The Logistics of Feeding the Roman Army on the Lower Danube

Stephen Richard Matthews

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Department of Classics

Royal Holloway

University of London

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Part Two

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Table T.1.1.1a: Yields

Bread wheat, ancient and Medieval

Source[1]	Sowing rate	Yield Fold	Yield *modii/iugerum*	Yield bushel/acre[2]	Yield l/ha	Yield kg/ha[3]	Yield less seed kg/ha
Varro	5 *modii/iugerum* [128kg/ha]	10-15	50-75		1712-2568	1284-1926	1156-1798
Columella	5 *modii/iugerum* [128kg/ha]	4	20		685	514	385
Cicero	6 *modii/iugerum* [154kg/ha][4]	8-10 fold	48-60		1644-2055	1233-1541	1079-1387
Hosebonderie [return by fold]	2-2.5bushels/acre [131-163kg/ha]	5		10-12.5	871-1088	653-816	490-686
Hosebonderie [return in bu]				11	958	718	555-588
Walter of Henley				10	871	653	490-522
Winchester manors	2-2.5bushels/acre [131-163kg/ha]	4.22		8.44-10.55	735-919	551-689	420-526
Battle manors	3bushels/acre [196kg/ha]	4.2		12.6	1097	823	627
Range							385-1798

[1] Cicero *Verr* 2.3.112; Varro *Rust* 1.44.1; Columella *Rust* 2.9.1, 11.2.75; & Medieval records collated by Slicher van Bath 1963; Titow 1972; Brandon 1972; Campbell 2007.
[2] Imperial bushel for ancient conversions; Winchester bushel for Medieval figures.
[3] A specific weight of 75kg/hl is assumed for bread wheat.
[4] 1 Sicilian medimnus = 6 *modii.*

Table T.1.1.1b: Yields

Barley ancient & Medieval

Source	Sowing rate	Yield Fold	Yield *modii/iugerum*	Yield bushel/acre[5]	Yield l/ha	Yield kg/ha[6]	Yield less seed kg/ha
Varro	6 *modii/iugerum* [132kg/ha]	10-15	60-90		2055-3082	1315-1973	1184-1841
Columella	5-6 *modii/iugerum* [110-132kg/ha]	4	20-24		685-822	438-526	328-395
P. Colt 82	5-6 *modii/iugerum* [110-132kg/ha]	8-8.7	40-52.2		1370-1788	877-1144	767-1012
Hosebonderie	4bushels/acre [223kg/ha]	8		32	2786	1783	1560
Winchester manors	4bushels/acre [223kg/ha]	4.22		16.88	1470	941	718
Battle manors	6bushels/acre [334kg/ha]	3.56		21.36	1860	1190	856
Range							328-1841

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[5] Imperial bushels for ancient conversions; Winchester bushels for Medieval figures.
[6] A specific weight of 64kg/hl is assumed.

Table T.1.1.1c: Yields

Emmer ancient, Medieval and by experiment (Butser)

Source	Sowing rate	Yield Fold	Yield modii/iugerum	Yield bushel/acre	Yield l/ha	Yield kg/ha[7]	Yield less seed kg/ha
Columella	10 *modii/iugerum* [171kg/ha]	4	40		1370	685	514
Butser	63kg/ha	28				1764	1701
Range							514-1701

Durum Wheat

Source	Sowing rate	Yield Fold	Yield modii/iugerum	Yield bushel/acre	Yield l/ha	Yield kg/ha[7]	Yield less seed kg/ha
Varro	5 *modii/iugerum* [130kg/ha]	10-15	50-75		1712-2569	1301-1952	1171-1822
Columella	5 *modii/iugerum* [130kg/ha]	4	20		685	521	390
Cicero	6 *modii/iugerum* [156kg/ha][8]	8-10 fold	48-60		1644-2055	1249-1562	1093-1406
P. Colt 82	5 *modii/iugerum* [130kg/ha][9]	6.7-7.2	33.5-36		1147-1233	872-937	742-807
Range							390-1822

Millet

Source	Sowing rate	Yield Fold	Yield modii/iugerum	Yield bushel/acre	Yield l/ha	Yield kg/ha[7]	Yield less seed kg/ha
Columella	0.25-03125 *modii/iugerum* [5.82-7.28kg/ha]						
Modern return on Columella's sowing		50	12.5-15.625		428-535	291-364	285-357

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[7] A specific weight of 50kg/hl is assumed for emmer, 76kg/hl for durum, 68kg/hl for millet.
[8] 1 Sicilian medimnus = 6 *modii.*
[9] Sowing rate assumed.

Table T.1.1.2: Land area required by unit type

Cereal type	Yield	*legio* 6059 men	*ala milliaria* 936 men	*ala* 624 men	*cohors equitata milliaria* 1204 men	*cohors equitata* 693 men	*cohors milliaria* 910 men	*cohors* 546 men
Bread wheat	385kg/ha	4647ha	718ha	479ha	923ha	531ha	698ha	418ha
Durum wheat	390kg/ha	4588ha	709ha	472ha	912ha	525ha	689ha	413ha
Emmer	514kg/ha	3481ha	538ha	358ha	692ha	398ha	523ha	313ha
Millet	285kg/ha	6278ha	970	647ha	1247ha	718ha	943ha	565ha
		144 horse	768 horse	512 horse	240 horse	120 horse		
Barley	395kg/ha	333ha	1774ha	1183ha	554ha	277ha		
Hay	1000kg/ha	263ha	1402ha	934ha	438ha	219ha		

Table T.2.1.1: Agricultural needs of Lower Moesia garrison and farmers − with 6ha landholding and alternate fallow at mid-range yields of 385/395kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[10]	Vineyards	Vegetables
31,238 garrison	47,917ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	20,893ha	8253ha			
	68,810ha[11]	8253ha	24,102ha stock raising	2774ha	8210ha
	103,939ha				Included within fallow
15,408 arable labourers 132 stock hands 1290 vine workers 16,830 workers	23,635ha 202ha 1979ha		614,295kg = 12,984 65% 399,292kg beef = 11,979ha 29% 178,146kg pork = 238ha 5% 30,715kg mutton = 768ha	1495ha	2211ha leguminous 2211ha other vegetables
	25,816ha		12,984ha stock raising	1495ha	4423ha
	40,295ha				Included within fallow
Totals	94,626ha	8253ha	37,086ha	4269ha	
	144,234ha				

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[10] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[11] Divided by $(6 – (0.767 \times 2)) = 4.466$ha, for number of workers.

Table T.3.2.1a: Agricultural needs of Novae garrison, service providers and farmers − with 6ha landholding and alternate fallow at mid-range yields of 385/395kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, 2.5kg barley horse	Arable need at 0.5663kg per day for service providers and farm labourers	Cavalry pasture	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[12]	Pasture need for meat at 0.07kg per day for service providers and their farm labourers by meat type beef, pork and mutton
6059 legionaries + 41 auxiliaries 6100 garrison	9357ha			222,650kg = 4706ha 65% 144,722.5kg beef = 4342ha 29% 64,568.5kg pork = 86ha 5% 11,132.5kg mutton = 278ha	
144 horse	665ha		263ha		
Garrison needs	10,022ha[13]				
2244 labourers for garrison	3442ha			81,906kg = 1731ha 65% 53,239kg beef = 1597ha 29% 23,753kg pork = 32ha 5% 4,095kg mutton = 102ha	
7520 service providers		8075ha[14]			192,136kg = 4061ha 65% 124,888kg beef = 3747ha 29% 55,719kg pork = 74ha 5% 9607kg mutton = 240ha
1639 labourers for service providers		1760ha			41,876kg = 885ha 65% 27,220kg beef = 817ha 29% 12,144kg pork = 16ha 5% 2094kg mutton = 52ha
Totals	13,464ha	9835ha	263ha	6437.4ha	4946ha
	23,299ha		263ha	11,384ha	
	34,946ha				

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[12] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[13] Divided by (6ha − (0.767 x2)) = 4.466ha, for number of agricultural workers.

[14] Divided by (6ha − (0.5368818 x2)) = 4.926236364ha, for number of agricultural workers.

Table T.3.2.1b Agricultural needs of Novae garrison, service providers, farmers and their dependents – with 6ha landholding and alternate fallow at mid-range yields of 385/395kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, 2.5kg barley horse	Arable need at 0.5663kg per day for service providers and farm labourers	Cavalry pasture	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[15]	Pasture need for meat at 0.07kg per day for service providers and their farm labourers by meat type beef, pork and mutton
6059 legionaries + 41 auxiliaries 6100 garrison	9357ha			222,650kg = 4706ha 65% 144,722.5kg beef = 4342ha 29% 64,568.5kg pork = 86ha 5% 11,132.5kg mutton = 278ha	
144 horse	665ha		263ha		
Garrison needs	10,022ha[16]				
3418 labourers for garrison 13,673 people	10,486ha			249,514kg = 5274ha 65% 162,184kg beef = 4866ha 29% 72,359kg pork = 96ha 5% 12,476kg mutton = 312ha	
7520 service providers		8075ha[17]			192,136kg = 4061ha 65% 124,888kg beef = 3747ha 29% 55,719kg pork = 74ha 5% 9607kg mutton = 240ha
2096 labourers for service providers 8384 people		4501ha			107,106kg = 2264ha 65% 69,619kg beef = 2089ha 29% 31,061kg pork = 41ha 5% 5355kg mutton = 134ha
Totals 29,577 civilians	20,508ha	12,576ha	263ha	9980ha	6325ha
	33,084ha		263ha	16,305ha	
	49,652ha				

[15] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[16] Divided by (6ha – (0.767 x2 x2)) = 2.932ha, for number of agricultural workers.

[17] Divided by (6ha – (0.5368818 x2 x2)) = 3.8525ha, for number of agricultural workers.

Table T.3.3.1a: Agricultural needs of Dobrogea garrison, service providers and farmers − with 6ha landholding and alternate fallow at mid-range yields of 385/395kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, 2.5kg barley horse	Arable need at 0.5663kg per day for service providers and farm labourers	Cavalry pasture	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[18]	Pasture need for meat at 0.07kg per day for service providers and their farm labourers by meat type beef, pork and mutton
12,827 garrison	19,676ha			468,186 kg = 65% 304,321kg beef = 9130ha 29% 135,774kg pork = 181ha 5% 23,409kg mutton = 585ha	
1738 horse	8030ha		3172ha		
Garrison needs	27,706ha[19]				
6204 labourers for garrison	9517ha			226,446kg = 65% 147,190kg beef = 4416ha 29% 65,669kg pork = 88ha 5% 11,322kg mutton = 283ha	
13,920 service providers		14,947ha[20]			355,656kg = 7517ha 65% 231,176kg beef = 6935ha 29% 103,140kg pork = 137ha 5% 22,484kg mutton = 445ha
3034 labourers for service providers		3258ha			77,519kg = 1639ha 65% 50,387kg beef = 1512ha 29% 22,481kg pork = 30ha 5% 4901kg mutton = 97ha
Totals	37,222ha	18,205 ha	3172ha	14,682ha	9156ha
	55,427ha		3172ha	23,838ha	
	82,436ha				

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[18] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[19] Divided by (6ha − (0.767 x2)) = 4.466ha, for number of agricultural workers.

[20] Divided by (6ha − (0.5368818 x2)) = 4.926236364ha, for number of agricultural workers.

Table T.3.3.1b: Agricultural needs of Dobrogea garrison, service providers, farmers and their dependents – with 6ha landholding and alternate fallow at mid-range yields of 385/395kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, 2.5kg barley horse	Arable need at 0.5663kg per day for service providers and farm labourers	Cavalry pasture	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[21]	Pasture need for meat at 0.07kg per day for service providers and their farm labourers by meat type beef, pork and mutton
12,827 garrison	19,676ha			468,186 kg = 9896 65% 304,321kg beef = 9130ha 29% 135,774kg pork = 181ha 5% 23,409kg mutton = 585ha	
1738 horse	8030ha		3172ha		
Garrison needs	27,706ha[22]				
9450 labourers for garrison 37,800 people	28,992ha			689,850kg = 14,581 65% 448,403kg beef = 13,452ha 29% 200,057kg pork = 267ha 5% 34,493kg mutton = 862ha	
13,920 service providers		14,947ha[23]			355,656kg = 7517ha 65% 231,176kg beef = 6935ha 29% 103,140kg pork = 137ha 5% 22,484kg mutton = 445ha
3880 labourers for service providers 15,520 people		8332ha			198,268kg = 4191ha 65% 128,874kg beef = 3866ha 29% 57,498kg pork = 77ha 5% 9913kg mutton = 248ha
Totals 67,240 civilians	56,698ha	23,279 ha	3172ha	24,477ha	11,708ha
	79,977ha		3172ha	36,185ha	
	119,334ha				

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[21] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[22] Divided by (6ha – (0.767 x2 x2)) = 2.932ha, for number of agricultural workers.

[23] Divided by (6ha – (0.5368818 x2 x2)) = 3.8525ha, for number of agricultural workers.

Table T.3.3.2a: Agricultural needs of *poleis* – with 6ha landholding and alternate fallow at mid-range yields 385/395kg/ha

Consumer	Arable need at 0.5663kg per day for service providers and their farm labourers
30,000 urban dwellers	32,213ha[24]
6539 labourers for *poleis* -1500 urban dwelling farmers = 5039 labourers	5411ha
Total	37,624ha

Table T.3.3.2b: Arable needs of *poleis* with farmers and their dependents – with 6ha landholding and alternate fallow at mid-range yields 385/395kg/ha

Consumer	Arable need at 0.5663kg per day for service providers and their farm labourers
30,000 urban dwellers	32,213ha[25]
8382 labourers for *poleis* -1500 urban dwelling farmers = 6862 labourers	7368ha
Total	39,581ha

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[24] Divided by (6ha – (0.5368818 x2)) = 4.926236364ha, for number of agricultural workers.
[25] Divided by (6ha – (0.5368818 x2 x2)) = 3.8524728ha, for number of agricultural workers.

Table T.3.3.3: Distribution of positively located cIMeC sites against soil type[26]

Type	O = No	% of located sites	Land area km^2	% of land	E	O-E	$\frac{(O-E)^2}{E}$
A = Alluvial	14	5.79	312	2.84	6.86	7.14	7.43
SA = Alluvial soil	7	2.89	135	1.23	2.97	4.03	5.47
BP = Brown lessive	0	n/a	189	1.72	4.16	- 4.16	4.16
CA = Alluvial chernozems	0	n/a	7	0.06	0.15	- 0.15	0.15
Ck = Calcareous chernozems	53	21.9	3623	32.92	79.67	- 26.67	8.93
CLm = Moderately leached chernozems	0	0	12	0.11	0.26	- 0.26	0.26
CLs = Slightly leached chernozems	10	4.13	519	4.72	11.41	- 1.41	0.17
CLuN = Sandy leached chernozems	2	0.83	4	0.04	0.09	1.91	40.53
Cn = Chernozems	21	8.68	1473	13.38	32.39	-11.39	4.01
CNi = Dark grey leached chernozems	12	4.96	474	4.31	10.42	1.58	0.24
CNn = Typical grey	0	n/a	117	1.06	2.57	- 2.57	2.57
CV = Compacted clayey chernozems	0	n/a	41	0.37	0.90	- 0.90	0.90
L = Humic grey	0	n/a	27	0.25	0.59	- 0.59	0.59
LA = Alluvial humic	0	n/a	82	0.75	1.80	- 1.80	1.80
LS = Lithosols & rock	6	2.48	349	3.17	7.67	- 1.67	0.36
N = Weakly developed sandy soil	3	1.24	110	1.00	2.42	0.58	0.13
R = Rendzinas	14	5.79	375	3.41	8.25	5.75	4.01
RS = Rhegosols	37	15.29	649	5.90	14.27	22.73	36.21
SBi = Dark chestnuts	18	7.44	1078	9.80	23.71	- 5.71	1.38
SBn = Typical chestnuts	38	15.70	944	8.58	20.76	17.24	14.31
SC = Solenchalks	0	n/a	47	0.43	1.03	- 1.03	1.03
X = Forest chestnuts	7	2.89	438	3.98	9.63	-2.63	0.72
Total	242	100%	11005	100%	242		135.36
Z = Inland water			483				
χ^2 Critical value for p > 0.05 with 21 degrees of freedom = 32.671 χ^2 = 135.36 = Significant							

[26] Survey area = 11,488km^2; Total dry land [less inland water area] = 11,005km^2; E = % of land multiplied by total n = 242, divided by 100.

Table T.3.3.4: Distribution of tumuli buffers against soil type

Type	O = No	% of tumuli	Land Area	% of land	E[27]	Density per km^2	O-E	$\frac{(O-E)^2}{E}$
Ck = Calcareous chernozems	911	40.52	1,672km^2	38.44	864	0.544	47	2.56
Cn = Chernozems	577	25.67	1,119km^2	25.72	578	0.515	-1	0.0002
Cls = Slightly leached chernozems	267	11.88	312km^2	7.17	161	0.85	106	69.78
CV = Compacted clayey and leached chernozems	46	2.04	33km^2	0.76	17	1.39	29	49.47
CNn = Typical grey	21	0.93	35 km^2	0.8	18	0.6	3	0.5
CNi = Dark grey & degraded leached chernozems	11	0.49	28 km^2	0.64	14	0.39	-3	0.64
R = Rendzinas	81	3.6	125km^2	2.87	64	0.65	17	4.52
SBi = Dark chestnuts	119	5.29	234km^2	5.38	121	0.51	-2	0.33
SBn = Typical chestnuts	17	0.76	87 km^2	2	45	0.19	-28	17.42
X = Forest chestnuts	81	3.6	237 km^2	5.44	122	0.34	-41	13.78
RS = Rhegosols	98	4.36	310 km^2	7.12	160	0.31	-62	24.1
SA = Alluvial soil	19	0.85	59 km^2	1.36	30	0.32	-12	4.03
Z = Inland water	0	0	115 km^2	2.59	0	n/a	n/a	n/a
Total	2248	100	4350km^2	100		Ave = 0.52		187.13
	χ^2 Critical value for p> 0.05 with 11 degrees of freedom = 19.675						χ^2 = 187.13 = significant	

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[27] E = % of land multiplied by n = 2248, divided by 100.

Table T.4.3.1: Vehicular requirements for overland supply of wine to Novae

	Vehicles	Distance from port	Travelling days (return journey)	Feed req	Loads (need/(350-feed))	vehicles *pa* ((loads x days)/300)
333,975kg Aegean component						
	23km wags	240km from Odessus	21	95kg	1305	91
	32km wags		15	68kg	1184	59
	50km wags		10	160kg	1757	59
	50km trains		10	160kg	835	28
	23km wags	400km from Traianoplis	35	158kg	1739	203
	32km wags		25	113kg	1409	117
	50km wags		16	256kg	3553	189
	50km trains		16	256kg	1009	59
	23km wags	560km from Amphipolis	49	221kg	2589	423
	32km wags		35	158kg	1739	203
	50km wags		22	352kg	ineffective	n/a
	50km trains		22	352kg	1606	118
183,686kg Pontic component						
	23km wags	240km from Odessus	21	256kg	718	50
	32km wags		15	282kg	651	33
	50km wags		10	160kg	967	32
	50km trains		10	160kg	459	15
	23km wags	400km from Traianoplis	n/a	n/a	n/a	n/a
	32km wags					
	50km wags					
	50km trains					
	23km wags	560km from Amphipolis	n/a	n/a	n/a	n/a
	32km wags					
	50km wags					
	50km trains					

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Table T.4.3.2: Vehicular requirements for overland supply of wine to Dobrogea

Site & need	Vehicles	Distance from nearest port	Travelling days (return journey)	Feed req	Loads (need/(350-feed))	vehicles *pa* ((loads x days)/300)
Durostorum 1515 men 414,731kg	23km wags 32km wags 50km wags 50km trains	120km from Tomis & Callatis	10 7.5 5 5	45kg 33.75kg 80kg 80kg	1360 1311 1536 864	45 33 25.5 14.5
Sucidava 347 men 94,991kg kg	23km wags 32km wags 50km wags 50km trains	94km from Tomis	8 6 4 4	36kg 27kg 64kg 64kg	303 294 332 192	8 6 4.5 2.5
Tropaeum Traiani 619 men 169,451kg	23km wags 32km wags 50km wags 50km trains	60km from Tomis	5 4 2.5 2.5	22.5kg 18kg 40kg 40kg	517 510 546 332	9 7 4.5 3
Sacidava 273 men 74,734kg	23km wags 32km wags 50km wags 50km trains	76km from Tomis	7 5 3 3	31.5kg 22.5kg 48kg 48kg	235 228 247 146	5.5 4 2.5 1.5
Axiopolis 400 men 109,500kg	23km wags 32km wags 50km wags 50km trains	57km from Tomis	5 3.5 2 2	22.5kg 15.75kg 32kg 32kg	334 328 344 207	5.5 4 2.5 1.5
Capidava 546 men 149,468kg	23km wags 32km wags 50km wags 50km trains	58km from Histria	5 3.5 2 2	22.5kg 15.75kg 32kg 32kg	456 447 470 283	7.5 5 3 2
Carsium 624 men 170,820kg	23km wags 32km wags 50km wags 50km trains	69km from Histria	6 4.5 3 3	27kg 20.25kg 48kg 48kg	529 518 566 334	10.5 8 5.5 3.5
Cius 347 men 94.991kg	23km wags 32km wags 50km wags 50km trains	78km from Histria	7 5 3 3	31.5kg 22.5kg 48kg 48kg	298 290 315 186	7 5 3 2
Troesmis 6059 men 1,658,651kg	23km wags 32km wags 50km wags 50km trains	30km from Noviodunum	3 2 2 2	13.5kg 9kg 32kg 32kg	4929 4864 5216 3141	49 32.5 35 21
Arrubium 624 men 170,820kg	23km wags 32km wags 50km wags 50km trains	44km from Noviodunum	4 3 2 2	18kg 13.5kg 32kg 32kg	515 507 537 324	7 5 3.5 2
(Barboşi) 137 men 37,504kg	23km wags 32km wags 50km wags 50km trains	45km from Noviodunum	4 3 2 2	18kg 13.5kg 32kg 32kg	113 111 117 71	1.5 1 1 0.5
Dinogetia 136 men 37,230kg	23km wags 32km wags 50km wags 50km trains	30km from Noviodunum	3 2 2 2	13.5kg 9kg 32kg 32kg	111 109 117 71	1 1 1 0.5
Noviodunum 1200 men 328,500kg	No vehicles required					0
Total cargo 4,681,855kg					157 23km wags,112 32km wags, 92 50km wags, 55 50km trains	

