Geomorphologic and anthropogenic impacts on artifact distribution within the plowzone in the Podere Funghi, Tuscany, Italy

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ABSTRACT

Geomorphological examination of archaeological sites on plowed hillslopes is useful to understand the natural and human impacts on sediment horizons in and around the anthropogenic site. The Podere Funghi archaeological site lies within a modern hayfield on the southern slopes of the Mugello Valley in Tuscany, Italy. Used for living and ceramic production during Etruscan habitation between 400 and 200 BC, the site was abandoned and has been subject to natural erosive processes and agricultural soil tillage. Shovel Test Pits (STPs) made on a 5 m grid throughout the field show current artifact distribution in the plowzone to be directly above or slightly downslope of the pottery source sites, either kilns or middens. Soil horizon thicknesses are greater in wooded areas than in fields, suggesting the influence of tillage erosion on soil and possibly artifacts in the field. Soil thicknesses within the field vary with respect to slope shape, but are not dependent on slope gradient. The field has likely experienced multiple plowing directions over time, which has worked to essentially cancel plow drag influence on artifact displacement. Agricultural tillage erosion caused an overall slight downslope artifact migration and is responsible for variable soil thicknesses between forest and field environments.

Keywords: Geoarchaeology, tillage erosion, geomorphology, land use, archaeological sites

INTRODUCTION

Geoarchaeology is an interdisciplinary field that uses geological study techniques to better understand remnants of ancient human settlements. Geomorphological surveys in and around archaeological sites develop geological context for the surface activity both before and since habitation. Understanding how the landscape geology has changed after initial human activities can help archaeologists develop more precise survey techniques through accurately predicting the changes in artifact placement over time (Waters and Kuehn, 1996).

Developing a site's geomorphic context benefits plowzone archaeology because the loose nature of plowed soil combined with the cultivating mechanism from plowing has a significant effect on soil erosion and artifact displacement. Tillage research indicates soil movement by plowing to be greatest on convex sections of the field, whereas concave areas experience net accumulation (Olson et al., 2002). Studies have shown that gradient is the primary influence on soil translocation and dispersion (Heckrath et al., 2005; Turkelboom et al., 1999; Van Oost et al., 2000). Existing research on cultivation impact on sloped fields varies from tractor-plowed gentle slopes (Govers et al., 1994) to steep slopes (Poesen et al., 1997), some with manual tilling in hilly and tropical areas (Turkelboom et al., 1997) and generally conclude that soil erosion increases with higher slope gradient and cultivation frequency. Determining the land use history and agricultural impacts on fields in the Mugello valley in Italy is difficult because the sites may have witnessed a wide spectrum of vegetation and cultivation since Etruscan habitation.

Studies on artifact displacement by plowing on flat surfaces suggest that cultivation has a minimal effect on moving small artifacts through the plowzone (Roper, 1976). After several plowing episodes, most artifacts had migrated less than one meter from the original starting point; however, when tilling does redistribute artifacts, displacement usually occurs in the direction of plowing (Odell and Cowan, 1987; Roper, 1976). Flat, plowed fields naturally experience fewer geomorphic mechanisms for erosion than plowzones on a hillslope (Lespez, 2003). A plowzone archaeology study on a hillslope in southern Italy indicated minimal artifact downslope migration after several plowing episodes in a direction perpendicular to the slope (Ammerman, 1985). After a plowing episode parallel to the slope and presumably in a downslope direction, artifacts were recovered 5-10 times farther downslope than had those recovered after previous plowing patterns. This suggests that combined downslope plowing and erosional movement have the greatest effect on repositioning artifacts (Ammerman, 1985).

This study in Tuscany, Italy defines both the agricultural and geological impacts on Etruscan artifacts since their original deposition. A survey of the plowzone for archaeological potential through shovel test pits (STPs) shows pottery sherd distribution throughout the plowzone. The highest artifact concentrations, however, were discovered slightly down slope of the Etruscan workshop and midden sites (the assumed artifact source sites) determined by trench excavations. Analysis of soil cores from within the plowzone and in the forested area upslope of the field indicate that the forest generally has thicker soil horizons than the field below it. Statistical tests comparing colluvial thicknesses from 20%- and 7%-slope east-west transects of the field show no significant difference between soil thicknesses on variable slopes; therefore, soil layers in the field are likely thinner because of tillage erosion. Through analysis of geomorphic evidence and environmental features, I determine that soil movement and current artifact placement in the field have been primarily influenced by tillage erosion.

BACKGROUND

Geological Setting

The Podere Funghi archaeological site is located in the Mugello Valley, a depression within the northern Apennine Mountain range in northeastern Tuscany, Italy, within a one-hectare field in the southern mountains of the valley (Fig. 1). The field is located ~320 m above sea level, in contrast to the bottom of the Sieve River valley ~180 m above sea level. The Podere Funghi lies on Holocene colluvial sediments and the bedrock underlying the colluvium is the Monte Senario formation, a Paleocene-Oligocene felspathic-quartz sandstone containing coarse quartz pebbles, mica, phyllite, and calcareous material (Fig. 2). Some local hills within the valley, especially those north of the Sieve River, currently experience high rates of surface erosion and even have badland structures (Fig. 3). The hillslopes on which the Podere Funghi and nearby Poggio Colla field sites are located are less actively erosive and the colluvial sediments are mapped as results of "ancient" landslide activity (Fig. 3). Erosion surveys in Tuscany have estimated tillage erosion to be 2 cm yr^{-1} of surface lowering on average, and as much as 4 cm yr^{-1} of surface lowering on convex features in the plowzone (Borselli et al., 2002). The forested area south (and upslope) of the field site shows evidence of erosional gullies running parallel to the slope. Two ~30-cm manmade trenches lay E-W, or

