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FROM THE LATE MEDIEVAL TO EARLY MODERN IN THE RIETI BASIN (AD 1325–1601)

Paleoecological and Historical Approaches to a Landscape in Transition

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ABSTRACT: From the fourteenth through the end of the sixteenth centuries, the primary political, economic, and environmental changes in Italy have been considered to be the impacts of a century of plague following 1348 and the transition from medieval to early modern political and social systems. While at the macro level across the politically divided Italian peninsula these are well attested, in the intermountain basin of the Velino River north of the central Italian city of Rieti, the historical and paleoecological data point to a range of other factors having an effect on the changing landscape. As events such as the arrival of the Black Death resonated in the resurgent forest following the steep decline in population, other local activities, such as the city's political realignment with Rome and its interest in controlling the hydrology of the basin as a free commune, equally left their mark on the local ecology of the basin. Ultimately, the historical and paleoecological evidence demonstrates influence by continental climate patterns; regional demographic, political, and economic changes; and local priorities in concert.

KEYWORDS: *Italy, late medieval period, landscape transformation, paleoecology, pollen analysis, consilience, Black Death*

INTRODUCTION

In 1348 the first fatalities from the Black Death portended the enormous human cost from illnesses in Italy and much of western Europe in the decades to come. The disease's pace of mortality surged and receded for

more than a century, reducing the Italian population to 60 percent of its preplague levels by 1450.¹ The effects were significant not only in their demographic impacts but also in political, economic, social, and cultural dimensions. In addition to the direct declines in population resulting from death, shortages of food caused in part by the decline of rural and agricultural labor continued to affect the demographics of the population for the following century. This same decline in available labor eventually increased the costs of goods. This is visible most prominently in the records of Tuscany, where the price of grain had doubled in the decades after 1350, and remained regularly in flux for another two centuries.² On account of both factors, there was significant loss to both urban and rural communities; however, the decline of labor precipitated the rise in real wages and the ascendancy of a new mercantile urban elite. Beyond the human toll, the arrival of the plague reverberated culturally, in literature (like Boccaccio's *Decameron*), art, religious practices, and cults, and spurred on technological advances.³

It has been argued that the plague was a phenomenon related to a shift to a predominantly cooler, wetter climate known as the Little Ice Age (LIA) that began with periodically wetter summers during the thirteenth and fourteenth centuries, while a cold spell circa 1300 likely contributed to widespread famine across central Europe. During the LIA, although climate was dominated by cooler conditions and glacial advances, there was a great deal of climatic variability across Europe, including periods of significant drought. Evidence of cooler, wetter climate is preserved in data obtained from tree rings and glaciers, and by proxy increased historical accounts of flooding of the Tiber River. However, contemporary historians have long debated the timing and the effects of the LIA on the communities of Europe and beyond, especially given local climatic variability.⁴

It is clear from recent scholarship that the influences were felt regionally and were variable. For example, the Great Famines of 1315–18 that signaled the beginning of the LIA have been assigned as one of the primary causes of political unrest and peasant revolt in northwestern Europe, although they seem to have had fewer effects in Italy.⁵ That did not mean that Italy was immune from famine-related violence. The Florentine chronicler Giovanni Villani described its effects in a number of particular episodes. Most notably, he recorded that in 1329, the citizens of Rome rebelled against their ruler, a baron of the Kingdom

of Naples who was the secular administrator of the city, due to a food shortage. The episode in his chronicle (from book 10, chapter 117) concluded when the Romans

rose up in protest . . . [a]nd storming the Capitoline Hill, they attacked it with such a fury that [the Baron] Guiglielmo . . . left office with great humiliation and shame. And the Romans made Stefano Colonna and Poncello Orsini their senators, and in order to placate the people, they had their own grain and that of other Roman land-owners brought to the piazza.⁶

This observation is instructive, as it points to the fact that while the agricultural resources of the city of Rome diminished to the point of causing localized famine, its nobles who had properties much farther afield had the capacity to store reserves and did so. It is further worth noting that the families of both men mentioned as rescuing the city, the Colonna and Orsini, would be connected to Rieti during this same period.

These two phenomena, the Little Ice Age and the Black Death, had dramatic repercussions throughout Europe, but in a localized setting, other *human* factors played a role in the transformation of society and the landscape. Given what can be extrapolated from historical sources, the case of the Rieti basin in central Italy is one that points to factors beyond these two great fourteenth-century movers of demography and agriculture at work in the changes of the landscape for the subsequent two centuries. By juxtaposing paleoecological evidence with local and regional historical trends known from written sources, we argue that while climate played an important role, human dynamics were primarily responsible for changing the landscape around the Rieti basin.