Catalogue of Sites in Dobrogea

				limes facing sites	
FID	**cIMeC code**	**Classification**	**Location**	**Details**	
0[28]	n/a	fort	Silistra	Durostorum.	
1	n/a	*vicus* type	Silistra	*canabae Durostorum*, between fort and river.	
2	62547.01	*vicus* type	Ostrov	*vicus Gravidina* 4km from Durostorum 24ha site 'ferma 4' parallel to Soseaua 150m S of Ostrov branch of the Danube *cf* 62547.04 and 62547.05 Roman period tomb and tumuli nearby.	
3	n/a	*vicus* type	Vicinity Durostorum	Un-located *Arnuntum Supperiore*.	
4	62556.01	individual site	Almălău-Bugeac	In valley from Almălău to Lake Bugeac.	
5	62565.04	individual site	Bugeac	tumuli of Bugeac.	
6	62565.05	individual site	Bugeac	'Ceairul lui Marinciu', 4km SW of Bugeac village	
7	62565.08	fort	Bugeac	1.5km from the mouth of parallel channel.	
8	62583.01 & 62075.03	individual site	Gâlița & Canlia	Two sites reported: Dealul Dervent Gâlița and Dervent Canlia appear to be the same site.	
9	62075.01	individual site	Canlia	On both sides of the stream running from Canlia to the Danube between the Uscat and Ghivizlicu hills probably the Later Roman *Cimbrianae*.	
10	62128.02	individual site	Izvoarele [Constanța County]	'Plantatie' - between Canlia and Izvoarele.	
11	62128.01	*vicus* type	Izvoarele [Constanța County]	'Cale-Gherghi' extra mural site to Sucidava fort.	
12	62128.07	fort	Izvoarele [Constanța County]	'Dealul de la Cetate' military site of Sucidava.	
13	62510.02	*vicus* type	Satu Nou	'Valea lui Voici' 5km NW of village close to Sucidava, a Getic *dava* type settlement, significant clusters of tumuli nearby.	
14	62066.01	individual site	Lipnița	Tumuli around commune, no other habitation nearby so stand alone as	

[28] It is necessary to catalogue from 0 within ArcGIS hence I catalogue sites 0-356, there are 357 sites in total.

				indicator of habitation.
15	62495.02	individual site	Oltina	Tumuli around village.
16	61078.01	individual site	Baneasa	Within village.
17	61078.03	individual site	Baneasa	1km WNW of village far enough from 61078.01 to suggest separate habitation.
18	61032.01	individual site	Dunăreni	'Bracta' between right back of Danube and Lake Dunăreni.
19	61032.02	*vicus* type	Dunăreni	Military *vicus* alongside military fort of Sacidava on Muzait hill 5km to NE of Dunăreni.
20	61032.06	fort	Dunăreni	Sacidava camp on Muzait hill north of Lake Vederoasa, 5km NE of Dunăreni.
21	61014.10	individual site	Aliman	W bank Lake Vederoasa.
22	61014.01	individual site	Aliman	Tumuli around commune *cf* 61014.05 tomb within village.
23	61014.09	individual site	Aliman	4.5km SE of Aliman, Adâncata II at Adâncata = old village abandoned in 1977 in Poluci valley.
24	61041.01	individual site	Floriile	Within and SW of village.
25	60918.01	individual site	Hateg	Towards lake Bacui.
26	62002.02	individual site	Raristea	Within village.
27	60927.01	*vicus* type	Urluia	Unnamed *kome* in Poluci valley 3.3km north of Urluia on plateau alongside irrigation canal, 60927.02 = undated tumuli nearby.
28		*villa*		Senatorial *latifundia* of L. Aelius Marcianus suggested by *CIL* 3.12463.
29	60892.08, *et al*	*vicus* type	Adamclisi	60892.08 = the municipal site, 60892.22 = site to the east, 60892.02 = monument, 60892.10 = baths to west of city, 60892.02, 60892.03, 60892.04 60892.24 = tombs and tumuli about site, 60892.01, 60892.12 60892.13 = aqueducts to N, NW and SE of town respectively.
30		fort	Adamclisi	Military site assumed but not located.
31	61782.01	individual site	Pădureni	Within village.
32		*vicus* type	Cetatea	Findspot of boundary marker reporting *civitas Ausdecensium.*
33	60728.04	individual site	Şipotele	No location given.
34	61693.04	individual site	Petroşani	1.5 km NW of village.
35	61693.01	individual site	Petroşani	Within village to E.
36	61700.01	*villa*	Pietreni [com Deleni]	At IAS Pietrani to E of village, *cf* 61700.02 tumuli around commune.
37	61906.02	individual site	Fântâna Mare [Constanţa County]	Significant clusters of tumuli around the commune.

38		individual site	Independenţa	Significant clusters of tumuli around the commune.
39	61354.02	individual site	Negreşti	SW of village *cf* 61354.01 isolated finds 2km to the W.
40	61336.01	individual site	Conacu	On N bank of lake Conacu, between Conacu and Negreşti.
41	61238.01	*villa*	Credinţa	300m NE of Credinţa on Moncanilor hill.
42	61489.01	individual site	General Scărişoreanu	Movila de Ceusa 3km NE of General Scărişoreanu, two significant clusters of tumuli evident.
43	62404.01	individual site	Negru Vodă	On edge of marshes to N of village.
44	61327.01	individual site	Cobadin	In perimeter of village with necropolis.
45	61292.01	individual site	Ciocârlia	Tumuli in perimeter of village.
46	62743.01	individual site	Izvoru Mare	Within village next to school, tumuli with significant aggregation levels around village.
47	62752.02	individual site	Veteranu	Near neglected buildings, *cf* 62752.01 aqueduct thought to feed the village and a basin reported within the village.
48	62725.03	individual site	Ivrinezu Mare	4.2km NW of village on banks Lake Cochirleni.
49	62805.01	individual site	Rasova	'Malu Rosu' 2.5km NE of the village. *cf* 62805.05 tumuli in perimeter of commune.
50	62805.04	individual site	Rasova	'Pescarie' 3km SW of Rasova, remains of Roman *horreum* with legionary building inscriptions, *cf* 62805.05 tumuli in perimeter of commune.
51	62805.07	individual site	Rasova	1.5km E-NE of village in Caramancea valley, *cf* 62805.05 tumuli in perimeter of commune.
52	62805.02	fort	Rasova	2.5 km E of village in Caramancea valley, *cf* 62805.05 tumuli in perimeter of commune.
53	60875.03	*vicus* type	Cernovodă	Ancient Axiopolis, *cf* tumuli 60875.05 3km S of site.
54	60785.10	individual site	Cernovodă	On Autostrada A2 153km [from Bucharest].
55	60785.12	individual site	Cernovodă	On Autostrada A2 158km [from Bucharest].
56	62342.01	individual site	Stefan cel Mare	On Aleca hill to the S of the Danube-Black Sea canal.
57	60856.12	*vicus* type	Medgidia	Near cement factory but north of canal I associate with *vicus I Urb…..* where there were *c(ives) c(onsistentes)*. Significant cluster of tumuli to the N.
58	60856.10	individual site	Medgidia	IAS Medgidia 300m NW of Medgidia port.
59	61130.02	individual site	Castelu	500m NE of village *cf* 61130.03 tumuli along Agicab valley.
60	61130.10	individual site	Castelu	Near Gas pipeline exact location unclear.
61	61130.09	individual site	Castelu	Near Gas pipeline exact location unclear.

62	61158.01	individual site	Nisipari	4km N of village.
63	61149.01, 61149.02	individual site	Cuza Vodă	In zone CAP, *cf* 61149.01 = aqueduct included with this site; significant cluster of tumuli along Agicab valley.
64	62299.02	individual site	Micea Vodă	Tumuli in perimeter of commune.
65	60785.09	fort	Cernovodă	Roman fort on Dermengi hill to NE of town.
66	62930.02	individual site	Seimenii Mici	On perimeter of village.
67	62912.01	individual site	Seimenii	N bank of Siliştea valley to NE of Seimeni village.
68	62921.01	individual site	Dunărea	No location given.
69	63063.01	fort	Capidava	Ancient Capidava; 63063.07 baths to E.
70	63063.06	*vicus* type	Capidava	Military *vicus*; 63063.07 baths to E.
71	63063.05	*villa*	Capidava	Vlah Canara' *villa* site 1.5km NE of Capidava.
72		*villa*	Capidava	*ISM* 5.29, 5.30 refer to the owners of a *villa* seemingly over two generations near to Capidava.
73		*vicus* type	Vicinity Capidava	*vicus Scenopensis*.
74	61577.01	individual site	Băltăgeşti	On edge of village.
75	61568.01	individual site	Crucea	Location not given, *cf* 616568 tumuli.
76	61595.01	*vicus* type	Gălbiori	Inside village, I associate this with un-named *vicus* at Gălbiori, *cf* 61595.02 = associated tumuli.
77	62468.03	*vicus* type	Dorobanţu	I associate this with the *vicus Hi...*
78	62994.03	individual site	Târguşor	Sector zootechnic - no further details.
79	61416.02	individual site	Gura Dobrogei	On the confluence of Târguşor and Casimcea rivers W of village.
80	63009.06, 63009.01	*vicus* type	Casian	*vicus Casianus* 63009.06 = modern Gazoduct site, 63009.01 = Roman amphitheatre, treated as a single *vicus* together.
81	63018.03	individual site	Cheia	1km E of village, 500m NE of cave 'La Soci', in Carasu valley.
82	63018 .01	individual site	Cheia	Cave dwelling 'La Izvor' 500m S of Cheia near confluence of two streams evidence of sizable community.
83	63018.04	individual site	Cheia	Cave dwelling 'Pestera X' on Pestera hill
84	63018.05	individual site	Cheia	Cave dwelling 'La Baba' 1.25km SW of village 800m SW of 'La Izvor'.
85	63027.01	individual site	Grădina	500m SW of village.
86	62618.01	*vicus* type	Pantelimon	*vicus Ulmetum*, LRE fortification to East of town, here Roman citizens and members of the Bessi were *consistentes*.
87		*villa*	Pantelimon	*ISM* 5.59 refers to the *fines* of an individual near Pantelimon.
88		*villa*	Pantelimon	*ISM* 5.70 refers to an *actor* near Pantelimon.

89	62654.01	individual site	Runca	Location not given.
90	63054.01	individual site	Topalu	N of Topalu on high ground on left bank of Cerchirgea valley, possible fort according to Zahariade & Gudea.
91	61853.02	individual site	Ghindăreşti	2km S of village.
92	61853.01	fort	Ghindăreşti	NW of village.
93	60810.01	fort	Hârşova	Ancient Carsium, 60810.10, 60810.11 = towers to W and 375m to NW, 60810.08 = Roman road, 60810.09 = necropolis.
94	60810.04	*vicus* type	Hârşova	Military *vicus*, to W of fortified settlement, Str Crinului Vadului Concordiei.
95	60810.02	individual site	Hârşova	Tell - the original stone age settlement to SE of the town, area of Str Gradinilor and Gheorghe Doja, shows continuity through to Roman period.
96	not listed	*vicus* type	Hârşova	'La Moara' standalone Getic site probable *civitas* capital.
97	61265.01	individual site	Ciobanu	Within the village to the W.
98	not listed as fort	fort	Lake Hasarlâc /Gârliciu	Cius fort, 5km S of village and E of Lake Hasarlâc on the Hasarlâc hill.
99	61817.01	*vicus* type	Lake Hasarlâc Gârliciu	Military *vicus* assumed alongside fort 5km S of village and E of Lake Hasarlâc on the Hasarlâc hill, *cf* 61817.02 tumuli around commune.
100	not listed	*vicus* type	Vicinity Lake Hasarlâc /Gârliciu	*vicus Vergobrittiani* thought to be close to Cius.
101	not listed	*vicus* type	Vicinity Lake Hasarlâc /Gârliciu	*vicus Ram* thought to be close to Cius.
102		*villa*		Argued on the basis of an inscription *CIL* 3.14214[21] (*ISM* 5.116) recording a *vilicus*.
103	62850.01	individual site	Dulgheru	WNW of village.
104	62636.02	individual site	Nistoreşti	1.5km N of village.
105	62636.01	individual site	Nistoreşti	200m N of village.
106		*vicus* type	Vicinity Râmiciu de Jos	*vicus V...* near Râmiciu de Jos, on the road Carsium to Histria.
107		*vicus* type	Vicinity Râmiciu de Jos/Casimcea/Sarighiol de Deal	*vicus Secundini* where *cives Romani et Lai consistentes.*
108		*vicus* type	Vicinity Râmiciu de	*vicus ....stro* where *cives Romani consistentes.*

			Jos/Casimcea/Sarighiol de Deal	
109		*vicus* type	Vicinity Neatârnarea	Un-named *vicus* on the basis of an inscription recording a *magister*.
110	159874.01	*villa*	Sarighiol de Deal	3km N towards Neatârnarea.
111	159856.04	individual site	Beidaud	3km W of village exact location unclear *cf* 159856.03 cistern/fountain at same location.
112	159972.01	*villa*	Casimcea	300m N of village at the bend in the Dulbenci river.
113	159972.02	individual site	Casimcea	2.5km SE of village parallel with road to Sarighiol de Deal.
114	not listed	individual site	Casimcea	'La vie' on SW edge of village funeral architecture distinct from 159972.01-02 above, reported by Baumann and Bărbulescu.
115	161357.01	individual site	Stejaru [Tulcea county]	Between village of Vasile Alecsandri and Stejaru.
116	159801.01	*vicus* type	Camena	*vicus Petra* E of the village.
117	161277.01	*vicus* type	Slava Rusă	*vicus Ibida* within modern village to the W.
118	161268.02	individual site	Slava Cercheză	'La Vii' 1km NE of village.
119	160234.02	individual site	Ciucurova	'La Izvor' 1.5km NW of village.
120	161393.01	*villa*	Topolog	N edge of village.
121	161393.02	*villa*	Topolog	300 SW of village.
122	161455.01	individual site	Sâmbăta Nouă	200m SE of village.
123	161437.01	individual site	Luminița [Tulcea county]	300m S of village.
124	161428.01	individual site	Făgăraşu Nou	Within village.
125	160010.03	individual site	Rahman	2km NE of village.
126	160010.04	individual site	Rahman	'La Baba Caira' 200m NE of village.
127	160010.01	individual site	Rahman	Between Rahman and Haidar.
128		fort	Ostrov	Beroe - Roman period fort thought to underlie LRE fort, n.b. cIMeC code 160396.01 reported as Byzantine Beroe, but erroneously associated with other sites at Frecăţei further north in the county.
129	161115.01	individual site	Ostrov [Tulcea County]	'Piatra Frecăţei' 3km S of Ostrov on right bank of Danube = Beroe, a civilian settlement that was inhabited before and after the Roman period, Roman occupation not reported but assumed as individual settlement.
130	161115.02	individual site	Ostrov [Tulcea County]	Tell 5km N of Ostrov, size not given, assumed as individual settlement but could be larger.

131	161160.01	fort	Peceneaga	'La Cordon' on a hill to the S.
132	161160.02	individual site	Peceneaga	'La Piscul Sarat' on a hill to the S.
133	160163.01	individual site	Traian [Tulcea County]	On the Cale-Baie hill.
134	160537.02	*villa*	Horia	'La Baraj' alongside dam 2.5km NW of modern town.
135	160573.02	fort	Izvoarele [Tulcea County]	2km SW of village.
136	160500.01	individual site	Capioara	In the valley to the N of the village.
137	161473.01	fortress	Turcoaia	Troesmis Two LRE fortifications visible from the air evident of two separate hills, legionary camp between the two hills, home to legio V Macedonica.
138		*vicus* type	Turcoaia	*canabae Troesmis* to NE of legionary camp.
139		*vicus* type	Turcoaia	*municpium Troesmis* not positively located.
140	159749.03	fort	Macin	Arrubium LRE fort evident, earlier Roman period fort thought to lie underneath, *cf* 159749.02 = necropolis.
141	159749.01 159749.05	*vicus* type	Macin	159749.01 within town SW sector, 159749.05 = Str Nuferilor alongside Roman fort, *cf* 159749.02 = necropolis.
142	160635.03	fort	Garvăn	Dinogetia 'Bisericuta' 5km NW of Garvăn, *cf* 160635.07 LRE construction public edifice, 160635.05 LRE baths.
143		*vicus* type	Garvăn	Military *vicus* assumed.
144	75105.04	fort	Galaţi	Barboşi fort in Tirighiani district of Galaţi 300m N of Barboşi station.
145	75105.04	*vicus* type	Galaţi	Military *vicus* to South, cIMeC list both fort and *vicus* under same catalogue number, *cf* 75105.05 attendant necropolis.
146	75105.02	fort	Galaţi	Dunărea district 1.5km from Barboşi n.b. other possible fortlets and towers within military zone.
147	75105.01	individual site	Galaţi	Str Rosiori and Faleza Dunari, E of Barboşi fort and *vicus*.
148	75169.01	individual site	Vanatori	'La Jorica' two sites with the same location on the railway line = northern limit of militarised zone, *cf* 75187.01 Roman rampart at Odaia Manolache.
149	75169.02	individual site	Vanatori	'Amiral' two sites with the same location on the railway line = northern limit of militarised zone, *cf* 75187.01 Roman rampart at Odaia Manolache.
150	75123.01	individual site	Sendreni	Timber construction on the left bank of the river Siret.

151	160635.01	individual site	Garvăn	2km NW of Garvăn on north bank of Lake Jijila.
152	160635.06	individual site	Garvăn	On Crancanele hill 2.3km NNW of village towards Dinogetia.
153	160626.01	individual site	Jijila	3km SE of village.
154	160715.03	individual site	Văcăreni	In the Nevestelnița valley 2km E of village which discharges into Lake and Danube.
155	160699.03	fort	Luncavița	On Milan hill listed in Zahariade &Gudea, but cIMeC lists a LRE site here.
156	160699.02	individual site	Luncavița	On Cetatuia hill 4km South of Luncavița.
157	160706.01	fort	Rachelu	On W edge of village.
158	159696.05	fort	Isaccea	Noviodunum 2.5km NE of Isaccea dated as LRE on cIMeC.
159		*vicus* type	Isaccea	To south of Noviodunum fort.
160	159696.04	individual site	Isaccea	'La Suhat' NW of Isaccea, 1km S of Danube.
161		fort	Orlovka [Ukraine]	In Ukraine, suggested on the basis of Ptolemy & brick stamps.
162	161339.01	individual site	Parcheș	'Bugeac' - Parcheș wood 1km W of village.
163	161311.01	individual site	Somova	'La Poienita'.
164	161044.03	individual site	Niculițel	350m from Saon Monastery.
165	161044.04	individual site	Niculițel	3-3.5km NE of village 'Ceairul lui Iancu'.
166	161044.02	*villa*	Niculițel	In Capacilia valley 800m W of DN 22 parallel to river.
167	Baumann Bărbulescu	individual site	Niculițel	Pasoaiei knoll midway between Capacilia Valley and Iancu valley.
168	Baumann Bărbulescu	individual site	Niculițel	1500m NW of Capacilia site.
169	Baumann Bărbulescu	individual site	Niculițel	2000m NW of Capacilia site.
170	Baumann Bărbulescu	individual site	Niculițel	Cocos Monastery.
171	Baumann Bărbulescu	individual site	Niculițel	West of Iancu valley 1km NW of village.
172	161044.06	*villa*	Niculițel	In Gurgoaia suburb in N of village *cf* 161044.09 monetary finds in same area.
173	161044.08	individual site	Niculițel	'La Cornet'; at the head of the Capaclia valley N of village.
174	160421.01	*vicus* type	Telița	'La-Amza' 600m NE of village.
175	160421.03	individual site	Telița	Within village SW sector.

176	160421.05	individual site	Teliţa	In the Morilor valley near Celic Dere monastery.
177	160412.05	*villa*	Poşta	500m NE of road junction 229A and 229F to the Celic Dere monastery.
178	160412.07	*villa*	Poşta	Within village SW sector.
179	160412.03	individual site	Poşta	1km NW of village.
180	160412.08	individual site	Poşta	'La Piatra Frecăţei' near Celic Dere monastery. Site of military granary built by legio V Macedonica.
181	161026.05	individual site	Trestenic	350m NE of village.
182	161026.02	individual site	Trestenic	Within village SW sector.
183	161026.09	individual site	Trestenic	100m SE of village parallel to road to Nalbant.
184	161026.04	individual site	Trestenic	800m SE of village.
185	161026.06	individual site	Trestenic	1.5km SE of village.
186	161008.02	individual site	Nalbant	On E edge of village.
187	161008.01	individual site	Nalbant	2km NE of village.
188	160396.07	individual site	Frecăţei	Within village, *cf* 160396.02 funeral monuments 650m E of village.
189	160396.03	individual site	Frecăţei	'La Livada' 1.6km E of village, *cf* 160396.02 funeral monuments 650m East of village.
190	160403.05	individual site	Cataloi	1.1km W of village on terrace above river Teliţa.
191	160403.04	*villa*	Cataloi	600m W of village 600m N of road to Nalbant.
192	160403.03	individual site	Cataloi	200m W of village 500m S of road to Frecăţei.
193	160403.01	*villa*	Cataloi	750m E of village 1.5km S of station.
194	160403.02	individual site	Cataloi	500m SE of village between DN22 and railway line.
195		fort	Tulcea	Aegyssus fort on shore line.
196	159623.01 *et al*	*vicus* type	Tulcea	Ancient Aegyssus town, at Eroilor monument park and surrounding area, 159623.08 = Str Surorilor, 159623.10 = Str Veseliei, *cf* 159623.07 necropolis.
197	159623.04	individual site	Tulcea	'Taberei hill' NW of town.
198	159623.03	individual site	Tulcea	'La Vie Judecatorul' 4km E of town.
199	not recorded	*vicus* type	Vicinity Tulcea	*vicus Urbin….* vicinity of Tulcea.
200	not recorded	fort	Ismail [Ukraine]	In Ukraine.
201	161080.02	individual site	Malcoci	500m NW of village.
202	161062.03	individual site	Nufãru	1.5km SE of village, 1km S of route Nufãru – Beştepe.
203	161062.01	individual site	Nufãru	Within village.
204	160760.07	individual site	Beştepe	1.5km N of village.