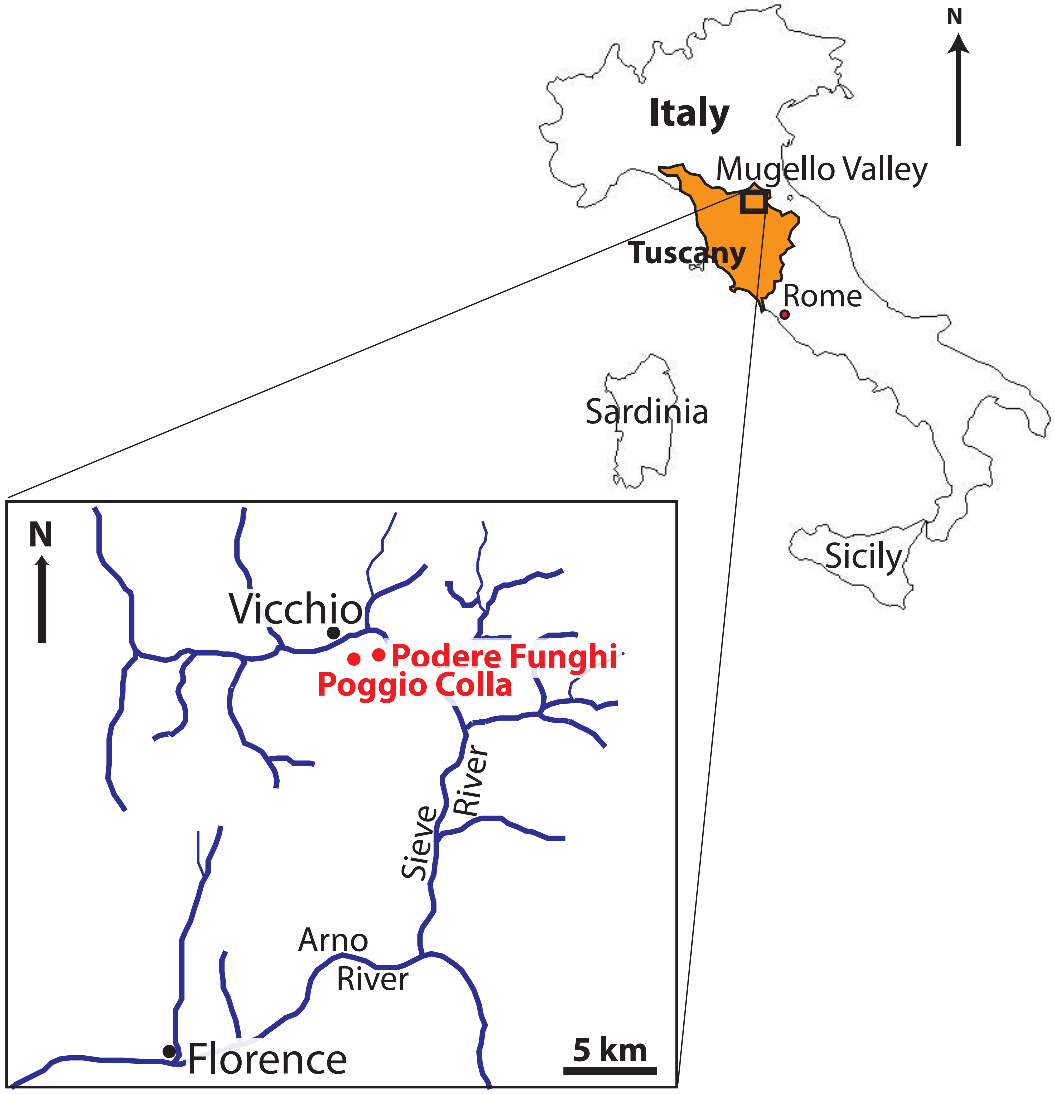

Figure 1. Regional map of the Mugello Valley and its location in the Italian peninsula. The Poggio Colla and Podere Funghi archaeological sites are marked; note the proximity to the Sieve River, which forms a waterway connection to the city of Florence. (Modified from Warden et al., 2005)

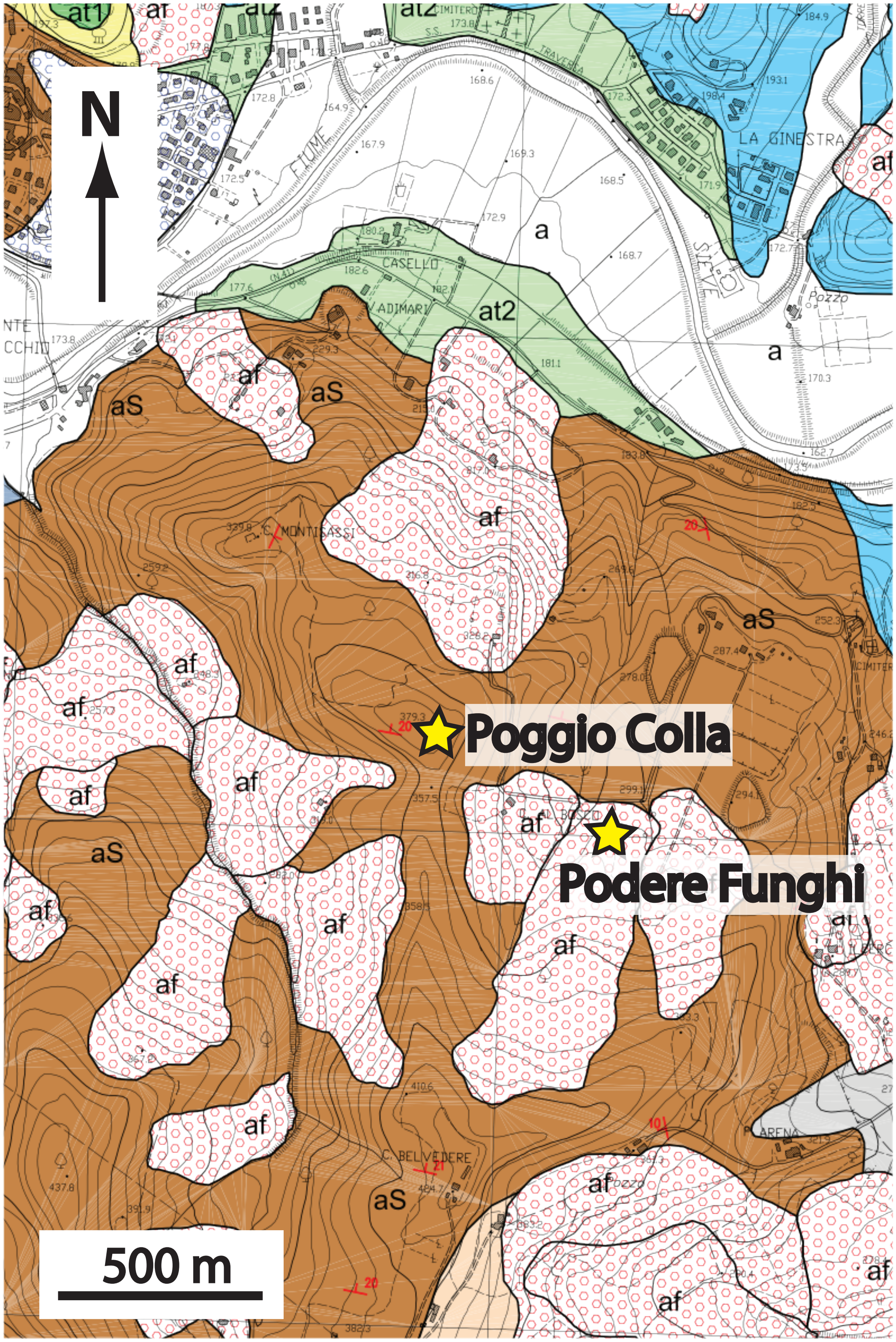

Figure 2. Geologic map of the the SW Mugello Valley with Poggio Colla and Podere Funghi field sites marked. Poggio Colla is situated on the Monte Senario sandstone with little colluvial cover; the Podere Funghi is located on colluvium directly overlaying the Monte Senario sandstone. Contour interval is 10 m.