COLLABORATION BETWEEN HISTORIANS AND PALEOECOLOGISTS

The effort to better incorporate socioeconomic complexity with paleoecologic data has recently been termed a consilient approach. In this approach, hypotheses are developed in collaboration between historians and paleoecologists at parallel chronological and spatial scales, to produce more nuanced causal interpretations between societies and the land.⁷ While interdisciplinary work is lauded in the current research environment, taking a consilient approach and seamlessly melding the

humanities and sciences remains challenging. Stumbling blocks to such collaborative work exist in how to choose the place of study, the sources of evidence available, how data are presented, the resolution of data, the scale of analysis, and the perpetual issue of attributing cause and effect to environmental changes in a system where humans respond simultaneously to both climate and sociopolitical forces.

There are three different sets of information that need to be considered when attempting to discern the relationship between humans and environmental change: paleoclimate, paleoecology, and history/archaeology. We think of this as a three-legged stool, or the tripod analogy; each leg is needed to support the study. The paleoecology often comes from pollen analysis of lake sediments, which is capable of providing physical evidence of landscape change. The lake site must be in a place impacted by humans, and the assumption is that the changes are primarily caused by human activity. This means that an independent paleoclimate record must be identified, typically from tree rings, speleothems, or isotopes. These records can provide high resolution reconstructions of temperature or precipitation, but they give no insight into landscape level changes. Finally, human socioeconomic change must come ideally from historical documents, or alternatively the archaeological record. When a study is designed without all three elements, invariably one dataset does not match the others, leading to the “shoehorn” dilemma, forcing one dataset to fit with the others. Most studies to date have taken this post-hoc approach, which invariably does not allow for robust comparison of all three essential data types. Below we identify some challenges to following a consilient approach and provide a few tentative suggestions in pursuing this methodology.

Our experience suggests that not only do studies need to be designed from the beginning with an eye for each of the three different data types, but it is most appropriate to let historians dictate suitable study sites and research questions, since historical sources containing information on land use and ecology are harder to find than are suitable physical sedimentary sites, or appropriate sources for climate reconstruction. Historians of the premodern period are limited by the availability and scope of sources, primarily documents, particularly going back farther in time. Physical scientists must work closely with their historian/archaeologist partners in the site selection process to ensure that there is sufficient well-dated interpretable socioeconomic information to accurately

interpret the human causes associated with noted vegetation or climatic change.

Another challenge, particularly in studies that rely on ^{14}C dating for a chronology, is that the chronologic resolution of sedimentary records may not allow for precise correlation with historical dates. This is ameliorated to some extent with varved (annually laminated) sediments, but these are rare. The best alternative is to identify sites with relatively high sedimentation rates, which allow for close sampling intervals with decadal or multidecadal resolution. Tree-ring studies provide annually dated climate reconstructions, but long tree-ring records are often limited to regions far from population centers, thus always presenting the challenge of relating the climate data to a specific locality. Climate data networks seek to combine multiple tree-ring datasets to infer climatic change across a large region; however, for those regions without local datasets, the reconstructions sometimes show no skill and do not provide reliable climate information.⁸

A particular challenge in publishing interdisciplinary studies is that scholarly historical narratives are largely text based, while presentations of scientific data value graphical figures with limited text. The result is that publications oriented toward scientific audiences remove much of the critical historical narrative, and alternatively, scientific figures intended for publications oriented toward humanities audiences may result in oversimplification of the data for a nonspecialist audience. Even the citation referencing systems between the sciences and humanities are different, leading to challenges in reading across the disciplines.

Scale of analysis presents yet another challenge. There is a temptation among scientists to look for broad data patterns that generally only emerge at the regional to global scale, and then use these patterns to point to cultural events, such as wars or famines, that are coincident in time as potential causes—a classic instance of the shoehorn effect. In such efforts, the historical evidence demonstrating an actual link between the cultural event and the evidence for physical change is rarely discussed in detail, often because at a regional to global scale, physical data become “aspatial” and can no longer be identified with a specific area where the event has taken place. In such analyses, the linkage between historical and physical evidence sometimes relies on generalizations about changes in population, plagues, wars, and other human factors that are rarely documented with demographic evidence. On the

other hand, local scale studies can actually develop a clear link between human activity and landscape change, but they are more easily dismissed as singular case studies.

