CONSTRUCTING MONUMENTS, PERCEIVING MONUMENTALITY & THE ECONOMICS OF BUILDING

THEORETICAL AND METHODOLOGICAL APPROACHES TO THE BUILT ENVIRONMENT

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Ann Brysbaert, Victor Klinkenberg, Anna Gutiérrez Garcia-M. & Irene Vikatou

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Comparative labour rates in cross-cultural contexts

Daniel R. Turner

9.1 Introduction

This paper focuses on the logistics of preindustrial construction and the potential for a comparative method. A comparative method is advocated here due to the proliferation of isolated approaches that have led to false equivalencies in labour costs. Simply put, future labour studies would benefit from a quick-reference guide of task rates, and this paper aims to jump-start that process with the least problematic–and most prominently reported–task rates in manual earthmoving. Labour or task rates are combined with the dimensions of a built feature in a process known as architectural energetics, a phrase coined by Elliot Abrams in the 1980s to describe a concept recorded since at least the Early Dynastic Period (2900-2350 B.C.E.): the measuring of construction output or potential via time and personnel required.[493] Energetics in its current form offers labour time estimates for past construction, which authors globally have stretched into models of demography and power.[494] One major challenge to the validity of energetics has been the use of single task rates, which, depending on the source, can skew the picture of the past that archaeologists attempt to sketch through interpretative models based on labour predictions.

Labour predictions falter foremost in selecting appropriate task rates for modelling simplified acts or stages of construction, such as digging a ditch, shaping a wooden post, or setting a stone block into place. Since task rates dictate construction efficiency, arbitrary selection of rates yields arbitrary results: useful for thought exercises and isolated case studies but not for posterity and progress in empirical labour methods. While both adherents and opponents of architectural energetics have already written at length on its advantages and limitations, a summary of the consensus suffices here. Although actual rates from prehistory are inevitably lost without direct recording, pre-

493 Abrams 1987, 489-490; Abrams and Bolland 1999, 264; Ristvet 2007, 198-199.
494 See Abrams 1994; Kolb 1997; Arco and Abrams 2006; Lacquement 2009; Murakami 2015; Picket *et al.* 2016.

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dictions remain viable through the use of convincing ranges and midpoints in manual labour efficiency.[495] Analogous rates from history, ethnography, and experimental archaeology allow such predictions, but published compilations of these rates are rare and regionalised in archaeology if they exist at all.[496] It is proposed herein to list as many observations of manual labour as access permits to allow for more off-the-rack comparisons in the future. This paper highlights earthmoving task rates, outlining problems of variability in transportation and manufacture of other building materials.

Exploring manual labour efficiency, I will offer three case studies, one using the old method of targeted single task rates at Moundville (Alabama, United States) and two others showing a comparative range for earthmoving at early medieval Dublin (Ireland) and Repton (Derbyshire, United Kingdom). Earthmoving for enclosures at these sites required communal effort and rapid completion, making them ideal for labour cost analyses by narrowing the window of variability. These examples will help compare task rates and begin modelling labour with restraint: that is to say, modelling labour without spreadsheets or computer-aided algorithms,[497] for the goal is not the unknowable exact cost of construction, but rather a comparative range for basic tasks more readily transferable to other studies.

9.2 Comparative labour and repetitive tasks

If architectural energetics is a way of quantifying labour invested in the built environment, then comparative labour is a way of linking studies in architectural energetics together. Both operate on the uniformitarian assumption that physiological capabilities and building mechanics are essentially the same now as in the distant past. So, digging in medieval Europe is relatable to digging in the Pacific islands during the Second World War. Indeed, both long- and short-handled digging implements are morphologically similar in shape and technique, since ergonomics and logic limit our preferred methods of shifting soil.[498] We model our tools as extensions of our hands, increasing leverage, sparing our skin direct contact with abrasive materials, and removing our bodies to a safer distance should the weight we are moving become an unbalanced threat to fingers and toes. Transferring power to larger core muscles also reduces fatigue, which is easily proven first-hand if one attempts to hold a weight at arm's length rather than cradle it to the chest. Cutting surfaces and their associated labour rates differ as technology progresses, with metallurgy offering the clearest advantages in labour efficiency over tools with wood, bone, or stone working edges. Even so, the average 3:1 ratio for efficiency of a metal shovel over a digging stick, for instance, allows

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495 For European contexts, see Webster 1991; Ashbee and Jewell 1998; Squatriti 2002; Squatriti 2004; Tyler 2011; Pakkanen 2013; Harper 2016. For the Americas, see Erasmus 1965; Abrams 1987; Abrams 1989; Hammerstedt 2005; Lacquement 2009; Ortmann and Kidder 2013.

496 For the Aegean, see Burford 1969, 248-250; Devolder 2013, 42-47; Harper 2016, 519-530. For historical building manuals, see Hurst 1865; Rankine 1889; Cotterell and Kamminga 1990, 294. For experimental observations too narrow to extrapolate into comparative rates, see Xie 2014, 281-286.

497 Compare with Abrams and Bolland 1999, 282-284; Harper 2016, 72.

498 For examples of digging sticks, chert hoes, and separate-bladed shovels, see Morris 1980; Morris 1981; Kirch *et al.* 2005; Milner *et al.* 2010; Xie 2014, 100-112. Illustrated, side-by-side comparisons of these tools were drawn by Bogdan Smarandache and featured in Turner 2012, 29.

for comparisons using surrogate rates where tools are unknown except through analogy.[499] The flexibility to draw comparisons from experiments with a variety of tools is especially useful in contexts where poor preservation or limited intensive study has not given a full picture of the average worker's toolkit. Mycenaean Greece and the pre-Columbian U.S. Southeast are some examples where these analogies prove useful.

Comparative labour with energetics finds its anchor in repetitive tasks. All of the predictions here are reliant on limiting unnecessary detail, rather like emphasising tempo over every note played in a symphony. This translates into tracking incremental action, scaled upward to encompass the full range of steps leading to a built feature. In other words, the steady swing of a tool or the laying of a brick acts as a snapshot of the process that is later extrapolated to the scale of the finished building. Of course, this leads only to entry-level estimates and invites contextualisation in case-specific applications. Since any attempt to track all construction tasks will lead to confusion, such elaborations are abandoned herein as a non-starter in comparative study. A multitude of elaborations must give way to core tasks if communal construction is to find its initial momentum, and the same applies to the intent behind comparative labour.

The semantics of comparative labour, or our language choices in describing each variable in the process of construction, demand a brief aside, particularly concerning gendered pronoun use in modern descriptions of work. Although considered convenient or traditional, there are pitfalls to using the normative adult male shorthand for human capabilities (e.g., manpower, man-day), most notably the subversive invitation to omit active roles by women and children throughout most construction processes. Perpetuating that omission, many historical writers did not share an inclusive perspective on labour, and the familiar archetype of male movers and creators has defined the course of classical and historical studies.[500] For newer research, the usual unit format of man-day has been replaced by the more inclusive (and accurate) person-day. The bodies in motion, whether referred to as labourer, worker, or some other task-defined persona, will assume a male-dominated workforce where this expectation persists but will not preclude contributions from the entire population.

