

ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

**EXAMINING 4600 YEARS OF HUMAN-ENVIRONMENT INTERACTION:
CLIMATE AND VEGETATION HISTORY AROUND LAKE BURDUR
(SOUTHWESTERN TÜRKİYE) THROUGH PALYNOLOGICAL ANALYSIS**



M.Sc. THESIS

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Department of Ecology and Evolution

Geoanthropology Programme

MAY 2024

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İSTANBUL TEKNİK ÜNİVERSİTESİ ★ LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ

**4600 YILLIK İNSAN-ÇEVRE ETKİLEŞİMİNİN ARAŞTIRILMASI: BURDUR
GÖLÜ (GÜNEYBATI TÜRKİYE) ÇEVRESİNDEKİ İKLİM VE BİTKİ ÖRTÜSÜ
TARİHİNİN PALİNOLOJİK ANALİZLERLE İNCELENMESİ**

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To Vere Gordon Childe, comrade of those make themselves,



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ABBREVIATIONS

EMCOL	: Eastern Mediterranean Centre of Oceanography and Limnology
BP	: Before present
G.Ö.	: Günümüzden Önce
yr	: Year
cal	: calibrated
cm	: centimeter
mm	: millimeter
km	: kilometer
BOP	: Beyşehir Occupation Phase
BA	: Bronze Age
EBA	: Early Bronze Age
MBA	: Middle Bronze Age
LBA	: Late Bronze Age
XRF	: X-ray fluorescence
CHELSEA	: Climatologies at high resolution for the earth's land surface areas
OWDA	: Old World Drought Atlas
LIA	: Little Ice Age
MCA	: Medieval Climate Anomaly
DACP	: Dark Ages Cold Period
RCO	: Roman Climatic Optimum
MCA	: Medieval Climate Anomaly
AP	: Arboreal Pollen
NAP	: Non-arboreal Pollen
API	: Anthropogenic Pollen Indicator
PDI	: Pollen Disturbance Index
OJC	: <i>Olea, Juglans, Castanea</i>
OJCV	: <i>Olea, Juglans, Castanea, Vitis</i>
CI	: Cultural Indicators
PI	: Primary Indicators
SI	: Secondary Indicators



SYMBOLS

Ca	: Calcium
Fe	: Iron
°C	: Degree Celcius
Ti	: Titanium
δ	: Delta
O	: Oxygen
C	: Carbon



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EXAMINING 4600 YEARS OF HUMAN-ENVIRONMENT INTERACTION: CLIMATE AND VEGETATION HISTORY AROUND LAKE BURDUR (SOUTHWESTERN TÜRKİYE) THROUGH PALYNOLOGICAL ANALYSIS

SUMMARY

Burdur, located at the intersection of the Mediterranean, Aegean, and Central Anatolia, boasts a rich history of continuous human habitation spanning millennia. Despite extensive scholarly focus on the region's historical and archaeological development through various methods, a significant research gap persists regarding ancient climate, vegetation, and the intricate relationships between humans and the environment. To address this comprehensively, sediment core BRDR-2, retrieved from Lake Burdur and dating back approximately 4,600 years BP (around 2650 BC), underwent palynological analysis. This analysis integrates multiple approaches, including the examination of various proxy records around the study region and the incorporation of paleoclimatic data from sources like CHELSA and Paleoview, as well as historical accounts. By merging diverse scientific approaches, this research aims to illuminate the complex interactions that have shaped the historical landscape of the Burdur Basin and offer insights into its enduring significance. According to the pollen analysis, the basin is dominated by *Quercus ilex-coccifera* type (evergreen *Quercus*), *Olea* (olive), *Juglans* (walnut), and pine trees (*Pinus brutia* and *Pinus nigra*). Additionally, among coniferous trees, *Cedrus libani* (cedar) stands out, indicating the long-distance transportation of this species from the Taurus mountain ranges. The fossil pollen analysis shows that alongside salient climatic changes during the Early Bronze Age, settlement expansion and population growth had a noticeable impact on vegetation, resulting from a significant increase in agricultural activities. This analysis also indicates the signals of the Beyşehir Occupation Phase (BOP), marked by increased agricultural activities and a significant trend toward extensive deforestation, a pattern commonly observed in pollen sites across the Eastern Mediterranean. Notably, this phase occurred in Burdur within a distinct timeframe, beginning during Roman expansion and persisting until the Early Modern Ottoman Period, compared to other sites in the region. While other regions experienced similar anthropogenic influences, Burdur's unique timeline of these events highlights a distinct pattern. During the Roman period, significant agricultural intensification and deforestation were evident, continuing into the Early Modern Ottoman period. This contrasts with other areas where such activities might have started later or ended earlier. Considering the amplification of this anthropogenic activity alongside corroborating proxy data and paleoclimate models in the area, it can be suggested that the climatic influence on this trend might be relatively indirect, while humans may have had a more significant impact on the landscape. The distinct pattern observed in Burdur underscores the region's unique response to broader climatic and human-induced changes, offering a valuable case study for understanding human-environment interactions over millennia.



**4600 YILLIK İNSAN-ÇEVRE ETKİLEŞİMİNİN ARAŞTIRILMASI:
BURDUR GÖLÜ (GÜNEYBATI TÜRKİYE) ÇEVRESİNDEKİ İKLİM VE
BİTKİ ÖRTÜSÜ TARİHİNİN PALİNOLOJİK ANALİZLERLE
İNCELENMESİ**

ÖZET

Akdeniz, Ege ve Orta Anadolu'nun kesişiminde yer alan Burdur, binlerce yıllık yerleşim geçmişine sahip zengin bir tarihe sahiptir. Bölgenin tarih ve arkeolojik gelişimi üzerine kapsamlı çalışmalar yapılmış olsa da, geçmiş iklim, bitki örtüsü ve insan-çevre etkileşimleri konusunda önemli bir araştırma boşluğu bulunmaktadır. Bu araştırma boşluğunun doldurulması, bölgenin geçmişine dair daha kapsamlı bir anlayış sağlayacaktır. Bu eksikliği gidermek amacıyla, yaklaşık 4,600 yıl öncesine (MÖ 2650 civarı) tarihlenen Burdur Gölü'nden alınan sediman karotu BRDR-2 üzerinde palinolojik analiz yapılmıştır. Bu analiz, bölgedeki çeşitli vekil verilerin incelenmesini ve CHELSA ve Paleoview gibi paleoiklimsel verilerle birlikte tarihsel kayıtların entegrasyonunu içermektedir. Farklı yöntemlerin birleştirilmesiyle, bu araştırma Burdur havzasının tarihi peyzajını şekillendiren karmaşık etkileşimleri aydınlatmayı ve uzun vadeli değişimlere dair bakış açısı sunmayı amaçlamaktadır. Bu kapsamlı yaklaşım, bölgenin ekolojik ve kültürel evrimini daha iyi anlamamıza olanak tanıyacaktır.

Holosen süresince (son 12.000 yıl), insanlık doğal çevresi üzerinde etkili olmuş ve aynı zamanda çeşitli şekillerde doğal çevreyi şekillendirmiştir. Ancak, insan etkisi özellikle Geç Holosen döneminde (yaklaşık MÖ 4000'den itibaren) belirginleşmiş ve günümüze doğru giderek artmıştır. Bu dönemde, tarım ve yerleşik yaşamın yaygınlaşması, çevresel değişimlerin hızlanmasına neden olmuştur. Paleo-ekoloji, paleo-vejetasyon, paleoiklim, paleocoğrafya, jeoloji ve jeofizik alanlarındaki bilimsel ilerlemeler sayesinde, insan kaynaklı çevresel etkilerin belirlenmesi ve detaylı olarak incelenmesi mümkün hale gelmiştir. Holosen döneminde Anadolu'da çeşitli önemli olaylar yaşanmıştır, bunlar arasında iklim değişimleri, orman örtüsünün genişlemesi veya daralması, plüvyal göllerin yok olması, yerleşik yaşama geçiş, tarımın başlaması, yoğun yerleşimlerin oluşması ve bazı yerleşimlerin çeşitli sebeplerle terk edilmesi yer almaktadır. Bu olaylar, bölgenin kültürel ve ekolojik yapısını derinden etkilemiştir. Bu değişimler, genel olarak Akdeniz Havzası'nda yaşananlarla benzerlikler gösterse de Anadolu'nun özgün coğrafi ve kültürel dinamikleri nedeniyle önemli farklılıklar da içermektedir. Güneybatı Anadolu, arkeolojik zenginliğiyle Erken ve Orta Holosen dönemlerindeki kültürel gelişimimize büyük bir ışık tutmaktadır. Bölgede, Neolitik dönemden Demir Çağı'na kadar uzanan önemli yerleşimler özellikle Burdur ve çevresinde yoğun olarak belirlenmiştir. Bu yerleşimler, bölgenin tarihi ve kültürel gelişimini anlamamız açısından kritik öneme sahiptir. Burdur İl merkezinin 27 km güneybatısında bulunan Hacılar Köyü'ndeki Hacılar yerleşmesi, Erken Neolitik dönemdeki ilk yerleşik yaşam örneklerinden biridir ve bu sürecin anlaşılmasında kritik bir rol oynamaktadır. 1957-1960 yılları arasında J. Mellaart başkanlığında gerçekleştirilen kazılar, bölgenin geçmişini aydınlatan önemli bulgular ortaya çıkarmıştır. Hacılar'ın 400 m kuzeyinde yer alan Hacılar Büyük Höyük, aynı şekilde

bölgenin arkeolojik önemini koruyan bir başka yerleşimdir. Mellaart'ın kazıları, yaklaşık MÖ 3000'e tarihlenen ve Anadolu'da eşi benzeri olmayan kazamatlı savunma sistemini gün yüzüne çıkarmıştır. Bu bulgular, bölgenin savunma stratejileri ve toplumsal yapısı hakkında önemli bilgiler sunmaktadır.

Burdur Gölü, Türkiye'nin en büyük tektonik göllerinden biri olarak Batı Anadolu'nun önemli doğal kaynaklarından biridir. Göl, Batı Toroslar'ın güney kesiminde, aktif bir fay hattı olan Burdur-Fethiye Fayı üzerinde yer alır ve yaklaşık 180 km²'lik bir alanı kaplar (Şener vd., 2005). Gölün uzunluğu yaklaşık 34 km'dir ve derinliği ortalama 40 m olarak ölçülmüştür; en derin noktası ise 110 m'yi bulmaktadır. Burdur Gölü, bölgenin hidrolojik ve ekolojik dengesini belirleyen önemli bir unsur olarak öne çıkmaktadır. Burdur Gölü, yeraltı suları ve çevresindeki dereler tarafından beslenir ve kapalı bir havza olması nedeniyle su kaybı genellikle buharlaşma yoluyla gerçekleşir. Son yıllarda, göldeki su seviyesinde ve alanında önemli ölçüde küçülme gözlemlenmiştir, bu durum göl ekosistemi ve çevresel denge açısından ciddi endişelere yol açmaktadır. Bu küçülme, bölgedeki yaşam ve tarım faaliyetlerini de doğrudan etkilemektedir. Burdur Gölü'nün hidrolojisi, yağış rejimi ve beslenme kaynakları üzerine yapılan araştırmalar, göl ekosisteminin evrimini anlamak için önemli bir temel oluşturmuştur. Göl, kapalı bir havza şeklinde olup, havza dışına herhangi bir boşalım olmadığından su kaybı büyük ölçüde buharlaşma ile gerçekleşir. Yağış miktarı ve mevsimsel değişiklikler, gölün su seviyesi ve alanı üzerinde belirleyici faktörlerdir; bu durum, göl ekosisteminin sürekli olarak değişen bir denge içinde olduğunu göstermektedir. Bu değişimler, göl çevresindeki bitki örtüsü ve biyolojik çeşitlilik üzerinde de etkili olmuştur.

Burdur Gölü ve çevresi, jeolojik ve limnolojik açıdan dikkat çekici bir araştırma potansiyeline sahiptir. Ancak, göl ve çevresinin paleocoğrafyası ve ekosistem dinamikleri hakkında detaylı çalışmalar sınırlıdır. Daha fazla araştırma, bölgenin ekolojik tarihini ve gelecekteki olası değişimleri daha iyi anlamamızı sağlayacaktır. Günümüze kadar yapılan palinolojik çalışmalar, Anadolu'daki büyük göller ve bataklıklar üzerinde yoğunlaşmıştır ve bu çalışmalar genellikle Van Gölü, Tuz Gölü, Bafa Gölü gibi bölgeleri kapsamıştır (van Zeist vd., 1975; Bottema ve Woldring, 1984; Karadaş, 2013). Örneğin, Van Gölü çevresinde yapılan çalışmalar, geç Holosen dönemdeki bitki örtüsü değişimlerini incelemiş ve iklimsel değişimlerle ilişkilendirmiştir. Bu çalışmalar, GÖ 20-14 bin yıllar arasındaki kuraklık dönemlerinden sonra ağaç türlerinin stepler arasında yaygınlaşmaya başladığını göstermiştir. Bu bulgular, bölgedeki ekolojik değişimlerin iklimsel etkenlerle nasıl şekillendiğine dair önemli ipuçları sunmaktadır. GÖ 8500'den itibaren ise nemlilik artmış ve orman vejetasyonu önemli ölçüde gelişmiştir (van Zeist vd., 1975). Bu bakımdan, Burdur Gölü çevresindeki araştırmaların eksiklikleri, göl ekosisteminin tarihsel ve ekolojik bağlamda tam olarak anlaşılmasını engellemektedir. Göldeki su seviyesi düşüşleri ve iklim değişikliklerinin etkileri, bölgedeki insan etkileşimlerini de içerecek şekilde daha kapsamlı bir şekilde araştırılmalıdır. Bu tür çalışmalar, bölgenin sürdürülebilir kalkınma planlarının oluşturulmasına da katkı sağlayabilir. Bu çalışmalar, bölgenin çevresel sürdürülebilirliği ve su kaynaklarının korunması için önemli bilgiler sunabilir. Burdur Gölü'nün biyolojik çeşitliliği, ekosistem sağlığının bir göstergesi olarak değerlendirilmeli ve korunmalıdır.

Burdur Gölü'nün biyolojik çeşitliliği de göl ve çevresindeki araştırmaların merkezinde yer almalıdır. Gölde yaşayan balık türleri, su kuşları ve bitki örtüsü gibi unsurlar, göl ekosisteminin sağlığı ve çevresel denge üzerinde önemli etkilere sahiptir. Ayrıca, göl çevresindeki insanların göl kaynaklı geçim kaynakları ve kültürel bağları da araştırılmalıdır. İç Anadolu, Ege ve Akdeniz bölgelerindeki bazı çoklu-proksi anlayışa

sahip alıřmalar Tuz Gölü, Bafa Gölü, Köyceğiz Gölü, Gölhisar Gölü, Söğüt Gölü, Ova Gölü, Pınarbaşı Gölü, Hoyran Gölü ve Karamık bataklığı ve Bornova Ovası'nda yapılmıştır (van Zeist vd., 1975; van Zeist ve Woldring, 1978; Bottema ve Woldring, 1984; Sullivan, 1989; van Zeist ve Bottema, 1991; Bottema, 1995; Eastwood vd., 1999; Karadař, 2013). Sözü edilen alıřmalarda bitki örtüsünde zaman içinde meydana gelen deęiřmeler saptanmıř ve kronolojik olarak bazı dönemler ayırt edilmiştir. Örneğın, Göller yöresinde Karamık bataklığı ve Söğüt gölüne ait polen kayıtlarından hareketle son 20 bin yılda bitki örtüsünde meydana gelen deęiřimler ortaya konmuřtur (van Zeist vd., 1975). Bu alıřmaya göre günümüzden önce (GÖ) 20-14 bin yıllar arasındaki dönemde kuraklık etkindir ve kurak řartlar altında step vejetasyonu hakimdir. 14.000'den sonra ise stepler arasına ağa türleri karıřmaya bařlamıştır. Daha bařka bir ifade ile řartlar ağa yetiřmesi için uygun hale gelmiştir. Bu durum nemlilikte bir artışı ifade etmektedir. GÖ 12.000'den itibaren iklim kořulları yine ağa yetiřmesine elveriřsiz duruma gelmiř ve orman vejetasyonu ancak GÖ 8500'den sonra önemli ölçüde geliřmeye bařlamıştır. Kuřkusuz bu duruma nemlilik ve sıcaklık artışı neden olmuřtur. GÖ 8500'den itibaren artmaya bařlayan nemlilik günümüzden 6000 yıl önce bugünkü seviyesine ulařmıştır. Buna paralel olarak, günümüz vejetasyonu da GÖ 6000'den itibaren oluřmaya bařlamıştır. GÖ 6000'den 3000 yıl öncesine kadar vejetasyon üzerinde insan etkileri pek saptanmamıştır. Ancak, Orta-Ge Holosen'e ait birok polen diyagramında günümüzden 3000 yıl öncesinde önemli bir deęiřimin gerekleřtiğı bir dönem tespit edilmiştir. Orman vejetasyonunun önemli ölçüde azaldığı bu dönemde, insan etkisinin kanıtı olacak řekilde, tarım ürünlerine ait polenlerde artış gözlenmiştir (van Zeist vd., 1975). Karot ökellerinde yapılan polen analizleri sonucunda elde edilen veriler ile ge Holosen döneminde vejetasyonda meydana gelen deęiřimler detaylı bir řekilde arařtırılmıştır.

Göller Bölgesi ve Güneybatı Anadolu'nun Erken Holosen dönemine iliřkin arkeolojik veriler, Neolitik dönemin Anadolu'daki ekirdek bölgelerinden olan Burdur ve yakın çevresinden (örneğin Hacılar, Höyücek) bilinmektedir. Ancak, bölgenin Orta Holosen, özellikle İlk Tun Çağı dönemine iliřkin arkeolojik veriler, Hacılar Büyük Höyük'teki kazılardan önce oldukça sınırlıydı. Bu dönem için bölge, adeta terra incognita durumundaydı. 2011 yılından beri Hacılar Büyük Höyük'te ortaya ıkarılan arkeolojik kalıntılar, bölgeyi ve sunduğı kaynakları kontrol eden merkezi bir otoriteye ait bir yerleřim olarak öne ıkarmaktadır.

Burdur Gölü'nden alınan karota dayalı olarak yapılan polen analizine göre, havza genel olarak *Quercus ilex-coccifera* tipi (herdem yeřil meře), *Olea* (zeytin), *Juglans* (ceviz) ve am ağaları (*Pinus brutia* ve *Pinus nigra*) ile domine edilmiştir. Ayrıca, *Cedrus libani* (sedir) gibi kozalaklı ağalar da belirgin bir řekilde tespit edilmiştir, bu da bu türün Toros Dağları'ndan uzun mesafeli tařınmasını iřaret etmektedir. Burdur Gölü'nden alınan karot üzerinden yapılan fosil polen analizi sonuçları, Erken Tun Çağı'nda iklim deęiřikliklerinin yanı sıra yerleřim geniřlemesi ve nüfus artışının, muhtemelen tarımsal faaliyetlerden kaynaklanan, bitki örtüsü üzerinde önemli bir etkisi olduėunu göstermektedir. Bu analizler, Doėu Akdeniz genelindeki fosil polen alıřmalarında belirtilen ve artan tarımsal faaliyetler ile geniř aplı ormancılıėa iřaret eden Beyřehir İřkan Dönemi'nin izlerini de ortaya koymaktadır. Bu dönemin, bölgedeki diėer fosil polen alıřmalarından farklı olarak, Roma İmparatorluk döneminde bařlayıp Erken Modern Osmanlı Dönemi'ne kadar devam eden belirgin bir zaman diliminde meydana gelmesi dikkate deėerdir. Vekil veriler ve paleoiklim modellerinin ıktıları birlikte deėerlendirildiğinde, bu faaliyetlerde iklimin etkisinin nispeten dolaylı olabileceğı ve insanların peyzaj üzerinde daha büyük bir etkiye sahip olduėu öne sürülebilir.



1. INTRODUCTION

The examination of human-environment interactions in archaeology has gained significant attention in recent years, especially with the emergence of the Anthropocene concept (Lane, 2015). While archaeology has traditionally explored the impact of environmental dynamics, such as changes in climate, on civilizations, contemporary perspectives emphasize the importance of understanding the intricate, mutual relationships between humans and their environments. With advancements enabling more detailed exploration of paleoenvironmental shifts, paleoecology, and archaeology now go beyond traditional inquiries, aiming to comprehend how past societies influenced ecological dynamics rather than just assessing the impacts of environmental changes on societies. Thus, grasping the interplay of non-human factors alongside human influences becomes imperative. However, advocating that this interdisciplinary approach consistently yields positive outcomes presents challenges. Understanding the dissemination of scientific knowledge through the lens of Snow's (1959) "two cultures" criticism reveals a fundamental misunderstanding between the humanities and natural sciences, hindering comprehensive comprehension. This critique can also prompt an exploration of the potential contributions of "consilience" understanding wherein diverse disciplines converge to find common ground, to elucidate human-environment interactions as the challenge with the Anthropocene paradigm lies in archaeology constructing narratives solely based on data from select disciplines, posing a significant obstacle to understanding this relationship comprehensively.

This study endeavors to bridge these gaps by examining past human-environment interactions, focusing on fossil pollen analysis from Lake Burdur (Figure 1.1). By integrating insights from natural sciences, particularly palynology, with archaeological perspectives, it aims to present a nuanced understanding of vegetation changes spanning approximately 4600 years BP in Burdur Province. Notably, Lake Burdur, previously unexplored palynologically, was chosen as the focal point, with efforts

directed towards establishing a robust chronology to enhance better dating precision compared to other pollen sites in the region.

Interpreting variations in fossil pollen types under microscopic scrutiny, this study seeks to interpret vegetation changes with the archaeological history of the region. By considering diverse approaches to understanding human influence, it offers a comprehensive assessment of human-environment interaction dynamics. Furthermore, it acknowledges the limitations of solely relying on settlement history to examine vegetation changes, integrating high-resolution paleoclimatic data and models to elucidate the intertwined influences of climate and human activity on vegetation dynamics.

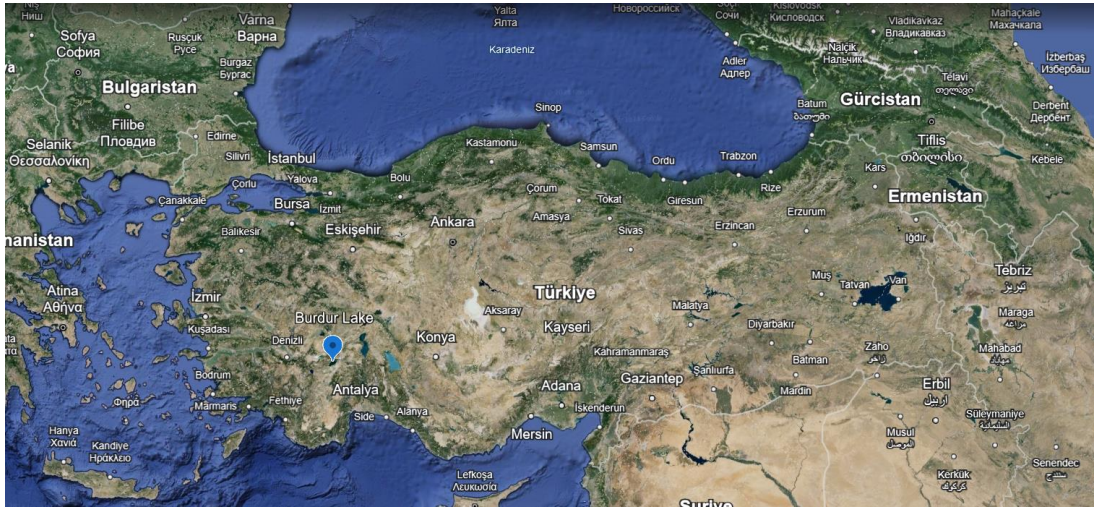


Figure 1. 1: The map showing the location of Lake Burdur.

Findings suggest that during the Early Bronze Age, human settlements around Lake Burdur likely exerted a significant impact on vegetation, although concurrent climatic events amplify the complexity of attributing changes solely to human activity. Conversely, the scarcity of information regarding settlements during the Middle and Late Bronze Ages complicates the understanding of vegetation dynamics for this period. Nevertheless, indications of Mediterranean-specific species hint at the persistence of human presence in varied forms. The study also sheds light on the interplay between vegetation changes and settlement patterns during the Archaic and Hellenistic periods, suggesting a more pronounced influence of human activity.

Notably, the Roman period emerged as a pivotal phase marked by deforestation and arboricultural agricultural practices, which may be indicative of the Beyşehir

Occupation Phase (BOP), a well-known settlement phase in Southwest Anatolia. This distinct settlement phase extends into the Early Modern Ottoman period in Lake Burdur, albeit with uncertainties stemming from chronological data and pollen records. Despite these challenges, the study's comprehensive approach, integrating diverse datasets and proxies, sets it apart from previous endeavors in the region. By acknowledging both the limitations and advantages of employed methodologies, it presents a holistic understanding of human-environment interaction dynamics in Lake Burdur and its environs.

1.1 The Study Area and Geological Background Information

Burdur Province is situated at the heart of the Mediterranean Region and lies within the boundaries of the Lakes Region. Burdur Province occupies a pivotal geographical position that connects the Mediterranean, Aegean, and Central Anatolian Regions, forming a transitional zone rich in natural diversity. Spanning between the eastern longitudes of 29°-24' to 30°-53' and the northern latitudes of 36°-53' to 37°-50', the province boasts a distinctive topography within the renowned "Lake Region," depicted in Figure 1.1. This diverse landscape encompasses an array of landforms including towering mountains, rolling hills, expansive plains, winding valleys, and serene lakes, as meticulously cataloged by the Burdur Provincial Directorate of Agriculture and Forestry. This unique blend of geographical features not only shapes the province's scenic landscape but also influences its ecological dynamics and agricultural practices, highlighting Burdur's significance as a crossroads of natural and cultural heritage in Turkey.

Burdur Province, depicted in Figure 1.2, is bounded by Antalya to the south, Denizli to the west, Muğla to the southwest, and Isparta and Afyon provinces to the east and north. It encompasses 7,176 square kilometers with an average elevation of 950 meters. According to data from the provincial directorate's official website, the province's land is distributed as follows: 60.6% mountainous, 2.7% plateau, 19% plain, and 17.6% hilly regions. Clayey and calcareous soils dominate the area, as reported by the Burdur Provincial Directorate of Agriculture and Forestry. The province's diverse topography includes mountains, plateaus, plains, and hills, contributing to its unique landscape within the region (Figure 1.3).

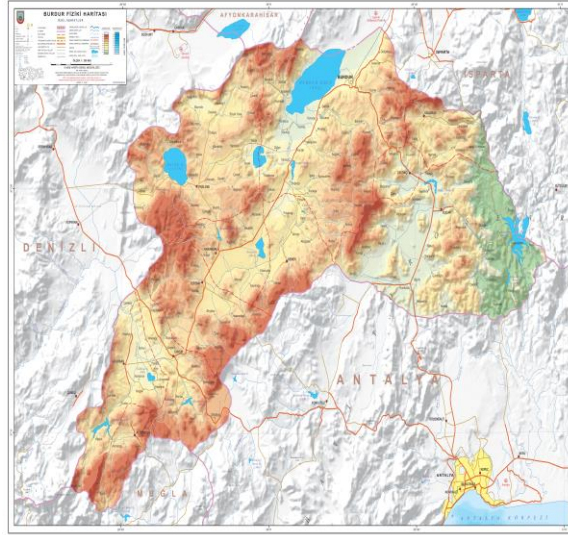


Figure 1. 2: Physical geographical map of modern Burdur Province (Harita Genel Müdürlüğü, 2023).

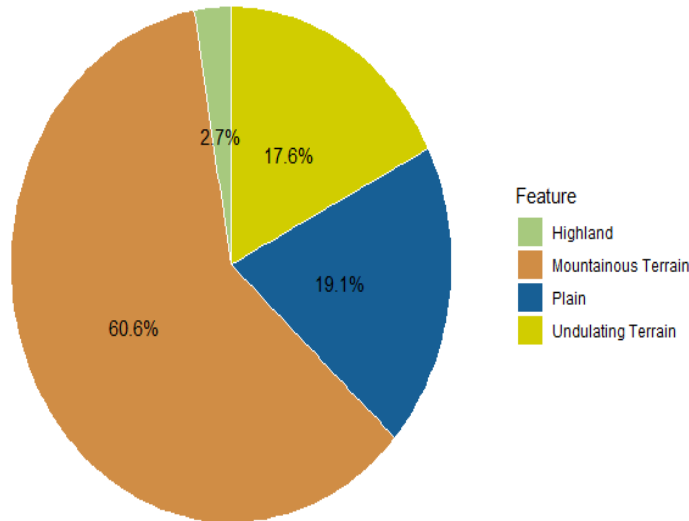


Figure 1. 3: Major soil groups of modern Burdur (Environmental Status Report of Burdur Province, 2021).

The land within the Burdur Province exhibits a diverse geological structure, with formations from different geological periods coexisting. Before the second geological period, the land within the Tethys geosyncline area underwent transformations influenced by the origin of the Alpine Plateau, resulting in its second, third, and fourth appearances. Formations from meteoric and tertiary periods can be found throughout the province. Currently, the most common soil group in Burdur is brown forest soil, followed by noncalcareous brown forest soil and chestnut-colored soils.

1.1.1 Lake Burdur and Burdur Lake basin

Lake Burdur, located in Southwest Anatolia, is a significant natural resource in the Lakes Region and one of the largest lakes. It is considered one of Turkey's largest tectonic lakes along an active fault line (Dolmaz et al., 2003). Until approximately 20 years ago, the water level of Lake Burdur remained relatively stable (Table 1.1). However, since 1987, the lake has experienced a continuous decline in water levels, losing a total of 1.65 km³, corresponding to one-fourth of its volume (Ataol, 2010). The lake boasts a diverse topography with a notable average depth of 40 meters, while its depths reach remarkable extremes, ranging from 68 to 110 meters. Moreover, as indicated in Figure 1.4 below, the lake extends to higher altitudes, approximately at an elevation of 854 m, and its expansive surface area expands to a maximum of 140 km² (Davraz et al., 2019). On the other hand, the Burdur Lake Basin spans an area of 3264 km², encompassing regions within Burdur and Isparta provinces. This basin includes districts such as Burdur Merkez, Kemer, Keçiborlu, Tefenni, and partially Gönen in Isparta. The Burdur Lake Basin consists of 12 subbasins, with the largest being the basin of Bozçay, surpassing the combined area of the other subbasins (Gülle et al., 2008; Ataol, 2010). The Burdur basin is positioned geologically between the Taurus fold system and the Saruhan-Menteşe metamorphic mass, extending in a northwest–southeast direction alongside Burdur Lake. In the western part of the basin, the Söğüt Mountains rise to altitudes of 1600-1700 meters, while the Beşparmak Mountains, exceeding 2000 meters in height, extend eastwards from erosion surfaces overlying Neogene formations at altitudes of 1250-1300 meters. The southern border of the basin is marked by Büyük Damıkdağı (1375 m), composed of Mesozoic limestones to the south of Yarisli Lake and mountainous areas reaching altitudes of 1500 m in the north (Atalay et al., 2017; Gözükara et al., 2019).

Table 1.1 : Lake Burdur: changes in lake level, area, and volume through years.

Date	Lake Level (m)	Lake Area (km ²)	Lake Volume (km ³)
1975	855.20	210	6.475
1987	853.72	203	6.056
1990	851.70	202	5.600
1996	847.90	164	4.923
2000	846.28	156	4.683
2002	845.36	152	4.420
2009	843.79	141	4.202
2013	842.59	135	4.065

The Burdur Lake Basin is an enclosed watershed situated between the Western Taurus Mountains. Precipitation within the basin accumulates in the Burdur Lake basin, which represents its deepest point, and is discharged from the lake area through surface runoff and evaporation via groundwater flow. Numerous streams and rivers, which are active during specific periods, contribute to the lake's water supply, primarily during rainy seasons. The distribution of rainfall throughout the seasons and intense downpours in arid months can result in soil erosion. Erosion within the Burdur Lake Basin can be categorized as follows: 17.7% minor erosion, 22.3% moderate erosion, 31.4% severe erosion, and 28.6% very severe erosion. Burdur Lake water possesses antiseptic properties and is commonly recognized as alkaline brackish water (Kiziroğlu et al., 1995). The closed nature of the basin, which relies on precipitation, streams, and groundwater (aquifers), leads to water loss occurring solely through evaporation since there is no outflow. The water level and surface area of a lake experience variations contingent upon precipitation patterns, yearly fluctuations, and seasonal factors (Şener et al., 2005).

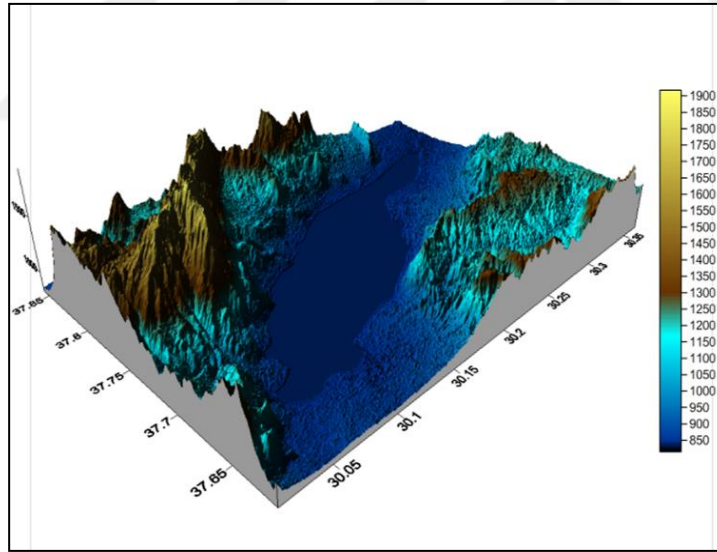


Figure 1. 4: Bathymetric features of Lake Burdur.

The Burdur Basin experiences a transitional climate, displaying characteristics of both Mediterranean and terrestrial climates. The summers are hot and dry, while the winters are notably cold. The basin has an average annual temperature of 13°C and receives an average annual precipitation of 405 mm (Yiğitbaşıoğlu and Uğur, 2010). Its average altitude is 843 meters. Burdur Lake stretches 34 kilometers in length and 9 kilometers in width. Lake water has a salinity level of 24 per thousand. It is a tectonic lake formed through the filling of a groove-shaped tectonic depression with water. Such lakes

emerge when pits resulting from tectonic movements become filled with water. In the southwest and northeast regions, salt marshes are present due to alluvial accumulation. Lake water contains salinity and arsenic, which contribute to a low number and diversity of aquatic plants and fish species in the lake together with endemic species (Kaya et al., 2015).

1.1.2 Geological background

The Burdur-Göhlhisar basin, where Burdur Lake is located, is located between the Toros Mountains orogenic belt and the Menderes Massif in the northwest (Atalay et al. 2017). The Burdur-Göhlhisar Basin is a geosyncline area where the Tethys Sea settled during the Mesozoic period. The main geological units observed around Burdur Lake are given in Figure 1.5).

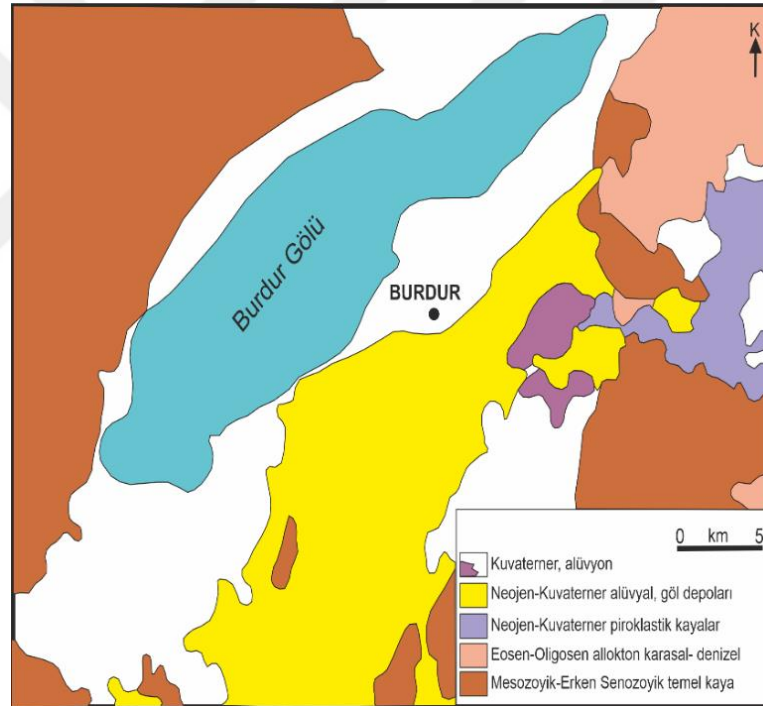


Figure 1. 5: Geological map of Lake Burdur and surroundings (adapted from Yıldız, 2016; Alçiçek et al., 2013).

Ultramafic rocks: Peridotite serpentines are widely observed at the base of the Burdur-Göhlhisar basin, around Göhlhisar, and in the southwest of the Burdur basin.

Limestone and marble: There is clayey and calcareous mud on the peridotite-serpentine interface. These clayey and calcareous muds turned into limestone as they curled and rose with the closure of the Tethys geosyncline since the end of the

Mesozoic period. Afterward, they underwent metamorphism, and today's marbles were formed (Atalay et al. 2017). Areas where limestone and marble are found are seen at higher elevations because they are resistant to abrasion. These areas are located northwest and east of Burdur Lake.

Serpentine-limestone complex: Structures such as the serpentine-limestone complex called the *mélange* are a complex formed as a result of the mixing of volcanic peridotite-serpentine and limestones (Atalay et al. 2017). Melanges are located in southeastern Burdur Lake, between Çendik Beach and Hacılar. Sandstones and conglomerates: The northern line roughly between Günelan village in northern Burdur Lake and İlyaslar village in the west became a hollow area in the early Eocene. In this hollow area where the lake environment is located, sand and gravel, which are mostly limestone in high areas and are partially carried by serpentine streams, have accumulated. Conglomerate and sandstones were formed as a result of the lithification of accumulated sandy and gravelly materials combined with lime cement (Atalay et al. 2017). Siliceous sandstones were formed as a result of the combination of siliceous cement and sand between Günelan and Gelincik villages in northeastern Burdur Lake.

Marl Depots: The area where the Gölhisar and Burdur Lake Basins were located collapsed during the Miocene, which was the beginning of the Neogene, and this collapsed area was occupied by the lake. In this lake environment, clayey and calcareous deposits called marl were formed by the accumulation of clayey and calcareous substances, which were mostly obtained from the chemical erosion of limestones (Atalay et al. 2017). In the lake environment, where the lake receded and became land, river reservoirs consisting of gravel and sand formed, and these reservoirs were covered with the lake again and covered with marl.

Alluviums: Alluviums, which are formed by the accumulation of clay, sand, and silt-sized materials carried by streams on the plains where the carrying capacity of the streams spreads and decreases, are widespread in the northern and southern regions of Burdur Lake and the bottom of the Gölhisar basin. Alluvial fans are common in southeastern Burdur Lake, where clayey-silty materials accumulate (Atalay et al. 2017). These deposits create fertile soils that support diverse vegetation and influence local hydrology. Additionally, the study of these alluvial formations provides valuable insights into past climatic conditions and sediment transport processes in the region.

1.1.3 Vegetation and climate

Burdur Lake and its surroundings are located in the northern part of the Mediterranean region climate zone. The summers are hot and dry, and the winters are cold and rainy. The annual rainfall amount is approximately 400 mm. The month with the heaviest rainfall is December.

The average rainfall in December reaches 63.4 mm (Kiziroğlu et al., 1995). The average temperature in July is 24.2°C, and the average temperature in January is 2.4°C (Kiziroğlu et al., 1995). There are two main plant zones around Burdur Lake, located in the Burdur-Göhlhisar basin (Figure 1.6 and Figure 1.7). These forest communities are red pine and larch forests. The red pine forest belt (*Pinus brutia*), which is resistant to drought and heat, is one of the main trees of the coastal zone of the Mediterranean climate region in Turkey. The average annual temperature is 15-16°C, and the amount of precipitation is approximately 1000 mm. Red pine forests start from the bottom of the Burdur-Göhlhisar basin at depths up to 1200 m and up to 1300 m on the south-facing slopes of the Göhlhisar basin.