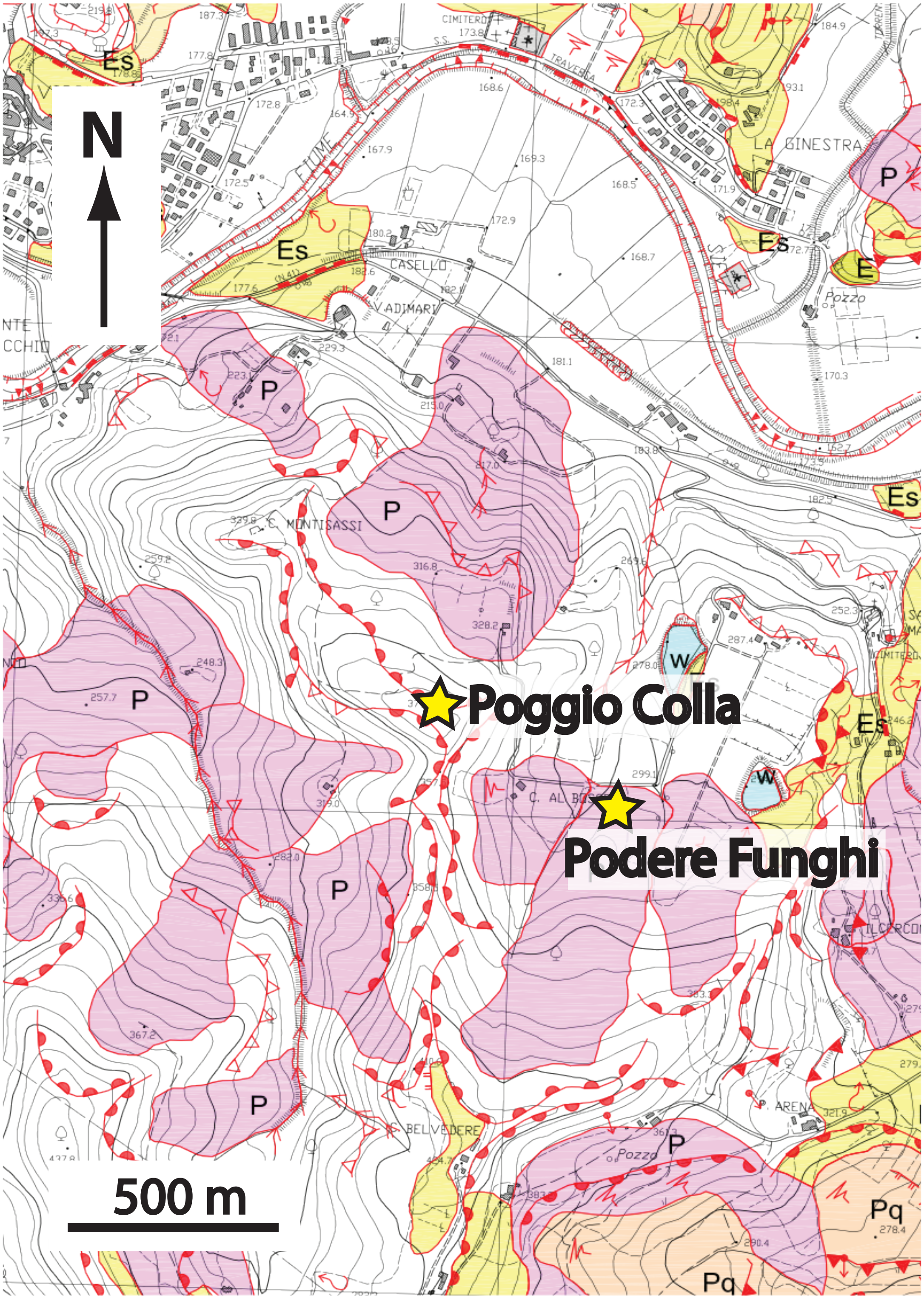

Figure 3. Geomorphologic map of the the SW Mugello Valley with Poggio Colla and Podere Funghi field sites marked. Poggio Colla is situated on a hill acropolis with weathering sandstone bedrock that moves in NE and SW directions away from the site; the Podere Funghi is located on ancient landslide deposits. Contour interval is 10 m.

perpendicular to the slope gradient and direct water into a drainage ditch east of the field (Fig. 4). Although the ages of the trenches are not known, the straight nature indicates the trenches are not filling with eroded sediments or other debris washed from above. Therefore, the trenches are likely either recent or well-maintained features, suggesting there is currently human manipulation of both the field and the forest in the Podere Funghi. Other evidence of human involvement in the forest is an active trail leading from the field and upslope ~150 meters. This trail is ~1.5 meters wide and the sediments are well packed. Horse hoof prints observed on the path suggest the trail is currently used for recreational purposes. Undergrowth consisted of holm oak, or *Quercus Ilex.* The largest, and therefore presumably oldest coniferous trees in this forest ranged from 188-193 cm in circumference at breast height. Calculations based on the suspected growth rates for coniferous trees suggest these trees (and thus much of the forest) are at least 70 years old (Cherubini et al., 2003). The ~1 m high soil bank between the field and forest (Fig. 5) is evidence of land leveling, a technique used to lower slope gradient for high-erosion tree crops like vineyards, olive groves and orchards (Torri et al., 2006). The southern section of the field was likely flattened to limit water runoff and soil erosion.

Archaeological Setting

The larger Mugello Valley Archaeological Project (MVAP) oversees the excavation of two Etruscan sites in the area: Podere Funghi, a habitation and ceramic production site within a modern hayfield, and Poggio Colla, a religious ceremonial site atop a hill acropolis ~700 meters west of the Podere Funghi (Fig. 6). Poggio Colla lies ~390 m above sea level and oversees the juncture of the Sieve River valley, an integral