We would argue that only local scale studies that have equal representation of historical, paleoecological, and paleoclimatological data will be able to approach the problem of attributing cause and effect to environmental changes in a system where humans respond simultaneously to both climate and sociopolitical forces. Until we can produce more of these local scale studies that can draw a clear relationship between specific human actions and their consequent environmental impacts, global scale explanations of human impacts will continue to fail to disentangle the complex interactions between politics, economics, technology, land use, and climate that are likely the true drivers behind ecosystem change through time.

STUDY AREA

The Rieti basin is an intermontane depression in the central Apennines at roughly 370 meters above sea level and 70 km north of Rome (fig. 1). Its major settlement, the city of Rieti, sits at the basin's southern edge, connected to Rome and the rest of Italy by the ancient Via Salaria. At its center flowed the Velino River, although the basin held a large shallow lake, known in antiquity as the *Lacus Velinus*, between ~4,000 and 1,000 years BC. This would be dramatically reshaped under the control of Rome, when around 270 BC a consul of the early Republic, Manius Curius Dentatus, cut a channel through the calcareous tufa sill where the Velino River spilled over, called the *Marmore*, creating new meadows and leaving a series of smaller lakes across the basin. This presents the first documentation of partial draining of the basin wetlands for reclamation, but efforts would continue.⁹ Historical documents related that in the early Middle Ages, roughly 750–900 AD, parts of this territory had been under the local control of the monastery of Farfa, and later under the Diocese of Rieti itself, while extensive archaeological surveys have revealed a continuous occupational history from the third century BC, although with different patterns of settlement over time.¹⁰ The villas and nucleated settlements at the lower reaches of the basin of the late Roman period gave way to relatively sparse habitation until fortified hilltop settlements ringing the basin largely became established in the twelfth and thirteenth centuries (fig. 1).

FIG. 1. Site map with medieval settlements first noted in monastery records between 1050 and 1250 AD. Dates represent first year of first mention (when known) in Farfa monastery documents (S. Coccia, D. J. Mattingly, P. Beavitt, H. Elton, P. Foss, I. George, C. O. Hunt et al., "Settlement History, Environment and Human Exploitation of an Intermontane Basin in the Central Apennines: The Rieti Survey 1988–1991, Part I," *Papers of the British School at Rome* 60 (1992): 213–89). Names in bold are still occupied. AP–**Apoleggia** (1152); BU–Butro (1150); CA–Casarine; CB–Collebaccaro (1128); CF–Castelfranco; CG–**Contigliano** (1157); CL–**Cantalice** (1081); CO–Cocione (1152); FG–Fortemonte Gambaro (1112); GR–**Greccio** (1091); LA–**Labro** (1152); LR–La Rochetta; MO–**Moggio** (1152); MR–Monte Rotundo; PB–**Poggio Bustone** (1117); RI–**Rivodutri** (1171); SC–Santa Maria in Consanano; SM–San Matteo (1205); SP–San Pastore (1254); TM–Torre di Morro Vecchio.

Since the Renaissance, historical maps portray substantial changes in the size and shape of lakes in the basin, their proximity to the Velino River, and the extent of wetlands through time. Four lakes remain today: Lungo, Ripasottile, Ventina, and Piediluco. Our site, Lago Lungo, presently has a maximum depth of 4.5 m with a surface area of 0.41 km². The lake is surrounded by agriculture today with heavily managed coppice, dominated by oak (*Quercus pubescens* and *Q. cerris*) and hop hornbeam (*Ostrya carpinifolia*) forest on the surrounding slopes. Sedimentation

rates are very high, locally averaging 3–12 mm yr⁻¹ and attributed to the high levels of catchment erosion due to agriculture and forest coppice.¹¹

METHODS

Archival and Historical Resources

The historical sources for Rieti are widely dispersed during this period. Narrative sources touch upon the basin sparingly except for those detailing the growing religious communities, many of which were connected to movements inspired by Saint Francis. On the other hand, the Catholic Diocese of Rieti maintained extensive documentary records dating back to the tenth century.¹² Some of the records are related to its holdings as well as the maintenance of the basin (or at least the areas that fell under its control), although often centered on activities taking place within the city. It is primarily from these records, many of which remain unpublished and understudied, that the local history of the basin in the earlier medieval period can be best assessed.¹³ The development of the local commune in 1226, on the other hand, led to an institutional practice of record keeping maintained to the present day, one that preserved premodern regulations, deeds, and legal disputes, from which various aspects of land use may be ascertained.¹⁴

