Supporting Information

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SI Methods

Data Recording Methods. In view of the constant presence of warm running water emerging from the numerous hot springs spread over the entire excavated area, all of the items were described, and their spatial coordinates were recorded, on a set of 1:20 scale maps. Each map covers only a few square meters of the excavated surface. When the excavation was completed, all of the collected data were translated into digital format. A vectorization procedure (image tracing) yielded a complete picture of the distribution of the finds. This was repeated for each of the excavated levels. A number of specifications are reported for each item in the attribute tables associated with each excavation data layer: identification number, type of material, stratigraphic unit, cut, elevation, original plan, date, and any notes. At the same time, all of the information provided by the research conducted by the different specialists involved in the study of the fauna, the wooden and lithic industry remains, and the stones was summarized in tabular databases, which were added to the attributes of the polygons of findings. This activity was aimed at obtaining thematic maps, thereby providing accurate and reliable data to reconstruct the formation of the site.

Methods of Wood Analysis. Three-dimensional representations of the most representative wooden artifacts were obtained using a triangulation NextEngine 3D Scanner HD (45). The NextEngine is equipped with a fully automated turntable for 360° acquisition. The solution adopted to optimize the scanning of wet and dark wood artifacts with the budget-priced scanner was superficial blotting with absorbent paper before the scanning session. A set of scans was obtained using the Studioscan HD functionalities and open-source software (46).

The complete acquisition of a specimen, which means scanning the top and bottom sections of an artifact, requires at least three sets of 7 to 10 shots with 360° acquisition. About eight shots are necessary to digitize an entire artifact, also including its texture and mesh.

The woods of U 2 and U 6 were identified from samples collected following criteria of minimal invasiveness. Before sampling, to avoid repeatedly examining the same specimen, the fragments were mechanically refitted where possible. The Italian technical standard Ente Nazionale Italiano di Unificazione (UNI) 11118:2004 was followed for both sampling and identification. Light (DM LB 2; Leica) and electron (Quanta 200; FEI) microscopes were used for micromorphological analysis of the samples. Thin sections from the brown waterlogged part of the sticks, useful for wood identification, were prepared using hand blades (Fig. S2). For wood species identification, the collected images/data were compared with reference wood atlases (47, 48). *Buxus* is a hardwood (a broadleaved species); thus, it is characterized by the presence of different kinds of cells distinguished by function: large-lumen and thin-walled vessels for sap transportation, thick-walled fibers for mechanical support, and parenchymatic cells (mostly organized in rays) for storage of nutrients. Compared with other hardwoods, boxwood displays small-lumen vessels yielding a uniform appearance and a very fine texture.

To assess the presence of a charred surface on the Poggetti Vecchi findings, an oxidative chemical test, specifically developed from what is available in literature (9, 10), was carried out. Samples from the black surface layers of sticks nos. 2, 3, 9, 11, 49b, and 50 were separately soaked in 60% and 130% hydrogen peroxide solutions. The same test was performed on modern boxwood fragments (same dimensions as the Poggetti Vecchi samples) totally or only partially charred and on lignite fragments (fossil wood from the S. Barbara mine in Tuscany, Italy). Beakers containing samples were put in a steam bath until no more bubbles appeared from the treatment solution (up to about 6 h): While the Poggetti Vecchi samples and totally or partially charred boxwood remained unchanged, the lignite was completely bleached.

To check the presence of charred wood, SEM analysis was also performed on black samples from findings 9 and 49b obtained from natural fractures. The SEM images of the two black samples were compared with recently charred boxwood and fresh boxwood at different, but identical, magnifications (Fig. S1).

The excavation of the wooden artifacts proved extremely difficult since they were poorly preserved and the sediment, despite being constantly wet, was of a much tougher and more compact consistency than the wood. As a result, in the excavation phase, the finds were occasionally damaged during the removal of the sediment covering them. The preservation of wood over the long burial time span was due to the prevalent anoxic and waterlogged conditions of the clayey sediment, which rapidly embedded the findings. These conditions permitted the finds to retain their shape and size, although decay of the wood cells must have occurred in some extensions (49). The decay caused the wood to lose part of the cell wall components and to dimensionally compensate the loss with water imbibition (8). As a result, the excavated wood had poor mechanical properties; was easily subject to rupture; and was perishable, especially via spontaneous drying (50, 51).

The preliminary analysis of signs of manufacture on the archeological and experimental tools was obtained using a digital microscope (Dino-Lite AM 4113 ZT-A).

Conservation Treatment of Wood. The wooden tools of Poggetti Vecchi were recorded and measured; drawings and photographs were taken to complete the records. The artifacts were then mechanically cleaned, and the wood was desalinized by repeated washing in demineralized water.