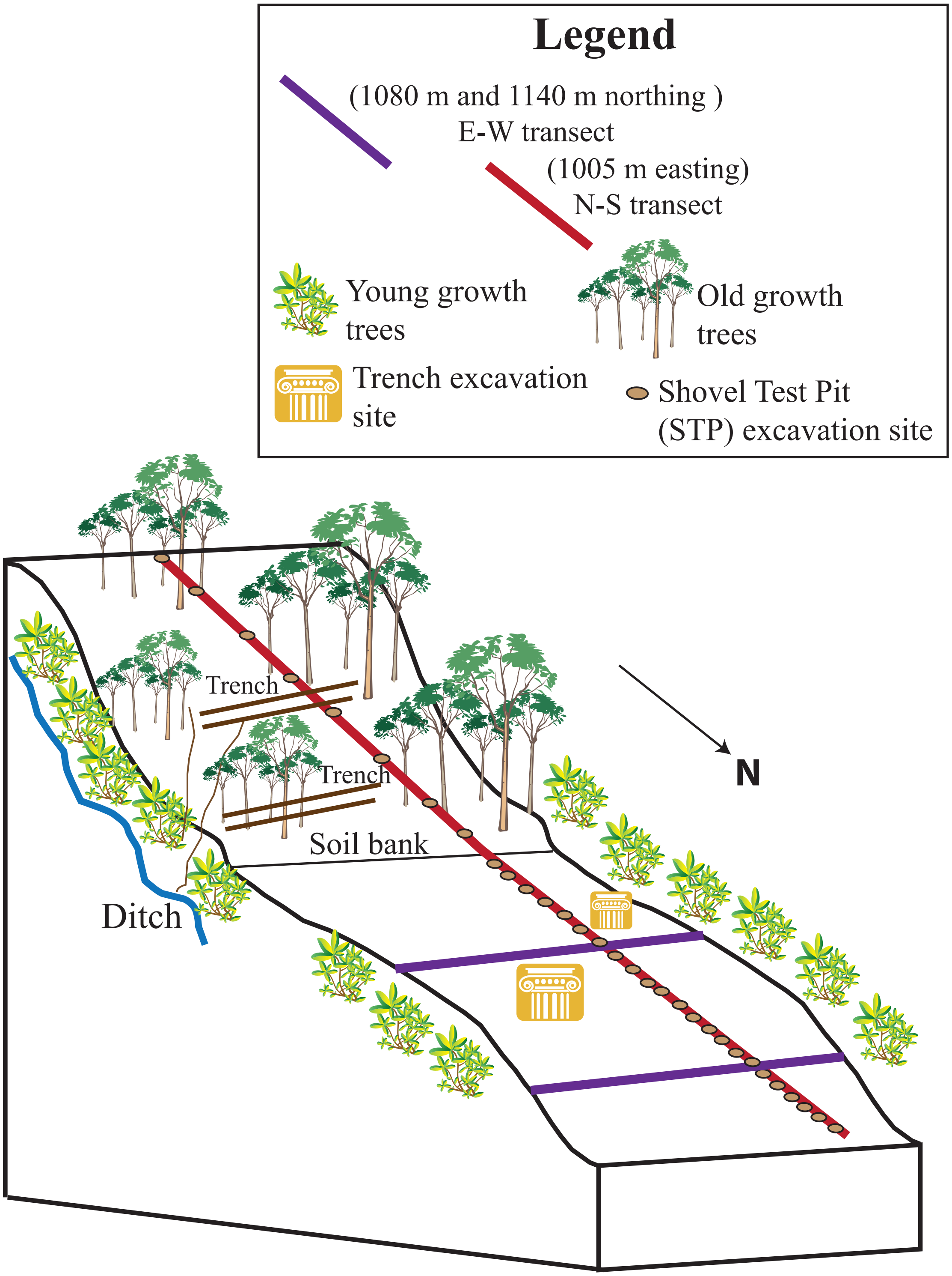

Figure 4. 3D schematic diagram of the forest and field hillslope system around the Podere Funghi archaeological site. Anthropological features such as trenches, building and midden sites and soil bank at the forest/field boundary are labeled. Note the 1005 m easting, 1080 m and 1140 northing line transects with STP excavations and drainage ditch east of the forest and field.

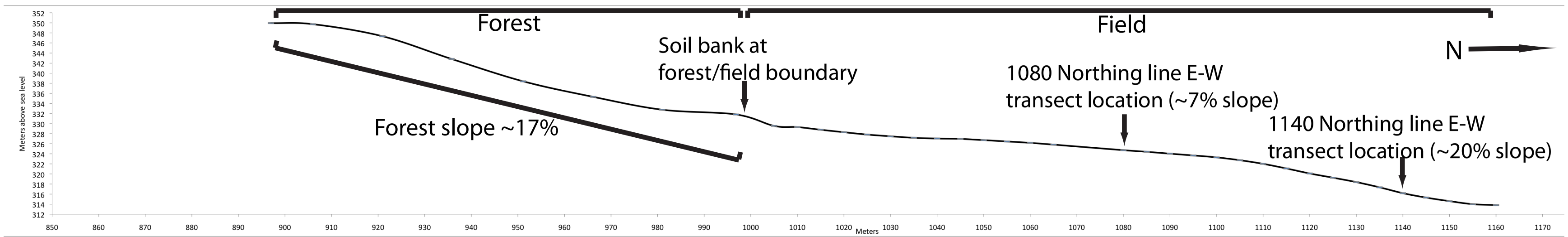

Figure 5. Slope profile facing west (without vertical exaggeration) of the 1005 Easting line, N-S transect of forest and field environments. Locations of the 1080 and 1140 Northing E-W transects are marked, as well as slope gradients along the N-S profile.

