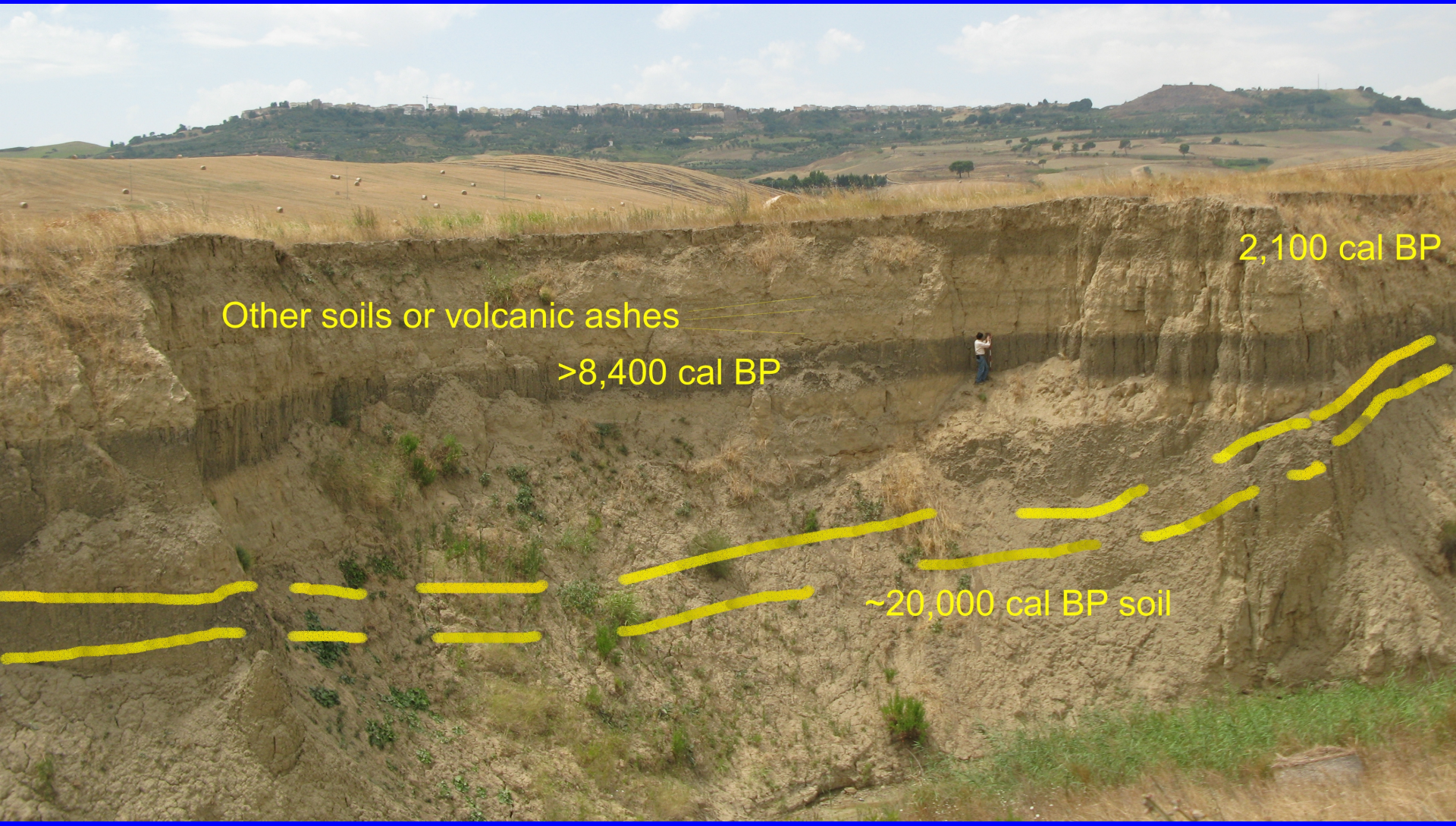
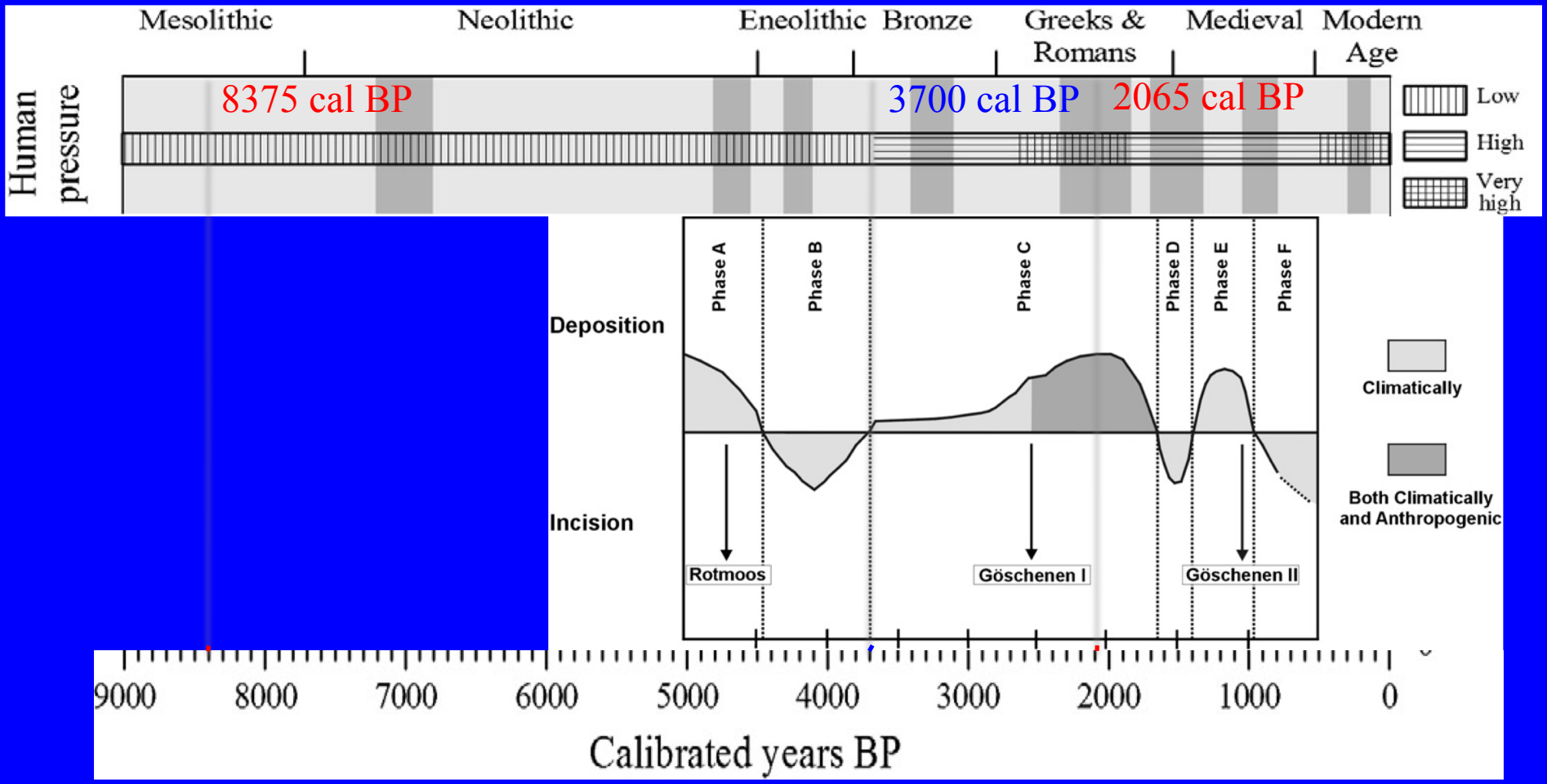
Dated Strata of Irsina Exposure



Based upon correlation with other exposures we have dated in the region there is at least 21,000 years of alluvial history exposed in this stream bank. The current 15 m-deep alluvial cutting is unequalled at any time during the last 21,000 years, and is due to current land use practices coupled with the change in precipitation timing and intensity.