As a consequence of both its topography and its proximity to Rome and other important monastic centers in Italy, Rieti's landscape also was a sacred one. In the early thirteenth century, Francis of Assisi spent time in the city and in its surrounding area, and in the following century a number of small monastic communities and hermitages were established there, many specifically housing nuns.¹⁵ Between 1296 and 1319, an anonymous chronicler described Francis's interactions within these places, and although a literary text, it offered a glimpse into the economic activities within the landscape, with fishing in the lakes and the care of cows in the surrounding plain.¹⁶ Yet the communities could struggle: the sisters of San Pietro de Molito, just northeast from Lago Lungo, did not practice radical poverty but were aware of their needs for economic security beyond owning land in the basin (the community lasted from 1220 through 1500, through some of the most difficult periods in the basin's history).¹⁷ Following the interest of Francis, religious houses both large and small were scattered across the edges

of the basin, including a Cistercian community often at odds with the church of Rieti (and therefore appearing frequently in litigation).¹⁸ The documents these communities produced, from narratives to legal cases, improve on the historical records that are mostly centered on the city of Rieti itself.

Paleoecological Methods

The primary method for reconstructing environmental history was fossil pollen analysis from lake sediments, and much work has already been done on their analysis and the construction of an age model to assist in their interpretation.¹⁹ Overlapping sediment cores were recovered from an anchored floating platform and core sections were split and imaged, and magnetic susceptibility measured every 0.5 cm. Magnetic susceptibility and imagery were used to correlate core sections. Rock magnetic and paleomagnetic properties were measured at 1 cm spacing for constructing an age model. Development of an age model was challenging because ¹⁴C age dates proved to be unreliable. The carbonate bedrock introduced significant old carbon. Measures of ¹³⁷Cs and ²¹⁰Pb activity and the presence of pollen from the introduced crop *Zea mays* constrained the age at 134 cm to between 1700 and 1750 AD. Accelerator mass spectrometry (AMS) ¹⁴C ages on macrofossils from 159 and 170 cm depth produced dates of 680 and 1175 AD—significantly older than the *Zea mays* pollen date. We therefore developed two independent age models: one from fifteen ¹⁴C AMS dates between the 159 and 1000 cm depths, and the other using biostratigraphic markers (*Zea mays*, *Cannabis sativa* var. *vulgaris*) and paleomagnetic trends (declination, inclination, and paleointensity) correlated to available paleomagnetic secular variation (PSV) curves and models for Europe. After extensive comparison, reviewed in detail elsewhere, we concluded that the PSV age model produced the most accurate chronology, with an error estimate of ± 50 to 70 years at 1200 AD.²⁰

Twenty-seven samples were analyzed for pollen from the period 1200 to 1850 AD, with an average of twenty-four years between samples. Pollen percentages were calculated from the sum of terrestrial pollen, excluding indeterminate grains and *Cannabis* type (which was retted in the lake at certain periods). Nonmetric multidimensional scaling (NMDS), based on Bray-Curtis distances calculated on taxa pollen

percentages, was used to summarize the multivariate time matrix in a low (biplot) dimensional space. NMDS can indirectly reveal the presence of gradients to assess ecological community dynamics and provide support for comparing the timing of abrupt ecological change with historical events.

RESULTS AND DISCUSSION

Although historical and documentary sources can be useful in understanding the impacts of natural phenomena in Italy, such as in recording the freezing or sea flooding of the Venetian lagoon, they leave much unanswered.²¹ This is not only because of their inconsistency, as no Renaissance chronicler measured average temperatures annually, for example, but because their perspectives on the natural world and the landscape were also shaped by literary conventions and popular tropes.²² In addition, although as we have seen with the example of Villani above, some chroniclers include the repercussions of climatic changes, they were often concerned principally with the political ramifications. The problem for Rieti is that while there is in general good documentation for the fourteenth century, there are no chronicles or other documentary or historical sources that are effective at specifically corroborating demographic and ecological changes. Instead, the view of the basin is dominated by the political struggles in the city itself and the changing nature of religious and monastic communities in the area more broadly. In this case, our interpretation of the paleoecological data suggests that all three factors—political events, demographic decline associated with the Black Death, and the changing climatic conditions—played a role in shaping the landscape, but that humans continued to respond to changes brought about by the demographic decline and periods of cooler and wetter climate.

Rieti's political fortunes in the fourteenth century were tied to both internal and external struggle. Situated at the border between papal territory and Naples, Rieti fell under the influence of the Kingdom of Naples after 1305, when the papacy relocated to Avignon in southern France, leaving Roman territory to be disputed among its noble families. The city itself was often the site of internal political struggles of factions of the Guelfs and the Ghibellines, originally supporters of the papacy and the Holy Roman emperors, respectively, but by this time,

networks of alliances in Italy (the papacy would resume control of the city in 1354, but local rivalries would continue). Although the city would return to relative stability, it would continue to be affected by recurring plague, famines, and floods, tragedies that were often interrelated. Key to the region's recovery at the end of the 1400s ultimately proved to be the eventual dormancy of the Black Death and new methods of and interest in controlling the hydrology of the basin.