9.3 Production efficiency

Task rates have been calculated for a wide spectrum of traditional building materials. However, variability limits coverage here of rates for turf, stone, and wood, as different production circumstances amplify uncertainty over what constitutes an acceptable midspread for efficiency. The general labourer does not fully grasp the production process for secondary materials requiring more manufacturing steps without some level of practice (trial and error) or instruction (observation). Adequately redressing the deficiency of comparative rates in woodworking and stoneworking requires much more than a paper can deliver. This limitation is not as prevalent in soil movement, since its exhaustive treatment in previous literature can be condensed quickly absent the intricacies seen in working other materials.

499 Atkinson 1961, 295; Erasmus 1965, 285; Ashbee and Jewell 1998, 490; Milner *et al.* 2010, 109.

500 See DeLaine 1997, 106; Brysbaert 2013, 50; Pakkanen 2013, 55-56. Gender bias from classical writers like Theophrastus and the elder Pliny permeated the natural world; for instance, male trees were perceived as stronger and tougher than female ones (Meiggs 1982, 15). Such ingrained thoughts would hardly lead to a progressive recall of a diverse workforce in the absence of debates over inclusivity.

Supplement for Rate IDs					
ID	**Reference**	**Method**	**Material Description**	**Tool Description**	**Original Rate**
1a	Milner et al. 2010:109	experimental	compact silt to clay loam, variable moisture and occasional rocks	Mill Creek chert hoe replica, hafted on short wooden handle with rawhide, scooping assisted by white-tailed deer scapula and excavator's hands	0.202 m^3 in 1.78 hr
1b					0.609 m^3 in 4.05 hr
1c					0.171 m^3 in 1.00 hr
1d					0.131 m^3 in 0.68 hr
1e					0.085 m^3 in 0.42 hr
1f					0.250 m^3 in 1.00 hr
1g					0.367 m^3 in 1.00 hr
1h					0.369 m^3 in 1.00 hr
2a	Ashbee and Jewell 1998:491	experimental	chalk	antler pick, scapula shovel, woven basket	5 cwt/m-h, 1 cwt = 1 ft^3
2b					8.3 cwt/m-h, 1 cwt = 1 ft^3, assisted basketing not counted
2c	Ashbee and Jewell 1998:491, citing Pitt Rivers 1875	experimental	chalk	antler pick	9 cwt/m-h, 1 cwt = 1 ft^3
3a	Squatriti 2002:41, citing Vulpe 1957	ethnographic	unspecified	unspecified	1.5 m^3 in 8 hr
3b	Squatriti 2002:31, citing Hofmann 1965 and the Royal Frankish Annals	historical	unspecified	unspecified	750,000 m^3, 6,000 workers, 55 days
4a	Ristvet 2007:199, citing tablet M.288 in Charpin 1993:196	historical	unspecified	unspecified	2.25 m^3/m-d
5a	Hammerstedt 2005:46	experimental	root-penetrated, compact silty loam	Mill Creek chert hoe replica, metal bucket	0.29 m^3 in 1 hr
5b	Hammerstedt 2005:50, citing ECAFE 1957	ethnographic	dry hard clay	modern hand tools	0.334 p-d per m^3
5c			common soil		0.1 p-d per m^3
6a	Coles 1973:74, citing Pitt Rivers 1875	experimental	chalk	antler pick	1 m^3 in 1.5 hr for 2 men
6b					9 m^3 in 12 hr for 2 men
7a	Bachrach 2005:270, citing Bachrach 1993:65-72	ethnographic	unspecified	19th century hand tools	400,000 m^3 in 850,000 m-h
7b	Bachrach 2005:270, citing Bachrach 1993:65-72	ethnographic	unspecified	19th century hand tools	600,000 m^3 in 850,000 m-h
8a	Erasmus 1965:285	experimental	Las Bocas sandy soil	digging stick	2.6 m^3/m-d, m-d = 5 hr
8b				modern shovel	7.2 m^3/m-d, m-d = 5 hr
9a	DeLaine 1997:118, citing Pegoretti 1865	ethnographic	clay for brickmaking	19th century hand tools	93 m^3 in 14 m-d
9b					49 m^3 in 7 m-d

Table 9.1: Supplement for context IDs used in Table 9.2 showing references cited and original task rates.

Soil, perhaps above all other materials, factors heavily in monumental construction, yet it remains simple enough for children to manipulate into sand castles and rudimentary building blocks. Unless the construction objective involves building an ice palace in a land of perennial snow or cutting directly into bedrock, builders will likely end up displacing, compacting, or otherwise modifying earth. Such as it is, the near-universal occurrence of earthen architecture allows for global comparative examples with an inspiring diversity of approaches (see the contribution by Chris Scarre, this volume). This also brings with it the disadvantage of aligning scattered objectives into a singular purpose, but that common denominator can be found through comparing production efficiency.

Soil extraction rates							
Context		Material	Tool			Rate	
ID	Stamina	Type	Cutting Surface	Handle Length	Description	p-h/m³	m³/p-h
1a	average	silt loam	stone	short	chert hoe	8.850	0.113
2a	average	chalk	bone	short	antler pick	7.042	0.142
1b	average	silt loam	stone	short	chert hoe	6.667	0.150
1c	conditioned	silt loam	stone	short	chert hoe	5.848	0.171
3a	conditioned	unspecified	unsp (steel?)	unsp (long?)	unspecified	5.263	0.190
1d	average	silt loam	stone	short	chert hoe	5.236	0.191
1e	conditioned	silt loam	stone	short	chert hoe	4.902	0.204
4a	conditioned	unspecified	unsp	unsp	unspecified	4.444	0.225
2b	maximum	chalk	bone	short	antler pick	4.255	0.235
1f	conditioned	silt loam	stone	short	chert hoe	4.000	0.250
2c	maximum	chalk	bone	short	antler pick	3.922	0.255
5a	average	silt loam	stone	short	chert hoe	3.448	0.290
3b	conditioned	unspecified	unsp (wood?)	unsp (long?)	unspecified	3.030	0.330
6a	average	chalk	bone	short	antler pick	3.030	0.330
1g	conditioned	silt loam	stone	short	chert hoe	2.725	0.367
1h	conditioned	silt loam	stone	short	chert hoe	2.710	0.369
6b	average	chalk	bone	short	antler pick	2.667	0.375
7a	conditioned	unspecified	steel	variable	pre-modern industrial	2.123	0.471
8a	conditioned	sandy loam	wood	long	digging stick	1.923	0.520
9a	conditioned	clay	steel	variable	pre-modern industrial	1.806	0.554
9b	conditioned	clay	steel	variable	pre-modern industrial	1.715	0.583
5b	conditioned	clay	steel	variable	modern	1.667	0.600
7b	conditioned	unspecified	steel	variable	pre-modern industrial	1.416	0.706
8b	conditioned	sandy loam	steel	long	modern	0.694	1.440
5c	conditioned	loam	steel	variable	modern	0.500	2.000