Baron Spring

A 4,000-year record of Spring Discharge contains at least three major increased discharge events, that can be correlated with episodes of soil formation, and periods of increased rainfall.



Composite diagram showing the relationship between:

1) deposition and erosion stages in the Fossa Bradanica
2) the main European climatic epochs during the Holocene (F. Boenzi et al. (2008) 297–306)
3) related human cultural periods for southern Italy (M. Piccarreta et al. (2011) 137–147.)

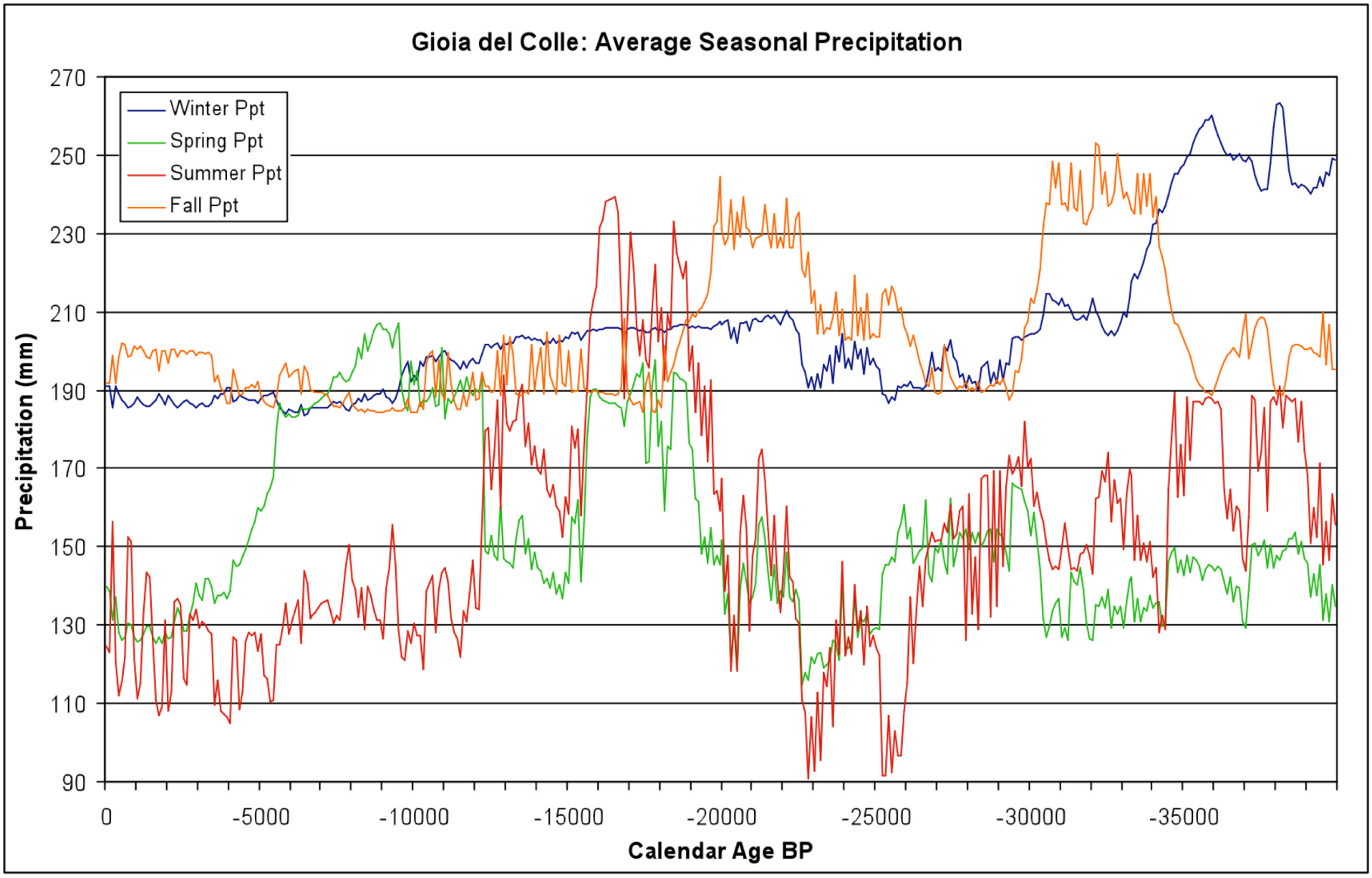
*The ages associated with the red lines are dates that we have from alluvial exposures. The blue date is on the deepest spring discharge event at Baron Spring and a major regional phase of soil development when there was also no erosion.

Using the Meso-scale Climate Model (MCM) to Assess the Impact of Climate Change and Landscape Dynamics

- We are assessing the impact of variations not only of annual precipitation and temperature, but also of their seasonal variation.
  - Seasonal variation may result in significant changes in the kind and density of vegetation cover. These changes impact landscape processes (erosion and deposition).

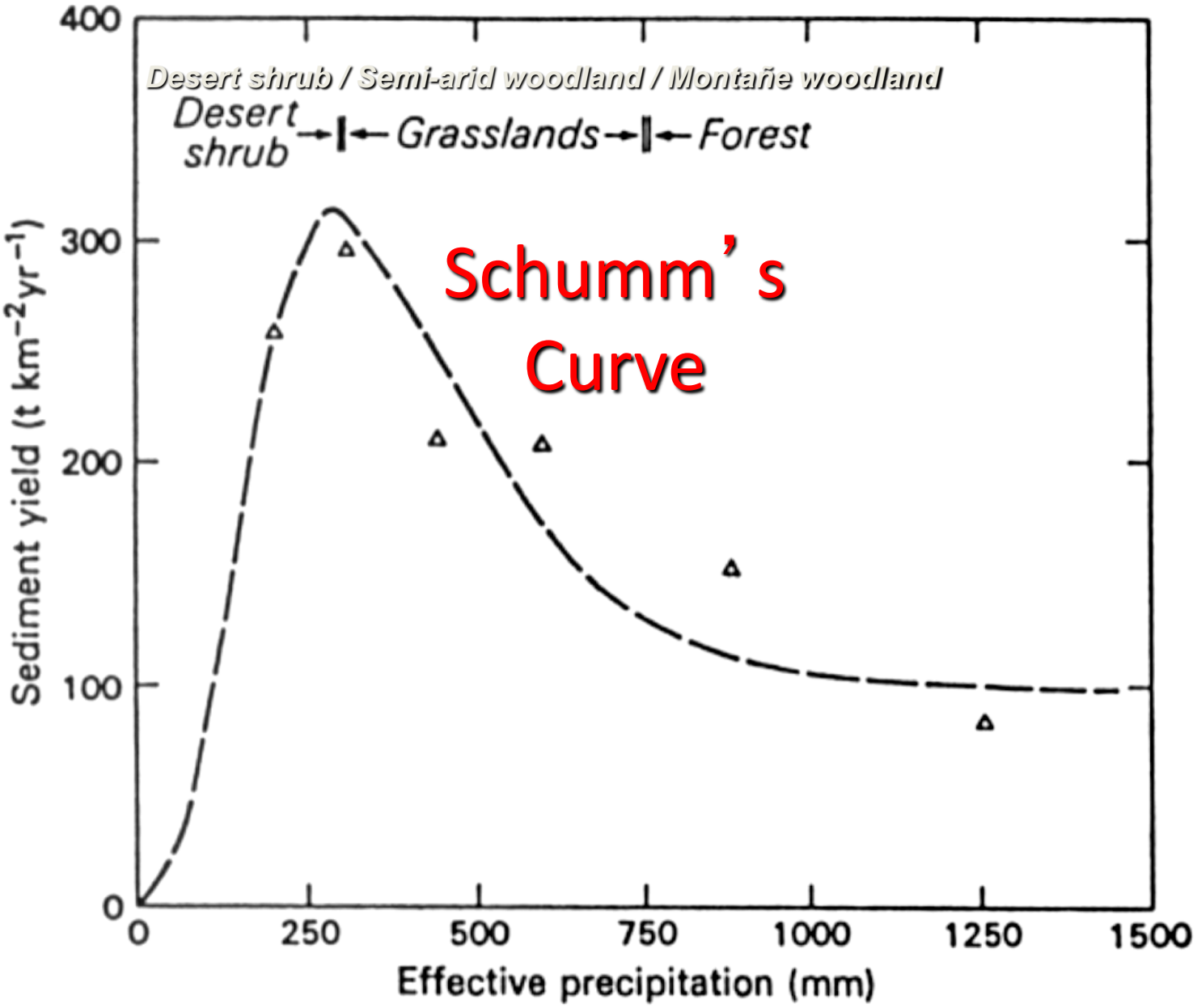
- We are investigating the evidence of human land use and its impact upon the landscape.
  - Because the surface geology is extremely sensitive to human activity, we are mapping sites on the landscape and the type of surface geology that was being impacted.

