***Quantitative model: Pompeiian fuel consumption AD 79 (Robyn Veal)***

The basic calculation required is as follows:

**Population (000s) X Consumption of fuel (tons) per head / Forest productivity (tons/hectare) = Forest Area to provide the fuel (hectares)**

*POPULATION*

Jongman (1988: 108-112) provides a good review of the various estimates of Pompeii’s population provided by different scholars. In the model proposed, one of the lower figures is Eschebach’s of 8,000, while Nissen’s figure of 20,000 provides an upper limit. These are figures for inside the city walls, and exclude those people living outside the city walls, but likely equally involved in consumption of all sorts of commodities brought to the city as the place of central commerce for the area. Beloch’s revised figure of 15,000 inside the walls, and a population density of 180 people/sq km, is used as a base by Jongman to argue for a total economic territory supporting 36,000 people, (inside and outside the walls). For convenience of calculation we shall adopt figures of 15,000 inside the walls and 15,000 outside, following Jongman (nearly). For the purposes of simplifying the analysis, then, the model examines the smallest (8,000) and largest (20,000) figures, and the composite allowing for inhabitants in the city and its immediate surrounding territory (15,000/15,000).

*CONSUMPTION*

For consumption levels, ethnographic proxies for wood dependent societies, describe a range of ‘low’ fuel consumption of 0.5 tons/person/year, to a ‘high’ of about 2 tons/person/year. Both of these extremes are considered together with a more ‘average’ consumption of 1 ton/person/year.

*PROPORTIONS OF RAW WOOD AND CHARCOAL FUEL*

Complicating the matter somewhat is the definition of ‘fuel.’ The Pompeiians used both raw wood, and raw wood converted into charcoal as fuel. With regard to proportions of fuel types used there is sometimes a reflection of the pareto principle in wood/charcoal usage in wood-fuel dependent societies: in the city, 80% of fuel is charcoal, and 20% is wood; while in the country, the reverse is true: 20% of fuel used is charcoal and 80% is wood. These proportions are considered in the model, as well as a 50/50 split.

*EFFICIENCY OF CHARCOAL MAKING*

With regard to charcoal making, moderately efficient conversion (probably the most common) involving wood mounds in the open typically requires 6 or 7 tons of wood to make 1 ton of charcoal (at best). Therefore the model must include factors to account for differential use of raw wood and charcoal; and possible different levels of productivity of charcoal making. The model thus becomes:

**POPULATION (a range of possible figures) X FUEL CONSUMPTION / FOREST PRODUCTIVITY, where**

**FUEL CONSUMPTION = ( % RAW WOOD + % CHARCOAL) and**

**CHARCOAL = RAW WOOD X (EFFICIENCY FACTOR from 4 – 7)**

**to make a total of Raw Wood required for Charcoal production**

That is, the figure for Fuel Consumption reflects consumption of raw wood, together with consumption of charcoal, the making of which has entailed the use of more raw wood. The resultant figure shall be called the Total Biomass Required.

*FOREST PRODUCTIVITY*

There are no specific figures in the ancient literature for forest productivity. General agricultural yields vary from poor to good, according to Spurr (1986: 82-88). If 5 tons/ha/year is used by Grove and Rackham to describe modern forest productivity in fertile areas with good rainfall (2001: 174), and 2-3 tons/ha/year define ‘sustainable’ use of beech wood in New Zealand, then a productivity of 1 ton/hectare can be described as ‘poor.’ It is possible ancient practices may have been more, and less efficient, depending on the wood type, soil fertility, altitude, and other factors. This model does not at this stage concern itself about these details, but a range of possible productivity levels from 1 ton/hectare to a maximum of 4 tons/hectare is considered.

