6_3_2: Interpretation of Plant Macrofossil Results

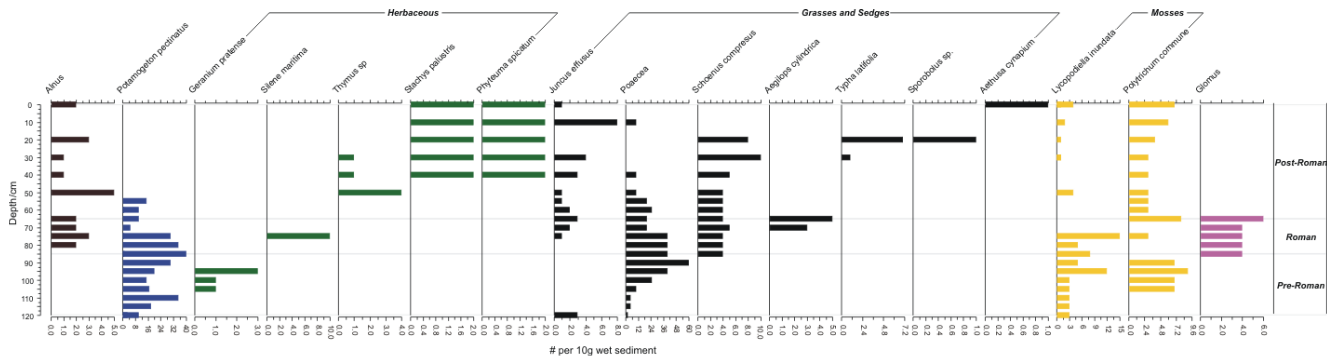
The plant macrofossil results shown in Figure 1 from D6/Core 3 were subdivided into arboreal (brown), aquatic (blue), herbaceous (green), grasses and sedges (black). The arboreal macrofossil record in the pre-Roman period shows relatively few species present, Betula becomes increasingly dominant into the Roman period but is the largely absent between 132 to 101 cm and then present again during the post-Roman period. This record also correlates with the pollen record and with the influx of charcoal, which suggests that this is a species may be absent as a result of increased local fire frequency. In general, abandonment ca. 420 AD is associated with an increase in arboreal species within the plant macrofossil record.

The presence of Betula in the pre-Roman, and part of the Roman period is also shown in the pollen record, which is indicative of the presence of such vegetation within 100 m to several km, thus, although Betula is not found locally during the later Roman period there was still a presence nearby. As noted in the pollen records Alnus tends to have a local signal, therefore, despite its absence within the plant macrofossil record until the Post-Roman period, it is likely that this species grew not far from D6.

Aquatic species dominate the pre-Roman vegetation, with species such as *Myriophyllum, Potamogeton, Apium* and *Ceratophyllum*, which are macrophytes or pond weeds. In the Roman period there are fewer aquatic species, with *Myriophyllum* being replaced by *Ceratophyllum* at 135/134 cm Both *Myriophyllum* and *Ceratophyllum* are oxygenating plants, i.e. they quickly assimilate excess nitrogen in the water, however other proxies such as the bryozoan statoblasts suggest that the local environment was becoming increasingly eutrophic which may have led to a decline in macrophytes. In contemporary Finish lakes, only *Ceratophyllum demersum* appears to be resistant to eutrophication. *Typha angustifolia* which replaced *Ceratophyllum demersum* grows in contemporary hyper-eutrophic lakes, particularly those rich in phosphorous and nitrogen. Contemporary studies are examining the potential of T. angustifolia as a remediation tool for eutrophic lakes. *A. nodiflorum* is a valuable indicator of high mineral content in other areas of Europe, and has the ability to oxygenate its substrate and has been reported to be a good competitor in eutrophic waters. Therefore despite the apparent increase of eutrophication during the Roman period *A. nodiflorum* may have remained present. During the Post-Roman period macrophytes return (e.g. *Potamogeton obtusifolius*), and eventually the bryozoan *Plumatella repens* also returns.