Applied Bryson and Bryson MCM Physical Climate Model:
Precipitation and Temperature for 40,000 years



Modeling Past Erosion Cycles

To determine the contribution of past climate to regional erosion we applied the Langbein and Schumm model to the MCM climate reconstruction from Gioia del Colle.



The relationship between sediment yield (erosion) and effective precipitation (adjusted for temperature variations; after Langbein and Schumm 1958).

Explanation of Langbein & Schumm's

- The relationship between precipitation and sediment yield is not linear because precipitation has an opposite effect on the two factors which directly determine sediment yield — stream discharge and sediment concentration.
    - Stream discharge increases with greater precipitation.
    - Sediment concentration decreases in response to the associated increase in plant cover.
    - The maximum sediment yield observed occurs under semiarid conditions because a semiarid climate has sufficient precipitation to promote ample runoff, yet insufficient rainfall to produce a vegetative cover which will inhibit erosion.

Langbein & Schumm's Curve & Changing Erosion Rates

- Interglacial Conditions:
  - ✓ less precipitation
  - ✓ less vegetation cover
  - ✓ less ground surface protection
  - ✓ more surface erosion

Interglacial to Glacial Climates: transition to wetter conditions

1. precipitation increases

2. ground cover increase lags behind the increased precipitation

3.the increase in ground surface protection also lags behind the increase in precipitation

4. erosion rates increase until the vegetation cover and ground surface protection are finally in equilibrium

5. at that point erosion rates are low because even though there is abundant precipitation vegetation cover and ground surface protection is high

- Glacial Conditions:
  - ✓ more precipitation
  - ✓ more vegetation cover
  - ✓ more ground surface protection
  - ✓ less surface erosion

Glacial to Interglacial Climates: transition to drier conditions

1. precipitation decreases

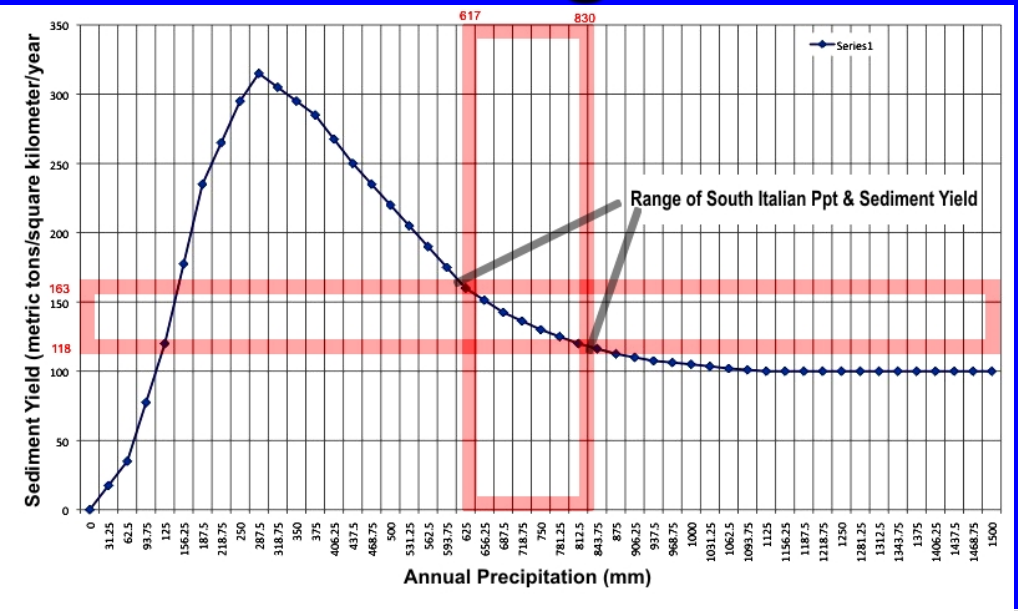
2. ground cover decrease lags behind the decreased precipitation

3. fire thins and clears relict glacial vegetation

4. the decrease in ground surface protection results in increased erosion rates

5. however if the trend is to even lower amounts of precipitation, even though ground cover becomes minimal, because precipitation is minimal, little erosion occurs