*RESULTS*

Highlighted within the results are a number of the more likely figures of interest:

a) Highlighted in blue are possible figures for a population of 20,000 people, consuming 1 (or 2) tons of wood each per year in a ratio of 80% charcoal and 20% wood, assuming the least efficient charcoal production method in the table (7 tons of wood to produce 1 ton of charcoal), and alternate forest productivity scenarios of 1 or 2 tons per hectare. In these cases we see that at consumption levels of 1 or 2 tons per head per year, the resultant forest area required ranges from 58,000 to a maximum of 232,000 hectares.

b) If one wishes to take the theoretical position on population that also takes the inhabitants just outside the city walls into consideration, then we may use the figures for consumption at the rate of 1 ton/person/hectare for the population of 15,000 (yellow and green highlights) and add together amounts for the city dwellers and the country dwellers; i.e. 43,500 +16,500 = 60,000 hectares at a productivity of 2 tons per hectare; or 87,000 + 33,000 = 113,000 hectares at a productivity of 1 ton/hectare. Clearly, forest areas required will be more conservative for any population below 15,000/30,000; with better productivity in charcoal production; or indeed with forest productivity in excess of 2 tons/hectare. All of these figures must be considered in light of the forest areas which were potentially available in ancient Campania and Samnium. .



Wood fuel supply: quantitative model to predict forest area for annual consumption in AD 79.

Blue highlights show figures for a population of 20,000 people (intramural only), consuming 1 (or 2) tons of fuel/person/year at a ratio of 80% charcoal and 20% wood, assuming the least efficient charcoal production method (7 tons of wood to produce 1 ton of charcoal), and alternate forest productivity scenarios of 1 or 2 tons per hectare. Yellow and green highlights show figures for a population of 30,000 (15,000 inside and 15,000 outside the walls) consuming 1 ton/person/year, at a charcoal productivity level of 7, and a forest productivity of 1 (green) or 2 (yellow) tons per hectare; in this case the figures must be combined to provide total consumption for intra and extra-mural consumers.

Beech constituted ca. 50% of the wood fuel supply in the 1st c. AD, and growing at least above 300m at the very minimum (for a population of 20,000), had to be supplied from the mid to upper montane areas in forests of 29,000 hectares (from a total of 58,000 hectares); or 116,000 hectares (from a total of 232,000 hectares), using the figures analysed above. Of the remaining 50% of the wood-fuel required, approximately half (namely the hornbeams and oaks) will have also likely come from the mountains, with only about 20-25% (being the orchard fruits and nuts) likely to have come from inside and just outside the city walls, or alternatively the lower montane slopes.

Data for the breakdown of (modern) Campania’s altitudinal makeup are provided (Regione-Campania, 2007):

*Modern* Campania[[1]](#footnote-1) is made up of 1,359,025 hectares, consisting of:

 15% ‘plain’ (199,216 hectares)

 11% ‘coastal hills’ (154,568 hectares)

 39% ‘internal hills’ (535,477 hectares)

 35% ‘mountains (469,763 hectares)

These figures relate to all of Campania, north and south, yet it is likely that the wood-fuel catchment area for Pompeii is limited to the southern half of the region, so we might consider that the southern slopes of Vesuvius, the parts of the Apennines directly east of the Sarno Valley and the northern slopes of the Lattari mountains would be of direct concern: i.e about half of the total ‘mountain’ area, or ca. 235,000 hectares. Now the figure estimates for forests have real relevance: total forest required for a population of 20,000, consuming 1 ton/head/year, and the lowest charcoal making and forest productivity rates was estimated to be 232,000 hectares, of which approximately 116,000 needed to be beech (however, a direct relationship between the proportions of the wood types in the charcoal assemblage and the environment cannot be assumed). In this scenario, it would appear nearly all of the available forested area would have been under management, and possibly even under pressure. The bringing of wood (from outside the delimited area) by ship from the Sorrentine peninsula may have occurred. Examining perhaps the more realistic population figures of 15,000 inside and 15,000 outside the city walls (where the differing proportions of charcoal for city and country dwellers are added together), and considering a higher rate of 2 tons/hectare productivity, still 60,000 total hectares are required, a far more manageable one-quarter of the montane forested area. More efficient rates of conversion to charcoal, or use of less charcoal, would mean much lower utilisation of potential forest. This is all predicated on this simple model having some moderate reliability, but there are a number of factors which have not been included here which will require consideration in the future (such as quality of charcoal, and volumes of same used in industrial vs domestic contexts).

1. Modern Campania stretches north to south more or less in keeping with the ancient points on the Tyrrhenian coast; to the east however, it stretches all the way up to the apex of the central Apennines. For the purposes of this analysis, this is useful, since we want to consider the mountain slopes facing the Sarno Plain in their entirety as a possible supply source without regard in the first instance to limitations of political or other restrictions. [↑](#footnote-ref-1)