Rosin (colophony), a pine resin in acetone solvent, was the selected product for the impregnation and consolidation of the wooden tools. Both the Florence Restoration Centre and, from 2006, the Pisa Centre for the Restoration of Waterlogged Wood normally treat medium/small-sized wooden findings by this method since it gives the samples a good mechanical strength. Finally, the display of the artifacts is easy since the consolidation substance is not hygroscopic.

Boxwood Characteristics. *Buxus* is a slow-growing evergreen in the form of a small tree or shrub, usually occurring as an understory in forests of larger trees. It can be associated with *Juniperus* and some xero-thermophilus *Quercus* in shrubs or thickets on well-drained calcareous substrates from the plain to low slopes (50–200 m). Normally, the principal branches of *Buxus* are straight and up to 1.5–2 m long.

Boxwood is pale yellow in color, and it has a very fine texture, is mostly straight-grained (Fig. S2*D*), and is extremely hard and rigid; in view of these features, it can be easily finished to a very smooth surface.

The wood of the common boxwood is very heavy and hard, possibly the hardest European wood. Table S2 shows the principal physical and mechanical characteristics of boxwood compared with those of wood species possibly available in the same environment (ash and oak) and other species found in similar European excavations in Schöningen and Lehringen (Germany), and Clacton-on-Sea (England) (3–5, 52).

Clearly, boxwood represents the heaviest and hardest wood in the list, but the table shows that it also records the best performances for strength (modulus of rupture in bending).

Another feature that may have been of particular interest for humans at that period was the availability of strong, small-sized elements of the right length. They were also easy to harvest, being in the understory level of the forest, while small branches of ash and oak were located at heights. Moreover small-sized branches of oak and ash are rarely straight.

The Experimental Activity. Four branches of *Buxus sempervirens*, of lengths and thicknesses comparable to the wooden artifacts of Poggetti Vecchi, were selected. The experimental program was developed to define different technical procedures: (*i*) the harvesting of branches, (*ii*) the use of fire, and (*iii*) the manufacturing of tips and handles and the flattening of knots (Fig. S5).

In the first procedure, fresh branches were harvested using cutting flakes or chipped pebbles; the former tools were used to cut the base of the branch, while the latter were used as "heavy duty" chopping tools. Whatever tool was used, the activity caused serious damage to the proximal section of the branch due to the organic features of the wood. Once detached from the plant, the branches were cleaned of their ramifications: The smaller ones were removed by ripping them manually, and the stronger ones were removed by cutting them with lithic implements. These incisions were made by digging out the base of the knots so as to reduce damage to the stick potentially caused by a final strain of the ramification.

In the second procedure, three branches were exposed to fire. Three different types of exposure were tested to assess the effects of fire on the treatment of the wood. The fire was lit directly on the ground using dry *Ulmus* and *Populus* wood. The fire temperature was maintained constant between 400 °C and 500 °C. The first branch was put under the embers, the second was burned on top of the embers, and the branch was burned via direct contact with the flames. All of the branches were cut into three sections (proximal, mesial, and distal), and variables, such as time of exposure and temperature, were controlled for each of them (Table S3).

The three sections of the first branch rapidly lost internal liquids, causing hardening of the wood structure; incidentally, no evidence of external carbonization comparable to that of the archaeological artifacts was visible despite the length of time under the embers (5–10 min). Structural changes in the other two branches were monitored in real time, since the effects of the heating were clearly visible to the naked eye. More specifically, the second branch dried out very suddenly and the area in direct contact with the embers carbonized rapidly. Conversely, the combustion of the bark in direct contact with the flames generated a carbonized film on its surface; subsequently, the ends of the branch began to carbonize progressively from the outside inward.

In the third procedure, placing the wood on the embers or in direct contact with the flames (second and third branches) proved to be a better solution for removing the burnt bark by means of abrasion. The mesial sections of the branches were used to test the flattening of the knots. The branch placed under the embers remained a little harder, making its final shaping difficult. To work the handles and points, proximal and distal sections of each branch were shaped after their exposure to fire. Since fire burns the wood from the bark inward, this produces a naturally pointed morphology; subsequent abrasion performed using a coarse-grained stone made shaping the tip easy. Instead, in the case of the proximal (i.e., thicker) sections of the branches, despite having been burned, the hardness of the wood did not permit a perfect shaping of a rounded handle. A fourth branch (not included in the table) was shaped without monitoring the experimental parameter to empirically test the previous observations.

Finally, a fifth branch was used to reproduce the entire production sequence suggested for manufacturing the Poggetti Vecchi wooden artifacts. The branch was harvested by chopping it at the base; subsequently, the proximal part was chopped at an angle of 45° toward the base. This created a rounded preformed base that facilitated shaping the handle. Guided by the previous observations, the stick was burned by putting it into the flames, after which the carbonized surface was progressively abraded using a quartzite pebble. This action was repeated several times until a rounded handle and pointed tip were produced. During this activity, the burnt bark was removed and a very thin burnt black film remained visible on the stick (Fig. S5*F*).