Quick Guide (p-h/m³)*						
Tool	Soil	N**	Center Index***	Reference ID	Min.	Max.
Non-metal	Loose	1	2.0	8a		
	Compact	14	[4.2]	1a-h, 2a-c, 5a, 6a-b	2.7	8.9
Metal	Loose	2	0.6	8b, 5c	0.5	0.7
	Compact	5	1.8	5b, 7a-b, 9a-b	1.5	2.2
Unsp.	Unsp.	3	[4.5]	3a, 4a, 3b	3.1	5.3

*Table 9.2: Soil extraction rates and quick reference guide (*Round up to nearest 0.1 person-hour; **Number of studies cited; *** Greater of mean and [median]). Supplement to context IDs can be found in Table 9.1 with references cited and original task rates.*

Task rates for soil excavation appear in a variety of sources but are so scattered in the literature that few studies cite more than one rate for each task. Compounding the problem of scattered sources, several critical variables are left implicit where authors believe the information to be self-evident or of no consequence to their stated goals. Table 9.2 serves to illustrate variation in soil excavation rates and how these should be reported, acknowledging tool and material type and converting rates into a standard metric based on person-hours, rather than leaving them in units that are culturally variable, such as a workday. This limits conversion errors, gives researchers alternate options for referencing away from the most popular studies, and can aid experiment design to refine task rates even more. The original rates and references can be found in Table 9.1.

Other task rates are less straightforward. Cutting times for wood, for instance, vary according to species, sap flow (time of year), tool, and technique.[501] Turf- and stone-cutting times also vary based on tool and technique, including the experience and proficiency level of the producer.[502] I have left these out of tabular form for now since they are incomplete, wildly different, and not ready for the same comparative approach applied to soil movement. Placing an arbitrary threshold of ten sources as the minimum sample size for comparative rates in working other materials, patterns should appear with a convincing midspread as we have seen with soil. This, however, must await further study.

9.4 Transport efficiency

Similar to production efficiency in materials other than soil, transport is also variable in its cost and efficiency, but for transport there is more literature available. Journals of physiology and ergonomics have tracked human capabilities for decades, and there are litanies of sources, from 19th century building manuals to farmer's almanacs, that make suggestions about what the appropriate load is for a mule.[503] When cycling through these numbers, it is important to keep a few things in mind. Many sources list maximum carrying capacity by estimating mechanical energy, but since biology is not perfect and joints are not frictionless, mechanical energy does not equate to physiological effort.[504] In raising and lowering our centre of gravity in a single step, one joule of mechanical energy actually ramps up to five joules of physiological effort.[505] Because prolonged exertion over distance amplifies as the distance becomes longer, transport capabilities drop substantially, as shown in timed observations from Charles Erasmus.[506] Differences in load weight are not the only factor at work here, as the unloaded trip back takes progressively longer at greater distances. The people walking the shortest and the longest distances in Erasmus's study are actually carrying a similar load weight, roughly 20 kg. Due to com-

501 Custance 1968, 100; Meiggs 1982, 15; Hammerstedt 2005, 51-62.
502 Erasmus 1965, 293; Burford 1969, 247-250; Coles 1973, 81; Shirley 1996, 124; DeLaine 1997, 120-121.
503 Burford 1960; Heizer 1966; Betancourt *et al.* 1986; Cotterell and Kamminga 1990; Knapik *et al.* 1996; DeLaine 1997; Malville 1999, 2001; Bastien *et al.* 2005; Vaz *et al.* 2005.
504 Cotterell and Kamminga 1990, 193-195.
505 Cotterell and Kamminga 1990, 195.
506 Erasmus 1965, 287.

pounding fatigue over the longer journey, however, it takes the person transporting loads 1 km that much longer to walk back for a new load.

It is partly due to the variability in multi-material construction and transport that I have deferred case studies using a comparative labour range with these to another time. The remainder here will discuss single-stage earthen construction and associated wooden palisades. Multiple task rates for soil are combined with targeted experimental work with wood, a marriage of necessity for old and new labour predictions. The inclusion of woodworking rates in the older single-rate format shows the compatibility of a comparative range in one material (soil) that can be added or subtracted at will. This permits an interpretative model combining each rate format without derailing the comparative enterprise through the nuances of preindustrial labour and the scarcity of rates for more complex tasks.

9.5 Case study 1: Moundville, Alabama

The first case study, Moundville, was one of the largest sites in North America at its peak around 1200 C.E., consisting of at least 32 earthen mounds arranged around an artificially levelled plaza (Figure 9.1). With a resident population estimated at 3,000, Moundville collected agricultural surplus from a hinterland of single-mound centres and smaller settlements scattered across west-central Alabama. Long-distance exchange brought materials like obsidian and copper from as far afield as Colorado and Michigan, and intricately crafted prestige goods showed imagery representative of a highly influential regional iconographic tradition known as the Southeastern Ceremonial Complex.[507]

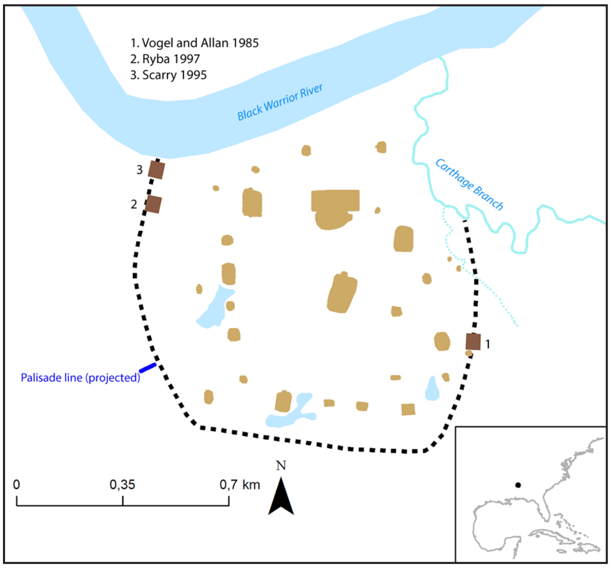

Figure 9.1: Map of Moundville showing the locations of excavations intersecting the former palisade line (c. 1200 C.E.). Mound locations are approximate and not to scale. Based on Turner 2010, 69, original figure by John H. Blitz, 2008.

507 See Knight and Steponaitis 1998; Blitz 2008.

Moundville Defensive Perimeter (c. 1200 C.E.) *							
Wall Trench							
Scenario	**Perimeter (m)	Bastions	Volume (m^3)	Rate (p-h/m^3)	Cost (p-h)	Workforce	Days (10 hr)
1	2,700	50	1,350	3.45	4,657.5	200	2.3
2	2,890	60	1,445	3.45	4,985.3	200	2.5
3	3,080	70	1,540	3.45	5,313.0	200	2.7
Palisade							
A	2,700	50	6,750	1.6	10,800.0	200	5.4
B	2,890	60	11,075	1.6	17,720.0	200	8.9
C	3,080	70	15,400	1.6	24,640.0	200	12.3
Total							
1A	2,700	50			15,457.5	200	7.7
2B	2,890	60			22,705.3	200	11.4
3C	3,080	70			29,953.0	200	15.0

*Table 9.3: Labour costs of the Moundville defensive perimeter (c. 1200 C.E.) with single-source task rates and variable estimated bastion numbers. (*Scenarios A-C list post count under volume and labor rates as p-h/post; adapted from Turner (2010, 72-75) using rates from Hammerstedt (2005); **Curtain wall plus added bastion length (14 m per bastion)).*