205	160760.06	individual site	Beştepe	On N limit of village.
206	160760.04	individual site	Beştepe	2km NE of village.
207	160760.03	individual site	Beştepe	'cetate' in valley Curpenisului to E of village.
208	160742.01	individual site	Băltenii de Jos	Within village.
209	160733.12	fort	Mahmudia	Salsovia LRE fortified settlement, Roman period fort supposed to underlie visible remains, but no evidence of military *vicus.*
210	160733.04	individual site	Mahmudia	2.5km East of village to the north of the Filip Rosu canal.
211	160920.02	fort	Murighiol	Ancient Halymris pre-Roman settlement, Roman LRE fortified site 2km SE of village, 200m N of route to Dunavatul de Sus, 1.5km S of Sf Gheorghe branch of Danube.
212	not listed	*vicus* type	Murighiol	*vicus classicorum* to the S of ancient Halmyris where c*(ives) R(omani) consist(entes).*
213	160920.01	individual site	Murighiol	1.7 km SE of village to left of route to Dunavățu de Sus, 160920.09 = LRE camp on same site.
214	160920.03	individual site	Murighiol	2km SE of village, N of Murighiol hill.
215	160975.01	individual site	Sarinasauf	750m N of village.
216	161516.01	individual site	Iazurile	2km E of village.
217	161491.01	individual site	Valea Nucarilor	SE of village.
218	161507.03	individual site	Agighiol	1.5km SE of village on banks of Lake Omonim.
219	161507.08	villa	Agighiol	1.5km North of village in Tulcei valley.
220	161507.04	individual site	Agighiol	1km NW of village.
221	161204.01	individual site	Sabangia	'La Tantana Ialnascu' 2km N of village close to DJ222 direction of Agighiol.
222	161204.03	individual site	Sabangia	Within village of Sabangia on premises of SMA.
223	161188.01	individual site	Sarichioi	Within village on northern limit.
224	161188.10	individual site	Sarichioi	On banks of Lake Razim.
225	161188.04	individual site	Sarichioi	1.5km S of Sarichioi in Saratura Valley.
226		fort	Vicinity Agighiol Sarichioi	*vallis Domitiana* recorded in *IA* 226.5.
227	161197.01	individual site	Enisala	NE of village right side of road to Sarichioi on banks of Lake Razim.
228	161197.05	individual site	Enisala	On West of village 200m S of road to Babadag.
229	161197.03	individual site	Enisala	Within the village, W sector, *cf* 161197.10 = monetary finds at LRE 'Pestera' site.

230	161213.01	individual site	Visterna	Within village on N sector *cf* 161213.02 necropolis 500m distant.
231	159669.02	*vicus* type	Babadag	*vicus Novus* 500m SW of village at junction of DN22 and the 223A road to Slava Rusă.
232	159669.03	individual site	Babadag	No location given.
233	159669.01	individual site	Babadag	2km NE of town, on banks of Lake Babadag.
234	160840.03	*vicus* type	Mihai Bravu	On the W of the village this ought to be associated with *vicus Bad…..* where *(veterani) et c(ives) R(omani) consist(entes)*.
235	160840.07	individual site	Mihai Bravu	'La Moara' 750m N of village on left bank of the Taiţa river.
236	160868.02	individual site	Turda	NW sector of village between Taiţa and DJ.

Polis facing sites				
FID	**cIMeC code**	**Classification**	**Location**	**Details**
237	160653.02	*vicus* type	Jurilovca	Cape Doloşman, ancient Argamum within *regio Histriae*.
238	160653.01	individual site	Jurilovca	Within village SW sector.
239	160653.05	individual site	Jurilovca	Within village to the W of LRE site.
240	160653.03	individual site	Jurilovca Insula Bisericuta	Island in Lake Razim LRE site with earlier Roman finds.
241	160671.05	individual site	Sălcioara	4.5km N of village near Calugara hill.
242	160671.06	individual site	Sălcioara	Within the village, this shows occupation either side of Roman period.
243	160622.02	individual site	Vişina	On eastern edge of the village on bank of Lake Goloviţa.
244	160622.01	individual site	Vişina	Within village eastern sector.
245	160118.02	individual site	Lunca	200m NE of village 150m from road to Vişina.
246	97287.01	individual site	Lunca	On the eastern edge of the village South of the road to Vişina *cf* 160118.04, 160118.05, 160118.06 undated tumuli.
247	160109.02	individual site	Ceamurlia de Jos	250m SE of road to Lunca on eastern edge of village.
248	160109.01	*villa*	Ceamurlia de Jos	NW of town N of road to Slava Rusă SE of railway, *cf* 160109.03, 160109.04, 160109.05 undated tumuli nearby.

249		individual site	Ceamurlia de Jos	NW of Town, N of railway 1.5 km from 160109.01 above, *cf* 160109.03, 160109.04, 160109.05 undated tumuli nearby.
250		fort	Vicinity Lunca Ceamurlia de Jos	*ad salices* recorded in *IA* 227.
251	159794.06	individual site	Baia	On SE limits of town.
252	159794.02	individual site	Baia	2km E of Baia station which puts it on the banks of Lake Ceamurlia, so distinct from 159794.08.
253	159794.08	individual site	Baia	E of village on banks of Lake Goloviţa.
254	159794.04	individual site	Baia	On railway unable to locate exact location.
255	62271.01	*vicus* type	Sinoe	*vicus Quintionis* 6km E of village on Cale hill, Bessi & Lai *consistentes*.
256	62271.02	individual site	Sinoe	1km SSE of village school.
257	not listed	*vicus* type	Mihai Viteazu	*vicus Buteridavensis, cf* 632262.02 Roman period tumuli in vicinity of modern village.
258	not listed	*villa*	Mihai Viteazu	*ISM* 1.359-360 record boundary between *vicus Buterdavensis* above and the property of Messiea Pudentilla.
259	61407.01	*vicus* type	Fântânele	*vicus* South of Fântânele village.
260	61443.05	individual site	Tariverde	Tariverde III, 800m E from bridge on Constanţa-Tulcea highway.
261	61443.04	individual site	Tariverde	100m NE of bridge on Constanta-Tulcea highway.
262	61443.07	individual site	Tariverde	In E of town.
263	61443.01	individual site	Tariverde	S of town.
264	61443.03	individual site	Tariverde	Tariverde Duingi Dere unable to locate.
265	61381.01	individual site	Cogealac	Cogealac 'Bent' 300m E of village, *cf* 61381.03 tumuli around commune.
266	61381.04	individual site	Cogealac	On the route between Gura Dobrogei and Tariverde, *cf* 61381.03 tumuli around commune.
267	62048.02	individual site	Nuntaşi	300m SW of village.
268	62048.04	individual site	Nuntaşi	'Baile Nuntasi' 400m SW of road intersection.
269	62039.01	*polis*	Istria	Ancient Histria 5km SE of village on bank of Lake Sinoe.
270		*vicus* type	Istria	Un-named *kome* in Caranasuf suburb considered separate from Histria *polis*.
271	62039.10	individual site	Istria	Histria hill 2km SW from town distinct from ancient Histria.
272	62039.05	individual site	Istria	Histria β Roman rural site 1.5km SE of modern village.
273	62039.06	individual site	Istria	Histria α and γ two separate sites close together on Lake Sinoe.
274	62039.06	individual site	Istria	Histria α and γ two separate sites close together on Lake Sinoe.

275	62887.02	individual site	Săcele	300m SE of village.
276	62896.02	individual site	Traian [Constanța County]	2.5km E of site, *cf* 62896.04 tumuli around town.
277	61540.03	individual site	Vadu	'Pepiniera' 2km NW of village.
278	61540.04	*vicus* type	Vadu	*vicus Celeris*, 1.5km S of Vadu.
279	61540.06	individual site	Vadu	'Bardalia' 2km S of village E of frontier picket.
280	61540.05	individual site	Vadu	5km NE of village on banks of Chituc Island.
281	not listed	*vicus*	Vicinity of Vadu	*vicus Parsul.*
282	not listed	*vicus*	Vicinity of Vadu	*vicus C….cos.*
283	not listed	*vicus*	Vicinity of Histria	*vicus Arcidava.*
284	61522.03	individual site	Corbu	1km NW of village.
285	61522.02	individual site	Corbu	Between upper and lower Corbu.
286	61531.01	individual site	Luminița [Constanța County]	No location given.
287	61522.04	individual site	Corbu	Cape Midia 3.5km SSE of village on peninsula.
288	not listed	*vicus* type	Vicinity Corbu	*Tres Protomae* - location uncertain but 27 Roman miles = 40km from Tomis.
289	not listed	*vicus* type	Vicinity Corbu	*Chora Dagei.*
290	not listed	*vicus*-type	Vicinity Corbu	*Laigos Pyrgos.*
291	62226.01	individual site	Palazu Mic	1km NW of highway bridge.
292	62244.01	individual site	Sibioara	NW of Lake Tasaul exact location unclear *cf* 62244.02 Roman period tumuli in vicinity.
293	62208.02	*vicus*-type	Mihail Kogălniceanu	*vicus Clementiani*, on the Roman road Constanta - Calachioi exact location unclear.
294	60516.06	individual site	Navodari	Northern limits of town.
295	60516.01	individual site	Navodari	South of town on road to Mamaia.
296	60446.01	individual site	Palazu Mare	In village.
297		*vicus* type	Vicinity Constanța	*vicus Sc[ap]ia* N of Constanța between outer suburbs and Palazu Mare.
298		*vicus* type	Vicinity Constanța	*vicus Turris Mucapoeos* northern suburbs of Constanța *cives Romani et Lai consistentes.*
299	60428.33, 60428.34	individual site	Constanța	Site and necropolis at the Real 2 shopping centre 5km from ancient Tomis so treated separately.

				Ancient Tomis, 60428.01 = Tomis, 60428.02 = cathedral park, 60428.09 = amphitheatre, 60428.16 = Str Traian site & necropolis, 60428.17 = South of port, vicinity of oxygen plant, 60428.21 = Str Arhiepiscopiei, 60428.04 = aqueduct near 'modern' beach, 60428.30 = Str Mihai Viteazu, 60428.11 = baths SE of Edifice with mosaics, 60428.32 = Str
300	60428.01 *et al*	*polis*	Constanța	Brancoveanu, 60428.16 = Bd Lapusneanu.
301		*villa*	Constanța	The estate of Marcus Ulpius Longinus posited on the basis of *ISM* 2.180.
302		*vicus* type	Vicinity Constanța	*kome Appollonion.*
303		*vicus* type	Vicinity of Poiana	*vicus Nacissiani,* note significant clusters of tumuli to the NW in Ovidiu valley.
304	62770.02	fort	Porta Albă	Roman period round fort associated with Valu lui Traian.
305	62379.05	individual site	Murfatlar [formerly Basarabi]	Graeco-Roman site on IAS farm to NE.
306	62379.04	individual site	Murfatlar [formerly Basarabi]	Centre of village.
307	62379.02	fort	Murfatlar [formerly Basarabi]	Location not given.
308	60589.01	individual site	Lazu	Centre of village, significant tumuli nearby.
309	63269.01	individual site	Agigea	Location unclear, W of mill site.
310	63269.03	individual site	Agigea	Location unclear, significant tumuli nearby.
311	61639.01	individual site	Cumpăna	Location not given.
312	61666.01	individual site	Straja	W of road to Cumpăna.
313	60543.03	individual site	Techirghiol	On the shore Lake Techirghiol.
314	60543.02	individual site	Techirghiol	1.5km W of town.
315	60543.04	individual site	Techirghiol	4km SW of village 600m from shore Lake Techirghiol.
316	60730.02	individual site	Tuzla	West of village 1km S of Lake Techirghiol.
317	60730.04	individual site	Tuzla	West of the Tuzla-mare gulf.
318	60730.03	individual site	Tuzla	Between Tuzla-mica and Tuzla-mare gulfs.
319	60464.01	individual site	Eforie Sud	In southern part of town.
320	not on cIMeC	*vicus*-type	Vicinity Cape Tuzla	*vicus Strationis.*
321	60749.01	*vicus*-type	Costinești	Ancient Parthenopolis, location presumed on site of Hellenistic sites 60729.02 = 2km NE of intersection of main highway and road to Costinești.

322	60749.03	individual site	Costineşti	On small promontory between lake and sea.
323	60605.06	individual site	23-Aug	Location not given.
324	60605.05	individual site	23-Aug	1.5km S of village.
325	60605.04	individual site	23-Aug	On shore of Lake Tătlăgeac exact location not given.
326	60605.01	individual site	23-Aug	On shore of Lake Tătlăgeac exact location not given.
327	60605.03	individual site	23-Aug	Small peninsula SW Lake Tătlăgeac many sites located on Lake Tătlăgeac exact location unclear.
328	60605.02	individual site	23-Aug	At the end of Lake Tătlăgeac many sites located on Lake Tătlăgeac exact location unclear.
329	not on cIMeC	*vicus* type	Vicinity Lake Tătlăgeac	*vicus Amlaidina.*
330	60614.02	individual site	Dulceşti	0.5 km South of village.
331	60623.02	individual site	Moşeni	SW of Moşeni alongside road to Peceneaga.
332	60623.01	villa	Moşeni	1km SW of IAS Moşeni.
333	62681.03	individual site	Pecineaga	5km NW of village.
334	62681.04	individual site	Pecineaga	200m S of Karachioi hill, significant tumuli clusters nearby.
335	62681.01	individual site	Pecineaga	3km E of village.
336	60963.02	individual site	Arsa	NE of village, significant tumuli clusters nearby.
337	60491.03, et al	*polis*	Mangalia	Ancient Callatis, 60491.27 = Str Stefan cel Mare, 60491.10, 60491.20 = Str Tepes Voda, 60491.16 = Str Vasile Parvan, 60491.29 = Str Oituz, 60491.13 = Str Mihai Eminescu, 60491.05 = Hotel President, 60491.29 = Scoala Generala, 60491.30 = Hellenistic town.
338	60491.32	individual site	Mangalia	3.2km West of town, distinct from *polis.*
339	60669.01	individual site	2 Mai	Civil settlement.
340	60641.07	individual site	Limanu	450m North of village, exact location not given (four different sites N of Limanu).
341	60641.05	individual site	Limanu	200m from village, exact location not given (four different sites N of Limanu).
342	60641.04	individual site	Limanu	220m from village, exact location not given (four different sites N of Limanu).
343	60641.06	individual site	Limanu	1.3km NW of village, exact location not given (four different sites N of Limanu).
344	60650.04	individual site	Hagieni	SE edge of village.

345	60954.04	*villa*	Albeşti	On a plateau 500m S from village.
346	60954.07	individual site	Albeşti	Within the village NE of the route to Mangalia.
347	60990.01	individual site	Vârtop	700m NE of village.
348	60981.01	individual site	Cotu Văii	On via lui Avram.
349	60678.01	individual site	Vama Veche	North of village, significant clusters of tumuli to N.
350	not on cIMeC	*vicus* type	un-located	*kome Ke…*
351	not on cIMeC	*vicus* type	un-located	*kome Val….*
352	not on cIMeC	*vicus* type	un-located	*kome Asbolodina*
353	not on cIMeC	*vicus* type	un-located	*kome Sardes*
354	not on cIMeC	*vicus* type	un-located	*kome ….myle*
355	not on cIMeC	*vicus* type	un-located	*kome P….*
356	not on cIMeC	*vicus* type	un-located	*Pyrgos.*

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Appendices
A– Tables of land requirements
B, C, D Calculations for Transport Solutions

Appendix A.1.1a: Agricultural needs of Lower Moesia garrison – with 6ha landholding and alternate fallowing at low yields of 200kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[29]	Vineyards	Vegetables
31,238 garrison	92,241ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	41,263ha	8253ha			
	133,504ha[30]	8253ha	24,102ha stock raising	2774ha	8210ha Included within fallow
			168,633ha		
43,813 arable labourers 132 stock hands 1290 vine workers 45,235 workers	129,373ha 390ha 3809ha		1,651,078kg = 65% 1,073,200kg beef = 32,196ha 29% 478,812 kg pork = 638ha 5% 82,554kg mutton = 2064ha	4017ha	5944ha leguminous 5944ha other vegetables
	133,572		34,898ha stock raising	4017ha	11,888ha Included within fallow
			172,487ha		
Totals	267,076ha	8253ha	59,000ha	6791ha	
			341,120ha		

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[29] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[30] Divided by (6 – (1.476ha x2)) = 3.04715ha, for number of workers.

Appendix A.1.1b: Agricultural needs of Lower Moesia garrison – with 6ha landholding and alternate fallowing at mid-range yields of 385/385kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[31]	Vineyards	Vegetables
31,238 garrison	47,917ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	20,893ha	8253ha			
	68,810ha[32]	8253ha	24,102ha stock raising	2774ha	8210ha
	103,939ha				Included within fallow
15,408 arable labourers 132 stock hands 1290 vine workers 16,830 workers	23,635ha 202ha 1979ha		614,295kg = 12,984 65% 399,292kg beef = 11,979ha 29% 178,146kg pork = 238ha 5% 30,715kg mutton = 768ha	1495ha	2211ha leguminous 2211ha other vegetables
	25,816ha		12,984ha stock raising	1495ha	4423ha
	40,295ha				Included within fallow
Totals	94,626ha	8253ha	37086ha	4269ha	
	144,234ha				

[31] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[32] Divided by (6 - 0.767x2) = 4.466ha, for number of workers.

Appendix A.1.1c: Agricultural needs of Lower Moesia garrison – with 6ha landholding and alternate fallowing at high yields of 600kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[33]	Vineyards	Vegetables
31,238 garrison	30,747ha ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	13,754ha	8253ha			
	44,501ha[34]	8253ha	24,102ha stock raising	2774ha	8210ha
	79,630ha				Included within fallow
8872 arable labourers 132 stock hands 1290 vine workers 10,294 workers	8733ha 130ha 1270ha		375,731kg = 65% 244,225kg beef = 7327ha 29% 108,962kg pork = 145ha 5% 18,787kg mutton = 470ha	914ha	1353ha leguminous 1353ha other vegetables
	10,132ha		7942ha stock raising	914ha	2705ha
	18,988ha				Included within fallow
Totals	54,633ha	8253ha	32,044ha	3688ha	
	98,618ha				

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[33] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.
[34] Divided by $(6 - (0.492141 \times 2)) = 5.015717$ha, for number of workers.

Appendix A.1.2a: Agricultural needs of Lower Moesia garrison – with 6ha landholding, without alternate fallowing at low yields of 200kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[35]	Vineyards	Vegetables
31,238 garrison	46,121ha ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	20,631ha	8253ha			
	66,752ha[36]	8253ha	24,102ha stock raising	2774ha	8210ha
	110,091ha				
14,756 arable labourers 132 stock hands 1290 vine workers 16,178 workers	21,786ha 195ha 1904ha		590,497kg = 65% 383,823kg beef = 11515ha 29% 171244kg pork = 228ha 5% 29,525kg mutton = 738ha	1437ha	2126ha leguminous 2126ha other vegetables
	23,886ha		12,481ha stock raising	1436ha	4252ha
	42,055ha				
Totals	90,638ha	8253ha	36,583ha	4211ha	12,462ha
	152,147				

[35] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[36] Divided by (6– 1.476425) = 4.523575ha, for number of workers.

Appendix A.1.2b: Agricultural needs of Lower Moesia garrison – with 6ha landholding, without alternate fallowing at mid-range yields of 385/395kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[37]	Vineyards	Vegetables
31,238 garrison	23,959ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	10,446ha	8253ha			
	34,405ha[38]	8253ha	24,102ha stock raising	2774ha	8210ha
	77,744ha				
6575 arable labourers 132 stock hands 1290 vine workers 7997 workers	5043ha 101ha 989ha		291,891kg = 65% 189,728kg beef = 5692ha 29% 84,648kg pork = 113ha 5% 14595kg mutton = 365ha	710ha	1051ha leguminous 1051ha other vegetables
	6133ha		6170ha stock raising	710ha	2102ha
	15115ha				
Totals	40538ha	8253ha	30,272ha	3484ha	10312
	92,859ha				

[37] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[38] Divided by (6 - 0.767) = 5.233ha, for number of workers.

Appendix A.1.2c: Agricultural needs of Lower Moesia garrison – with 6ha landholding, without alternate fallowing at high yields of 600kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[39]	Vineyards	Vegetables
31,238 garrison	15,374ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	6877ha	8253ha			
	22,251[40]	8253ha	24,102ha stock raising	2774ha	8210ha
			65,590ha		
4040 arable labourers 132 stock hands 1290 vine workers 5462 workers	1988ha 65ha 635ha		199,363kg = 65% 129,586kg beef = 3888ha 29% 57,815kg pork = 77ha 5% 9968kg mutton = 249ha	485ha	718ha leguminous 718ha other vegetables
	2688ha		4214ha stock raising	485ha	1435ha
			8822ha		
Totals	24,939ha	8253ha	28316ha	3259ha	9645ha
			74,412ha		

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[39] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[40] Divided by (6 - 0.492141) = 5.50786ha, for number of workers.

Appendix A.2.1a: Agricultural needs of Lower Moesia garrison – with 3ha landholding and alternate fallowing at low yields of 200kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[41]	Vineyards	Vegetables
31,238 garrison	92,241ha ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	41,263ha	8253ha			
	133,504ha[42]	8253ha	24,102ha stock raising	2774ha	8210ha Included within fallow
			168,633ha		
2,831,474 arable labourers	8,360,918ha not viable		103,348,801kg not viable		
			not viable		
Totals					
			not viable		

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[41] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[42] Divided by (3 – 1.476hax2) = 0.04715ha ha, for number of workers.

Appendix A.2.1b: Agricultural needs of Lower Moesia garrison – with 3ha landholding and alternate fallowing at mid-range yields of 385/395kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[43]	Vineyards	Vegetables
31,238 garrison	47,917ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	20,893ha	8253ha			
	68,810ha[44]	8253ha	24,102ha stock raising	2774ha	8210ha
	103,939ha				Included within fallow
46,937 arable labourers 132 stock hands 1290 vine workers 48,359 workers	71,999ha 202ha 1979ha		1,765,104kg = 65% 1,147,317kg beef = 34,420ha 29% 511,880kg pork = 683ha 5% 88,255kg mutton = 2206ha	4295ha	6354ha leguminous 6354ha other vegetables
	74,180ha		37,308ha stock raising	4295ha	12,709ha
	115,782ha				Included within fallow
Totals	142,990ha	8253ha	61,410ha	7069ha	
	219,722ha				

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[43] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[44] Divided by (3 - 0.767x2) = 1.466ha, for number of workers.