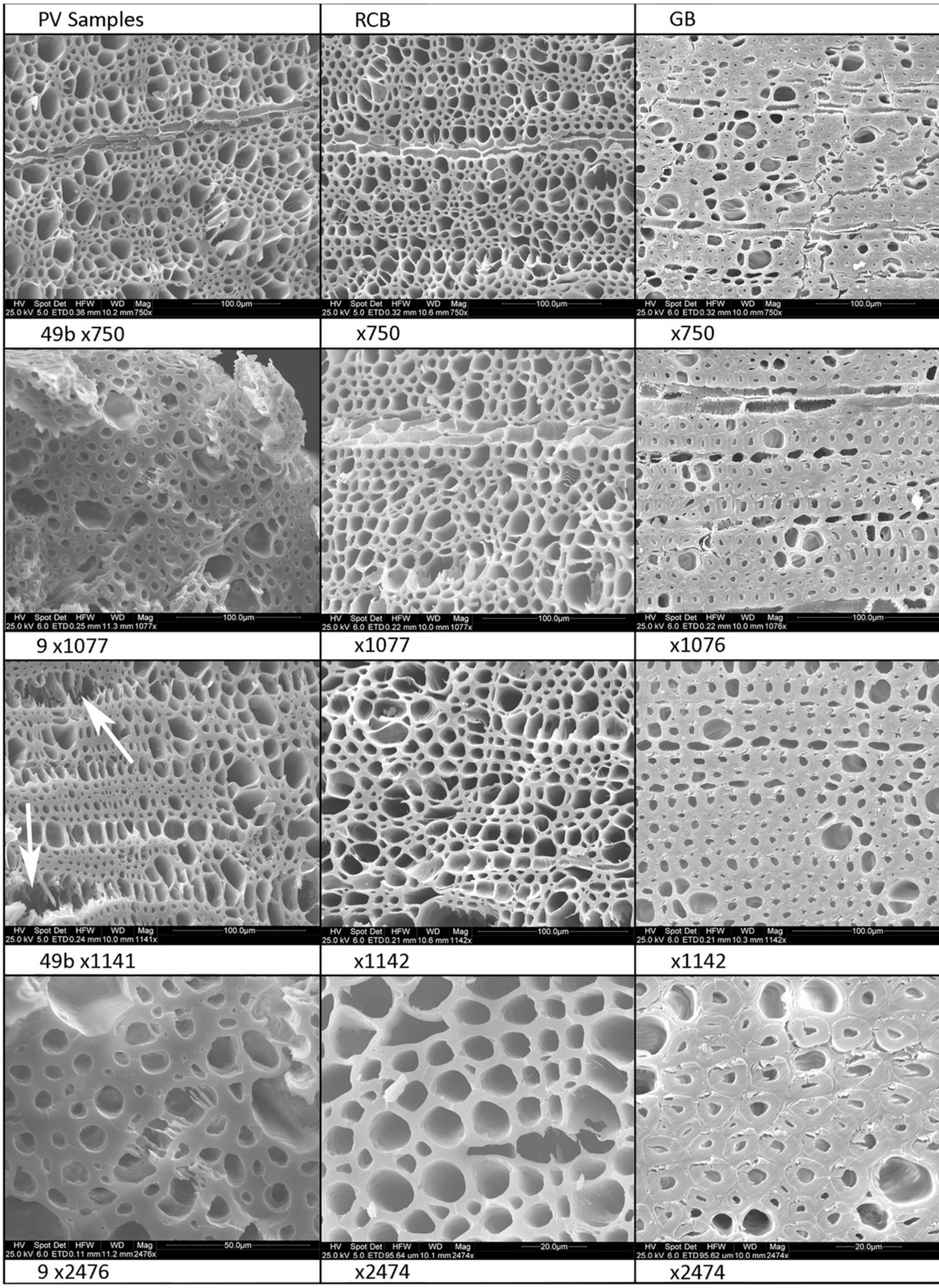


Fig. S1. SEM images of Poggetti Vecchi black surface samples (PV; *Left*), recently charred boxwood (RCB; *Center*), and green boxwood (GB; *Right*). In each row PV, RCB, and GB are compared at the same instrumental magnification (the scale bar is shown in the photographs). PV and RCB maintained the anatomical structure of GB, but the cell walls of the former became thinner, homogeneous, and of glossy appearance; for the most part, they lost their multiple-layer structure (composite middle lamella and secondary cell wall laminated in turn) as a consequence of combustion at over 350 °C (13). At the microscopic level, in PV samples (arrows in "49b ×1141"), increasing porosity due to expulsion of combustion gas is highlighted.