The total soil shifted for Moundville's mounds and plaza amounted to roughly 375 million kg, as recalculated by Cameron Lacquement using a digital gridding method.[508] From the perspective of the soil mover, this equates roughly to 19 million basket loads or, for a modern equivalent, 31,000 cycles with a standard dump truck. Looking beyond this undeniably impressive feat, our energetics focus here is not on the mounds; rather it is on what has not survived. A bastioned wooden palisade over 2 km in length once enveloped this complex, and where traces have been found in excavations in the western and eastern portions of the site, the number of posts used can be extrapolated roughly to a mean of 11,000.[509] The palisade was rebuilt six times according to realignments witnessed in the excavations, and John Blitz's 2008 original map (referred to in Figure 9.1) shows the projected outline citing intersecting excavations and reports from 19th century observers of a low rise following the outer perimeter of mounds.[510]

One of the reasons the palisade needed so many rebuilding episodes is that the climate in west-central Alabama is not kind to untreated wood. Pine and other common species tend to decay within a matter of decades, and the rebuilding phases seen in excavation seem to corroborate this with a close reading of associated ceramics.[511] In any case, the site was walled for at least a century, after which it became less of a

508 Lacquement 2009, 102-103.
509 Turner 2010, 74.
510 Vogel and Allan 1985; Scarry 1995, 178; Ryba 1997, 53-55; Turner 2010, 69.
511 Scarry 1995, 197; Milner 2000, 62; Hammerstedt 2005, 220.

population centre and more a place for people living elsewhere to return to in order to bury their dead. Reconstructed palisades, such as one at the site of Town Creek in North Carolina, approximate what Moundville's would have looked like with wattle-and-daub closing the gaps, reducing fire risk and screening movement, and with the bastions offering an excellent firing platform for bow-wielding defenders.[512]

What does it take to build something like this? Labour-time estimates using Scott Hammerstedt's figures in Kentucky–that is, rates from timed observations using stone tool replicas to chop trees and move soils of a relatable density–allow a prediction of the final cost, which is roughly 30,000 person-hours (see Table 9.3, Scenario 3C).[513] Now what does that actually mean? For a major population centre estimated to have 3,000 people in the immediate area, community security within a matter of weeks is very manageable (15 [ten-hour] or 30 [five-hour] days for 200 workers). Although prohibitive costs were absent in the initial construction of the palisade, issues did arise with the upkeep, especially having to maintain a massive perimeter with a depleted labour pool as people began moving away from the site.

Continuing to explore Moundville through its labour potential, the debate deepens with each new wave of studies. Part of the allure of Moundville for archaeological research is its scale relative to other sites in the region, and indeed, a windfall of recent literature has duly attested the importance of major Mississippian centres like it.[514] One would need to travel over 300 km to witness another multi-mound centre of comparable scale, which raises the question: Why take such steps to fortify? Warfare in the Mississippian period (1000 – 1500 C.E.) has been characterised as endemic raiding in the smash-and-grab fashion rather than conquest, so prolonged sieges are safely out of the question.[515] Seizing food, captives, or rare materials would represent some possible raiding objectives for populations to guard against. Protecting food stores from outsiders sneaking into the perimeter of house groups certainly sounds more in line with valid reasons for Moundvillians to erect a barrier, but again, an estimated 60 bastions for archers seems excessive for repelling simple corn thieves.[516] Fear of abduction must have played a role, and the antagonists, wherever they originated, would need numbers and no shortage of bravado to crack an engorged nut that size. So, one must next ask what internal forces could cause that nut to crack from within, possibly warranting the construction and upkeep of such an overt symbol of power while simultaneously risking collateral blowback from the local environment or leaders with a different vision for communal labour projects.

Before exploring reasons why the population fortified Moundville, reasons not to do so take priority. What risks applied to the inhabitants in erecting a massive timber fortification and rebuilding it again and again? Apart from the obvious labour demand that might force the builders to rethink their cooperation in a moment of heavy lifting, changes to the immediate landscape could pose unintended consequences. Complications from erosion, for instance, famously jeopardised early 20th century crop yields in the region, owing in part to land overuse and deforestation, and that

512 Milner 2000; Keeley *et al.* 2007.
513 Hammerstedt 2005, 227-231; Turner 2010, 75.
514 See Anderson and Sassaman 2012; Blitz 2010.
515 Milner 1999; Milner 2000, 55-61; Krus 2016.
516 Turner 2010, 75; Table 9.3, this volume.

risk certainly applied to those less-developed agricultural systems that made population accretion at Moundville possible. Reliance on fragile crop yields would render the settlement and its exchange network vulnerable if and when food stores failed, triggering population fission back to dispersed smaller settlements.[517] Environmental repercussions from overcutting timber may not have been such a concern but bear mentioning in this context. After all, the Black Warrior River bending north of the site would have allowed floating timbers from upstream, alleviating immediate concerns of deforestation. That possibility does not preclude overuse of local woodland out of convenience or some other motivation, such as clearance for agriculture.

If not used for repelling full-scale assaults and not a liability for the local ecology, what did the Moundville palisade accomplish? The timber, wattle-and-daub wall acted both as a visible deterrent and physical barrier to outsiders and as a reminder to the population inside the perimeter (or with access to the inside) of its own communal labour potential and relative strength, an assumption also made self-evident by the mounds at their impressive final heights. Whether and when the palisade as a symbol of power was co-opted by the elite for their own benefit is another matter to be abstracted and theorised. Firing platforms at regular intervals, however, kept the wall at least partly functional until these were dropped in its final incarnations.

The implication of the task rates used at Moundville is that a single-rate approach is still viable so long as the rates originate in a closely related context. In this instance, Hammerstedt's experimental tree-cutting and soil movement data used replica stone-bladed tools in soils similar to those at Moundville.[518] The estimated labour costs for Moundville's palisade, 30,000 person-hours, or no more than 30 (five-hour) days for 200 workers (see above and Table 9.3), offers a snapshot of the settlement's labour potential in defence, wherein an extended construction period defeats the purpose of a functional deterrent for internal rivals and external threats. Unlike Moundville, the case studies at Dublin and Repton, presented below, do not have single-rate observations that mirror construction circumstances in their earthen settlement boundaries. As with many poorly preserved archaeological features, measurements are incomplete and must be extrapolated. To meet these challenges, measurements and task rates follow a range showing the potential scale of labour involved.

