Chapter 9 The regional context of the Gordano Valley Pleistocene palaeoenvironments

9.1 Introduction

This chapter addresses the fourth objective: to review and revise as appropriate the current models of Pleistocene events and environments of the Bristol Channel/Severn Estuary region. The sedimentary record outlined in Chapter 6 and the interpretations and reconstruction provided in Chapters 7 and 8 illustrate the variety of local environmental changes in the Gordano Valley. In this chapter the Gordano Valley Pleistocene palaeoenvironments are integrated with previous models for the Gordano Valley. Findings are then considered within a regional context; comparisons are made with previous research in the Bristol Channel/Severn Estuary to establish whether the valley's sedimentary archive follows a regional trend or if it developed out of context with other regional coastal lowland sites. The Gordano Valley palaeoenvironments are then considered in the wider context of Pleistocene palaeoenvironments of southern England and northwest Europe, notwithstanding the difficulty in fitting the small-scale changes recorded in the Gordano Valley, to the wider, broader frameworks discussed in Chapter 2.

9.2. Comparison with previous palaeoenvironmental models of the Gordano Valley

In this section, the findings of this research are compared with previous palaeoenvironmental models for the Pleistocene of the Gordano Valley. Previous models for the depositional environments of the Gordano Valley have suggested the presence of a cross-valley sediment ridge which has divided the valley into two depositional basins (Jefferies *et al*. 1968, Hill 2006, Hill *et al*. 2008). No evidence was found in this research for a cross-valley sediment ridge or two basins, although this is possibly because the area in which it can be found was not sampled.

The findings of this research appear to confirm the suggestion of Jefferies *et al*. (1968) and Gilbertson & Hawkins (1983) of water-lain valley floor minerogenic deposits, and that an alluvial fan is a probable mechanism for their emplacement, with the poorly sorted sands and gravels being the result of slope-processes reworking pre-existing glacial deposits, as speculated by Hill (2006) and Hill *et al*. (2008). Timing of fan emplacement must predate deposition of the biogenic muds; Hill (2006) theorised Mid-Devensian formation, with later short-term catchment-wide instability during the Younger Dryas Stadial. However, this study suggests sedimentation probably took place in three phases: one during Early Devensian time, a second following the LGM and a third during the Younger Dryas Stadial, probably in response to progressively deteriorating climatic conditions when landscape instability and gullying of valley-side sediments as a result of reduced vegetation cover, and rapid accumulation of sediment on valley floors, is known to have occurred both in southern Britain and northwest Europe (Frechen *et al*. 2001, Lewis *et al*. 2001, Vandenberghe 2008, Lewin & Gibbard 2010).

In contrast to Hill (2006), who reported the majority of gravel clasts for this part of the valley were limestone, the gravels of the Weston Moor fan were found to show an upwards change from a limestone dominated lithology to one dominated principally by brown sandstone, which suggests a change in provenance for the upper gravels. Also in contrast to Hill (2006), this study has found a number of pedogenic units within the alluvial gravel fan sediments, suggesting pulses of sedimentation were interspersed with periods of landscape stability. At least one pedogenic unit pre-dates the LGM, and could be of MIS 3 age or earlier.

This research has determined the possible existence on Weston Moor of a very shallow lake (maximum depth of <1 m) or ponds/pools in which marl was deposited. Alluvial fan sediments possibly prograded across the valley, resulting in impoundment of water on Weston Moor as suggested by Hill (2006). Hill (2006) also inferred the existence of a Late Devensian fluvial network which drained Clapton Moor in the direction of the Severn Estuary. This study has also revealed valley floor minerogenic deposits, interpreted as fluvial, although the deposits pre-date those identified by Hill (2006) on Clapton Moor and extend onto Weston Moor.