Appendix A.2.1c: Agricultural needs of Lower Moesia garrison – with 3ha landholding and alternate fallowing at high yields of 600kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[45]	Vineyards	Vegetables
31,238 garrison	30,747ha ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	13,754ha	8253ha			
	44,501ha[46]	8253ha	24,102ha stock raising	2774ha	8210ha
	79,630ha				Included within fallow
22,077 arable labourers 132 stock hands 1290 vine workers 23,499 workers	21,730ha 130ha 1270ha		857,714kg = 65% 557,514kg beef = 16725ha 29% 248,737kg pork = 332ha 5% 42,886kg mutton = 1072ha	2087ha	3088ha leguminous 3088ha other vegetables
	23,130ha		18,129ha stock raising	2087ha	6176ha
	43,346ha				Included within fallow
Totals	67,631ha	8253ha	42,231ha	4861ha	
	122,976ha				

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[45] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[46] Divided by $(3 - (0.492141 \times 2)) = 2.01572$ha, for number of workers.

Appendix A.2.2a: Agricultural needs of Lower Moesia garrison – with 3ha landholding without alternate fallowing at low yields of 200kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[47]	Vineyards	Vegetables
31,238 garrison	46,121ha ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	20,631ha	8253ha			
	66,752ha[48]	8253ha	24,102ha stock raising	2774ha	8210ha
	110,092ha				
43,813 arable labourers 132 stock hands 1290 vine workers 45,235 workers	64687ha 195ha 1904		1,651,078kg = 65% 1073200kg beef = 32196ha 29% 478,812kg pork = 638ha 5% 82,554kg mutton = 2063ha	4017ha	5944ha leguminous 5944ha other vegetables
	66,786ha		34,898ha stock raising	4017ha	11,888ha
	117,589ha				
Totals	133,538ha	8253ha	59,000ha	6791ha	
	227,681				

[47] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[48] Divided by (3 – 1.476425) = 1.523575ha, for number of workers.

Appendix A.2.2b: Agricultural needs of Lower Moesia garrison – with 3ha landholding without alternate fallowing at mid-range yields of 385/395kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[49]	Vineyards	Vegetables
31,238 garrison	23,959ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	10,446ha	8253ha			
	34,405ha[50]	8253ha	24,102ha stock raising	2774ha	8210ha
	77,744ha				
15,408 arable labourers 132 stock hands 1290 vine workers 16,698 workers	11818ha 101ha 989ha		609,477kg = 65% 396,160kg beef = 11884ha 29% 176,748kg pork = 236ha 5% 19,580kg mutton = 762ha	1483ha	2194ha leguminous 2194ha other vegetables
	12908ha		12,882ha stock raising	1483ha	4388ha
	31,661ha				
Totals	48313ha	8253ha	36,984ha	4257ha	12,598
	110,405ha				

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[49] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.
[50] Divided by (3 - 0.767) = 2.233ha, for number of workers.

Appendix A.2.2c: Agricultural needs of Lower Moesia garrison – with 3ha landholding without alternate fallowing at high yields of 600kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[51]	Vineyards	Vegetables
31,238 garrison	15,374ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	6877ha	8253ha			
	22,251[52]	8253ha	24,102ha stock raising	2774ha	8210ha
			65,590ha		
8873 arable labourers 132 stock hands 1290 vine workers 10,295 workers	4367ha 65ha 635ha		375,768kg = 65% 244,249kg beef = 7327ha 29% 108,973kg pork = 145ha 5% 18,788kg mutton = 470ha	914ha	1353ha leguminous 1353ha other vegetables
	5067ha		7942ha stock raising	914ha	2706ha
			16,629ha		
Totals	27318ha	8253ha	32,044ha	3688ha	2706ha
			82,219ha		

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[51] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[52] Divided by (3 - 0.49214) = 2.507858ha, for number of workers.

Appendix A.3.1a: Agricultural needs of Lower Moesia garrison, farmers and their dependents – with 6ha landholding and alternate fallowing at low yields of 200kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[53]	Vineyards	Vegetables
31,238 garrison	92,241ha ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	41,263ha	8253ha			
	133,504ha[54]	8253ha	24,102ha stock raising	2774ha	8210ha Included within fallow
			168,633ha		
1,390,666 workers unviable 132 stock hands 1290 vine workers	Unviable		Unviable	Unviable	Unviable
Totals					

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[53] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[54] Divided by (6 – (1.476ha x2 x2)) = 0.096ha unviable.

Appendix A.3.1b: Agricultural needs of Lower Moesia garrison, farmers and their dependents – with 6ha landholding and alternate fallowing at mid-range yields of 385/395kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[55]	Vineyards	Vegetables
31,238 garrison	47,917ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	20,893ha	8253ha			
	68,810ha[56]	8253ha	24,102ha stock raising	2774ha	8210ha
			103,939ha		Included within fallow
23,469 arable labourers 132 stock hands 1290 vine workers 24,891 workers 99,564 civilians	72,000ha 405ha 3958ha		1,817,043kg = 65% 1,181,078kg beef = 35,432ha 29% 526,942kg pork = 703ha 5% 90,852kg mutton = 2271ha	4421ha	6541ha leguminous 6541ha other vegetables
	76,363ha		38,406ha stock raising	4421ha	13083ha
			119,190ha		Included within fallow
Totals	145,173ha	8253ha	62,508ha	7195ha	
			223,129ha		

[55] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[56] Divided by (6 – (0.767x2x2)) = 2.932ha, for number of workers.

Appendix A.3.1c: Agricultural needs of Lower Moesia garrison, farmers and their dependents – with 6ha landholding and alternate fallowing at high yields of 600kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[57]	Vineyards	Vegetables
31,238 garrison	30,747ha ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	13,754ha	8253ha			
	44,501ha[58]	8253ha	24,102ha stock raising	2774ha	8210ha
			79,630ha		Included within fallow
11,039 arable labourers 132 stock hands 1290 vine workers 12,461 workers 49,844 civilians	21,731ha 260ha 2539ha		909,653kg = 65% 591,274kg beef = 17,738ha 29% 263,799kg pork = 352ha 5% 45,483kg mutton = 1137ha	2213ha	3275ha leguminous 3275ha other vegetables
	24,530ha		19,227ha stock raising	2213ha	6550ha
			64,537ha		Included within fallow
Totals	69,031ha	8253ha	43,329ha	4987ha	
			125,600ha		

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[57] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[58] Divided by (6 – (0.49214x2 x2)) = 4.0314, for number of workers.

Appendix A.3.2a: Agricultural needs of Lower Moesia garrison, farmers and their dependents – with 6ha landholding without alternate fallowing at low yields of 200kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[59]	Vineyards	Vegetables
31,238 garrison	46,121ha ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	20,631ha	8253ha			
	66,752ha[60]	8253ha	24,102ha stock raising	2774ha	8210ha
	110,091ha				
21,906 arable labourers 132 stock hands 1290 vine workers 23,328 workers 93,312 civilians	64,685ha 390ha 3809ha		1,702,944kg = 65% 1,106,914kg beef = 33,207ha 29% 493,854kg pork = 658ha 5% 85,147kg mutton = 2129ha	4143ha	6131ha leguminous 6131ha other vegetables
	68,884ha		35,995ha stock raising	4143ha	12,261ha
	121,283ha				
Totals	135,636ha	8253ha	60,097ha	6917ha	20,471ha
	231,374ha				

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[59] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.
[60] Divided by (6 – 1.476425 x2) = 3.04715ha, for number of workers.

Appendix A.3.2b: Agricultural needs of Lower Moesia garrison, farmers and their dependents – with 6ha landholding without alternate fallowing at mid-range yields of 385/395kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[61]	Vineyards	Vegetables
31,238 garrison	23,959ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	10,446ha	8253ha			
	34,405ha[62]	8253ha	24,102ha stock raising	2774ha	8210ha
			77,744ha		
7704 arable labourers 132 stock hands 1290 vine workers 9126 36,504 civilians	11,818ha 202ha 1979ha		666,198kg = 65% 433,029kg beef = 12,991ha 29% 193,197kg pork = 258ha 5% 33,310kg mutton = 833ha	1621ha	2398ha leguminous 2398ha other vegetables
	13,999ha		14,081ha stock raising	1621ha	4797ha
			34,498ha		
Totals	48,404ha	8253ha	38,183ha	4395ha	13,007ha
			112,242ha		

[61] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[62] Divided by (6 - 0.767 x2.) = 4.466ha, for number of workers.

Appendix A.3.2c: Agricultural needs of Lower Moesia garrison, farmers and their dependents – with 6ha landholding without alternate fallowing at high yields of 600kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[63]	Vineyards	Vegetables
31,238 garrison	15,374ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	6877ha	8253ha			
	22,251[64]	8253ha	24,102ha stock raising	2774ha	8210ha
			65,590ha		
4436 arable labourers 132 stock hands 1290 vine workers 5858 23,432 civilians	4366ha 130ha 1270ha		427,634kg = 9039 65% 277,962kg beef = 8339ha 29% 124,014kg pork = 165ha 5% 21,382kg mutton = 535ha	1040ha	1539ha leguminous 1539ha other vegetables
	5766ha		9039ha stock raising	1040ha	3079ha
			18,924ha		
Totals	28,017ha	8253ha	33,141ha	3814ha	11,289ha
			84,514ha		

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[63] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[64] Divided by (6 – (0.492141 x2)) = 5.0157ha, for number of workers.

Appendix A.4.1a: Agricultural needs of Lower Moesia garrison, farmers and their dependents, – with 3ha landholding and alternate fallowing at low yields of 200kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[65]	Vineyards	Vegetables
31,238 garrison	92,241ha ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	41,263ha	8253ha			
	133,504ha[66]	8253ha	24,102ha stock raising	2774ha	8210ha Included within fallow
			168,633ha		
Unviable number of arable labourers 132 stock hands 1290 vine workers	Unviable		Unviable	Unviable	Unviable
Totals					

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[65] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[66] Divided by (3 – (1.476ha x2 x2)) = 3-5.904, unviable for number of workers.

Appendix A.4.1b: Agricultural needs of Lower Moesia garrison, farmers and their dependents, – with 3ha landholding and alternate fallowing at mid-range yields of 385/395kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[67]	Vineyards	Vegetables
31,238 garrison	47,917ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	20,893ha	8253ha			
	68,810ha[68]	8253ha	24,102ha stock raising	2774ha	8210ha Included within fallow
			103,939ha		
Unviable number of arable labourers 132 stock hands 1290 vine workers	Unviable		Unviable	Unviable	Unviable
Totals					

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[67] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[68] Divided by (3 - 0.767 x2 x2) = 3-3.835 = unviable for number of workers.

Appendix A.4.1c: Agricultural needs of Lower Moesia garrison, farmers and their dependents, – with 3ha landholding and alternate fallowing at high yields of 600kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[69]	Vineyards	Vegetables
31,238 garrison	30,747ha ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	13,754ha	8253ha			
	44,501ha[70]	8253ha	24,102ha stock raising	2774ha	8210ha
	79,630ha				Included within fallow
43,145 arable labourers 132 stock hands 1290 vine workers 44,567 workers 178,268 civilians	84,934ha 260ha 2539ha		3,253,391kg = 65% 2,114,704kg beef = 63,441ha 29% 943,483kg pork = 1258ha 5% 162,670kg mutton = 4067ha	7916ha	11712ha leguminous 11712ha other vegetables
	87,733ha		68,766ha stock raising	7916ha	23,424ha
	164,415ha				Included within fallow
Totals	132,234ha	8253ha	92,868ha	10690ha	
	244,045ha				

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[69] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[70] Divided by (3 - 0.49214 x2 x2) = 1.03143333, for number of workers.

Appendix A.4.2a: Agricultural needs of Lower Moesia garrison, farmers and their dependents – with 3ha landholding without alternate fallowing at low yields of 200kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[71]	Vineyards	Vegetables
31,238 garrison	46,121ha ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	20,631ha	8253ha			
	66,752ha[72]	8253ha	24,102ha stock raising	2774ha	8210ha
	110,092ha				
1,415,737 arable labourers = unviable 132 stock hands 1290 vine workers	Unviable		Unviable	Unviable	Unviable
Totals					

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[71] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.
[72] Divided by (3 – 1.476425 x2) = 0.04715, for number of workers.

Appendix A.4.2b: Agricultural needs of Lower Moesia garrison, farmers and their dependents – with 3ha landholding without alternate fallowing at mid-range yields of 385/395kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[73]	Vineyards	Vegetables
31,238 garrison	23,959ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	10,446ha	8253ha			
	34,405ha[74]	8253ha	24,102ha stock raising	2774ha	8210ha
			77,744ha		
23,469 arable labourers 132 stock hands 1290 vine workers 24,891 workers 99,564 civilians	36,000ha 202ha 1979ha		1,817,043kg = 65% 1,181,078kg beef = 35,432ha 29% 526,942kg pork = 703ha 5% 90,852kg mutton = 2271ha	4421ha	6541ha leguminous 6541ha other vegetables
	38,182ha		38,406ha stock raising	4421ha	13,083ha
			94,092ha		
Totals	72,587ha	8253ha	62,508ha	7195ha	21,293ha
			171,836ha		

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[73] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[74] Divided by (3 - 0.767 x2) = 1.466ha, for number of workers.

Appendix A.4.2c: Agricultural needs of Lower Moesia garrison, farmers and their dependents – with 3ha landholding without alternate fallowing at high yields of 600kg/ha

Consumer	Arable need at 0.809kg per day for garrison and their farm labourers, & 2.5kg barley horse	Cavalry pasture 5kg a day	Pasture need for meat at 0.1kg per day for garrison and their farm labourers by meat type beef, pork and mutton[75]	Vineyards	Vegetables
31,238 garrison	15,374ha		1,140,187kg = 65% 741,123kg beef = 22,236ha 29% 330,654kg pork = 441ha 5% 57,009kg mutton = 1425ha	2774ha	4105ha leguminous 4105ha other vegetables
4522 horse	6877ha	8253ha			
	22,251[76]	8253ha	24,102ha stock raising	2774ha	8210ha
			65,590ha		
11,039 arable labourers, 132 stock hands 1290 vine workers 12461workers 49,844 civilians	10,866ha 130ha 1270ha		909,653kg = 65% 591,274kg beef = 17,738ha 29% 263,799kg pork = 351ha 5% 45,483kg mutton = 1137ha	2213ha	3275ha leguminous 3275ha other vegetables
	12,265ha		19,227ha stock raising	2213ha	6550ha
			40,255ha		
Totals	34,516ha	8253ha	43,329ha	4987ha	14,760ha
			105,845ha		

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[75] Beef divided by 200kg carcass weight x 6ha per animal, pork divided by 50kg carcass weight divided again by 15 pigs per ha, mutton divided by 20kg carcass weight divided again by two sheep per ha.

[76] Divided by $(3 – (0.492141 \times 2)) = 2.015716$ha, for number of workers.

Appendix B: Transport solutions Novae-Nicopolis

The total arable needs of garrison, cavalry, their farmers and service providers has been calculated as 23,299ha [Table T.3.2.1a], and this total need can be seen to have been met with a 68% surplus from the immediate vicinity between Novae and Nicopolis, but this calculation ignored the problems of transporting such foodstuffs.

It is assumed that the garrison at Novae was at full strength 6059 men and a 15% part of the garrison of Sextaginta Prista was also present a mere 41 men. It was calculated on the basis of a rough population estimate for the area that there could have been 7520 service providers resident alongside the garrison also. 55 of these were allocated to Sextaginta Prista and the remaining 7465 were resident at Novae

The total need of 23,299ha included the food that would have fed the farmers working the fields, who are presumed to have eaten at source, so that the total was reduced by the needs of these farmers to 18,097ha. As a percentage of the annual need, this represents 77.673%, a factor which ought to also be applied to the total agricultural potential argued to be seen in Chapter Three of 39,185ha, - to arrive at an available potential of 30,436ha allowing for that part of the potential which was being consumed at source by the farmers. Throughout Chapter Three, all needs and potentials were doubled to allow for alternate fallowing, but here in Chapter Four it is the annual potential which would have been required to be moved to consumer year on year, so that the potential was halved to 15,218ha.

Initially radii were produced from both forts. Sextaginta's needs were easily met within a single day. Then radii continuing up to four days distance in the 23km model were produced although the needs of Novae were seen to have been met within two days. Thereafter Service Areas were produced according to the lie of the road network. The needs of Sextaginta Prista were still met within the first day. For the needs at Novae in the case of the oxen-drawn wagons the needs were not met until three travelling days, using mules this could be achieved within two days.

The calculations below take the hectares to several decimal points to avoid rounding errors between kilograms and hectares; but the number of wagon loads is calculated to whole or half wagons, and the wagon days to whole days which are then divided by a 300 working day year

Appendix B.1: 23km Oxen-drawn wagons radii Novae-Nicopolis

Garrison	Settlements, weight and wagons	+ surplus - deficit	Settlements, weights & wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit
	One day		Two days		Three days		Four days	
Sexaginta Prista 41 + 55 = 60.97443506ha [77]	1 *vicus*, 10 of Conrad's 83 *villae* (12.048% of 10960ha) 960 + 1320.481928 = 2280.481928ha /2 x 0.77673 = 885.6593639ha avail, but 62.54298922ha req = 60.97443506ha w 1.568554271ha feed	+ 823.1163746ha	+ 823.1163746ha to Novae					
w = wheat = 23475kg	23475kg w kg feed b							
Wagons loads Wagon days	69 loads 138 wagon days							
Novae 6059 + 144+ 7465 = 8987.576624ha [78] = 8654.918396ha w 332.65228ha b	Area A, 4 *vici*, 55 of Conrad's 83 *villae* (66.265% of 10960ha), 7 Poulter *villae* = 695ha + 3840ha + 7262.650602ha + 840ha = 12637.6506ha /2 x 0.77673 = 4908.021175ha avail = 4452.054952ha w 332.658228ha b 123.3079951ha feed b	- 4202.863444ha	3 un-located *vici*, 18 of Conrad's 83 sites (21.687% of 10960ha) 49 Poulter *villae* 16 Poulter Individual sites = 2880 + 2376.86747ha + 5880 + 163.2 = 11300.06747ha /2 x 0.77673 = 4388.550703ha + 823.1163746ha Sextaginta Prista surplus = 5211.667078ha avail but 4424.960773ha req = 4202.863444ha w 222.0973286ha feed b	+ 786.706306ha surplus	3 *vici* (2 un-located), 62 Poulter *villae*, 74 Poulter Individual sites =2880 +7440 + 754.8 = 11074.8ha /2 x 0.77673 = 4301.064702ha	+ 5087.771008h a	15 Poulter *villae*, 9 Poulter Individual sites = 1800 + 91.8 = 1891.8 /2 x 0.77673 = + 734.708907ha	+ 5822.479915 ha
Weight w = wheat = 3,332,144kg b = barley = 131400kg	1,714,041kg w 131,400kg b 48,707kg feed b		1,618,102kg w 87,728kg feed b					
Wagons loads Wagon days	5412 loads 10824 wagon days		4874 loads 19495 wagon days					
Wagon day totals	10961		19495					
Wagons *pa*	30456 = 102 wagons required *pa*							5822.479915ha surplus

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[77] 41 soldiers 55 service providers = 12107kg w from 31.44593506ha and 11368kg w from 29.5285ha = 60.97443506ha.

[78] 6059 soldiers, 144 horse 7465 service providers = 1,789,132kg w from 4647.095623ha, 131400kg b from 332.658228ha, 1,543,011kg w from 4007.822773ha = 8987.576624ha.

Appendix B.2: 32km Oxen-drawn wagons radii Novae-Nicopolis

Garrison	Settlements, weight and wagons	+ surplus - deficit	Settlements, weights & wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit
	One day		Two days		Three days	
Sexaginta Prista 41 + 55 = 60.97443506ha [79]	I *vicus* 9 of Conrad's 83 *villae* (10.84337% of 10960) = 960 + 1188.433735 =2148.433735ha /2 x 0.77673 = 834.3764675 avail, 62.54298933ha req = 60.97443506ha w 1.568554271ha feed	+ 771.8334782ha				771.8334782ha
w = wheat = 23475kg	23475kg w kg feed b					
Wagons loads Wagon days	69 loads 138 wagon days					

Novae 6059 + 144+ 7465 = 8987.576624ha [80] = 8654.918396ha w 332.65228ha b	Area A, 4 *vici*, 70 of Conrad's 83 *villae* (84.3373% of 10960ha) 21 of Poulter's *villae* = 695 + 3840 + 9243.373494 + 2520 = 16298.37349ha /2 x 0.77673 = 6329.717822ha avail
	
	= 5838.09599ha w
	  332.6582278ha b
	  158.9636037ha feed b
		- 2816.822406ha	6 *vici*, 4 of Conrad's 83 *villae* (4.8193% of 10960ha), 85 of Poulter's villae, 82 of Poulter's Individual sites 5760 + 528.1927711 + 10200 + 836.4 =17324.59277 /2 x 0.77673 = 6728.265472ha avail but 2965.675382ha req
			
			= 2816.822406ha w
			  148.852976ha feed b
				+ 3762.59009ha	27 of Poulter's *villae*, 17 Poulter's Individual sites = 3240 + 173.4 = 3413.4ha /2 x 0.77673 = 1325.645091ha	+ 5088.235181ha

Weight w = wheat = 3,332,144kg b = barley = 131400kg	2,247,667kg w 131,400kg b 62,791kg feed b		1,084,577kg w 58,797kg feed b			
Wagons loads Wagon days	6977 loads 13953 wagon days		3266 loads 13066 wagon days			
Wagon day totals	14091		13066			
Wagons *pa*	27157 = 91 wagons required *pa*					5860.06866ha surplus

[79] 41 soldiers 55 service providers = 12107kg w from 31.44593506ha and 11368kg w from 29.5285ha = 60.97443506ha.
[80] 6059 soldiers, 144 horse 7465 service providers = 1,789,132kg w from 4647.095623ha, 131400kg b from 332.658228ha, 1,543,011kg w from 4007.822773ha = 8987.576624ha.