Based on the species within the aquatic macrofossil record, the depth of water pre-Roman would have been less than 3m), as all

Fig.1: Plant Macrofossil Results from D6



species found are surface dwelling macrophytes In the Roman period both *Ceratophyllum demersum* and *Typha angustifolia* were both found suggesting that a water depth of at least 1.5m was present, which would have been suitable for a fish tank.

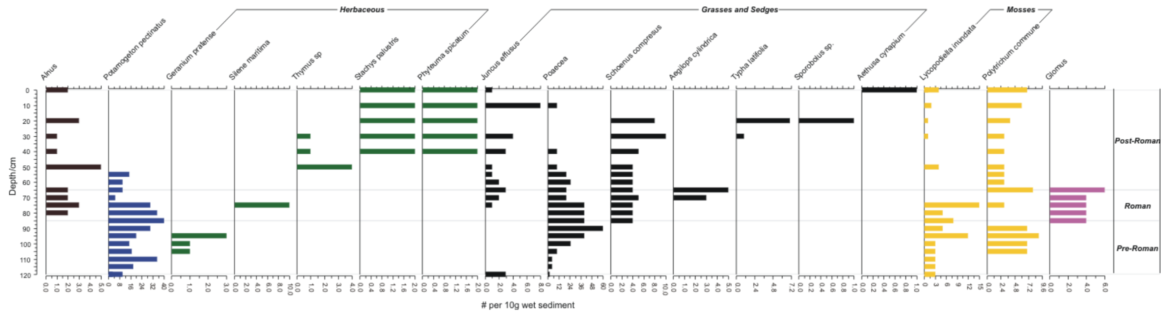
Herbaceous species also dominate in the pre-Roman period, with species such as *Ranunculus repens, Silene dioica,* and *Senecio vulgaris*, all of which suggest an adjacent vegetated fixed dune, with *R. repens* indicating a slack. The Roman and post-Roman periods are marked by the absence of any herbaceous species. Eutrophication of herbaceous wetlands has been found to lead to a decrease in species density and richness, dominance by a few nutrient-responsive species, and loss of endemic and characteristic species.

Grasses and sedges are present pre-Roman, and during the Roman period, *Eleocharis palustris, Poaceae* and *Juncus effuses* appear to dominate. The addition of nitrogen to dune slacks has been shown to lead to an increase in *E. palustris* which again is an indicator of eutrophication. Furthermore, *E. palustris* also shows a correlation with the influx of charcoal, this may be due to fire tolerance when dormant and the tops are killed by fire during the growing season. The post-Roman absence of grasses and sedges may be linked to an increased arboreal presence in the local environment, as noted in the arboreal plant macrofossil record. Thus suggesting a change in the local environment in post-Roman times from a sedge-dominated environment into wet woodland with seasonal wetness, at least ephemerally if not permanently, as indicated by the presence of *P. Obtusifolius* macrofossils.

Pozzo Napoliello/Core 7

The results of core 7 (Fig 2) show an immediate difference between this and the record at D6, with the presence of mosses, in particular *Lycopodiella inundata* (marsh club moss) and *Polytrichum commune* (hair-cap moss) suggesting a wet sandy location. The only arboreal macrofossils were those of *Alnus glutinosa* in the Roman and post-Roman periods, indicates the presence of local wet woodland or fen. Wet woodlands can also

Figure 2: Pozzo Napoliello Plant Macrofossils



be thought of as swamps, in the same way that wet grassland is a marsh however the boundary between the two may be indistinct. The influx of charcoal to this area in pre-Roman times may be associated with early (Iron Age) settlement. The absence of arboreal plant macrofossils in the pre-Roman period with only *A. glutinosa* being found later may be indicative of the practice of cutting and burning of forests or woodlands to create fields for agriculture or pasture for livestock, which has been found to improve the nutrient content, and increases digestibility of forage However, this does not suggest the Romans deforested the area as the pollen record for D6/Core 3 showed that trees were present at Castelporziano during this period.