Maquis vegetation consists of the trees that form the shrub layer of red pine forests. The maquis vegetation in the Burdur-Göhlhisar basin consists mainly of *Quercus coccifera* (kermes oak), *Phillyrea latifolia* (green olive), *Pistacia terebinthus* (terebinth), and *Styrax officinalis* (rosary) plants, and *Nerium oleander* (oleander) and *Vitex agnus-castus* (vissum) plants are found on the riverbanks. can be seen. *Spartium junceum* is found on the slopes. *Quercus coccifera* (Kermes oak), which is widely found in maquis forests, is the most common in the region.

In the Burdur-Göhlhisar basin, Anatolian black pine forests flourish within the elevation range of 1200-1300 meters, marking the transition from the lower reaches of the Mediterranean mountain belt's red pine forests to heights exceeding 2000 meters, where the forest limit reaches its highest extent. These forests, predominantly composed of Anatolian black pine (*Pinus nigra* subspecies), thrive in areas characterized by a transition from marine to continental climates, where the average annual temperature hovers around 8°C and annual precipitation exceeds 600 mm (Atalay and Efe, 2010). The Kermes oaks, starting their ascent from 900-1000 meters, gradually replace the larch forests and extend up to 1600 meters, contributing to the diverse ecological tapestry of the region.

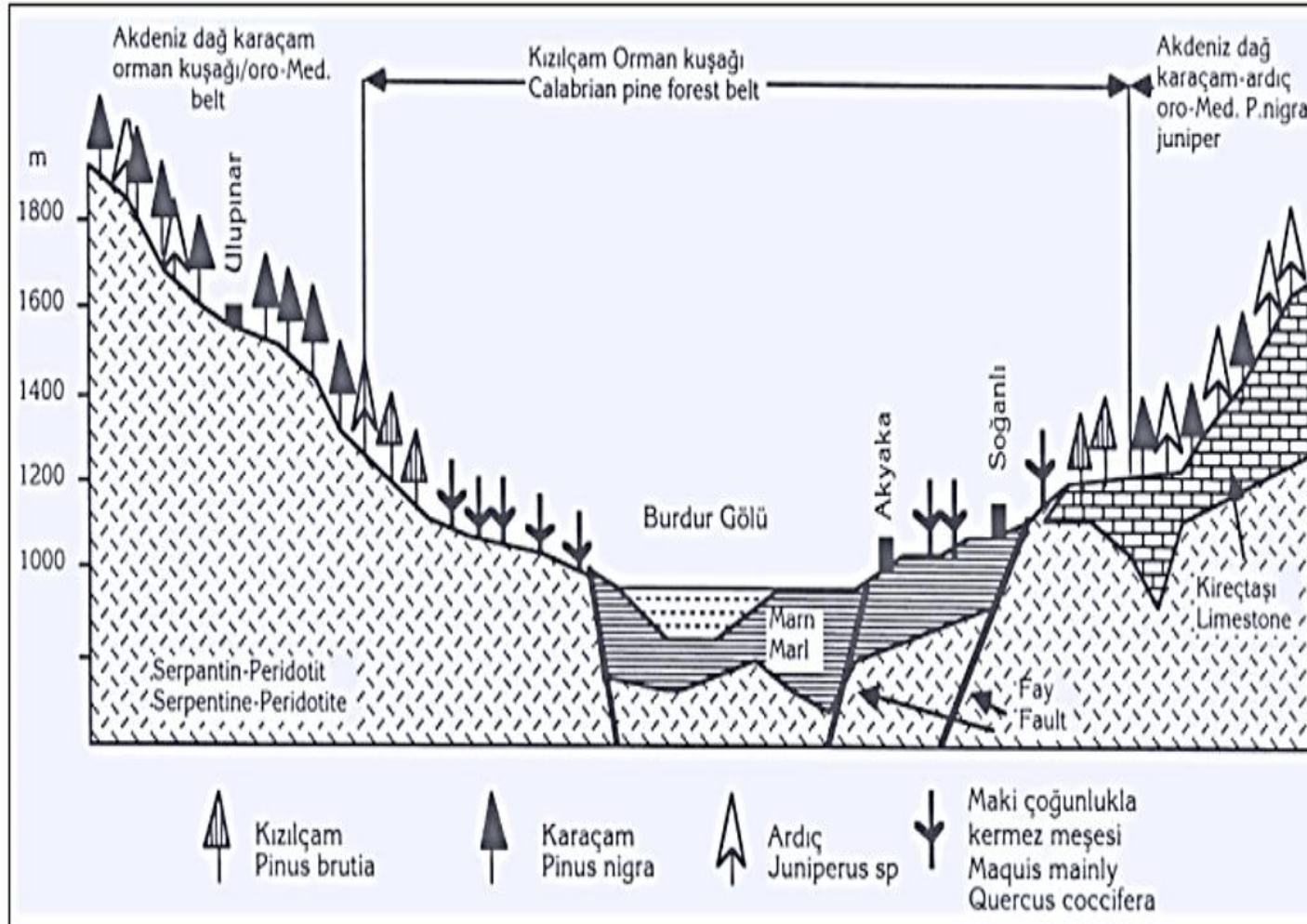


Figure 1. 7: Distribution of vegetation belts in the northern part of the Burdur Basin (From Atalay et al., 2019).

The majority of herbaceous plants are xeric, thorny species belonging to the Iran–Turan region. *Euphorbia* sp. on conglomerates around Senir village, northwest of Burdur Lake. In areas with red pine forests, *Astragalus* sp. (astragalus), *Acantholimon* sp. (shepherd's cushion), and *Verbascum* sp. (oxtail) are observed. The spread of herbaceous plants has become widespread due to human influence (e.g., overgrazing). According to a study carried out by Çetin (2011) between 2009 and 2011, 70 families, 275 genera, and 465 taxa belonging to these families were recorded around Burdur Lake. According to the distribution of taxa according to family, the plants identified in terms of the number of taxa were Compositae (Asteraceae), Gramineae (Poaceae), Leguminosae (Fabaceae), Labiatae, Boraginaceae, Caryophyllaceae, Cruciferae (Brassicaceae), Scrophulariaceae, Liliaceae, and Rosaceae (Çetin, 2011).

1.2 A Brief History and Archaeology of the Study Region

1.2.1 Early Bronze Age

The Bronze Age in Southwestern Anatolia is represented as a time of big changes, as societies grew more complex and organized. During this period, communities got larger, metalworking became more common, and defensive structures were built, showing a move toward more sophisticated and hierarchical societies. Trade networks expanded, hinting at a shift from simple village life to more complex societal systems. The growing demand for raw materials like copper and tin, as well as precious metals like gold and silver, drove the development of this trading system and the formation of the elite classes that organized it (Fidan et al., 2015)

Many parts of SW Anatolia were extensively settled in the region during the period corresponding to the Bronze Age. It has been suggested that especially Early Bronze Age (EBA) settlements were concentrated in the area including Burdur in the north, rather than in the coastal areas of Antalya in the south. Although Bademağacı and Kuruçay settlements are considered to be the only long-lasting Bronze Age settlements, traces of material culture of EBA settlements were also found in Hacılar Büyük Höyük, Tepecik, Yassigüme Höyük and İncirdere Höyük (Duru, 2008; Umurtak, 2015).

Excavations at Hacılar Büyük Höyük revealed a planned settlement with a clear defensive concept. The outer walls of rooms formed a roughly circular fortification,

and access to the settlement was only through closable city gates. This sawtooth-shaped wall structure dates to the early part of the Bronze Age. The presence of large storage jars and seal stamps in the central buildings suggests a system of control over produced goods (Umurtak, 2021). While agriculture and livestock remained the economic foundation, metalworking and pottery production also evolved. Unique ceramic styles characteristic of the Burdur-Korkuteli culture began to emerge. By the last quarter of the 3rd millennium BCE, wheel-made pottery was produced in the Burdur area (Fidan et al., 2015). In the Early Bronze Age I (around 3000-2700 BCE), regional differences in pottery styles gave archaeologists clues about the diverse cultures (Figure 1.8) (Fidan et al., 2015).

The Lycia-Pisidia area, for example, was known for its unique red and brown pottery with white paint and intricate designs, showing distinct cultural boundaries (Efe, 2003). Settlements also changed, with megaron-style buildings, which had multiple rooms around a central courtyard, becoming more popular. Defensive walls appeared in some places, suggesting a need for protection due to the changing dynamics of the time (Türkteki, 2020).

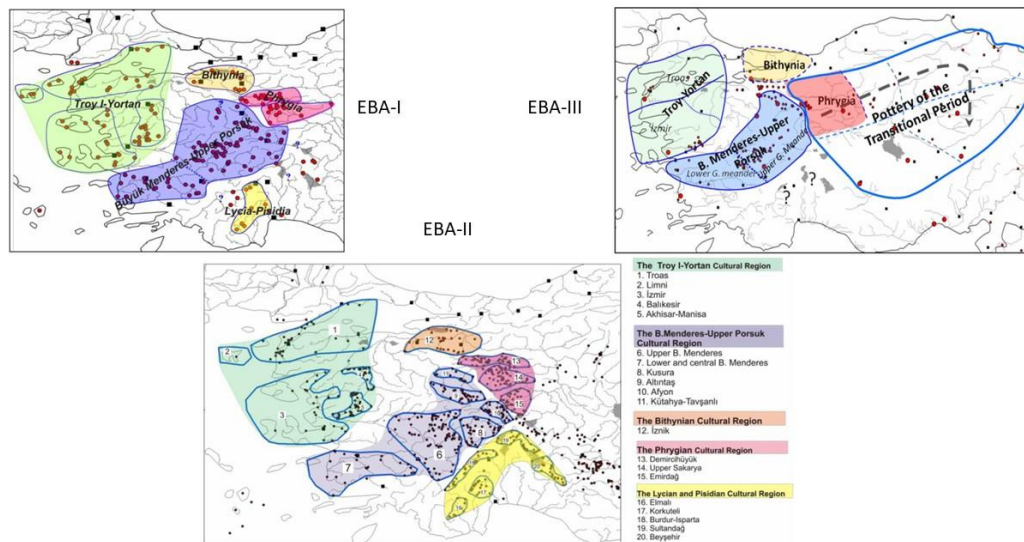


Figure 1. 8: Early Bronze Age ceramic culture groups (from Fidan et al., 2015).

The Early Bronze Age II (2700-2400 BCE) saw more complex settlement structures and increased social stratification. Settlements grew in size, and there were more fortified buildings and signs of a ruling class. Metallurgy improved, leading to more trade, and villages began engaging in crafts and trading, not just agriculture and animal

husbandry. Two-handled cups and other wine-drinking vessels became common, indicating a rise in elite culture. Settlements like Bademağacı had rear house walls that doubled as defensive barriers, and structures interpreted as "palaces" appeared, suggesting a more centralized governance structure.

The Early Bronze Age III (2400-1900 BCE) was a period when the number of settlements decreased, but the size of the remaining settlements grew, indicating increased urbanization. This period saw more interaction with the Aegean world in coastal regions and increased cultural and political integration with Central Anatolia (Massa, 2016). The growth of settlement size, combined with buildings arranged around central courtyards, suggests that societies were becoming more complex and moving toward centralized governance. Rich burial chambers indicate high levels of social hierarchy (Alpay, 2023). As societies became more complex, long-distance trade networks grew, and urbanization intensified. During this time, changes in ceramics and a shift from smaller settlements to larger city-states indicated the transformation toward a more organized and centralized social structure. The decrease in the number of smaller settlements, especially in the island and lakeshore regions, points to these societal shifts (Figure 1.9; Beck, 2013).

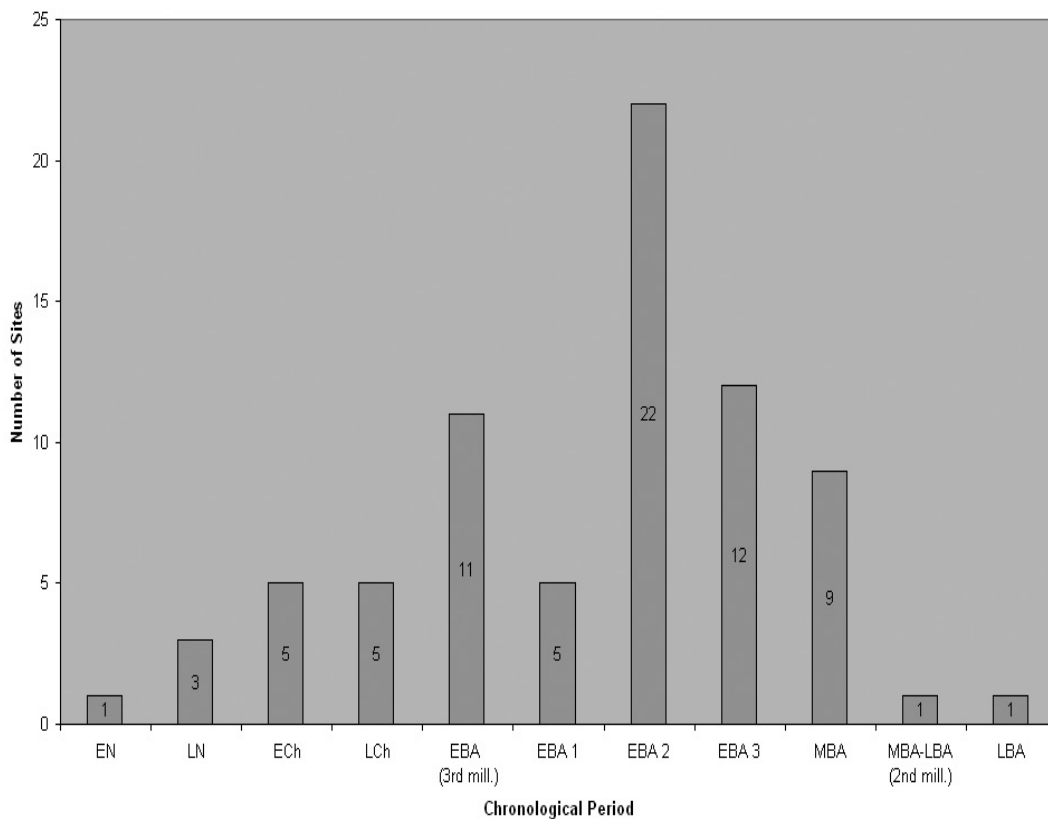


Figure 1. 9: Island and lake-shore sites in the Lake District. (From Beck, 2013).

1.2.2 Middle and Late Bronze Age

The Middle Bronze Age (2000-1600 BCE) in Anatolia was a time of considerable transformation, with notable changes in settlement patterns and cultural dynamics. In the Burdur region, evidence from archaeological sites such as Kozluca Höyük and Çavdır Höyük demonstrates these shifts through evolving burial practices and consistent ceramic traditions, indicating a complex social structure (Koçak, 2013).

During the Bronze Age (3000-2000 BCE), settlements in and around Burdur showed signs of decline by the end of the period, suggesting disruptions due to regional changes, social transformations, or migrations. By the Early Bronze Age III, many settlements had diminished, likely due to a combination of factors including environmental shifts, internal conflicts, demographic changes, or the movement of Indo-European/Luwian groups into the area. Even though the Middle Bronze Age cannot be considered a complete period of abandonment, one of the notable features of this era in Burdur is the continued decline in the total number of potential settlement areas in the Lakes Region, a trend that began during the Early Bronze Age III (Sarı, 2013).

Bademağacı Höyüğü is another example where new migration movements and short-term settlements occurred at the beginning of the Middle Bronze Age, following the decline of the Early Bronze Age III settlements. These migrations brought new cultural elements, illustrating the dynamic and ever-changing nature of the region's social landscape (Duru, 2002).

Despite these developments, the Late Bronze Age (1600-1200 BCE) in Burdur and surrounding areas is less understood due to limited research. Surface surveys during this period have found few signs of settlements, with sites like Dereköy I and II, Mancarlı, yielding only a limited number of ceramics (Özsait, 2007). This scarcity indicates a significant gap in our understanding of the Late Bronze Age in this region, possibly due to changing settlement patterns, socio-economic shifts, or increased nomadism (ÖzsaitandÖzsait, 2010).

Despite these findings, significant Early Bronze Age mounds like Kuruçay were abandoned by the Middle and Late Bronze Ages, indicating a discontinuity in settlement patterns (Fidan et al., 2015). The reasons for this could range from environmental changes and demographic shifts to civil wars or migrations. Written

sources from the Hittite era mention the Arzawa and Lukka lands, of which Burdur is thought to be a part, but they do not provide detailed information about the socio-cultural structure of Burdur during the Bronze Age (Poblome, 2012).

Yet, to truly understand the Middle and Late Bronze Age in Burdur and surrounding areas, more extensive archaeological excavations and research are needed. The current findings offer limited information, indicating the need for a more thorough investigation into the socio-cultural structures, settlement patterns, and dynamics of the communities during this period.

1.2.3 Iron Age

Following the Late Bronze Age, archaeological data for the region surrounding Burdur Lake during the Early Iron Age period (c. 1200-800 BCE) is limited. Intensive and extensive surveys were conducted in the Burdur Plain, just south of Lake Burdur, between 2010-2012. Based on the pottery found during these surveys, multiple settlements dating to this period have been identified (Kaptijn et al. 2012). However, the lack of comprehensive archaeological excavations of these sites, along with the absence of contemporaneous written texts, significantly complicates the reconstruction of the settlement and political organization of this period (Kaptijn et al. 2012; De Cupere et al. 2017).

Early on, the Iron Age in this area saw fewer people living there. But by the 8th to 6th centuries BCE, known as the Archaic Period, the population grew, and settlements became more common. Researchers have found a lot of evidence of these settlements and various artifacts through excavations and surveys. The Burdur Plain had, in comparison to the Early Iron Age, an increase in sites occupied during the Archaic period. Results from surveys conducted in the Burdur Plain also indicate a rise in the number of settlements, albeit primarily smaller rural sites (Kaptijn et al. 2012). People tended to build their homes on high hills or mounds. Düver, a site 10 kilometers southwest of Lake Burdur, is suggested to have been a central settlement to the smaller sites in the area (Poblome et al. 2013). Located approximately 40 kilometers southeast of Lake Burdur, the site of Seydiköy is purported to be another central hub during the Archaic period, characterized by a similar settlement pattern in which smaller sites are distributed around the large site (Braekmans et al. 2017; Poblome et al. 2013).

The expansion of the Achaemenid empire (c. 550-323 BCE) into Anatolia in the 6th century is not entirely clear in the region of Pisidia. Achaemenid imperial administration of the region is said to have been more subtle, suggesting that their authority was more focused on the central hubs of the satraps (Daems and Tolloen, 2022). Archaeological surveys in the region also indicate a lack of apparent cultural influence of the Achaemenids in the region. Surveys conducted in the Ağlasun valley suggest that confidently differentiating between Achaemenid and Hellenistic period pottery is difficult (Willet and Poblome 2019). The field survey done in the Burdur Plain makes no mention of the Achaemenids but rather considers this period to be “Classical/Hellenistic” (Kaptijn et al., 2012). Pottery dating to the late Achaemenid period from Düzen tepe and Sagalassos has been reported (Daems and Poblome 2017a; Daems and Poblome 2017b). The area of Sagalassos was within the satrapy of Greater Phrygia. However, the absence of securely identifiable and visible Achaemenid material culture, along with the lack of excavations that date to this period, make it difficult to understand the political and cultural dynamics, especially with only ceramic typologies.

1.2.4 Hellenistic-Classical

Pisidia is frequently mentioned in the works of ancient Greek scholars, indicating its significance during that era (Horsley, 2000). Although the archaeological record from this period is limited, one significant site that provides insights into Pisidia's Classical Period is Düzen Tepe, near Sagalassos. This settlement, which existed from the 5th century BCE to the 2nd century BCE, is spread across a slope and enclosed by a simple wall. Its irregular architectural planning reflects a practical adaptation to the landscape, focusing on functionality and local elements. This indicates that the settlement's design prioritized economic and pragmatic needs, highlighting the Pisidian emphasis on practicality (Vanhaverveke et al., 2010).

Pisidia's history changed dramatically with the Hellenistic period, initiated by Alexander the Great's conquest of the Persian Empire in 334 BCE (Kosmetatou, 1997). The conquest by Alexander and his successors brought the region into the fold of Hellenistic kingdoms, including the Antigonids, Seleucids, and Attalids, indicating a shift toward Hellenistic culture and politics. Sagalassos, a significant settlement during this period, gained prominence and expanded its boundaries, reflecting the Seleucids'

policies. Ancient sources characterize the Pisidians as warlike and fiercely independent, demonstrating their resistance to Alexander in cities like Termessos, Selge, and Sagalassos (Daems and Talloen, 2022).

On the other hand, Roman dominance over Pisidia began in 133 BCE, integrating the region into the Roman provincial system. Under Roman rule, Sagalassos became a crucial city, experiencing rapid urbanization and significant architectural developments, such as the construction of imperial baths, libraries, and monumental structures. This "building boom," particularly during the Augustan and Hadrianic periods, signaled Sagalassos' emergence as an economic and cultural hub in the region (Mitchell and Vandeput, 2013).

Roman influence in Pisidia was also visible in the region's infrastructure, with roads and transportation networks, built to enhance access and control. The establishment of Roman colonies, such as Kremna, Komama, and Olbassa, further underscored Roman expansion and integration. These colonies underwent substantial reconstruction, featuring Roman architectural styles like forums, baths, propylons, and colonnaded streets (Martens, 2008).

While the Roman Empire's impact was significant, local elements remained influential, maintaining Pisidia's unique character amid the changes. Pisidian settlements, from urban centers to rural farms, reflected a blend of local traditions and Roman influences, illustrating a dynamic and adaptive region. Despite the Roman rule, Pisidia's heritage retained its unique identity, demonstrating a complex interplay between external influence and local culture (De Giorgi, 2011).

1.2.5 Byzantine

Sagalassos and its surrounding region underwent significant changes during the Byzantine period. In the 4th and 5th centuries, the city was prosperous, with public buildings and churches being constructed or renovated. However, by the mid-6th century, Sagalassos began to decline due to a combination of factors, including climatic issues, security concerns, earthquakes, epidemics, and social unrest. Construction activities halted, and the city contracted in size, with large estates giving way to smaller rural activities (Bakker et al., 2024).

In rural areas, settlement patterns shifted from urban centers to villages and small settlements, often in strategic locations such as mountainous areas and hilltops. This

shift indicated a decrease in Sagalassos' regional importance as rural areas became more independent and productive. The climate change and droughts during Late Antiquity affected agriculture, while earthquakes, particularly in the 6th century, caused significant damage to the city, contributing to its decline (Hirschfeld, 2006)

Security concerns also influenced settlement patterns. Attacks by the Isaurians in the 5th century and later Arab raids led to the construction of local defense structures and further migration to safer locations. Economically, villages became more self-sufficient, with increased production capacity, particularly in ceramics, suggesting a move away from reliance on urban centers. Despite these changes, evidence of life continued in Sagalassos during the Byzantine period, with repairs and construction occurring despite damage from earthquakes. The construction of several churches between the 5th and 6th centuries reflected ongoing religious activity. However, the late 6th century saw a less urban structure with fewer public buildings (Figure 1.10), indicative of Sagalassos' declining role as an urban center (Waelkens, 1993; Vanhaverbeke et al., 2007).

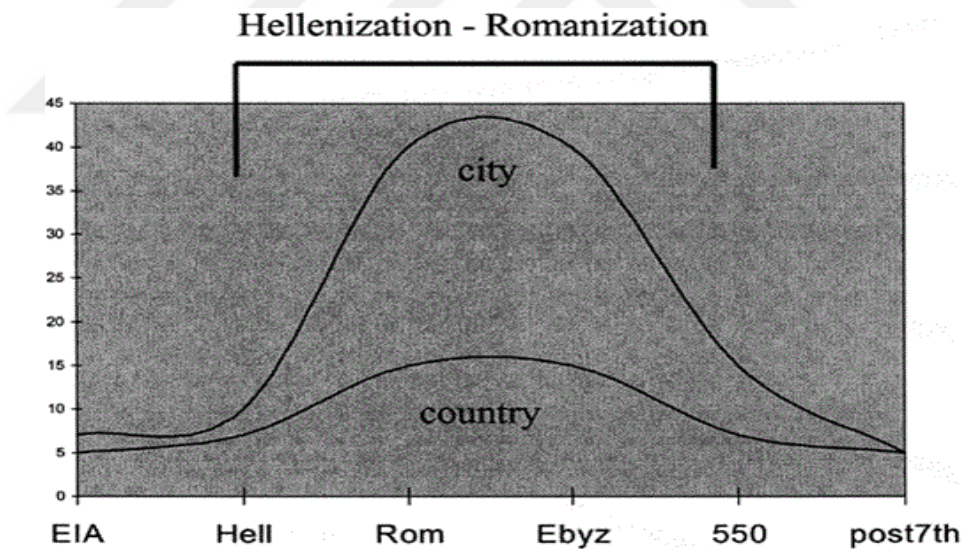


Figure 1. 10: Changes in the number of city-countryside settlements from the Early Iron Ages (from Vanhaverbeke et al., 2007).

1.2.6 Middle Ages

Burdur, located in southwestern Turkey, saw significant changes during the Middle Ages with the arrival of the Oghuz Turks. The Seljuk Empire, emerging in the 11th century, encouraged the Oghuz to settle across Anatolia, leading to the spread of Turkish-Islamic culture. The Seljuk Sultan Tughril's policies played a central role in

resettling the Oghuz tribes, which led to their spread from the Caucasus and Azerbaijan into Eastern Anatolia, Syria, and ultimately into Western Anatolia, including Burdur (Sağlam, 2021)

The Middle Ages in Burdur were marked by both growth and turmoil. The Crusades, starting in the late 11th century, destabilized Western Anatolia and weakened the Seljuk Empire. The Mongol invasions of the 13th century caused further disruption, fragmenting Seljuk territory. Despite this instability, the Mongol advance led to more Oghuz tribes settling in Anatolia, reinforcing the Turkish-Islamic presence in regions like Burdur (Sağlam, 2021).

Burdur became part of the Hamitoğulları Beylik, a Turkish principality, during this time. Hamit Bey, the beylik's founder, gained control over Isparta and Burdur in the mid-13th century. His leadership laid the foundation for Turkish-Islamic identity in the area. Dündar Bey, a significant figure within the beylik, contributed to Burdur's development by constructing the Ulu Mosque in 1300, a key example of Turkish-Islamic architecture. He also initiated commercial growth by establishing bazaars and shops (Tuncel, 2024; Kofoğlu, 2016).

Ottoman records from the late Middle Ages give insights into Burdur's growth. In 1478, the city had four neighborhoods with a population of 166. By 1522, this number had doubled, and by 1568, it exceeded 1,500, indicating steady growth and the city's continued integration into the broader Ottoman economy. Despite the challenges faced during the Middle Ages, Burdur adapted and grew, maintaining its Turkish-Islamic identity while becoming a part of the Ottoman Empire's cultural and administrative structure. This evolution reflects the region's resilience and capacity for growth even during periods of turmoil and change (Sağlam, 2021).

This marked the beginning of Ottoman rule in the region, but after the Battle of Ankara in 1402, the city fell into turmoil as various Ottoman princes and the Karamanids fought for control during the Interregnum (Fetret Devri). It wasn't until 1423 that the Ottomans regained stable control over Burdur. Following this period of instability, Burdur started to grow, spreading toward areas like Seccade Tepe and Susamlık Tepe. This expansion laid the groundwork for the city's development through the Ottoman era and beyond. From 1478 to 1568, Burdur was a district center in the Hamid Liva, an Ottoman administrative region. The city had four neighborhoods, including one

Christian and three Muslim, with a population of 166 in 1478. By 1522, Burdur's population had grown to 408 people, indicating a quick recovery from earlier disruptions like the 1511 Şahkulu Rebellion, during which Şahkulu's forces briefly took control and killed the city's judge (Gölen, 2021).

By 1568, Burdur had expanded to 17 neighborhoods. However, the late 16th century was marked by unrest due to the "suhtes" (religious students) rebellions, followed by the more destructive Celâli Rebellions from 1595 to around 1610. During the 17th and 18th centuries, there was limited information available about Burdur's development. However, when Paul Lucas visited in 1706, he described the city as relatively stable, with significant influence from large landowners like Baki Bey. Religious sites like the Ulu Mosque, rebuilt by Çelik Mehmed Pasha, played a central role in the city's cultural and religious life (Arıkan, 1998; Gölen, 2021). In the 19th century, Burdur saw administrative changes, becoming a district within the Konya Vilayet, Hamid (Isparta) Sanjak, with some shifts between Konya and Isparta. By the end of the century, Burdur had a population of around 4,000 houses, with several religious and cultural institutions, including mosques, prayer houses, and churches (Uysal, 2020).

1.3 Purpose of Thesis

Lake Burdur has great social and economic importance for the human communities here. The limnological evolution of Lake Burdur in the last 4600 years BP and the changes in lake level reflect the paleoenvironmental changes in the region, and the relationship of these changes with the paleoclimate is gaining importance for archaeological communities. Since no comprehensive paleoenvironmental research has yet been carried out in Lake Burdur, one of the aims of the thesis is to close a large gap in this field. The aim of the thesis is to investigate the adaptation and adaptation mechanisms of the human communities in the region during the Holocene to the paleoclimatic changes, natural or human-induced paleoenvironmental changes experienced here, and to understand and holistically evaluate the complex societies that began to emerge with the Early Bronze Age in Southwest Anatolia. As a result of pollen analysis, paleoenvironmental changes of the region were revealed and the results of the study were compared with the results of the paleoclimate model applied to the region.



2. THEORY

2.1 Archaeological Sciences in a Nutshell

The growing trend of incorporating natural, computational, or data sciences into archaeological studies enables us to investigate the human past through unique methodological approaches. Quantitative analysis can be a useful tool to challenge pre-existing theories or present specific inquiries within archaeological studies. This trend undeniably extends the multidisciplinary nature of archaeology.

Archaeological sciences—which generally refer to the application of scientific techniques to archaeological questions—have sometimes played a secondary role, impacting their effectiveness in various theoretical approaches to archaeology. Analysing the dynamics of how different theoretical positions influence archaeological sciences can be a valuable method for constructing a distinct archaeological theory that combines science and archaeology in a mutually beneficial way (Pollard et al., 2023). Archaeology has gradually shifted from a discipline focused solely on excavation to a unique field that increasingly incorporates different applied or natural sciences. Despite this evolution, archaeology has sometimes been viewed as a social science that is inconsistent and subjective and lacks scientific rigor. When scientific methodology was dominant, archaeology sought to establish its relevance within the broader scientific community.

Furthermore, with the transition from relative dating to absolute dating, the use of radiocarbon dating in archaeological studies led to a methodological shift that positioned archaeology as a "science." However, this understanding underwent a significant change in the postmodern era, as archaeology began to question scientific approaches, serving as a counterargument to traditional methods (Ribeiro, 2023).

The importance of archaeological sciences is undeniably increasing. However, this raises the question of whether these sciences are too focused on contributing to archaeological theory rather than validating the methods and techniques themselves. Although archaeological sciences have made significant contributions to some existing concepts in theoretical archaeology, as this article explores, there is a potential shift

away from being mere contributors to archaeological theory toward a new methodological construction approach.

Defining archaeological sciences is challenging, as it is a relatively new field compared to archaeology. The following definitions, taken two decades apart, illustrate this challenge: "The application of techniques and approaches from the full range of natural sciences to archaeological materials" (Bayley and Heron, 1998) and "Engagement of a wide range of disciplines such as physics, chemistry, biology, genetics, computing, or medicine to the study of both organic and inorganic archaeological remains, as well as associated sediments or contextual information such as their date or spatial location" (Martinon-Torres, 2018). The main difference between these definitions, which are similar in essence, is the broader scope of disciplines and contexts involved in the application of archaeological sciences.

Given this evolving context, ignoring the history of archaeology and archaeological sciences would be imprudent. A clearer definition might help set boundaries or open the field to broader interpretations. Therefore, I propose that the definition of archaeological sciences should include the application of natural, computational, and data sciences to investigate all aspects of the human past, with dynamic engagement among archaeologists, scholars in archaeological sciences, and scientists from related fields. Although this definition may seem complex and ambitious, a review of the history of archaeological sciences can reveal why such a comprehensive approach is necessary.

2.2. Two Cultures and Consilience

The relationship between archaeology and various scientific disciplines has a long history. Initially, archaeology was a relatively informal field, with early archaeologists often driven by curiosity and adventure. In the 19th century, several early scientific practices were used to research the human past, with geologists contributing significantly to the systematization of archaeology. This period saw the development of methodologies and techniques that helped transform archaeology into a more structured and scientific discipline. Mineralogists, metallurgists, architects, chemists, and palynologists also contributed to studying the human past, even before archaeology became a consistent discipline. However, after archaeology established itself as an academic discipline, social archaeology, which examines cultural dynamics

and evolution, became dominant. The findings from archaeological excavations were often theorized within the framework of cultural evolution. Notably, Darwin's theory of evolution pushed cultural evolution into the realm of social sciences, leading to the dominance of evolutionist archaeology in anthropology and archaeology.

The middle of the 20th century marked a period when science was recontextualized in the West. This era was characterized by a growing emphasis on empirical methods and the separation of scientific disciplines into distinct categories. The scientific approach, also known as "Western science," was thought to focus only on subjects who could yield empirical or objective results in experimental settings. This empirical approach was defined as the scientific method (Sutton, 2018). Although this definition is generally associated with the natural sciences, it was believed that social sciences should also develop frameworks within this empirical structure, resulting in a division between physical, natural, and social sciences. However, social sciences are often viewed as less descriptive and quantitative than other sciences, leading to the perception that they are less scientific (Dincauze, 2000). This accused structure of social sciences, seen as inadequate, caused these disciplines to be regarded as unscientific after the 1950s, leading to greater polarization between the natural and social sciences.

Although it is not the focus of this article to determine what triggered reunification in subsequent years, the arguments made by C.P. Snow, who criticized the increasingly polarized structure of social and natural sciences, are worth exploring. In his well-known lecture *Two Cultures* (1959), Snow distinguishes between science and literature and criticizes the disconnect between the social sciences and natural sciences. He compares science—which seeks to understand nature, society, human beings, and their interactions with the environment—to literature, which strives to achieve similar goals using different linguistic and methodological approaches. Snow (1962) argues that literary intellectuals and scientists should not be so distant and ignorant of each other's fields, as this mutual suspicion and lack of understanding reduce the chances of success in addressing world problems and understanding human nature. Instead, science should benefit from art, and art should benefit from science, leading to more productive outcomes. Snow's vision emphasized the importance of bridging the gap between disciplines to foster a more holistic approach to knowledge.

Similarly, the "natural sciences," which basically study nature, the "social sciences," which study society and its dynamics, and the "human sciences," which study humans, are parts of the same endeavor with formal differences. Snow believed that scientists need to understand literature and that literary scholars should be familiar with basic scientific concepts. In this respect, the convergence of these two cultures could significantly impact humanity's quest for knowledge. It is dangerous for these two cultures to remain mutually exclusive, especially when scientific development is closely related to societal progress (Schneider and Morton, 1981).

Wilson's concept of "Consilience" (1998) posits that integrating different disciplines can yield richer insights by addressing complex subjects from multiple perspectives. Consilience suggests that the integration of diverse academic disciplines can lead to more comprehensive solutions to complex problems. However, in practice, achieving this ideal is challenging. Interdisciplinary collaboration requires balance and mutual respect to prevent one discipline from dominating. If this occurs, the result can be a reductionist approach where the dominant discipline overshadows others, leading to a narrower understanding (Figure 2.1).

A successful understanding of consilience requires clear communication, adaptability, and a shared goal that transcends individual disciplines. Effective consilience relies on the collaboration of diverse disciplines working towards common objectives. Teams must recognize and value each discipline's unique contributions, ensuring that insights from all fields are integrated. Consilience can foster a deeper, more comprehensive understanding of complex issues when done well.

Interdisciplinary collaboration requires equal contributions from all participants (Izdebski et al., 2016). This means that from the initial stages of a project, all disciplines should be equally represented, with research questions determined through collaborative effort and ongoing interactions. This approach fosters a richer scientific environment by integrating diverse perspectives.

In this context, equal participation ensures that all viewpoints are considered, supporting a more inclusive and effective research process. Moreover, it allows for the comprehensive integration of methodologies, enhancing the robustness of the findings. However, if equal participation is not achieved, the research process can be reduced to just a few disciplines' viewpoints, contradicting the concept of "convergence".

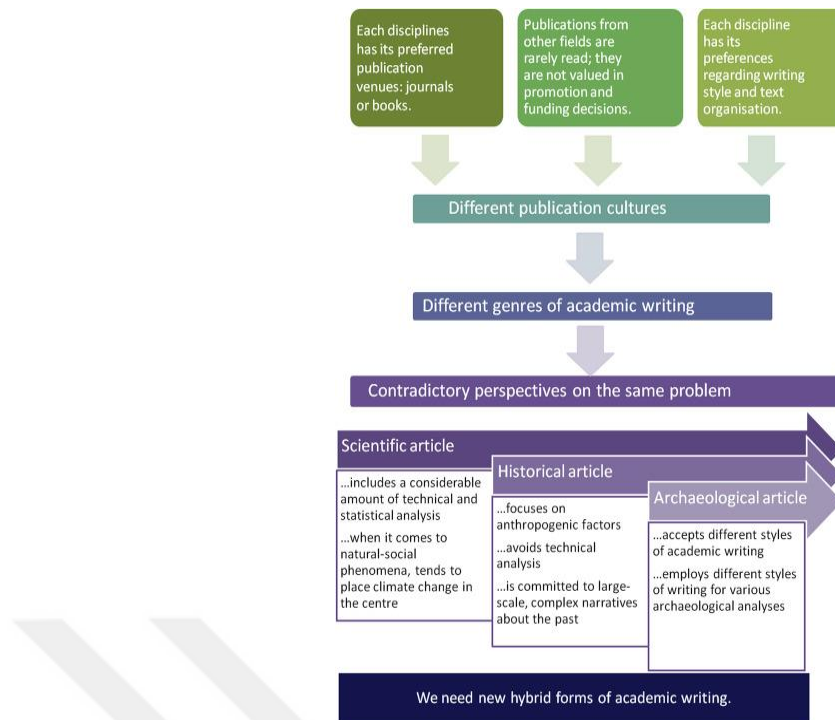


Figure 2. 1: Figure shows some obstacles to interdisciplinary collaboration (from Izdebski et al., 2016).

Archaeology provides a prime example of interdisciplinary collaboration. In this field, the convergence of various disciplines, such as anthropology, history, geography, geology, and biology, offers a comprehensive approach to understanding the past. However, for such collaborations to succeed, specialists from each discipline must participate equally and cooperate.

The interaction of each discipline with others, while maintaining its own area of expertise, strengthens collaboration. "Consilience" requires mutual respect and understanding among different disciplines. When researchers from various fields set aside their methodological and theoretical differences to focus on common goals, scientific research becomes more comprehensive and creative (Haldon et al., 2018; Izdebski et al., 2016).

Successful interdisciplinary efforts in archaeology illustrate how combining different approaches can lead to new discoveries and insights. However, for these collaborations to succeed, equal participation from all parties must be ensured from the project's inception, and research questions must be defined collectively. This not only strengthens the culture of collaboration but also fulfills the primary goal of "conformance": to combine the strengths of different disciplines to find more effective solutions to complex problems.

2.3. Some Major Views in Archaeological Theory on Archaeological Sciences

Although interdisciplinary views are not limited to these two approaches, the views of Snow and Wilson, which were quite radical compared to the academic environment of the time, influenced the emergence of significant perspectives in various fields. In the context of archaeology, especially since the 1960s, the application of the radiocarbon dating method has led to a "revolution" in archaeological disciplines. This was the first time that "archaeometry," referred to as archaeological sciences, was discussed so intensely (Renfrew, 1971). In addition, processual archaeology (New Archaeology), which challenged traditional archaeology in a significant way, advocating an effort to examine culture as a process with a neo-positivist approach, especially with statistical quantitative research methods, became widespread in the 1960s and signaled a shift in the general realm of archaeology (Renfrew and Bahn, 2012). In the 1960s, archaeology underwent a radical change with the emergence of the processual approach. This new approach provides a scientific and analytical perspective for archaeological work, allowing archaeologists to study ancient cultures and social changes in greater depth. Processual archaeology aims to explain the reasons and mechanisms behind cultural changes rather than merely describing them (Johnson, 2019).