In addition, this research fills some of the temporal gap in deposition between Ipswichian (MIS 5e) and Lateglacial (MIS 2) identified by Hill (2006) and has considerably extended the timescale for Pleistocene deposition in the Gordano Valley through the use of techniques with longer temporal ranges than the previously utilised radiocarbon technique. Previous age interpretations for the minerogenic sediments were hampered by lack of chronological control, the only available technique for most previous studies being radiocarbon dating. Hill (2006) attributed minerogenic deposition to Late Devensian cold climate accumulation based on radiocarbon dating of the overlying biogenic deposits. The radiocarbon date provided for the cessation of pedogenesis from NR15 of 13430 to 131990 Cal BP compares well with the youngest date of biogenic sedimentation of Hill *et al*. (2008).

9.3 Regional context of the Pleistocene minerogenic sediments of the Gordano Valley

A number of features common to deposits found across the region are present in the Gordano Valley. These are summarised in Table 9.1 which illustrates the relationships of the Gordano Valley Pleistocene sediments to those of the Bristol Channel/Severn Estuary region and shows the contribution made by this thesis to knowledge of the Pleistocene deposits and landforms regionally.

The Gordano Valley is one of a number of regional sites with deposits that have been correlated with MIS 7; others are Portfield, Somerset (freshwater silty clays), Weston in Gordano (marine gravels, intertidal sands, fresh water sands), Kenn Church (estuarine and freshwater sands), the Greylake Member of the Burtle Beds (marine sand and freshwater channel fill), Middle Hope, north Somerset (palaeosol), Butterslade and Overton, Gower (raised beach), Minchin Hole Cave, Gower (marine sands), Horton (beach gravel) and possibly Holly Lane (shore platform) (ApSimon & Donovan 1956, Gilbertson & Hawkins 1974, Campbell & Bowen 1989, Hunt 1998a, Campbell *et al*. 1999, Hunt & Bowen 2006b, Westaway 2010b).

9.3.1 The fluvial context of the Gordano Valley Pleistocene minerogenic sediments

Multiple occasions of cold stage fluvial gravel deposition have been inferred for the Gordano Valley; similar evidence of Pleistocene fluvial cold stage gravel deposition is also widespread in Somerset and there is limited evidence for possible Devensian (MIS 5d-2) cold-stage fluvial gravels in Gower and Gwent, although these are undated and may equally be MIS 5e (Allen 2001b).

At Wookey Station, in the Upper Axe valley, there are Pleistocene gravels deposited under high energy flow conditions, overlying low energy fine sediments to form an upward coarsening sequence, typical of downstream bar migration (Macklin & Hunt 1988). These gravels are correlated with MIS 2 (Macklin & Hunt 1988, Campbell *et al*. 1999). Macklin & Hunt (1988) also note that coarse–grained sedimentation of the Wookey Village gravel, a meandering gravel-bedded river with variable rates of flow and sediment supply, ceased by early Holocene times (*c*. 9 ka). Other Devensian (MIS 5d-2) cold stage fluvial gravels are found at Huish Episcopi (Doniford Formation), where fluvial gravels probably of MIS 2 age are overlain by channel fill of Bølling/Allerød Interstadial age (Campbell *et al*. 1999), whilst fluvial sands with a sparse molluscan fauna, correlated with MIS 4, are found at Combe. Fluvial gravels from earlier cold stages are found at Hurcott, correlated with MIS 10, at Whatley where calcreted gravels overlain by a rubified palaeosol are correlated with MIS 8, and at Portfield, where fluvial sands, sandy gravels and silts have been correlated with MIS 6 (Campbell *et al*. 1999).

Warm stage fluvial deposits in the region tend to be gravel- or silt-bedded meandering streams. The Chadbrick River gravels, deposited in a meandering stream or river, contain a fossil land mollusc fauna and have an AAR geochronology broadly consistent with MIS 9 (Hunt *et al*. 1984, Campbell *et al*. 1999). Freshwater silty clays at Portfield have been correlated with MIS 7, whilst at Weston in Gordano freshwater silts overlying marine gravels (ApSimon & Donovan 1956) are undated, but correlated with MIS 7-9 (Campbell *et al*. 1999). A sand-bedded river with nearby intertidal streams and pools of late MIS 7 or early MIS 5e age has been inferred for Gordano Valley warm stage fluvial sediments.