Appendix B.3: 50k Mule-drawn wagons radii Novae-Nicopolis

Garrison	Settlements, weight and wagons	+ surplus - deficit	Settlements, weights & wagons	+ surplus - deficit
Sexaginta Prista 41 + 55 = 60.97443506ha [81]	All of potential within 50km of Sexaginta Prista also within 50 km of Novae so this calculation carried out first to supply needs to Sexaginta Prista 66.95489076ha req 60.97443506ha w 5.980455696ha feed b	+ Needs met		
w = wheat = 23475kg	23,475kg w 2,362kg feed b			
Wagons loads Wagon days	74 loads wagon days148			

Novae 6059 + 144+ 7465 = 8987.576624ha [82] = 8654.918396ha w
  332.65228ha b
	Area A + Area B + 8 *vici* + 65 Poulter's *villae* + 30 Poulter's Individual sites
	695 + 10960 + 7680 + 7800+ 306
	= 27441ha /2 x 0.77673
	= 10657.12397ha – [66.95489076ha for Sexaginta Prista above]
	= 10590.16908ha avail but 9869.937858ha req
	
	= 8654.918396ha w
	  332.6582278ha b
	  882.3612343ha feed b
		+ 720.23122ha surplus	3 *vici* + 68 Poulter's *villae* + 69 Poulter's Individual sites
			2880 + 8160 + 703.8
			= 11743.8ha /2 x 0.77673
			= 4560.880887ha
				+ 5281.112107

Weight w = wheat = 3,332,144kg b = barley = 131400kg	3,332,144kg w
	  131,400kg b
	  348,533kg feed b			

Wagons loads Wagon days	loads 10892 wagon days 21783			
Wagon day totals	21931			
Wagons *pa*	= 73 wagons *pa*			5281.112107ha surplus

[81] 41 soldiers 55 service providers = 12107kg w from 31.44593506ha and 11368kg w from 29.5285ha = 60.97443506ha.
[82] 6059 soldiers, 144 horse 7465 service providers = 1,789,132kg w from 4647.095623ha, 131400kg b from 332.658228ha, 1,543,011kg w from 4007.822773ha = 8987.576624ha.

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Appendix B.4: 50k Mule-trains radii Novae-Nicopolis

Garrison	Settlements, weight and wagons	+ surplus - deficit	Settlements, weights & wagons	+ surplus - deficit
Sexaginta Prista 41 + 55 = 60.97443506ha [83]	All of potential within 50km of Sexaginta Prista also within 50 km of Novae so this calculation carried out first to supply needs to Sexaginta Prista 64.57630042ha req 60.97443506ha w 3.601865ha feed b			
w = wheat = 23475kg	23,475kg w 1,423kg feed b			
Wagons loads Wagon days	Mule trains = 44 Mule train days = 89			
Novae 6059 + 144+ 7465 = 8987.576624ha [84] = 8654.918396ha w 332.65228ha b	Area A + Area B + 8 *vici* + 65 Poulter's *villae* + 30 Poulter's Individual sites 695 + 10960 + 7680 + 7800+ 306 = 27441ha /2 x 0.77673 = 10657.12397ha – [64.57630042ha req for Sexaginta Prista above] = 10592.54767ha avail but 9518.998731ha req 8654.918396ha w 332.6582278ha b 531.422107ha feed b	+ 1073.548939ha surplus	3 *vici* + 68 Poulter's *villae* + 69 Poulter's Individual sites 2880 + 8160 + 703.8 = 11743.8ha /2 x 0.77673 = 4560.880887ha	+ 5634.429826ha
Weight w = wheat = 3,332,144kg b = barley = 131400kg	3,332,144kg w 131,400kg b 209,912kg feed b			
Wagons loads Wagon days	Mule-trains 6560 Mule-trains days 13119			
Mule train day totals	13208			
Mule train *pa*	= 44 Mule-trains required *pa*			5634.429826ha surplus

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[83] 41 soldiers 55 service providers = 12107kg w from 31.44593506ha and 11368kg w from 29.5285ha = 60.97443506ha.
[84] 6059 soldiers, 144 horse 7465 service providers = 1,789,132kg w from 4647.095623ha, 131400kg b from 332.658228ha, 1,543,011kg w from 4007.822773ha = 8987.576624ha.

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Appendix B.5: 23km Oxen-drawn wagons Service Areas Novae-Nicopolis

Garrison	Settlements, weight and wagons	+ surplus - deficit	Settlements, weights & wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit
	One day		Two days		Three days		Four days		Five days	
Sexaginta Prista 41 + 55 = 60.97443506ha [85]	I *vicus* + 9 of Conrad's 83 *villae* (10.843% of 10960) = 960 + 1188.433735 =2148.433735ha /2 x 0.77673 = 834.3764675ha avail but 62.54298933ha req 60.97443506ha w 1.568554271ha feed b	+ 771.833478ha								
w = wheat = 23475kg	23,475kg w 620kg feed b									
Wagons loads Wagon days	69 wagon loads 138 wagon days									
Novae 6059 + 144+ 7465 = 8987.576624ha [86] = 8654.918396ha w 332.65228ha b	Area A, 4 *vici*, + 40 of Conrad's 83 *villae* (48.19277% of 10960) 695 + 3840 + 5281.927711 = 9816.927711ha /2 x 0.77673 = 3812.55113ha =.3384.058877ha w 332.658228ha b 95.83402506ha feed b	- 5270.859519ha	34 of Conrad's 83 *villae* (40.96386% of 10960) + 16 Poulter's *villae* 4489.638554 + 1920 = 6409.638554ha /2 x 0.77673 = 2489.279277ha + 771.833478ha Sexaginta surplus = 3261.112755ha = 3097.431207ha w 163.6815481ha feed b	- 2173.428312ha	37 Poulter's *villae* + 21 Poulter's Ind sites = 4440 + 214.2 = 4654.2ha /2 x 0.77673 = 1807.528383ha = 1671.354609ha w 136.1737745ha feed b	- 502.073704ha	6 vici + 35 Poulter's *villae* + 53 Poulter's Ind sites = 5760 + 4200 + 540.6 = 10500.6ha /2 x 0.77673 4078.065519ha avail but 558.1790135ha req = 502.073704ha w 56.1053095ha feed b	+ 3519.886505ha	45 Poulter's *villae* + 25 Poulter's Individual sites = 5400 + 255 = 5655ha /2 x 0.77673 2196.204075ha	+ 5716.09058 ha
Weight w = wheat = 3,332,144kg b = barley = 131400kg	1,302,863kg w 131,400kg b 37,854kg feed b		1,192,511kg w 64,654kg feed b		643,472kg w 53.789kg feed b		193,298kg w 22,162kg feed b			
Wagons loads Wagon days	4206 loads 8412 wagon days		3592 loads 14368 wagon days		1992 loads 11953 wagon days		616 loads 4925 wagon days			
Wagon day totals	8550		14368		11953		4925			
Wagons *pa*	39795 = 133 wagons required *pa*									5716.09058 ha surplus

[85] 41 soldiers 55 service providers = 12107kg w from 31.44593506ha and 11368kg w from 29.5285ha = 60.97443506ha.
[86] 6059 soldiers, 144 horse 7465 service providers = 1,789,132kg w from 4647.095623ha, 131400kg b from 332.658228ha, 1,543,011kg w from 4007.822773ha = 8987.576624ha.

Appendix B.6: 32km Oxen-drawn wagons Service Areas Novae-Nicopolis

Garrison	Settlements, weight and wagons	+ surplus - deficit	Settlements, weights & wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit
	One day		Two days		Three days		Four days	
Sexaginta Prista 41 + 55 = 60.97443506ha [87]	I *vicus* 11 of Conrad's 83 *villae* (13.253% of 10960) = 960 + 1452.53012ha = 2412.53012ha /2 x 0.77673 = 936.9422602ha but 62.54298933ha req 60.97443506ha w 1.568554271ha feed b	+ 874.3992709ha						
w = wheat = 23475kg	23,475kg w 620kg feed b							
Wagons loads Wagon days	69 loads 138 wagon days							
Novae 6059 + 144+ 7465 = 8987.576624ha [88] = 8654.918396ha w 332.65228ha b	Area A,+ 4 *vici*, + 56 of Conrad's 83 *villae* (67.46987% of 10960) + 3 Poulter's *villae* 695 + 3840 + 7394.698795ha + 360 = 12289.6988ha /2 x 0.77673 = 4772.888873ha = 4320.311717ha w 332.658228ha b 119.9189286ha feed b	- 4347.940650ha	16 of Conrad's 83 *villae* (19.2771% of 10960) + 43 Poulter's *villae*, + 15 Poulter's Ind sites 2112.771084 + 5160 + 153 = 7425.771084ha /2 x 0.77673 = 2883.909587ha + 874.3992709ha Sextaginta surplus = 3758.308858ha = 3569.672077ha w 188.6367808ha feed b	- 764.934602ha	6 *vici* + 46 Poulter's *villae*, + 63 Poulter's Ind sites = 5760 + 5520 + 642.6 = 11922.6ha /2 x 0.77673 = 4630.320549ha avail but 827.2577214ha req 764.934602ha w 62.3231194ha feed b	+ 3803.062828ha	41 Poulter's *villae* + 21 Poulter's Ind sites 4920 + 214.2 = 5134.2ha /2 x 0.77673 1993.943583ha	+ 5797.006411ha
Weight w = wheat = 3,332,144kg b = barley = 131400kg	1,663,320kg w 131,400kg b 47,368kg feed b		1,374,324kg w 74,512kg feed b		294,500kg w 24,618kg feed b			
Wagons loads Wagon days	5263 loads 10526 wagon days		4140 loads 16,558 wagon days		912 loads 5471 wagon days			
Wagon day totals	10664		16,558		5471			
Wagons *pa*	32693 wagon loads = 109 wagons required *pa*						5797.006411ha surplus	

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[87] 41 soldiers 55 service providers = 12107kg w from 31.44593506ha and 11368kg w from 29.5285ha = 60.97443506ha.

[88] 6059 soldiers, 144 horse 7465 service providers = 1,789,132kg w from 4647.095623ha, 131400kg b from 332.658228ha, 1,543,011kg w from 4007.822773ha = 8987.576624ha.

Appendix B.7: 50km Mule-drawn wagons Service Areas Novae-Nicopolis

Garrison	Settlements, weight and wagons	+ surplus - deficit	Settlements, weights & wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit
	One day		Two days		Three days	
Sexaginta Prista 41 + 55 = 60.97443506ha [89]	1 *vicus*, 11 of Conrad's 83 sites 960 + [13.253012% of 10960] 960 + 1452.53012 = 2412..53012ha /2 x 0.77673 = 936.9422602 avail but 66.95489069ha req 66.95489069ha = 60.974435ha w 5.98045569ha feed b	+ 869.9873695ha				
w = wheat = 23475kg	23,475kg w 2,362kg feed b					
Wagons loads Wagon days	loads 74 wagon days148					
Novae 6059 + 144+ 7465 = 8987.576624ha [90] = 8654.918396ha w 332.65228ha b	Area A, 4 *vici*, 61 of Conrad's 83 sites, 22, Poulter's *villae* 695 + 3840 + [73.494% of 10960 = 8054.939759] + 2640 = 15229.93976ha /2 x 0.77673 = 5914.775555ha + 869.9873695ha Sextaginta surplus = 6784.762925ha = 5845.313362ha w 332.6582278ha b 606.791335ha Feed b	- 2809.605034ha	6 *vici*, 11 of Conrad's 83 sites, 83 Poulter's *villae*, 80 Poulter's Individual sites 5760 + [13.253012% of 10960 = 1452.53012ha] + 9960 + 816 = 17988.53012ha /2 x 0.77673 = 6986.1155ha avail but 3422.410806ha req 2809.605034ha w 612.8057718ha Feed b	+ 3563.704694ha	28 Poulter's *villae*, 19 Poulter's Individual sites 3360 + 193.8 = 3553.8ha /2 x0.77673 = 1380.171537ha	+ 4943.876231ha
Weight w = wheat = 3,332,144kg b = barley = 131400kg	2,250,446kg w 131,400kg b 239,683kg feed b		1,081,698kg w 242,058kg feed b			
Wagons loads Wagon days	loads 7490 wagon days 14,980		loads 3782 wagon days 15129			
Wagon day totals	15,128		15129			
Wagons *pa*	30,256= 101 wagons required *pa*					4943.876231ha surplus

[89] 41 soldiers 55 service providers = 12107kg w from 31.44593506ha and 11368kg w from 29.5285ha = 60.97443506ha.

[90] 6059 soldiers, 144 horse 7465 service providers = 1,789,132kg w from 4647.095623ha, 131400kg b from 332.658228ha, 1,543,011kg w from 4007.822773ha = 8987.576624ha.

Appendix B.8: 50km Mule-trains-Service Areas Novae-Nicopolis

Garrison	Settlements, weight and wagons	+ surplus - deficit	Settlements, weights & wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit
	One day		Two days		Three days	
Sexaginta Prista 41 + 55 = 60.97443506ha [91]	1 *vicus* 11 of Conrad's 83 sites 960 + [13.253012% of 10960] 960 + 1452.53012 = 2412..53012ha /2 x 0.77673 = 936.9422602ha avail but 64.57630042ha req = 60.974435ha w + 3.601865362ha feed b	+ 872.3659598ha				
w = wheat = 23475kg	23,475kg w 1,423kg feed b					
Wagons loads Wagon days	Mule-trains 44 Mule-train days 89					
Novae 6059 + 144+ 7465 = 8987.576624ha [92] = 8654.918396ha w 332.65228ha b	Area A, 4 *vici*,, 61 of Conrad's 83 sites, 22 Poulter's *villae* 695 + 3840 + [73.494% of 10960 = 8054.939759] + 2640 = 15229.93976ha /2 x 0.77673 = 5914.775555ha + 872.3659598ha Sexaginta Prista surplus = 6787.141515ha = 6075.435687ha w 332.6582278ha b 379.0475998ha Feed b	- 2579.482709ha	6 *vici*, 11 of Conrad's 83, 83 Poulter's *villae* 80 Poulter's Ind sites 5760 + [13.253012% of 10960 = 1452.53012ha] + 9960 + 816 = 17988.53012ha /2 x 0.77673 = 6986.1155ha avail but 2903.892948ha req = 2579.482709ha w 324.4102386ha feed b	+ 4082.222552	28 Poulter's *villae* 19 Poulter's Individual sites 3360 + 193.8 = 3553.8ha /2 x0.77673 = 1380.171537ha	+ 5462.394089ha
Weight w = wheat = 3,332,144kg b = barley = 131400kg	2,339,043kg w 131,400kg b 149,724kg feed b		993,101kg w 128,142kg feed b			
Wagons loads Wagon days	4679 mule-trains 9358 mule-train days		2002 mule-trains 8009 mule-train days			
mule train day totals	9447		8009			
mule trains *pa*	17456 = 58 mule trains required *pa*					5462.394089ha

Appendix B.9: Summary Table Novae-Nicopolis

Model	Surplus available	Wagons/mule trains required
Direct routes across country calculated using radii		
23km Oxen	5822.479915ha +64.35%	30,640 wagon-days = 102 wagons *pa*
32km Oxen	5860.06866ha +64.76%	27,157 wagon-days = 91 wagons *pa*
50km Mule-drawn wagons	5281.112107ha +58.36%	21,931 wagon-days = 73 wagons *pa*
50km Mule-train	5634.429826ha +62.27%	13,208 wagon-days = 44 Mule trains *pa*
According to road network calculated using Service Areas		
23k Oxen	5716.09058ha + 63.17%	39,795 wagon-days = 133 wagons *pa*
32km Oxen	5797.006411ha +64.07%	32,693 wagon-days = 109 wagons *pa*
50km Mule-drawn wagons	4943.876231ha +54.64%	30,256 mule-train days = 101 wagons *pa*
50km Mule-trains	5462.394089ha +60.37%	17,456 mule-train days = 58 mule-trains *pa*

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[91] 41 soldiers 55 service providers = 12107kg w from 31.44593506ha and 11368kg w from 29.5285ha = 60.97443506ha.

[92] 6059 soldiers, 144 horse 7465 service providers = 1,789,132kg w from 4647.095623ha, 131400kg b from 332.658228ha, 1,543,011kg w from 4007.822773ha = 8987.576624ha.

Annex C Transport Solutions: Dobrogea

The total arable needs of garrison, cavalry, their farmers and service providers has been calculated as 55,427ha [Table T.3.3.1a], and this total need can be seen in Chapter Three to have plausibly been 76.35% met from the immediate vicinity of Dobrogea, but this calculation ignored the problems of transporting such foodstuffs.

The location of the soldiers can be posited because of the known garrison, accepting that many forts are known without a certain garrison so that the situation was probably very much more fluid than I will model upon. Nevertheless it was felt best to stick with the recorded distribution of forces. It is also necessary to locate 13,920 service providers derived from 20% of the suggested population for Dobrogea. There were three municipal centres, Durostorum, Tropaeum Traiani and Troesmis which have been excavated sufficiently to suggest populations on the basis of the ground plans of 5000 and a mere 800 individuals respectively. In the former case, because Durostorum was on the edge of my survey area I only model a quarter of that town's population as being provided from my study area, so 1250 civilians are allocated to Durostorum. Troesmis' urban area is not clearly defined, but the most recent survey suggests a 16ha *canabae* area; this work does not however describe the *municipium*, so this figure is doubled to a best guess of 3200 urbanites. Therefore 1250, 800 and 3200 service providers are imagined in these three *municipia* respectively; the remaining 8670 putative service providers are nominally split equally between the remaining 10 sites. Of course, this is arbitrary, putting 867 in each, and in some cases this is more than the garrison size, but any other adjustment for garrison size is no less speculative.

Having calculated a need for each site, in the first instance those settlements within a one day's travelling distance were considered using the Service Area function of ArcGIS. These Service Areas were generated so as to divide equally between adjacent consumption centres. Calculations below show in the first column what part of the need is met within one day's travelling time. Where there is deficit after a single day's travel, sites are sought from two or more days' travelling distance, by generating new Service Areas from the consumption centre where a deficit is felt. What is shown on the table below is a solution to the transport needs of the *limes* garrison in terms of vehicle loads and travelling days travelling to any particular garrison site. It is of course only one solution; there are countless possibilities, but what this method shows is the most effective transport solution using the minimum number of travelling days, and although there was no ArcGIS in antiquity, it is fair to assume that the Roman garrison derived its foodstuffs in as economical manner as possible, in terms of time and cost even if performed as *munera*.

The total need of 55,427ha included the food that would have fed the farmers working the fields, who are presumed to have eaten at source, so that the total was reduced by the needs of these framers to 42,653ha. As a percentage of the annual need, this represents 76.95279%, a factor which ought to also be applied to the total agricultural potential argued to be seen in Chapter Three of 42,320ha, - to arrive at an available potential of 32,566ha, allowing for that part of the potential which was being consumed at source by the farmers. Throughout Chapter Three, all needs and potentials were doubled to allow for alternate fallowing, but here in Chapter Four it is the annual potential which would have been required to be moved to consumer year on year, so that the potential was halved to 16,283ha.

The calculations below take the hectares to several decimal points to avoid rounding errors between kilograms and hectares, but the number of wagon loads is calculated to whole or half wagons, and the wagon days to whole days which are then divided by a 300 working day year.

Appendix C.1: 23km Oxen-drawn wagons Dobrogea

Garrison	Settlements, weight and wagons	+ surplus - deficit	Settlements, weights & wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit	Deficit after 5 days
	One day		Two days		Three days		Four days		Five days		Long-d solution
Durostorum 1515 + 36 + 1250 1162 + 83 + 671 = 1916.232479ha[93]	3 *vici*, 3 Ind = 2910.6ha /2 x 0.769527 = 1119.893953ha 1008.588709ha w 83.164557ha b 28.14068729ha feed b	- 824.479213 ha	No new solutions	- 824.479213ha	No new solutions	- 824.479213ha	No new solutions	- 824.479213ha	No new solutions	- 824.479213ha	- 824.479213ha
Weight w = wheat = 705731kg b = barley = 32850kg	388,306kg w 32,850kg b 11116kg feed b										
Wagons loads Wagon days	Loads = 1235 Wagon days = 2470										
Sucidava 347 + 78 + 867 266 + 180 + 465 = 911.8063968ha[94]	2 *vici* 4 Ind = 1960.8ha /2 x 0.769527 = 754.4451532ha 555.216705ha w 180.1898734ha b 19.03857516ha feed b	- 176.399819 ha	2 Ind = 20.4 /2 x 0.7695279 = 7.84918458ha 7.455218845ha w 0.393965735ha feed b	- 168.9446ha	No new solutions	- 168.9446ha	No new solutions	- 168.9446ha	No new solutions	- 168.9446ha	- 168.9446ha
Weight w = wheat = 281672kg b = barley = 71175kg	213,758kg w 71,175kg b 7,520kg feed b		2870kg w 156kg feed b								
Wagons loads Wagon days	Loads = 836 Wagon days = 1672		Loads = 8.6 Wagon days = 35								
Tropaeum Traiani 619 + 78 + 800 475 + 180 + 430 = 1084.45225[95]	3 *vici*, 2 *villae* 14 Ind = 3262.8ha /2 x 0.769527 = 1255.407816ha avail 1112.46995ha req 904.262377ha w 180.189873ha b 28.01770025ha feed b										
Weight w = wheat = 348141kg b = barley = 71175kg	348,141kg w 71,175kg b 11,067kg feed b	Needs met +142.937868 58ha to Sacidava	= 8.892585136 to Axiopolis = 134.0452807 to Sacidava	Needs met		Needs met		Needs met		Needs met	Needs met
Wagons loads Wagon days	Loads = 1230 Wagon days = 2459										
Sacidava 273 + 867 209+ 465 = 674.8604455ha[96]	1 *vicus* 6 Ind = 1021.2ha /2 x 0.769527 = 392.9209457ha 383.066639ha w 9.854307155ha feed b	- 291.793807 ha	1 Ind = 10.2 /2 x 0.7695279 = 3.92459229 + 134.0452807ha Tropaeum surplus = 137.969873ha 131.0448986ha w 6.924974417ha feed b	- 160.748908ha	1 *villa* +2 Ind = 140.4 /2 x 0.7695279 = 54.02085858ha 49.9510889ha w 4.069769682ha feed b	- 110.797819ha	1 Ind = 10.2 /2 x0.7695279 =3.92459229ha 3.530112283ha w 0.394480007ha feed b	- 107.267707ha	No new solutions	- 107.267707ha	- 107.267707ha
Weight w = wheat = 259821kg	147,481kg w 3,892 feed b		50,452kg w 2,735kg feed b		19,231kg w 1,608kg feed b		1359kg w 156kg feed b				
W wagons loads Wagon Days	Loads = 432 Wagon days = 865		Loads = 152 Wagon days = 608		Loads = 60 Wagon days = 357		Loads = 4.3 W-days = 35				
Axiopolis 400 +867 307 + 465 = 772.2661468ha[97]	1 *polis*, 7 Ind = 1031.4 / 2 x 0.769527 = 396.845538ha 386.892804ha w 9.95273443ha feed b	- 385.373343 ha	1 *vicus* 7 Ind = 1031.4 /2 x 0.7695279 = 396.845538ha + 8.89258 surplus = 405.7381231 385.373343ha w 20.36478014ha feed b	Needs met		Needs met		Needs met		Needs met	Needs met
Weight w = wheat = 297322kg	148,954kg w 3,931kg feed b		145,117kg w 7868kg feed b								
Wagons loads Wagon days	Wagon loads = 437 Wagon days = 874		Wagon loads = 447 Wagon days = 1788								
% of 5359.617718ha moved by travelling day	3681.571536ha = 68.6909%		523.8734604ha = 9.7745%		49.9510889ha = 0.932%		3.530112283ha = 0.0659%				1100.691521ha = 20.5368%
Wagon days sub total	8339		2430		418		35				
Wagon days this page	11161 = 37 pa										

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[93] 1515 men, 36 horse, 1250 service providers = 447357kg bread wheat, 32,850kg barley, 25,8374kg bread wheat from1161.965649ha, 83.164557 and 671.102273ha = 1916.232479ha.