During this period, the underlying paradigms of archaeology experienced a significant transformation. Previous approaches have typically focused on cataloging and classifying archaeological artifacts, whereas processual archaeology has adopted a broader perspective. This new outlook encouraged the analysis of archaeological data within a more scientific framework, using statistics, computer modeling, and other scientific methods to understand cultural processes and dynamics (Redman, 2002).

Lewis Binford and David Clarke, pioneers of processual archaeology, placed this new methodology at the center of archaeology, enhancing the scientific credibility of the discipline. They approached archaeology as a field aimed at explaining the complex structures of past cultures and their changes over time. This approach provided an analysis focused on understanding the cause-and-effect relationships of cultural phenomena, offering a more comprehensive explanation of historical events (Jones, 2001).

Other notable archaeologists, such as Colin Renfrew and Paul Bahn (2013), also emphasized the importance of an interdisciplinary perspective. They highlighted that

archaeology was not only about excavations and artifact collection but also about understanding the lifestyles, social structures, and environmental interactions of prehistoric societies. This approach encouraged the integration of knowledge from fields such as anthropology, sociology, geography, and ecology into archaeological analyses.

However, while the use of archaeological sciences in studies related to this theoretical trend has become normalized, it is incorrect to say that processual archaeology has fully adopted archaeological sciences at a methodological level. It is therefore essential to distinguish between "scientific archaeology", as it is currently understood, and archaeological sciences. Scientific archaeology, in the context of the processual approach, signifies that archaeology is moving closer to the knowledge production systems of the natural sciences—regardless of whether the scientific method is used. In contrast, archaeological sciences refer to how these scientific methods and techniques can be incorporated into archaeological studies without necessarily aligning with a specific theoretical framework (Martín-Torres and Killick, 2015).

The interaction of the postprocessual approach, which became increasingly prominent in archaeology, especially in the 1980s and 1990s, with archaeological sciences is quite different. According to archaeologists influenced by this approach, knowledge production through scientific methods arises from a drive for hegemony and domination, which does not allow for alternative perspectives. In this sense, the role of archaeology is not only to reconstruct the human past using empirical methodologies but also to shape the present by considering the agency inherent in cultural and cognitive practices from different viewpoints. The complexity of human actions and agency cannot be treated as a puzzle to be solved with strict methodologies. Instead, it creates a unique phenomenological experience each time, reflecting the relationship between today's archaeologists and the material world and their perceptions of societies from the past (Renfrew and Bahn, 2012).

Although the primary criticism of this approach is aimed at scientific archaeology—not scientific methods and techniques—the archaeological sciences, which involve the application of various techniques and methods, are not necessarily the target of these criticisms. Nevertheless, archaeologists who use this approach often avoid the techniques and methods offered by the archaeological sciences for a long time. However, even Ian Hodder, one of the leading figures in postprocessual archaeology,

adopted an interdisciplinary approach in the Çatalhöyük project, which demonstrates that this avoidance is gradually diminishing (Marciniak and Rączkowski, 2001; Richards and Britton, 2020; Martínón-Torres and Killick, 2015).

2.4. Towards a Theory of Archaeological Sciences

From our earlier discussion on the evolving relationship between archaeology and the archaeological sciences, it is clear that while the archaeological sciences traditionally encompass methods and techniques, their role in theoretical debates has often been uncertain. Historically, archaeological sciences have provided tools for data collection and analysis but have struggled to influence broader theoretical frameworks in archaeology. Martínón-Torres and Killick (2015) outlined several contributions that archaeological sciences have made to theoretical archaeology, including a) materiality, b) the social construction of technologies, c) models of technological change, and d) diffusion versus independent invention. However, in my opinion, these contributions represent only a limited perspective. To progress further, it is crucial to consider the need for the archaeological sciences to evolve into a more cohesive discipline or subdiscipline characterized by internal consistency and systematic methodologies. This evolution requires a concerted effort to align scientific methods with theoretical frameworks and to foster interdisciplinary dialogue. This can be achieved through rigorous research designs and appropriate methods.

In this context, Crabtree and Dunne (2002) introduced a diagram demonstrating the principles of "archaeoecology," illustrating a mode of research that fosters greater interaction between archaeological studies and other scientific fields. Crabtree and Dunne (2022) discussed how the study of human-environment interactions could become more participatory through archaeology. They introduced the branch of archaeoecology, which merges the methodologies and tools of ecology with archaeological data and cultural interpretations. This field examines past changes in ecological structures, integrating the insights from archaeology, which often focuses on long-term changes, with the perspective of current ecology, which typically addresses shorter-term shifts. By bridging these approaches, archaeoecology offers a more nuanced understanding of both historical and contemporary environmental issues.

Archaeoecology emerges from a process of interrelational interaction rather than merely combining the separate efforts of archaeologists, palaeoecologists, and ecologists. This branch provides a holistic view that none of the individual disciplines can achieve alone (Figure 2.2). The essence of this interdisciplinary approach lies in its capacity to draw from multiple perspectives, fostering a more comprehensive understanding of human-environment interactions.

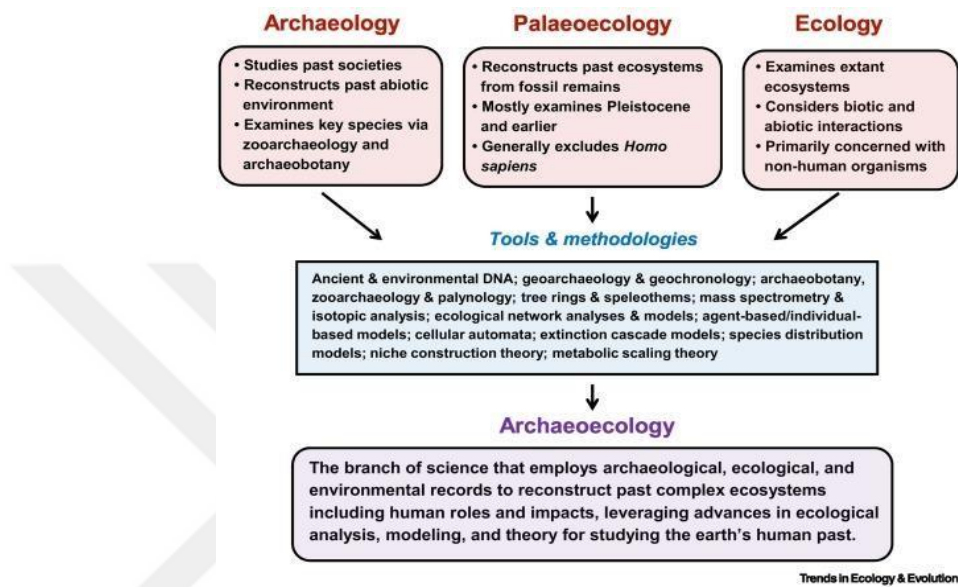


Figure 2. 2: Integrating, archaeology, palaeoecology, and ecology disciplines (From Crabtree & Dunne, 2022).

The “archaeoecological” model proposed by Crabtree and Dunne points to a broader framework for dividing archaeological sciences into various branches (such as geoarchaeology, zooarchaeology, and archaeobotany) in a contemporary context. This model emphasizes the interconnectedness of these disciplines, suggesting that their traditional boundaries are not as rigid as previously thought.

By acknowledging these overlaps, the model advocates for a more holistic approach to archaeological research. For instance, the interaction between geoarchaeology and zooarchaeology within this model suggests that the traditional distinctions among these branches may need to blur or overlap in certain contexts.

This idea encourages a more integrated approach, which contrasts with the typical division among these branches. Such integration allows for a more comprehensive examination of past human-environment interactions and supports the development of new interdisciplinary research methods.

This comprehensive approach, particularly suited to topics involving human-environment interactions, might not apply universally across all archaeological contexts. The fundamental branches in archaeological sciences generally split into discrete areas of study, offering a different perspective compared to the more holistic approach of archaeoecology. However, the diagram presented in this study does not fully demonstrate how the archaeological sciences can collaborate with other disciplines and nonarchaeologist experts. This provides a limited view of the potential for cross-disciplinary cooperation. To address this limitation, the diagram below (Figure 2.3) suggests a more generalized framework illustrating how the archaeological sciences can operate in various modes and with which groups they can collaborate. The components labeled as A-B-C-D represent different configurations of interaction among scholars from various fields, depending on the scope and content of a given archaeological study.

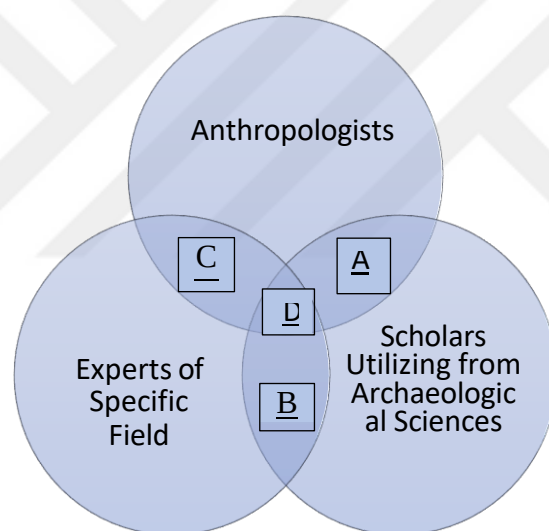


Figure 2. 3: Archaeology operates within different modalities.

"A" represents a common scenario where archaeology and archaeological sciences work together in current archaeological studies. It is quite typical to see experts such as geoarchaeologists and archaeobotanists involved in excavations or other research methods. This kind of collaboration has become increasingly standard in modern archaeology. "B" indicates a more specialized case. Here, a nonarchaeologist expert needs to collaborate with an archaeological anthropologist, drawing on knowledge from the archaeological sciences. This occurs when archaeological data alone cannot provide sufficient insight. In this situation, a specialist in archaeological sciences must be familiar with archaeological periods—even if not as much as an anthropologist—

while also possessing expertise in the tools and methods appropriate for the specific study. For example, a zoologist might work with a zooarchaeologist on a project examining animal diversity in the Konya Plain because the zoologist's knowledge of zoological identification extends beyond what a typical zooarchaeologist might know. "C" refers to interdisciplinary studies, which have become more prevalent. For instance, if a palynologist examining a core discovers significant changes relating to archaeological periods, they might collaborate with an anthropologist to explore whether these changes have archaeological implications.

"D" illustrates the interdisciplinary nature of archaeoecology, a concept explored earlier. This scenario exemplifies collaboration among experts from three distinct fields, where each contributes specialized knowledge without any one discipline overshadowing the others. Here, experts are required to comprehend fundamental ecological principles and appreciate the boundaries and capabilities of each other's disciplines. This collaborative approach ensures a comprehensive understanding of complex environmental dynamics and human interactions throughout history, emphasizing the importance of integrating diverse perspectives to unravel the intricacies of past ecosystems and societies.

Returning to the beginning, the definitions of archaeological sciences often hinge on subtle distinctions. These typically refer to innovative applications of methods or techniques from various fields that might not have been considered previously. The idea that archaeological sciences only use these different branches of science as tools for consumption could indicate a lack of evolution in this discourse. However, while providing a comprehensive and unified definition might be challenging due to the inherent flexibility of archaeological sciences, this adaptability should not imply that they are passive actors.

The relationships among anthropologists, archaeological scientists, and experts from other fields vary depending on the context and scope of the study. If these relationships are dynamic, with constant contact and collaboration, the archaeological sciences can move beyond merely contributing, potentially offering completely new concepts, perspectives, and approaches to archaeology. By fostering a collaborative environment, the archaeological sciences can help shape a more integrated and forward-thinking approach to understanding the past.

2.5. Archeology and Environment: So Far However, So Close

Although the concept of archaeoecology has been discussed in the context of archaeological sciences and some surface-level debates have been held regarding the applications of human-environment interactions in archaeology, it is important to examine these topics in more depth and consider new approaches. This is particularly critical for this thesis, which focuses on the overview of human-environment interactions and their emerging concepts.

Studies on archaeology and environmental changes are recognized as fields where various disciplines intersect or complement each other. Archaeologists have conducted extensive research to understand how humanity has interacted with its environment throughout history and the social, cultural, and ecological implications of these interactions (Figure 2.4). Understanding the impact of environmental factors on human societies plays a key role in these studies (Davis, 2019).

In this context, the significance of archaeological research lies in understanding the changes in human-environment interactions over time. Archaeologists not only conduct excavations but also utilize methods from various disciplines to explore the effects of environmental factors on societies and how humans respond to their environment. Tools from physics, chemistry, geography, biology, and geology broaden the scope of archaeology, allowing for a deeper analysis of past human-environment interactions (Carleton and Collard, 2020).

The processual archaeology movement of the 1960s strengthened the scientific approach in archaeology, facilitating a better understanding of cultural changes within an environmental context. During this period, environmental archaeology gained popularity, with subdisciplines such as geoarchaeology, archaeobotany, and zooarchaeology aiming to study the biophysical relationships between human societies and their environments. Geoarchaeology has examined the geological context of archaeological sites and the natural influences on these areas, while archaeobotany has explored ancient environments through plant remains such as pollen, seeds, and phytoliths. Zooarchaeology, on the other hand, studies bones and other animals to understand how humans used animals and their domestication processes (Willey and Philips 2001).

The rise of environmental archaeology opened new avenues for understanding how environmental changes throughout human history affected social and cultural structures. However, toward the end of the 20th century, criticisms against environmental determinism emerged. The postmodernist movement and postprocessualism argued that environmental factors were not the sole cause of cultural changes. According to this perspective, human agency, social dynamics, and other cultural factors also need to be considered to understand cultural processes. (Davis, 2019).

In the 21st century, archaeology and climate change studies expanded with interdisciplinary approaches. New technologies, computational ecology, and palaeoenvironmental data analysis have allowed archaeologists to explore human-environment interactions more comprehensively. Concepts such as "niche construction" and "socioecology" help to better define the reciprocal interactions between the environment and human communities (Davis 2019; Seuru and Albouy, 2023).

Environmental archaeology continues to be profoundly relevant, particularly amidst the backdrop of pressing contemporary challenges such as climate change and environmental degradation. By delving into the ways ancient societies adapted to environmental shifts, archaeologists offer valuable insights that can inform present-day strategies for resilience and sustainability. Analyzing past human responses to environmental changes not only enhances our understanding of historical dynamics but also provides a comparative framework for addressing current global issues (Arponen et al., 2019).

Nevertheless, environmental archaeology faces significant methodological and interpretive challenges. Establishing clear causal relationships between human behavior and environmental factors requires meticulous analytical rigor to avoid oversimplifications or misinterpretations based solely on correlations. This demands the integration of high-resolution data from diverse sources, including archaeological, ecological, and climatological records, to construct nuanced narratives of human-environment interactions over time. Additionally, interdisciplinary collaboration is essential for synthesizing data from these varied sources to produce comprehensive and accurate interpretations of past environments and human behaviors.

Interdisciplinary collaboration is paramount in overcoming these challenges. Archaeologists, alongside experts in climatology, ecology, anthropology, and other fields, work together to synthesize complex data and perspectives. This collaborative approach not only enhances the robustness of research findings but also fosters innovative methodologies for studying past environmental changes and their implications for human societies.

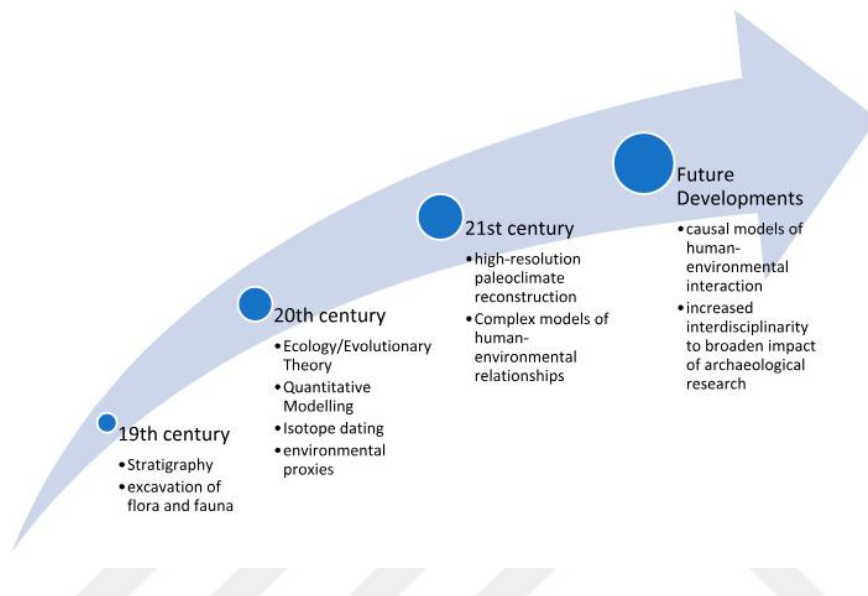


Figure 2. 4: Archaeology and environment relationship through centuries (from Davis, 2019).

In essence, while environmental archaeology confronts formidable obstacles, its potential to offer profound insights into both historical and contemporary environmental issues underscores its critical importance in shaping sustainable practices and policies for the future. In summary, archaeology and environmental studies provide a significant perspective for understanding human history. Understanding how past human communities interact with their environment can help develop more culturally and environmentally conscious approaches.

Furthermore, the integration of archaeological findings with environmental science facilitates a more comprehensive approach to understanding long-term ecological and societal changes. As interdisciplinary research continues to gain importance, archaeologists are using new technologies and methodologies to better understand the impact of environmental changes on human societies. This synergy not only enriches the interpretation of archaeological data but also provides valuable insights into the complex interactions between humans and their environment over time.

2.6. Archaeology of Sustainability

Archaeological studies are gaining a new perspective and approach in light of Anthropocene thinking. By examining the impact of past climate changes and environmental degradation on societies, archaeology is believed to reveal human responses to such changes, offering valuable lessons for today. The strategies that human societies have developed in response to climate change might be useful in addressing similar challenges we face in the modern world. Although this does not necessarily denote a specific field and often falls under the broader umbrella of environmental archaeology, the topic of "archaeology of sustainability" is becoming increasingly significant.

Although sustainability is a ubiquitous concept, it lacks a unitary definition. This is especially relevant in the context of developing countries being urged to develop underdeveloped regions, stemming from the notion that economic development should occur with minimal environmental damage and with respect to the sociopolitical and economic dynamics of the areas in which development is expected. However, sustainability has gradually shifted from the context of sustainable development, being redefined and recontextualized in various fields. Archaeology has not been immune to this dynamic process, with nonstatic interpretations leading to definitions that do not align with contextual and relational coexistence, a trend that has become dominant within the discipline (Hutchings and La Salle, 2019).

Sustainability in archaeology has been seen as a "checklist" developed to mitigate its potentially destructive impact (Childs and Benden, 2017), with calls for greater continuity in interaction at the academic, governmental, and global levels (e.g., Majewski, 2017; Ferris and Welch., 2015). Others have proposed that sustainability should be considered a priori historical, arguing that the sustainability of both biophysical change and human values requires a diachronic process (Tainter, 2002). Another perspective posits that ecological sustainability cannot be achieved unless third-party organizations, such as the Intergovernmental Panel on Climate Change (IPCC), incorporate historical disciplines into their work (Richer et al., 2019; Jackson et al., 2018). Furthermore, it has been suggested that the resilience observed in human societies in response to sudden environmental changes during past events, such as the

Holocene Climatic Optimum and the Medieval Warm Anomaly, could inform our understanding of contemporary climate change (Jerardino, 2012).

However, there are also criticisms of linking sustainability and archaeology. Richer et al. (2019) argue that seeking relevance for sustainability in every aspect of archaeology is misguided and that this discipline can only contribute to sustainability through a specific "Mode of Research." Howard (2013) and Hutchings and La Salle (2019) contend that sustainability in archaeology is frequently reduced to climate change, criticizing the notion that a "low carbon economy" past could serve as a meaningful model for highly complex modern societies. They suggest that such an approach reflects a capitalist-driven search for significance rather than a realistic or holistic understanding of sustainability's broader implications. There are countless examples demonstrating sustainability from various perspectives. However, to provide a general overview, a table categorizing articles that discuss sustainability in archaeology can offer insights into the subject's diversity (Table 2.1).

The focus here, rather than the different approaches to sustainability in archaeology, will be on the factors preventing the successful operation of the archaeology of sustainability. This issue is often due to a lack of or misunderstanding regarding the diachronic perspective within the thought systems that seek to find meaning and significance in archaeology. The reason for this deficiency will be analyzed through the conceptualization proposed by Bybee et al. (1994), which was originally designed to explain linguistic evolution. Bee et al.'s framework delineates the differences and relationships between "tense," "aspect," and "modality."

Table 2.1 : Sustainability issues in archaeology. Source: (LeFebvre et al., 2022).

Sustainability Issues in Archaeology
Human responses to climate change (settlement patterns, migrations, collapse idea)
Subsistence practices and resource protection
Overexploitation of resources and development of domestication
Biodiversity loss (paleoecology and ecology, i.e. fossil pollen grains and spores)
Seafaring triggered by climate
Indigenous and local perspectives, colonial impacts of what is forgotten
Ethics and Political Ecology/Economy

The concept of sustainability, defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" by the United Nations Brundtland Commission in 1987, has gained significance with the growing awareness of environmental issues caused by the ongoing climate crisis. The Brundtland Report of 1987, where environmental protection became a primary objective, discussed the use of renewable resources, the importance of environmentally friendly economic development, and the dimensions of environmental ethics. It contextualized sustainability within the broader scope of economic development's implications for environmental issues, which were widely recognized as a serious threat for the first time (Howard, 2013). Sustainability, as an "ill-defined" concept, is influenced by the sociocultural, political, and economic structures of its time. Consequently, sustainability has been divided into various subdivisions (Carman, 2016). For example, based on the United Nations' fundamental principles of sustainability, MacFarlane (2000) divides sustainability into economic, social, and cultural sustainability, while Selman (2008) also includes political and aesthetic sustainability.

Today, sustainability permeates nearly every sector, evolving from a mere buzzword to a concept that undergoes continual reconceptualization and recontextualization across various disciplines, professions, and societies over time (Beatly, 1995; Howard, 2013). This evolution is evident in the increasing number of scholarly articles dedicated to sustainability, underscoring its entrenched position in academic discourse.

In recent years, the diffusion of sustainability concepts into the social sciences, including archaeology, has been striking. Social sciences contribute significantly by examining sustainability through its political, economic, and social dimensions, especially when considering sustainability beyond mere developmental contexts. This broad and varied reconceptualization within the social sciences plays a crucial role in advancing sustainability research and discourse (Becker et al., 1999; Shahadu, 2016).

By integrating sustainability into their frameworks, social scientists and archaeologists alike enrich our understanding of how sustainability principles can be applied across diverse cultural and historical contexts. This interdisciplinary approach not only enhances our ability to address contemporary environmental challenges but also informs strategies for promoting long-term resilience and stewardship of our planet's

resources. Thus, sustainability continues to evolve as a pivotal concept shaping both academic inquiry and practical initiatives worldwide.

2.7. Archaeology as an Asset Between Past and Future: Utilitarian Perspectives

Today, archaeology is a discipline that claims to examine human history in an all-encompassing way, contrary to the traditional focus on material culture. The traditional definition of archaeology, which examines the human past through the excavation and analysis of artifacts and sites, has evolved into a more inter/multi/transdisciplinary approach, engaging different branches of natural and social sciences (Maggio, 2018; Lombardo et al., 2023). This internal inclusiveness and the relative difficulty of providing a generally accepted definition of the field have led to open-ended interpretations. Among them, the question of whether archaeology is relevant to various current issues within diversified temporal frameworks has made notable breakthroughs. However, as discussed later in this paper, the growing expectation that archaeology should be assigned certain utilitarian duties might be problematic unless it supports systematic knowledge production and practice. Therefore, whether these expectations contribute to the theoretical and methodological framework of archaeology should be discussed among archaeologists, governmental or private funding agencies, and global organizations such as the United Nations.

The idea of relating archaeology to current issues is not entirely new. By emphasizing the unique applicability of archaeology to different issues, such as recreating traditional agricultural and land-use practices, Erickson defines "applied archaeology" as archaeological research that can provide insights to address current humanitarian concerns (Erickson, 1992). His analysis of using the past to inform the present and future claims to be "diachronic," although this approach does not fully discuss change and continuity within traditional and modern contexts. Tainter, on the other hand, views archaeology's potential contribution as the "only" field that can shed light on today's problems by examining developments across long temporal processes from different perspectives (Tainter, 2002).

Sabloff, in his book that details why archaeology matters, divides archaeology's potential contribution to current issues into themes such as a) sustainable environments, b) warfare, c) urbanism, and d) conservation of past remains.

According to these themes, archaeology's claim to relevance can be seen in raising awareness and respecting cultural achievements, providing lessons from the past, and understanding problem-solving and resilience among people (Sabloff, 2016). However, Sabloff cautions against overestimating the potential of these claims, emphasizing that archaeological knowledge can offer a "useful perspective and some real solutions" but should not be viewed as a comprehensive application tool (Sabloff, 2016). This careful approach reflects the understanding that approaching archaeological knowledge as a practical application could be overly ambitious. From the examples discussed, it is clear that the most typical concern among archaeologists regarding the relevance of archaeology is whether it can be applied to past, present, and/or future contexts.

In this respect, studies that point out the insufficiency of archaeology's relationship with the contemporary world are also manifold. Kerr suggested that while archaeology has the potential to address current global problems, problem-oriented research is often underestimated by archaeologists. He also noted that even though interdisciplinary methods are ubiquitous today, archaeology has not sufficiently integrated these approaches with contemporary funding bodies' goals (Kerr, 2020). Another common concern is the societal and public relevance of archaeology within the context of problem-solving-oriented research (Richer et al., 2019). Archaeology is often perceived as ignorant and "irrelevant" because it does not sufficiently "resonate with the public, including local and descendant communities" (Sabloff, 2016). Additionally, findings from archaeological studies and publications tend to reach only groups of archaeologists rather than broader audiences interested in these topics, who might benefit from understanding the relevance of past data (Smith, 2021; 2017).

The significance of archaeology is theorized within the nondynamic relationship between “tenses” rather than “aspects.” Even though it is not the main focus of this paper, the distinction between “tense” and “aspect”, as described by Bybee et al. (1994), is worth discussing here to better understand the lack of a diachronic approach in applying archaeological knowledge across various temporal frameworks. In their work, the concept of tense refers to conditions where states or actions are temporally specific, while aspect refers to extended conditions that are unitary in time or contain traces of their continuity or repeatability. Modality, their third term, refers to uncertain

possibilities or imperatives of actions or situations from a present perspective. Archaeological knowledge cannot be neatly categorized into any of these three temporal terms. Although the raw information obtained from archaeological studies can be contextualized temporally and spatially, it largely aligns with the concept of tense, allowing us to find specific spatiotemporal traces in a synchronic context. However, this specific information can be useful for examining the continuity of actions or situations through existing or new studies, which are often nonunitary and potentially repeated in different contexts. This transition into a diachronic perspective involves acknowledging change by incorporating both small and large variations in analogy. In this sense, synchronic elements form a thought system through relational interactions. However, presenting this exaggeratedly by blending synchronic information with diachronic information can lead to a deterministic modality. When applied to archaeology, what determines its usefulness is neither the synchronic demonstration of successful life practices from the past nor the uncertain possibilities or imperatives of similar changes and continuities suggested through a diachronic lens.

Overall, sustainability has become a buzzword, permeating nearly every field and often being overexploited. The proliferation of this concept in various disciplines has resulted in new conceptualizations and contextualizations. This raises the question of whether sustainability is a goal to be achieved in different fields or simply a popular topic that offers a certain perspective. In a world where the debate about archaeology's relevance to contemporary issues is perhaps more intense than ever, it is not surprising that sustainability finds a prominent place within it. However, as in every field, this concept does not inherently bring a consistent or coherent perspective and can become increasingly challenging to understand. The societal relevance demanded by different funding agencies also offers a synchronic perspective, promoting a tendency to draw analogies between the past and future. However, as a discipline that studies the past with modern theories and methods, it is essential to recognize that synchronicity alone is insufficient. What is needed is modality—a complex temporal "aspect" that arises from both synchronic information and other interacting conditions—a mode that can easily become meaningless if pushed too far into excessive subjectivity.

3. EARLIER STUDIES ON PAST CLIMATE AND VEGETATION IN THE STUDY REGION

3.1 Palynological Studies and Their Importance in Questioning Human-Environment Relationships

Palynology is a scientific field frequently used in archaeology to understand environmental changes and human activities. The term "palynology" is derived from the Greek word "παλυνειν" (palunein), meaning "to disperse," and was first used by Hyde and Williams (1944). Initially, focused on studying pollen and spores, palynology has since expanded to include other organic particles, such as marine plankton and foraminifera (Kooistra and Kooistra, 2003).

Pollen, the reproductive cell of plants, is dispersed by wind, insects, or other animals, while spores are microscopic structures produced by fungi and ferns for reproduction (Shukla et al., 1998). By examining pollen and spore traces in fossil records and sediment layers, palynology aims to understand past plant species, climate conditions, and human-environment interactions.

In archaeology, palynology provides a unique perspective by allowing archaeologists to analyze the distribution of pollen and spores in stratigraphic layers. This helps them make inferences about past vegetation and climate changes. For instance, the emergence of different pollen types within a particular layer can indicate the plant diversity of that period, suggesting how ecosystems changed and how these changes might be related to human activities (Bryant and Holloway, 1983).

Environments conducive to preserving pollen and spores are typically organic-rich bogs, lakes, and mud sediments (Chevalier et al., 2020). These natural settings can maintain pollen and spores for long periods without significant degradation. As a result, analyzing preserved pollen in these environments can reveal which plant species were predominant during specific periods and suggest possible reasons for shifts in plant communities (Figure 3.1). Changes in pollen types can also reflect climate variations or human influences. Thus, archaeologists can use these findings to trace

environmental history and understand the impact of human activities over time (Marshall, 2007).

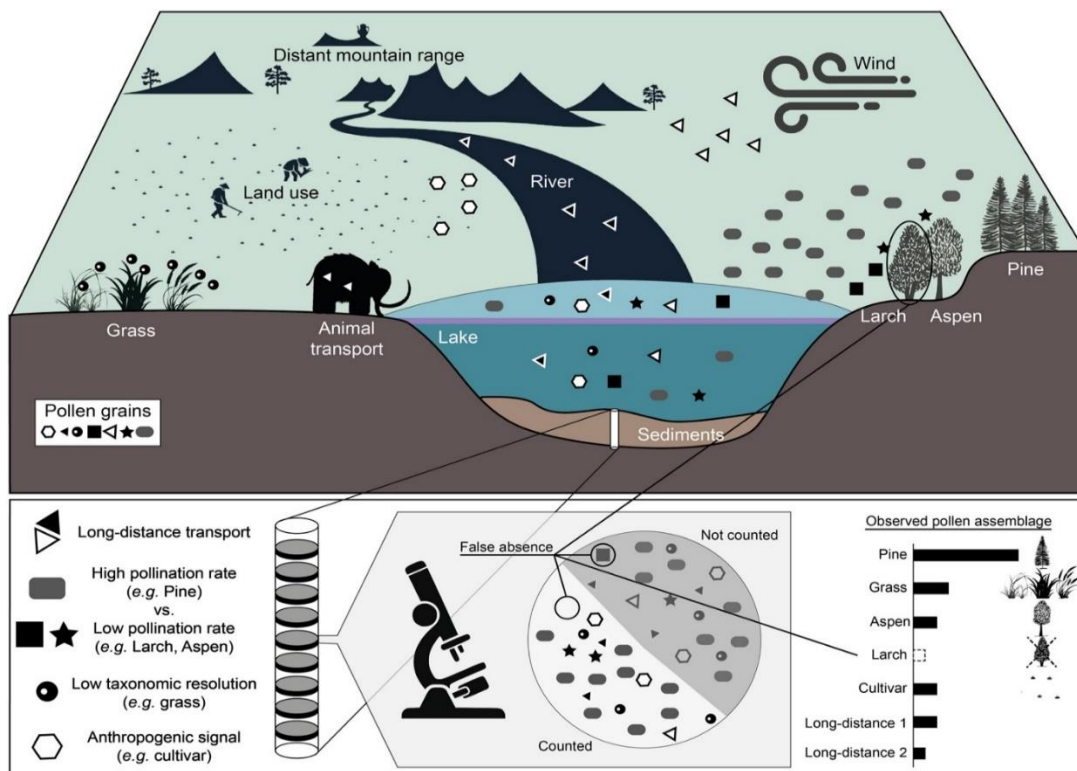


Figure 3. 1: Schematic diagram showing the conceptual model of different processes contributing to pollen preservation in lake sediments (from Chevalier et al., 2020).

Fossil pollen analysis, also is a crucial tool in paleoclimatic studies, offering unique insights into past climates and environmental conditions. The diagram below illustrates the space-for-time principle in pollen-based climate reconstruction. Most models utilize current climate-pollen correlations to infer past climates, assuming that similar pollen compositions reflect equivalent climatic conditions (Figure 3.2).

Pollen grains are produced by plants in vast quantities and are highly resistant to decay. They are dispersed by wind, water, or animals, and their presence in sedimentary deposits provides a record of the vegetation that existed at the time of deposition. By studying the types and abundance of pollen grains, past vegetation communities can be reconstructed. Changes in pollen assemblages over time indicate shifts in plant distribution and composition, which are strongly influenced by climate. Fossil pollen analysis covers a vast temporal range, extending from the present to tens of millions of years ago. This extensive record enables to study (paleo)climatic variations over different timescales, from annual to millennial and even longer cycles. By examining

changes in vegetation and climate over geological time, patterns and drivers of past climate variability can be identified, providing valuable context for understanding contemporary climate changes.

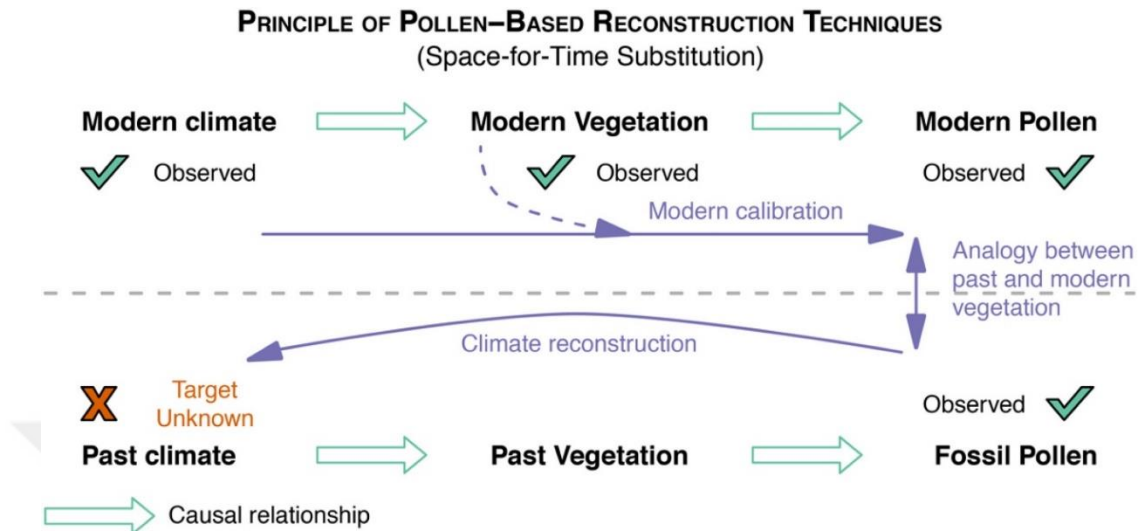


Figure 3. 2: The space-for-time principle in pollen-based climate reconstruction (from Chevalier et al., 2020).

Pollen analysis can also track traces of human activity in archaeological studies. In situ pollen analysis, for example, can reveal the impact of activities such as agriculture, construction, fire history (along with charcoal analysis), and religious ceremonies on pollen distribution (Feaser and O’Connell, 2010; Kelso and Beaudry, 1990; Nelle et al., 2010; Mora et al., 2017).

This type of analysis offers insights into cultural and social practices. For example, pollen analysis in agricultural fields can indicate which crops were grown and how farming methods changed over time, providing valuable information about ancient societies' agricultural practices. Additionally, pollen analysis at burial sites can help identify which plants were used during funeral rituals, shedding light on cultural perspectives regarding death and ceremonies.

Pollen analysis can also reveal insights into past diets and nutrition. Certain plant pollen types can indicate what foods ancient societies consumed (Hall, 1985; Geib and Smith, 2008). Additionally, pollen analysis can help in understanding which medicinal plants or aromatic herbs ancient people used. For example, if various medicinal plant pollen traces are found in an archaeological excavation, they could provide clues about a society's medical practices (Chaves and Reinhard, 2003).

Over time, the scope of palynology has expanded due to technological advancements, allowing palynologists to collect and analyse much more data. With large online pollen databases, researchers can compare pollen profiles from different regions worldwide, leading to a broader perspective (Edwards et al., 2015).

These advancements have made palynology more accessible and comprehensive, complementing traditional fieldwork. By analysing pollen profiles, archaeologists can draw conclusions about climate change, migration patterns, and cultural interactions, offering a more complex view of past societies.

Burdur province and Burdur Basin have been the subject of extensive palynological studies. These investigations have even involved a re-examination of older core samples, shedding new light on the area's past vegetation and climate dynamics.

While some studies have focused solely on understanding the Late Holocene ecosystem, others have been part of broader expeditions seeking to unravel the entirety of the Holocene era. A location map of the regions studied to date is presented in Figure 3.3.

Additionally, it is worth mentioning a notable fossil pollen study conducted in the Ağlasun area, a valley adjacent to the ancient site of Sagalassos in Burdur. However, this particular study by Vermoere (2004) was published in a book that is not readily accessible to the public. Despite efforts to obtain access to this publication, unfortunately, obtaining a copy has proven elusive.

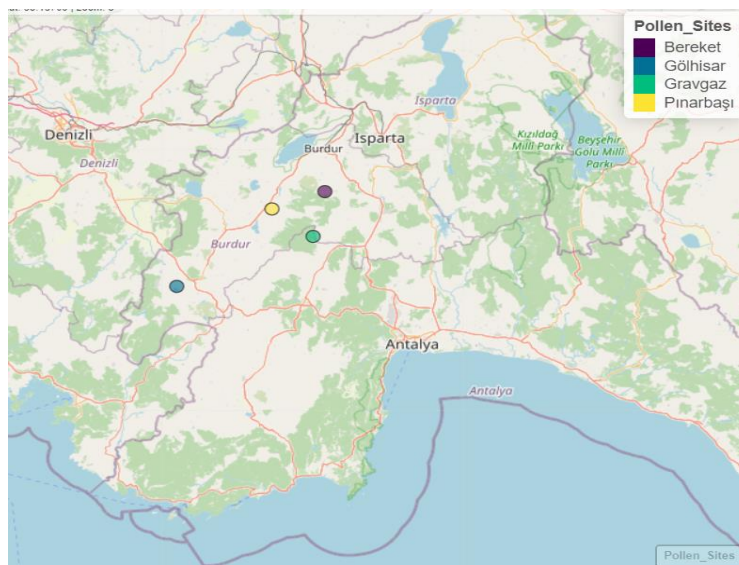


Figure 3. 3 : Location map of earlier fossil pollen studies in Burdur.

3.1.1 Pınarbaşı

The study conducted by Bottema and Woldring (1984) on the drained lake and marshland in Pınarbaşı covers a significant time period ranging from approximately 1000 to 8500 BP (Before Present). Adequate pollen was not found between 255-360 cm and from 380-545 cm depths of the 715 cm core, which were designated as hiatuses. The original publication did not include age-depth reconstruction based on two radiocarbon datings, thus the age-depth relationship is merely based on biostratigraphy. Additionally, zonal spectra intervals were provided in the publication without diagrams, but it is not clear what these spectra encompass. However, as can be inferred from the comments, the zones increase from top to bottom given below (Figure 3.4).