9.3.2 The palaeosol context of the Gordano Valley Pleistocene minerogenic sediments

This study has found a number of pedogenic units within alluvial gravel fan sediments, suggesting pulses of sedimentation interspersed with brief periods of landscape stability during which soil formation commenced on recently deposited surfaces. There do not appear to be any regional records of Devensian (MIS 2) Lateglacial palaeosols, such as that recorded from soil organic matter in NR15 (13430 to 13190 Cal BP), or of Devensian (MIS 5d-2) pedogenic units within alluvial fan deposits, as proposed in this study. Other alluvial fan palaeosols in the region are correlated with MIS 5e (Burrington and Whatley Palaeosols) or MIS 7 (Middle Hope Palaeosol) (Campbell *et al*. 1999, Findlay & Catt 2006).

Table 9.1: Summary of key Pleistocene deposits and landforms in the Bristol Channel/Severn Estuary region (sources: sources: Andrews *et al*. 1984, Campbell & Bowen 1989, Campbell *et al*. 1998, 1999, Allen & Rippon 1997, Allen 2000b, 2001a and b, Lewis & Richards 2005, Findlay & Catt 2006, Hunt & Haslett 2006, Westaway 2010b). Uncertainties of evidence or age are signified ?

Timescale (ka)	MIS	Gower	Gwent	Somerset	Gordano Valley	This study
c. 116-11.7	5d-2	Glaciofluvial outwash; head; coversands; loess; gravels	Head; cryoturbation; ice wedge casts; gravels	Head; coversands; fluvial gravels; alluvial fans	Coversands; ice wedge casts; breccias	Alluvial fans; Pedogenesis; gravel bedded river
c. 125	5e	Raised beach	Raised beach; marine sands & gravels; fluvial gravels	Raised beach; shore platform; intertidal sands & muds; palaeosol	?Shore platform	Muddy/sand bedded river
c. 150	6	Cave earth; ?moraine		Head ; fluvial gravels		Gravel bedded river
c. 200	7	Raised beach; marine sands; beach gravel		Pedogenesis; freshwater, estuarine, & marine sands; fluvial terraces; fluvial channel fill	Marine gravels; intertidal sands; freshwater sands; ?shore platform	Sand-bedded river; interconnected freshwater pools; intertidal sands & muds; ?braided stream
c. 250	8 (or earlier)	Moraine		Braided rivers	Glacial muds	? Gravel-bedded river

Similarly, there are no regional records of Middle Devensian (MIS 3) palaeosols such as that suggested for CGA6, although possible incipient soil formation at Clevedon Court and Tickenham Waterworks was attributed to Devensian (MIS 5d-2) by Gilbertson (1974) and Gilbertson & Hawkins (1983) and Gilbertson & Hawkins (1974) reported calcareous root concretions, diagnostic of pedogenic carbonate (Alonso-Zarza 2003), from two sandy loam units at Holly Lane to which they assigned cold dry climatic conditions. However, it is possible that the palaeosol of CGA6 pre-dates this, in which case it could be correlated with the Burrington Palaeosol (MIS 5e) or the Early Devensian (MIS 5c or a) palaeosol at Hunts Bay, Gower (Case 1993), although, given that soil formation ceased *c*. 22 ka, a MIS 3 age seems more likely.

9.3.3 The alluvial fan context of the Gordano Valley Pleistocene minerogenic sediments

Although alluvial fans are present in the Severn Estuary/Bristol Channel region (Findlay 1965, Macklin & Hunt 1988) there are only a limited number of comparators with which to assess the Gordano Valley deposits. Extensive spreads of gravel, which bear at least a superficial resemblance to the Gordano Valley deposits, occur opposite the gorges of Burrington, Churchill, Cheddar, Winscombe, Draycott, Wookey and Wells (Findlay 1965). All are underlain by Mercia Mudstone, occur at the foot of dry limestone valleys, have sub-angular clasts, some displaying ventifact morphology, and spread out fanwise across the floodplain beneath alluvium (Palmer 1931, 1934), although in contrast to those of the Gordano Valley, they are usually overlain by a loamy deposit (Findlay 1965). However, alluvial fan deposition has only been attributed to those of Burrington Combe and Wookey Station; the remainder are regarded as 'head' (Pounder & Macklin 1985, Macklin & Hunt 1988, Green 1992, Kellaway & Welch 1993).