9.6 Case study 2: Dublin, Ireland

Dublin arose in the time of Scandinavian raiding in the mid-ninth century C.E. from an Irish monastic settlement and the Viking encampments that targeted it near the confluence of the Liffey and Poddle (Figure 9.2). Over time the Vikings stayed, and the resulting Hiberno-Norse population dug itself in to withstand local pushbacks and further raiding from latecomers. Earthwork settlement boundaries arose along the landward side of the town, and the phrase *settlement boundary* is deliberately used in place of *defensive rampart* for the earlier incarnations to denote their comparatively smaller size and evident lack of defensive value.[519] The perimeter earthworks did in-

517 Blitz 1999, 578.
518 Hammerstedt 2005, 227-231.
519 Walsh 2001, 94-98; Scally 2002, 17.

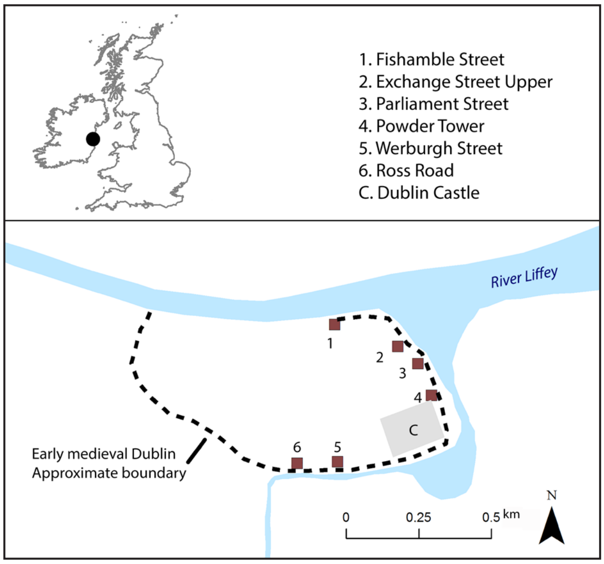

Figure 9.2: Map of Dublin showing the locations of excavations intersecting perimeter earthworks (c. 850-1150 C.E.) in relation to the later Dublin Castle. Based on maps by Wallace 1990 and Clarke 2002.

crease in estimated dimensions over time, roughly doubling in the course of the first hundred years after initial raiding before exploding in size to a full defensive rampart by the time of the early 11th century. These early earthworks were ultimately replaced by a battered stone circuit wall, but circumstances did not afford much opportunity for the population to reap the benefits as the Anglo-Norman invasion of 1170 C.E. ultimately removed control from the entrenched Hiberno-Norse elite.

Part of the comparative spirit of multiple task rates demands the listing of raw data such as that shown in Table 9.4. If in need of a quick reference, focus should fall on the final two columns on the far right of the table showing suggested labour scenarios. The other columns record the variables involved in each choice, a necessity for accountability where rates and dimensions might be disputed. Recall the warning about single-rate predictions leading interpretation in a particular direction and imagine being unknowingly led down that road by a preemptive omission of all other possibilities. What appears in Table 9.4 is a range of dimensions given by excavations for earthen enclosures at early medieval Dublin and Repton (discussed below), combined with a range of task rates for moving earth as recorded in experimental and ethnographic examples. Pairing least volume with maximum plausible efficiency, an absurdly low number results for labour-time investment in Scenario 1. At the opposite end of the spectrum–so most volume and least efficiency (Scenario 7)–the sum is more than 42 times larger than that of the least cost. In a traditional energetics study, only one of the conservative middle rows appears (Scenarios 3-5), but more often than not, a paragraph discussing three cells in particular suffices, the total labour-time estimate and the arbitrary estimate of workers and associated completion time (the three right-most columns in Table 9.4). If the prediction highlighted one task rate but not another, how differently would one interpret the evidence? Whatever Scenarios 1 and 7 show, it does not mesh with reality. Reality probably lies somewhere in the middle (Scenario 4), but if only one side of the story appears, then alternate interpretations that the early medieval Dublin locals cared

<table>
<tr><th colspan="8">Labour comparison of Viking earthen enclosures</th></tr>
<tr><td colspan="8"></td></tr>
<tr><th colspan="8">Dublin Settlement Boundary (c. 950 C.E.)</th></tr>
<tr><th>Scenario</th><th>Dimensions (m)</th><th>Profile</th><th>Volume (m^3)</th><th>Rate (p-h/m^3)</th><th>Cost (p-h)</th><th>Workforce</th><th>Days (10 hr)</th></tr>
<tr><td>1</td><td>940 × 0.7 × 2.5</td><td>V</td><td>823</td><td>1.5</td><td>1,234.5</td><td>100</td><td>1.2</td></tr>
<tr><td>2</td><td>940 × 1.7 × 3.7</td><td>|_|</td><td>5,913</td><td>1.5</td><td>8,869.5</td><td>100</td><td>8.9</td></tr>
<tr><td>3</td><td>940 × 0.7 × 2.5</td><td>V</td><td>823</td><td>4.2</td><td>3,456.6</td><td>100</td><td>3.5</td></tr>
<tr><td>4</td><td>Ranged</td><td>_/</td><td>3,368</td><td>4.2</td><td>14,145.6</td><td>100</td><td>14.1</td></tr>
<tr><td>5</td><td>940 × 1.7 × 3.7</td><td>|_|</td><td>5,913</td><td>4.2</td><td>24,834.6</td><td>100</td><td>24.8</td></tr>
<tr><td>6</td><td>940 × 0.7 × 2.5</td><td>V</td><td>823</td><td>8.9</td><td>7,324.7</td><td>100</td><td>7.3</td></tr>
<tr><td>7</td><td>940 × 1.7 × 3.7</td><td>|_|</td><td>5,913</td><td>8.9</td><td>52,625.7</td><td>200</td><td>26.3</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td>Palisade*</td><td>940 × 0.3 × 0.15</td><td>|||||</td><td>2,090</td><td>1.6</td><td>3,344.0</td><td>100</td><td>3.3</td></tr>
<tr><th colspan="8">Dublin Defensive Rampart (c. 1050 C.E.)</th></tr>
<tr><th>Scenario</th><th>Dimensions (m)</th><th>Profile</th><th>Volume (m^3)</th><th>Rate (p-h/m^3)</th><th>Cost (p-h)</th><th>Workforce</th><th>Days (10 hr)</th></tr>
<tr><td>1</td><td>1,325 × 0.9 × 2.3</td><td>V</td><td>1,372</td><td>1.5</td><td>2,058.0</td><td>100</td><td>2.1</td></tr>
<tr><td>2</td><td>1,325 × 4 × 7</td><td>|_|</td><td>37,100</td><td>1.5</td><td>55,650.0</td><td>500</td><td>11.1</td></tr>
<tr><td>3</td><td>1,325 × 0.9 × 2.3</td><td>V</td><td>1,372</td><td>4.2</td><td>5,762.4</td><td>100</td><td>5.8</td></tr>
<tr><td>4</td><td>Ranged</td><td>_/</td><td>19,236</td><td>4.2</td><td>80,791.2</td><td>500</td><td>16.2</td></tr>
<tr><td>5</td><td>1,325 × 4 × 7</td><td>|_|</td><td>37,100</td><td>4.2</td><td>155,820.0</td><td>500</td><td>31.2</td></tr>
<tr><td>6</td><td>1,325 × 0.9 × 2.3</td><td>V</td><td>1,372</td><td>8.9</td><td>12,210.8</td><td>100</td><td>12.2</td></tr>
<tr><td>7</td><td>1,325 × 4 × 7</td><td>|_|</td><td>37,100</td><td>8.9</td><td>330,190.0</td><td>1,000</td><td>33.0</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td>Palisade*</td><td>1,325 × 0.3 × 0.15</td><td>|||||</td><td>2,945</td><td>1.6</td><td>4,712.0</td><td>100</td><td>4.7</td></tr>
<tr><th colspan="8">Repton Defensive Rampart (c. 873 C.E.)</th></tr>
<tr><th>Scenario</th><th>Dimensions (m)</th><th>Profile</th><th>Volume (m^3)</th><th>Rate (p-h/m^3)</th><th>Cost (p-h)</th><th>Workforce</th><th>Days (10 hr)</th></tr>
<tr><td>1</td><td>160 × 8.5 × 4.2</td><td>V</td><td>2,856</td><td>1.5</td><td>4,284.0</td><td>100</td><td>4.3</td></tr>
<tr><td>2</td><td>160 × 10 × 4.2</td><td>|_|</td><td>6,720</td><td>1.5</td><td>10,080.0</td><td>100</td><td>10.1</td></tr>
<tr><td>3</td><td>160 × 8.5 × 4.2</td><td>V</td><td>2,856</td><td>4.2</td><td>11,995.2</td><td>100</td><td>12.0</td></tr>
<tr><td>4</td><td>Ranged</td><td>_/</td><td>4,788</td><td>4.2</td><td>20,109.6</td><td>100</td><td>20.1</td></tr>
<tr><td>5</td><td>160 × 10 × 4.2</td><td>|_|</td><td>6,720</td><td>4.2</td><td>28,224.0</td><td>100</td><td>28.2</td></tr>
<tr><td>6</td><td>160 × 8.5 × 4.2</td><td>V</td><td>2,856</td><td>8.9</td><td>25,418.4</td><td>100</td><td>25.4</td></tr>
<tr><td>7</td><td>160 × 10 × 4.2</td><td>|_|</td><td>6,720</td><td>8.9</td><td>59,808.0</td><td>200</td><td>29.9</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td>Palisade*</td><td>160 × 0.3 × 0.15</td><td>|||||</td><td>356</td><td>1.6</td><td>569.6</td><td>100</td><td>0.6</td></tr>
</table>