[94] 347 men, 78 horse and 867 service providers = 102464kg bread wheat, 71175kg barley, 179208kg bread wheat from 266.139987ha, 180.1898734ha and 465.4765364ha = 911.8063968ha.

[95] 619 men, 78 horse, 800 service providers = 182781kg bread wheat, 71175kg barley, 165360kg bread wheat from 474.756922ha, 180.189873ha and 429.505455ha = 1084.45225ha.

[96] 273 men, 867 service providers = 80613kg + 179208kg bread wheat from 674.860445ha.

[97] 400 men, 867 service providers = 118114kg + 179208kg bread wheat from 772.266146ha.

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So the table above shows that in the southern part of Dobrogea, after three days travel, 4259ha of arable was potentially available to the garrison, leaving a deficit of 1101ha, as a percentage only 20.54% of the need.

Because of shortfalls that will become evident in north Dobrogea, it is suggested this was either met by shipments from the Novae-Nicopolis region or through an overseas solution that will be considered through Appendix D.

Garrison	Settlements, weight and wagons		Settlements, weights & wagons		Long distance solution
	One day		Two days		
Capidava 546 +867 419 + 465 = 884.2443546ha[98]	5 *vici*, 4 *villae*, 4 Ind = 5320.8ha /2 x 0.7695279 = 2047.252025ha = 906.9913515ha 884.244355ha w 22.74699647ha feed b	Needs met + 1140.260674ha	= 1140.260674ha to Carsium		
Weight w = wheat = 340434kg	340,434kg w 8,985kg feed b				
Wagons loads 973 Wagon days	Loads = 998 Wagon days = 1997				
Carsium 624 + 662+ 867 479 + 1529 + 465 = 2473.372126ha[99]	2 *vici* 3 Ind = 1950.6ha / 2 x 0.7695279 = 750.5205609 = 356.193060ha w 375.2602805ha b 19.06722038ha feed b	-1741.918785ha	4 *vici*, 1 *villa*, 13 Ind = 4092.6 /2 x 0.769528 = 1574.684942 +1140.260674ha Capidava surplus = 2714.945616ha avail but 1835.55326ha req = 587.875269ha w 1154.043517ha b 93.63447476ha feed b	Needs net + 879.3923558ha	Needs net + 870.3923558ha
Weights w = wheat = 363466kg b = barley = 604075kg	137,134kg w 148,228kg b 7,532kg feed b		226,332kg w 455,847kg b 36,986kg feed b		
Wagons loads 2764 Wagon days	Loads = 837 Wagon days = 1674		Loads = 2055 Wagon days = 8219		
Cius 347 + 78 + 867 266 + 180 + 465 = 911.8063968ha[100]	3 *vici* 1 *villa* 3 Ind = 3030.6ha /2 x 0.7695279 = 1166.065627ha avail but 935.3828195hareq = 731.6165234ha w 180.1898734ha b 23.57642268ha feed b	+ 230.6828075ha			+ 230.6828075ha
Weights w = wheat = 281672kg b = barley = 71175kg	281,672kg w 71,175kg b 10,378g feed b				
Wagons loads 1008 Wagon days	Loads = 1035 Wagon days = 2069				
% of 4269.422877ha moved by travelling day	2527.504093ha = 59.2%		1741.918786ha = 40.8%		+ 1101.020431ha surplus
Wagon loads sub totals	5740		8219		
Wagon days this page	13959 = 47pa				

In the centre of Dobrogea, the needs of Capidava, Carsium and Cius can be seen to have been met locally with a surplus of 1101ha directed to the north.

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[98] 546 men, 867 service provider = 161225.61kg + 179208.46kg bread wheat from 418.767818 + 465.4765364 = 884.2443546ha.
[99] 624 men, 662 horse 867 service providers = 184258kg bread wheat, 604075kg barley, 179208kg bread wheat from 478.5917922ha, 1529.303797ha 465.4765364ha respectively = 2473.372126ha.
[100] 347 men, 78 horse and 867 service providers = 102464kg bread wheat, 71175kg barley, 179208kg bread wheat from 266.139987ha, 180.1898734ha and 465.4765364ha respectively = 911.8063968ha.

In the north in the first instance, because the legionary garrison at Troesmis was closer to most sites than Arrubium, Dinogetia and [Barboşi], it took all the arable potential, while the latter three forts had no supply solutions beyond their immediate vicinity, this despite Troesmis being only a little closer than Arrubium and Dinogetia to many of the producer sites. Therefore, the programme was interrogated with overlapping Service Areas rather than dividing the Service Areas between nearest consumption centres. Sites within two days, 46km, of Troesmis and Noviodunum were divided between the two so that Noviodunum's needs were met and a surplus was available to Dinogetia and [Barboşi] within three, or four days' travelling of these. At three days distance from Troesmis and Arrubium, sites were divided between the two: those within 69km only of Arrubium were directed there, and those within 69km of both which were directed to Troesmis. Further afield it was impossible to discern which of these two forts was closer to particular producer sites, so that producer sites were divided evenly between the pair. Similarly, the surplus from Capidava was divided evenly between Troesmis and Arrubium, although this surplus could have reached Troesmis in a shorter time than Arrubium.

Garrison	Settlements, weight & wagons	+ surplus - deficit	Settlements, weights & wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit	Deficit after 5 days
	One day		Two days		Three days		Four days		Five days		Long distance solution
Troesmis 6059 + 144 + 3200 4647ha + 333ha + 1718ha = 6697.775669ha[101]	2 *vici*, 1 *villa* 3 Ind = 2070.6ha /2x 0.7695279 = 796.6922349ha 443.836571ha w 332.658228ha b 20.19743655ha feed b	- 5921.280871ha	1 *villae* 12 Ind102 = 242.4ha /2 x 0.7695279 = 93.26678148ha w 88.58554157ha w 4.681239909ha feed b	- 5832.695329ha	3 *vici* 2 Ind = 2900.4ha /2 x 0.7695279 = 1115.969361 1031.895572ha w 84.07378911ha feed b	- 4800.799758 ha	1 *villa* 10 Ind = 222ha /2 x 0.7695279 = 85.4175969 + (1110.075163ha centre surplus /2 = 555.0375816) = 640.4551785ha 576.0798894ha w 64.37528912ha feed b	- 4224.719868ha	(1 *vicus* 6 Ind)/2 = 510.6ha /2 x 0.7695279 = 196.4604729ha 171.7603454ha w 24.70012754ha feed b	- 4052.959523ha	- 4052.959523ha
Weights w = wheat = 2450570kg b = barley = 131400kg	170,877kg w 131,400kg b 7978kg feed b		34,105kg w 1,849kg feed b		397,280kg w 33,209kg feed b		221,790kg w 25,428kg feed b		66,128kg w 9,757kg feed b		
Wagons loads Wagon days	Loads = 886 Wagon days = 1773		Loads =103 Wagon days =411		Loads = 1230 Wagon days = 7380		Loads = 706 Wagon days = 5651		Loads = 217 Wagon days = 2168		
Arrubium 624 + 662 + 867 479ha + 1529ha + 465ha = 2473.372126ha[103]	I *vicus* 2 Ind = 980.4ha /2 x 0.7695279 = 377.2225766 179.027825ha w 188.6112883ha b 9.583462967ha feed b	- 2105.733012 ha	No new solutions	- 2106.798613 ha	2 *vici* 1 *villa* 2 Ind = 2060.4ha /2 x0.7695279 = 792.7676426 335.8834356ha w 396.3838213ha b 60.50038567ha feed b	- 1373.465755	1 *villa* 10 Ind = 222ha /2 x0.7695279 = 85.4175969 34.01155398ha w 42.70879845ha b 8.697244465ha feed b	- 1296.745403	(1 *vicus* 6 Ind)/2 = 510.6ha /2 x 0.7695279 = 196.4604729 + (1110.075163ha centre surplus /2) = 555.0375816 = 751.4980545ha 280.0393727ha w 375.7490273ha b 95.70965458ha feed b	- 640.957003 ha	- 640.957003ha = 115.106141ha w 525.850862ha b
Weights w = wheat = 363466kg b = barley = 604075kg	68,926kg w 74,501kg b 3,785kg feed b				129,315kg w 156,572kg b 23,898kg feed b		13,094kg w 16,870kg b 3,435kg feed b		107,815kg w 148,421kg b 37,805kg feed b		
Wagons loads Wagon days	Loads = 421 Wagon days = 841		Loads Wagon days		Loads = 885 Wagon days = 5310		Loads = 95 Wagon days = 763		Loads = 840 Wagon days = 8401		
(Barbosi) 137 + 867 105ha + 465ha = 570.551978ha[104]	1 *vicus* 4 Ind = 1000.8ha /2 x 0.7695279 = 385.0717612ha 375.414309ha w 9.657452607ha feed b	- 195.137669 ha	No new solutions	- 195.137669 ha	No new solutions	- 195.137669 ha	+ 203.9647641ha Noviodunum surplus 183.4632659ha w 20.50149815ha feed b	- 11.674403ha	No new solutions	- 11.674403ha	- 11.674403ha
Weight w = wheat = 219662kg	144,535kg w 3,815kg feed b						70,633kg w 8,098kg feed b				
Wagons loads Wagon days	Loads = 424 Wagon days = 848						Loads = 225 Wagon days = 1800				

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[101] 6059 men, 144 horse, 3200 service providers = 1789132 bread wheat, 131400kg barley, 661438kg bread wheat from 4647.095623ha, 332.6582278ha and 1718.021818ha = 6697.775669ha.

[102] Including sites closer to Noviodunum, but still within 2 days travel of Troesmis and while Noviodunum has a surplus from two days travel it is logical to divert these to Troesmis.

[103] 624 men, 662 horse, 867 service providers = 184258kg bread wheat, 604075kg barley 179208kg bread wheat, from 478.5917922ha, 1529.303797ha and 465.4765364ha = 2473.37126ha.

[104] 137 men, 867 service providers = 40454kg + 179208kg bread wheat from 105.0754416 + 465.4765364 = 570.551978ha.

Dinogetia 136 + 867 104ha + 465ha = 569.7850039ha[105]	1 *vicus* 3 Ind = 990.6ha /2 x 0.7695279 = 381.1471689ha w 371.588144ha w 9.559025332ha feed b	- 198.196860ha	No new solutions	- 198.196860ha	+ 214.344968ha w Noviodunum surplus 198.196860ha w 18.20767409ha feed b	Needs met		Needs met		Needs met	
Weight w = wheat = 219367kg	144,535kg w 3,776kg feed b				76,306kg w 6,379236kg feed b						
Wagons loads 627 Wagon days	Loads = 420 Wagon days = 839				Loads = 240 Wagon days = 1417						
Noviodunum 1200 + 867 920ha + 465ha =1385.845368ha[106]	2 *vici* 3 *villae* 15 Ind = 2433ha /2 x 0.7695279 = 936.1306904 912.652890ha w 23.47779995ha feed b	- 473.192477ha	2 *vicus* 3 *villae* 10 Ind = 2382ha /2 x 0.76952279 = 916.5077289ha avail but 498.1979968ha req 473.192477ha w 25.00551974ha feed b	Needs met + 418.3097321ha =214.344968ha w To Dinogetia + 203.9647641ha to (Barboşi)							
Weight w = wheat = 533550kg	351,371kg w 9,274kg feed b		182,179kg w 9,877kg feed b								
Wagons loads 1524 Wagon days	Loads = 1030 Wagon days = 2061		Loads = 549 Wagon days = 2195								
% 11697.33014ha moved by travelling day	2803.789254ha = 23.9695%		561.7780186ha = 4.8026%		1962.359689ha = 16.7761%		836.2635078ha = 7.1492%		827.5487453ha = 7.0747%		4705.59093ha = 40.23% 4179.740067ha w 525.850862ha b
Wagon days sub total	6362		2606		14108		8214		10569		
Wagon days this page	41858 = 139.5 pa										
Total wagon days	13959 + 11161 from centre & south + 41767 = 66978 wagon days /300 working days pa = 223 wagons at work										

As was seen in Chapter Three, there was insufficient settlement activity to provide food to the garrison: of a need of 11,697ha in the north, even when surpluses are moved from Carsium and Capidava, there was still a 40.23%, 4706ha deficit.   Therefore, a long distance solution would have been necessary.

Appendix C.1a: Comparison table % moved by travelling day - see Table 4.2.3.1 in main thesis

	Day one	Day two	Day three	Day four	Day five	deficit
% of 5359.617718ha moved by travelling day	3681.571536ha = 68.69%	523.8734604ha = 9.77%	49.9510889ha = 0.93%	3.530112283ha = 0.066%		1100.691521ha = 20.54%
Total Number of wagon days for southern area 11161 = 37 pa wagons *pa*						
% of 4269.422877ha moved by travelling day	2527.504093ha = 59.2%	1741.918786ha = 40.8%				0%
Total Number of wagon days for central area = 13959 = 46.5pa						
% 11697.33014ha moved by travelling day	2803.789254ha = 23.97%	561.7780186ha = 4.80%	1962.359689ha = 16.78%	836.2635078ha = 7.15%	827.5487453ha = 7.07%	4705.59093ha = 40.23%
Total number of wagon days for north 41858 = 139.5 pa						
For whole Dobrogea						
% of original 21,326.37074ha need by travelling day	9012.864883ha = 42.26%	2827.570265ha = 13.26%	2012.31078ha = 9.44%	839.79362ha = 3.94%	827.5487453ha = 3.88%	5806.282450ha = 27.23%
Total number of wagon days = 66,978 = 223 *pa*						

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[105] 136 men, 867 service providers = 40159kg + 179208kg bread wheat from 104.3084675 + 465.4765364 = 569.7850039ha.
[106] 1200 men, 867 service providers = 354342kg + 179208kg bread wheat from 920.3688312 + 465.4765364 = 1385.8453676ha.

Appendix C.2: 32km Oxen-drawn wagons, Dobrogea

Garrison	Settlements, weight and wagons	+ surplus - deficit	Settlements, weights & wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit	Deficit after 5 days
	One day		Two days		Three days		Four days		Long-d solution
Durostorum $1515 + 36 + 1250$ $1162 + 83 + 671$ $= 1916.232479$ha[107]	3 *vici*, 3 Ind = 2910.6ha /2 x 0.7695279 = 1119.893953ha 1008.588709ha w 83.16455696ha b 28.14068729ha feed b	- 824.479213ha	No new solutions	- 824.479213ha	No new solutions	- 824.479213ha	No new solutions	- 824.479213ha	- 824.479213ha
Weight w = wheat = 705731kg b = barley = 32850kg	388,307kg w 32,850kg b 11,116kg feed b								
Wagons loads Wagon days	Loads = 1235 Wagon days = 2470								
Sucidava $347 + 78 + 867$ $266 + 180 + 465$ $= 911.8063968$ha[108]	2 *vici* 5 Ind = 1971ha /2 x 0.7695279 = 758.3697455ha 559.042879ha w 180.1898734ha b 19.13700243ha feed b	- 172.573654ha	No new solutions	- 172.573654ha	No new solutions	- 172.573654ha	No new solutions	- 172.573654ha	- 172.573654ha
Weight w = wheat = 281672kg b = barley = 71175kg	215,232kg w 71,175kg b 7,559kg feed b								
Wagons loads Wagon days	Loads = 840 Wagon days = 1680								
Tropaeum Traiani $619 + 78 + 800$ $475 + 180 + 430$ $= 1084.45225$[109]	3 *vici*, 3 *villae* 18 Ind = 3423.6ha /2 x 0.7695279 = 1317.277859ha avail but 1112.46995ha req 904.2623766ha w 180.1898734ha b 28.01770025ha feed b								
Weight w = wheat = 348141kg b = barley = 71175kg	348,141kg w 71,175kg b 12,333kg feed b	Needs met +204.8079088ha	= 6.456957152 to Axiopolis = 198.6750388 to Sacidava	Needs met		Needs met		Needs met	Needs met
Wagons loads Wagon days	Loads = 1233 Wagon days = 2466								
Sacidava $273 + 867$ $209+ 465$ $= 674.8604455$ha[110]	1 *vicus* 6 Ind = 1021.2ha /2 x 0.7695279 = 392.9209457ha 383.066639ha w 9.854307155ha feed b	-291.793807ha	2 Ind = 20.4 /2 x 0.7695279 = 7.84918458 + 198.6750388ha Tropaeum surplus = 206.2001364a 195.8505533ha w 10.34958313ha feed b	- 95.635433ha	1 Ind = 10.2 /2 x 0.76953 = 3.92459229ha 3.628925262ha w 0.295667028ha feed b	- 92.006508	No new solutions	- 92.006508	- 92.006508
Weight w = wheat = 259821kg	147,480kg w 3,892kg feed b		75,402kg w 4,088kg feed b		1397kg w 117kg feed b				
Wagons loads Wagon Days	Loads = 432 Wagon days = 865		Loads = 227 Wagon days = 908		Loads = 4.3 Wagon days = 26				
Axiopolis $400 +867$ $307 + 465$ $= 772.2661468$ha[111]	2 *vicus/polis* 12 Ind = 2042.4ha / 2 x 0.7695279 = 785.8418915ha 766.133277ha w 19.70861431ha feed b	- 6.132870	+ 6.456957152ha Tropaeum surplus 6.132870ha w 0.3240871519ha feed b	Needs met		Needs met		Needs met	Needs met
Weight w = wheat = 297322kg	294,961kg w 7,785kg feed b		2361kg w 128kg feed b						
Wagons loads Wagon days	Loads = 865 Wagon days = 1730		Loads = 7 Wagon days = 28						
% of 5359.617718ha moved by travelling day	4064.638175ha = 75.838%		201.9834233ha = 3.7686%		3.596001928ha = 0.067%				1089.059374ha = 20.3197%
Wagon day sub totals	9204		937		24				
Wagon days this page	10169 = 34 *pa*								

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[107] 1515 men, 36 horse, 1250 service providers = 447357kg bread wheat, 32,850kg barley, 25,8374kg bread wheat from1161.965649ha, 83.16455696and 671.1022727ha = 1916.23247866ha.

[108] 347 men, 78 horse and 867 service providers = 102464kg bread wheat, 71175kg barley, 179208kg bread wheat from 266.139987ha, 180.1898734ha and 465.4765364ha = 911.8063968ha.

[109] 619 men, 78 horse, 800 service providers = 182781kg bread wheat, 71175kg barley, 165360kg bread wheat from 474.7569221ha, 180.1898734ha and 429.5054545ha = 1084.45225ha.

[110] 273 men, 867 service providers = 80613kg + 179208kg bread wheat from 209.3839091 + 465.4765364 = 674.8604455ha.

[111] 400 men, 867 service providers = 118114kg + 179208kg bread wheat from 306.7896104 + 465.4765364 = 772 .2661468ha.

In the 32km model, the above table above shows that in southern Dobrogea all the self-suggested *limes* providing sites, except for three individual sites, were within a 32km of the five garrison sites. Of the 5360ha need, 4270ha was visible in the south, resulting in a 20.32% deficit of 1089ha, suggested to have been met either from Novae-Nicopolis or by overseas shipments.

Garrison	Settlements, weight and wagons		Settlements, weights & wagons		Long distance solution
	One day		Two days		
Capidava 546 +867 419 + 465 = 884.2443546ha[112]	6 vici, 4 villae, 10 Ind = 6342ha /2 x 0.769528 = 2440.172971ha 909.5931317ha 884.2443546ha w 22.74699646ha feed b	Needs met + 1533.18162ha to Carsium			
Weight w = wheat = 340434kg	340434kg w 10013kg feed b				
Wagons loads Wagon days	Loads = 1001 Wagon days = 2002				
Carsium 624 + 662+ 867 479 + 1529 + 465 = 2473.372126ha[113]	2 vici 3 Ind = 1950.6ha / 2 x 0.769528 = 750.5205609 356.193060ha w 375.2602805ha b 19.06722038ha feed b	-1741.918785ha	4 vici, 2 villa, 8 Ind = 4161.6 /2 x 0.7695279 = 1601.233654 + 1533.18162ha Capidava surplus = 3134.415274ha avail but 1835.55326ha req 587.875269ha w 1154.043517ha b 93.63447451ha feed b	Needs net + 1298.862014ha = to north	+ 1298.862014ha
Weights w = wheat = 363466kg b = barley = 604075kg	137,134kg w 148,228kg b 7,532kg feed b		226,332kg w 455,847kg b 36,986kg feed b		
Wagons loads Wagon days	Loads = 837 Wagon days = 1674		Loads = 2055 Wagon days = 8219		
Cius 347 + 78 + 867 266 + 180 + 465 = 911.8063968ha[114]	3 vici 1 villa 6 Ind = 3061.2ha /2 x 0.769528 = 1177.839404ha 938.0794691 731.6165234ha w 180.1898734ha b 23.57642268ha feed b	+ 242.4565845			+ 242.4565845
Weights w = wheat = 281672kg b = barley = 71175kg	281672kg w 71175kg b 10378kg feed				
Wagons loads Wagon days	Loads = 1038 Wagon days = 2076		Loads = 2055 Wagon days = 8219		+1541.318599
% of 4269.422877ha moved by travelling day	2527.5041ha = 59.2001%		1741.918786ha = 40.7999%		0%
Wagon day sub totals	5740		8219		
Wagon days this page	13959 = 47 *pa*				

In the centre of Dobrogea the needs of Capidava, Carsium and Cius can be seen to have been met within two 32km travelling days with a surplus of 1541ha that can have been directed to Troesmis and Arrubium.