A number of similarities have been identified between the Weston in Gordano fan and that at Burrington Combe (Pounder & Macklin 1985): both are low-angled gravel fans comprising the same kind of poorly sorted angular material; both demonstrate surfaces dissected by a series of channels or on the Weston in Gordano fan, hollows which may be channels, and both display a series of distinct depositional units. The Burrington Combe fan displays two phases of deposition (Findlay & Catt 2006): the lower gravel predates the interglacial Burrington Palaeosol and has been correlated with MIS 6 (Campbell *et al*.

1999) whilst a Late Devensian (MIS 2) age has been inferred for the upper gravel (Findlay & Catt 2006). At Wookey Station, Mendip, Pleistocene gravel in the upper part of the Axe valley displays a distinct convex profile and lobate planform (Macklin & Hunt 1988) similar to that of the Weston in Gordano fan. The movement of coarse clastic debris was attributed to active Pleistocene cold stage erosion and deposition and inactive underground channels due to permafrost (Pounder & Macklin 1985). Similar to the model envisaged in this study for the Weston in Gordano fan, Macklin & Hunt (1988) found subsequent remobilisation of fine channel fill when flows across the fan were of sufficient strength to transport and re-deposit sand and silt-size material but not of sufficient magnitude to rework the coarse grained sediment,. Macklin & Hunt (1988) also found that sedimentation took place in two phases; the second of these demonstrated an upwards increase in grain size which typically develops as a result of downstream fluvial bar migration (Macklin & Hunt 1988). This represents a fluvial regime dominated by major, short-lived floods, similar to the findings of this study. However, unlike the Gordano Valley, the Wookey Station gravel demonstrates little falling stage or low stage reworking of channel sediments. The Wookey Station gravel is believed to be the remains of a coarse-grained alluvial fan deposited by a low-sinuosity single thread stream (Macklin & Hunt 1988). In contrast to the Gordano Valley fan, deposits which characterise braided channel streams are absent. The Wookey Station gravel was deposited in stadial conditions prior to Lateglacial time, and has been correlated with MIS 2 (Campbell *et al*. 1999). However, OSL and radiocarbon dates obtained for the Gordano Valley indicate fans here were probably deposited in two or possibly three phases, during MIS 5, MIS 2 and the Younger Dryas Stadial.

9.3.4 The sea level context of the Gordano Valley Pleistocene minerogenic sediments

Regional evidence indicates that interglacial sea-levels were relatively higher than is indicated by the evidence from the Gordano Valley. The raised beach at Swallow Cliff lies at ~ 5 m OD above present day sea-level, although it has been interpreted as a storm beach and is therefore probably not a good indicator of MIS 5e mean sea level (Campbell *et al*. 1999, Hunt 2006m). Within the Burtle Beds, which lie between ~ 4 m and 9 m above present day sea level (Kidson & Haynes 1972, Kidson *et al*. 1974, Kidson & Heyworth 1976, Kidson *et al*. 1978, Andrews *et al*. 1979, Andrews *et al*. 1984), estuarine deposits correlated through AAR geochronology with Ipswichian (MIS 5e) deposition probably provide a better indication, whilst sand with a shelly marine fauna and channel fills with a freshwater fauna are correlated with MIS 7 (Campbell *et al*. 1999). Even the only recorded Devensian interstadial high sea level at Low Ham, correlated with MIS 5a, indicates a mean sea level of 2 to 5 m OD (Campbell *et al*. 1999, Hunt & Bowen 2006a). At Holly Lane Gilbertson & Hawkins (1974) found near-marine foraminifera at approximately 20 m OD, which they attributed to local derivation from previous glacial or interglacial deposits, which Westaway (2010b) has suggested may be MIS 7. Brackish water and marine deposits at Kenn Church (Gilbertson & Hawkins 1978b) have correlated with MIS 7 (Andrews *et al*. 1984); a maximum mean sea level of 14-21 m OD is inferred for this marine transgression (Hunt 1998a), which is considerably higher than the fossilferous sediments of Gordano (~ -1.8 m OD). Marine and estuarine deposits recorded in two gravel units at Weston in Gordano (ApSimon & Donovan 1956), correlated with MIS 7-9 (Campbell *et al*. 1999) although they may be younger (MIS 5e-7, Westaway 2010b), demonstrate superficial similarities to the Gordano Valley deposits. However, the base of the Weston in Gordano sequence is about 12 m higher than the intertidal Gordano sediments. No similarly high sea levels have been found during this study. The MIS 5e intertidal lagoonal environment inferred for shelly gravels at Llanwern, Gwent Levels, at -2.6 to -3 m OD (Andrews *et al*. 1984) is altitudinally much closer to the Gordano Valley intertidal sediments (~ -1.8 m OD).