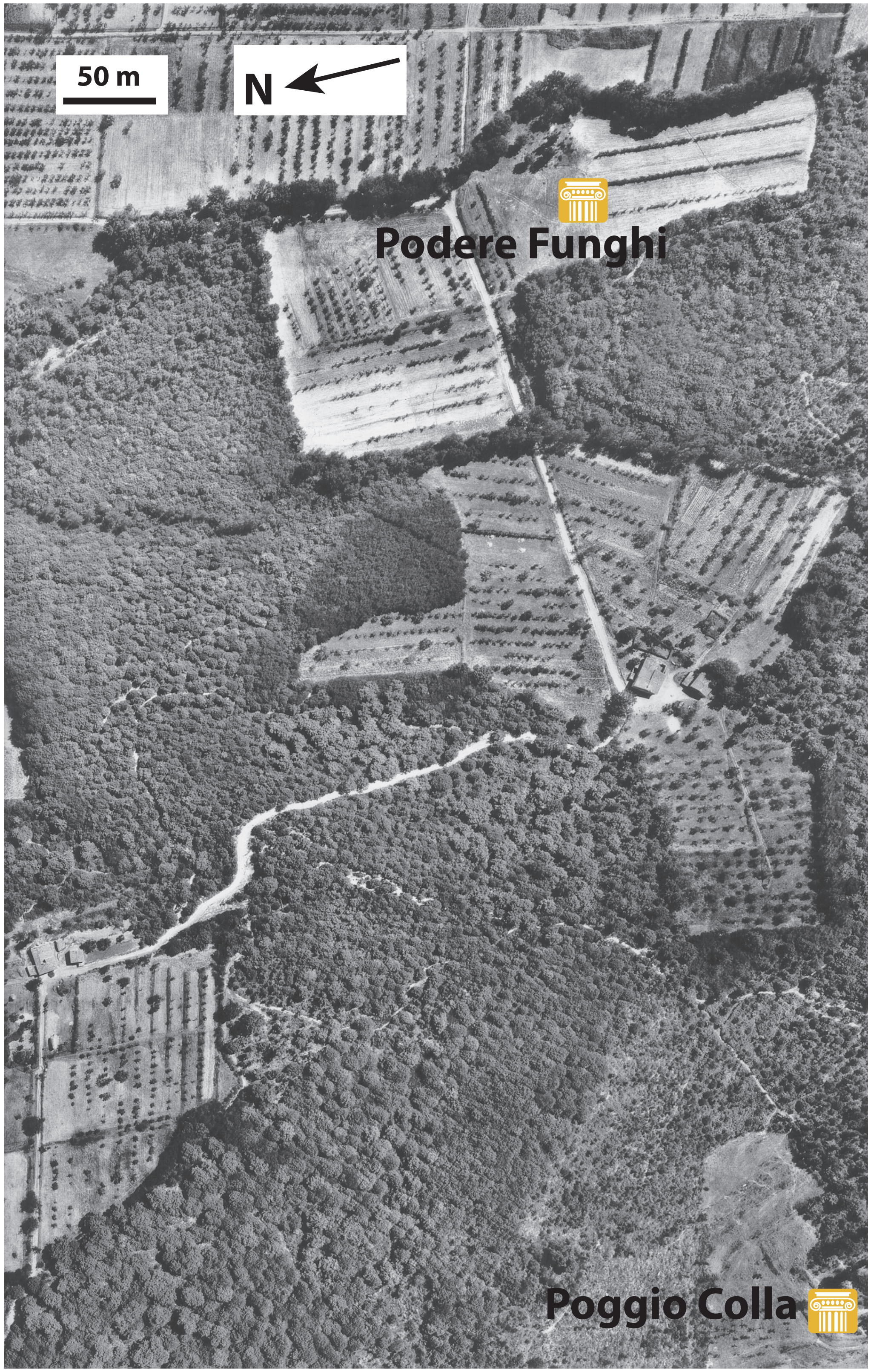

Figure 6. 20th Century site map noting location and land use of Podere Funghi and Poggio Colla. Note the vineyard rows south of the Podere Funghi building site in the field section with minimal (~7%) slope.

position over water routes connecting the Arno river valley to the northeastern Apennines and Bolognese plain (Gleba, 2002-2003). The Poggio Colla site was inhabited from at least the 7th century BC - 2nd century BC (Gleba, 2002-2003). It is currently wooded and believed to have lacked significant soil disturbance since the Etruscans because artifacts found in that location are more often intact and presumably found *in situ*. The Podere Funghi site, however, has been physically altered since Etruscan occupation from 400-200 BC (Coughlin et al., 2003). Located within a sloped field, the site was discovered in 1998 when plowing brought artifacts to the surface and the landowner reported the finds. The MVAP received the archaeological rights to the site and in 2001 excavated an artisan's workshop and midden site within the field (Warden et al., 2005).

METHODS

Artifact Distribution Methods

The purpose of STP excavation is to determine artifact concentrations throughout the plowzone as a means of spatial sampling (Shott, 1985). The Podere Funghi field site artifact distribution has been tested through STP excavation at a 5-meter interval (measured by total station) on an orthogonal grid over the one-hectare field during the 2007 and 2008 seasons (Fig. 7). The STPs were circular, 50 cm in diameter and ~20-60 cm deep, down to bedrock or a distinct soil layer below plowzone (Fig. 8). Soil from each STP excavation was screened with quarter inch mesh to recover all artifacts, which were bagged together and later washed and weighed. Artifacts recovered from the STPs were primarily terracotta coarseware and rarely fineware potsherds. The total mass of

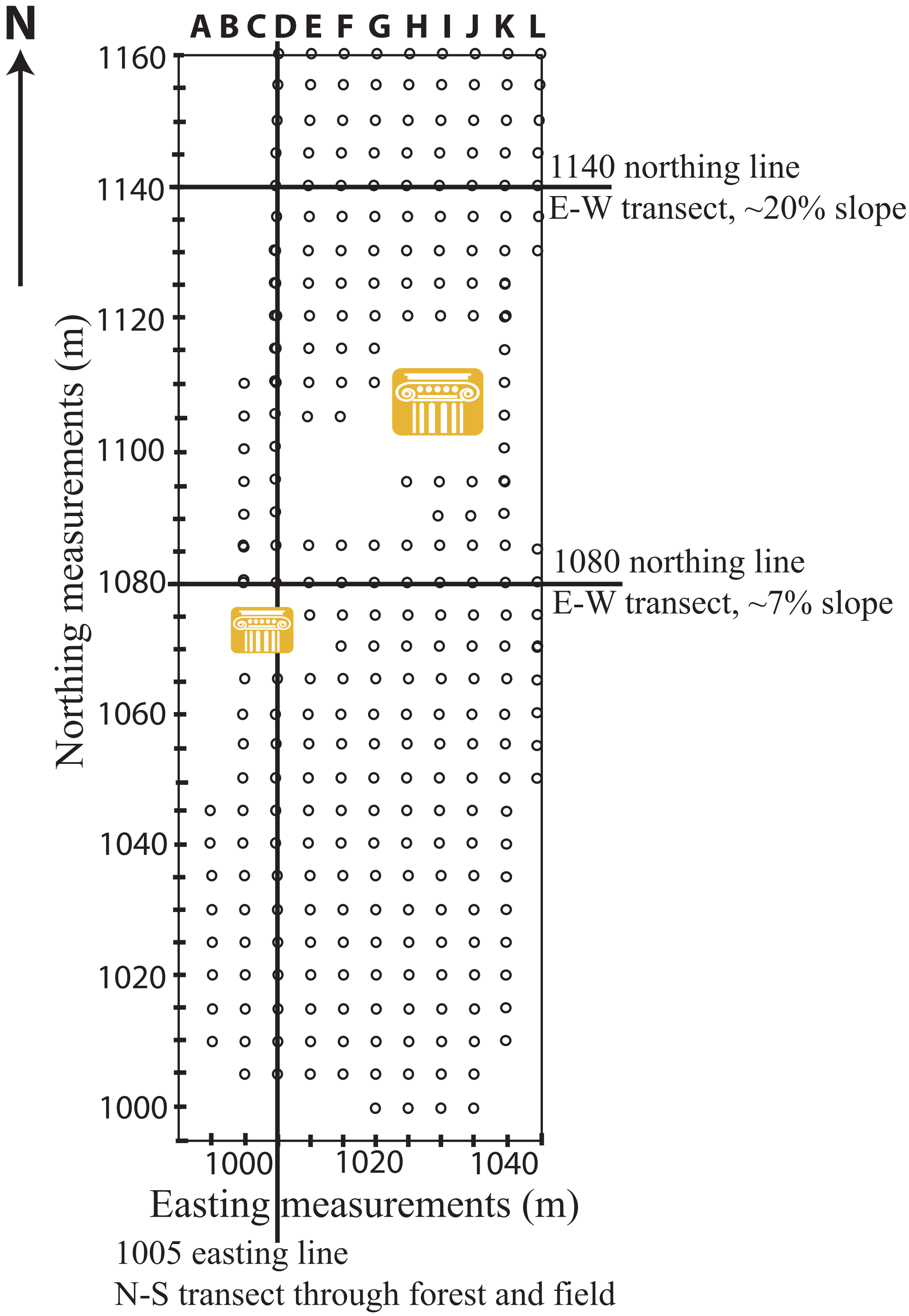

Figure 7. 5-meter grid coordinate system for field; 1140 and 1080 Northing and 1005 Easting transects marked with building and midden sites noted. Small circles denote STP excavation sites.