Langbein and Schumm Curve



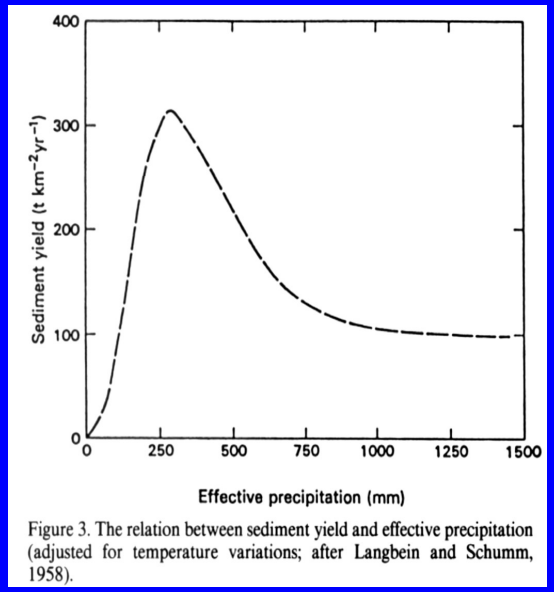
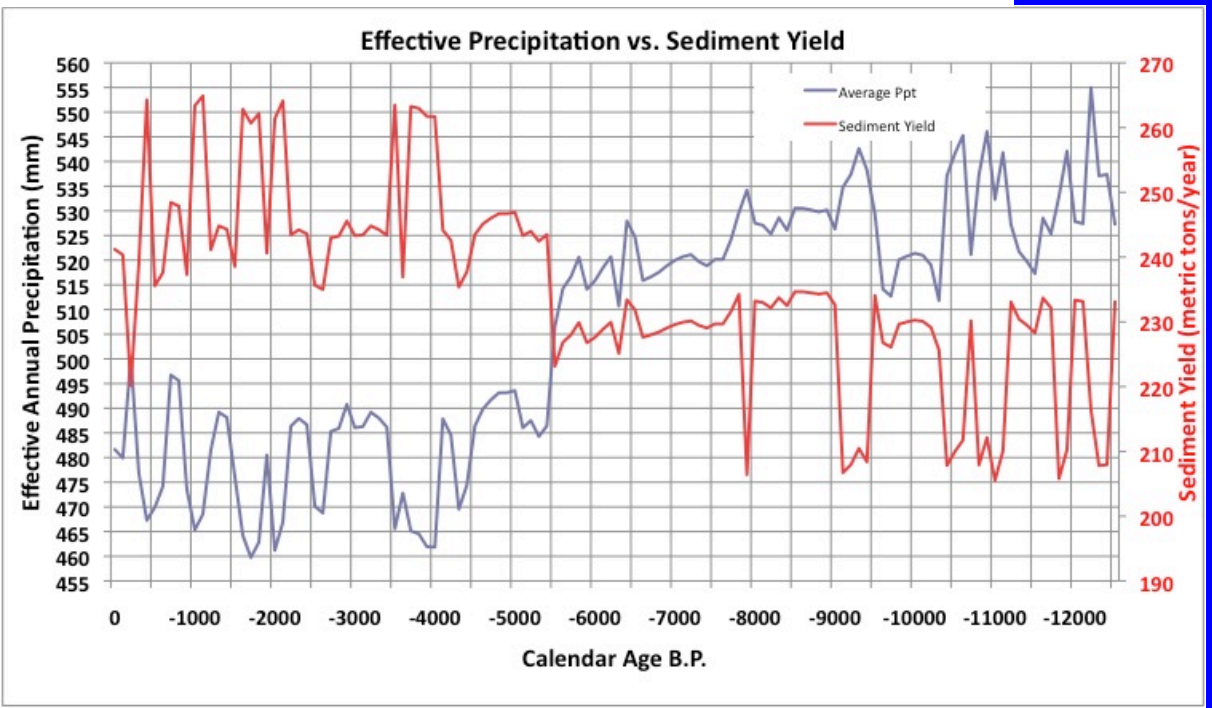
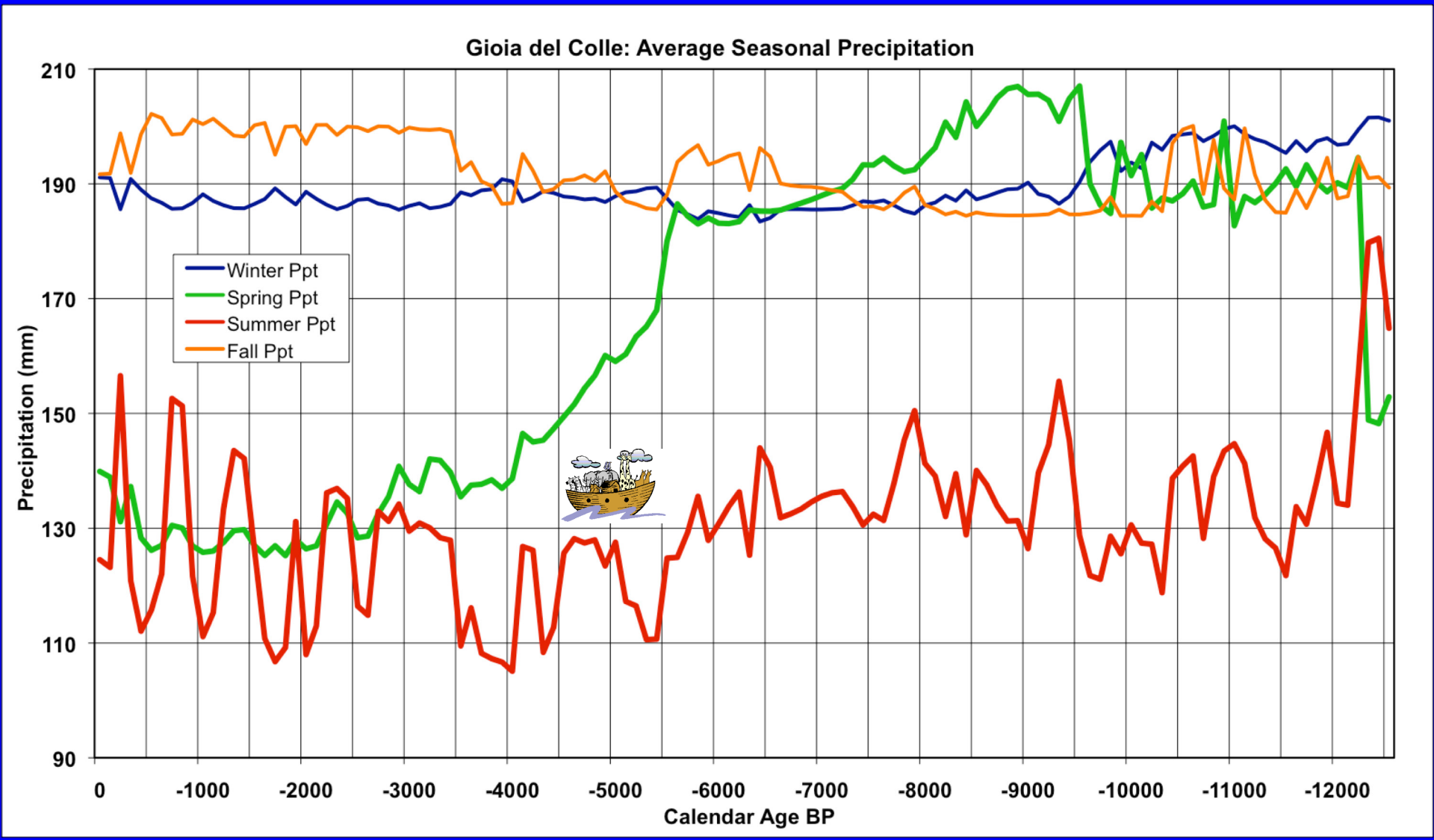


Figure 3. The relation between sediment yield and effective precipitation (adjusted for temperature variations; after Langbein and Schumm, 1958).



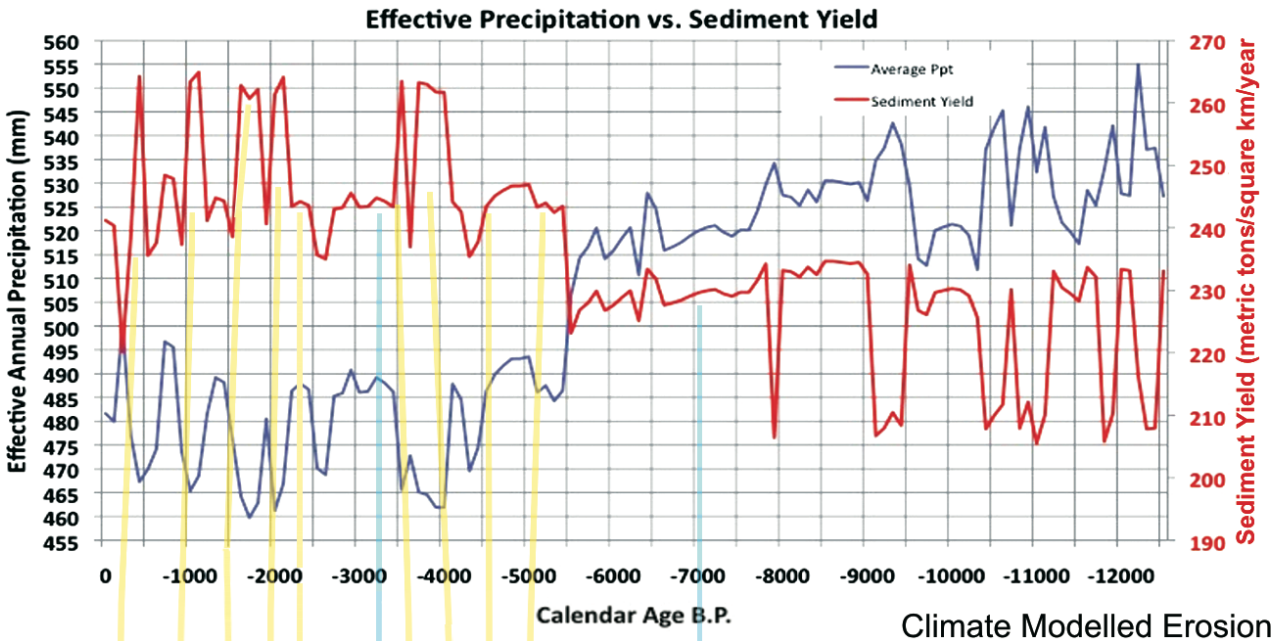
We have converted the MCM modeled precipitation to effective precipitation, and plotted it with respect to sediment yield from the Langbein and Schumm (1958) model to show predicted correspondence between effective precipitation and erosion cycles in southern Italy.