The faunal evidence is equivocal: there are elements of the Gordano Valley ostracod, foraminifera and mollusc faunas which are similar to those described from the Burtle Beds, although marine, brackish water and land molluscs are absent from the Gordano faunas. A similar lack of brackish water and land molluscs was also noted in the estuarine deposits at Kenn Pier by Gilbertson & Hawkins (1978a). However, the faunas all appear to be similar regardless of which interglacial they have been attributed to, indicating only that the faunas are not specific to any one interglacial.

The differences could be explained by different locations in the tidal frame. Alternatively, altitudinal and faunal differences could reflect different sub-stages of MIS 7, so that the Kenn deposits may represent a sea-level high stand whereas those of the Gordano Valley reflect a recessional sea-level. Higher sea-levels inferred during MIS 7c than MIS 7a (Bard *et al*. 2002, Waelbroeck *et al*. 2002) may explain the apparent discrepancy in sea-levels between Kenn and the Gordano Valley (i.e. Kenn deposits could represent MIS 7c whereas those of Gordano could represent MIS 7a). The altitude for

TG7/TG8 agrees with the sea-level inferred from the Argentarola stalagmite in Italy for MIS 7a of between -18 m and -9 m relative to modern datums (Bard *et al*. 2002) and with the MIS 7a sea-level of *c*. -10 m derived from benthic foraminifera isotope records (Waelbroeck *et al*. (2002).

Although evidence in this study is limited, the intertidal sediments have an altitude much lower than the accepted altitude of MIS 7 intertidal sediments (3-20 m OD, Campbell *et al*. 1999, Westaway 2010b) in this region. If TG8 represents early MIS 5e, then TG9-12 could represent MIS 5c-4 when sea level was 20-50 m lower than present, possibly relating to the sands and gravels of this age from TG-OSL, or MIS 3 when sea level was ~ 50 m lower than present (Lambeck *et al*. 2002b, Waelbroeck *et al*. 2002). However, faunal evidence seems to indicate sea level fell between deposition of TG7 and TG8, in which case a late MIS 7 age for TG8 is indicated, thus providing a date for closure of the East Clevedon Gap, and the prevention of further tidal ingress on Weston Moor, of sometime during MIS 6. Support for this comes from the MIS6/7 faunal evidence at Holly Lane. The presence of marine shelf taxa in TG7 and TG8 suggests that ingress from the east is unlikely.

9.4 The wider significance of the Gordano Valley Pleistocene environments

Chapter 2 identified British landscape response to Pleistocene climatic fluctuations. Sedimentological changes recorded in the Gordano Valley also appear to reflect these broader, climate-driven environmental fluctuations, in particular through recognition of the complexity of climate change reflected in marine and ice core records in the small-scale terrestrial events recorded in the Gordano Valley, made possible through the use of recently developed technologies. The limited number of absolute and relative dates available for the Gordano Valley has allowed tentative correlation to be made with the established marine isotope chronology discussed in Chapter 2 not just to marine isotope stage, but to sub-stage level, enabling a detailed palaeoenvironmental interpretation to be attempted.