For the north of Dobrogea, again because the legionary garrison at Troesmis was closer to the producers than Arrubium, Dinogetia and [Barboşi], initially it took all the arable potential, while the latter three forts had no supply beyond their immediate vicinity. Therefore, the programme was again interrogated with overlapping service areas. At two days' distance the sites within 64km of Noviodunum, Troesmis and Arrubium were divided first between Noviodunum whose needs were met in full and the latter two sites on the basis of proximity to Noviodunum, but also as to whether they were within three days of Dinogetia and [Barboşi]. To the

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[112] 546 men 867 service provider = 161225.61kg + 179208.46kg bread wheat from 418,7678182ha + 465.4765364 = 884.2443546ha.
[113] 624 men 662 horse 867 service providers = 184258kg bread wheat, 604075kg barley, 179208kg bread wheat from 478.5917922ha, 1529.303797ha 465.4765364ha respectively = 2473.372126ha.
[114] 347 men, 78 horse and 867 service providers = 102464kg bread wheat, 71175kg barley, 179208kg bread wheat from 266.139987ha, 180.1898734ha and 465.4765364ha respectively = 911.8063968ha.

south and east the potential from those sites that were within 64km of just Arrubium was directed there, and that within 64km of both, which was directed to Troesmis. Similarly, the surplus from Carsium (originally mostly from Capidava) and Cius was divided evenly between both consumer sites, although this could have reached Troesmis in a shorter time than Arrubium.

Garrison	Settlements, weight and wagons	+ surplus - deficit	Settlements, weights & wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit	Settlements, weight and wagons	+ surplus - deficit	Deficit after 4 days
	One day		Two days		Three days		Four days		Long distance solution
Troesmis 6059 + 144 + 3200 4647ha + 333ha + 1718ha = 6697.775669ha[115]	2 *vici*, 1 *villa* 4 Ind = 2080.8ha /2x 0.769528 = 800.6168272ha 447.662736ha w 332.658228ha b 20.29586382ha feed b	- 5917.454706ha	3 *vici* 1 *villae* 6 Ind[116] = 3061.2ha /2 x 0.7695279 = 1177.839404ha 1118.721369ha w 59.1180347ha feed b	- 4798.733337ha	(9 Ind /2 = 45.9) + (1 *vicus* 1 Ind)/2 = 485.1) =531 /2 x 0.7695279 = 204.3096575 + 63.61397317ha Noviodunum 2 day surplus + (1541.318599 centre surplus /2 = 770.6592995) = 1038.582293ha avail 960.3392028ha w 78.24372718ha feed b	- 3838.394134	(1 Ind) = 10.2 /2 x 0.769528 3.92459229ha 3.5301123ha w 0.39448ha feed b	- 3834.864022ha	- 3834.864022ha
Weights w = wheat = 2450570kg b = barley = 131400kg	172,350kg w 131,400kg b 8,017kg feed b		430,708kg w 23,352kg feed b		369,731kg 30,906kg feed b		1359kg w 156kg feed b		
Wagons loads Wagon days	Loads = 891 Wagon days = 1782		Loads = 1297 Wagon days = 5189		Loads = 1145 Wagon days = 6868		Loads = 4.3 Wagon days = 34		
Arrubium 624 + 662 + 867 479ha + 1529ha + 465ha = 2473.372126ha[117]	1 *vicus* 2 Ind = 980.4 /2 x 0.7695279 = 377.2225766ha = 179.027825ha w 188.6112883ha b 9.583462967ha feed b	- 2105.733012ha	1 *vicus* 2 *villa* 5 Ind = 1251ha /2 x 0.7695279 = 481.3397015 = 216.1967234ha w 240.6698508ha b 24.47312738ha feed b	- 1648.866438ha	(9 Ind /2 = 45.9) /2 x 0.7695279 = 17.66066531 7.482551786ha w 8.83033266ha b 1.347780869ha feed b	- 1632.553554	(1 *vicus* 1 Ind/2) = 485.1 /2 x 0.7695279 = 186.6489921 + (1541.318599 centre surplus /2 = 770.6592995) = 957.3082916ha avail 381.18074ha w, 478.65415ha b 97.473408ha feed b	- 772.718670ha	- 772.718670ha
Weights w = wheat = 363466kg b = barley = 604075kg	68,926g w 74,501kg b 3,785kg feed b		82,236kg w 95,065kg b 9,667kg feed b		2881kg w 3488kg b 532kg feed b		146,755kg w 189,068kg b 38,502kg feed b		
Wagons loads Wagon days	Loads = 421 Wagon days = 841		Loads = 537 Wagon days = 2148		Loads = 20 Wagon days = 118		Loads = 1069 Wagon days = 8556		
(Barbosi) 137 + 867 105ha + 465ha = 570.551978ha[118]	1 *vicus* 4 Ind = 1000.8ha /2 x 0.7695279 = 385.0717612ha 375.414309ha w 9.657452607ha feed b	- 195.137669ha	No new solutions	- 195.137669ha	+ 211.0365291ha Noviodunum 2 day surplus 195.137669ha w 15.89886ha feed b	Needs met			
Weight w = wheat = 219662kg	144,534kg w 3,815kg feed b				75128kg w 6280kg feed b				
Wagons loads Wagon days	Loads = 424 Wagon days = 848				Loads = 233 Wagon days = 1396				
Dinogetia 136 + 867 104ha + 465ha = 569.7850039ha[119]	1 *vicus* 3 Ind = 990.6ha /2 x 0.7695279 = 381.1471689 371.5881441ha w 9.559025332ha feed b	- 198.196860ha	No new solutions	- 198.196860ha	+ 214.344968ha Noviodunum 2 day surplus 198.196860ha w 16.148108ha feed				
Weight w = wheat = 219367kg wagons loads 628	14,3061kg w 3,776kg feed b				76306kg w 6379kg feed b	Needs met			
Wagon days	Loads = 420 Wagon days 839				Loads = 236 Wagon days = 1417				

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[115] 6059 men, 144 horse, 3200 service providers = 1789132 bread wheat, 131400kg barley, 661438kg bread wheat   from 4647.095623ha, 332.6582278ha and 1718.021818ha = 6697.775669ha.

[116] Including sites closer to Noviodunum, but still within 2 days travel of Troesmis and while Noviodunum has a surplus within two days' travel it is logical to divert these to Troesmis.

[117] 624 men, 662 horse, 867 service providers = 184258kg bread wheat, 604075kg barley 179208kg bread wheat, from 478.5917922ha, 1529.303797ha and 465.4765364ha = 2473.37126ha.

[118] 137 men, 867 service providers = 40454kg + 179208kg bread wheat from 105.0754416 + 465.4765364 = 570.551978ha.

[119] 136 men, 867 service providers = 40159kg + 179208kg bread wheat from 104.3084675 + 465.4765364 = 569.7850039ha.

Noviodunum 1200 + 867 920ha + 465ha =1385.845368ha[120]	3 *vici* 4 *villae* 23 Ind = 3594.6 /2 x 0.7695279 = 1383.072495 1348.385565ha w 34.6869296ha feed b	- 37.459802ha	1 *vicus* 2 *villae* 17 Ind [excluding sites also within 2 days of Troesmis] = 1373.4 /2 x 0.7695279 = 528.4348089avail but 39.43933859ha req 37.459802ha w 1.979536586ha feed b	Needs met + 488.9954703	= 214.344968ha to Dinogetia = 211.0365291ha to Barbosi = 63.61397317ha to Troesmis			
Weight w = wheat = 533550kg	519,128kg w 13,701kg feed b		14422kg w 782kg feed b					
Wagons loads Wagon days	Loads = 1522 Wagon days = 3045		Loads = 43 Wagon days = 174					
% of 11697.33014ha northern needs by travelling day	3243.348094ha = 27.727%		1613.047746ha = 13.7899%		1369.986617ha = 11.711%		863.365ha = 7.3809%	4607.582692ha = 39.39% 3995.044512ha w 612.538180ha b
Wagon days sub total	7354		7511		9712		8591	
Wagon days this page	33255 = 110 *pa*							
Total wagon days	10167 + 13959 from south & centre + 33255= 57381 wagon days /300 working days pa = 191							

As was seen in Chapter Three, there is insufficient settlement activity to provide food to the garrison: of a need of 11,697ha in the north, even when surpluses were moved from Carsium and Capidava, there was still a

4606ha deficit. Therefore, a long distance solution would have been necessary.

Appendix C.2a: Comparison table % moved by travelling day - see also Table 4.2.3.1 in main thesis

% 21326.37074 to be moved by travelling day	Day one	Day two	Day three	Day four	Day five	deficit
% of 5359.617718ha moved by travelling day	4064.638175ha = 75.84%	201.9834233ha = 3.77%	3.596001928ha = 0.067%			1089.059374ha = 20.3197%
Total Number of wagon days for southern area 10167 = 34 *pa*						
% of 4269.422877ha moved by travelling day	2527.504093ha = 59.2%	1741.918786ha = 40.8%				0%
Total Number of wagon days for central area = 13959 = 46.5pa						
% 11697.33014ha moved by travelling day	3243.348094ha = 27.73%	1613.047746ha = 13.79%	1369.986617ha = 11.71%	863.365ha = 7.38%		4607.582692ha = 39.39% 3995.044512ha w 612.538180ha b
Total number of wagon days for north 33255 = 111 *pa*						
For Whole Dobrogea						
% of original 21,326.37074ha need by travelling day	9835.4903608ha = 46.12%	3556.949954ha = 16.68%	1373.61554ha = 6.44%	863.365ha = 4.05%		5696.949887ha = 26.71%
Total number of wagon days = 57381 = 191 *pa*						

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[120] 1200 men, 867 service providers = 354342kg + 179208kg bread wheat from 920.3688312 + 465.4765364 = 1385.8453676ha.

Appendix C.3: 50km Mule-drawn wagons, Dobrogea

Garrison	Settlements, weight & wagons	+ surplus - deficit	Settlements, weight & wagons	+ surplus - deficit	Deficit after Two days
	One day's distance, two days travelling = 32kg feed from 0.08101265823ha barley		Two days' distance, four days travelling = 64kg feed from 0.1620253165ha barley		Long Distance Solution
Durostorum 1515 + 36 + 1250 1162 + 83 + 671 = 1916.232479ha [121]	3 *vici* 3 Ind = 2910.6 /2 x 0.7695279 = 1119.893953ha Total Potential Load = ((Cargo = (Potential w – Feed b) + Potential b) + Feed b 936.506776ha w + 83.164557ha b + 100.2226201ha Feed b	- 896.561146ha		- 896.561146ha	- 896.561146ha
Weight w = wheat = 705731kg b = barley = 32850kg	360,555kg w 32,850kg b 39,588kg feed b				
Wagons loads Wagon days	Loads = 1237 Wagon days = 2474				
Sucidava 347 + 78 + 867 266 + 180 + 465 = 911.8063968ha [122]	2 *vici* 5 Ind = 1971 /2 x 0.7695279 =758.3697455ha Potential Load = ((Cargo = (Potential w – Feed b) + Potential b)) + Feed b 510.023736ha w + 180.1898734ha b + 68.1561365ha Feed b	- 221.592788ha		- 221.592788ha	- 221.592788ha
Weight w = wheat = 281672kg b = barley = 71175kg	196,359kg w 71,175kg b 26,922kg feed b				
Wagons loads Wagon days	Loads = 841 Wagon days 1682				
Tropaeum Traiani 619 + 78 + 800 475 + 180 + 430 = 1084.45225 [123]	3 *vici* 3 *villae* 18 Ind = 3423.6 /2 x 0.7695279 = 1317.277859ha Potential Load = (Cargo = Potential w + Potential b) + Feed b 904.262377ha w + 180.1898734ha) + 106.8235992ha Feed b	Needs met +126.00200 09	= 54.31998594ha to Axiopolis = 71.6820236ha to Sacidava		Needs met
Weight w = wheat = 348141kg b = barley = 71175kg	348,141kg w 71,175kg b 42,195kg feed b				Needs met
Wagons loads Wagon days	Loads 1319 Wagon days 2637				
Sacidava 273 + 867 209 + 465 = 674.8604455ha [124]	1 *vicus* 6 Ind = 1021.2ha /2 x 0.7695279 = 392.9209457ha Potential + 71.6820236ha Tropaeum surplus = 464.602969ha avail Load = (Cargo = (Potential w – Feed b) + Feed b) = 423.104321ha w + 41.49864792ha Feed b	- 251.756124ha	1 Ind = 10.2 /2 x0.7695279 = 3.92459229ha Potential Load = (Cargo = (Potential w – Feed b)) + Feed b = 3.221867601ha + 0.702724689ha	- 248.534257ha	- 248.534257ha
Weight w = wheat = 259821kg	162,895kg w 16,392kg feed b		1240kg w 278kg feed b		
Wagons loads Wagon Days	Loads = 512 Wagon days = 1024		Loads = 4.337 Wagon days = 17		
Axiopolis 400 +867 307 + 465 = 772.2661468ha [125]	2 *vici* 14 Ind = 2062.8 /2 x 0.7695279 = 793.6910761 Potential + 54.31998594ha Tropaeum Surplus within 1 day of Axiopolis = 848.011063ha Load = (Cargo = Potential w) + Feed b 772.266147ha w + 75.74491521ha Feed b	Needs met			Needs met
Weight w = wheat = 297322kg	297,322kg w 29,919kg feed b				
Wagons loads Wagon days	Loads 935 Wagon days 1870				
% of 5359.617718ha moved by travelling day	3989.70766 = 74.440%		3.221867601ha = 0.0601%		1366.688190ha = 25.4997%
	Total Number of wagon days for southern area 9705 = 32 wagons *pa*				

With increased feed-barley requirements the deficit was greater than that seen with oxen above.

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[121] 1515 men, 36 horse, 1250 service providers = 447357kg bread wheat, 32,850kg barley, 25,8374kg bread wheat from1161.965649ha, 83.16455696and 671.1022727ha = 1916.23247866ha.

[122] 347 men, 78 horse and 867 service providers = 102464kg bread wheat, 71175kg barley, 179208kg bread wheat from 266.139987ha, 180.1898734ha and 465.4765364ha = 911.8063968ha.

[123] 619 men, 78 horse, 800 service providers = 182781kg bread wheat, 71175kg barley, 165360kg bread wheat from 474.7569221ha, 180.1898734ha and 429.5054545ha = 1084.45225ha.

[124] 273 men, 867 service providers = 80613kg + 179208kg bread wheat from 209.3839091 + 465.4765364 = 674.8604455ha.

[125] 400 men, 867 service providers = 118114kg + 179208kg bread wheat from 306.7896104 + 465.4765364 = 772 .2661468ha.

Garrison	Settlements, weight & wagons	+ surplus - deficit	Settlements, weight & wagons	+ surplus - deficit	Long Distance Solution
	One day's distance, two days travelling = 32kg feed from 0.08101265823ha barley		Two days' distance, four days travelling = 64kg feed from 0.1620253165ha barley		
Capidava 546 +867 419 + 465 = 884.2443546ha[126]	10 *vici*, 5 *villae*, 15 Ind = 10353 /2 x 0.7695279 = 3983.461174ha avail but 970.972245 req Load = (Cargo = Potential w + Potential b) + Feed b 884.244355ha w + 86.72789031ha b feed	Needs met + 3012.488929ha	= 1965.414684ha to Carsium within 1 day = 1047.074245ha to Troesmis within 2 days		
Weight w = wheat = 340434kg	340,434kg w 34,258kg feed b				
Wagons loads Wagon days	Loads 1071 Wagon days 2141				
Carsium 624 + 662+ 867 479 + 1529 + 465 = 2473.372126ha[127]	2 *vici* 4 Ind = 1960.8 /2 x 0.7695279 = 754.4451532ha Potential + 1965.414684ha Capidava surplus within one day of Carsium = 2719.859837ha req Load = (Cargo = Potential w + Potential b) + Feed b = 944.0683286ha w + 1529.303797ha + 246.4877111ha feed b	Needs met			
Weights w = wheat = 363466kg b = barley = 604075kg	363,466kg w 604,075kg b 97,363kg feed b				
Wagons loads Wagon days	Loads = 3043 Wagon days = 6085				
Cius 347 + 78 + 867 266 + 180 + 465 = 911.8063968ha[128]	4 *vici* 4 *villae* 9 Ind = 4411.8 /2 x 0.7695279 = 1697.501595ha avail but 1001.696656ha req Load = (Cargo = Potential w + Potential b) + Feed b 731.6165234ha w + 180.1898734ha w + 89.89025886ha feed b	Needs met + 695.8049393ha	= 695.8049393ha Surplus to Arrubium within 2 days		
Weights w = wheat = 281672kg b = barley = 71175kg	281,672kg w 71,175 kg b 35,507kg feed b				
Wagons loads Wagon days	Loads = 1110 Wagon days = 2219				
% of 4269.422877ha moved by travelling day	4269.422877ha = 100%				
	Total Number of wagon days for central area = 10445 wagons = 35 *pa*				

When considering those sites between 50 and 100km from consumption centres, part of Noviodunum's surplus was directed to Dinogetia and [Barboşi], while those sites that were within 100km of both Arrubium and Troesmis were allocated to Arrubium, whereas those that were only within 100km of Troesmis were allocated to the fortress there.   Similarly, the surpluses available from the south were divided between Troesmis and Arrubium, that from Capidava further south going to Troesmis, that from the more northerly Cius going to Arrubium; this division is of course arbitrary for the purposes of modelling and the surplus could have been directed in any proportion between the two sites.

Garrison	Settlements, weight & wagons	+ surplus - deficit	Settlements, weight & wagons	+ surplus - deficit	Long Distance Solution
	One day's distance, two days travelling = 32kg feed from 0.08101265823ha barley		Two days' distance, four days travelling = 64kg feed from 0.1620253165ha barley		
Troesmis 6059 + 144 + 3200 4647ha + 333ha + 1718ha = 6697.775669ha [129]	2 *vici*, 1 *villa*, 5 Ind = 2091 /2 x 0.7695279 = 804.5414195ha Potential Load = ((Cargo = (Potential w – Feed b) + Potential b) + Feed b = 399.249241ha w + 332.658228ha b + 72.63395053ha Feed b	- 5965.868200ha	1 *vicus*, 1 *villa*, 8 Ind = 1161.6 /2 x0.7695279 = 446.9418043ha + 1047.074245ha from Capidava surplus = 1494.016049ha Total Potential Load = ((Cargo = (Potential w – Feed b) + Potential b) + Feed b = 1226.50241ha + 267.5136385ha	- 4739.365790 ha	- 4739.365790 ha
Weights w = wheat = 2450570kg b = barley = 131400kg	153,711kg w 131,400kg b 28,690kg feed b		472,203kg w 105,668kg feed b		
Wagons loads	Loads = 897		Loads = 1651		

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[126] 546 men, 867 service provider = 161225.61kg + 179208.46kg bread wheat from 418.767818 + 465.4765364 = 884.2443546ha.

[127] 624 men, 662 horse 867 service providers = 184258kg bread wheat, 604075kg barley, 179208kg bread wheat from 478.5917922ha, 1529.303797ha 465.4765364ha respectively = 2473.372126ha.

[128] 347 men, 78 horse and 867 service providers = 102464kg bread wheat, 71175kg barley, 179208kg bread wheat from 266.139987ha, 180.1898734ha and 465.4765364ha respectively = 911.8063968ha.

[129] 6059 men, 144 horse, 3200 service providers = 1789132 bread wheat, 131400kg barley, 661438kg bread wheat from 4647.095623ha, 332.6582278ha and 1718.021818ha = 6697.775669ha.

Wagon days	Wagon days = 1793		Wagon days = 6604		
Arrubium 624 + 662 + 867 479ha + 1529ha + 465ha = 2473.372126ha [130]	1 *vicus* 2 Ind = 980.4 /2 x 0.7695279 = 377.2225766 Total Potential Load = ((Cargo = (Potential w – Feed b) + Potential b) + Feed b = 154.479934ha w + 188.6112883ha b + 34.13135429ha Feed b	-2130.280904ha	3 *vici* 16 Ind = 3043.2 /2 x 0.7695279 = 1170.913653 Potential + 695.8049393ha from Cius surplus = 1866.718592ha Total Potential Load = ((Cargo = (Potential w – Feed b) + Potential b) + Feed b = 594.7698662ha w + 933.359296ha b + 338.5894298ha Feed b		-602.151742ha = 194.818528ha w 407.333213ha b
Weights w = wheat = 363466kg b = barley = 604075kg	59,475kg w 74,501kg b 13,482kg feed b		228,986kg w 368,677kg b 133,743kg feed b		
Wagons loads Wagon days	Loads = 421 Wagon days = 843		Loads = 2090 Wagon days = 8359		
(Barbosi) 137 + 867 105ha + 465ha = 570.551978ha [131]	1 *vicus* 4 Ind = 1000.8 /2 x 0.7695279 = 385.0717612ha Potential Load = ((Cargo = (Potential w – Feed b)) + Feed b = 350.676894ha w + 34.39486725ha Feed b	-219.875084ha	+ 187.018983ha from Noviodunum surplus Load = ((Cargo = (Potential w – Feed b) + Potential b) + Feed b = 153.5319742ha w + 33.4870082ha Feed b	-66.343110ha	-66.343110ha
Weight w = wheat = 219662kg	135,011kg w 13,586kg feed b		59,110kg w 13,227kg feed b		
Wagons loads Wagon days	Loads = 425 Wagon days = 849		Loads = 207 Wagon days = 827		
Dinogetia 136 + 867 104ha + 465ha = 569.7850039ha [132]	1 *vicus* 3 Ind = 990.6 /2 x 0.7695279 = 381.1471689ha Total potential Load = (Cargo = Potential w) + Feed b = 347.102849ha w + 34.04432004ha Feed b	-222.682155ha	+ 187.018983ha from Noviodunum surplus Load = ((Cargo = (Potential w – Feed b) + Potential b) + Feed b = 153.5319742ha w + 33.4870082ha Feed b	-69.150181ha	-69.150181ha
Weight w = wheat = 219367kg	133,635kg w 13,448kg feed b		59,110kg w 13,227kg feed b		
Wagons loads Wagon days	Wagons loads = 420 Wagon days = 840		Loads = 207 Wagon days = 827		
Noviodunum 1200 + 867 920ha + 465ha =1385.845368ha [133]	4 *vici*, 6 *villae* ,36 Ind = 4927.2ha /2 x 0.7695279 = 1895.808934ha avail but 1521.770968ha req Load = (Cargo = Potential w) + Feed b 1385.8453674ha w + 135.9256006ha	Needs met + 374.037966ha	= 374.037966ha/2 = 187.018983ha to Dinogetia = 187.018983ha to (Barboşi)		Needs met
Weight w = wheat = 533550kg	533,550kg w 53,691kg feed b				
Wagons loads 1524 Wagon day	Loads = 1678 Wagon days = 3355				
% 11697.33014ha moved by travelling day	3158.623801ha = 27.00294%		3061.695521ha = 26.1743%		5477.010822 ha = 46.8227% =5069.677609ha w 407.3332ha b
	Total number of wagon days for north = 24298/300 working day year = 81 *pa*				

Appendix C.3a: Comparison table % moved by travelling day - see also Table 4.2.3.1 in main thesis

% of 5359.617718ha southern needs by travelling day	3989.70766 = 74.44%	3.221867601ha = 0.06%	1366.688190ha = 25.4997%
	Total Number of wagon days for southern area 9706 = 32 wagons *pa*		
% of 4269.422877ha central needs by travelling day	4269.422877ha = 100%	0%	0%
	Total Number of wagon days for central area = 10445 wagons = 35 *pa*		
% of 11697.33014ha northern needs by travelling day	3158.623801ha = 27.00294%	3061.695521ha = 26.1743%	5477.010822ha = 46.8227% = 5069.677609ha w 407.3332ha b
	Total number of wagon days for north = 24298/300 working day year = 81 *pa*		

For Whole Dobrogea

% of original 21,326.37074ha need by travelling day	11417.75434ha = 53.54%	3064.917389ha = 14.3715%	6843.699013ha = 32.09%
	Total number of wagon days = 44449 /300 working days = 148 *pa*		

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[130] 624 men, 662 horse, 867 service providers = 184258kg bread wheat, 604075kg barley 179208kg bread wheat, from 478.5917922ha, 1529.303797ha and 465.4765364ha = 2473.37126ha.