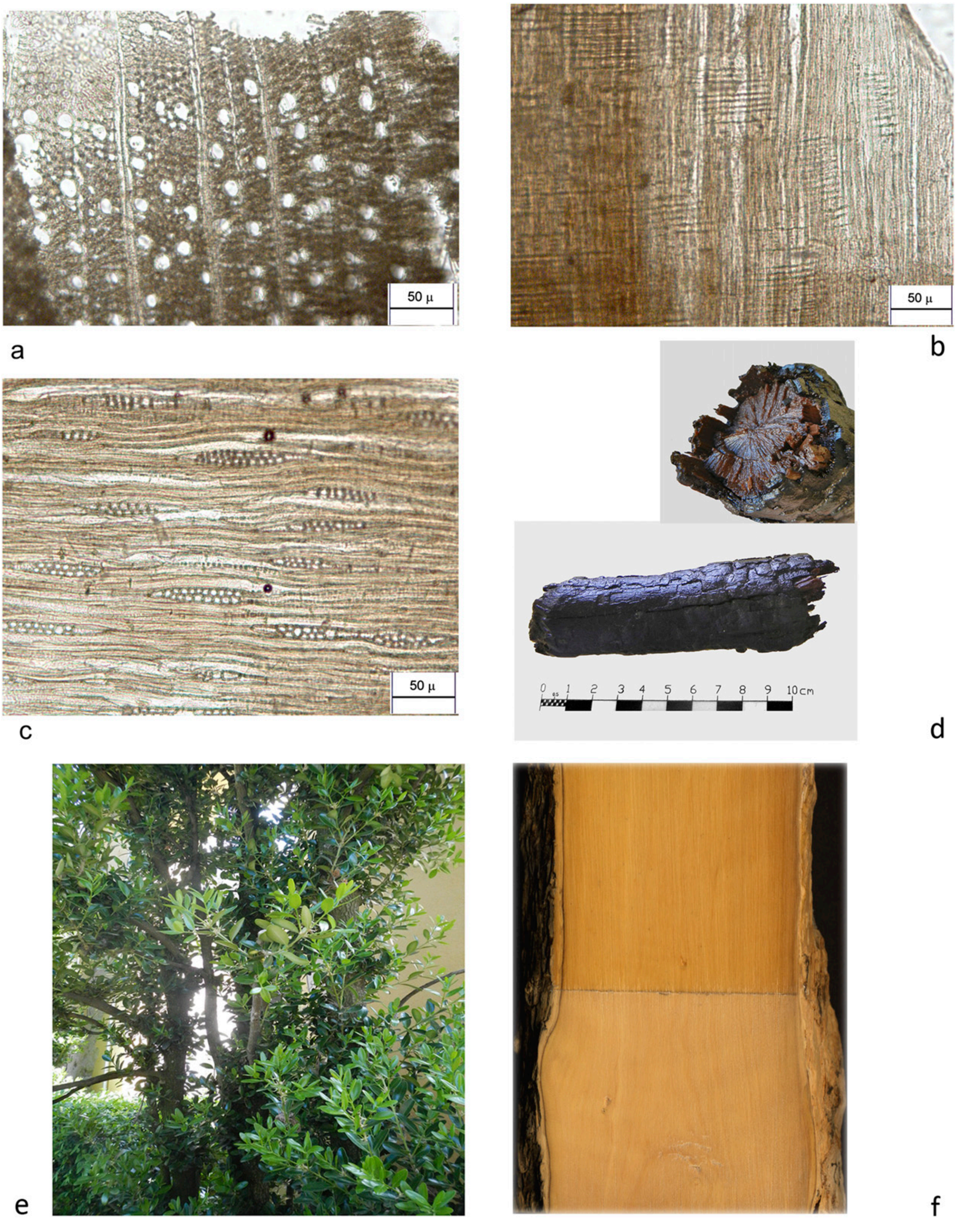


Fig. S2. (*A*–*C*) Transmission light microscopic images of the three diagnostic anatomical sections on one of the Poggetti Vecchi sticks (no. 3) made from *B. sempervirens*. Images of cross-sections (*A*), longitudinal radial sections (*B*), and longitudinal tangential sections (*C*) are shown. (*D*) Poggetti Vecchi wood fragment 49b. The black superficial layer is dissected by cuboid fractures due to the charring process. During combustion, the polysaccharide component is transformed and an almost isotropic shrinkage of the wood takes place (15). (*E*) Boxwood plant of *ca.* 4 m height (Villa "Le Balze," Fiesole–Florence). (*F*) Macroscopic aspect of a tangential cut of boxwood. A pale yellow color, fine texture, and straight grain can be observed. In the image, the upper part of the wood is varnished (from the Istituto per la Valorizzazione del Legno e delle Specie Arboree collection).