9.4.1 Mid-Pleistocene (MIS 7)

The Mid-Pleistocene (MIS 7) landscape record of the Gordano Valley (sand-bedded river, interconnected freshwater pools at the limit of tidal influence, occasionally marine incursions) is broadly comparable to that at Norton Farm, Sussex, where Bates *et al*. (2000) record a coastal tidal creek environment with a mixed marine and freshwater fossil assemblage which indicates streams and flooding of surrounding pools by high spring tides. However, the deposits of the Gordano Valley appear to be anomalously low (*c*. -1.8 m OD) when compared with other MIS 7 coastal sites in southern England and northwest Europe where deposits commonly lie at between 4–15 m OD, although this may be due to local differences in uplift characteristics. For example the Norton Farm tidal creek deposits lie between 5.3 and 9.1 m OD (Bates *et al*. 2010), estuarine deposits at Aveley, Thames estuary, lie at *c*. 15 m OD (Schreve 2001a and b), the marine-marginal deposits at Morston, Norfolk, lies at *c*. 5 m OD (Hoare *et al*. 2009) and the raised beach at Tourville, N. France lies between 8 and 15 m NGF (French Geodetic leveling standard), suggesting sea-level was relatively high at this time (Balescu *et al*. 1997, van Vliet-Lanoë *et al*. 2000, Bates *et al*. 2000). Indeed, indications from Nortons Farm (Bates *et al*. 2010) and the MIS 7 raised beach at Tancarville, northern France (Lefebvre 1993) are that cooling preceded sea-level fall at the onset of MIS 6.

However, the sea-level indicated by the Gordano Valley deposits is in keeping with that suggested by the marine isotope sea-level curve, i.e. that sea-level for MIS 7 was lower than present (Waelbroeck *et al*. 2002). The Gordano Valley therefore appears to provide terrestrial validation for a low MIS 7, probably sub-stage 7a, sea-level as indicated by marine sediment cores without recourse to an uplift model; alternatively it is possible that the valley floor either subsided or remained static relative to interfluve uplift.

9.4.2 Devensian (MIS 5d-2)

Evidence from the Gordano Valley suggests Devensian valley floor sediment accumulation probably took place in three phases in response to deteriorating climatic conditions; the first during Early Devensian time (probably MIS 5b), a second following the LGM and a third during the Younger Dryas Stadial. In the Gordano Valley this may have resulted in the initiation of alluvial fan formation. Similar evidence is recorded at other sites in southern England and northwest Europe which are outside the limits of the last glaciation. Examples are found in the upper Thames valley at Ashton Keynes, Wiltshire, where Early Devensian slope destabilisation resulted in enhanced sediment supply to the river (Lewis *et al*. 2001), at Churchdown, Gloucestershire, where hillslope mudslides attributed to the Younger Dryas Stadial are recorded (Hutchinson 1991) and on Alderney, Channel Islands, where repetitive debris flows occurred throughout Devensian (MIS 5d-2) time (James & Worsley 1997). In northwest Europe examples of Devensian/Weichselian (MIS 5d-2) landscape instability are found at Harmignies, Belgium, where colluvial sediments dated to MIS 5 coincide with known phases of landscape instability and active run-off (Frenchen *et al*. 2001) and the Seine valley, France, where hillslope degradation resulted in enhanced sediment input preceded fluvial incision during MIS 4 (Antoine *et al*. 2007).