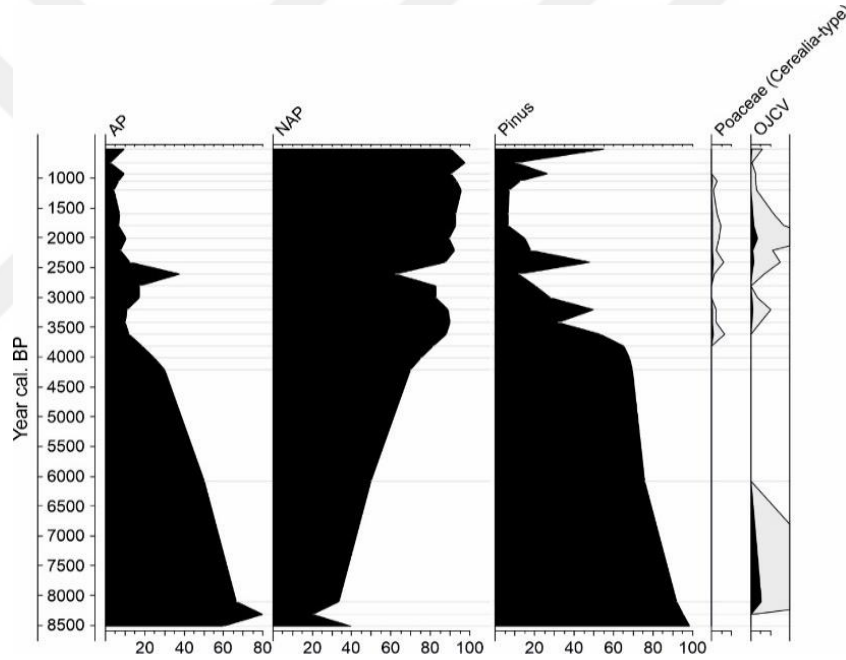


Figure 3. 4: Pınarbaşı summary pollen diagram with a focus on *Olea*, *Juglans*, *Castanea*, *Vitis* sp. given as OJCV (Data: Botema and Woldring, 1984).

Between 1000-2500 years BP in the Pınarbaşı basin and its surrounding mountains exhibited a treeless landscape, with sparse occurrences of trees, mainly *Cedrus*, possibly indicating a more favorable habitat further south towards the Mediterranean Sea. The prevalence of Compositae pollen hindered the identification of herb composition in the prevailing steppe. Towards the latter part, a shift from desert-type to steppe climate occurred, marked by an increase in *Artemisia* and *Chenopodiaceae* at the expense of other herb types. Despite a lack of precise dating, the pollen record suggests a transition from extreme Pleniglacial conditions to a milder climate.

Following this a period of approximately 3000-5000 years BP saw the transformation from steppe to dense coniferous forest dominated by pine, with some cedar presence. This transition coincides with a hiatus in the pollen record, indicating sediment deposition in a winter-dominated lake environment. Zone 2, spanning around 7500-8000 years BP, is characterized by high *Pinus* percentages, differing from nearby zones.

Zone 3 witnesses a decline in pine forest cover, giving way to open vegetation with increased presence of *Artemisia*, *Chenopodiaceae*, and *Compositae*. Cedar remains prominent, particularly towards the zone's end. The transition is marked by increased NAP values, indicating a shift towards more open vegetation akin to zone 1 but with a higher prevalence of *Compositae* species. Subzone 3b sees a decline in cedar pollen coinciding with the rise of *Pinus*, potentially linked to human activities like agriculture and woodcutting.

Zone 4 introduces deciduous and evergreen species, indicative of a significant ecological shift. Human impact, including agriculture and deforestation, is evident through pollen types suggesting farming and grazing activities.

The subsequent development of a pine/juniper forest in subzone 4b reflects further environmental changes, with species like *Pistacia*, *Olea*, and *Fraxinus ornus* disappearing. The interplay between climate and human activity becomes apparent, with indications of forest clearing, grazing, and marsh development coinciding with human settlement.

The introduction of Mediterranean elements into the region, such as olive cultivation, suggests shifts in climatic conditions or human intervention. The disappearance of certain tree species like *Olea* raises questions about past land-use practices and climate variability. The transition from pine-dominated to oak-dominated landscapes around 3000 BP may reflect climatic shifts or human influence, with oak forests replacing pine forests due to regeneration capabilities and potentially lighter grazing pressure.

The subsequent resurgence of pine forests around 1400 BP, accompanied by the consolidation of juniper species, highlights the dynamic nature of vegetation patterns influenced by both climatic and anthropogenic factors.

3.1.2 Gölhisar

The initial investigation of Gölhisar by Bottema and Woldring (1984) analyzed the pollen layers of a 2-meter lake-margin core. Although lacking radiocarbon dates, the core showed elevated levels of *Artemisia* and Chenopodiaceae in the lower sections, implying a Late-Glacial steppe-like environment. It also revealed the onset of intensive land use, characterized by fruit cultivation (olives, manna, pistachio, walnut), cereal farming, and pastoralism. However, the pollen analysis only covered about 40 cm, leaving a partial record of vegetation changes and missing the end of this period of extensive land use (Figure 3.5).

Bottema and Woldring (1984) emphasized the largely organic composition of Gölhisar's sediments, suggesting the potential for radiocarbon dating. A subsequent study in 1992 aimed to fill this gap. In subzone 1a, Gölhisar exhibited predominantly open vegetation with high *Artemisia* and Chenopodiaceae pollen, indicating steppe-like conditions. The absence of *Ephedra*, which thrives in extremely arid climates, suggested a relatively mild climate. The presence of diverse Compositae pollen indicated a variety of flora during this time.

Subzone 1b showed changes, including an uptick in *Pinus* pollen and a decrease in Compositae types. Chenopodiaceae pollen levels surged, possibly indicating local growth around the lake or in nearby upland steppes. Subzone 2a witnessed a rapid increase in forestation, with evergreen and deciduous oaks, along with *Juniperus*, establishing in the region. The appearance of *Platanus* signaled further diversification in vegetation.

Human influence became evident with farming indicators like high *Cerealia*-type pollen percentages. As pine forests declined, likely due to human activities, gramineous pollen increased significantly. The sediment sequence suggested heightened precipitation, fostering the expansion of certain tree species and forest cover.

Following a period of intense human activity, farming pressure decreased, allowing for slight vegetation recovery. Mediterranean pollen types became dominant, possibly reflecting changes in landscape dynamics. The upper subzone showed ongoing species diversity expansion, indicating continuous environmental shifts and human impacts on Gölhisar.

Another study by Eastwood et al. (1999) offers a more comprehensive insight into the environmental changes and human impacts on vegetation in the region surrounding the Gölhisar Lake in southwest Turkey over a period of approximately 9500 years. Sediment cores were collected from two locations at Gölhisar Lake. One set, GHA and GHB, was taken 5 meters apart from exposed mud along the southern shore, while another set, GHC, and D, was obtained from peat deposits between the "rock island" and the limestone hills on the northern edge of the lake (Figure 3.5). GHA ve GHB are matched through magnetic susceptibility and lithology of the core and the summary diagram presented in Figure 3.6.

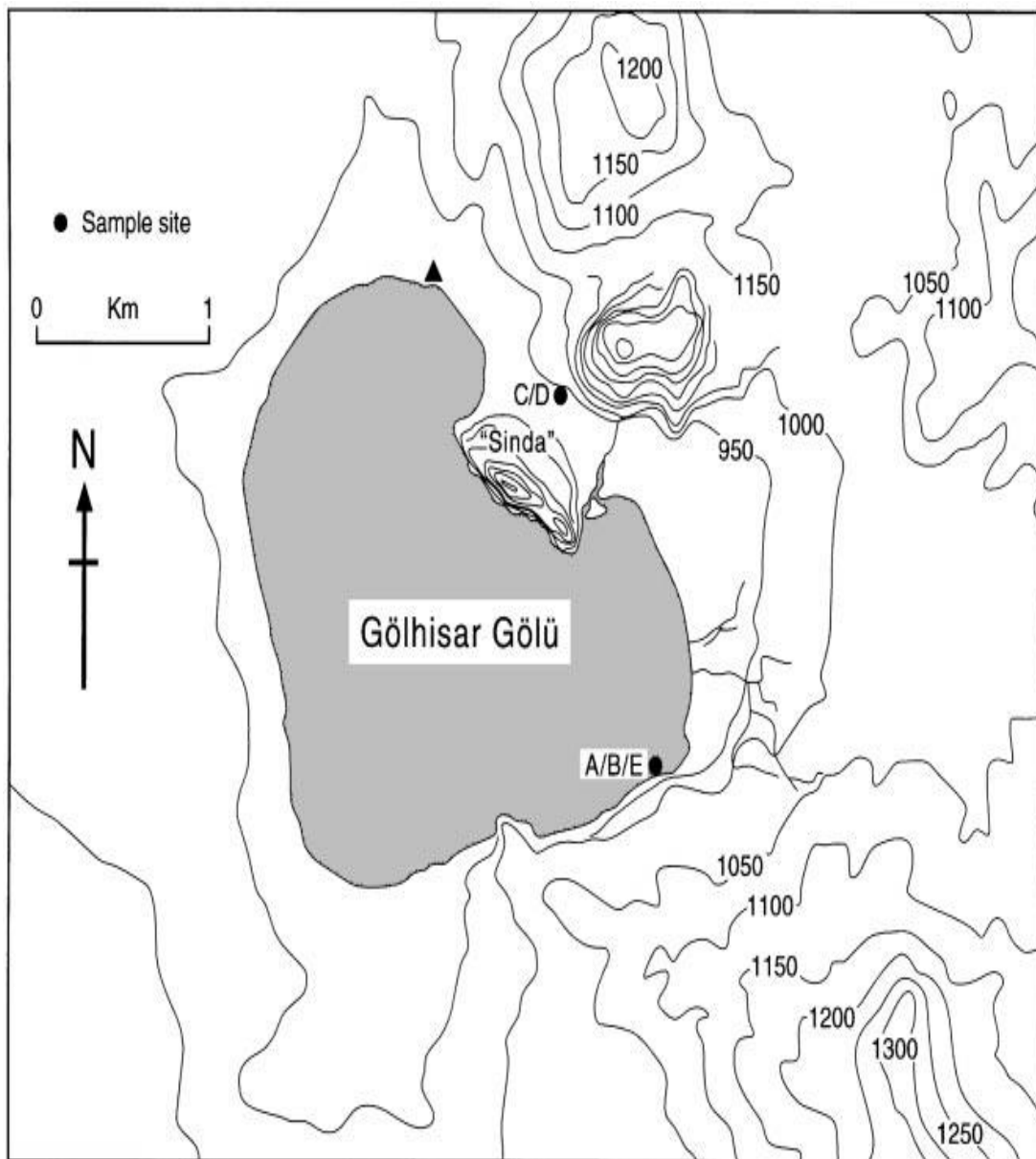


Figure 3. 5: Coring locations in Gölhisar (from Bottema and Woldring 1984).

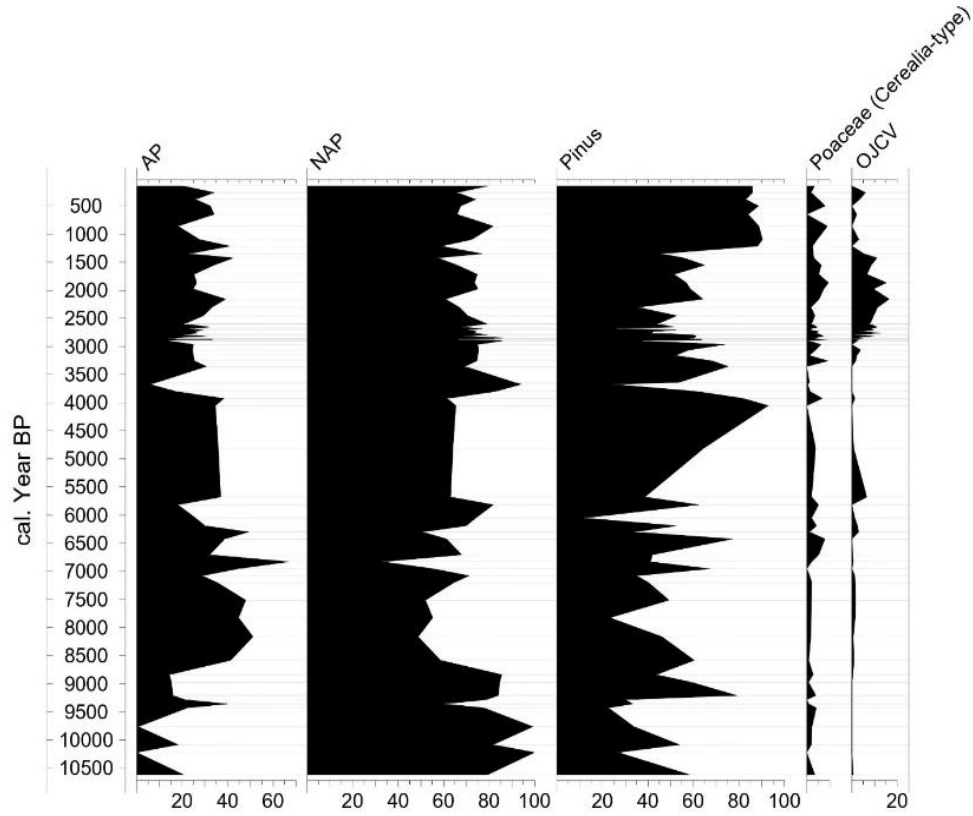


Figure 3. 6 : Gölhisar (GHA and GHB cores combined) summary pollen diagram with a focus on *Olea*, *Juglans*, *Castanea*, *Vitis* sp. given as OJCV (Data: Eastwood et al., 1999).

The methodology employed primarily focuses on the examination of pollen data, diatom analysis, and sedimentation patterns to reconstruct past vegetation and lake productivity dynamics. While this study acknowledges the influence of both natural and anthropogenic factors, including climate variability and human activities such as forest clearance and agriculture, it particularly emphasizes the significance of archaeological evidence, especially the Beyşehir Occupation phase, in understanding the landscape transformations.

The pollen spectra revealed a transition from an open landscape to a mixed forest dominated by oak, pine, and juniper around 8500 BP, indicative of climatic conditions favorable for forest development. However, a significant shift in vegetation composition occurred around 3000 BP, corresponding to the onset of the BO phase characterized by human occupation. This phase marked the clearance of forests for agriculture, cultivation of fruit trees, cereal farming, and pastoralism, as evidenced by the presence of pollen types associated with cultivated plants such as *Olea*, *Juglans*, and *Castanea*. The BO phase brought about notable changes in vegetation, including

the decline of certain arboreal species and the dominance of pine forests, indicating a human-induced alteration of the landscape.

The sedimentation patterns observed in the lake cores provide further insights into environmental changes. Variations in lithologies suggest fluctuating water levels, with silty marls deposited during periods of higher lake levels and peat layers formed during lower lake levels, indicating dynamic hydrological conditions. The deposition of volcanic ash or tephra layers, particularly the Santorini tephra layer, serves as a crucial marker horizon for correlating pollen sequences and understanding chronological contexts. Changes in sedimentation above the tephra layer indicate shifts in lake productivity and catchment processes, possibly influenced by anthropogenic activities and climatic perturbations.

This study also discusses the timing and magnitude of early Holocene vegetation changes, emphasizing the establishment of pine-dominated forests around 8500 BP. While the initial increase in tree cover might be attributed to climatic factors, the subsequent dominance of pine forests suggests the influence of long-distance pollen transport and human activities. Furthermore, this study highlights regional variations in forest composition during the early to mid-Holocene period, reflecting localized environmental conditions and human interactions.

In the later Holocene, the BO phase represents a significant anthropogenic impact on the landscape, characterized by forest clearance, agricultural expansion, and subsequent woodland regeneration. The pollen data indicated fluctuations in forest composition, with pine regaining dominance following human-induced deforestation. The gradual transition from forest clearance to abandonment and woodland regeneration underscores the complex interactions between human activities and environmental dynamics over millennia.

Overall, this study underscores the importance of multidisciplinary approaches, integrating archaeological, palynological, and sedimentological data, to reconstruct past environmental changes and human impacts accurately. By elucidating the complex interplay between natural processes and anthropogenic activities, this study contributes to our understanding of long-term landscape evolution in montane southwestern Turkey.

3.1.3 Gravgaz

In the study by Vermoere et al. (2002), three pollen sequences in the Sagalassos region are correlated with each other, and a brief comparison is made between the pollen diagrams of Gravgaz and Çanaklı with other Southwest Turkey pollen diagrams. It is noted that high-resolution pollen analysis of Gravgaz cores enabled and the nature of sediments (good preservation of plant material) allowed for AMS radiocarbon dating. A summary pollen diagram published by the authors is provided in Figure 3.8. As the data is not publicly available, this figure is based upon the authors' diagram in Vermoere et al., (2002).

The rapid accumulation of sediments in the Gravgaz wetland is indicated by radiocarbon chronology: it is stated that the base of the core (at a depth of 8 m) is not older than 2600 BP. Additionally, when compared with the Gravgaz pollen diagram, it is assumed that the base of the Çanaklı core extends to about 2400 BP. Overall, the start and end dates of pollen community zones in the two Gravgaz cores are generally quite compatible with each other, but this is not always the case. It is noted that the end date of pollen community zone G2-B is not certain. In this landscape study, it is mentioned that the high percentage of olive pollen grains indicates that olive trees were cultivated in the Gravgaz valley in ancient times. In other pollen sequences in Southwest Turkey, it is stated that especially after the beginning of the Beyşehir Occupation Period, the percentage of *Artemisia* pollen increased. It is precisely known from the high-resolution data obtained from Gravgaz cores that fruit trees were not cultivated during this period (G1). It is difficult to determine whether agriculture played an important role during that time. The evolution of local pollen curves in Gravgaz cores indicates a sudden increase in water level around c. 2500 BP. It is stated that there is evidence of human impact, which could be interpreted as "disturbance," in both Gravgaz and Çanaklı cores, indicating a disturbed landscape. In the Gravgaz and Çanaklı cores, the Beyşehir Occupation Period is characterized by the emergence of trees, especially olive trees. This intensive agricultural period starts much later in the Gravgaz cores when compared to other cores in Southwest Turkey. The Beyşehir Occupation Period in the Gravgaz and Çanaklı cores can be perfectly correlated with other pollen sequences in Gravgaz and Çanaklı and is consistent with archaeological data. Finally, following the G3 and C3 zones (Beyşehir Occupation Phase) in the pollen sequences, there comes a phase dominated by *Pinus* pollen. An increase in pine

pollen percentage is evident in Gravgaz cores during this period compared to other cores in Southwest Turkey. The increase in *Pinus* pollen percentage is thought to be due to overgrazing and degradation of the region. In conclusion, the cores from the Gravgaz wetland offer a unique opportunity to examine the evolution of vegetation and the impact of human pressure in the late Holocene period in detail. Human pressure appears to have begun around c. 2530 BP/c. 2480 BP and is stated to have had a significant impact on the landscape. With the high-resolution data obtained from Gravgaz cores, it is noted that the role of agriculture during this period (G1) is not clear. It is stated that the Beyşehir Occupation Phase, as recorded in the Gravgaz and Çanaklı cores, is perfectly consistent with archaeological data. The uppermost pollen-assemblage zones in Gravgaz and Çanaklı cores correspond to the abandonment of Sagalassos and the decrease in population in the region.

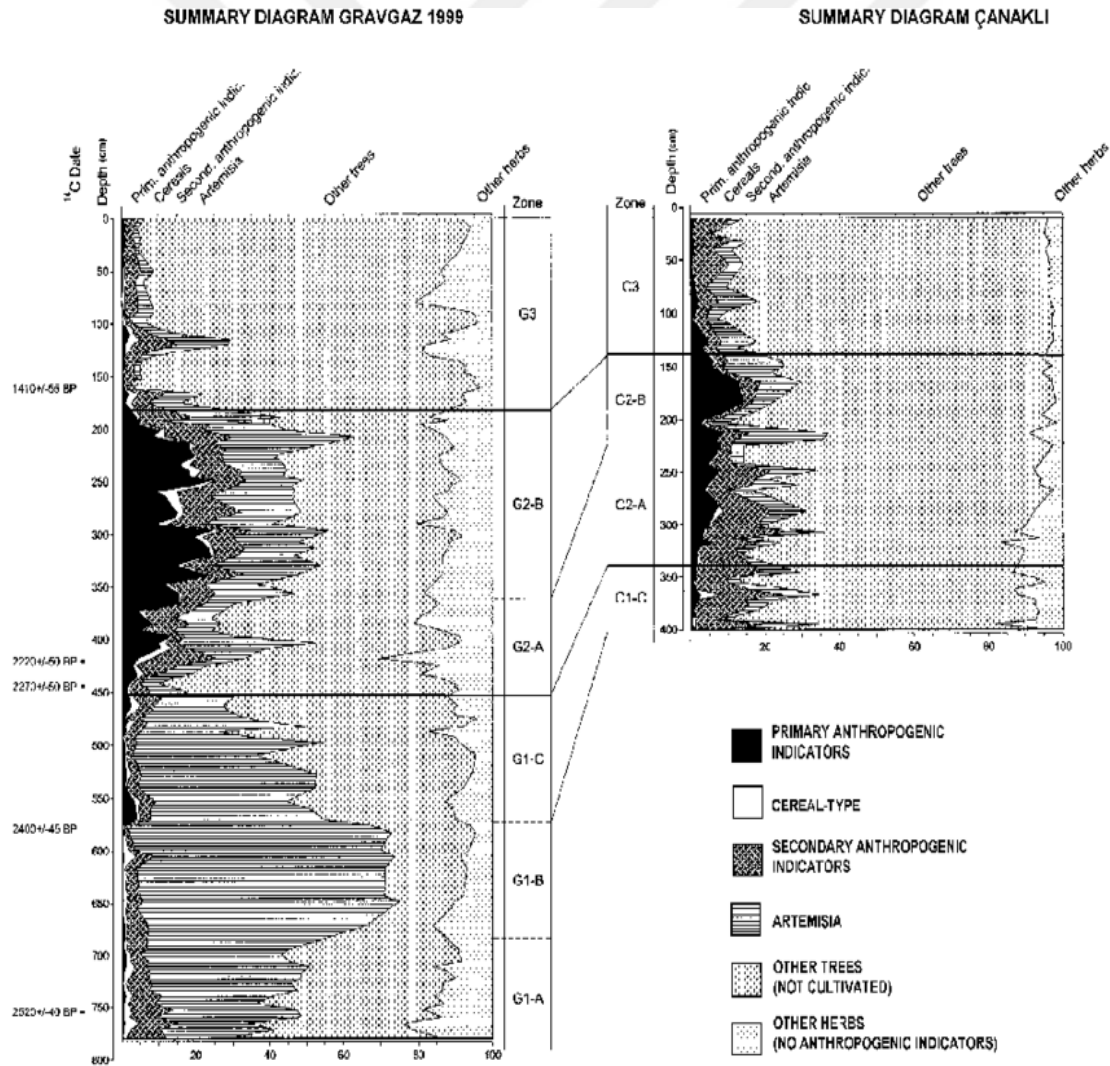


Figure 3. 7: Summary pollen diagrams of Gravgaz and Çanaklı cores (from Vermoere et al., 2002).

Another study at Gravgaz by Bakker et al. (2012) presents findings from their study on pollen data obtained from Gravgaz marsh focused more on the last 2000 years of the region. They uncover correlations between these vegetation shifts and climate changes in Europe, such as dry periods aligning with Europe's early Middle Ages (640-940 AD) and wetter phases corresponding to the Medieval Climate Anomaly (940-1280 AD). As the data is not publicly available, the summary pollen diagram below is based upon the authors' diagram given in Bakker et al., (2012) (Figure 3.9).

The study suggests that during dry periods, like those observed around 1280 AD coinciding with Europe's Little Ice Age, cereal cultivation disappeared until the present day, with human impact in the region largely influenced by climatic fluctuations.

The analysis identifies five significant humid or dry periods, mirroring well-known climate events such as the Medieval Climate Anomaly and the onset of the Little Ice Age. Through this research, insights emerge into the effects of past climate change on both human settlement patterns and vegetation dynamics in the Near East.

Following a period of intensive arboriculture, a dry phase commencing around 650 AD coincided with cold and dry climates in Europe, leading to reduced human activity and an increase in pine forest coverage. Conversely, a wetter phase from 940 to 1280 AD saw heightened human activity during the Medieval Climate Anomaly. Subsequently, a drier phase from 1280 AD onwards coincided with the onset of Europe's Little Ice Age. These climatic fluctuations are believed to profoundly influenced land use patterns and human settlement dynamics in the region.

The current landscape, characterized by juniper woodlands, likely owes its composition to extensive logging activities that occurred in the nineteenth century. These historical deforestation events significantly altered the natural vegetation, paving the way for the dominance of juniper.

Additionally, since the mid-twentieth century, intensified agricultural practices have further transformed the landscape. These agricultural activities, including the expansion of farmland and changes in land use, have had profound impacts on the natural vegetation patterns, contributing to the mosaic of habitats we observe today.

Throughout different climatic periods, the landscape has witnessed various vegetation dynamics. During wetter periods, the region was dominated by meadow-steppe ecosystems and riparian woodlands, which thrived in the more favorable moisture

conditions. These wet phases supported a rich biodiversity and a complex array of plant communities that adapted to the abundant water availability.

Conversely, during drier phases, the landscape was characterized by the prevalence of dryland steppe and maquis vegetation. These vegetation types are well-adapted to arid conditions, with maquis shrublands consisting of hardy, drought-resistant species. Pine forests also flourished during these dry periods, particularly in areas where grazing pressure was low. The reduced grazing allowed pine seedlings to establish and mature, contributing to the spread of pine woodlands.

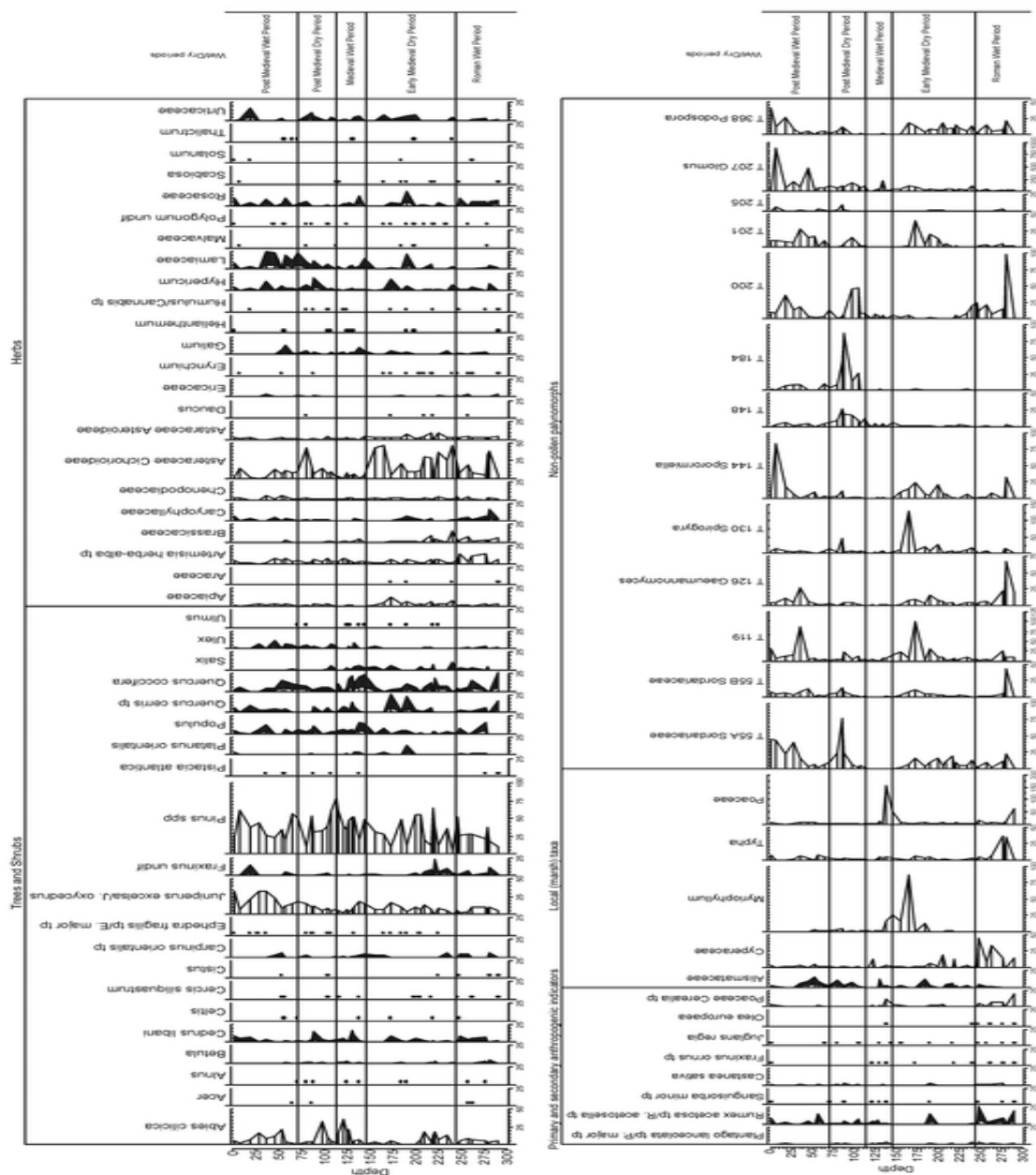


Figure 3. 8 : Summary pollen diagram for Gravgaz (from Bakker et al., 2012).

3.1.4 Bereket

Kaniewski et al. (2007) conducted an extensive investigation into the Late Holocene evolution of vegetation and geomorphology in the Bereket basin, with a particular focus on understanding the profound impact of human activities on the landscape. Through a meticulous examination of chronological, palynological, and sedimentological data, the researchers aimed to reconstruct the intricate changes in vegetation and geomorphic dynamics within a 6.3 km² basin. A summary diagram of this study is presented in Figure 3.10.

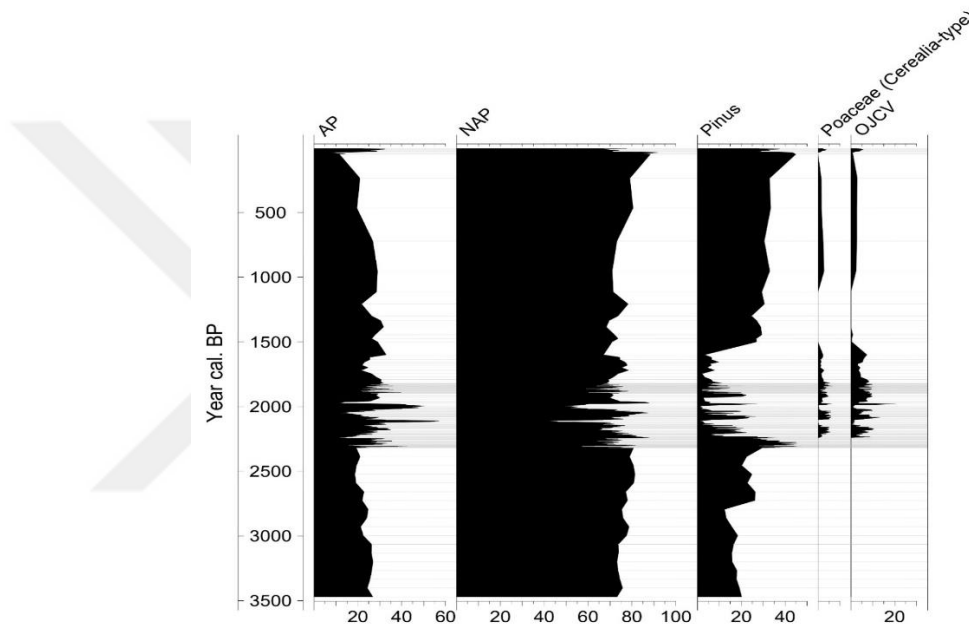


Figure 3.9: Bereket Basin summary pollen diagram with a focus on *Olea*, *Juglans*, *Castanea*, *Vitis* sp. given as OJCV (Data: Kaniewski et al., 2007).

Their findings unveil the extensive influence exerted by humans on vegetation communities since the Late Bronze Age. The evidence points to a landscape profoundly altered by activities such as widespread clearance, intensive grazing, and recurrent fire episodes. One of the most significant revelations of the study is the notable delay of approximately 800 years for the onset of cultivation in the Bereket area compared to nearby well-dated sites.

As early as 1520 BC, signs of human-induced disturbances in the natural ecosystem, including vegetation clearance and soil erosion, became apparent. During this period, the landscape was dominated by meadow-steppe vegetation, indicative of intensive grazing activities. However, around 360 BC, a transition occurred, marked by a surge

in frequent fires, likely employed for land clearance purposes, possibly driven by drier climatic conditions.

The transition from meadow-steppe to human-induced brushland interspersed with xeric steppe vegetation between 360 BC and AD 294 suggests an adaptation to the recurrent fire regime. This period witnesses significant changes in land use practices, with the introduction of olive orchards around 23 BC marking a notable milestone. The establishment of olive orchards during this period corresponds with the onset of the Imperial period, indicating a favorable climate for olive cultivation, potentially supported by warm Mediterranean air masses.

However, post-AD 294, there is a decline in olive pollen, signaling a shift in cultivation practices. This period witnesses the regeneration of deciduous oak and fen tree species, indicating the cessation of intensive cultivation practices. Subsequent periods witness expansions in meadow steppe vegetation due to increased herding activities, alongside minor arboriculture and crop cultivation endeavors.

In the modern era, the landscape undergoes further transformations, with phases of artificial drainage and agricultural development. The study underscores the intricate relationship between human activities and environmental changes over millennia, emphasizing the importance of comprehending past human-environment interactions for effective landscape use strategies.

3.2 Proxy Data

Climate proxies also play a critical role in examining the dynamics of past climates. These techniques are used to understand past climate conditions and to delve deeply into human history. Methods such as isotope analysis help determine past climate changes using data obtained from plant, animal, and human remains. These analyses can determine factors such as temperature, precipitation, and sea level in a specific region. This information contributes to the understanding of significant historical events such as the evolution of agriculture, changes in settlement patterns, and societal changes.

While the studies to be discussed below may not have extensively addressed human-environment interactions, understanding what these data can show, as well as the temporal and spatial resolution they provide, are important factors. Furthermore, it

should be noted that climate proxy data cannot be limited to pollen, isotopes, tree rings, and X-ray fluorescence (XRF) data. However, as the available proxy data regarding the past climate changes in Burdur and its surroundings are interpreted based on isotope and XRF data, only these proxies will be considered.

3.2.1 Stable isotope from lake records

Isotopes are variants of a given element that differ in their neutron count. Among oxygen isotopes, there are O-16, O-17, and O-18, while carbon isotopes include C-12 and C-13. These isotopes behave differently in various physical and chemical processes, making them useful in climate analysis. Researchers use oxygen and carbon isotope analysis to learn about past climates by examining lake sediments and other geological samples. These studies help reveal past temperatures, rainfall, and other climate-related factors (Kendall and Caldwell, 1998).

Oxygen isotopes, especially the ratio of O-18 to O-16, are often used in climate studies. Because O-18 is heavier, it acts differently from O-16 during processes like evaporation and condensation. This is why researchers can use the ratio of these isotopes in lake sediments to understand past weather conditions. Temperature impacts how oxygen isotopes behave. When it is warmer, water evaporates faster, but the heavier O-18 isotope doesn't evaporate as quickly, leading to a higher O-18/O-16 ratio in lake water and sediments. In cooler conditions, the opposite happens, with more O-16 in the mix, reducing the ratio. This is why measuring this ratio helps estimate past temperature changes (Gibson et al., 2016).

Rainfall source and quantity also affect the oxygen isotope ratio. Tropical regions, with high evaporation rates, tend to have a lower O-18/O-16 ratio because the heavier isotopes separate more during evaporation. Changes in rainfall sources or shifts in regional climates can influence these ratios, so studying them helps us understand past rainfall patterns and water sources (Horton et al., 2016).

Carbon isotopes, on the other hand, help us understand biological processes such as organic matter cycles (McGowan et al., 2016). C-12 and C-13 are used by plants in different ways, depending on their photosynthesis strategy. There are three main types of plants: C3, C4, and CAM. C3 plants, common in cooler, moister climates, contain more C-13, while C4 plants, which thrive in hotter, drier climates, have less C-13. By examining carbon isotopes in lake sediments, researchers can determine which types

of plants were common in the past and gain insights into historical climates. Carbon isotopes also reveal information about atmospheric carbon dioxide levels. A higher C-13 level can suggest periods when atmospheric CO₂ dropped or when photosynthetic activity was higher. This makes carbon isotope analysis a useful tool for studying past atmospheric conditions and plant activity (Leng and Marshall, 2004).

Isotope analysis requires careful lab work. Researchers take samples from lake sediments or other geological sources and then use a machine called a mass spectrometer to measure the masses and amounts of different isotopes. They clean the samples, separate the organic matter, and then process them to isolate the isotopes. During this process, they also figure out which layers of sediment correspond to which time periods. Any changes in isotope composition over time can indicate shifts in climate. The mass spectrometer works by ionizing a small sample and then separating isotopes based on their mass. By measuring different isotope ratios, researchers gain insights into past climate changes. This technique helps them understand historical climate variations and environmental conditions, giving them a clearer picture of past temperatures, rainfall, and biological processes (Ghosh and Brand, 2003).

3.2.1.1 Lake Gölhisar stable isotope values

Eastwood et al. (2007) studied a small mountain lake called Gölhisar, located in Gölhisar district in Burdur, to gain insight into Holocene climate changes (Figure 3.11). The study focused on isotopic evidence found in sediment cores from the lake's edge. Researchers collected these cores and analyzed endogenic calcite and mollusk shells (Jones et al., 2006). They used carbon-14 dating and tephra chronologies to establish a reliable timeline, providing a solid framework for examining climate trends throughout the Holocene. They took samples of lake water and nearby source waters to gather isotopic data, which they analyzed with a spectrometer. Specifically, they looked at $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ isotopic values in sediment samples from the GHA core, collected in 1992. These isotopic markers are instrumental in understanding the climatic shifts over time. The results showed that the early Holocene had lower isotopic values, indicating a more humid climate compared to today. This finding aligns with evidence from pollen records, suggesting that the region experienced more rainfall during this period. However, there were some inconsistencies in the data. For example, while the isotopic analysis implied a humid environment, the pollen data

suggested a drier condition. This discrepancy hints at a lag in how vegetation responds to climatic shifts, indicating that it might take time for ecosystems to adjust to changing moisture levels.

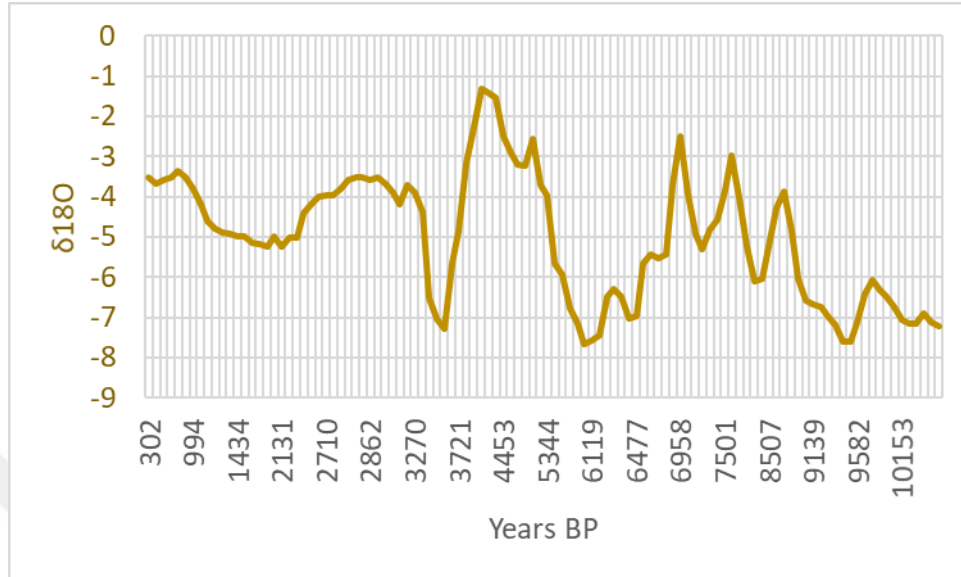


Figure 3. 10 : Gölhisar Oxygen Isotope Values (Data: Roberts et al., 2008).