The record of aquatic plant macrofossils is equally sparse, with the presence of *Potamageton* sp., throughout the record until recent times. This macrofossil, along with the *Lycopodiella inundata, Polytrichum commune,* and *Alnus* glutinosa shows the presence of a fen.

The dominant species are grasses and sedges with the domination of *Poaceae* throughout almost all of the three time periods, thus suggesting a sedge fen. Other species, such as *Juncus effusus* and *Schoenus compressus* are present during the Roman and post-Roman periods and are also consistent with the presence of a fen environment. Although no crop remains were found in the core, the presence of *Aegilops cylindrica* was noted at a depth of 70-65 cm, this plant can be found in wheat fields or other cereal grain fields. This does not demonstrate the presence of agriculture at the site, but it is possible that this is the remains of cattle feed which may suggest possible grazing activity upon the fen, which the other plant macrofossils may also suggest in terms of being either, suitable for grazing or indicators of disturbed ground.

Evidence of ground disturbance or local erosion comes from the presence of the non-pollen palynomorph of *glomus* c.f. fasciculatum chlamydospores, this fungus was present throughout the Roman period only, which may suggest the Roman impact at the site.

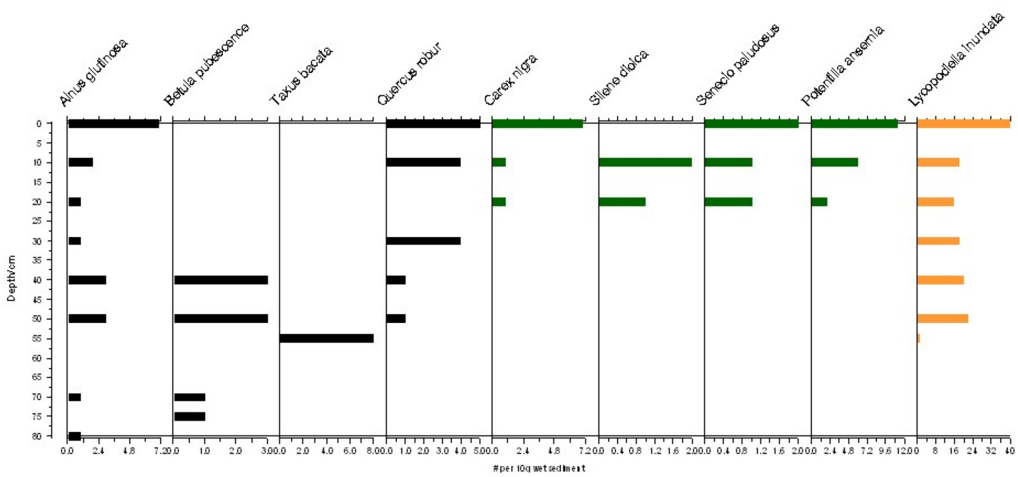
It appears that this area started off as a dune slack fen, before becoming a sedge fen in character and then a wet forest. The pre-Roman period may show evidence of “slash and burn” agriculture to improve the pasture of the area for grazing. The Romans may have continued to use the area in a similar way to the pre-Roman settlers, but there is the presence of arboreal species in this period. By the post-Roman period the site was abandoned, allowing the arboreal species to dominate. Some grazing by *Cervus elaphus* in the post-Roman period is confirmed by the disturbed ground taxa.

Muraccioli/Core 9

The ^{14}C dating results from this core (Fig. 3) show that it effectively represents a post-Roman sequence only, no plant macrofossils were found below 95 cm. The arboreal plant macrofossils of *Alnus glutinosa, Quercus robur* and *Betula pubescence* suggest a wet forest. The presence of *Lycopodiella inundata* is indicative of wet woodland. This is further shown by the presence of *Silene dioica, Potentilla anserina, Senecio paludosus* and *Carex nigra*, which may also indicate the grazing of animals.