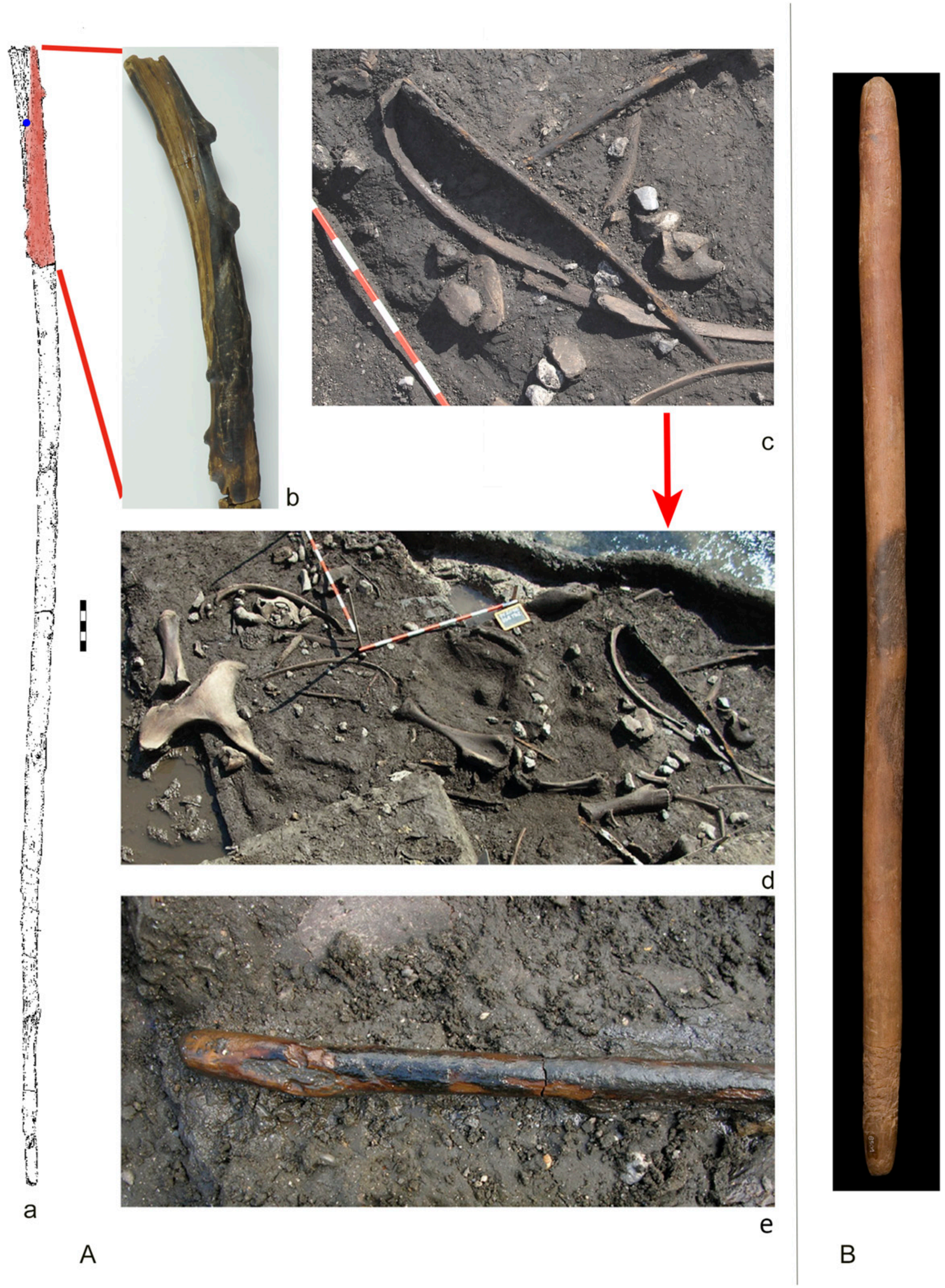


Fig. S3. (*A*) Stick no. 11: drawing (*a*; charred part is shown in red, blue spots indicate measurements of film thickness); detail of the handle with prominent knots (*b*); the same stick on the paleosurface U 2 (*c*); and the same stick with the tip (*d*). (*A*, *e*) Stick no. 2 on the paleosurface. (*B*) Australian "Waddy" in the Museum of Anthropology collection of Florence (inventory no. 8501). Traces of charring in the central part of the shaft are evident. The artifact is indicated as a hunting stick in the museum's label: length of 103 cm, diameter between 3.5 and 4 cm, and weight of 825 g.