[131] 137 men, 867 service providers = 40454kg + 179208kg bread wheat from 105.0754416 + 465.4765364 = 570.551978ha.

[132] 136 men, 867 service providers = 40159kg + 179208kg bread wheat from 104.3084675 + 465.4765364 = 569.7850039ha.

[133] 1200 men, 867 service providers = 354342kg + 179208kg bread wheat from 920.3688312 + 465.4765364 = 1385.8453676ha.

The total number of wagon days using mules is lower than those using oxen because they are moving faster: 148 would have been required rather than 191 on a 32km travelling day and 223 on a 23km travelling day. However, a smaller percentage of the need is provided from the immediate hinterland because a greater quantity of feed barley has been deducted, so that in this model only 68% of the overall need is available locally

Appendix C.4: 50km Mule-trains Dobrogea

Garrison	Settlements, weight & wagons	+ surplus - deficit	Settlements, weight & wagons	+ surplus - deficit	Deficit after Two days
	8 mule-train carrying 70kg each less 2kg feed per day, so 560kg load less 32kg feed b from 0.08101265823ha for a day return		8 mule-train carrying 70kg each less 2.5kg feed per day, so 560kg load less 64kg feed b from 0.1620253165ha for two day return		Long Distance Solution
Durostorum 1515 + 36 + 1250 1162 + 83 + 671 = 1916.232479ha [134]	3 *vici* 3 Ind = 2910.6 /2 x 0.7695279 = 1119.893953ha Total Potential Load = ((Cargo = (Potential w – Feed b) + Potential b) + Feed b 974.14407ha w + 83.164557ha b + 62.58468905ha Feed b	-858.923215ha			-858.923215ha
Weight w = wheat = 705731kg b = barley = 32850kg	375,046kg w 32,850kg b 24,720kg feed b				
Wagons loads Wagon days	Trains = 773 Mule-train days = 1545				
Sucidava 347 + 78 + 867 266 + 180 + 465 = 911.8063968ha [135]	2 *vici* 5 Ind = 1971 /2 x 0.7695279 =758.3697455ha Potential Load = ((Cargo = (Potential w – Feed b) + Potential b)) + Feed b 535.619314ha w + 180.1898734ha b + 42.56055775ha Feed b	-195.997209ha			-195.997209ha
Weight w = wheat = 281672kg b = barley = 71175kg	206,213kg w 71,175kg b 16,811kg feed b				
Wagons loads Wagon days	Trains = 525 Mule-train days = 1051				
Tropaeum Traiani 619 + 78 + 800 475 + 180 + 430 = 1084.45225 [136]	3 *vici*, 3 *villae*,18 Ind = 3423.6 /2 x 0.7695279 = 1317.277859ha Potential avail but 1148.789191ha req Load = (Cargo = Potential w + Potential b) + Feed b 904.262377ha w + 180.1898734ha) + 64.3369411ha	Needs met + 168.488668	+ 144.2945ha to Sacidava + 24.194168ha to Axiopolis		Needs met
Weight w = wheat = 348141kg b = barley = 71175kg	348,141kg w 71,175kg b 25,413kg feed b				
Wagons loads Wagon days	Trains = 794 Mule-train days = 1588				
Sacidava 273 + 867 209+ 465 = 674.8604455ha [137]	1 *vicus*, 6 Ind = 1021.2ha /2 x 0.7695279 = 392.9209457ha Potential + 144.2945Tropaeum surplus = 537.2154457ha Total Potential Load = (Cargo = (Potential w – Feed b) + Potential b) + Feed b = 507.251238ha + 29.96420804ha Feed b	-167.609208ha	1 Ind = 10.2 /2 x0.7695279 = 3.92459229ha Potential Load = (Cargo = (Potential w – Feed b)) + Feed b = 3.486151793ha + 0.438440497ha Feed b		-164.123056ha
Weight w = wheat = 259821kg	195,292kg w 11,836kg feed b		1,342kg w 173kg feed b		
Wagons loads Wagon Days	Trains = 370 Mule-train days = 740		Trains = 2.7 Mule-train days = 11		
Axiopolis 400 +867 307 + 465 = 772.2661468ha [138]	2 vici 14 Ind = 2062.8 /2 x 0.7695279 = 793.6910761 Potential + 24.19416798ha Tropaeum surplus = 817.8852441ha Cargo w + Feed b 772.2661468ha w + 45.61909714ha Feed b	Needs met			Needs met
Weight w = wheat = 297322kg	297,322kg w 18,020kg feed b				
Wagons loads Wagon days	Trains = 563 Mule train days = 1126				
% of 5359.617718ha moved by travelling day	4137.0880874a = 77.19%		3.486151793ha = 0.065%		1219.04348ha = 22.75%
	Total Number of mule train days for southern area 6061= 20 *pa*				

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[134] 1515 men, 36 horse, 1250 service providers = 447357kg bread wheat, 32,850kg barley, 25,8374kg bread wheat from1161.965649ha, 83.16455696and 671.1022727ha = 1916.23247866ha.

[135] 347 men, 78 horse and 867 service providers = 102464kg bread wheat, 71175kg barley, 179208kg bread wheat from 266.139987ha, 180.1898734ha and 465.4765364ha = 911.8063968ha.

[136] 619 men, 78 horse, 800 service providers = 182781kg bread wheat, 71175kg barley, 165360kg bread wheat from 474.7569221ha, 180.1898734ha and 429.5054545ha = 1084.45225ha.

[137] 273 men, 867 service providers = 80613kg + 179208kg bread wheat from 209.3839091 + 465.4765364 = 674.8604455ha.

[138] 400 men 867 service providers = 118114kg + 179208kg bread wheat from 306.7896104 + 465.4765364 = 772 .2661468ha .

Garrison	Settlements, weight & wagons	+ surplus - deficit	Settlements, weight & wagons	+ surplus - deficit	Long Distance Solution
	8 mule-train carrying 70kg each less 2kg feed per day, so 560kg load less 32kg feed b from 0.08101265823ha for a day return		8 mule-train carrying 70kg each less 2.5kg feed per day, so 560kg load less 64kg feed b from 0.1620253165ha for two day return		
Capidava 546 +867 419 + 465 = 884.2443546ha[139]	10 vici, 5 villae, 15 Ind = 10353 /2 x 0.7695279 = 3983.461174ha Potential avail but 936.4781983ha req Load = (Cargo = Potential w + Potential b) + Feed b 884.2443546ha w + 52.23384357ha b feed	Needs met + 3046.982976ha	= 1867.379801ha to Carsium within 1 day = 1179.603175ha to Troesmis within 2 days		
Weight w = wheat = 340434kg	340,434kg w 20,632kg feed b				
Wagons loads Wagon days	Trains = 645 Mule-train days = 1290				
Carsium 624 + 662+ 867 479 + 1529 + 465 = 2473.372126ha[140]	2 *vici* 4 Ind = 1960.8 /2 x 0.7695279 = 754.4451532ha Potential + 1867.379801ha Capidava surplus = 2621.824954ha Potential Load = (Cargo = Potential w + Potential b) + Feed b = 944.0683286ha w + 1529.303797ha + 148.4528275ha feed b	Needs met			
Weights w = wheat = 363466kg b = barley = 604075kg	363.466kg w 604,075kg b 58,639kg feed b				
Wagons loads Wagon days	Trains = 1832 Mule-train days = 3665				
Cius 347 + 78 + 867 266 + 180 + 465 = 911.8063968ha[141]	4 vici 4 villae 9 Ind = 4411.8 /2 x 0.7695279 = 1697.501595ha Potential avail but 965.9448489ha req Load = (Cargo = Potential w + Potential b) + Feed b 731.6165234 haw + 180.1898734ha w + 54.13845193ha feed b	+ 731.5567461	= 731.5567461 Surplus to Arrubium		
Weights w = wheat = 281672kg b = barley = 71175kg	281,672kg w 71,175kg b 21,385kg feed b				
Wagons loads Wagon days	Trains = 668 Mule-train days = 1337				
% of 4269.422877ha moved by travelling day	4269.422877ha = 100%				
	Total Number of mule-train days for central area = 6291 /300 = 21 *pa*				

When considering those sites between 50 and 100km from consumption centres, part of Noviodunum's surplus was directed to Dinogetia and [Barboşi], while those sites that were within 100km of both Arrubium and Troesmis were allocated to Arrubium, and those that were only within 100km of Troesmis were allocated to the fortress there. Similarly, the surplus seen above at Capidava was directed to Troesmis and that seen at Cius was directed to Arrubium, a simple arbitrary division for modelling purposes.

Garrison	Settlements, weight & wagons	+ surplus - deficit	Settlements, weight & wagons	+ surplus - deficit	Long Distance Solution
	8 mule train carrying 70kg each less 2.5kg feed per day, so 560kg load less 40kg feed b from 0.10126582ha barley		8 mule train carrying 70kg each less 2.5kg feed per day, so 560kg load less 80kg feed b from 0.2025316456ha barley		
Troesmis 6059 + 144 + 3200 4647ha + 333ha + 1718ha = 6697.775669ha 142	2 *vici*, 1 *villa*, 5 Ind = 2091 /2 x 0.7695279 = 804.5414195ha Potential Load = ((Cargo = (Potential w – Feed b) + Potential b) + Feed b = 426.526433ha w + 332.658228ha b + 45.35675883ha Feed b	- 5938.59 1009ha	1 *vicus*, 1 *villa*, 8 Ind = 1161.6 /2 x0.7695279 = 446.9418043ha + 1179.603175ha from Capidava surplus = 1626.544979ha Total Potential Load = ((Cargo = (Potential w – Feed b) + Potential b) + Feed b = 1444.833572ha w + 181.7114075ha Feed b	- 4493.7574 37ha	- 4493.7574 37ha
Weights w = wheat = 2450570kg b = barley = 131400kg	164,213kg w 131,400kg b 17,916kg feed b		556,261kg w 71,776kg b		
Wagons loads Wagon days	Trains = 560 Mule-train days = 1120		Trains = 1121.49 Mule-train days = 4486		

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[139] 546 men, 867 service provider = 161225.61kg + 179208.46kg bread wheat from 418.767818 + 465.4765364 = 884.2443546ha.

[140] 624 men, 662 horse 867 service providers = 184258kg bread wheat, 604075kg barley, 179208kg bread wheat from 478.5917922ha, 1529.303797ha 465.4765364ha respectively = 2473.372126ha.

[141] 347 men, 78 horse and 867 service providers = 102464kg bread wheat, 71175kg barley, 179208kg bread wheat from 266.139987ha, 180.1898734ha and 465.4765364ha respectively = 911.8063968ha.

[142] 6059 men, 144 horse, 3200 service providers = 1789132 bread wheat, 131400kg barley, 661438kg bread wheat from 4647.095623ha, 332.6582278ha and 1718.021818ha = 6697.775669ha.

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Arrubium 624 + 662 + 867 479ha + 1529ha + 465ha = 2473.372126ha [143]	1 *vicus*, 2 Ind = 980.4 /2 x 0.7695279 = 377.2225766ha Total Potential Load = ((Cargo = (Potential w – Feed b) + Potential b) + Feed b 167.297735ha w + 188.6112883ha b + 21.3135537ha Feed b	- 2117.46 3103ha	3 *vici*, 16 Ind = 3043.2 /2 x 0.7695279 = 1170.913653 Potential + 731.5567461ha from Cius surplus = 1902.470399ha Total Potential Load = ((Cargo = (Potential w – Feed b) + Potential b) + Feed b 735.938238ha w + 951.2351995ha b + 215.2969615ha Feed b	- 430.28966 6ha	430.28966 = 40.832356 ha w 389.45731 0ha b

Weights
w = wheat =
363466kg
b = barley =
604075kg
	64,410kg w
	74,501kg b
	  8,419kg feed b
			283,336kg w
			375,738kg b
			  85,042kg feed b
					-

Wagons loads Wagon days	Trains = 263 Mule-train days = 526		Mule trains = 1329 Mule train days = 5315		
(Barbosi) 137 + 867 105ha + 465ha = 570.551978ha[144]	1 *vicus* 4 Ind = 1000.8 /2 x 0.7695279 = 385.0717612ha Potential Load = ((Cargo = (Potential w – Feed b)) + Feed b 363.593655ha w + 21.47810614ha Feed b	- 206.958 323ha	+ 214.0496415ha Noviodunum surplus Load = (Cargo = Potential w) + Feed b 190.1368311ha w + 23.91281036ha	- 16.821492 ha	- 16.821492 ha

Weight
w = wheat =
219662kg
	139,984kg w
	  8,484kg feed b
			73,203ha w
			  9,446ha feed b		

Wagons loads Wagon days	Trains = 265 Mule-train days = 530		Trains = 148 Mule-train days = 590		
Dinogetia 136 + 867 104ha + 465ha = 569.7850039ha 145	1 *vicus* 3 Ind = 990.6 /2 x 0.7695279 = 381.1471689ha Total potential Load = (Cargo = Potential w) + Feed b 359.887964ha w + 21.25920458ha Feed b	- 215.221 4682	+ 214.0496415ha Noviodunum surplus Load = (Cargo = Potential w) + Feed b 190.1368311ha w + 23.91281036ha	- 19.760208 ha	- 19.760208 ha

Weight
w = wheat =
219367kg
	138,557kg w
	  8,397kg feed b
			73,203ha w
			  9,446ha feed b		

Wagons loads Wagon days	Trains = 262 Mule-train days = 525		Trains = 148 Mule-train days = 590		
Noviodunum 1200 + 867 920ha + 465ha =1385.845368ha 146	4 *vici*, 6 *villae*,36 Ind = 4927.2ha /2 x 0.7695279 = 1895.808934ha avail but 1467.709651req Load = (Cargo = Potential w) + Feed b 1385.845368ha w + 81.86428331ha feed b	Needs met + 428.099 283ha	428.099283ha /2 = 214.0496415ha to Dinogetia = 214.0496415ha to (Barboşi)		Needs met
Weight w = wheat = 533550kg	533,550kg w 32,336kg feed b				
Wagons loads 1524 Wagon day	Trains = 1011 Mule-train days = 2021				
% 11697.33014ha moved by travelling day	3224.420671ha = 27.565%		3512.280672ha = 30.026%		4960.6288 03ha = 42.408% 4571.1714 93ha w 389.45731 0ha b
	Total number of mule-train days for north = 15704/300 working day year = 52*pa*				

Appendix C.4a: Comparison table % moved by travelling day - see also Table 4.2.3.1 in main thesis

% of 5359.617718ha southern needs by travelling day	4137.0880874a = 77.19%		3.486151793ha = 0.065%		1219.04348ha = 22.75%
	Total Number of mule train days for southern area 6061= 20 *pa*				
% of 4269.422877ha central needs by travelling day	4269.422877ha = 100%				
	Mule trains 3195 x 2 travelling days = 6390				
	Total Number of mule-train days for central area = 6291 /300 = 21 *pa*				
% of 11697.33014ha northern needs by travelling day	3224.420671ha = 27.565%		3512.280672ha = 30.026%		4960.628803ha = 42.408% = 4571.171493ha w 389.457310ha b
	Total number of mule-train days for north = 15704/300 working day year = 52*pa*				
% of original 21,326.37074ha need by travelling day	11630.93164ha = 54.5378%		3515.766824ha = 16.4855%		6179.672283ha = 28.9767%
	Total number of mule trains required = 28056 /300 = 94 mule trains pa				

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[143] 624 men, 662 horse, 867 service providers = 184258kg bread wheat, 604075kg barley 179208kg bread wheat, from 478.5917922ha, 1529.303797ha and 465.4765364ha = 2473.37126ha.

[144] 137 men, 867 service providers = 40454kg + 179208kg bread wheat from 105.0754416 + 465.4765364 = 570.551978ha.

[145] 136 men, 867 service providers = 40159kg + 179208kg bread wheat from 104.3084675 + 465.4765364 = 569.7850039ha.

[146] 1200 men, 867 service providers = 354342kg + 179208kg bread wheat from 920.3688312 + 465.4765364 = 1385.8453676ha.

Observations

The total number of mule-train days is lower than wagon days pulled by mules because a mule train is estimated to have carried 560kg before feed while a wagon carried only 350kg so that only 94 mule trains would have been required. Again, the total amount supplied from the forts' hinterland is decreased because of their greater requirement for feed-barley over oxen, but because mule-trains were more economical than wagons in terms of load carried, the deficit, that part of the need that would require an overseas solution, was less than with mule-drawn wagons.

Appendix C.5 summary % Arable Available by Travelling Day - see Table 4.2.3.1 in main thesis

	One day	Two days	Three days	Four Days	Five days	Long distance solution
23km oxen-drawn wagon						
South	68.69%	9.77%	0.93%	0.07%		20.54%
Centre	59.2%	40.8%				0%
North	23.97%	4.8%	16.78%	7.15%	7.07%	40.23%
Total	42.27%	13.26%	9.44%	3.94%	3.88%	27.23%
32km oxen-drawn wagon						
South	75.84%	3.77%	0.07%			20.32%
Centre	59.2%	40.8%				0%
North	27.73%	13.79%	11.71%	7.38%		39.39%
Total	46.12%	16.68%	6.44%	4.05%		26.71%
50km mule-drawn wagon						
South	74.44%	0.06%				25.5%
Centre	100%					0%
North	27%	26.17%				46.82%
Total	53.54%	14.37%				32.09%
50km mule-train						
South	77.19%	0.07%				22.75%
Centre	100%					
North	27.565%	30.025%				42.41%
Total	54.54%	16.49%				28.98%

Appendix C.6 Comparison of transport methods – see Table 4.2.3.2 in main thesis

Model	% deficit of original needs	% increase in overall needs for feed-barley	Vehicles required
23km oxen-drawn wagon	- 27.23%	+ 3.58%	223
32km oxen-drawn wagon	- 26.71%	+ 3.07%	191
50k mule-drawn wagon	- 32.09%	+ 8.44%	148
50k mule-train	- 28.98%	+ 5.33%	94

Appendix D.1 Long distance calculations summary

Model	Deficit, that part not available locally of original needs	Total needs % increase in needs	Wagons /trains local supply	Wagons/ trains overseas supply	Total wagons/ trains
South central & North by Noviodunum					
23k oxen overseas t/port feed	5806.28ha 27.23%	22430.89ha + 5.18%	223	100	323
23k oxen local t/port feed	6170.17ha 28.93%	22453.31ha + 5.28%	221	109	330
32k oxen overseas t/port feed	5696.95ha 26.71%	22,215.57ha + 4.17%	191	69	260
32k oxen local t/port feed	5941.45ha 27.85%	22,275.97ha + 4.21%	189	73	262
50k mule-wagon overseas t/port feed	6843.70ha 32.09%	24010.82ha + 12.59%	148	73	221
50k mule-wagon local t/port feed	7809.74 36.62%	24092.88ha + 12.97%	140	87	227
50k mule-train overseas t/port feed	6179.67ha 28.98%	22935.61ha + 7.55%	94	39	133
50k mule-train local t/port feed	6673.14ha 31.29%	22956.27ha + 7.64%	91	43	134
South central & North by Histria					
23k oxen overseas t/port feed	5806.28ha 27.23%	22,850.55ha + 7.15%	223	223	446
23k oxen local t/port feed	6592.16ha 30.91%	22875.29 + 7.26%	199	254	453
32k oxen overseas t/port feed	5696.95ha 26.71%	22,537,79ha + 5.68%	191	163	354
32k oxen local t/port feed	6316.73ha 29.62%	22,548.47ha + 5.73%	178	180	358
50k mule-wagon overseas t/port feed	6843.70ha 32.09%	24,727.66ha + 15.95%	148	132	280
50k mule-wagon local t/port feed	8572.68ha 40.2%	24855.81ha + 16.55%	121	169	290
50k mule-train overseas t/port feed	6179.67ha 28.98%	23,285.29ha + 9.19%	94	68	162
50k mule-train local t/port feed	7035ha 32.99%	23,318.13ha + 9.34%	86	78	164
South central & North by Tomis					
23k oxen overseas t/port feed	5806.28ha 27.23%	23.088.87ha +8.26%	223	292	515
23k oxen local t/port feed	6879.32ha 32.25%	23,162ha +8.61%	188	349	537
32k oxen overseas t/port feed	5696.95 26.71%	22,682.15ha +6.36%	191	205	396
32k oxen local t/port feed	6429.83ha 30.15%	22,712.96ha +6.50%	173	233	406
50k mule-wagon overseas t/port feed	6843.70ha 32.09%	25503.14ha +19.59%	148	195	343
50k mule-wagon local t/port feed	9663.94ha 45.31%	25,947.08ha +21.67%	101	279	380
50k mule-train overseas t/port feed	6179.67ha 28.98%	23645.49ha +10.87%	94	97	191
50k mule-train local t/port feed	7466.08ha 35.01%	23749.21ha +11.36%	81	118	199

Map 1