The plant macrofossils from Muraccioli together with cores 7 and 8 show the development of this part of the estate from a fen into a wet woodland in the post-Roman period

Figure 3: Muraccioli Plant Macrofossils



Plant Macrofossil Muraccioli (Core 9)

Various lines of evidence based on the proxies from D6 appear to show evidence of the onset of eutrophic conditions at start of Roman period including a rise in organic matter, increased sedimentation rate, fewer aquatic plant macrofossils, which lead to absences of the ostracods, herbaceous plant macrofossils, *P. repens* statoblasts, and the oospores of stoneworts. This time period is also associated with the presence of *Myriophyllum spicatum, Ceratophyllum demersum*, and Typha *angustifolia* in the aquatics, *Lophopus crystallinus* and *Cristatella mucedo* in the bryozoan statoblasts.

The increased organic matter was clear from the LOI, which was likely to be related to nutrient enrichment enhancing primary production with the system, which has been defined as eutrophication. The *Plumatella repens* statoblast became absent as did the ostracods. This absence can be explained by *P. repens* being highly sensitive to organic matter, whereas the absence of ostracods may be due to hypoxia. Oxygen depletion, or hypoxia, is a common effect of eutrophication in bottom waters. This effect have may be episodic, occuring annually (most likely in summer/autumn), persistent, or periodic due to the coastal location of D6. Further evidence for eutrophication came from the presence of *Lophopus* and *Crisatella* given their contemporary environments are high in nitrogen and phosphorous. The overloading with nitrogen and phosphorus may have lead to a series of undesirable effects, for example excessive growth of planktonic algae increasing the amount of organic matter settling to the bottom. The question is 'what caused a nutrient poor dune slack to become so nutrient rich?'. The following section will examine possible causes of eutrophication.

Anthropogenic impacts can cause eutrophication via cultural eutrophication, which is the process by which human activities increase nutrient input rates to aquatic ecosystems and thereby cause undesirable changes in surface-water quality. One example of this is the eutrophication event that occurred in Lago Monterosi associated with deforestation during the construction of the Via Cassia in 171 BC.

As the fish ponds were early forms other aquaculture, impacts from contemporary fish farms may point to reasons why eutrophication may have occurred at D6. Despite the fact no fish bones were found in any of the cores, it is now known from the archaeological evidence this was the intended use of the site. The potential eutrophication effects of fish farming can be considered at several different scales, from local effects in the immediate surroundings of the fish farm to the contribution to a larger area away from the farm. Farm emissions consist of uneaten feed, faeces and urinary excretions. The uneaten feed and a considerable part of the faeces are emitted as rapidly sinking particles that settle on the sediments under the fish cages if conditions are still, if not they will take longer to settle, and thus have an impact further a field Most of this material is organic and the nutrient concentrations are high. Phosphorus concentrations in the farm emissions are typically a magnitude higher than in unaffected sediments.

Another possible cause of eutrophication within D6 is also related to the use of it as a fishpond. The addition of water to make the slack permanently wet, would be done via artificial piping, which would raise the water table in the slack, but at the same time may have led to the nutrient enrichment of the dune slack habitat through increasing calcium from calcium carbonate from molluscs, gastropods, sand, etc, being washed along in the pipe to the pond.

Unlike other piscinae, there was no evidence that this was brackish, as the results from all the proxies indicated a freshwater environment. D6 is larger than the rock-cut fish ponds described by Higginbotham (1997). Although fish ponds were a fashionable accessory for rich Roman households, they were also extremely expensive to maintain (Higginbotham, 1997). The archaeological evidence from D6 points to a relatively early date, the structure is one of the oldest on the Laurentine Shore, but also that any use was short-lived.

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