Although Lake Gölhisar data compiled by Eastwood et al., (2006) and shared by Roberts et al., (2008) provides a generally robust chronology thanks to the inclusion of tephra layers, its temporal resolution from the early Holocene to the present is quite low. This poses a significant obstacle to making valid comparisons with climate models and other proxies. However, as will be discussed later, the fact that other proxies extend back to around 3000 BP was utilized in this study, which examined 4600 years of vegetation change through pollen analysis and aimed to understand past climate with the help of climate models.

3.2.1.2 Lake Nar stable isotope values

Jones et al., (2006) studied Lake Nar, a crater lake in the Cappadocia region of central Turkey, to learn about climate changes over the past 1,700 years. This lake, located at 1,363 meters above sea level, has a simple water system with no rivers flowing in or out. This setup reduces the impact of human activities or other outside factors on the lake's sediment record. The area around the lake has seen minimal human activity during the late Holocene, which helps keep the climate-related signs in the sediments intact. The team collected a 3.76-meter sediment core from the deepest part of Nar Gölü, containing 1,725 layers known as varves. These varves have summer-deposited

calcium carbonate layers and organic layers rich in diatoms, deposited between autumn and spring. The dating of the top 50 cm, using ^{210}Pb and ^{137}Cs , verified that these layers form annually, providing a precise timeline. The rest of the core sequence was dated by counting the varves and then converting that count into calendar years to better understand the climate record.

Through $\delta^{18}\text{O}$ analysis of the sediment core, the researchers developed a detailed record of changes in precipitation and evaporation over time (Figure 3.12). They found significant shifts between dry and wet periods. The dry periods were from AD 300–500 and AD 1400–1950, while the wet periods were from AD 560–750 and AD 1000–1350. These findings align with other climate data and show a link between dry summers in the Eastern Mediterranean and increased monsoon rainfall.

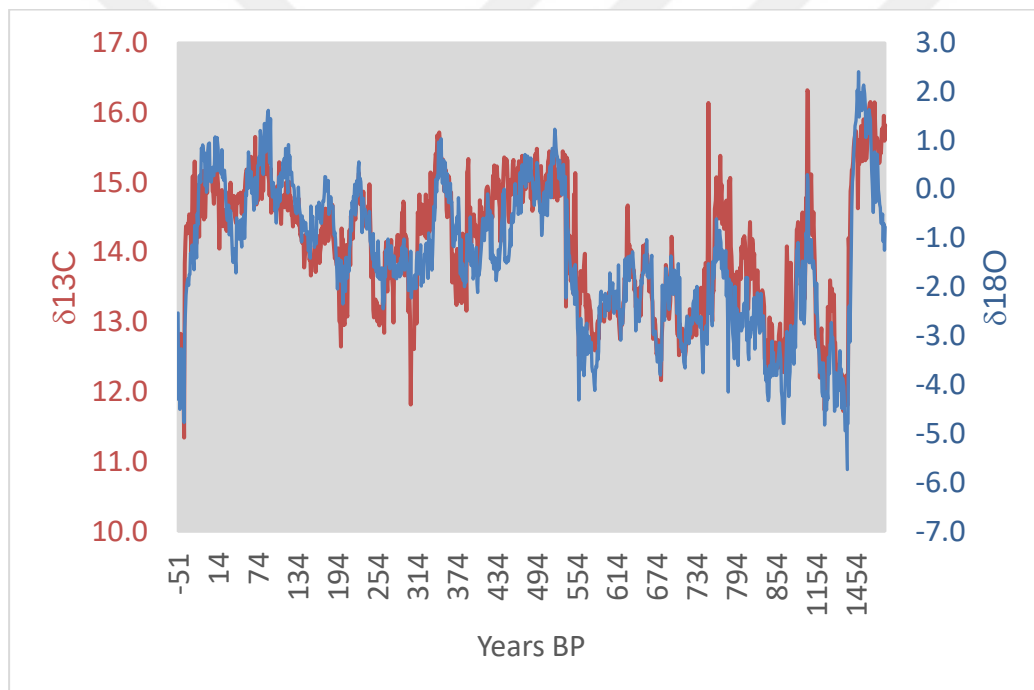


Figure 3. 11 : Lake Nar Oxygen and Carbon Isotope Value (Jones et al., 2006).

3.2.2 Stable isotope from cave records

Cave stalactites and stalagmites give us valuable clues about past climates. Stalactites hang from cave ceilings, while stalagmites grow up from the floor. Both form when water drips from the ceiling, leaving behind minerals. By studying them, researchers can learn about how the climate has changed over time. One key way they do this is by examining the oxygen and carbon isotopes in these formations, which can tell us about past weather patterns (Bar-Matthews et al., 1996; Kaufman, 2003).

Stalactites and stalagmites form because the water that seeps through the cave contains a mineral called calcium carbonate. As the water drips from the ceiling, it loses carbon dioxide, causing calcium carbonate to solidify into stalactites. When the drops hit the ground, the same process creates stalagmites. Because these formations are connected to the water cycle and surface weather, they are useful for studying climate (White, 2019).

One method researchers use to study these formations is oxygen isotope analysis. This involves looking at the ratio between two types of oxygen, O-18 and O-16. The balance between these isotopes changes with temperature and rainfall. In warmer climates, the heavier O-18 isotope tends to stay behind when water evaporates, leading to a higher ratio of O-18 to O-16. In cooler climates, this ratio is lower. By measuring this ratio in stalactites and stalagmites, researchers can get a sense of how temperatures have changed in the past (Lachniet, 2009).

Carbon isotope analysis provides another clue. This method looks at the ratio between two carbon isotopes, C-12 and C-13. These ratios can indicate what kind of vegetation was growing on the surface when the stalactite or stalagmite was forming. Different types of plants thrive in different climates. For example, C3 plants grow in cooler, wetter places, while C4 plants are more common in hotter, drier regions. By examining these ratios, researchers can infer what the environment was like (Baldini et al., 2005).

Studying stalactites and stalagmites is detailed work that requires careful lab analysis. Researchers take samples from these formations and use various methods to date them. They use sophisticated machines like mass spectrometers to measure isotope ratios and trace how they've changed over time. (Erkan et al., 2022).

3.2.2.1 Kocain Cave

Jacobson et al. (2021) conducted research at Kocain Cave, situated in the western Taurus Mountains in southwest Turkey. The cave is 730 meters above sea level. They collected a stalagmite sample (Ko-1) from about 450 meters inside the cave to study the cave's past climate. They used a technique called Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) to measure elements like calcium, magnesium, strontium, and phosphorus. This involved taking 31,503 measurements from the top 156 millimeters of the stalagmite, with each measurement spaced about 5 microns apart. They also analyzed oxygen and carbon isotopes ($\delta^{18}\text{O}$ and $\delta^{13}\text{C}$) by

sampling the first 174.5 millimeters at intervals of 0.5 millimeters or less, producing 370 measurements. The trace-metal concentrations and carbon isotope ratios told them about the cave's water levels, indicating historical climate trends, while oxygen isotope ratios pointed to rainfall patterns. Uranium measurements were used to determine the age of the climate changes. Furthermore, signs of seismic activity that tilted the stalagmite helped set a timeline.

The study found significant climate fluctuations in the past (Figure 3.13). Around 1150 and 800 BCE, conditions were dry. Wetter conditions followed between 330 and 460 CE, but then a rapid shift to drier weather occurred between 460 and 830 CE. During the Medieval Climate Anomaly and the Little Ice Age, the climate alternated between dry and wet periods. Surprisingly, these patterns did not always match those found in other parts of Turkey. Instead, they often resembled records from Greece, Lebanon, and Israel's coastal areas. This inconsistency underlined the varied climate regions in Turkey and suggested that interpreting past climate data, especially in the context of societal impacts, requires careful consideration.

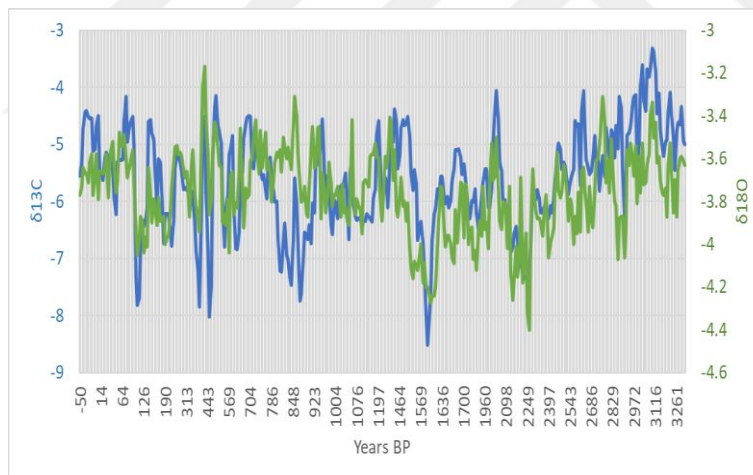


Figure 3. 12 : Kocain Cave Oxygen and Carbon Isotope Value. (Jacobson et al., 2021).

3.2.3 Old World Drought Atlas (OWDA)

Cook et al. (2015) compiled the Old World Drought Atlas (OWDA), a climate database used to study past drought events in certain regions of Europe and Asia. This atlas employs tree-ring data from extensive geographic areas to reveal spatial and temporal patterns of drought throughout history. The OWDA contains maps for each year showing reconstructed data for summer droughts, based on the Palmer Drought Severity Index (scPDSI) (van der Schrier et al., 2013). The maps are based on a grid

of 5,414 points, each half a degree apart in latitude and longitude. These maps are created using tree rings to estimate past climate, and they are tested for accuracy by comparing them with other data from the 20th century that wasn't used in the original calibration. To validate the OWDA, the researchers used data from 1928-1978 for calibration and then checked against 1901-1928 data, confirming the OWDA's accuracy. This database offers a more detailed look at changes in water availability over time compared to earlier records.

To build the OWDA, the researchers used methods that connect different sets of climate data (Figure 3.14). They derived scPDSI data from the Climatic Research Unit Time Series (CRU TS) dataset, which includes monthly temperature and rainfall data from 1901-2012 (Harris et al., 2014). However, there were fewer rainfall monitoring stations in some areas, like Turkey and the Middle East, before 1930, which could affect the OWDA's accuracy for the 1901-1927 validation period. Still, this limitation probably doesn't have a big impact on tree-ring-based reconstructions because the calibration period from 1928-1978 had enough data.

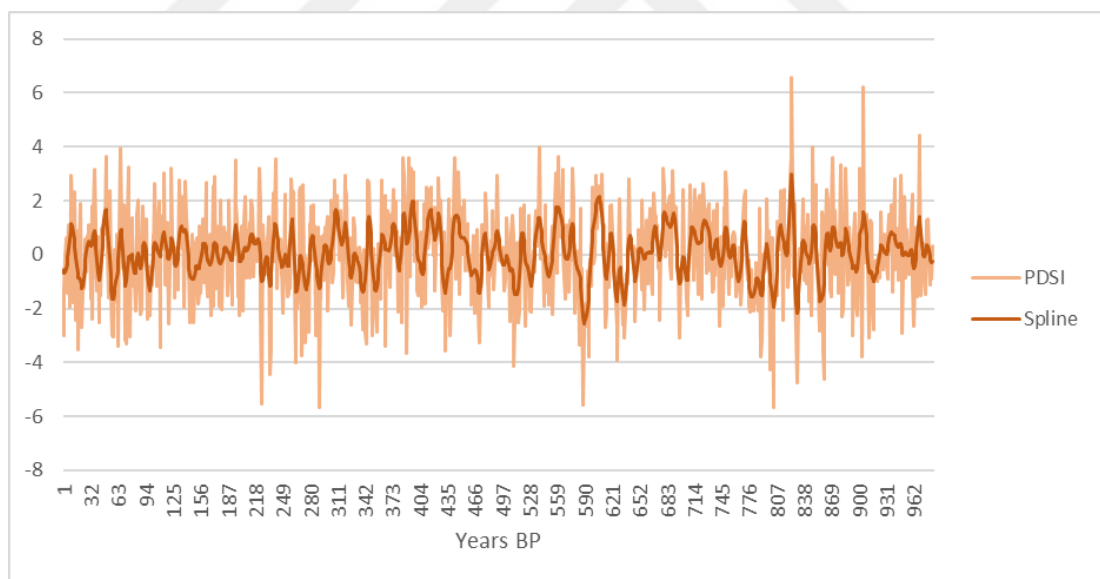


Figure 3. 6 : OWDA-scPDSI Results (Data: Cook et al., 2015) .

On the other hand, Burnette (2021) developed a web application that allows users to access summer (June-August) reconstructions of the self-calibrating Palmer Drought Severity Index (PDSI) on a 0.5° latitude/longitude grid, covering Europe, North Africa, and the Middle East from AD 0 to 2012. These reconstructions are based on

106 tree-ring chronologies, consistent with the methodology used in the Old World Drought Atlas (OWDA).

The web application offers tools for creating maps and time series. Under the "Maps" menu, users can generate visual representations of drought severity across the specified regions for any given year. The "Time Series" menu allows for the creation of longitudinal charts depicting trends in drought over time.



4. MATERIALS AND METHODS

4.1 Field Studies

Within the scope of the İTÜ BAP Project (number MGA-2021-42781), a 146 cm long (BRDR-2) sediment core was drilled using a hand core barrel (Figure 4.1). A sedimentological examination of the cores was carried out in the Sedimentology Laboratory of the ITU-EMCOL Research Center. After the cores were opened, their surfaces were cleaned and smoothed to distinguish the different colours they showed and to better define the sedimentary structures. The lithological characteristics of the sediments observed in the cores were determined by the sedimentological identification-logging process performed along the core. In this way, the type of sediments the core consists of and the sedimentary structure and texture of these sediments are shown. Digital photographs were taken of the cores that were opened and divided into two parts.



Figure 4. 1 : Core drilling with a hand core barrel and field studies in Burdur Lake.

4.2 Chronology

Establishing a ‘true’ chronology in palaeolimnological studies that address sedimentary records and the various reconstructions from these records for geological, archaeological, historical, etc., purposes is extremely challenging. Under normal circumstances, a priori knowledge about sedimentary sequences is derived from the law of superposition. That is, the base of the sediments represents the oldest layer, and the following layers are progressively younger within the sequence (Telford et al., 2004; Rieppel, 2010; Blaauw and Heegaard, 2012).

As one of the fundamental tools in palaeolimnology, sediment cores have chronologies that are frequently constructed merely via radiocarbon dating methods, except for some annually laminated sedimentary sequences where depositional changes are more easily trackable, such as in varved sediments (Telford et al., 2004). Thus, a few known ages from different sequences were utilized to represent the rest of the sequences. However, this approach can be quite optimistic because of a) the complexity of the depositional process and the influence of external factors, b) issues in dating processes and techniques, and c) research-related problems.

First, the deposition process, including that of lakes, is quite complex because of the combination of various geological, meteorological, and ecological events and because physical, chemical, and biological variables are involved in ecosystems, and these variables are quite changeable from one lake or region to another (Forsberg, 1989; Hairston and Fussmann, 2014). These variables may include environmental changes, changes in the composition of the sediments, and nutrient levels for the formation of organisms. Moreover, most of the processes within lake sedimentation operate over long time scales, making it difficult to study and document changes. This is particularly true for older lakes, which might be affected by various factors lasting for thousands of years (Dearing and Jones, 2003). On the other hand, the randomness of the deposition process does not only come from natural factors.

The impact of anthropogenic practices on the ecosystems of lakes can be manifested both in their use of goods, such as fish harvest, or in their use of services, such as water supplies (Erlandson and Rick, 2010). On the other hand, erosion caused by agricultural practices or anthropogenic disturbances in different habitats may also affect ecosystems in lakes, especially in littoral areas (Horne and Goldman, 1994; Mayle and

Iriante, 2014; Quante et al., 2022). Although the impact of these practices on lake ecosystems is evident, it is quite challenging to understand to what extent these practices affect the depositional process in lakes and therefore the sedimentation rate. Considering that human societies have had a salient effect on lake ecosystems, especially since the Neolithic, when settlements became widespread and agricultural and herding practices revealed more complex land use types, human influence should not be neglected because of changes in sediment sequences (Quante et al., 2022). However, although the effects of these practices on ecosystems are often direct, their effects on changes in sedimentation rates are rarely obvious (Hairston and Fussmann, 2002). Situations such as slumps or archaeological site formation processes arising from the combination of natural and anthropogenic factors cause more abrupt changes in deposition (Ramsey, 2007). Among these, the use of water resources that feed lake basins in some archaeological settlements for land development, logging, and even ancient mining can directly influence the sediment transport process into lakes (Butzer, 1982; Schubert et al., 2020; Silva-Sánchez and Armada, 2023).

Another general reason why the sedimentation rate and the chronologies that have been developed accordingly are likely to be problematic is the choice of material to be dated, which dating method is used, and the margin of error in these methods (Blaauw and Heegaard, 2012; Blaauw et al. 2018; Pfalz et al., 2021). As mentioned, one of the most common absolute dating methods used when dating sediment cores is radiocarbon dating. In this process, cores are generally divided into slices, and dating is performed from certain slices (Blaauw and Christen, 2011). However, which material is used and how much material should be used is a critical point.

The development of dating methods today allows the use of much smaller samples and different materials for dating (Hajdas et al., 2021). However, dating various materials is problematic. For example, it has now been suggested that applying dating to pollen-concentrated samples in sediment cores causes the samples to be independent of the reservoir effect, which mixes with different levels of carbon in natural aquatic environments and makes them appear older (Philippsen, 2013; Brown et al., 1989). However, as shown by Kilian et al. (2002) and Neulieb et al. (2016), in some cases, this technique creates a serious difference when compared to the dating of different materials and sometimes provides a much younger dating result. On the other hand, dating applied to bulk sediments also has many problems, such as the possibility of

insufficient organic compounds in the sediment, inhomogeneous compounds, large reservoir offsets, and how well the sediment sample used reflects the true age range of that level (Strunk et al., 2020; Heegard et al., 2005).

The third problem is research-related problems, which is one of the most important reasons why we are inadequate in some cases, especially in finding solutions to the second problem. Research budget constraints are often a salient obstacle to sufficient dating required to make a robust chronology of core sediments more robust (Blaauw and Heegard, 2012; Lacourse and Gajewski, 2020). Moreover, the majority of palaeolimnological inquiries diverge from the anticipated chronology in disciplines such as archaeology or history. Archaeological research inquiries typically do not serve as the primary genesis for such studies, and in certain instances, archaeology assumes a secondary role, leveraging and adopting the findings of these investigations without much scrutiny. Thus, the significance of chronological data can sometimes be downplayed, but as stated by Blaauw and Heegard (2012), “palaeolimnology without chronology is history without dates.”

4.2.1 Modeling the age-depth relationship

Modeling approaches are the fundamental response to the aforementioned problems in understanding the sedimentation history of lakes, which consequently impacts the establishment of a ‘true’ chronology. In age-depth models, the sedimentation rate at the core level is an explanatory variable, whereas age is the response variable. Thus, the observed changes in sedimentation rate are used in constructing ages, and their error envelopes are assigned to that level.

There are many statistical methods and related models for determining the age-depth relationship. In this regard, each model gives very different results, and it is very difficult to understand which model reflects the changes in the real sedimentation rate. However, today, the availability of many user-friendly age-depth models makes a significant contribution to creating publishable quality figures with just a few codes and reaching the mean or median dates assigned to each level and their error envelopes. These tools not only streamline the process but also enhance the precision and accessibility of chronological data. Considering that each model has its strengths and weaknesses, being able to justify which model is used in research and addressing its weaknesses is still insufficient in many studies.

4.2.2 Establishing age-depth relationships in BRDR-2

Following lithological descriptions in the cores, the sediments were aged using the radiocarbon (^{14}C) dating technique. Radiocarbon age determinations were made at the TUBITAK-MAM center via the accelerator mass spectrometry (AMS) method. For this purpose, four pollen samples selected from the cores were prepared for dating analysis. Ages were calculated in the OxCal program after ^{13}C correction and calibrated to give ^{14}C years before the present (year BP; BP) (Table 4.1). Through radiocarbon (^{14}C) dating analyses of the cores, information was obtained about the chronological sequences of different sedimentary units within the ^{14}C analysis limits (between 40 thousand years B.C. and 1950 years ago); thus, precise chronostratigraphic studies of the core sediments were carried out. Age results were calibrated to the calendar year using the Calib program (Stuiver and Reimer, 2020).

Table 4.1 : Calibrated radiocarbon ages of the BRDR-2 core taken from Lake Burdur.

Depth (cm)	Lab No	Sample	Ages uncalibrated
70-72	TÜBİTAK-1971	Pollen	1436±34
99-101	TÜBİTAK-1972	Pollen	1997±25
120-123	TÜBİTAK-2257	Pollen	2834±28
140-142	TÜBİTAK-2258	Pollen	4077±24

While discussing the age-depth relationship of the BRDR-2 core, 4 different modeling strategies were applied and comparatively discussed, taking into account the chronological problem arising from the complex relationship in the aforementioned sedimentation history.

There are many models available for reconstructing in-depth relationships. Commonly applied methods include linear interpolation, splines, and linear regression models, as mentioned by Bennett. There are also other approaches, such as Bézier curves, mixed-effect models, and fuzzy regression, as proposed by Enters et al. (2006). However, these diverse techniques often yield markedly different outcomes (Bennett, 1994; Bennett and Fuller, 2002). They produce variable outputs not only for estimating age at specific depths but also for assessing the certainty surrounding those estimates,

which are given as error estimates. Ultimately, determining the most accurate representation of reality among these approaches remains a formidable challenge (Telford et al., 2003).

Currently, the most commonly used methods are linear interpolation, cubic spline, and Bayesian methods. The first approach, which is the most commonly used method, creates chronologies in many datasets. In linear interpolation, the age range given by the dated levels is assumed to be correct, and the sedimentation rate between dates is taken as constant. Therefore, the change in the accumulation rate occurs only at dated depths (Blaauw, 2010; Blaauw and Heegaard, 2012). However, the depth at which radiocarbon dating will be performed is haphazard, and the sedimentation rate estimate changes with each additional date, which is a very optimistic approach in that it provides a "true age" (Bennett and Fuller, 2002). However, since radiocarbon dating results generally include one sigma margin of error, interpolation should not be performed based on the laboratory mean results. Therefore, when performing linear interpolation in the BRDR-2 core, the interpolation method presented in the CLAM (Classical Age-Depth Modelling of Cores from Deposits) R Script (Blaauw and Christen, 2011) is used (Figure 4.2). Unlike traditional linear interpolation, CLAM, the selected calibration first calibrates the existing ages with the method and simulates values by randomly selecting calendar ages from a calibrated distribution. In this process, the likelihood of a calendar age being chosen is directly linked to how probable it is within the scale of the distribution, which is sometimes given as Monte Carlo sampling.

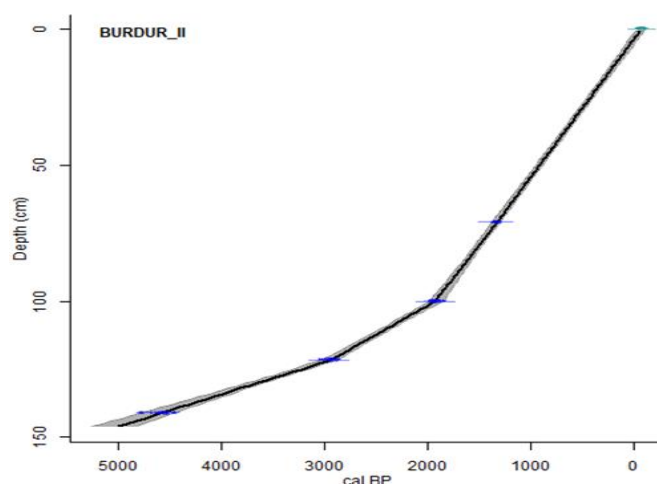


Figure 4. 2 : CLAM Linear Interpolation Results.

On the other hand, cubic spline is made using CLAM's Monte Carlo sampling method. The calibrated distribution of dates is sampled repeatedly to determine the age-depth for each model, and the data are treated as the "best age" and margins of error (Blaauw and Christen, 2011). However, unlike linear interpolation, the uncertainties between dated levels are relatively constant because, unlike linear interpolation, the sedimentation rate between dated levels has a variable structure. The greatest limitation of this method is that if the value-dated level results are irregular, it can give very elbowy results and sometimes lead to results that can return over time as the depth of the data increases. Therefore, it is more reasonable to use this method in cases where the dating frequency is high and the distribution is more regular (Blaauw and Heegaard, 2012; Trachsel and Telford, 2017; Lacourse and Gajewski, 2020). Although the calibrated cubic spline result of BRDR-2 core dating results is quite effective in that it does not leave the change in sedimentation rate constant between dated levels compared to linear interpolation, the rather narrow error envelope it offers, especially between datings, may be far from reality (Figure 4.3).

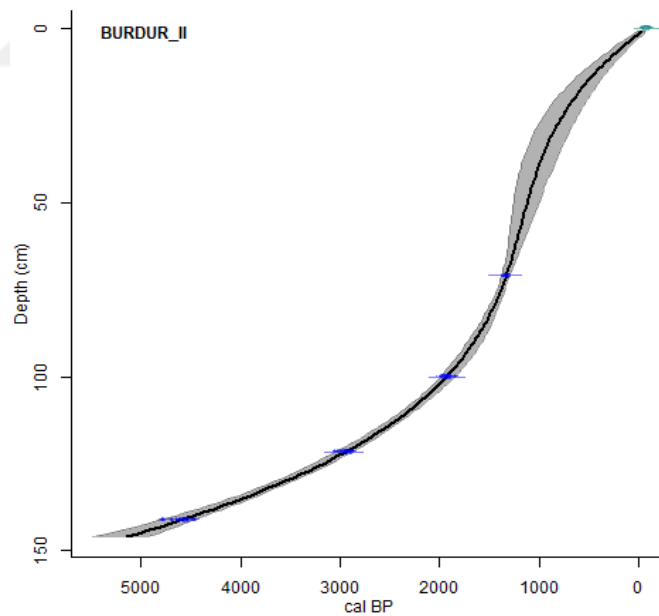


Figure 4. 3 : CLAM Cubic Spline Result.

Bayesian approaches differ from linear interpolation and cubic spline methods in a salient sense. They offer several advantages when used in age-depth models. First, it allows prior information to be included in the model. This allows existing knowledge

or beliefs to be integrated into the model to provide a more comprehensive perspective. This is of great benefit, especially if there is prior understanding or data on the relationship between age and depth. Second, Bayesian methods are very effective in dealing with uncertainty. This allows us to better understand the variability in results by expressing uncertainty in model parameters as well as uncertainty in predicted ages. Finally, Bayesian methods naturally handle dependencies between parameters. This helps create more robust and accurate models by taking into account the dependencies between age-depth relationships and other variables (Goring et al., 2012; Trachsel and Telford, 2017; Parnell et al., 2018).

One of the most widely used models in which the Bayesian approach is presented is Bacon (Blaauw and Christen, 2011). This model, which is also applied to the BRDR-2 core (Figure 4.4), uses prior distributions that suggest existing age ranges and mean sedimentation rates if we do not have prior information about the core. When the accumulation rate follows a gamma distribution, the autocorrelation of the simulation between the segments, which is called "memory", follows a beta distribution (Blaauw and Christen, 2011; Blaauw et al., 2018). In this regard, before running the model, it is necessary to give the accumulation rate mean with how many segments the core will be run with, and the "memory mean" should be given in terms of how the distribution of the simulation in the previous segments will be (Blaauw and Christen, 2011; Pfalz et al., 2022).

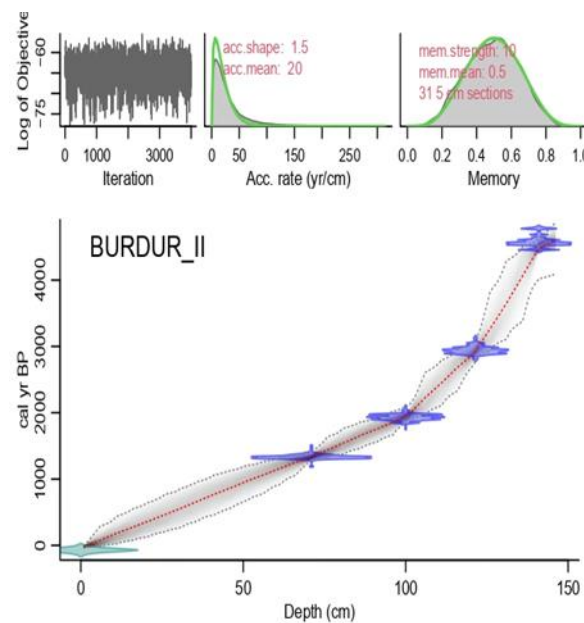


Figure 4. 4 : Bacon Age-Depth Model Results.

By simulating the distributions given as input with the Markov chain Monte Carlo method, the model converges to the distribution we want to sample and produces consecutive samples. Each sample is interdependent and obtained from the previous state, and the state of the chain represents the sample distribution (Blaauw and Heegaard, 2012; Trachsel and Telford, 2017; Lacourse and Gajewski, 2020).

4.2.3 The impact of model choice on chronology

It is not surprising that different statistical approaches to each age-depth relationship yield different results. In this case, the following question arises: which model should be used in fields that work with sediment records, such as palaeopalynology? It is quite difficult to answer this question. However, dating frequency is a very problematic situation for most studies, and in the absence of frequent dating, it is more reasonable to use models with more robust error estimates. For example, a study by Blaauw et al. (2018) suggested that the majority of late Quaternary cores in the Neotoma Database contain very limited radiocarbon, with an average of only 0.72 dates per millennium (1 date for every 1400 years). In this study, where they measured the performance of classical and Bayesian models, they concluded that Bayesian models should be preferred over traditional models in terms of their reconstructions and error estimates, including low-to-average dating frequency. Frequent dating and each additional date in the cores begin to affect the models more and gradually approach the classical models in terms of the "mean age" and confidence interval it offers. However, in cores with frequent dating intervals, the fact that the ages do not progress in a linear order and have a more irregular structure makes Bayesian approaches superior.

As mentioned above, the choice of model affects both the "mean" (sometimes given as "best") ages used in the diagrams to a significant degree. It is difficult to explain straightforwardly how much of this effect there is and is context dependent. In this regard, how the age-depth relationship of the BRDR-2 core changes with model selection should be examined.

As shown in Figure 4.5, the comparison of the results of various age-depth models is highly variable. In particular, the mean age offered by Bacon is quite distinct. The reason for this is that the MCMC simulations performed by Bacon remember every sampling in terms of memory, and the places where these are repeated the most often are close to the interpolated values. This situation is similar in most core drillings down

to the depth where the first date is made. On the other hand, the cubic spline method, which is used when there are nonlinear relationships between data points or when the dataset is measured at irregular intervals, provides a sedimentation accumulation that is very slow at first and accelerates over time until the first dated depth. The estimates up to the first dated depth likely gave a very erroneous mean age, as the known age of approximately 70 cm was not known and was assumed to be the date when the top part of the core was drilled. In this case, using Bacon as a more robust approach may be preferred in terms of intersecting error estimates with the mean values of the other models. However, the real differentiation begins with the shortening of the depth between two different dates.

Here, a different chronology reconstructed by Bacon differs from interpolated estimates by 800 years in almost 25 cm of the core and six years by Cubic Spline (Figure 4.5). Although the error envelope offered by Bacon approaches the estimates of the models in some cases, this shows that there is a difference that should be taken into account. Therefore, the following pages cover the fossil pollen results of the study, and the results of the Bacon model together with error envelopes will be considered the “best” chronological reconstruction.

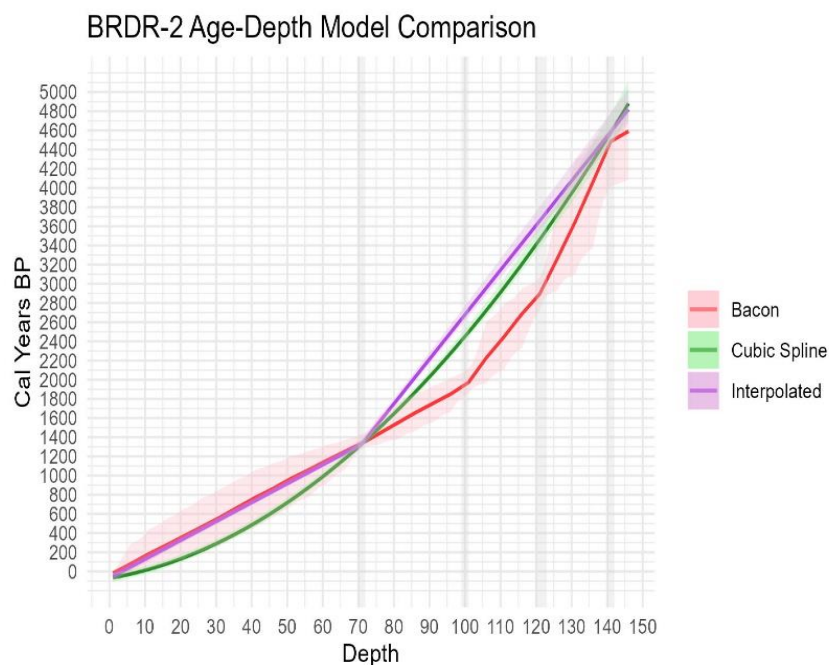


Figure 4. 5 : Model Outputs of BRDR-2 Ages. Solid lines represent the “mean” ages, shaded areas indicate error estimates and four shaded dark gray depth bars indicate dated levels. The top of the core was assumed as the year (± 25 years) core taken as suggested by Giesecke et al., (2014).

4.3 Pollen Analysis

Once lithological features were identified through macroscale observations, we collected sediment samples from core BRDR-2, which had a length of approximately 146 cm. These samples, approximately 20 grams each, were obtained at 5 cm intervals. We followed the standard pollen extraction method (Cour, 1974) to prepare these samples. The preparation process involved the addition of 33% HCl acid to remove carbonate and 70% HF acid to eliminate silica (Figure 4.6 and 4.7). Subsequently, we added a ZnCl₂ solution with a density greater than 2.0 to separate the palynomorphs. The remaining sediment sample was sieved through 200 µm and 10 µm sieves using an ultrasound bath. Microscopic sections of the sediment samples that remained on the sieves were created by applying glycerin to glass slides and covering them with cover slides. Pollen slides were analysed via transmission microscopy at the Microscope Laboratory of the Eurasia Institute of Earth Sciences, Istanbul Technical University. The analysis utilized immersion oil with different objectives, specifically, x63 and x100. For each sample, we performed pollen counts ranging from 300 to 500, with the exception of *Pinus*. Pine trees, known for their prolific pollen production and easy dispersal through both water and air, were excluded from the total pollen count due to their abundance in the samples. Pollen atlases (Reille, 1999) and pollen photographs were used for counting and identification. The findings are presented in comprehensive pollen diagrams generated using the TiliaIT program (version 2.0.41; Grimm, 1991-2015). To identify pollen zones, the TiliaIT program included CONISS (constrained incremental sum-of-squares cluster analysis) analysis, taking into consideration changes in pollen species.

Furthermore, To analyze the palynological data from Lake Burdur, a customized local pollen catalog was meticulously prepared. This catalog included palynomorph plates displaying characteristic taxa identified in the assemblage, detailed in Figures 4.8 and 4.9. It defined 74 genera and species, offering an extensive reference for categorizing pollen samples. The botanical classification involved examining the morphological characteristics of the pollen grains and comparing them with modern species from the same families. This rigorous process required extensive cross-referencing with botanical literature and modern pollen databases, significantly enhancing the precision and reliability of the analysis. This catalog provided critical insights into the historical

vegetation and climate conditions of the region, contributing to broader research in paleoecology and environmental archaeology.



Figure 4. 6 : Chemical treatment of the sediments for palynological slides.



Figure 4. 7 : Chemical treatment of the sediments for palynological slides (continued).



Figure 4. 8 : Pollen photos for Lake Burdur. Numbers are 1-2. *Amaranthaceae*; 3. *Asteraceae-Asteroideae*; 4. *Carpinus orientalis*; 5-6. *Caryophyllaceae*; 7-8. *Cedrus libani*; 9-10. *Centaurea cynaus*; 11-12. *Centarurea solstitialis*; 13-14. *Asteraceae-Cichorioidea* 15-17. deciduous *Quercus*; 18-19. *Fraxinus*; 20-22. *Juglans*; 23-24. *Juniperus*; 25-27. *Liquidambar orientalis*; 28-30. *Olea europaea*.

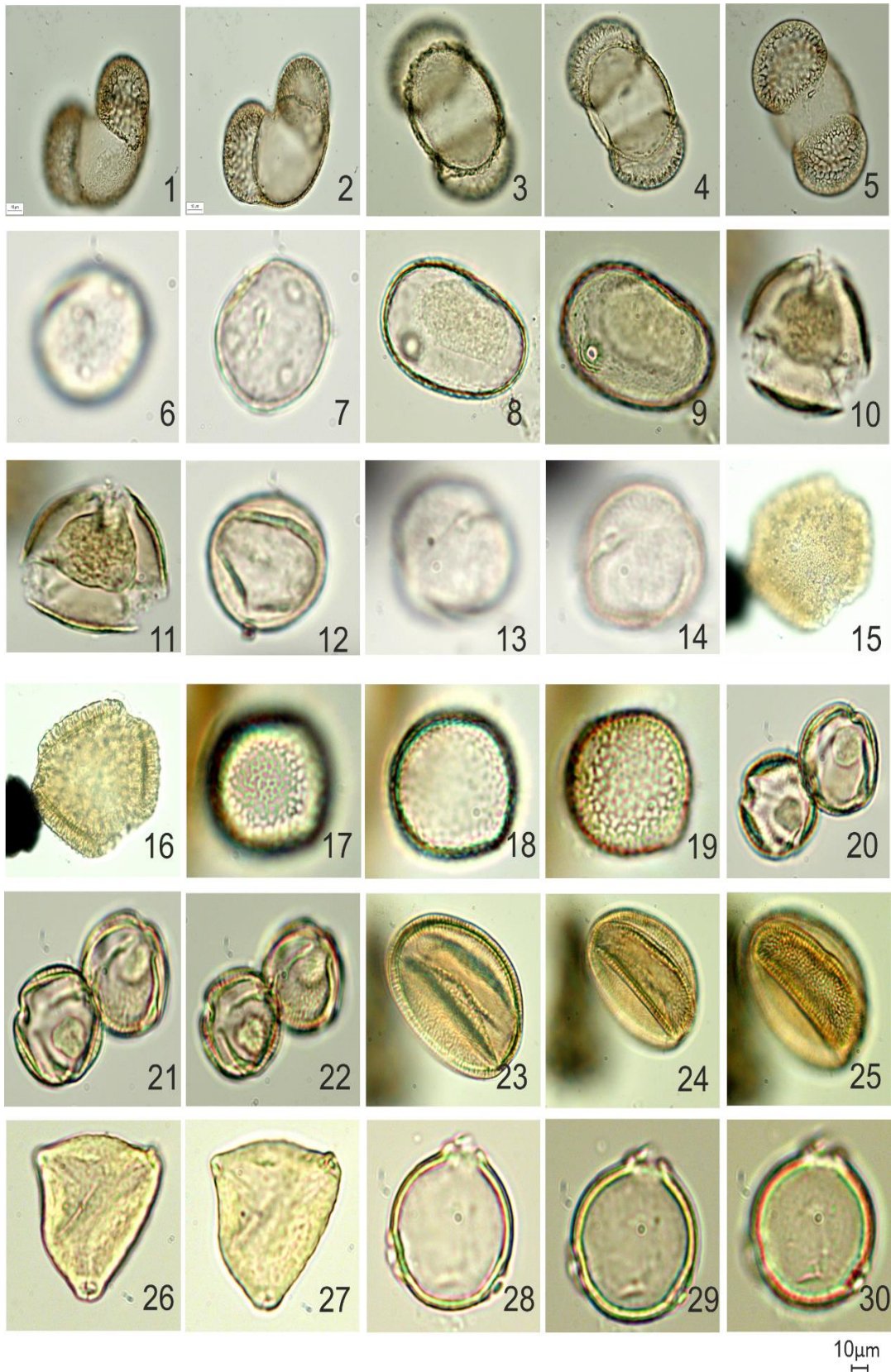


Figure 4.9 : Pollen photos for Lake Burdur. Numbers are 1-2. *Pinus brutia*; 3-5. *Pinus nigra*; 6-7. *Plantago*; 8-9. Poaceae; 10-11. *Prunus*; 12. *Quercus ilex*; 13-14. *Rumex acetosella*; 15-16. *Scabiosa*; 17-19. *Sparganium*; 20-22. *Vitis vinifera*; 23-25. *Convolvulus*; 26-27. *Elaeagnus*; 28-30. *Sanguisorba minor* – type.