Water Management in the Late Medieval Rieti Basin

During the late Middle Ages, agropastoralism was the dominant form of land management in the uplands, and warmer than average temperatures had allowed settlements and farming to move upslope nearly 1,000 m, a migration visible in the archaeological record.²³ The pollen evidence shows that in the first half of the thirteenth century, the landscape was primarily open woodland, grassy meadows, and plants associated with grazing and disturbance, with likely only scattered trees, probably coppiced extensively for fuel and livestock fodder (fig. 2). Though documents describing the use of the valley are scarce, the pollen records, and especially those of cereals, suggest that the floor of the basin was cultivated to some extent and possibly effectively drained through a network of canals. Historical narratives describe their initial construction under the Romans, and they were subsequently maintained by the community during the Middle Ages. Records from 1212 to 1214 describe efforts to keep the basin dry and indicate that the Cistercians, who maintained a monastery there, were exploiting the plain and intensifying cereal cultivation.²⁴ Attempts at intensification were likely widespread, as evidenced by the greater volume of legal challenges made to better determine property boundaries as the value of the drying marshland increased throughout the thirteenth century.²⁵

The first potential evidence of cooler temperatures and increased precipitation appears in the historical records in the late thirteenth century. In 1277 increasing regularity of flooding initiated discussions for a new drainage canal, eventually built in 1325 as noted in historical records.²⁶ The pollen data from this period offers a substantially more nuanced view, especially in levels of pollen from alder (*Alnus*) trees. Because alder trees require standing water to grow, their presence is a good proxy for floodplains in the basin. Furthermore, previous pollen

studies have shown a clear link between percent alder pollen and water level in the Rieti basin.²⁷ Today, the basin is intensively cultivated, and only tiny fragments of alder are found in close proximity to large spring systems, reflected in alder pollen percentages of <1 (fig. 2). In the thirteenth century, the very low percentages of alder, also of <1, suggest that the basin near the lake had also likely been drained. Climate reconstructions from a tree-ring network across the Mediterranean indicate drought in Italy between 1237 and 1253, which may have helped keep the basin drained.²⁸ The first increase in alder pollen begins about 1300, peaks about 1320, and is back to near zero by 1350. While our age model does not allow us to claim that the increase in alder at this time was directly the result of the flooding that prompted construction of a new drainage network, increased flooding would have led to alder incursion, and draining of the basin would have led to alder decline. The tree-ring network data suggest drought in southern Italy during the periods 1312–29 and 1351–66; however, this reconstruction indicates wet climate during these periods in central Italy, and it is important to note that the lack of tree-ring chronologies in their network from central Italy means that there is lack of skill in the reconstruction for most of Italy. Flood records in Rome from the early part of the fourteenth century also suggest that this was not a period of drought in Rieti.

If our assumptions concerning alder presence in relation to flooded or drained land are correct, the general timing of the flooding would also have preceded the periods of grain shortage reported by Villani, leading to the possibility that the attempts to drain the basin may have had negative effects elsewhere. For example, long-standing disputes with the city of Terni, north of the Rieti basin where the Velino meets the Nera before entering the Tiber, reemerged in the fifteenth century, notably in a lawsuit over the amount of water being released from the basin in 1426.²⁹

Finally, other pollen evidence, specifically the increase in Mediterranean woodland trees and the decrease of grass, also suggests that the end of the Medieval Climate Anomaly and beginning of cooling associated with the Little Ice Age may have already been a factor leading to forest recovery in the thirteenth century in the wake of the abandonment of higher elevation settlements, noticed in the archaeological record.³⁰

Changes Following the Black Death

In 1347 the city would be struck by a returning famine, and in 1348 the first instance of the Black Death, which would return again in waves, striking the city with major mortality events in 1363, 1374, 1400, and 1449. While this had a substantial impact on the population, the city's institutions, like its bishopric, continued without interruption. Many of its leading local families also survived, notably the Alfani, who after 1378 would gain control of the city for fifty years.³¹