Figure 8. Shovel Test Pit (STP) with bagged potsherd artifacts. STP is ~50 cm in diameter; field book for scale.

artifacts collected from each STP were recorded and plotted on the STP location grid to illustrate artifact distribution within the plowzone.

Geomorphological Methods

I used a 3 cm diameter Eijelkamp gauge to collect soil cores from surface to bedrock along a 265 m N-S transect of the hillslope along the 1005 Easting line (Fig. 9). I cored the top 100 m of the transect (in a moderately-forested wood) at a 15-m interval. The lower 165 m of the slope transect were in the field area, where I cored through the bottoms of STPs to bedrock on the 5-m interval. I also collected soil thickness data for two E-W transects within the field: Northing lines 1080 (shallow gradient) and 1140 (steep gradient) (Fig. 7). I recorded the soil cores using the same data collection methods and organization as the MVAP coring team; cores are recorded in 10 cm segments and are evaluated for grain size, soil texture, Munsell soil color, percentage and type of organic material, level of iron (Fe) and Manganese (Mn) present and presence and type of anthropogenic material. I recorded Munsell soil colors from moist samples and noted the depth at which the core ended and whether or not cores ended at bedrock. The soil cores along the transect provide greater lateral coverage for the larger MVAP coring data set.

RESULTS

The average slope along the 1005 Easting line in the forest is 17.5% while the field gradient itself averages 10% (Fig. 5). However, the areas south and north of the excavation site slope differently; south of the Etruscan building site, the slope is ~7%, whereas the slope is steeper (~20%) north of the site.

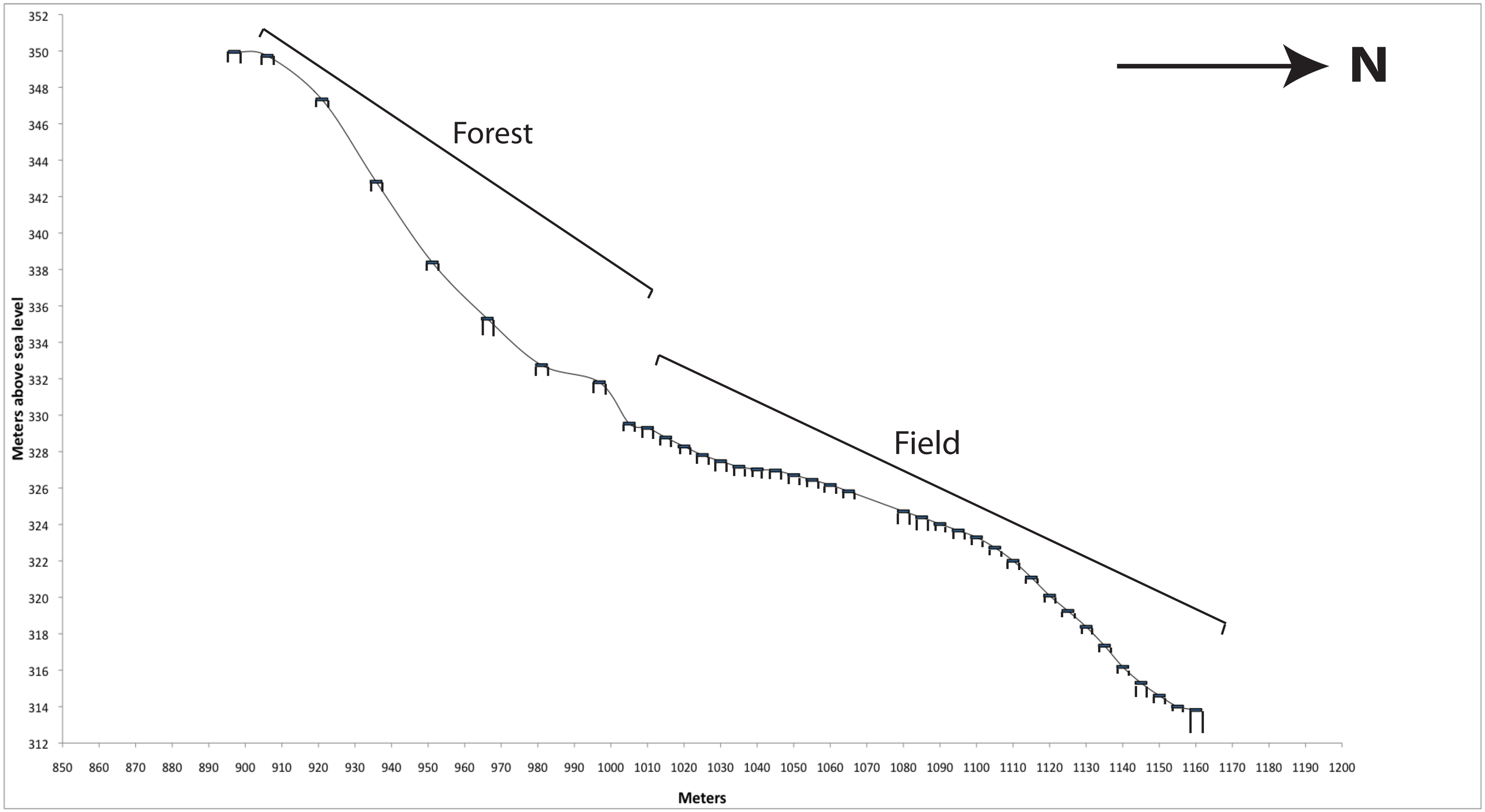

Figure 9. Slope profile along the 1005 Easting line with 5x vertical exaggeration and STP or soil core depths illustrated.

Plotting the artifact distribution of the field site on a map of the Etruscan site locations reveals that the highest concentrations of artifacts are found in the plowzone directly above or slightly downslope of the original source sites (Fig. 10).

The soil layers in non-cultivated areas typically consisted of a thin (<10 cm) humic layer, above a comparatively thick colluvial layer (20 cm-60 cm), above a clay layer (10 cm-40 cm) overlying feldspathic sandstone bedrock. Colluvial soil descriptions along the transect and throughout the field categorize the colluvium as sandy clay loam with a Munsell color value of 10YR5/4, or yellowish brown.