4.4 Palaeoclimatic changes around Lake Burdur

4.4.1 CHELSA-TraCE21k

The CHELSA-TraCE21k dataset marks a significant milestone in the realm of high-resolution climate modeling, representing a breakthrough that offers researchers an unparalleled resource for exploring a myriad of environmental science applications (Karger et al., 2021). At its core, this dataset leverages the sophisticated CHELSA V1.2 algorithm to scale TraCE-21k data, thereby providing an extensive archive of global monthly climate records for temperature and precipitation spanning a staggering 21,000 years (Karger and Zimmermann, 2021). What sets this dataset apart is its exceptional spatial resolution, which is finely detailed at 30 arcseconds and allows for nuanced analyses and insights into climate dynamics across diverse spatial scales.

The process of creating this dataset involves a meticulously crafted methodology, encompassing intricate steps such as reconstructing palaeo-orography at a granular level for each temporal increment (Karger et al., 2023). This reconstruction effort integrates a wealth of data sources, including comprehensive glacier databases spanning from prehistoric times to the Last Glacial Maximum, augmented by sophisticated glacial isostatic adjustment models such as ICE-6G_C (Peltier et al., 2015). Additionally, the incorporation of average annual temperature data from TraCE21k added another layer of refinement to the dataset, facilitating a holistic understanding of past climatic conditions.

Furthermore, the validation process for this dataset is rigorous and multifaceted. It entails meticulous comparisons with historical climate datasets to ensure accuracy and reliability. Expert constraints on glacier boundaries provide additional validation layers, corroborating the fidelity of the reconstructed climate records. Proxy data derived from Greenland ice cores serve as invaluable benchmarks, offering insights into past climatic variations and corroborating the dataset's fidelity. Moreover, simulations of species distributions further validate the dataset's utility, offering a tangible link between past climate dynamics and ecological responses. This connection is supported by the work of Karger et al. (2023) and Buizert et al. (2014), highlighting the dataset's relevance in ecological studies.

The significance of high-resolution climate data transcends mere academic interest; it underpins our understanding of past climate variations and their profound implications for contemporary ecosystems and human societies. Traditional numerical global circulation models (GCMs), while valuable, often lack the spatial granularity required to capture the intricacies of ecological processes and local climate phenomena (Glover, 1999; Soria-Auza et al., 2010). The CHELSA-TraCE21k dataset addresses this limitation head-on, providing a robust foundation for elucidating complex interactions between climate, geography, and biodiversity, thereby empowering researchers to address pressing environmental challenges with unprecedented precision and insight.

The CHELSA-TraCE21k dataset addresses these challenges by providing scaled ancient climate data from TraCE21k simulations at a remarkable 30 arc-second resolution using the CHELSA V1.2 algorithm. This dataset covers 100-year time steps from 21,000 years ago to 1950, including additional steps up to 1990 (Karger et al., 2017; 2021). Based on the CCSM3 climate model, the TraCE-21k simulation provides valuable insights into climate change over the past 21,000 years, including the Last Glacial Maximum, and reproduces postglacial climate dynamics worldwide. The CHELSA V1.2 algorithm used for scaling relies on dynamic forcings from TraCE-21k simulations and an approach to surface orography derived from various data sources (Karger et al., 2023; Liu et al., 2009).

Overall, the CHELSA-TraCE21k dataset offers a valuable resource with unique spatial and temporal resolutions for climate impact studies, ecological modeling, and understanding past climate changes. Its accessibility under a Creative Commons license facilitates its use in scientific research and applications, representing a truly revolutionary development in the field of environmental science.

4.4.2 PalaeoView

Palaeoclimate reconstructions serve as a crucial tool for understanding how climate change impacts biodiversity through various pathways, such as species richness, endemism, phylogenetic diversity, and functional diversity (Hagen et al., 2021). However, traditional palaeoclimate reconstruction approaches often fail to provide the spatial and temporal resolution necessary to accurately assess the ecological and evolutionary effects of climate change (Soria-Auza et al., 2010; Crucifix, 2012; Napier

et al., 2020). Fortunately, there is a tool called PalaeoView that addresses this issue by providing high-temporal-resolution palaeoclimate data.

PalaeoView utilizes data from the TRaCE21ka experiment derived from the Community Climate System Model version 3 (CCSM3), which offers insights into past climate conditions over the last 22,000 years (Collins et al., 2006; Fordham et al., 2017). These data provide detailed information on climate variables such as temperature, precipitation, humidity, and sea-level pressure at monthly time steps and a spatial resolution of $2.5^{\circ} \times 2.5^{\circ}$. This level of detail enables researchers to examine ecological and evolutionary processes with unprecedented accuracy, allowing for the investigation of phenomena such as El Niño events over millennia (Power et al., 1999; Fordham et al., 2017).

The tool provides flexibility in generating climate projections and allows researchers to determine temporal intervals and regions of interest. Climate variables can be calculated at customized time scales to meet the requirements of different ecological and evolutionary models. Additionally, PalaeoView enhances ecological significance by offering the ability to scale simulations to finer spatial resolutions (Fordham et al., 2017; Napier et al., 2020;).

By providing gridded data outputs and time series information, PalaeoView enables researchers to analyse palaeoclimate data using various statistical and modeling platforms. This accessibility encourages a better understanding of past extinction and evolutionary processes and assists in efforts to mitigate future biodiversity loss due to climate change. PalaeoView simulations effectively capture significant climate oscillations, such as meridional overturning circulation changes in the Atlantic Ocean, which led to rapid climate transitions during the late Quaternary. Detailed analyses reveal regional differences in climate responses and underscore the importance of local studies alongside global assessments (Fordham et al., 2017).

PalaeoView's application is based on simulations obtained from various coupled atmosphere-ocean general circulation models, with CCSM3 being one of the primary models used. Skill tests demonstrate CCSM3's ability to replicate key climatic features associated with glacial age and accurately predict present-day climate patterns from global weather station data. The application evaluates the potential skill of atmosphere-ocean general circulation models by comparing these simulations with independent

present-day weather station data (Brown et al., 2020; Fordham et al., 2017). This comparison demonstrated that the TRaCE21ka simulations aligned well with the observed regional and global climate patterns. Correlation coefficients for various climate variables, such as temperature, precipitation, and humidity, indicate robust performance at both global and regional scales (Otto-Bliesner et al., 2006; Fordham et al., 2018).

While differences between model projections and observed data exist, particularly in spatial and variable-specific variations, PalaeoView offers users the option to produce model projections with or without correction factors to address discrepancies. This means that users can choose to adjust model projections to better align with observed data if desired. Despite potential model drifts during the simulation period, the stability and accuracy of CCSM3 in predicting present-day climate patterns are noteworthy.

This makes it a valuable resource for researchers seeking transparent and flexible climate data analysis (Fordham et al., 2017; Fordham et al., 2018).

In summary, PalaeoView provides a comprehensive and reliable tool for researchers across various disciplines who wish to explore past climate dynamics and their ecological and evolutionary consequences. High-resolution palaeoclimate data and robust analytical capabilities facilitate a deeper understanding of Earth's climate history and its impact on biodiversity.

5. RESULTS

5.1 Lithology of the Core BRDR-2

In the second part, which is the lowest part of the BRDR-2 core taken from Burdur Lake (Burdur; 37°46'38,561" N, 30°15'40,403" E, altitude: 884 m), there is dark greenish gray mud between 146 and 140 cm. There are. Above this level, there is greenish-gray mud between 140 and 135 cm. There is very light gray mud between 130 and 115 cm. It consists of yellowish-green-gray mud between 115-110 cm (Figure 8). It consists of light greenish-gray mud between 110 and 100 cm. Between these levels, 1 mm black laminates are observed at 105 and 106 cm, and 3 mm black laminates are observed at 102 cm. It consists of dark gray mud between 100-75 cm (Figure 8).

While light grayish mud is observed between 55-40 cm, there is dark greenish-gray mud towards the top between 40 and 20 cm. One millimeter thick black laminae are observed at 35, 23, and 22 cm. In the upper part of the core, 20-19 cm of light gray mud consists of mud. In the uppermost part of the core (the first 5 cm), there is unconsolidated dark green-dark grayish-green mud (Figure 5.1).

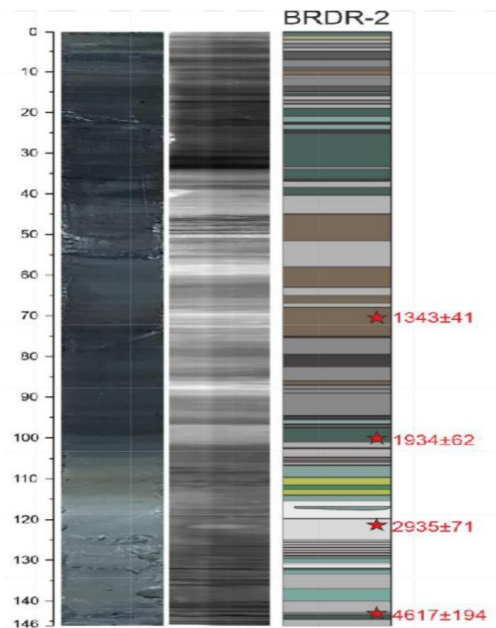


Figure 5. 1 : Lithology of the Core BRDR-2.

5.2 Pollen Analysis of the Core BRDR-2

The pollen diagram was made taking into account the pollen rate in each sample, but within the percentage value of the aerial pollen (AP) and nonarboreal (NAP) pollen types, *Pinus* sp. was not included in the case of the overrepresentation of *Pinus* due to its pollen production capacity (Heusser, 1988; Beaudouin, 2002). The *Pinus* ratios indicated in the diagram are created by the ratio of these grains to all pollen in the same section.

The bottom-to-top sequence delineated three main local pollen assemblage zones (BL1, BL2, and BL3) and two corresponding subzones (BL-2a and BL-2b) based on fluctuations in primary pollen percentages and the results of CONISS analysis (Grimm, 1987; Bennett, 1996) are given in Table 5.1. The changes in the percentages of 76 pollen types determined through microscopic examinations from today to approximately 4500 years ago are shown in Figures 5.2 and 5.3.

Table 5.1 : Local pollen zone of the assemblage and corresponding dates from the Bacon Model.

LPZA	Depth (cm)	Min Ages (Cal Yr. BP)	Best Ages (Cal Yr. BP)
BL-3	1-57	-72 – 813	-44 -1078
BL-2b	57-102	813 - 1905	1078 - 2023
BL-2a	102-117	1905 – 2431	2023 - 2727
BL-1	117-146	2431 - 4090	2727 - 4591

5.2.1 LPZA BL-1 (117-146 cm)

The pollen assemblage zone found between 146 and 117 cm of the core constitutes a complex segment requiring meticulous examination, primarily due to its fluctuating minimum and maximum values. This zone's placement within a chronological framework becomes a nuanced approach, which would encompass a wider temporal range, spanning approximately 4800 to 2400 BP (~500 - ~2900 BC). This extended period encapsulates the diverse range suggested by the minimum and maximum values, providing a broader context for understanding environmental and ecological shifts.

The temporal expansion from approximately 4500 to 2700 BP marked a pivotal phase characterized by a discernible transformation in regional vegetation. Initially, between 4500 and 3800 BP, the pollen record delineates an intriguing pattern—a conspicuous

increase of approximately 5% in the overall count of *Pinus* species and deciduous *Quercus*, followed by a commensurate decline, indicating a cyclical ecological response. In stark contrast, *Quercus ilex* exhibits an inverse trajectory—initially witnessing a decline, followed by a notable resurgence. Additionally, the category representing trees and shrubs other than *Pinus* (AP in the diagram) revealed a striking doubling, followed by a subsequent 5% decrease, indicating fluctuations in regional flora.

Simultaneously, the proportion of *Artemisia* species, identified as secondary anthropogenic indicators according to Behre (1986), exhibited a notable 4% increase, which was sustained until approximately 3800 BP. This increase in *Artemisia* might denote variations in land use or environmental changes influenced by human activities.

The OJCV index, acknowledged as a robust indicator in the region's pollen diagrams associated with population and settlement dynamics (Roberts et al., 2019), demonstrated a consistent and gradual increase of approximately 6% within this temporal span. Conversely, the PDI (Deza-Araujo et al., 2020; Kouli, 2015), which encompasses various plant species, appears relatively stable. Similarly, the API (Mercuri et al., 2013), which integrates diverse plant types, decreased substantially by 10% until approximately 4250 BP, after which it maintained a steady trajectory thereafter (Figure 5.2).

Transitioning to the subsequent interval between 3800 and 2700 BP, a shift in the pollen record became apparent. Despite an initial marginal decrease in *Pinus*, a subsequent increase of nearly 12% is observable, indicating renewed dominance. In contrast, 15% of non-*Pinus* tree and shrub grains exhibited a notable surge, whereas the OJCV decreased markedly, almost halving during this phase. Moreover, although cereal-type grains depict a relatively diminished count, indicative of reduced agricultural activities, the sustained presence suggests the persistence of agricultural practices during this period, albeit at a subdued level compared to earlier phases.

5.2.2 LPZA BL-2a (102-117 cm)

Based on the mean age, the pollen subzone spanning 2700 to 2000 years BP (1900-3000 BP with a margin of error) signifies an era predominantly characterized by a *Pinus*-dominant forest landscape. The increase in the total count of *Pinus* species, notably *Pinus brutia*, commenced at approximately 3400 BP and steadily increased to

44%. At the onset of this zone, the AP/NAP ratio reached 7.7, increasing to 10.75 by approximately 2500 BP, likely indicating transformation into a densely wooded area. However, this surge, marked by an AP/NAP ratio of 4.5 at approximately 2000 BP, positioned it between a dense forest and open vegetation.

The collective arboreal pollen species, excluding *Pinus*, closely mirrored the overall nonarboreal pollen species. Among these, *Juglans regia* and *Cedrus libani* exhibited reduced rates compared to previous levels. The abundance of deciduous *Quercus* decreased by approximately 8%, while that of *Quercus ilex* initially increased by 35.9%, subsequently decreasing to 15%. There was an approximately 5% increase in *Juniperus* species compared to that in the preceding periods, and relatively consistent levels were maintained.

Pistacia lentiscus underwent a sudden 4% decline between 2700-2500 years BP, persisting until 2000-2200 years BP. Moreover, within nonarboreal pollen species, Poaceae exhibited a consistent increase, culminating in a 31% increase towards the zone's end. Conversely, despite a 5% decrease in Asteraceae-Asteroideae and Astreaceae-Cichorioideae family between 3000 and 2700 years BP, there was a gradual increase approaching 2000 BP. While *Centaurea solstitialis* grains experienced a gradual decline until 3000-2400 BP, a peak of 7% emerged between 2200-2400 years BP.

5.2.3 LPZA BL-2b (57-102 cm)

In the time span between approximately 2000 and 1000 BP, a profound transformation unfolded within this particular zone's ecosystem. A notable surge in the prevalence of *Pinus*-dominated tree species occurred over a span of approximately 300 years, notably approximately 1700 BP, transitioning from an open vegetation landscape observed at approximately 2000 BP. This rapid increase was succeeded by a gradual but consistent decline, culminating in a rare arboreal pollen species, including *Pinus*, at approximately 1465 BP. The densely forested landscape observed at this low point persisted until the resurgence at approximately 1000 BP. The underlying causes of these significant changes in forest composition remain a subject of ongoing research, with possible explanations including climatic shifts, human activity, and natural forest dynamics.

This dramatic shift in arboreal species manifested across various indicators. For instance, *Pinus brutia* exhibited a density of 24.9% among pollen types circa 2035 BP, peaking at 31.3% at approximately 1783 BP, and declining to 23.9% by 1465 BP. Following this dip, it increased to 27.2% at 1357 BP, maintaining similar levels until 1066 BP. These fluctuations in *Pinus brutia* could be linked to periods of climatic favorability and subsequent stress, possibly reflecting broader environmental trends. In contrast, *Pinus nigra* displayed less variability than *Pinus brutia*, initiating at 10% and increasing to 11.3% by approximately 1573 BP and remaining relatively stable at approximately 8% until it rose to 12.3% by 1066 BP.

Similarly, the fluctuations in *Quercus ilex* pollen density paralleled the trends observed for these arboreal species. Beginning at 15.3% at circa 2035 BP, it steadily increased until 1783 BP, reaching 30.7%. Subsequently, a protracted decline ensued until approximately 1465 BP, plummeting to 17.1% over nearly six centuries. Notably, there was a substantial resurgence, culminating in a remarkable 37.8% by 1066 BP, despite a minor 4% dip at approximately 1256 BP. The resurgence of *Quercus ilex* suggests a recovery phase, potentially driven by changes in land use practices or favorable climatic conditions.

Juniperus species and deciduous *Quercus* pollen species, although temporally distinct, mirrored these abrupt fluctuations. *Juniperus*, at 5.7% at approximately 2035 BP, experienced a sudden increase to 18.7% by 1884 BP, followed by a consistent decrease to 8.2% until 1679 BP. After it increased to 17.4% by 1573 BP, it then increased to approximately 10-11% by 1161 BP, dropping to 7.4% by 1066 BP. These changes in *Juniperus* populations highlight the species' sensitivity to environmental stressors and its role as an ecological indicator during this period.

Deciduous *Quercus*, starting at 10.7% at approximately 2035 BP, experienced a 5.7% increase by 1884 BP, followed by a notable albeit fluctuating decline, decreasing to 6% by 1357 BP. Subsequently, it increased to approximately 12%, but it decreased to 8% by 1066 BP, marking a period of notable changes within the ecosystem during this era. The fluctuations in deciduous *Quercus* pollen suggest varying environmental conditions, potentially linked to both natural and anthropogenic influences.

The fluctuations observed in arboreal species dominance seldom translated directly to individual nonarboreal species, typically manifesting in a collective manner. However,

intriguing alterations were noted in specific pollen types. For instance, *Amaranthaceae*, which was absent in samples from 2035 BP and 1884 BP, reappeared notably in 1783 BP and increased to 3.4% by 1573 BP. Despite a decline to 1% by 1465 BP, it maintained an approximate 5% presence by 1357 BP. Subsequently, after 1256 BP, it disappeared, reaching 2.7% by 1066 BP. This reemergence and persistence of *Amaranthaceae* highlight its resilience and potential adaptability to changing environmental conditions.

Conversely, *Centaurea solstitialis* sustained levels of approximately 2%-3% until 1256 BP, with the exception of the sample from 1783 BP, which persisted at 1% until 1066 BP. This stability in *Centaurea solstitialis* percentages suggests a relatively stable niche within the ecosystem, despite broader ecological changes.

Cyperaceae exhibited a stark contrast, registering at 4.3% at approximately 2035 BP and swiftly declining to 1% over the ensuing three centuries before increasing to 4.8% by 1679 BP. However, this elevation remained evident in a single sample, fluctuating between 1% and 2% until 1066 BP. The marked decline and subsequent fluctuations in *Cyperaceae* may reflect changes in hydrological conditions and habitat availability during this period.

Moreover, the percentage of *Asteraceae Asteroideae*, which was initially 5% circa 2035 BP, decreased to 0.7% in the 1884 BP sample but remained between 2% and 3% until 1465 BP. Subsequently, it continued hovering at approximately 2%-3%, except for the specimen at 1256 BP. These nuanced shifts in *Asteraceae Asteroideae* further underscore the complex and varied environmental changes within this era, likely influenced by a combination of climatic, ecological, and human factors.

5.2.4 LPZA BL-3 (1-57 cm)

Across the chronological span from 1078 BP to the present era, an intriguing narrative unfolds within this zone, encapsulating diverse shifts and alterations within the landscape. The transition reflects an evolution from a woodland dominated by "very close forest" tendencies after the zenith of *Pinus*-inclusive arboreal pollen approximately 1783 BP. However, a significant transition occurred at 284 BP, marked by a sudden shift from these low levels towards a remarkable upsurge in forestry, accompanied by a pronounced increase in nonarboreal pollen types.

Within this transformation, the prevalence of *Pinus brutia* oscillates between 20% and 30%, while that of *Pinus nigra* hovers within the range of 7% to 10%. Notably, despite the combined proportion of *Pinus* species hovering at approximately 40% and exhibiting no dramatic fluctuations, the oscillations in these arboreal pollens, their subsequent surge, and subsequent decline primarily stemmed from alterations in other tree species, shrubs, and herbaceous plants.

The prevalence of deciduous *Quercus* fluctuated: starting at 8% in 1066 BP, it abruptly decreased to 3.3% by 969 BP, maintaining levels between 3% and 4% until 575 BP. Thereafter, deciduous *Quercus* trees oscillated between 5% and 6% from 395 BP to 575 BP, followed by a range of 3% to 5% until 105 BP. However, the topmost sample at -28 BP exhibited a substantial deviation of 18.7%.

Quercus ilex underwent a gradual decrease from 37% at 1066 BP to 14.2% by 897 BP, followed by a continuous increase to 22.4% at 575 BP, and similar levels were sustained until the earliest sample at -28 BP, when it displayed a sudden increase to 40.7%. Conversely, *Juglans regia* spans the range of 1% to 2%, increasing to 7.4% by 774 BP. Chestnut trees remained relatively stable, ranging between 4% and 5% until a spike to 8.6% at 284 BP, subsequently maintaining levels of 6% to 7%.

The *Juniperus* species exhibited oscillations, ranging from 7% to 9% until 395 BP, except for a spike of 12.8% at 676 BP. However, it drastically declined to 0.7% at 284 BP, thereafter following an erratic pattern.

Olea europaea, which was previously negligible, suddenly increased to 10% at 1066 BP but subsequently decreased to 1% to 2% in subsequent samples, reaching a peak at 15.7% at 28 BP, likely attributed to modern cultivation. Conversely, *Cedrus libani* demonstrates fluctuating patterns, persisting at relatively low levels, except for instances between 284 and 206 BP. This intricate chronicle unveils the dynamic ebb and flow of various tree species, providing insights into their nuanced evolutionary trajectories and the potential influence of environmental shifts and human cultivation practices on their proliferation.

On the other hand, the evolution of several plant species, as depicted in the dataset across numerous years, revealed intriguing fluctuations and significant changes in their growth rates. Among these species, Amaranthaceae species exhibit notable shifts in growth rates at specific intervals. Initially, starting at % 3.7 in year 28, it gradually

increased to % 9.9 by year 284, indicating a steady upward trend. However, an abrupt decrease followed in subsequent years, dropping to % 1.7 by 575, after which it only slightly rebounded to % 4.2 by 897 before stabilizing.

The growth pattern of *Asteraceae-Asteroideae* plateaued from % 1 in year 28 to % 4.7 by the year 1066, with intermittent increases and minor fluctuations. In contrast, *Astaceae Cichorioideae* displayed sporadic growth, reaching peaks at % 2.7 in years 575 and 897 but otherwise maintaining relatively lower values throughout the observed period.

Centaurea solstitialis exhibited fluctuating growth rates, notably peaking at 5.4% in the year 774, followed by a decrease to 1% in the year 1066. The reasons behind these fluctuations might include varying climatic conditions, changes in soil composition, or competition with other plant species, all of which could have influenced the growth and prevalence of *Centaurea solstitialis* during these periods.

The growth of *Cyperaceae* exhibited sporadic spikes, particularly at 2.7% in the years 105 and 1066. These sporadic spikes in *Cyperaceae* growth could indicate temporary environmental conditions favoring their proliferation, such as changes in water availability, which *Cyperaceae* are particularly sensitive to. Such patterns suggest episodic wet periods that provided suitable habitats for these species.

The most striking changes manifested within the *Poaceae* species, showcasing substantial spikes and declines. Starting at 2.3% in the year 28, it skyrocketed to 35.1% by the year 105 before surging further to a remarkable 46.9% in the year 897. However, this rapid growth was followed by a substantial decrease to 12.4% by 1066, indicating a significant deviation from the previous trends observed for this species.

The dramatic increase in *Poaceae* could be associated with changes in land use, such as the expansion of grasslands due to human activities or natural succession processes. The subsequent decrease might reflect a shift back to woody vegetation or different land management practices.

These fluctuations and shifts in growth rates across the observed years underscore the dynamic nature of these plant species, hinting at the intricate interplay of environmental factors and inherent biological rhythms influencing their evolution and growth.

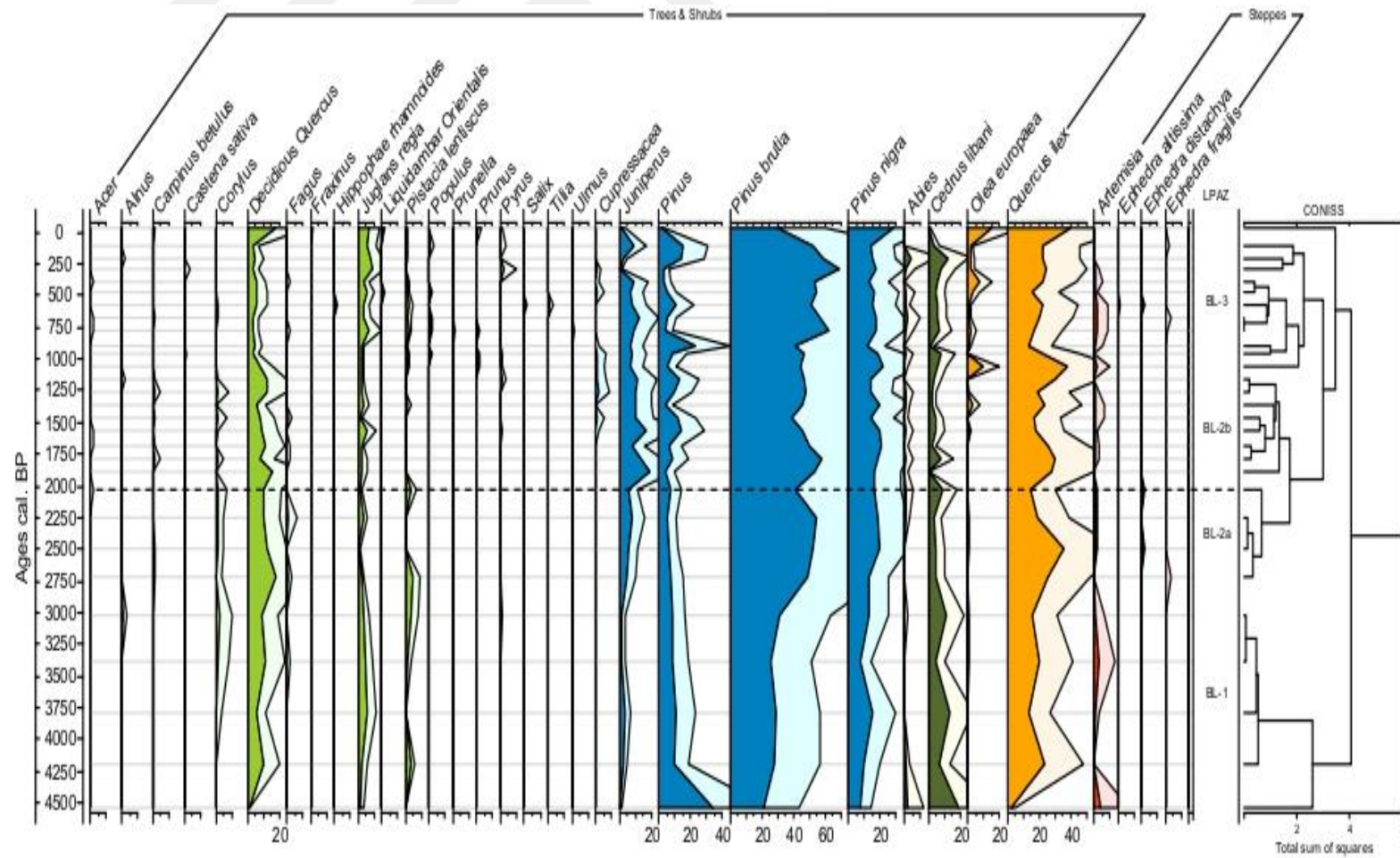


Figure 5. 2 : Arboreal and Steppe Pollen Species of Lake Burdur.

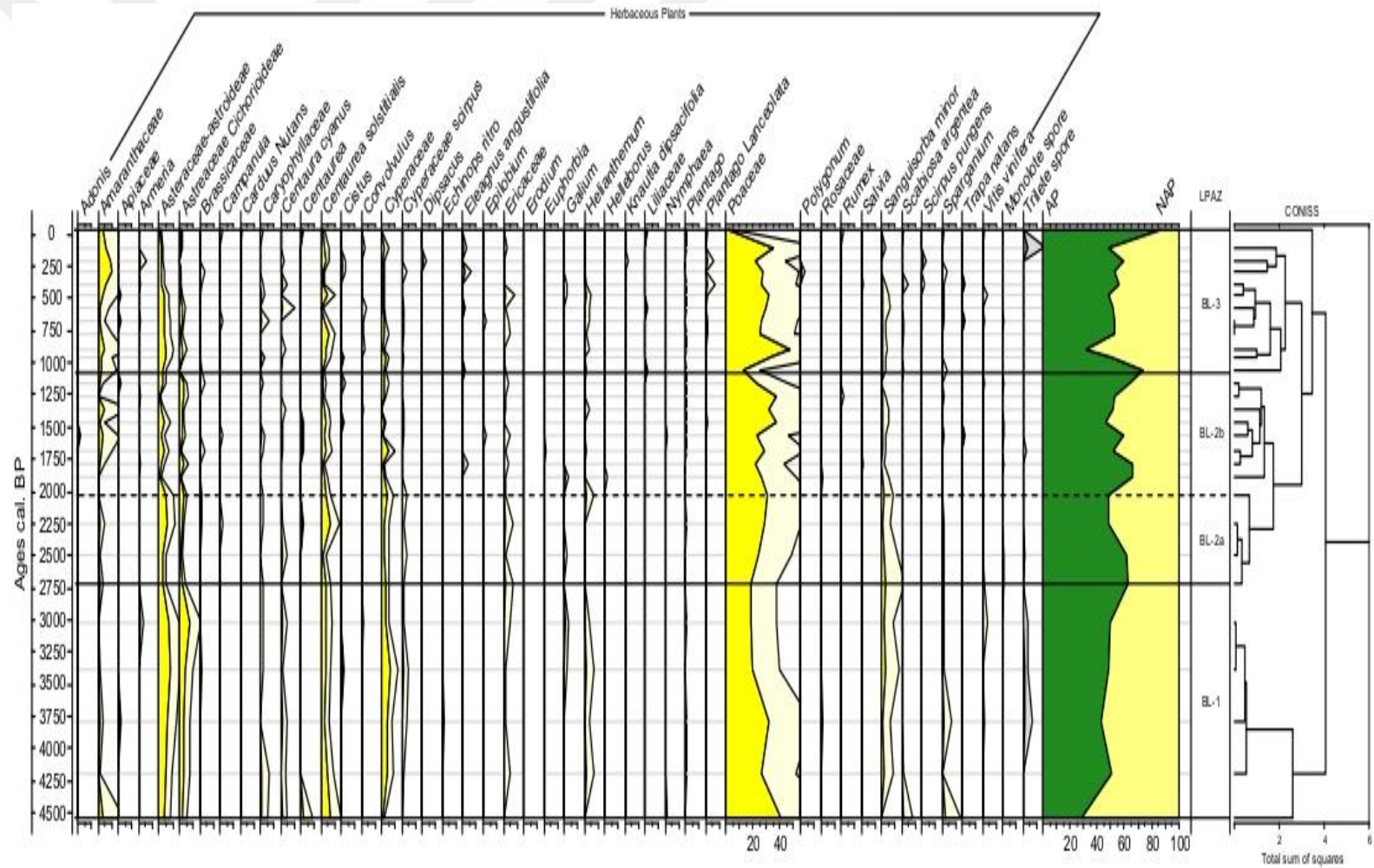


Figure 5. 3 : AP/NAP ratio and herbaceous plant species in Lake Burdur.

5.3 CHELSA-TraCE21k

In this study, examining Lake Burdur and its surroundings, while utilizing CHELSA annual average temperature and precipitation data, the unique climate characteristics of the region were considered. The Oro-Mediterranean climate zone, which is situated in a transitional location characterized by its highly mountainous terrain and hosting numerous lakes, significantly distinguishes this region from other inland regions (Van Zeist et al., 1975; Willett, 2023).

In this context, utilizing a grid covering the present-day provincial borders with coordinates between 29°-24' and 30°-53' east longitude and 36°-53' and 37°-50' north latitude, the averages for this area were calculated. Rainfall and temperature values on the grid for the past 0-4600 years were extracted using the R package “raster” (Hijmans, 2023). These values were calculated by averaging the annual mean temperature and precipitation values for each square kilometer (Figure 5.4). Moreover, maps in the Appendix A show the temperature and precipitation difference values per every 100 years over a span of 4600 years in Turkey (Figures A.1 and A.2, respectively). As can be understood from these maps, what is referred to as climate change actually manifests heterogeneously in different locations over short time periods.

According to the model results, the rainfall values varied between 641.7781 mm and 730.8518 mm from 4600 BP to the present, with an average of 691.1588 mm. During the period from 4600 BP to 2700 BP, relatively high rainfall amounts were observed, ranging between approximately 660 mm and 720 mm. However, between 2700 BP and 2100 BP, the rainfall values decreased almost steadily. The second lowest rainfall amount was observed from 2100 BP to the present.

After 2100 BP, a significant increase in rainfall was observed for 200 years, with these high amounts continuing until 1300 BP. The highest rainfall value for the period of interest was observed at 1300 BP. However, the period up to 700 BP showed an almost continuous decrease in rainfall. Following a relatively small increase between 700 BP and 400 BP, rainfall amounts continued to decrease until the present, likely reaching their lowest level today. Overall, these trends indicate significant fluctuations in rainfall over the millennia, reflecting changes in climate patterns and their potential impacts on the environment and human activities.

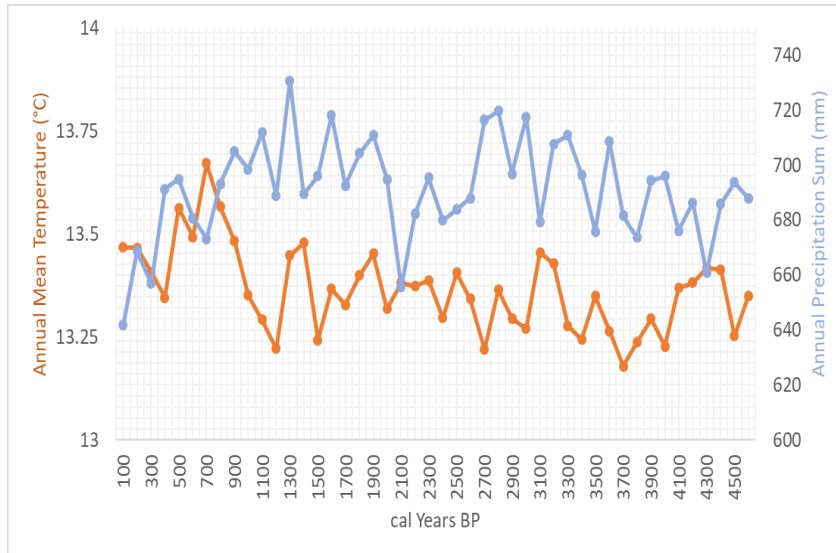


Figure 5. 4 : Annual mean temperature and precipitation sum obtained through CHELSA-TraCE 21K for Burdur.

Furthermore, over the 4600-year period, the average temperature in Burdur ranged between 13.17890 and 13.67165 degrees Celsius, with an average of 13.36571 degrees Celsius. The temperature was relatively high between 4500 and 400 BP, approximately 13.5 degrees Celsius. However, from 4100 to 3700 BP, the average temperatures almost continuously decreased, with the minimum temperature recorded at 3700 BP. Although temperatures fluctuated until 3100 BP, they generally increased, but between 1600 BP and 1500 BP, it was observed that the average value did not change much. However, a sudden increase in temperature was observed between 1500 BP and 1300 BP, followed by the second lowest annual temperature value at 1200 BP. From 1200 BP to 700 BP, temperatures continued to rise uninterrupted, and the highest temperature period in Burdur was observed at 700 BP. Between 700 BP and 400 BP, the previous period of steady increase was replaced by almost continuous but sudden temperature decreases. From 400 BP to the present, the average annual temperature steadily increased.

5.4 Paleoview

Considering PalaeoView's minimum spatial resolution of $2.5^{\circ} \times 2.5^{\circ}$, for this study investigating climate and vegetation changes in the Burdur Basin, a spatial range of 40°N , 37.5°N , 27.5°E , 30°E was selected. Due to Burdur's unique oro-mediterranean climate and its transitional location, it should ideally be included within the Inner

Anatolia region or treated together with the Aegean Region further west. While making this selection, it was determined that the drier regions of Inner Anatolia should also be considered, and Burdur was preferred due to the access of the Aegean Region to more current meteorological data. In this context, the region in the PalaeoView software was selected as "User Defined". Additionally, taking advantage of PalaeoView's high-resolution temporal range, 30-year intervals selected with 20-year steps were used. However, instead of determining the deviation from 4600 BP or present-day values while generating annual total precipitation and temperature data, the values were directly produced, and a bias correction method, commonly used in palaeoclimate modeling, was applied, where model outputs were compared with real observations and the model performance was enhanced (Figure 5.5). Moreover, maps in the Appendix B section illustrate temperature and precipitation difference values across Turkey at 200-year intervals over a span of 4600 years, derived from PaleoView output (Figures B.1 and B.2). These maps reveal the heterogeneous nature of climate change, demonstrating varied manifestations across different regions and short time periods.

According to the precipitation data, the annual total precipitation varied between 797.8565 and 1141.6111 mm between 4600 and 0 BP (approximately 0-12,000 years ago), averaging 988.3299 mm. While a decrease in precipitation was observed between 4600 and 4200 BP, this decreasing trend abruptly changed at 4200 BP, with precipitation increasing by approximately 21% within 100 years. Subsequently, there was a ~20% decrease over the following century, and a sudden increase was again observed up to 3900 BP. The fluctuations between 4200 and 3900 BP became relatively stable up to 3300 BP. However, there was another significant change at 3200 BP, with precipitation increasing by approximately 14% and returning to previous levels within the following 100 years. Between 2900 and 1800 BP, a nearly steady decline is observed, followed by a pronounced increase pattern over the next three centuries, with precipitation increasing by approximately 17%. The period between 1500 BP and 1100 BP represents the longest-term change in the studied timeframe, with annual total precipitation decreasing by approximately 33% over 400 years to reach the second lowest level. However, a gradual increase in precipitation patterns is observed over the following 300 years, resulting in an overall increase of 26%. From 800 to 200 BP, a significant and almost continuous decrease occurred, with

precipitation values decreasing by almost 31% over 600 years to reach the minimum precipitation value in the studied timeframe.