Despite the turn toward internal stability, the basin continued to be caught up in larger events due to its position along the frontier between Roman and Neapolitan territory. In 1408 it was occupied for ten years by a *condottiero* or captain of a mercenary army named Braccio da Montone on behalf of Ladislaus of Naples. It was during this period that the citizens of Rieti along with one of the minor lords of the basin, Nicolò Trinci of Piediluco, argued for cutting a new channel of the Velino River through the Marmore at Cava Reatina, which was finally completed in 1422.³² This hydrological project was said to have directly contributed to flooding along the Tiber in November of that same year, which now is famously marked by a contemporary medieval plaque on the wall of the church of Santa Maria *sopra* Minerva in Rome near the Pantheon, along with other major premodern floods.³³ Stefano Infessura, writing some fifty years after the event, accused da Montone directly for his role in the instigation of the channelization and the perceived destruction that followed its completion: "and this was the large flood of Braccio da Montone[;] because of [his anger toward] the Roman state, he broke through the Marmore of the Pedeluco lake, and did this to spite the Romans."³⁴ While this episode played into the historical rivalries between Rome and the Kingdom of Naples (in whose service Nicolò Trinci worked), as well as the above-mentioned conflict between Rieti and the city of Terni, it also illuminates some of the attempts to manage a landscape that had changed.

Contemporary to these events, the pollen record in the Rieti basin shows an increase in alder pollen beginning in 1400, peaking before 1420 and having subsided by 1430 (fig. 2). This pattern of a short-term increase and decrease once again seems to confirm the historical record of increased flooding on the Tiber and its tributaries related to the pe-

riod of increased precipitation, relieved for a period by new drainage work at Cava Reatina.³⁵ But the pollen record indicates that this time, percent alder pollen did not decline to near zero, suggesting that the work was only partially effective, or that the changing climate had increased the floodplain through regular flooding events, and by 1480 percent alder pollen is once again increasing. This was due to not only a steadily deteriorating LIA climate with more winter precipitation (and notably a particularly cold period in the 1450s, followed by a large volcanic eruption in 1453 at Kuwae in the South Pacific, which had a general global cooling effect through its “dust veil” evidenced in glacial cores) but also an increase in flood frequency and in local political instability as well.³⁶

In 1418 Rieti returned to the political sphere of the papacy under Martin V, and in 1425 he was responsible for eventually banishing the Alfani family from Rieti with an order forbidding their return to within fifty miles of the city. This stability may be visible in the decline of alder along the lake in the years following its reentry into the sphere of papal control. Yet the city would be threatened again, as its countryside was occupied in 1433 by a number of military captains loyal to Rome’s Colonna family and others who were in open rebellion against the pope, Eugene IV, who was of the rival Orsini family. These troops threatened the city for more than a decade. Although order was restored in 1447 with the installment of a new pope, in 1449 the plague would strike again; although its effects are hard to judge, it was enough to prevent the pope, Nicholas V, from making a scheduled trip to Rieti.³⁷ This did not stop major works on the basin, and in the following year, new attempts at the castle of Papigno to construct a new outflow for the Velino was met again with opposition, again from the people of Terni. Although the offending works were never completed, broader regional conflicts would continue to impact Rieti for most of the century. For example, from 1464 to 1491 Rieti would be once again swept up in the antagonisms between the Kingdom of Naples and the papacy, and beginning in 1495 the French would make forays into Italy, further disrupting the city. Although exact corroborations are difficult to determine, these changes in the political climate and dangers from the plague certainly influenced the effectiveness of large-scale hydrological projects that needed both human labor and oversight, and by extension influenced the types and intensity of land use.

Restoration and Stability in the Early Modern Period

In the sixteenth century these same patterns continued: external threats and political instability caused by rival families in Rome pulled at the city, while other more local tensions continued to simmer (like the rivalry with Terni over the construction of a new channel, Cava Paolina through the Marmore undertaken in 1545 by Antonio di Sangallo).³⁸ Once again, the pollen record appears to accurately record this new hydrologic work to reclaim parts of the basin. Percent alder pollen steadily increases to 20 percent by 1550 but then decreases, potentially in response to the reclamation work (fig. 2). Only thirty years later, in 1575, another major reclamation effort was made by reworking the previous Cava Reatina, an attempt that was substantially documented in records preserved in the communal archive of Rieti.³⁹ The two works combined must have had a significant effect in reducing the marshland because percentage of alder pollen continued to decrease until 1580.