Analysis of the STP and soil core thicknesses along the 1005 Easting line within the field indicate thicker soil horizons on locations with the least amount of slope, or in concave depositional areas (Fig. 9). Soil horizons in the forest south of the Podere Funghi are thicker than those in the cultivated field; the mean soil depth along the 1005 and 1015 Easting lines in the forest is 56 cm, whereas the mean soil depth along the 1005 Easting line in the field is 40 cm. A two-sample t-test comparing the two environments shows that the field and forest have significantly different ($p=0.0078$) soil thicknesses.

Soil thickness analysis along the 1080 and 1140 Northing lines constrains the impacts of slope gradient by comparing transects from the same field environment but with different slopes. The 1080 Northing transect had a slope gradient of ~7% and an average sediment thickness of 37 cm. The slope gradient along the 1140 Northing transect was far steeper at ~20%, but soil thicknesses averaged 32 cm. A two-sample t-test comparing the two transects shows that the high- and low-gradient locations do not have significantly different ($p=0.2831$) soil thicknesses.

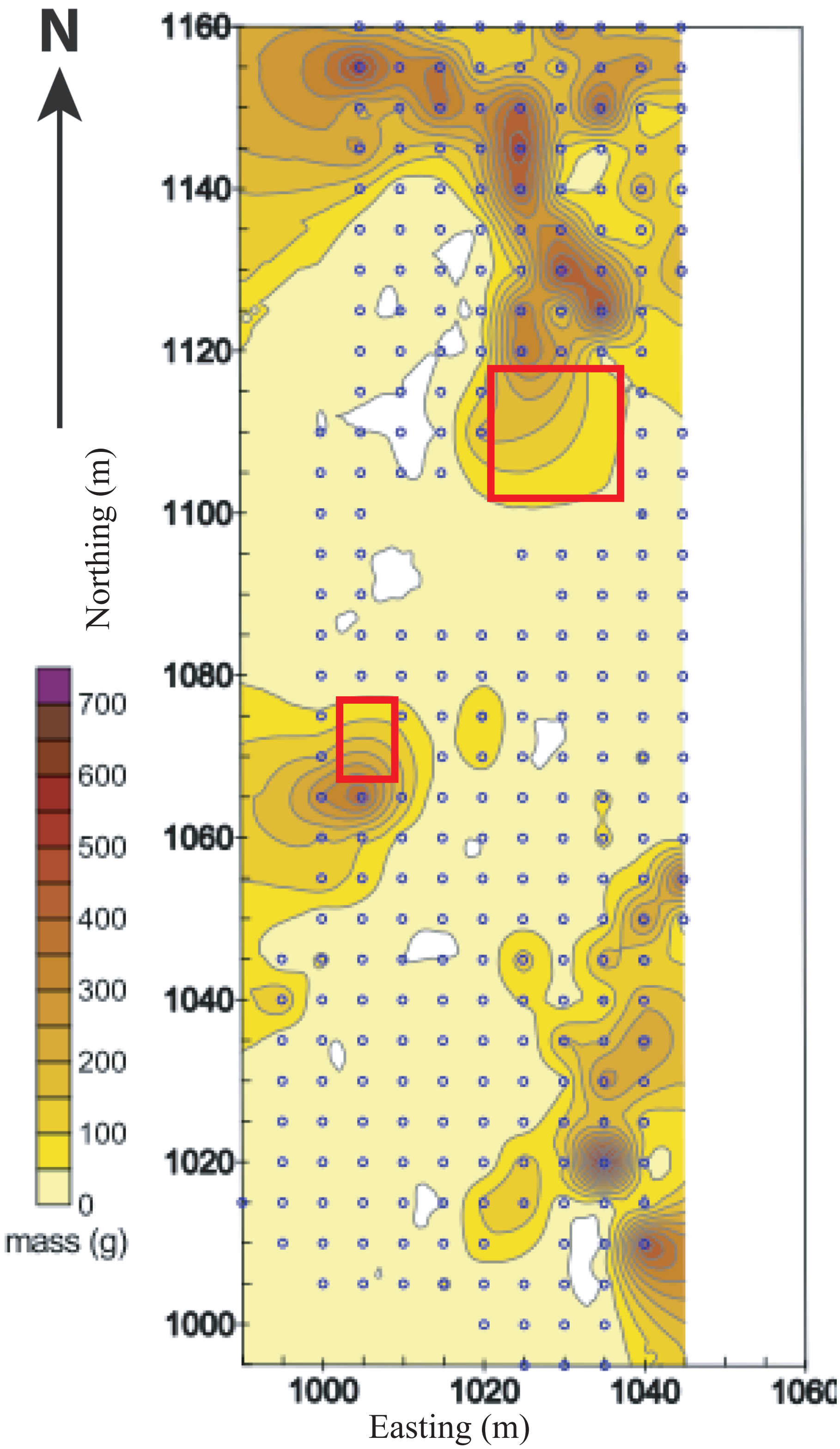

Figure 10. Field site coordinates with artifact distribution (mass in grams) mapped from STP excavations (marked with small circles). Building excavation site (2001) noted between 1080 and 1120 Northing lines; midden site between 1060-1080 Northing lines. (Modified from Sternberg and Bon-Harper, in press.)

INTERPRETATION & DISCUSSION

The primary agricultural impacts on artifact displacement within the Podere Funghi field site are plow drag and tillage erosion. Plow drag refers to the force on artifacts that come in contact with a plow moving through the soil. The effects of plow drag on artifact distribution are therefore heavily dependent on plow direction because artifacts will move in the same direction as the plow. Tillage erosion refers to the soil and artifacts' increased susceptibility to downslope movement as a result of being loosened by cultivation.

Studies have demonstrated that vegetation lessens erosion (Collins and Bras, 2004), suggesting that the southern, forested area might have a thicker soil profile than the tilled field in the north. Although statistical tests prove the forest has a thicker soil base, the differences between environments are subtle (Fig. 9); it is not unusual to take soil cores in both the forest and field that are 40 cm deep. However, there are more areas with thicker soil horizons (~90 cm) in the forest, and with thinner soil horizons (~20 cm) in the field. This discrepancy may be attributed to depositional areas within the forest and plow scouring of convex areas within the field (Olson et al., 2002). Statistical tests prove there is no significant difference between soil thicknesses E-W high- and low-gradient transects (along the 1080 and 1140 Northing lines) within the field. Soil thicknesses were not statistically greater along the ~7% slope transect than that with ~20% slope, thereby contradicting the importance of slope gradient on soil erosion and deposition. The soil thicknesses from cores along the 1005 Easting line, 1080 Northing and 1140 Northing line profiles through both the field and forest suggest the greatest influence on soil erosion and artifact placement is cultivation.