*Table 9.4: Labour costs of Viking earthen enclosures comparing the Repton winter encampment with 10th and 11th century Dublin perimeter earthworks. Multi-source task rates show variability possible when combined with the range of estimated dimensions (*Dimensions listed as perimeter, post diameter, and post spacing; volume reflects projected post count, and rate is p-h per post for cutting, transporting, and setting within 1 km (Hammerstedt 2005; Turner 2010)).*

very little or quite a lot to erect a town boundary could go unchallenged. The same applies for the later defensive barrier, which shows roughly six times the effort of the earlier settlement boundary, at least with reasonable variables.

As with the first case study in questioning the motives behind Moundville's over-zealous defence, questioning the purpose of an earthen bank perimeter not substantial enough to be any significant hindrance to an invader forms a natural line of inquiry.[520] Of course, most settlements situated between watercourses would spark interest in flood control, and such action would not seem unreasonable against the tidal Liffey. However, the perimeter crosses higher ground at Ross Road in the south and stays inland of the tidal marks witnessed in excavations at Exchange Street Upper in the northeast, calling into question the early 10th century embankment's function in water management.[521] When the perimeter expands half a century later, excavators proposed its role as part of a land reclamation programme, supported by post-and-wattle additions to the perimeter seen at Parliament Street in the northeast.[522] This is not uniformly encountered at other excavations intersecting the line, particularly along the southern border of the settlement, with Ross Road and Werburgh Street showing either a denuded form or the steady build-up of domestic refuse as locals took advantage of a convenient place to dump their trash.[523]

By the end of the 10th century, an unambiguous defensive rampart eclipsed the earlier earthen boundaries and doubled the intramural area of the town.[524] Whether triggered by population pressures from within or a need to include a fordable section of the Liffey within the circuit, the town kept this defensive enclosure until its replacement by a stone enceinte around 1100 C.E.[525] The spike in labour demand for increasingly larger earthworks could have coincided with the waxing and waning of Hiberno-Norse fortunes in the area, particularly the return of foreign elites around 917 C.E. after their expulsion by local rivals fifteen years prior.[526] The evidence for this is tenuous, however, and too reliant on historical sources written from the perspectives of unsympathetic Irish chroniclers in the *Annals of Ulster*. In any case, the concurrent wave of building seen in excavations at Temple Bar West does lend credence to the possibility that the Hiberno-Norse return was a boon to the local economy, even if there is no evidence to suggest that the locals suffered a catastrophic setback in the interim.[527]

Questions of motivations aside, what are the implications behind a comparative labour assessment for the Dublin perimeter earthworks? The uncharitable answer is that energetics runs into severe roadblocks in multi-century construction where a modern

520 Observed heights for the first perimeter range from 0.45 m at Exchange Street Upper to 0.8 m at Fishamble Street and Ross Road. The second boundary shows a height range from 0.7 m to 1.7 m in excavations at Ross Road, Parliament Street, Fishamble Street, and Werburgh Street. See report of excavations in Walsh 2001; Scally 2002.

521 Wallace 1990; Walsh 2001, 98; Scally 2002, 17.

522 Scally 2002, 18-21.

523 Walsh 2001, 98-100; Hayden 2002, 66.

524 Excavations under the Powder Tower of the later Dublin Castle give a conservative height for the embankment at 2.7 m, not including the possibility of a timber revetment. See report of excavations in Lynch and Manning 2001.

525 Walsh 2001, 106; Clarke 2002; Scally 2002, 25; Simpson 2010.

526 Clarke 1977; Simpson 2010.

527 Simpson 2010; Simpson 2011.

metropolis occludes investigation of the full perimeter, notably causing unavoidable speculation over the original dimensions of the earthworks and uncertainty surrounding their concurrent construction. With those reservations in mind, however, one can imagine that staggering construction into separate phases that leave an incomplete scatter of lines is less attractive than an unbroken perimeter, no matter its dubious initial purpose. Locking in a convincing volume from scattered excavation evidence is certainly a greater problem than the production efficiency of soil movers.

On the surface, the Dublin examples might appear to present a few hurdles too many in testing the validity of a comparative labour method. However, that is not the case. The labour estimates in Table 9.4, whatever their absolute value, still offer useful relative comparisons with the changing settlement boundaries of a growing early medieval town. As mentioned above, constructing Dublin's 11th century defensive rampart required roughly six times the effort of its 10th century settlement boundary counterpart and four times the cost of the embankment at the temporary encampment of Repton (see below and Table 9.4, Scenario 4). However, without assurances that task rates used in each case are comparable, as might be the case in separate single-rate examples, those comparisons evaporate. Where the maximum volume is used but the task rates differ in the extreme, the settlement boundary (Scenario 7) and defensive rampart (Scenario 2) reflect similar construction costs.