Draining the basin during this period must have been a major challenge. Multiple historical documents from central and southern Europe indicate that the century from about 1550 to 1650 was one of the coldest and wettest during the LIA. Ladurie has compiled much of the historical evidence for this shift, noting both glacial advances and severe winters during this time.⁴⁰ In the Alps of Italy, France, Switzerland, and Austria, glaciers advanced to their greatest extent in the historic period, including the Agues (Chamonix, France), Grindelwald, Allalin (Switzerland), and Rutor Glacier Val de Thuile (near Aosta, Italy). Between 1593 and 1602, Swiss glaciers in the Savoy and Tyrol regions suddenly advanced, crushing hamlets. Ladurie records that the years 1565, 1569, 1571, 1573, 1587, 1595, and 1600 all had olive-killing frosts in Mediterranean France, while the period 1525 to 1600 AD has been described as a very humid phase at Lac Pavin in south-central France.⁴¹ On the other hand, the years 1601 and 1643 had volcanic eruptions leading to some of the coolest temperatures across Europe.⁴²

Closer to Rieti, there is evidence that the frequency of major floods of the Tiber through Rome is also greatest during the sixteenth and seventeenth centuries, with the four biggest floods occurring in 1530, 1557, 1598, and 1606.⁴³ Ultimately, these major disasters did not reduce reclamation efforts in the Rieti basin. These would continue, primarily because a century of attempts to stabilize the water levels in the basin had

provided new fertile lands to come under cultivation, making the land-owners, many based in city of Rieti, new fortunes.⁴⁴

In 1596 the architect Giovanni Fontana was commissioned to create a new channel by Pope Clemente VIII, and we possess a rich trove of documents that describe not only the engineering and political planning but also the financial transactions behind its execution.⁴⁵ Fontana's career continued, and he was later commissioned to build the Fontana dell'Acqua Paola, the terminus of the aqueduct that brought drinking water from near Lake Bracciano to Janiculum Hill in Rome (although its execution has been attributed to Flaminio Ponzio), which is still functioning today. This points to a larger pattern, that the abilities of hydrologic engineers in Renaissance Italy had been continually improving, and the art of moving water for both practical urban and rural purposes became a means of demonstrating largess and status.⁴⁶

The channelization of the Velino slowly began to reshape the land. While maps of the Rieti basin in the seventeenth century show that Lago Ripasottile and Lago Lungo still remained merged into one lake, pollen data indicate that after 1601 alder no longer increased but rather began a slow but steady decline until it was largely absent from the basin by 1750, as wetlands were replaced by farmed fields. The near disappearance of alder is indicative of the fact that although the climate had not ameliorated, reclamation efforts were now successful and the stage was set for creation of the modern ecosystem.⁴⁷ The significance of the shift in the seventeenth century is also visible in the settlements along the basin's floor, which developed once again and increased throughout the modern period.⁴⁸ On the reclaimed lands, permanent agriculture was established, including expansion of hemp production and introduction of maize (fig. 2).

ECOLOGIC REORGANIZATION

An additional feature of the pollen record of the Rieti basin is the regional reorganization of the landscape after 1350, in response to both the Black Death and changing climate. Prior to 1350 the medieval landscape of the Rieti basin was dominated by pasture and open woodland, but after this time, a closed-canopy forest rapidly covered the upland slopes. This landscape conversion appears to have happened in as little as forty years (fig. 3). Even during the early Middle Ages, trees were likely not

FIG. 2. Selected pollen types, and soil and dung spores for Lago Lungo plotted against core depth and age (AD). Summary pollen groups (e.g., Mesic) were aggregated on the basis of the NMDS ordination: Mesic woodland taxa include *Fagus*, *Carpinus*, *Acer*, *Ulmus*, *Fraxinus excelsior*, *Betula*; Mediterranean woodland include *Quercus cerris* and *robur* types, *Q. ilex*, and *Ostrya*; Mediterranean shrubs include *Fraxinus ornus*, *Pistacia*, and *Myrtus*; Cultivated trees include *Olea*, *Castanea*, and *Junglans*; Disturbance type include *Apiaceae*, *Plantago*, *Amaranthaceae*, *Trifolium*, *Galium*, *Polygonum*, *Salvia*, *Caryophyllaceae*, *Asteraceae*, and *Cichorieae*; Poaceae includes *Cyperaceae*. Unfilled black line represents 3x magnification. Pollen zonation (e.g., LL-3) follows Scott A. Mensing, Irene Tunno, Leonardo Sagnotti, Fabio Florindo, Paula Noble, Claire Archer, Susan Zimmerman et al., “2700 Years of Mediterranean Environmental Change in Central Italy: A Synthesis of Sedimentary and Cultural Records to Interpret Past Impacts of Climate on Society,” *Quaternary Science Reviews* 116 (May 15, 2015): 72–94. Timing of construction of canal works are identified with letters (a) Unnamed canal, 1325; (b) Cava Reatina, 1422; (c) Cava Paolina, 1545; (d) Cava Georgiana, 1575; (e) Cava Clementina, 1601.