The human landuse history of the site is of major importance in determining the main physical mechanisms that influence artifact placement; unfortunately, detailed accounts are not readily available. Aerial photos show the Podere Funghi held a vineyard earlier in the 20th century, and give us some clues to the site's agricultural history (Fig. 6). The photo indicates vine and furrow direction was parallel to slope and only developed in the upper field section with lower slope angle (~7 %). The length of time the field has been used for vineyard growth is unknown, but considering grape vines' relatively long lives compared to other crops suggests such field use was not ephemeral. Grape vines can easily produce grapes for 60-70 years if they avoid disease, and some may even survive for hundreds of years (Denman, 1864). Fields containing grape vineyards experience greater soil erosion because most of the soil is tilled and exposed without any vegetation among the vines to limit erosion. Such fields are more susceptible to rapid erosion during a heavy rainfall, which induces gullying within the plowzone. Soil conservation tactics in vineyards in Spain include digging trenches upslope of the field to limit the amount of overland flow during a torrential rain (Martínez-Casasnovas and Ramos, 2006). The manmade trenches in the forest south of the field may have been developed for similar reasons: to offset overland water flow away from the field and limit gullying in both the forest and field.

Although plow direction was parallel to slope when the field held a vineyard, other past field uses might have called for a different plow direction. Italian medieval plowing techniques on hillslopes often followed the "crosswise" (or a *cavalcapoggio*) pattern in which a horse-drawn plow cultivated perpendicular to prevailing slope direction (Sereni, 1997). Development of the "roundabout" (or a *girapoggio*) contour plowing direction brought more efficient use of drainage ditches and less overall soil dispersion from the field, but the crosswise plowing technique still remained most popular across Italy for centuries (Sereni, 1997).

An important factor in erosional potential is the nature of colluvial sediments. The clay content varies slightly among samples, but is present throughout all samples of colluvial sediments. Clay increases cohesiveness of sediments in both wet and dry conditions and may limit surface runoff erosion. The clay content in the field sediments made STP excavation difficult as the topsoil became increasingly impenetrable under the hot and dry conditions. High packing ability helps the sediment withstand erosion by forming sediment clumps that are more resistant to geomorphic processes.

Studies at the Airfield site, Springfield, Illinois suggest that plowing has little impact on artifact distribution (Roper, 1976). Artifact distribution was random in a plowing study at the Butser Ancient Farm Project in England and followed a normal distribution with relation to original position (Frink, 1984). Studies on fairly flat field surfaces suggest that plow activity moves artifacts minimal distances (Roper, 1976), especially if artifacts are small (Lewarch and O'Brien, 1981), but it is important to remember in the archaeological sense that even minimal artifact redistribution in the plowzone can affect survey.

Artifact distribution experiments in plowzones indicate greater plow influence if the experiments are on sloping sites than on flat ones. Ammerman (1985)'s experiment site in Calabria, Italy was located on a south-facing 10% slope and monitored the lateral and vertical movement of 1,000 2.5 x 2.5 x 0.5 cm^3 tiles over multiple plowing episodes in four years. There was little relief in the east-west direction of the field. Plowing activity in the first years of the experiment ran E-W. Over 3 years and ~9 plowing episodes, the average artifact displacement was ~1 m in a downslope direction. Later observations, however, discovered artifact movement of a higher magnitude after the field had been plowed in at N-S (up/down slope) direction. After the initial N-S plowing episodes, the field observation found half of the tiles on the surface had moved 5-15 m south and a third of the tiles had moved more than 15 m south of their original placements. The next field observation found furrows in a N-S direction and that all seven tiles on the surface (after the previous observation) had moved over 15 m downslope of their starting places. Because the plowing was perpendicular to the slope and moved along a transect with minimal relief, it appears the mechanism that moved the artifacts downslope was not necessarily plow drag, but downslope tillage erosion. When the plow ran parallel to slope, artifacts traveled farther and at a faster rate. Although the furrows can only indicate that the plow ran in a northerly or southerly direction, the considerable artifact migration in the downslope direction suggests that was the direction of plow drag.

It is difficult to define the geomorphological and anthropological effects on such a complex field and forest system with diverse human influences. Soil erosion is influenced by vegetative cover, slope shape, plow direction, and soil composition. Thicker soil horizons in the forest may be attributed to vegetation, but trees do not always work to prevent erosion. Small vegetation (such as field grasses) is often more effective than large forests of trees in limiting soil erosion because the root systems have more contact with the soil (Collins and Bras, 2004). Slope angle and shape change in a complex manner from south to north along the transect. Soil thickness in the field is not as dependent on gradient as it is on slope shape; soil accumulates in slope concavities and is dispersed from slope convexities when moved by either natural geomorphic processes or cultivation (Olson et al., 2002).

Geomorphological results highlight the importance of tillage erosion on soil thicknesses within the field, while studies have showed the importance of plow direction on artifact migration on both flat and sloped field surfaces (Ammerman, 1985; Dunnel and Simek, 1995; Lewarch and O'Brien, 1981; Odell and Cowan, 1987; Roper, 1976). It cannot be known for certain how long the Podere Funghi field has been plowed, in which direction, or with what equipment. The relatively steep slope in the field suggests that a crosswise, perpendicular pattern would be more energy and soil-efficient; however, knowing that the field has been used as vineyard with row furrows parallel to slope refutes a singularly crosswise plowing theory. The current artifact distribution in the field shows little evidence of extensive artifact migration. This would concur with a primarily crosswise plowing pattern theory and moderate downslope migration of artifacts over time, as Ammerman (1985)’s research showed with perpendicular-to-slope plowing in Calabria, Italy. It is possible that the field has been used only for vineyard cultivation parallel to slope, in which case tillage erosion may have had a greater influence on artifact migration. The high concentrations of artifacts within plowzone on the lowest slopes of the field may have reached that location through downslope soil erosion and plow drag. If, however, prior agricultural developments primarily called for a crosswise plowing pattern, artifacts would have slowly migrated downslope through geomorphological processes and would be uncovered just downslope of their source locations, in this case, the habitation site. The proximal relationship between artifacts’ current placement and suspected source sites suggests that varied plow directions over time have essentially cancelled the lateral effects of plow drag, while tillage erosion is responsible for variable soil thicknesses between forest and field environments.

CONCLUSION

Geomorphological results at the Podere Funghi field site suggest increased erosion in the field due to anthropological effects, namely agricultural plowing. The soil thickness differentiation between field and forest indicates the influence of tillage erosion on soil resources in hilly fields. The lack of soil thickness differentiation between field areas of varied slope gradient suggests that slope angle is not the primary factor behind sediment loss or accumulation, but rather that local features along the slope determine the influence of geomorphological and tillage erosion. Previous studies (Ammerman, 1985; Roper, 1976) on artifact distributions within plowzone suggest the primary factors in artifact movement are gravity and plow direction along a slope; artifacts do not migrate at high rates, and, due to changing plow directions over time, artifacts are usually recovered close to the suspected source location. Agricultural tillage erosion caused an overall slight downslope artifact migration and is responsible for variable soil thicknesses between forest and field environments.

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