Bryson MCM Physical Climate Model: Role of Seasonal Precipitation

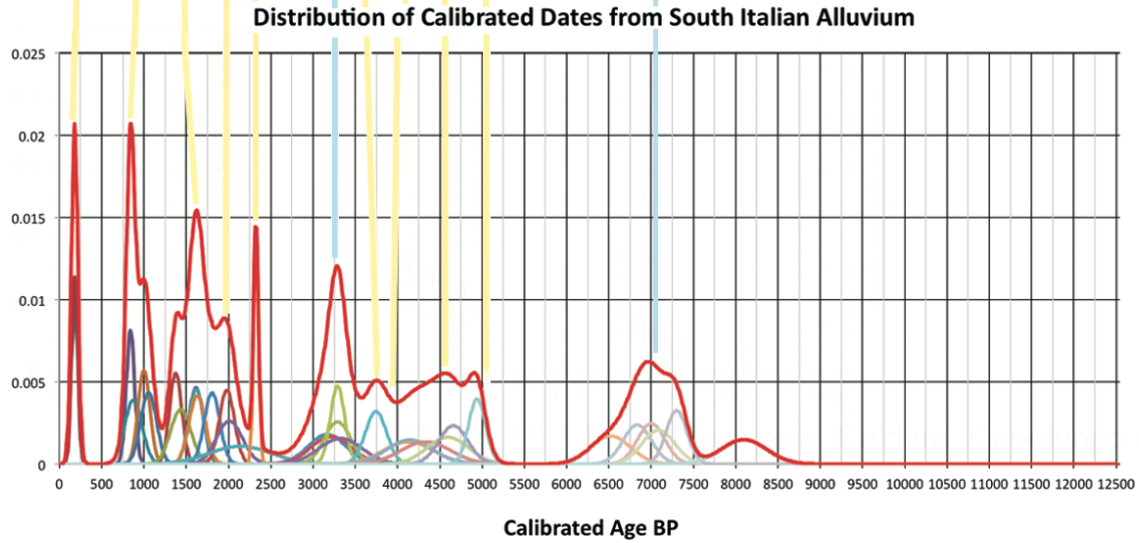


MCM modeled seasonal precipitation for the last 12,500 years. Fall and winter precipitation have not varied as much as spring and summer precipitation.

Correlation of Model with Alluvial History



Climate Modelled Erosion Cycles

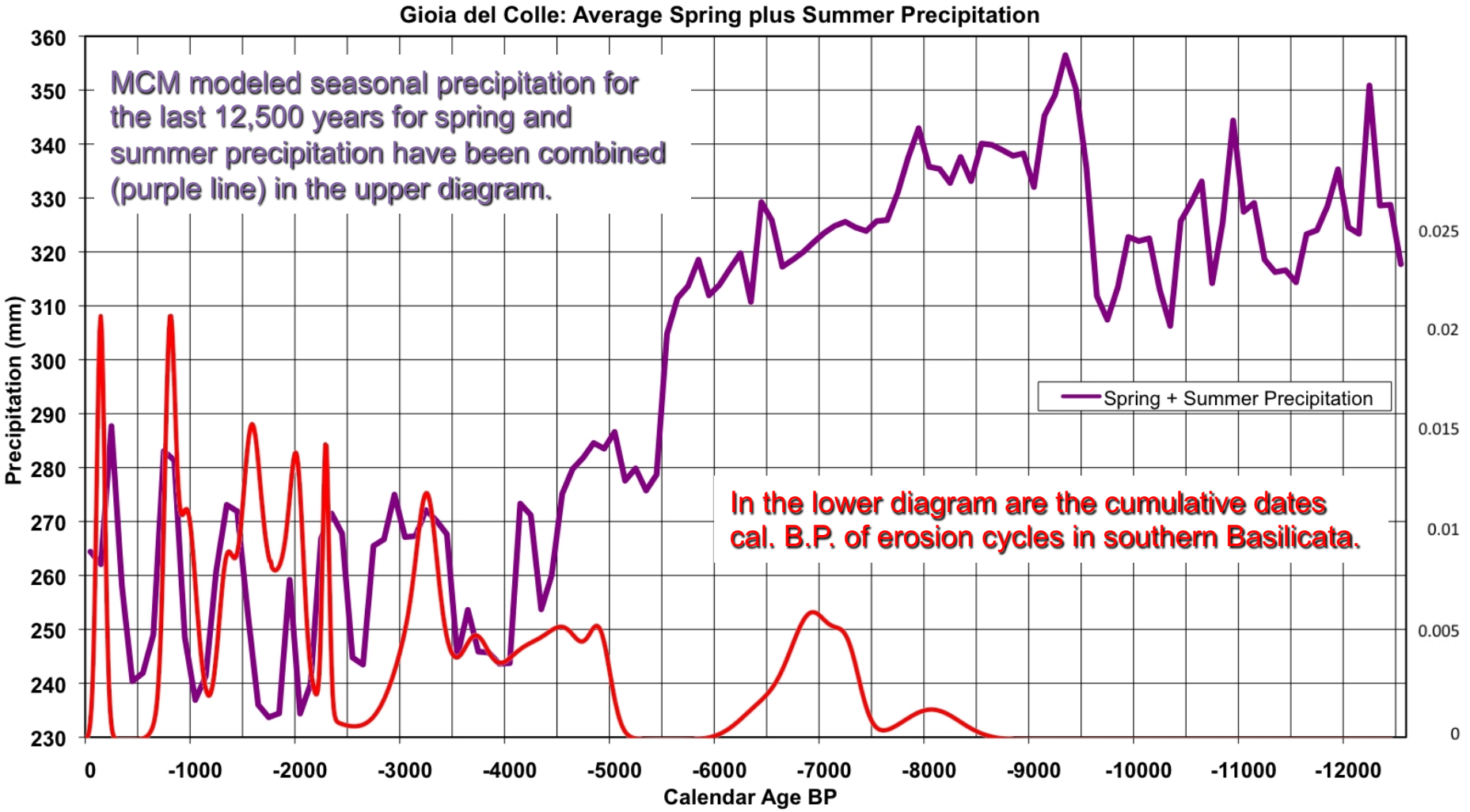


Calibrated Dates on Erosion Cycles from Picarretta *et al*. 2011

The model of predicted erosion corresponds with the sum of the record of calibrated ages B.P. of erosion cycles in the Mezzogiorno.

Events connected with yellow lines are climate based, whereas with blue lines are caused by intensified land use.

Overlay of the Σ of Spring and Summer Precipitation on the Σ of calibrated dates on erosion cycles.



Erosion cycles began after a major decline in spring precipitation during the last 8,000 years. Episodes of erosion during the last 5,000 years generally begin after the onset of episodes of summer precipitation after a significant drought.