In addition, changes in fluvial style in the Gordano Valley appear to broadly correspond to fluvial response to climate change found in southern England and northwest Europe. In the upper Thames valley at Ashton Keynes, Wiltshire, a change in fluvial style from a wandering to a braided style occurred at the MIS5/4 transition and later, during the Late Devensian Lateglacial Interstadial (MIS 2) the river probably adopted a sinuous planform, subsequently adopting a multi-channel system in response to Younger Dryas climate deterioration and consequent enhanced sediment supply (Lewis *et al*. 2001). Similar responses to climate change are recorded in northwest Europe; van Huissteden & Kasse (2001) provide a Mid-Late Weichselian (Mid-Late Devensian, MIS 3-2) succession for the Netherlands based on data from a number of rivers e.g. Maas, Dinkel, Mark, which shows planform changes from anastomosing during MIS 3 to braided during MIS 2, meandering during the Allerød Interstadial and a return to a braided style during the Younger Dryas Stadial (van Huissteden & Kasse 2001), change to a braided system at the MIS3/2 transition is recorded at the Somme valley, northern France where a MIS 2 braided system was probably replaced during the Allerød Interstadial by a single meandering channel (Antoine *et al*. 2007). However, changes in fluvial discharges, stream rejuvenation, mobilisation of coarse debris and changes in sediment loads in the Gordano Valley have been referred to fluvial changes in an alluvial fan setting. An example of fluvial changes in a similar setting is found in the upper Thames valley at Latton, Wiltshire, where a change from a meandering to a braided planform was interpreted as probably reflecting a shift in the depositional focus of an alluvial fan (Lewis *et al*. 2006).

Diminshed fluvial activity, often with channel abandonment, and increased aridity corresponds with two distinct episodes of aeolian deposition that are found in southern England, the lower dating to the LGM or earlier, and the upper to the Younger Dryas Stadial (Harris 1987). In the Gordano Valley this is reflected in erosional and nondepositional episodes which suggest channel abandonment and in fine and very fine sand deposits, interpreted as aeolian, which occur prior to and following an erosional episode coincident with the LGM. Channel abandonment, cessation of fluvial deposition in response to increased aridity and increased aeolian activity at this time is indicated at Brimpton, Berkshire, Baston, Lincolnshire (Bryant *et al*. 1983, Briant *et al*. 2004) and the Rhine and Meuse (Maas) Rivers in The Netherlands (Busschers *et al*. 2007). Two episodes of aeolian deposition are recorded at Manston, Kent (Baker & Bateman 2010) and from the Meuse (Maas) River valley, The Netherlands; one during the Younger Dryas Stadial and an earlier episode around the time of the LGM (Tebbens *et al*. 1999, Cohen *et al*. 2002).

Two dated pedogenetic units in the Gordano Valley indicate intervals of relatively stable landscape. The older unit probably relates to an interval of climate amelioration during MIS 3 which terminated around the LGM; the younger reflects climatic amelioration during the Late Devensian Lateglacial Interstadial which was terminated by the Younger Dryas Stadial. There appear to be no records of MIS 3 soil formation in southern England, although in northwest Europe gleysols are inferred to have formed during warmer climate intervals of MIS 3 at Kesselt (Vandenberghe *et al*. 1998) and at Harmignies, Belgium, where a well-developed MIS 3 palaeosol developed on loess deposits (Frechen *et al*. 2001). Evidence for pedogenesis prior to the Younger Dryas Stadial is in agreement with evidence for soil formation during the Late Devensian Lateglacial Interstadial at Heathrow Airport, London, and Dover Hill, Kent (Preece 1994, Rose *et al*. 2000) and widespread evidence for soil formation in northwest Europe. For example, van Huissteden & Kasse (2001) report soil profile development in the Maas valley, The Netherlands, during the Bølling/Allerød interstadials and humic soil development during this time is recorded in the Somme valley (Antoine *et al*. 2007).

The Gordano Valley therefore shows good agreement with other evidence for Devensian paleoenvironmental change, but whereas this tends to occur as one or two pieces of evidence at any one site, in the Gordano Valley it occurs in a more compact space, demonstrating the unique preservation potential of the valley and making it an important regional site. The setting of the earlier MIS 7 deposits may be more significant as this appears to differ altitudinally from most other coastal sites at this time. Establishing a geochronology for the Pleistocene development of the Gordano Valley has allowed deposition to be placed within a wider context, enabling the palaeoenvironmental changes in the valley to be compared to the known histories of other regional sites and the deposits to be linked to wider climatic forcing factors.