. Stapp, and J. H. Jones. 2010. "Plague Outbreaks in Prairie Dog Populations Explained by Percolation Thresholds of Alternate Host Abundance," *Proceedings of the National Academy of Sciences* 107, no. 32: 14247–50

- Shatzmiller, Joseph. 1974. "Les juifs de Provence pendant la peste noire," *Revue des études juives* 133: 457–80
- Shopkow, Leah. 2010. "Three Stories about Life along the Road: The Survival of the Benedictine Monastery of Andres," *Viator* 41: 227–56
- Smail, Daniel L. 1996. "Accommodating Plague in Medieval Marseille," *Continuity and Change* 11: 11–41
- Soldi Rondinini, Gigliola. 1989. "Milano tra XIV e XVI secolo," in *Florence and Milan: Comparisons and Relations, vol. I*, ed. Nicolai Rubenstein, Sergio Bertelli and Craig Hugh Smyth, 163–85 (Firenze: a Nuova Italia Editrice)
- Squatriti, Paolo. 2010. "The Floods of 589 and Climate Change at the Beginning of the Middle Ages: An Italian Microhistory," *Speculum* 85: 799–826
- Stenseth, N. Chr., N. I. Samia, H. Viljugrein, K. L. Kausrud, et al. 2006. "Plague Dynamics are Driven by Climate Variation," *Proceedings of the National Academy of Sciences* 103, no. 35: 13110–15
- Stenseth, Nils Chr., Bakyt B. Atshabar, Mike Begon, Steven R. Belmain, et al. 2008. "Plague: Past, Present, and Future," *PLoS Medicine* 5: e0009–13
- Summers, W. C. 2012. *The Great Manchurian Plague of 1910–1911: The Geopolitics of an Epidemic Disease* (New Haven: Yale University Press)
- Sumption, Jonathan. 2001. *The Hundred Years War, Volume 2: Trial by Fire* (Philadelphia: University of Pennsylvania Press)
- Suntsov, V. V. 2012. "Origin of the Plague Microbe *Yersinia pestis*: Structure of the Process of Speciation," *Biology Bulletin* 39, no. 1: 1–9
- Symes, Carol. 2011. "'The Medieval Archive and the History of Theatre: Assessing the Written and Unwritten Evidence for Premodern Performance,'" *Theatre Survey* 52: 1–30
- Theurillat, J.-P., and A. Guisan. 2001. "Potential Impact of Climate Change on Vegetation in the European Alps: A Review," *Climatic Change* 50: 77–109
- Tomé, C., and L. Chaix. 2003. "Marmot's Hunting and Exploitation in the Western Alps and the Southern Jura from Late Pleistocene to Holocene," in *Adaptive Strategies and Diversity in Marmots*, D. Allainé and M. Le Berre (ed.), 77–84 (Lyon: International Network on Marmots)
- Tomich, P. Q., and et al. 1984. "Evidence for the Extinction of Plague in Hawaii," *American Journal of Epidemiology* 119: 261–73
- Tropeano, D., and L. Turconi. 2004. "Using Historical Documents for Landslide, Debris Flow, and Stream Flood Prevention: Applications in Northern Italy," *Natural Hazards* 31: 663–79
- Tschudi, Friedrich von. 1870. *Le monde des Alpes: Description pittoresque des montagnes de la Suisse et particulièrement des animaux qui les peuplent* (Basle: Georg)
- Twigg, Graham. 1984. *The Black Death: A Biological Reappraisal* (London: Schocken)
- Ugolini, Piero. 1985. "La formazione del sistema territoriale e urbano della Valle Padana," in *Storia d'Italia, Annali, 8: Insediamento e territorial*, ed. Cesare De Seta, 159–240 (Turino: Einaudi)
- United States. 1907. *Public Health Reports*, 22: 50
- Varlık, Nükhet. 2012. "Conquest, Urbanization and Plague Networks in the Ottoman Empire, 1453–1600," in *The Ottoman World*, ed. Christine Woodhead, 251–63 (New York: Routledge)

- Varlık, Nükhet. 2014. "New Science and Old Sources: Why the Ottoman Experience of Plague Matters," *The Medieval Globe* 1: 193–227
- Vester, Matthew. 2013. "Introduction," in *Sabaudian Studies: Political Culture, Dynasty and Territory (1400–1700)*, ed. Matthew Vester, 1–36 (Kirkville, MO: Truman State University Press)
- Vogler, A. J., et al. 2013. "A Decade of Plague in Mahajanga, Madagascar: Insights into the Global Maritime Spread of Pandemic Plague," *mBio* 4: e00623-12
- Walsh, K., et al. 2013. "A Historical Ecology of the Ecrins (Southern French Alps): Archaeology and Palaeoecology of the Mesolithic to the Medieval Period," *Quaternary International*, 30: 1–22
- Wilschut, L. I., et al. 2013. "Potential Corridors and Barriers for Plague Spread in Central Asia," *International Journal of Health Geographics* 12: 15pp
- Wimsatt, J., and D. E. Biggins. 2009. "A Review of Plague Persistence with Special Emphasis on Fleas," *Journal of Vector Borne Diseases* 46: 85–99
- Zanetti, Dante. 1977. "A Milano nel 1524: i sospetti del Gentilino," in *Fatti e idee di storia economica nei secoli XII-XX: studi dedicati a Franco Borlandi* 105–15 (Bologna: il Mulino)
- Ziegler, Michelle. 2014. "The Black Death and the Future of the Plague," *The Medieval Globe* 1: 259–283
- Zimina, R.P., and I. P. Gerasimov. 1973. "The Periglacial Expansion of Marmots (*Marmota*) in Middle Europe during the Late Pleistocene," *Journal of Mammalogy* 54: 327–40

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Abstract Historical sources documenting recurrent plagues of the "Second Pandemic" usually focus on urban epidemic mortality. Instead, plague persists in remote, rural hinterlands: areas less visible in the written sources of late medieval Europe. Plague spreads as fleas move from relatively resistant rodents, which serve as "maintenance hosts" to an array of more susceptible rural mammals, now called "amplifying hosts." Using sources relevant to plague in thinly populated Central and Western Alpine regions, this paper postulates that Alpine Europe could have been a region of plague persistence via its population of wild rodents, particularly the Alpine marmot.

Keywords Plague, vector-borne disease, Alpine Europe, *Marmota marmota*, Milan, Savoy, Petrarch.