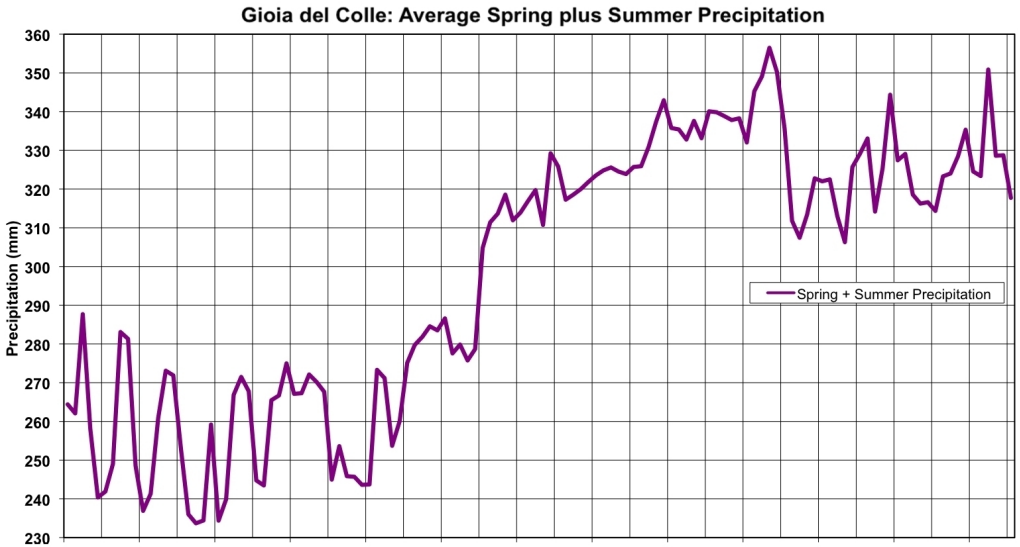
Stream Discharge

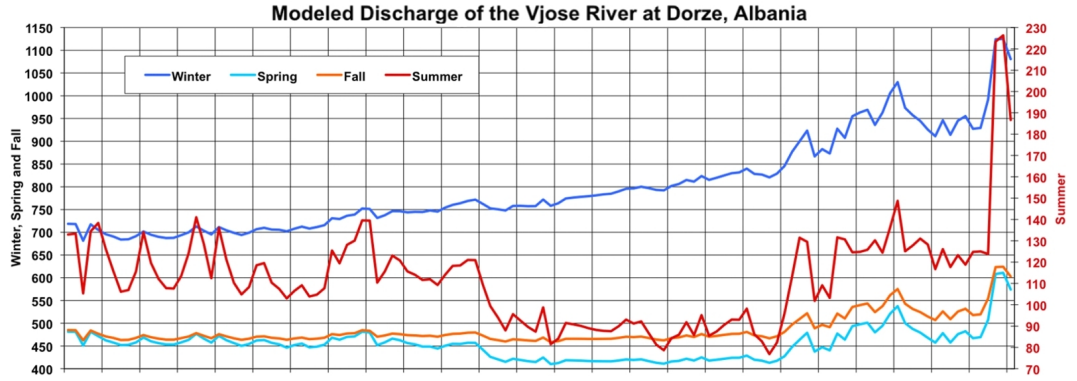
Reconstructed regional stream discharge during the Holocene is another clue to both the change in climate, and also to the sediment transport potential of streams.

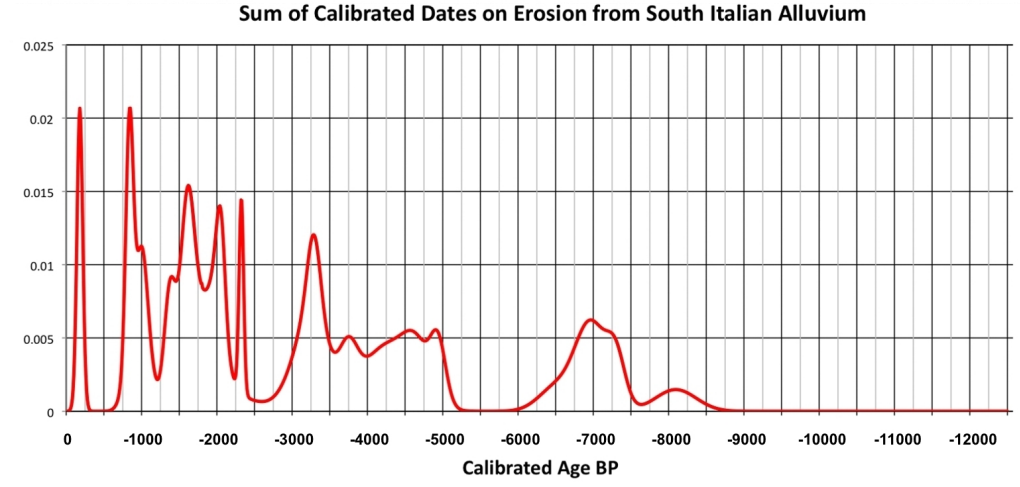
Stream discharge records in the Basilicata region are too short to create a reliable stream flow reconstruction, so the record from the lowest gage at Dorze, Albania, on the Vjose River was used.

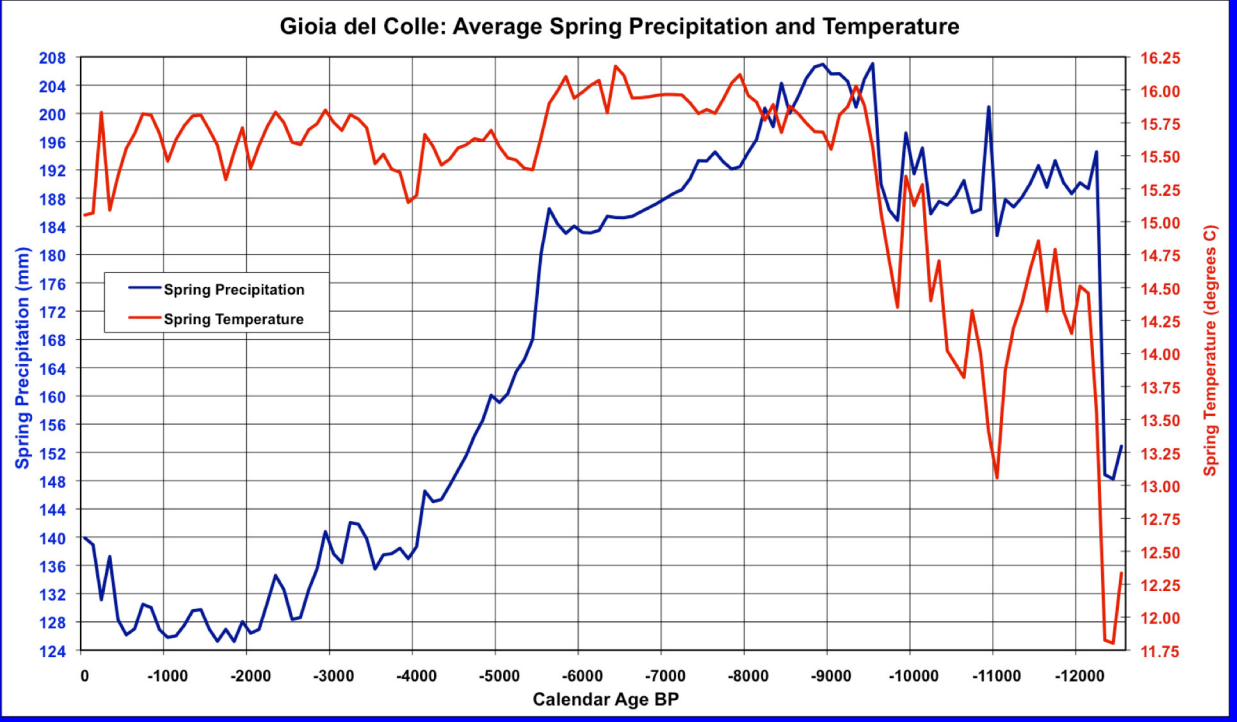
The similarity between the late Holocene summer stream discharge record of the Vjose River and the erosion cycles in southern Italy is evident.

Increased stream discharge enables streams to have greater sediment carrying capacity thereby facilitating landscape erosion.