9.7 Case study 3: Repton, United Kingdom

Seeing where complications arise and confidence wavers in multi-century construction and scattered excavation evidence, the final case study simplifies the labour equation through shortening the available timeline for the work in question. The Viking encampment at Repton was occupied for a single season in the winter of 873-874 C.E. (Figure 9.3). This was part of the campaign known from chroniclers as the 'Great Heathen Army', wherein several larger than life characters emerged, such as Ragnar Lothbrok's sons, many of whom continue in popular culture today through television series.[528] At Repton, the army moored their ships and erected a simple defensive earthwork using the local church as a gatehouse. The D-shaped ring with a watercourse as the non-curved edge shows a common form for the Viking *longphort*, the Irish reference for fortified camps such as that postulated for Dublin and confirmed in excavations at Repton and Woodstown, Co. Waterford.[529]

The simple fortifications marked the location for incoming ships to gather and gave the crews a chance to establish camp and consolidate what spoils they had won. For a temporary camp, announcing where buried treasure may lie with an obvious earthwork narrowing the area of search for others does not signify an effective strategy, but neither does burying goods in an inconspicuous location increase one's chances of finding it again.[530]

528 Biddle and Kjølbye-Biddle 1992; Biddle and Kjølbye-Biddle 2001.

529 Sheehan 2008; Raffield 2010.

530 What hoards remain for latecomers to find, however, clearly did not warrant reclaiming by the original owner, either due to their untimely death or some other circumstance that stopped them from withdrawing their deposit, which includes possibilities of votive offerings not meant to be reclaimed by the living.

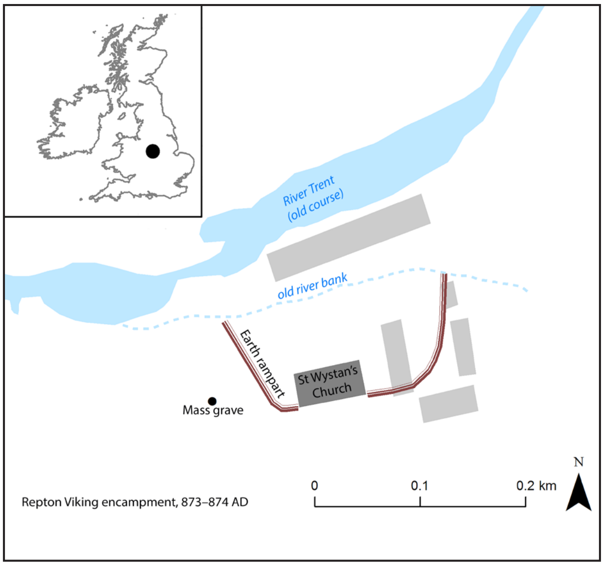

Figure 9.3: Map of Repton Viking encampment (873-874 C.E.) showing the location of earthworks around St Wystan's Church and later buildings of the Repton School. Based on maps by Biddle and Kjølbye-Biddle 2001.

Overshadowing other items that may have been deposited in camp owing to their covetous value among archaeologists as chronological markers and detectorists as unmistakable objects of wealth, coin and silver hoards would certainly have been meaningful for the soil movers to defend in addition to their own lives.[531] Five coins recovered among the finds at Repton support the association of the Viking occupation here with the overwintering noted in the chronicles, but the provenance of these and other finds associated with graves at the site have been hampered by later disturbances.[532]

Excavations at Repton identified the D-shaped earthwork as well as what appeared to be a foreign warrior burial of a prominent individual surrounded by a mass deposit of bones from the locals. Of course, this sparked discussion on whether this represented a mass execution or the vanquished enemy surrounding Ivar son of Ragnar, but a closer look at the bones says otherwise. Very few outward signs of trauma appear, and the interpretation now rests with the bones around the central grave signifying disturbance during the digging of the defences and redeposition in honour of the central burial.[533] Whatever the circumstance, the locals could hardly have missed the subtext of intimidation and humiliation in having their ancestor's bones used as decoration for the internment of an invading warlord, to say nothing of their church's use as a convenient door for an earthen rampart.

The time restriction of the Viking occupation at Repton offers a clear advantage to modelling the labour invested in its earthen rampart. Working down from the four-month maximum, only the rumour of imminent attack would spark continued construction in the final months leading up to a spring departure. It could be argued that discontent sown from boredom would be just as dangerous among the rank-and-file, but encouraging further construction over local raiding may also have proven a mis-

531 Kenny 1987; Sheehan 2000; Richards 2004; Goodrich 2010.
532 Richards 2004, 102.
533 Richards 2001; Richards 2004, 102.

guided strategy for leaders. Whereas plunder or popularity could be wrenched easily enough from locals, nothing could be gained from obsessing over fortifying a temporary camp in their midst. The digging would have stopped when perceived needs were met. It is for these reasons that construction after the initial month of occupation is disregarded as unnecessary or foolhardy. This leaves the question of what tactical value the diggers saw in a simple ditch-and-bank and how willing they were to push it to completion as quickly as possible.

The way we conceptualise early medieval defensive earthworks is typically one of expedient defence, where our view of serene grassy slopes challenges whether these mole hills could have any use in war. Some at least survive near their original height, such as the much larger example at Maiden Castle Dorset, where it is still apparent how slowing the enemy down and screening internal movements from view can produce a serious tactical advantage over sitting in an exposed camp. Again Table 9.4, showing the range of volumes paired against a range of task rates, leaves the middle ground (Scenario 4) as the most pleasing to the eye but not necessarily the one closest to reality. The seasonal occupation at Repton dictates that they dug this in the winter, so Scenario 7 is equally plausible and nearly three times the cost of Scenario 4. This also has important implications for inter-site comparisons. Comparing Scenario 4 to early medieval Dublin, the embankment at Repton was 50% more costly than the 10th century settlement boundary but only a quarter of the cost of Dublin's 11th century rampart. Scenario 7, however, considers the hardship of digging waterlogged soils in an English winter, elevating the cost of the Repton embankment to three quarters of Dublin's rampart (Scenario 4). Variability in volume estimates may account for more variation, but different task rates can multiply costs up to six times the minimum efforts often sought in single-rate labour assessments.

9.8 Comparative labour

In the Fermi or 'cocktail napkin' approach to labour costs and other mathematical exercises, everything outside the final sum stays behind the scenes, and what remains is something more visually pleasing and informative, a graph or a story for instance.[534] Variables and long-form calculations are simply tossed aside. However, keeping this information available, at the very least in a published appendix or endnote, not only provides a way to repeat it for other case studies, it allows others to confirm and cross-check the variables in use, as well as the validity of the calculations. Human error with numbers is quite unavoidable where pride does not suppress honesty.

In any case, there are much safer options for displaying data related to comparative labour investment, and Figure 9.4 makes such an attempt.[535] The palisade at Moundville appears surprisingly comparable in labour intensity to the enclosures at Repton and 10th century Dublin, but all of these are dwarfed by 11th century Dublin where the townspeople took their own defence to heart after centuries of repeated raids. It is not just renewed interest in defence that is at work here. Historical sources tell us that the

534 Peterson and Drennan 2012, 88-89.

535 The chart and its attendant data were adapted and updated from earlier work comparing several earthen enclosures from the early medieval British Isles. See Turner 2012, 81-82.