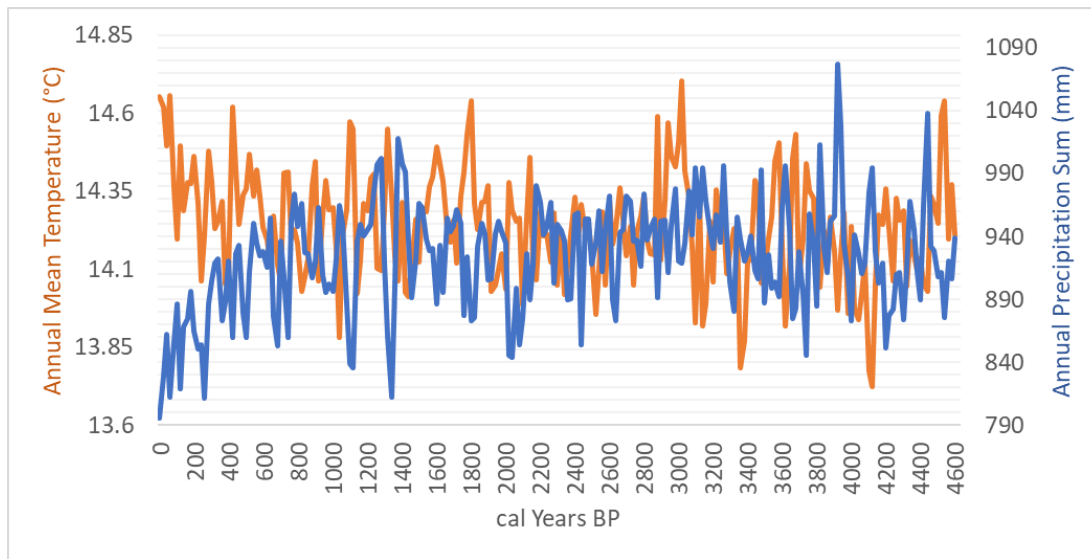


Figure 5. 5 : Annual mean temperature and precipitation sum obtained through Paleoview for Burdur.

The range of annual average temperature values fluctuates between 13.90485 and 14.72931 degrees Celsius, with an average of 14.2567 degrees. Fluctuations in temperature occurred between 4600 and 4100 BP, but a generally decreasing trend was observed. During this period, temperatures decreased by up to 0.5 degrees, reaching the lowest value of 13.9 degrees at 4100 BP. Temperatures consistently increased between 4100 BP and 3700 BP, increasing by 0.4 degrees over 400 years to increase the average temperature. The temperature, which was relatively stable until 3100 BP, increased by 0.4 degrees within 10 years. The temperature remained low between 3000 BP and 1800 BP for a long period. Over a 100-year period, increasing temperature values until 1600 BP experienced a significant decrease over the following 200 years until 1400 BP but returned to previous levels within the following 300 years until 1100 BP. The period between 1100 BP and 500 BP was another period dominated by low-temperature values. The period until 100 BP reached the warmest period today, with a sudden but continuous increase.

6. DISCUSSION

6.1 Beyşehir Occupation Phase and Burdur

Many parts of SW Anatolia were extensively settled in the region during the Bronze Age (approximately 3200-5000 BP). Early Bronze Age (EBA) settlements are likely concentrated in areas including Burdur in the north rather than in the coastal areas of Antalya in the south. Although the Bademağacı and Kuruçay settlements are considered to be the only long-lasting Bronze Age settlements, traces of the material culture of the EBA settlements were also found in Hacılar Büyük Höyük, Tepecik, Yassigüme Höyük and İncirdere Höyük (Umurtak, 2005; Duru, 2008; Umurtak and Congur, 2021).

However, among the settlements near Lake Burdur, only Hacılar Büyük Höyük has a long excavation history. The quality and variety of pottery such as plates, bowls, jugs, jars, and jars unearthed in these excavations, as well as marble and many terracotta idols belonging to the same layers, stone and terracotta stamp seals and tools such as metal needles, daggers, and spatulas, are rich and sophisticated here. As a mainly EBA settlement, the pottery, tools, fruit, and grain remains found in these places show that they were also used as residences within the defense system. Radiocarbon (¹⁴C) analysis of the burnt grain remains recovered from the buildings in question shows that the city lived between 3010 and 2980 BC (Umurtak, 2013; Vandam, 2014).

In addition to grain remains such as charred wheat, barley, lentils, chickpeas, and peas collected from storage facilities inside buildings and in courtyards after the fire disaster of the settlement, fruits such as grapes and figs and plants such as flaxseed and mustard herbs were used as food sources for the people who lived there 5000 years ago. It provides information about your habits (Vandam et al., 2019). In addition to wild animal species such as lions, deer, roe deer, wild cattle, wolves, foxes, and badgers, which were identified by archaeozoological studies in the center, it was determined that many domesticated pigs, sheep, and goats were raised for meat, milk, and skin. The diversity and richness of the architectural remains and finds unearthed thus far suggest that this settlement was a local royal center at the beginning of the Early

Bronze Age (Çakırlar et al., 2019). However, it is very difficult to detect changes in agricultural activity based on pollen, and archaeobotanical studies of the surrounding excavations are rather superficial, creating difficulties in interpreting the pollen diagrams of this period (De Cupere et al., 2017)

The history of Burdur in the early 2000s BC is generally full of unknowns. During this period, there was no clear information about the details of the settlement patterns of the region due to the lack of written sources and archaeological findings. However, it is thought that significant changes occurred in the region at the beginning of the Hittite Age in the 17th century BC. However, at the beginning of the Hittite period, when the Arzava Kingdom ruled in regions such as Pisidia, Pamphylia, and Lycia, specific information about the location or role of Burdur within this kingdom was limited. During this period, the region may have been exposed to various cultural interactions and shaped under the influence of various civilizations (Duru, 2008; Roosevelt and Luke, 2017).

Considering that the earliest Iron Age data identified and published thus far in the Pisidia Region, it seems that it did not go back before the 8th century BC (Mellart, 1955; Gerçek, 2014; Dökü and Çomak, 2023). It can be argued that this situation is due to inadequate study of the region, surface surveys, and especially excavations. On the other hand, the Iron Age chronology has not been established in the Lakes Region, as in other regions. To eliminate this deficiency, excavations should be carried out in the mounds and Iron Age centers in the region, and a new chronology should be created by evaluating the data obtained within the region.

Lydia stands out as the dominant culture in the lake district, including the Burdur Lake region, during the Middle and Late Iron Ages. The most intense data during this period consisted of Lydian effect ceramics. From the perspective of burial traditions, in addition to Lydian-type earthen mounds, they predominantly form stone mounds. Lydian ceramic samples can be seen in these stone masonry tumuli. Again, during this period, Iron Age settlements were concentrated, and these settlements were grouped as lakeside settlements, hillside settlements, and mounds (Roosevelt, 2003; Dökü, 2018).

The settlement types around the lake stand out with the lake, which was frequently observed in the Lakes District in ancient times, and the appearance of a hill

overlooking the lake or a peninsula. With the settlements around Gölhisar, Yarışlı, and Karataş Lakes in the geography of the region, settlements such as Kibyra, Balbura, Lysinia, and Olbasa were found on mound surfaces where they hosted a very crowded population. It is understood from the ceramics of the 1st millennium BC and later from the data belonging to the Iron Age (Özsait, 1989).

A well-known settlement pattern that makes this zone discussed separately in terms of settlement history is the Beyşehir Occupation Phase. In palaeopalynological research, a period of distinct land use and corresponding vegetation pattern changes, called the Beyşehir Occupation Phase (BOP or BO Phase), has occurred in a large part of southwestern Anatolia. Events that mark this land use type are generally intense forest clearance; significant increases in crop cultivation, such as cereal production, and resulting increases in plant species growing in destroyed places, especially weeds; and increases in cultivated crop tree species such as walnuts, olives, and vines, also called arboriculture (Bottema et al., 1986; Eastwood et al., 1998; Vermoere et al., 2002). On the other hand, the end of the BO phase is usually a sudden regrowth in the woodland, especially in pinus species, and a subsequent decline in agricultural plant species that signify arboriculture (Bottema and Woldring, 1990; Roberts et al.: 1997).

The beginning of this period was generally marked approximately 1000 BC by a decrease in forest areas and a significant increase in the presence of grasses, cereals, ruderal taxa (plants growing in destroyed places), and fruit trees such as olives, walnuts, and grapes. However, the onset of this land-use type is “time-transgressive” and is not the same at every pollen site (Roberts, 2015). This may be due to both the history of settlement in different regions and the time-lagged chronological records in pollen data (Haldon, 2019).

BOP was first described in pollen data from Beyşehir (van Zeist et al., 1975), other SW Anatolian sites (such as Kaniewski et al., 2007), Northern Anatolia and Northwest Anatolia (such as Leroy et al., 2009; Miebach et al., 2016), Central Anatolia (Roberts et al., 2015), and Eastern Anatolia, Cyprus and has even been suggested to exist in the Levant region (Castellano, 2021; Roberts et al., 2018) (Figure 6.1 and 6.2). Thus, the presence of similar pollen assemblages dating to the same period in many regions of Anatolia led to the idea of a land use pattern and, accordingly, a pattern of change in vegetation that was effective throughout most of the late Holocene.

increases in certain plant species may indicate the presence of agricultural activities, the obvious land regulation or traces of human impact observed in other regions are not as evident in Burdur.

It is suggested that geographic, climatic, or local factors in the region may have shaped past human impacts differently from those in other regions. Therefore, the fact that the BO phase is not evident as in other cases in Burdur suggests that the past land use and vegetation changes in the region differ from those in other regions. This issue can be an important point of discussion when examining human impacts and past settlements in a region.

In this case, how should the regrowth of arboreal species and the very marked increase in *Pinus*, manifested at approximately 3300 BP in the pollen zone called LPZA-1, be considered together with the gradual decrease in the proportion of *Cerelia*-type pollen and the significant decrease in the OJCV index attributed to arboriculture, consistent with the change in arboreal pollen should it be considered? As mentioned above, a significant increase in early and middle Bronze Age settlements has been observed, including around Lake Burdur, but this continuity of both settlement and material culture is not very clear in the Hittite-influenced Late Bronze Age of the region.

This may be because the SW Anatolian settlement in the LBA shifted from the area around Lake Burdur to another place not close to the lake. In the pollen diagram, different anthropogenic indicators are visible in both cereal agriculture and arboriculture in the EBA and MBA, which is quite compatible with the low-level monitoring of *Pinus* and arboreal species.

However, it can be considered that this region was not completely abandoned during the period that marked the end of the LBA in Anatolia (approximately 3200 BP) and continued to migrate. Instead, there may be a period in which similar agricultural activity continues at a lower level, but the use of trees and shrubs is lower. To avoid this relationship between the pollen diagram and the settlement date from remaining at a deterministic level, it is necessary to understand whether the changes in other pollen zones analyzed in the rest of the thesis are also compatible with historical and archaeological knowledge. Furthermore, integrating these findings with broader historical and archaeological contexts could provide a more nuanced understanding of human-environment interactions in the region over time

6.2 Examining the Anthropogenic Past of Lake Burdur and Around

In fossil pollen studies, uncovering the reflection of anthropogenic activity on plant assemblages is challenging, particularly due to the overlapping effects of natural processes and human activities. Human activities such as agriculture or deforestation in a region can leave distinct traces in pollen records, but these traces may also stem from various natural changes, including climate-related ones. Additionally, certain plants may be considered anthropogenic indicators in one region while being viewed as part of the local flora in another. The intensity of anthropogenic effects can also vary over time, complicating the interpretation of records. These challenges can affect the accuracy of results obtained through pollen analysis, emphasizing the need for careful evaluation of findings. In response to these concerns, many anthropogenic pollen indicator species have been identified, and indexes have been established (Table 6.1).

Deza-Araujo et al., (2020) examined the performance of anthropogenic indicators that can detect human impacts across different regions. The findings highlight the need to carefully choose and validate these indicators based on specific geographic contexts. The study also emphasizes the importance of archaeological evidence in confirming pollen-based reconstructions of human impact. Additionally, the study indicated that the OJCV index extensively used in SW Anatolia pollen analysis studies, similar to other indices, might be biased towards more recent periods, particularly the Modern Era, due to the intensive cultivation of these plants in recent history. This bias could limit the index's utility for tracing human impacts in earlier archaeological or historical periods.

Table 6.1 : Anthropogenic pollen indicators and their scope (Deza-Araujo et al., 2020).

Approach	Original Scope Area	Pollen types included	Index Explanation
PI	Central Europe, North of the Alps	Cereals: <i>Secale cereale</i> , <i>Hordeum</i> -type, <i>Triticum</i> -type, <i>Avena</i> -type, <i>Zea</i> . Dicotyledonous crops: <i>Fagopyrum</i> , <i>Linum usitatissimum</i> -type, <i>Vicia faba</i> , <i>Cannabis</i> -type	PI: Primary anthropogenic indicators and SI: Secondary anthropogenic indicators (Behre, 1981; Lang, 1994)

Table 6.1 (Continued) : Anthropogenic pollen indicators and their scope (Deza-Araujo et al., 2020).

Approach	Original Scope Area	Pollen types included	Index Explanation
PI	Central Europe, North of the Alps	Cereals: <i>Secale cereale</i> , <i>Hordeum</i> -type, <i>Triticum</i> -type, <i>Avena</i> -type, <i>Zea</i> . Dicotyledonous crops: <i>Fagopyrum</i> , <i>Linum usitatissimum</i> -type, <i>Vicia faba</i> , <i>Cannabis</i> -type	PI: Primary anthropogenic indicators and SI: Secondary anthropogenic indicators (Behre, 1981; Lang, 1994)
SI	Central Europe, North of the Alps	Adventives: <i>Centaurea cyanus</i> , <i>Lychnis/Agrostemma</i> -type, <i>Scleranthus annuus</i> , <i>Spergula arvensis</i> -type, <i>Polygonum convolvulus</i> -type, <i>Polygonum aviculare</i> -type, <i>Polygonum persicaria</i> -type (<i>Persicaria maculosa</i> -type), <i>Plantago lanceolata</i> -type, <i>Plantago major/media</i> . Apophytes: <i>Rumex acetosella</i> -type, <i>Rumex acetosa</i> -type, <i>Trifolium repens</i> -type, <i>Succisa</i> , <i>Jasione/Campanula</i> -type, <i>Urtica</i> , <i>Artemisia</i> , <i>Melampyrum</i> , <i>Pteridium</i> , <i>Polypodium</i> , <i>Calluna</i> , <i>Juniperus</i> -type	
CI	North and South of the Alps	<i>Plantago lanceolata</i> -type, Cereal-ia-type (excluding <i>Secale</i>)	CI: Cultural indicators (Tinner et al., 2003)
API	Mediterranean (Italy)	<i>Artemisia</i> , <i>Centaurea</i> , <i>Cichorioideae</i> , <i>Plantago</i> , Cereal-ia-type, <i>Urtica</i> , <i>Trifolium</i>	API: Anthropogenic pollen indicators (Mercuri et al., 2013a)
OJC	Mediterranean (Italy)	<i>Olea</i> , <i>Juglans</i> , <i>Castanea</i>	OJC: <i>Olea</i> , <i>Juglans</i> , <i>Castanea</i> (Mercuri et al., 2013b)
OJCV	Mediterranean (Italy)	<i>Olea</i> , <i>Juglans</i> , <i>Castanea</i> , <i>Vitis</i>	OJCV: <i>Olea</i> , <i>Juglans</i> , <i>Castanea</i> , <i>Vitis</i> (Bevan et al., 2019; Roberts et al., 2019)

Table 6.1. (Continued) : Anthropogenic pollen indicators and their scope (Deza-Araujo et al., 2020).

Approach	Original Scope Area	Pollen types included	Index Explanation
PDI	Mediterranean (northern Greece)	<i>Centaurea</i> , Cichorioideae, <i>Plantago</i> , <i>Ranunculus acris</i> -type, <i>Polygonum aviculare</i> type, <i>Sanguisorba minor</i> -type, <i>Urtica dioica</i> -type and <i>Pteridium</i>	PDI: Pollen Disturbance Index (Kouli, 2015)
AP/NAP	Northern Europe	Relative abundance of arboreal pollen to non-arboreal. Values are interpreted as: >10, very close forest; 4–10, close forest (at 4, first relevant vegetation openings); <1, open vegetation.	AP/NAP: Arboreal pollen/non-arboreal pollen ratio (Berglund et al., 1991; Favre et al., 2008).

Based on this, the pollen results of the BRDR-2 core will be comparatively analyzed in light of these indexes to what extent they reflect the region's settlement history and subsistence practices. This approach will be considered in conjunction with the settlement history of the region discussed above, regionally-specific climate models, and proxy data. Furthermore, the degree of compatibility of the settlement pattern claimed to exist in the Beyşehir Occupation Phase (BOP) in southwestern Anatolia with this study will also be discussed.

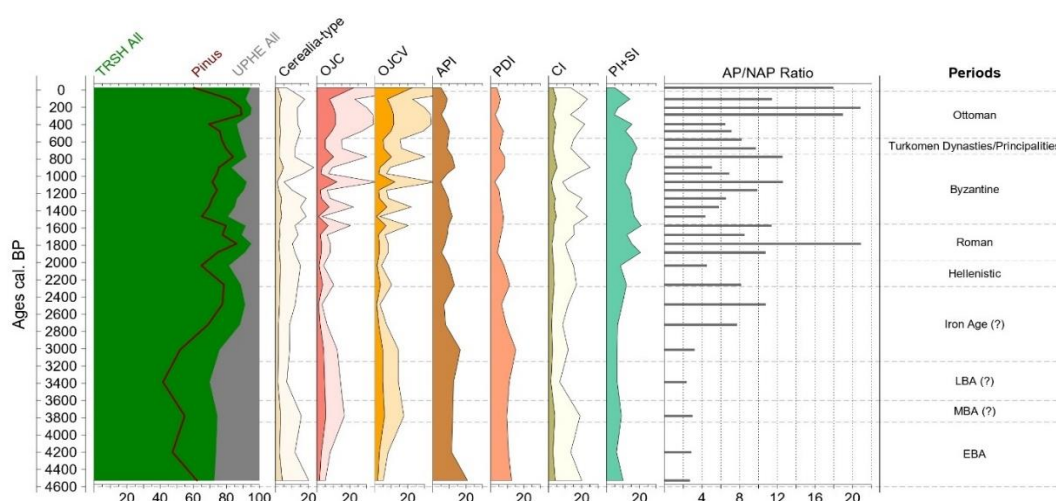


Figure 6. 3 : BRDR-2 Various Anthropogenic Pollen Indicator Indices together with *Cerealia*-type pollen *Poaceae* $\geq 40 \mu\text{m}$. *Cerealia*-type and CI are exaggerated 5 times whereas OJC and OJCV Indices are exaggerated 3 times.

Burdur Lake's fossil pollen analysis diagram, arranged according to various anthropogenic indexes and archaeological-historical chronology, is provided above (Figure 6.3). Additionally, comparative data over 4600 years, including the previously discussed CHELSA-Trace 21ka data, climatic results obtained through PaleoView software, and oxygen isotope data from Kocain Spelothem, Nar Lake, and Gölhisar Lake, are presented (Figure 6.4).

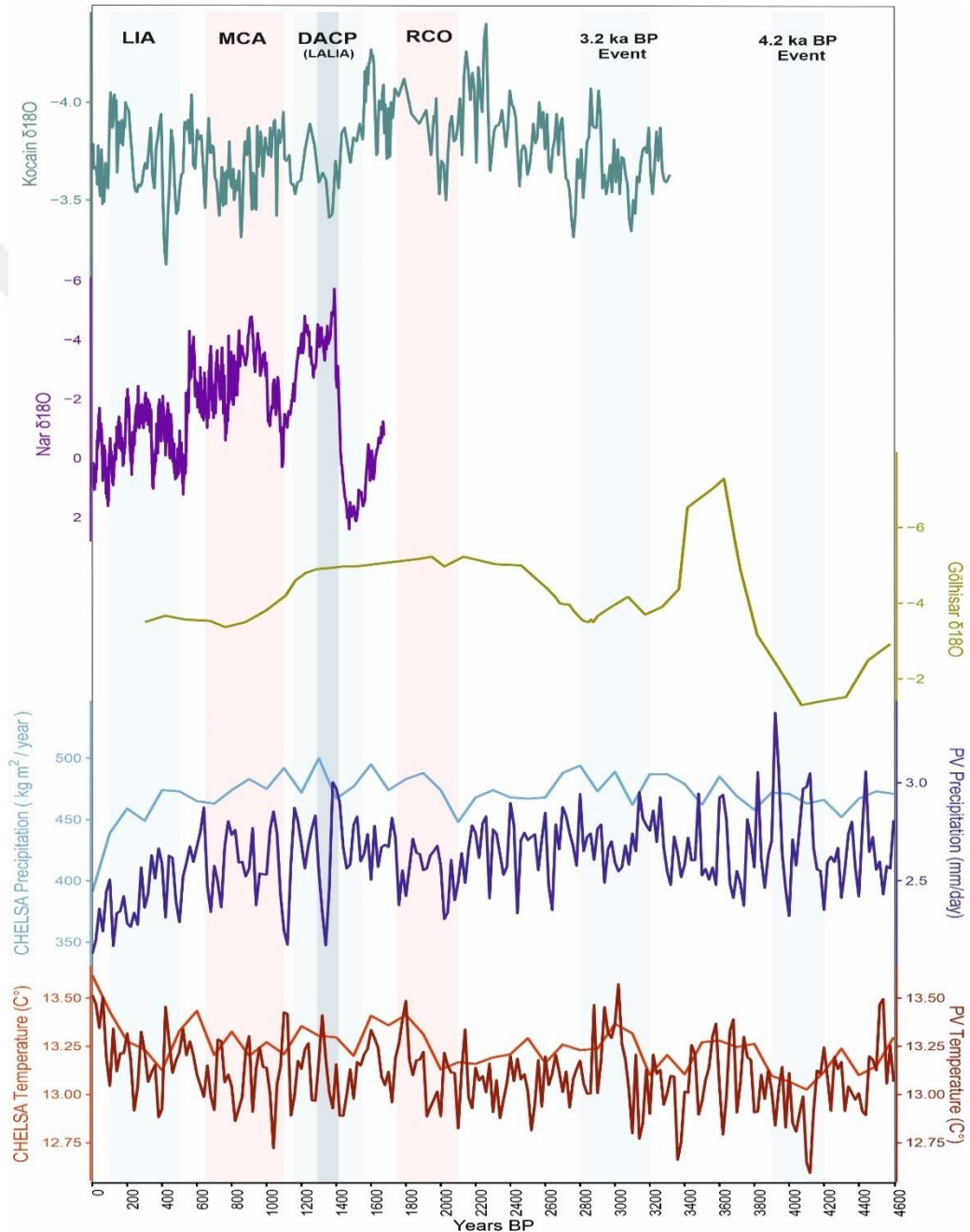


Figure 6. 4 : 4600 years of Climatic History of Burdur and Around through Paleoclimate and Proxy Data. Lower Oxygen isotope values indicate wetter and warmer conditions. Blue and red-shaded areas are common climatic events.

There are only two pollen samplings corresponding to the Early Bronze Age. While there is an AP/NAP ratio between open vegetation and closed forest in these, especially in *Pinus* species, the levels are very low. In anthropogenic pollen indicators, while API, PDI, and CI follow quite high levels, OJC and OJCV show a significant increase in these two samples corresponding to EB II and EB-3, while they are at very low levels in the first sample. The sum of PI and SI's, on the other hand, gives a relatively low level of constant monitoring. However, this period is a critical period covering the 4.2ka BP cooling event, which is also seen in previous studies in the vicinity. This situation corresponds to a period where the lowest temperatures were observed for 4600 years in PaleoView and CHELSA results, and according to Gölihsar data, it was the driest and coldest. This sudden drop in temperature also shows, within approximately a hundred years, an increase in rainfall followed by a drastic decrease, as seen in CHELSA and PaleView data—with minor changes in CHELSA. The exception to this is that CHELSA data does not show this sudden drop, which may be due to CHELSA's temporal resolution covering a century.

In the Early Bronze (EB) I, the observation of low AP levels in a period where settlement density begins to increase, and in EB II, with the occurrence of complex social organization, large and relatively centralized structures along with population growth, cannot solely be attributed to anthropogenic influence but rather indicates a potential combination of climatic change and anthropogenic influence. On the other hand, although it is quite optimistic to measure the short-term response of intense settlements in this period, the continuity of species in the OJCV index, despite their sensitivity to rainfall and temperature, may indicate resistance to climatic change.

Having only one example from the Middle and Late Bronze Ages (MBA and LBA) makes it difficult to make a healthy interpretation of the land use in this period. However, low AP ratios are still visible at these levels, while it is surprising that OJCV peaked at the beginning of MBA2 throughout the Bronze Age. Because neither in settlements around Lake Burdur nor in surface surveys has MBA has been significantly demonstrated. Although this initially suggests the existence of scattered and small settlements and the practice of arboricultural agricultural production, there is no evidence to support this with either archaeobotanical or archaeological data (De Cupere et al., 2017). The possibility of this situation arising from chronological error is high because the age-depth relationship reconstructed by the Bayesian method gives

an error margin of approximately 250 years to the level of this sample. On the other hand, the almost disappearance of *Cerealia*-type pollen according to morphological features in LBA may reflect this change in LBA, but the high OJCV amount and low sampling frequency prevent us from making a healthy interpretation. It is highly probable that the stability of temperature values and the presence of wetter conditions towards the end of LBA reflect an increase in the pollen production capacity of trees that were no longer practiced but still existed due to previous agricultural activities, despite the relatively low settlement in the region. On the other hand, the change in the very good climatic conditions in the Middle and Late Bronze Ages, often associated with sudden changes in the Late Bronze Age, has been reflected in both proxy and model results, even though there may be temporal lags in the model. However, as can also be seen from Gölhisar and PaleoView, a sudden drought occurred around 3400 BP, continued until about 3100 BP, and then returned to normal levels quite drastically within about a century, with high temperatures and relatively normal rainfall. Considering the conditions of this relatively normal period of drought, the invisibility of the Middle and Late Bronze in Burdur may arise more from dynamics such as socio-cultural, political, and perhaps economic.

The slow but steady increase in the *Cerealia* type during the Iron Age indicates a decrease in the number of pollen grains indicating arboriculture and fruit culture. Although settlements in this period do not seem archaeologically significant in the early period, as time goes on, especially towards the late periods, it can be expected that settlements with a population that is not considered too high would have the lowest levels of OJCV, but cereal type-based production would be expected. The fact that it is invisible archaeologically in a period where temperature, humidity, and rainfall values are relatively stable and good can be attributed either to the inadequacy of archaeological studies or to other dynamics. However, the almost disappearance in the OJC and OJCV indices indicate that this possibility is unlikely. On the other hand, the replenishment or increase in trees and shrubs is progressing very steadily and drastically in this period, which may be due to both the improvement of climatic conditions and the low anthropogenic activity.

In the Archaic and Hellenistic periods, although substantial information about the nature of settlements near Lake Burdur is not known, it is likely that during the Hellenistic period, the territory of Sagalassos extended as far as Burdur Plain

(Waelkens, 2019; De Cupere et al., 2015). This is evidenced by the relatively dense Archaic and Hellenistic findings and identifiable settlements closer to Lake Burdur in the west than to the east of Sagalassos in surveys conducted in Burdur Plain (Willett and Vandam, 2020). In the pollen sample corresponding to the Archaic-Hellenistic transition and the sample from the Hellenistic period, the low OJCV levels in the Iron Age reached Bronze Age levels and continue relatively steadily. On the other hand, the reflection of this change in all indices is quite a unique situation. However, interpreting this unique event in this period when we have limited knowledge about land use patterns and archaeological settlement forms in Burdur Plain is quite challenging. Moreover, having only two samplings, albeit for a short period, also hinders us from making an interpretation.

In the pollen samples from the Roman period, although archaeological data about Burdur Plain is scarce and more available for Sagalassos in the East, an interesting pattern has been identified that can be inferred from surveys conducted in Sagalassos and its surroundings. In a plain where over 10% is very closed, the AP/NAP ratio in the 2nd century AD shows a number above 20, and relatively consistently low levels are observed in OJCV, PI and SI indices.

This period, known as the Roman Climatic Optimum, which is associated with the expansion of Rome, has occurred quite differently in Burdur, and although initially low levels of temperature and precipitation were observed in all models and proxies compared, an increase occurred afterward in all but Gölhisar. Whether this could contribute to agricultural complexity and development climatically is a highly problematic interpretation. However, it is important to consider whether this abundance in arboreal pollen is related to climatic change.

The almost absence of ceramics indicating the Roman period in surveys conducted in Burdur Plain after the Hellenistic period and the significant difference in the number of settlements between the east and west of Sagalassos, indicating a relatively urbanized settlement structure (Vanhaverbeke et al., 2007), may have led to the loss of importance of Lake Burdur and its surroundings after the Hellenistic period, strengthening the possibility of low anthropogenic activity in the region, which suggests a strong relationship between this critical change in vegetation and the absence of both climate and anthropogenic activity.

On the other hand, the gradual shift of the settlement understanding towards the east, probably towards the Dereköy Highlands, from Late Antiquity to the 7th century due to Arabic raids (Vanhaverbeke et al., 2007), although it could explain the loss of importance of the area, is insufficient to explain this anthropogenic potential effect. On the other hand, this vegetation pattern was not quite persistent. As can be seen in the pollen samples that followed immediately, in the Late Roman and Byzantine periods, the AP ratio, which was almost 17th century, almost never exceeded 10. Although the AP/NAP ratio exceeded 10 only once in the Early and Late Byzantine periods, it may be problematic to consider them as a value in itself because this is a period when OJCV most frequently appeared in this amount, albeit fluctuating. However, the almost disappearance of *Cerealia* type around the 9th century has no historical or archaeological counterpart.

As mentioned before, the significance of this pattern lies in the Beyşehir Occupation Phase (BOP) type of land use, which has appeared in many other pollen sites in southwestern Anatolia. Interestingly, this pattern began during the Roman period and continued until the Ottoman period, marking a notably late end for such a land use phase.

This intriguing study investigates the relationship between climatic changes over the past 500 years and whether anthropogenic influence has been the predominant factor. To understand this situation, changes over the last 500 years are examined in relation to Burdur Lake, which is presumed to reflect temporal climatic variations due to its proximity to the lake. Climatic data is juxtaposed with changes in the Ca/Fe ratio in Lake Salda (Danladi and Akçer Ön, 2018), OWDA scPDSI data by Cook et al. (2015), Burnette's (2021) drought variations, and isotope values from Kocain and Nar (Figure 6.5).

However, the exclusion of Gölhisar (Eastwood et al., 2006; Roberts et al., 2008) from this comparison is due to its low temporal resolution, which makes establishing a robust relationship difficult. The comprehensive analysis of these diverse data sources aims to elucidate the interplay between climate and human activity in the region, providing valuable insights into how historical climatic fluctuations influenced land use and settlement patterns. By integrating various scientific approaches and historical accounts, the study contributes to a deeper understanding of the region's environmental history and the long-term impacts of climate and human actions.

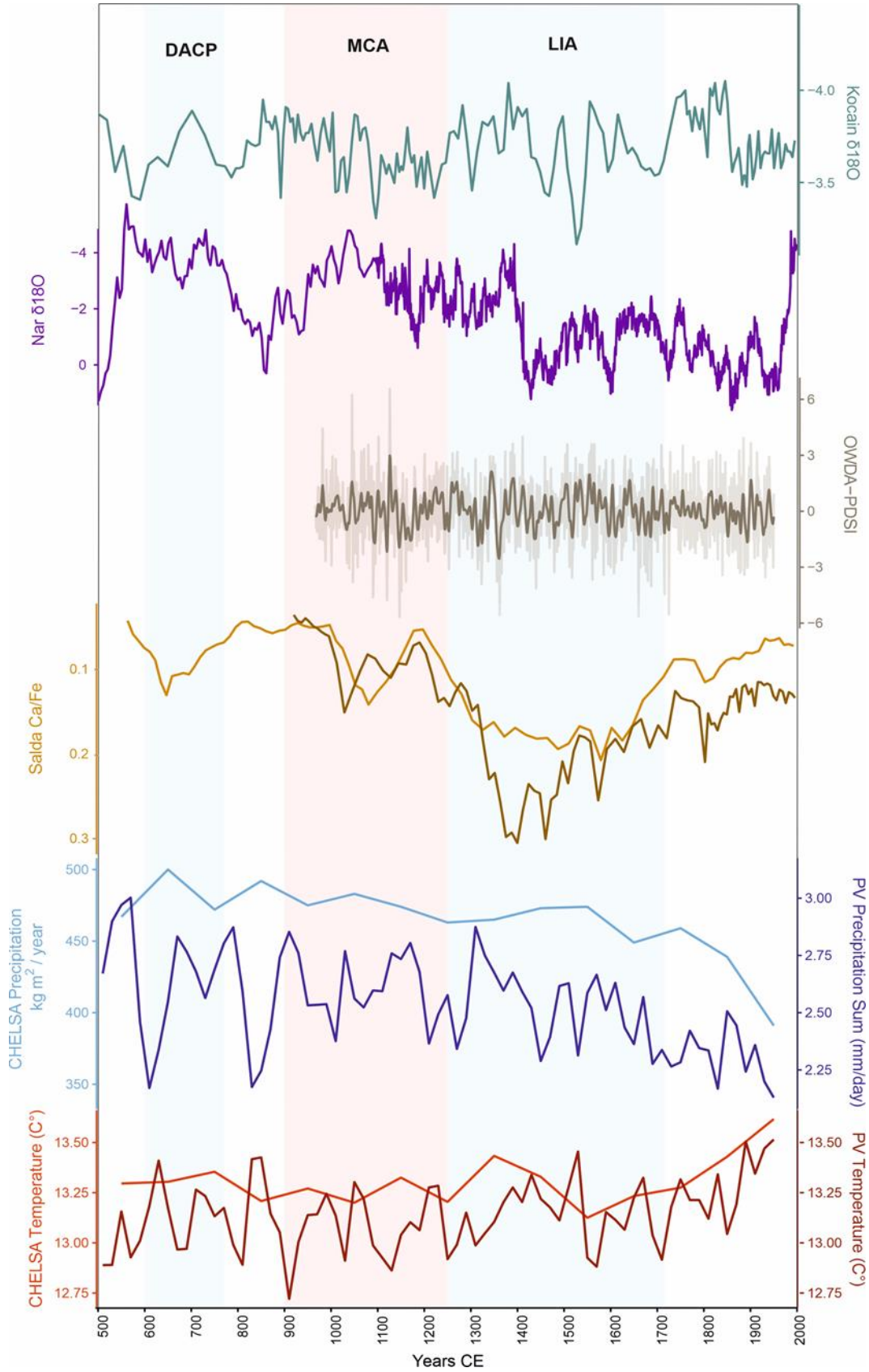


Figure 6. 5 : The last 1500 years of historical climatic changes in Burdur and Around. Note: Lower Oxygen isotope values indicate wetter and warmer conditions. The blue and red shaded regions indicate historical climatic events in Burdur, according to Danladi and Akçer-Ön (2018).

Danladi and Akçer-Ön (2018) solar changes deduced from cores G15 and G16's XRF data were used to contextualize certain historical climatic periods for Burdur. During the Dark Ages Cold Period (DACP), roughly estimated to be between the 6th and 8th centuries and generally characterized by changes in Europe, there were variable but high quantities of OJCV and Cereal-type, as well as PI and SI indices, while the AP/NAP ratio generally indicated conditions close to open forest.

On the other hand, the Medieval Climate Anomaly (MCA) manifested as a period of relatively favorable conditions following potential droughts in the 10th century. In the 11th century, barring a probable decline in cereal type, similar continuity indicated conditions close to close forest in terms of the AP/NAP ratio.

Especially influential in the European context, the Little Ice Age (LIA) between the 15th and 18th centuries was compatible with all proxy data, while OWDA2 also captured many successive drought periods. This period, particularly in Burdur, witnessed a surge in OJCV and Cereal-type pollen grains, indicating an explosion in PI and SI indices. Interpreting the AP/NAP ratio, which remained low but close to close forest, in light of this change would be a deterministic approach.

Thus it can be suggested that when using anthropogenic pollen indicators to study human-environment interactions, caution must be exercised. Although Deza-Araujo et al. (2020) found that some pollen indicators performed well within their original scope, overlooking issues such as chronology, sampling frequency, and pollen assemblage in fossil pollen studies is unwarranted.

The Burdur case highlights salient discrepancies between periods of substantial information despite the limited archaeological knowledge around Burdur Lake and its vicinity. The disappearance of settlements around the lake during the Middle and Late Bronze Ages, or the possibility that they preferred short-term settlements such as hamlets or villages, the low frequency of pollen sampling during these periods, and the non-association of the OJCV index performance with the region's settlement history are among the reasons. Not only for Burdur but also for most sites in the Lake District, the existence of extensive settlement traces or the absence of agricultural activity in communities thought to not exhibit extensive settlement or agricultural activity hinder a substantial interpretation. This could be due to traces of lakeside settlements in the region during the Middle Ages, which were probably relatively dense settlements and might have used trees and shrubs, possibly preventing us from correlating with climatic change.



7. CONCLUSIONS

The Burdur region in Turkey has been the focus of an interdisciplinary study that has integrated paleopalynological analysis with archaeological and climatological data. The study has spanned over 4,600 years and is centered on the sediment core BRDR-2 retrieved from Lake Burdur. This research has revealed valuable insights into the complex and multifaceted relationships between human societies and their environments in the region over the millennia. The study has provided a detailed understanding of the region's environmental history by examining the intricate and dynamic interplay of climate, vegetation, and human activity.

The study traverses through various epochs, from the Early Bronze Age to the Ottoman period, and has unearthed a remarkably intricate tapestry of human-environment interactions. Each period is marked by its own unique nuances and complexities. During the Early Bronze Age, the study observes the nascent stages of human settlement around Lake Burdur, accompanied by subtle but discernible shifts in vegetation dynamics attributable to early anthropogenic activities. However, disentangling the respective contributions of climate variability and human agency remains a formidable challenge, underscoring the inherent complexity of environmental change processes during this era.

As we progress through the Middle and Late Bronze Ages, the study encounters limitations in archaeological evidence and pollen sampling, which somewhat obscure our ability to comprehensively reconstruct land use practices and vegetation dynamics during these periods. Despite these challenges, tantalizing traces of Mediterranean-specific flora hint at the continued presence of human communities, albeit amidst uncertainties surrounding settlement patterns and agricultural strategies.

The Iron Age represented a notable shift towards cereal-based agriculture, as evidenced by the gradual decline in arboriculture indicators and the concurrent rise in cereal pollen types. However, the relative paucity of significant settlements during this period poses intriguing questions regarding the intricacies of human-environment interactions, suggesting the potential influence of socio-cultural or economic factors

yet to be fully elucidated. Conversely, the Archaic and Hellenistic periods present a denser archaeological footprint, possibly indicative of the territorial expansions of neighboring civilizations. Nonetheless, the limited scope of pollen sampling during these epochs impedes a comprehensive understanding of land use patterns and their environmental repercussions, leaving tantalizing gaps in our knowledge that beckon further investigation.

The Roman period emerged as a pivotal juncture characterized by heightened levels of anthropogenic activity, including widespread deforestation and intensive arboricultural practices, echoing broader trends observed across southwestern Anatolia during the Beyşehir Occupation Phase. This era of pronounced human influence coincides with notable climatic fluctuations, thereby complicating efforts to disentangle the respective roles of human agency and natural processes in shaping vegetation dynamics. Examining the past 500 years through the lens of historical climatic data and proxy indicators unveils a series of climatic oscillations, including the Dark Ages Cold Period, the Medieval Climate Anomaly, and the Little Ice Age. Each of these left an invisible mark on vegetation dynamics as human adaptations and land use practices in response to changing environmental conditions were probably superior.

However, amidst these myriad insights lie crucial caveats and challenges that merit careful consideration. The study's reliance on pollen indicators necessitates a cautious approach, acknowledging the myriad factors influencing their interpretation, including chronological considerations, sampling frequency, and the broader pollen assemblage. Furthermore, the inherent limitations imposed by sparse archaeological evidence and uneven pollen sampling underscore the pressing need for interdisciplinary collaboration and methodological rigor in future studies aimed at unraveling the complexities of human-environment interactions in the Burdur region and beyond.

Therefore, this comprehensive study offers a nuanced and deeply immersive exploration of human-environment interactions around Lake Burdur, illuminating the myriad dynamics that have shaped the landscape over millennia. By synthesizing archaeological, paleoenvironmental, and climatological perspectives, it lays the groundwork for a more holistic understanding of our shared past and the challenges that lie ahead in navigating the complexities of the Anthropocene. The quest for knowledge in this field remains ongoing, underscoring the importance of sustained

interdisciplinary collaborations and methodological rigor to glean deeper insights into the rich tapestry of human-environment interactions that have indelibly shaped our world.