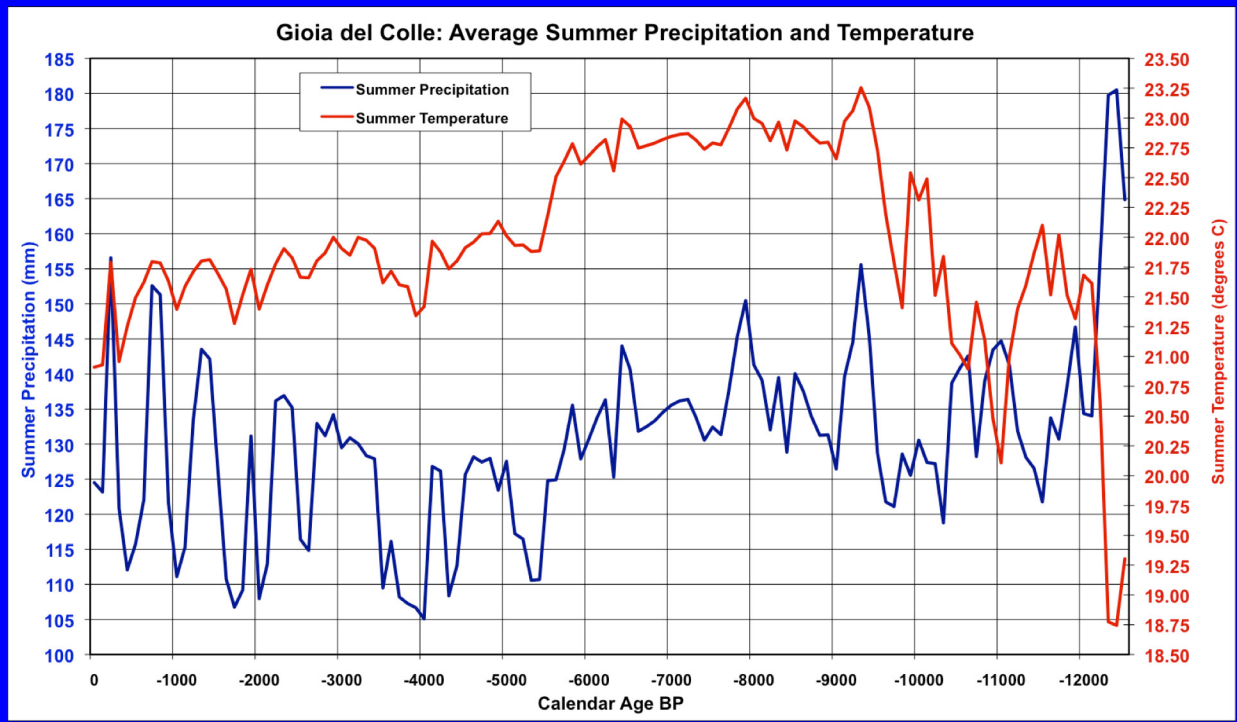






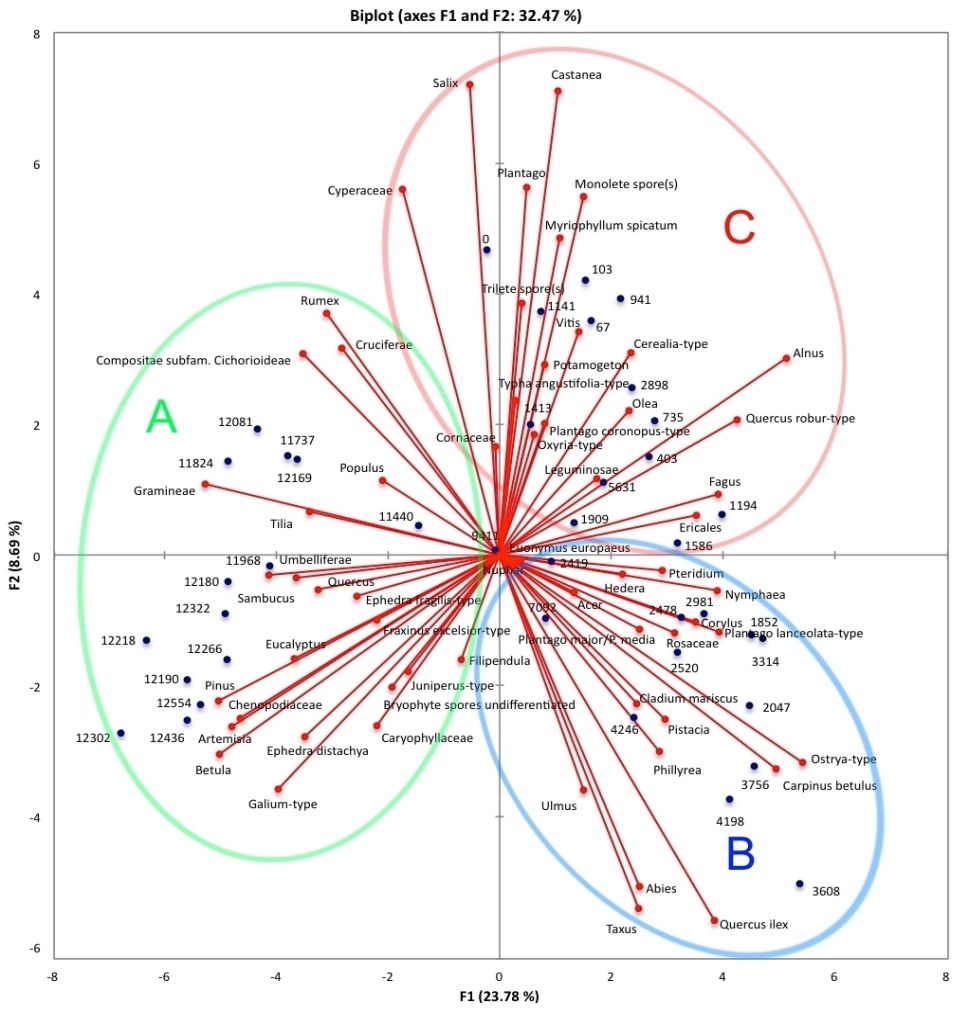
Holocene Precipitation vs Holocene Temperature

- Spring precipitation declined significantly 5,500 years ago, but there was only a slight decline of spring temperature.
- A decline of average summer temperature of ~1° C during the last 5,500 years, resulted in a significant increase in effective precipitation during episodes of increased summer precipitation.

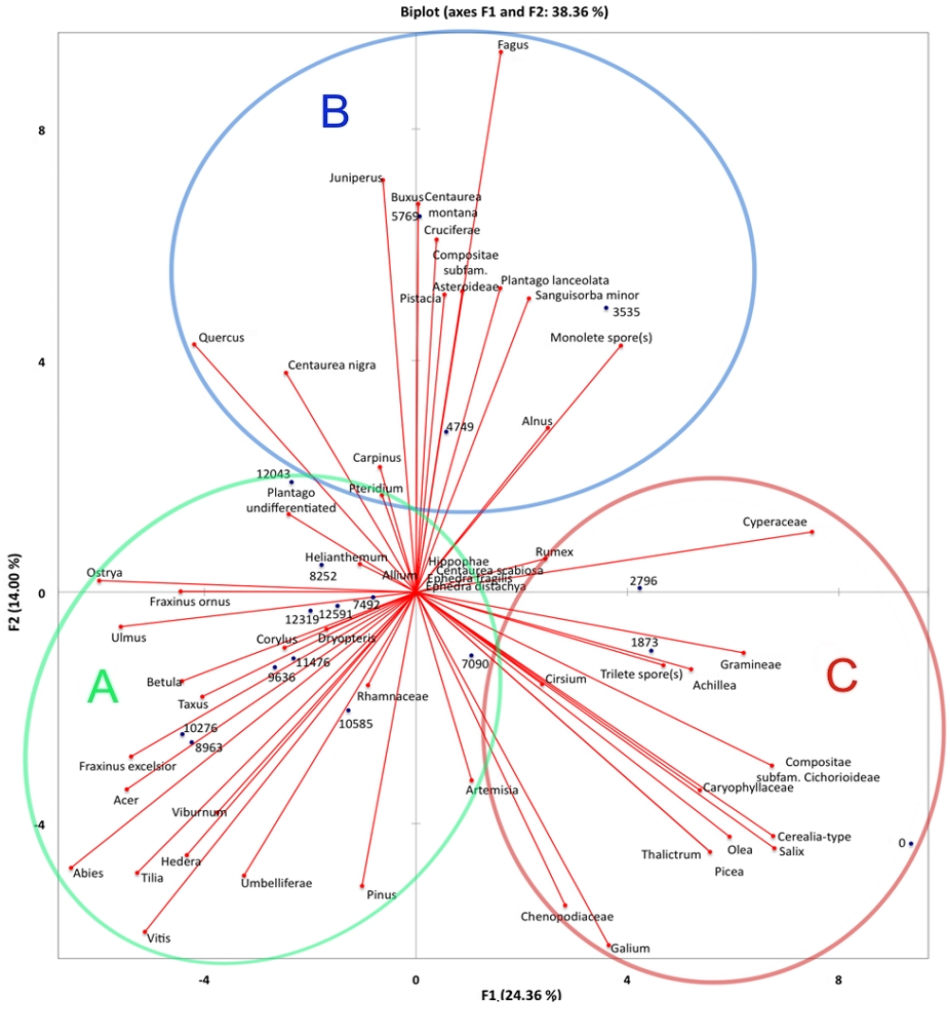


Holocene Pollen from Lago Grande Monticchio

LGM90D PCA last 12,500 cal. yr. B.P.