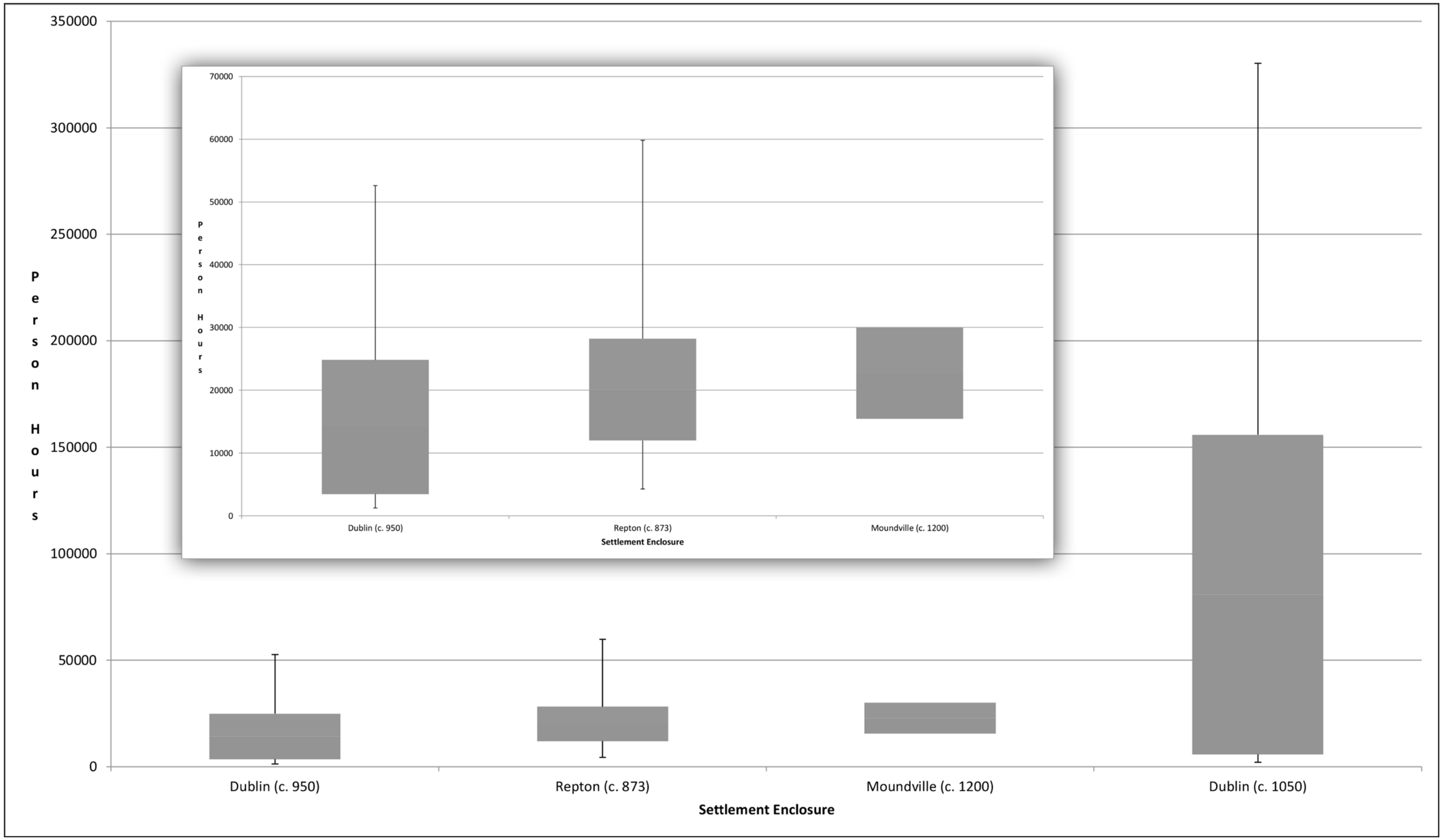

Figure 9.4: Chart showing comparative enclosure costs for case studies discussed herein.

barrier coincides roughly with the return of Hiberno-Norse elites that the locals had earlier expelled, so added to the necessity for community defence is the need for elites to secure their power base once more.

Although not known in detail, the population of each site and its available labour pool would also factor in the scale of its earthworks. Larger populations, such as that of 13th century Moundville and 11th century Dublin, would be capable of costlier architectural projects, though not necessarily inclined to attempt them. The multi-phase construction of Moundville's earthworks, unfortunately, does not allow for direct comparisons. Comparing Dublin and Repton, the population and labour potential of 11th century Dublin appears on the surface to outclass that of the ninth century Repton encampment. Substitute a more strenuous labour rate or maximise the projected volume to the advantage of one site, however, and the story changes. In separate studies unaware of task rate variability, that caveat might go unnoticed where variables are not explicitly stated. Comparative labour ranges may not offer the full story, but they can certainly tamper with the details of what we think we know.

I hope to have shown here that variability in even the simplest task rates (such as single stage earthmoving from ditch to adjacent bank) is excessive. In order for labour-time estimates to remain useful as a comparative proxy, closer attention should be paid to what constitutes an acceptable labour range based on the tools and materials in question. To expedite comparative ranges, work should progress toward the compilation of reported task rates that cover much more than soil movement. Manual work in stone, wood, and metal, as well as transport using humans and draft animals, must be compared in terms transferrable for comparative labour estimates. Case studies will continue to expand in the meantime, and so much the better, for the proliferation of examples strengthens the method and generates a pervasive understanding of how labour has shaped past economies. Further study can also inform how manual labour will shape future economies and the employment pressures of automation. There are still some hurdles to overcome, namely the challenges of multi-variable, multi-stage construction where confidence breaks down in the operational sequence. Also in question is what can be done to digitise labour rates for materials and processes that are not easily replicable anymore, such as quarrying and transporting in sensitive environments. In any case, all benefit from more task rates, readily laid out such that you can select the most appropriate rate for your sites wherever and whenever they are.

Acknowledgements

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CONSTRUCTING MONUMENTS, PERCEIVING MONUMENTALITY & THE ECONOMICS OF BUILDING

In many societies monuments are associated with dynamic socio-economic and political processes that these societies underwent and/or instrumentalised. Due to the often large human and other resources input involved in their construction and maintenance, such constructions form an useful research target in order to investigate both their associated societies as well as the underlying processes that generated differential construction levels. Monumental constructions may physically remain the same for some time but certainly not forever. The actual meaning, too, that people associate with these may change regularly due to changing contexts in which people perceived, assessed, and interacted with such constructions.

These changes of meaning may occur diachronically, geographically but also socially. Realising that such shifts may occur forces us to rethink the meaning and the roles that past technologies may play in constructing, consuming and perceiving something monumental. In fact, it is through investigating the processes, the practices of building and crafting, and selecting the specific locales in which these activities took place, that we can argue convincingly that meaning may already become formulated while the form itself is still being created. As such, meaning-making and -giving may also influence the shaping of the monument in each of its facets: spatially, materially, technologically, socially and diachronically.

The volume varies widely in regional and chronological focus and forms a useful manual to studying both the acts of building and the constructions themselves across cultural contexts. A range of theoretical and practical methods are discussed, and papers illustrate that these are applicable to both small or large architectural expressions, making it useful for scholars investigating urban, architectural, landscape and human resources in archaeological and historical contexts. The ultimate goal of this book is to place architectural studies, in which people's interactions with each other and material resources are key, at the crossing of both landscape studies and material culture studies, where it belongs.

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