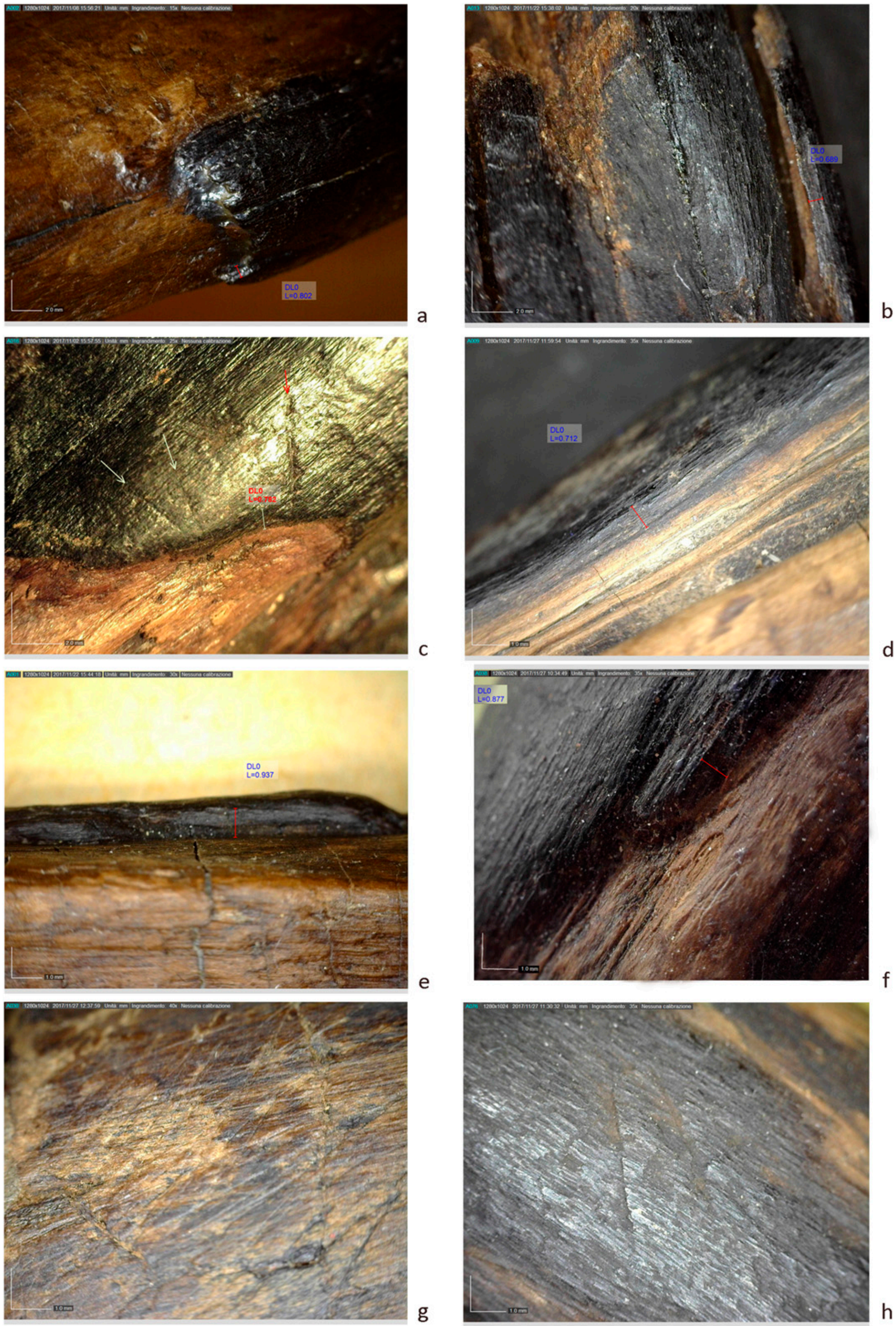


Fig. S4. Measurements of thickness of charred film on Poggetti Vecchi wooden tools: no. 50 (*A*), no. 3 (*B*), no. 9 (*C*), no.11 (*D*), no. 53 (*E*), and no. 2 (*F*). (*G*) Scratches on stick no. 26. (*H*) Cut marks on stick no. 2.