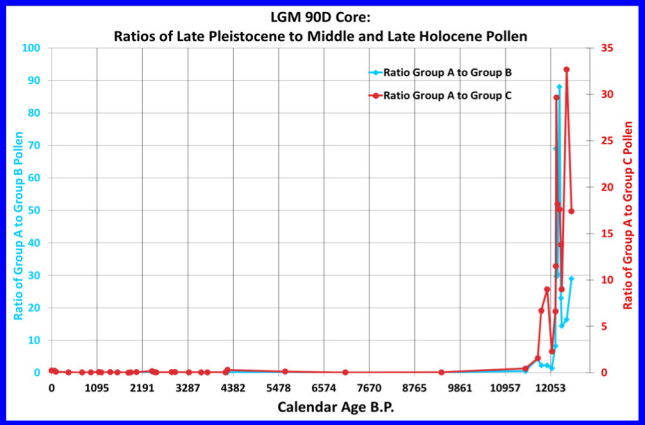


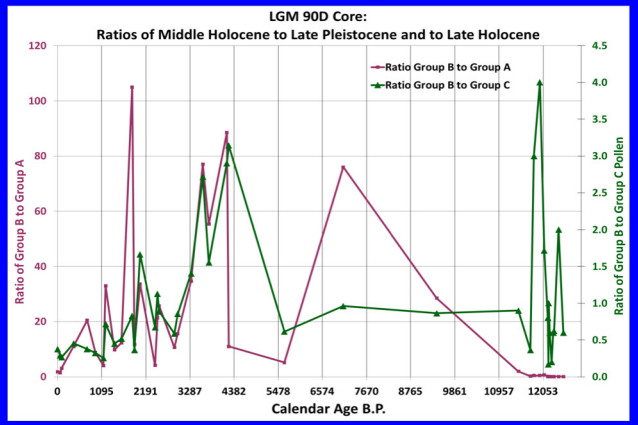
Mont82 PCA last 12,500 cal. yr. B.P.

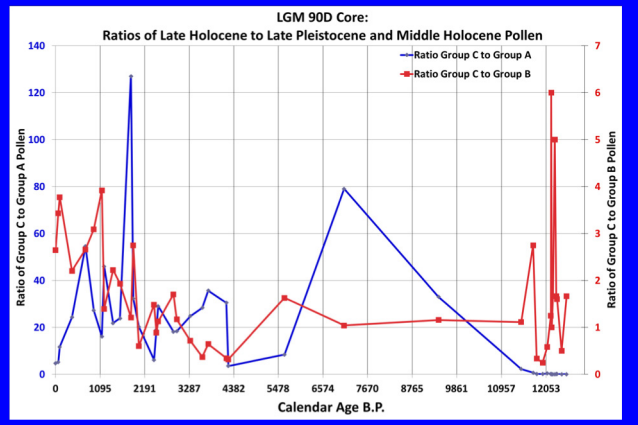


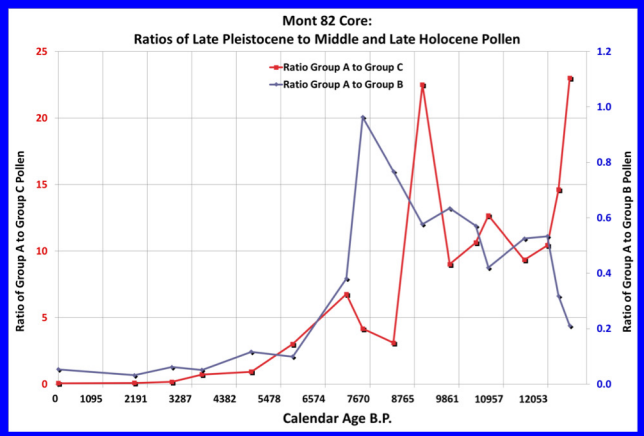
Principle component analysis the last 12,500 years of pollen from two Lago Grande Monticchio cores results in the formation of three statistically significant groups, which coincide with the three major breaks in Holocene climate revealed in the MCM reconstruction of Gioia dell Colle climate, A) 12,500-10,000; B) 10,000-5,500; C) 5,500-present.

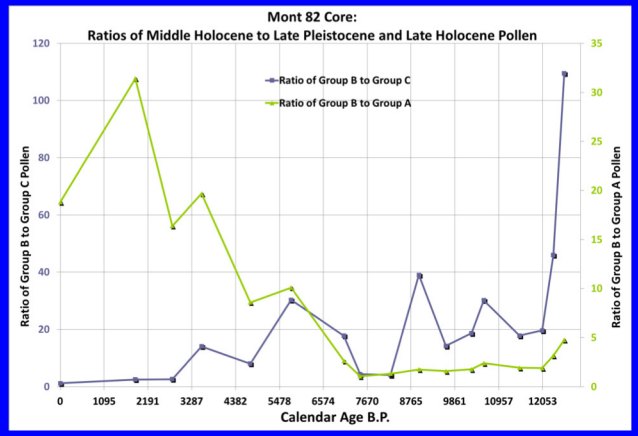
Holocene Pollen from Lago Grande Monticchio

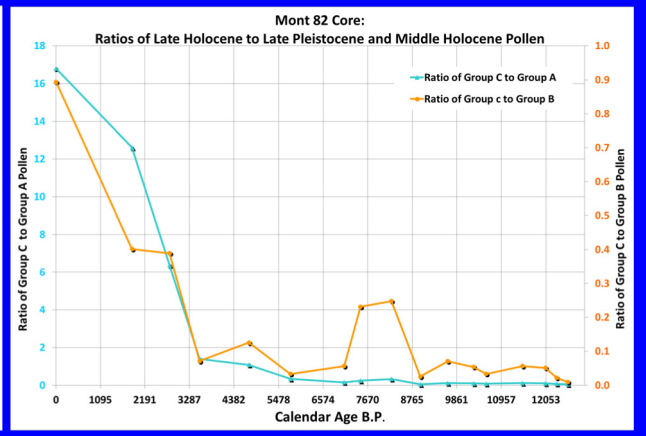












Plots of the ratios of pollen in the three PCA groups from the two cores, reveals the three part division of the Holocene pollen record. Human activity is evidenced by domesticated pollen, it includes pollen of cereals grasses, olive, and in the case of the LGM 90 core, vitis (grape). The dominance of domesticated plant pollen increases dramatically during the last 3,000 years.

The increases mirror episodes of greater summer precipitation, but during last 3,000 years its increases at rates greater than the increase in summer precipitation. These increases mirror the growing impact of human agriculture.

Torrential Summer rains following wheat harvest, chaff burning, and plowing in Italy during July of 2015 carried sediment downslope in low- scale debris flows. Sediment was carried into streams feeding the Bradano and directly into the Gulf of Taranto. The years 2013, 2014 and 2015 had several episodes of extreme flooding and erosion. These have been triggered by a shift from gentle winter to high intensity summer storms. This has caused significant erosion of hillsides and exposure of underlying 3rd interglacial (Riss-Würm/Ipswichian /Sangamonian) rubified soils, and in many places Pliocene marine marls. The resultant creation of infertile badlands threatens this important wheat growing region.