entirely cleared but coppiced to utilize for forage and fuel.⁴⁹ Although mature trees were likely only scattered across the landscape during the period of heaviest land use in the thirteenth century, with land abandonment and the decrease in foraging and agriculture, the presence of large coppiced trees likely helped reestablish woodlands much more rapidly. With the reestablishment of unmanaged woodlands, this new landscape came to dominate the Rieti basin for the next two centuries. On a larger scale, woodlands were reestablished in many sites across western Europe in the wake of the Black Death and initial LIA cooling, but in most regions the return to clearing of forests, grazing, and agriculture began only a century after the demographic decline.⁵⁰ Forest clearing did not begin for two centuries in the Rieti basin, perhaps reflecting the problems managing the hydrology of the basin discussed above.

After 1600, and increasingly after 1650, we see an upsurge in grass and disturbance species, and a steady decrease in forest (figs. 2 and 3) such that by the late seventeenth century the ecosystem has once again shifted back to being a more open landscape. Yet it did not return to its pre-1350 conditions, but rather a new modern semiwooded landscape. The shift in this case to a more open landscape can be again linked to both human and climatic causes. Ocean and atmosphere conditions that control storm systems in Europe shifted in this period to bring a drier climate to central Italy once again.⁵¹ At the same time, relative population stability in Italy, decreased political volatility (often underwritten by increased control and intervention of foreign powers), and the initiation of new land use laws facilitated reclamation of the basin and management of woodlands at less impactful levels than previous periods and in other areas of Italy.⁵²

CONCLUSION

While climate played an important role, human dynamics were primarily responsible for changing the landscape around the Rieti basin as preserved in the physical evidence from lake sediments. Prior to the Black Death and initiation of a cooler, wetter climate, agropastoralism dominated throughout the basin highlands, and the forest was heavily grazed and cultivated with scattered trees likely providing fuel wood and fodder through coppicing. In the early fourteenth century, the first evidence of basin flooding appears, associated with local efforts of canal building.

FIG. 3. Nonmetric multidimensional scaling (NMDS) based on Bray-Curtis similarity index (stress = 0.14; R^2 of the axis 1: 0.64 and of axis 2: 0.19) of the plant taxa (green text) from Lago Lungo. The length of the vectors (green lines) are arbitrarily scaled to make a readable biplot; only their directions and relative lengths should be considered. Black filled circles represent the location in biplot space of pollen strata; associated numbers represent ages (year AD) for each pollen strata. Suggested pollen-derived vegetation communities are given for each quadrant. Arrows reference specific rapid transitions from a late Medieval agrarian landscape to a forested landscape (1380–1420 AD) and then a return to a less forested landscape (1630–1670 AD).

Repeated plague in the century from 1350 to 1450, coupled with political instability and increased precipitation and flooding led to wide-scale land abandonment and rapid forest recovery. The basin was strategically positioned between Roman and Neapolitan territory, and in the fifteenth century, efforts continued to create new canals and control flooding, but for the most part these were unsuccessful. The fifteenth and sixteenth centuries recorded the most frequent and largest floods of the Tiber River through Rome, prompting new canal projects to mitigate these floods, with the effect that the reclamation of the fertile valley enriched landowners. The abilities of hydrologic engineers in Renaissance Italy had been continually improving, and large hydrologic projects had become a means of demonstrating largess and status. In 1601 a successful drainage system was designed and constructed, leading to sustained reclamation of the valley. Despite continued cool climate and above-average precipitation, the pollen evidence shows a steady shift from a largely naturalized forest into a managed, cultivated landscape. The resulting modern forest ecosystem represents a landscape completely different from anything that existed in the previous 2,700 years. The rapid shifts in landscape change through time are closely linked to patterns of local human land use, further amplified by climatic change.

Careful comparison between the physical record of environmental change and historical documentation of changing land use and policies has allowed us to more accurately identify the role humans have played in changing the environment. While the Rieti basin represents only a small-scale case study, the principle established through this study has broad implications for studies aimed at understanding the role humans and climate have played in environmental change at larger spatial scales. Local-scale studies play a critical role in determining human or climatic causality of environmental change. We need more local-scale studies that can explicitly link the history of socioeconomic actions with physical evidence of environmental change: this will provide a basis for identifying potentially broader spatial patterns of human-caused landscape change that can then be compared with regional climatic patterns.

NOTES

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