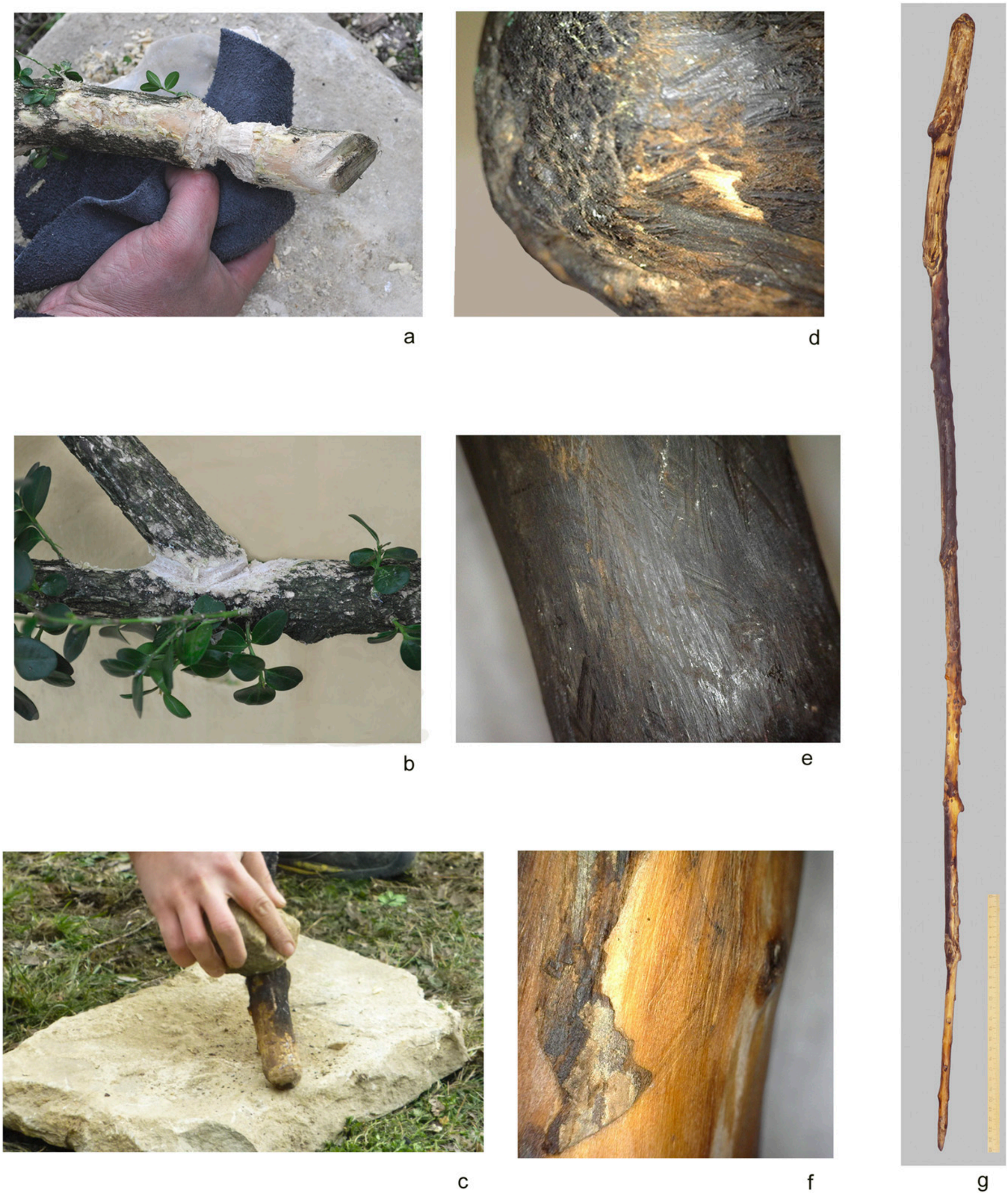


Fig. S5. Experimental study: secondary working to shape the handle (*A*), cutting the axil with a lithic flake (*B*), working the edges with abrasive stones (*C*), detail of edge of the handle (*D*), scratches on experimental stick (*E*), cut marks on experimental stick (*F*), and experimental stick (*G*).

Table S1. Poggetti Vecchi wooden tools: Specimens ≥10 cm in length

ID no.	U	Length, cm	Ø min/max, cm	Species	Type of implement	Charred	Film thickness (max), mm	Analysis performed	
								Chemical analysis	SEM
1	2	63.5	2.8/3	*B. sempervirens* L.	fr. stick				
2	2	91.5	3/3.5	*B. sempervirens* L.	fr. stick–handle	x	0.88	x	
3+28	2	12+12	2.5	*B. sempervirens* L.	fr. stick–point	x	0.69	x	
4	2	22	4	*B. sempervirens* L.	fr. stick				
6	2	64.5	2.5	*B. sempervirens* L.	fr. stick				
8	2	18	2.5	*B. sempervirens* L.	fr. stick				
9	2	46	2.8/3.2	*B. sempervirens* L.	fr. stick–handle	x	0.78	x	x
10	2	15	2	*B. sempervirens* L.	fr. stick				
11	2	114	1.2/2.6	*B. sempervirens* L.	fr. stick	x	0.71	x	
13	6	41.5	2/2.5	*B. sempervirens* L.	fr. stick				
14	2	16	1.5/2	n.i.	fr. stick	x?			
15	2	20.5	1/1.2	*B. sempervirens* L.	fr. stick				
16	2	35	2/3	*B. sempervirens* L.	fr. stick				
17	2	30	2/2.5	*B. sempervirens* L.	fr. stick–handle	x?			
18	2	35.5	2/2.5	*B. sempervirens* L.	stick–handle				
20	2	53.8	1.5/3	*B. sempervirens* L.	fr. stick				
23	2	20	1/2	n.i.	fr. stick–point				
24	2	53.5	2.5/3.5	*B. sempervirens* L.	fr. stick				
25	2	10	1	*B. sempervirens* L.	fr. stick	x?			
26	2	106	2/3	*B. sempervirens* L.	fr. stick				
27	2	16	2	*B. sempervirens* L.	fr. stick				
30	2	32	3.5/4	*B. sempervirens* L.	fr. stick				
31	6	40	3.5/4	*B. sempervirens* L.	fr. stick				
32	6	27	2/2.5	*B. sempervirens* L.	fr. stick	x?			
33	2	26	2.5	*B. sempervirens* L.	fr. stick–handle	x?			
34	2	27	2/4.2	*B. sempervirens* L.	fr. stick				
35	2	18	2.5	*B. sempervirens* L.	fr. stick				
37	2	29	1.5	*B. sempervirens* L.	fr. stick				
38+52	2	14+21	2/2.5	*B. sempervirens* L.	fr. stick				
40	2	16	1.5	*B. sempervirens* L.	fr. stick				
41	6	49	1.5/3	*B. sempervirens* L.	fr. stick–point				
45	2	10	3/4	*B. sempervirens* L.	fr. stick				
48	2	23	1.5	*B. sempervirens* L.	fr. stick				
49a	2	30	2	*B. sempervirens* L.	fr. stick				
49b	2	12	2.5	*B. sempervirens* L.	fr. stick	x	1.30	x	x
50	2	19	4	*B. sempervirens* L.	fr. stick–handle	x	0.80	x	
53	2	12.5	2.5	n.i.	fr. stick	x?	0.94		
55	2	26.5	1/2	*B. sempervirens* L.	fr. stick–point				
57	6	27	2/3	*B. sempervirens* L.	fr. stick				

Ø, diameter; fr., fragment; ID, identification; max, maximum; min, minimum; n.i., not identified; x, yes.

Table S2. Physical characteristics of boxwood compared both with those of the other wood taxa identified at Poggetti Vecchi and with those found in similar archaeological contexts at Schöningen and Lehringen, Germany, and Clacton-on-Sea, England

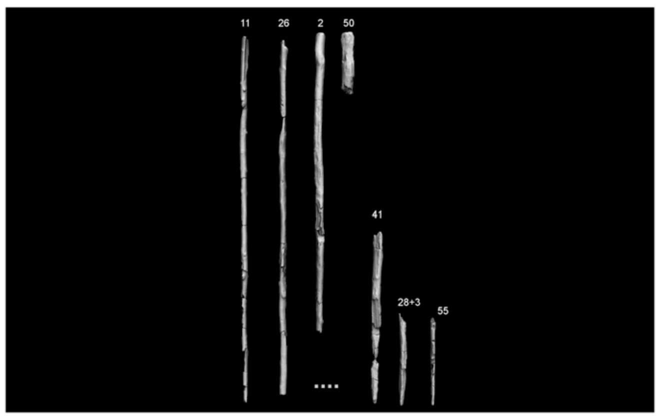
Wood	Density, kg/m^3	MOR, MPa	MOE, GPa	Janka hardness, *N*
Boxwood	975	144.5	17.2	12,610
Ash	680	103.6	12.31	6,580
Oak	710	97.1	10.47	4,990
Norway spruce	405	63.0	9.70	1,680
Scots pine	550	83.3	10.08	2,420
Yew	675	104.8	9.10	6,760

Physical characteristics of boxwood are compared with those of the other wood taxa identified in similar archaeological contexts at Schöningen (3) and Lehringen (4), Germany, and Clacton-on-Sea, England (5) (from The Wood Database; www.wood-database.com). MOE, modulus of elasticity; MOR, modulus of rupture in bending.

Table S3. Schematic description of the experimental procedure and of the data about each boxwood sample

	Branch 1				Branch 2				Branch 3				Branch 5			
Experimental data	Prox	Mes	Dist	TOT	Prox	Mes	Dist	TOT	Prox	Mes	Dist	TOT	Prox	Mes	Dist	TOT
Length, mm	370	350	480	1,200	270	330	300	900	400	440	350	1,190	/	/	/	1,130
Diameter, mm	19	17	17	/	22	22	18	/	27	25	20	/	33	23	17	/
Branch detachment	Flint cutting and strain				Flint chopping and strain				Flint cutting and strain				Metal cutting and strain			
Position	Under embers				Upon the embers				Direct flame				Direct flame			
Time	10 min	5 min	7 min, 30 s	/	14 min	10 min	14 min	/	10 min	10 min	7 min	/	/	/	/	/
Temperature, °C, start/end	427/360	540/598	427/397	/	235/488	601/589	235/488	/	428/543	470/429	428/454	/	/	/	/	/

Dist, distal; Mes, mesial; Prox, proximal; TOT, total; /, no value.



Movie S1. Boxwood tools, 3D model. The 3D models of specimens nos. 11, 26, 2, 50, 41, 3+28, and 55 are also shown.

Movie S1