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APPENDICES

APPENDIX A: Temperature and Precipitation Maps Obtained through CHELSA-TraCE 21ka

APPENDIX B: Temperature and Precipitation Maps Obtained through PaleoView



APPENDIX A

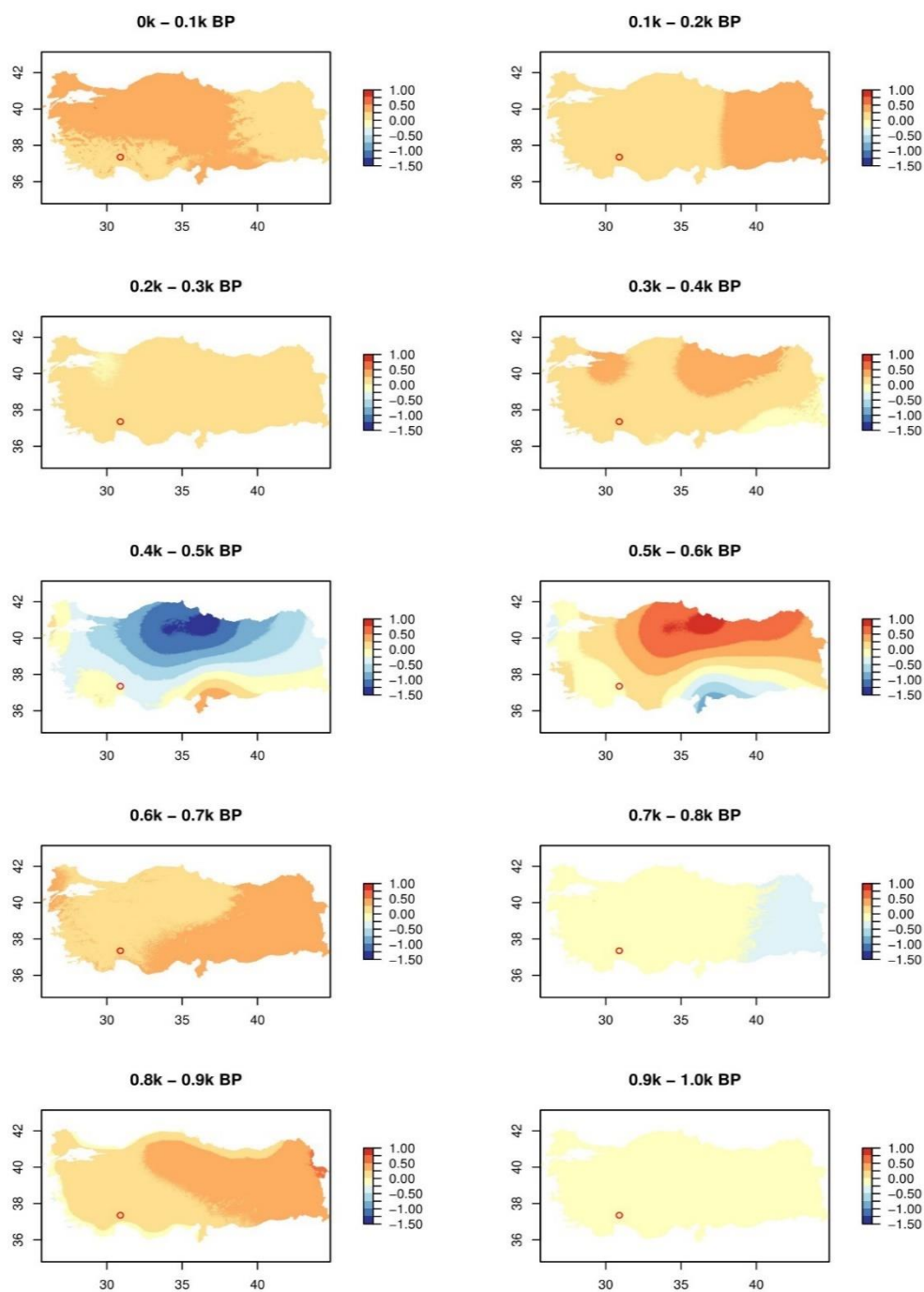


Figure A. 1 : CHELSA Temperature difference values per 100 years.

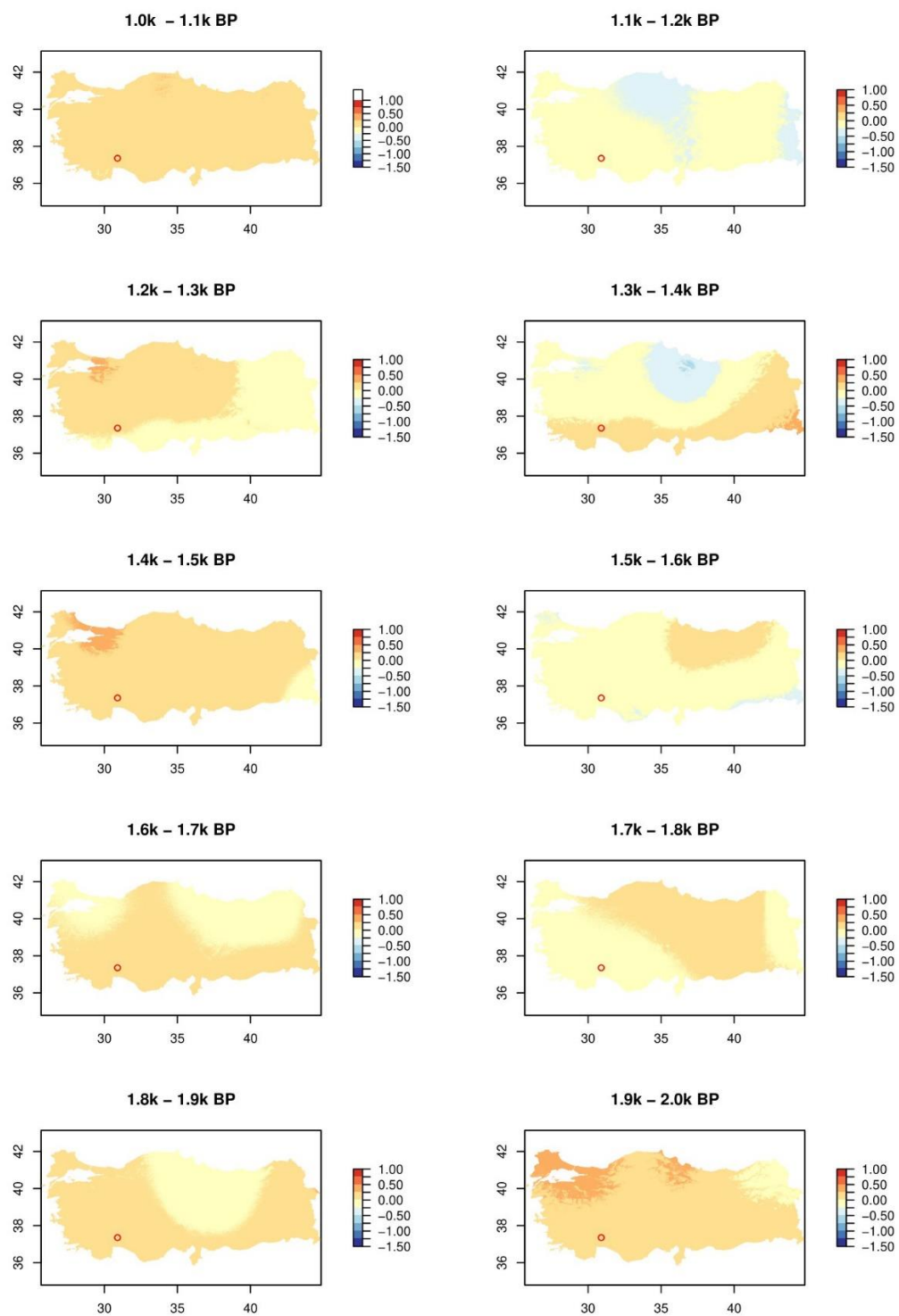


Figure A.1 (continued): CHELSA Temperature difference values per 100 years.

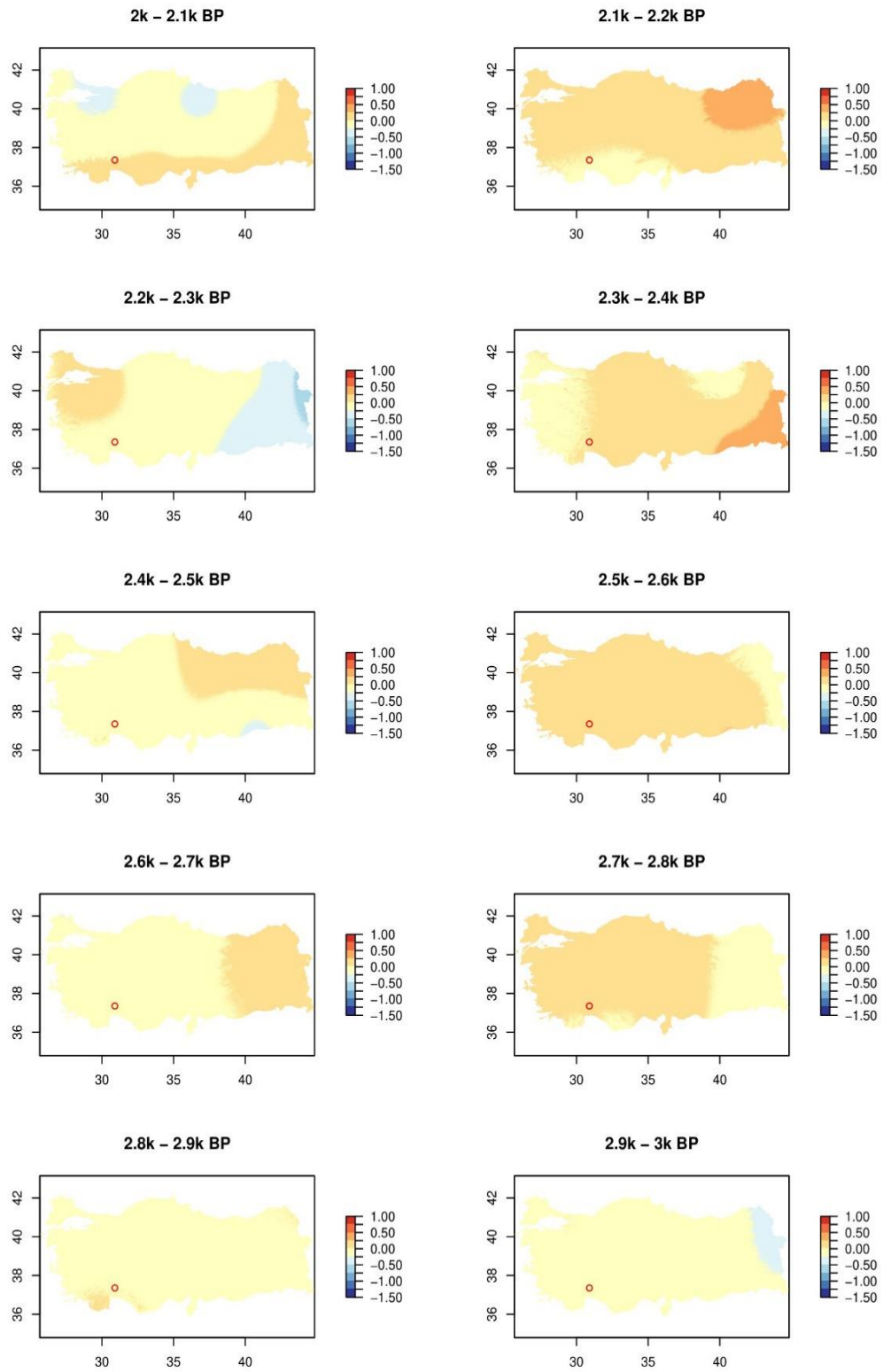


Figure A.1 (continued): CHELSA Temperature difference values per 100 years.

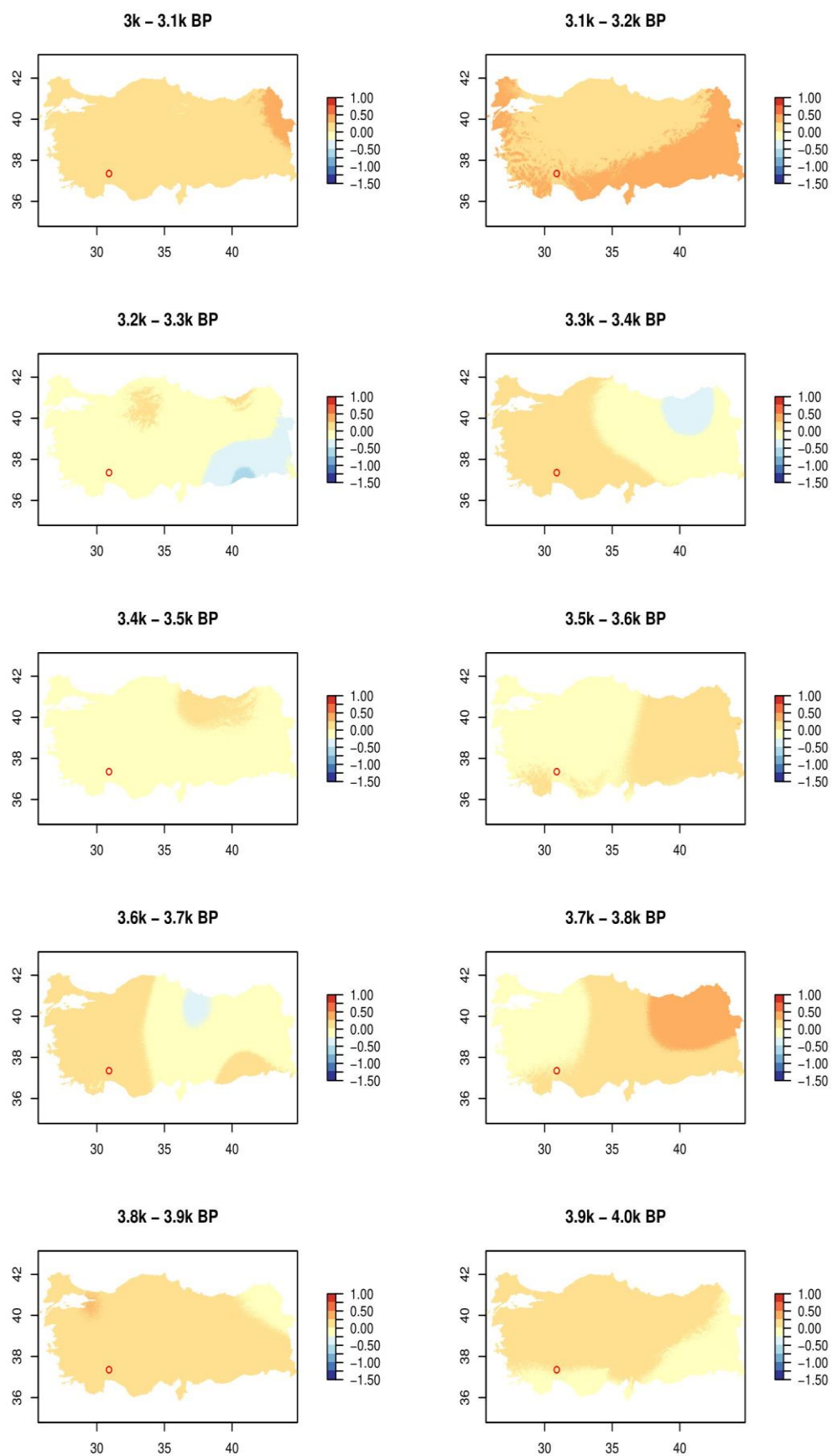


Figure A.1 (continued): CHELSA Temperature difference values per 100 years.

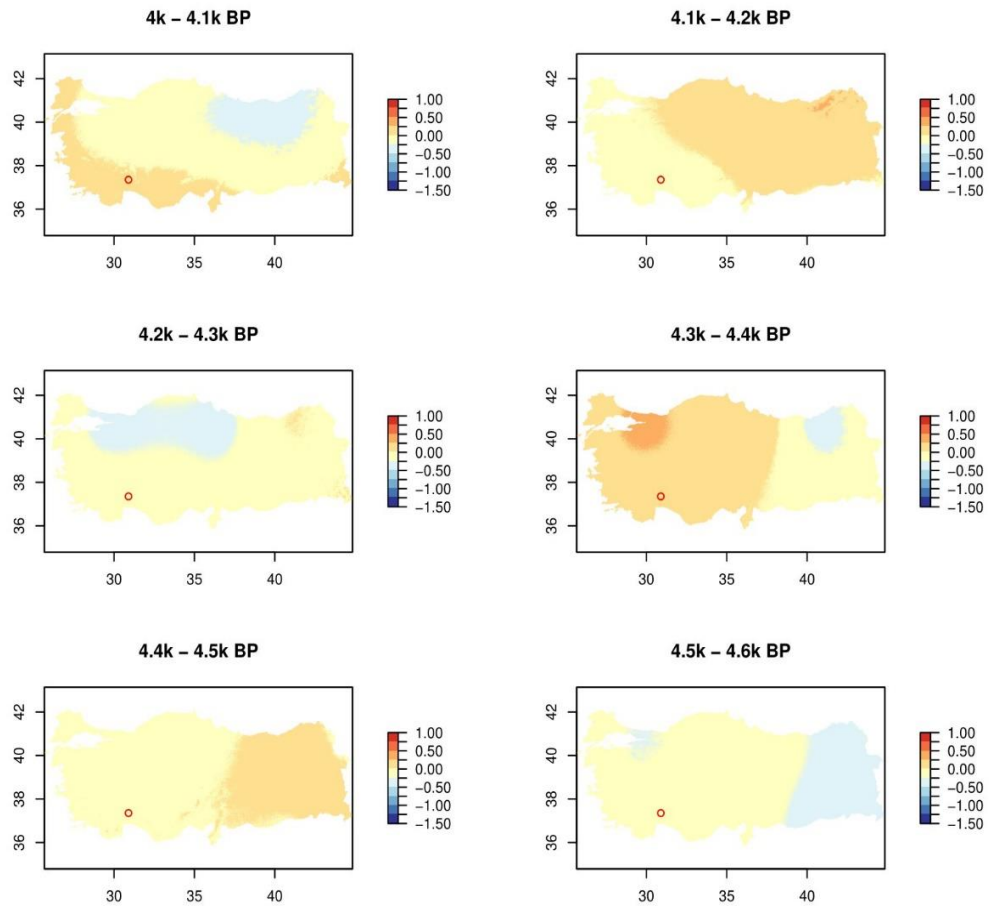


Figure A.1 (continued): CHELSA Temperature difference values per 100 years.

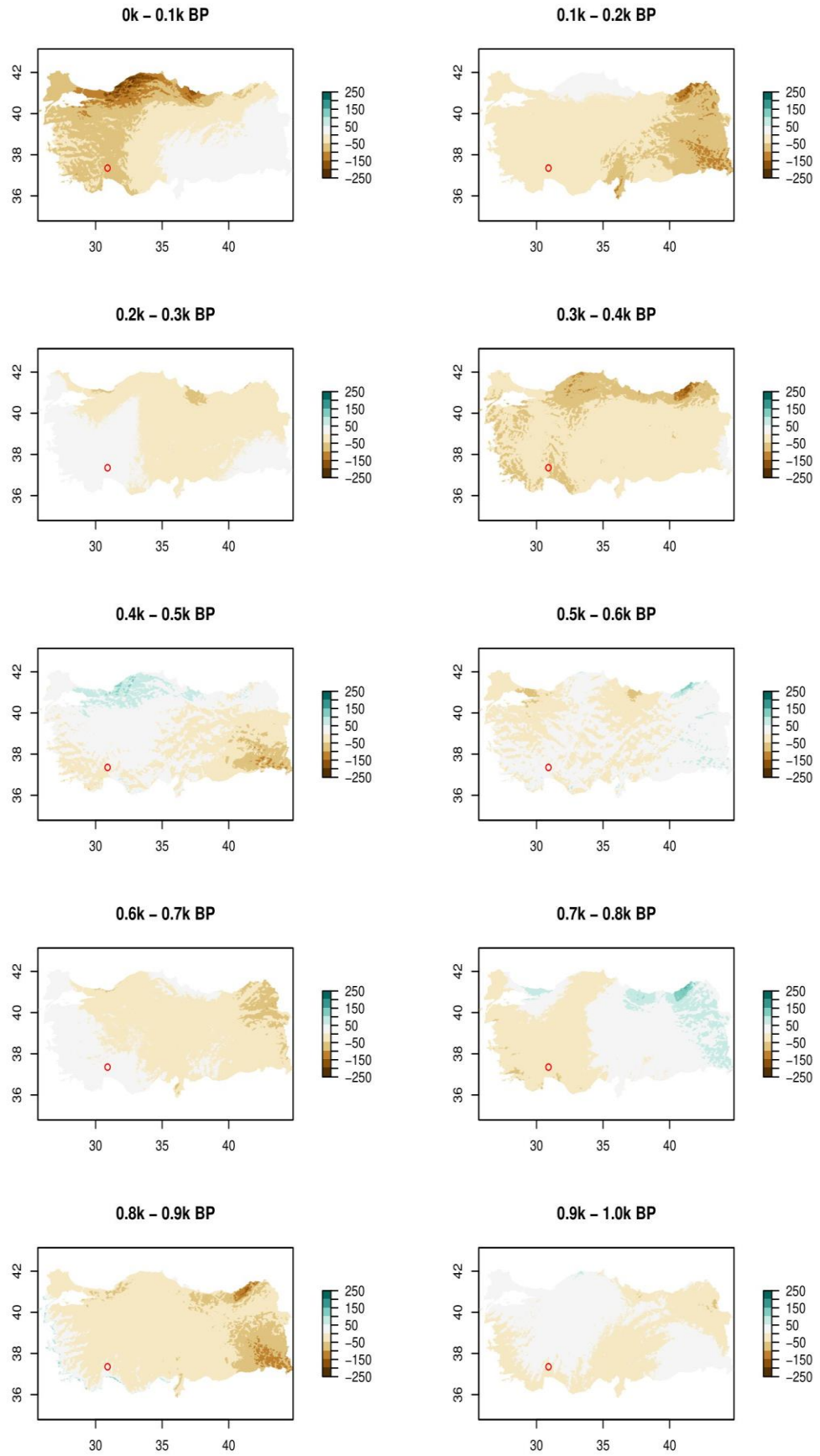


Figure A. 2 : CHELSA Precipitation difference values per every 100 years.

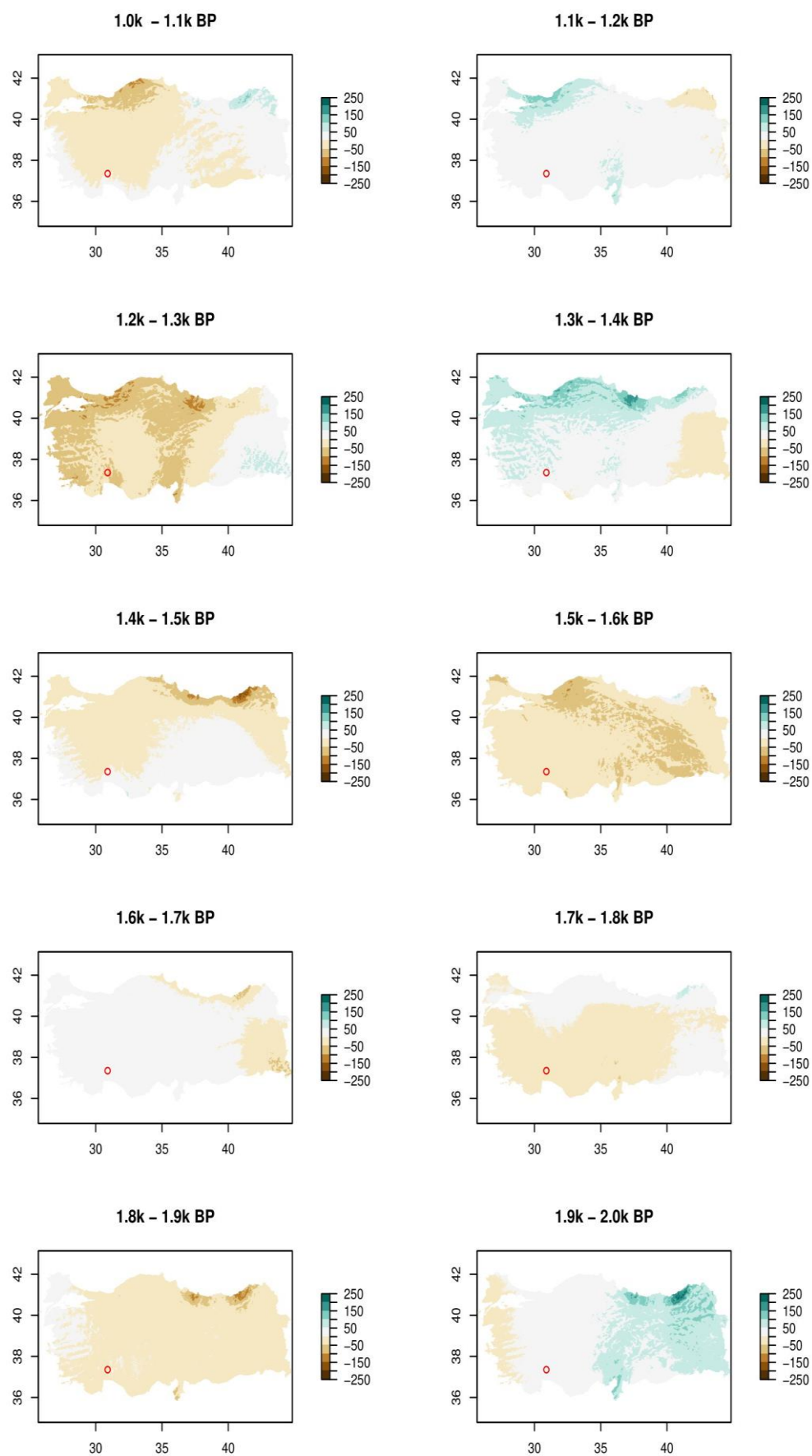


Figure A.2 (continued): CHELSA Precipitation difference values per 100 years.

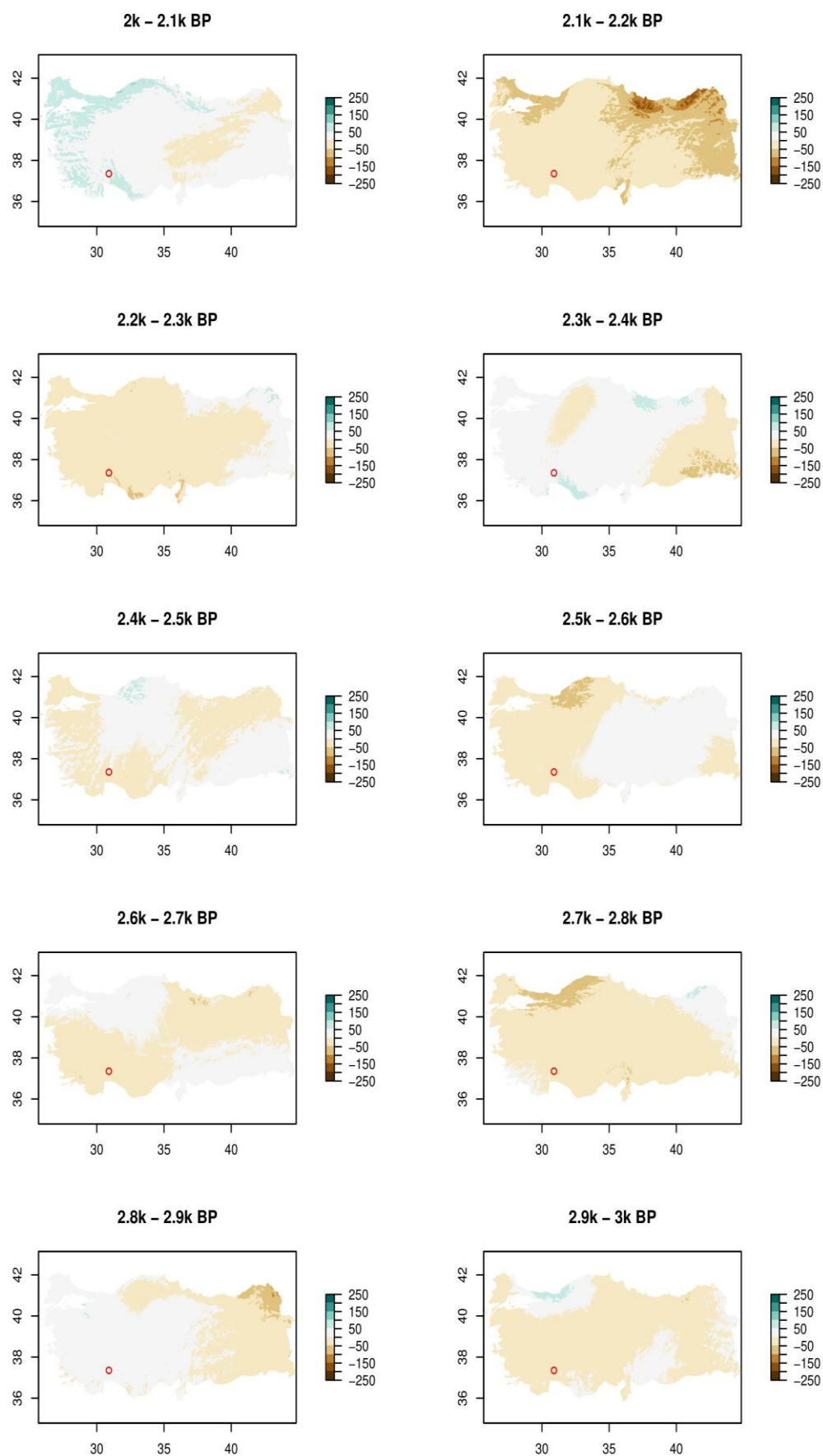


Figure A.2 (continued): CHELSA Precipitation difference values per 100 years.

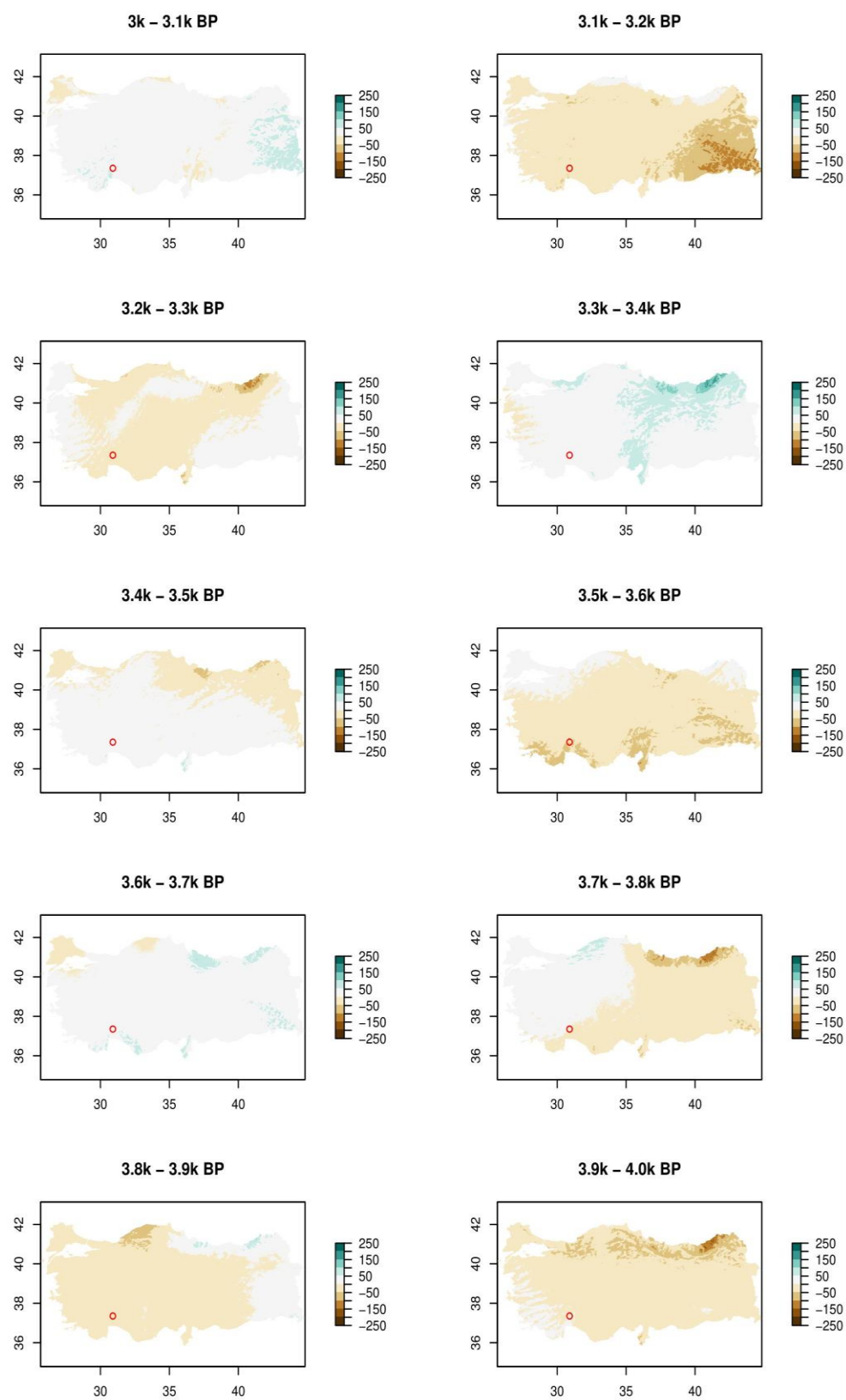


Figure A.2 (continued): CHELSA Precipitation difference values per 100 years.

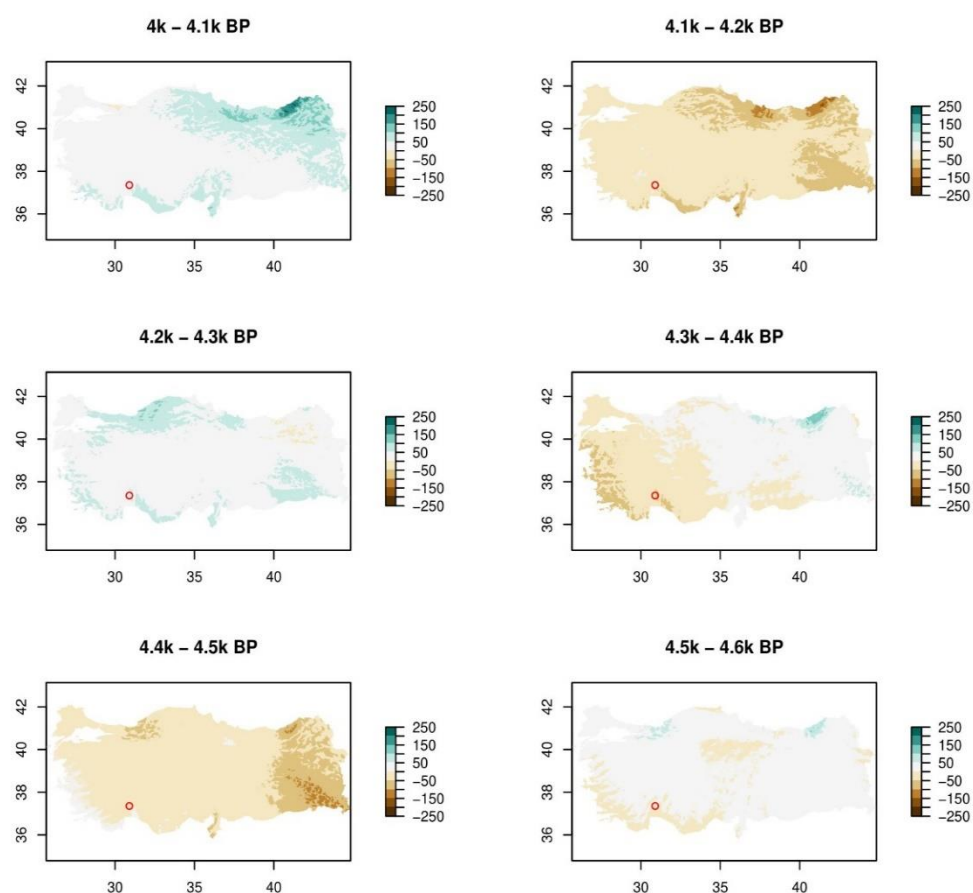


Figure A.2 (continued): CHELSA Precipitation difference values per 100 years.

APPENDIX B

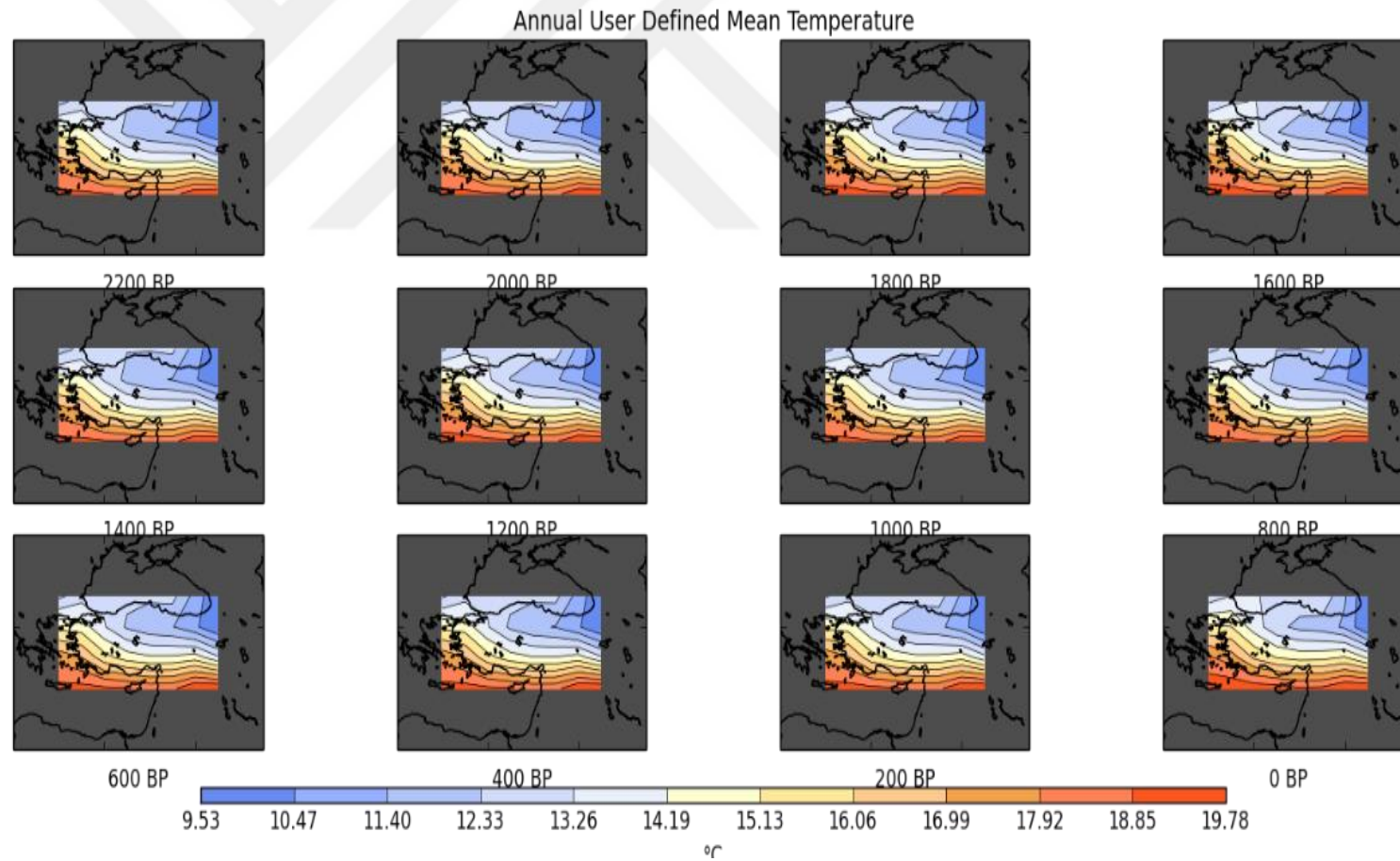


Figure B. 1 : PaleoView Temperature values per 200 years.

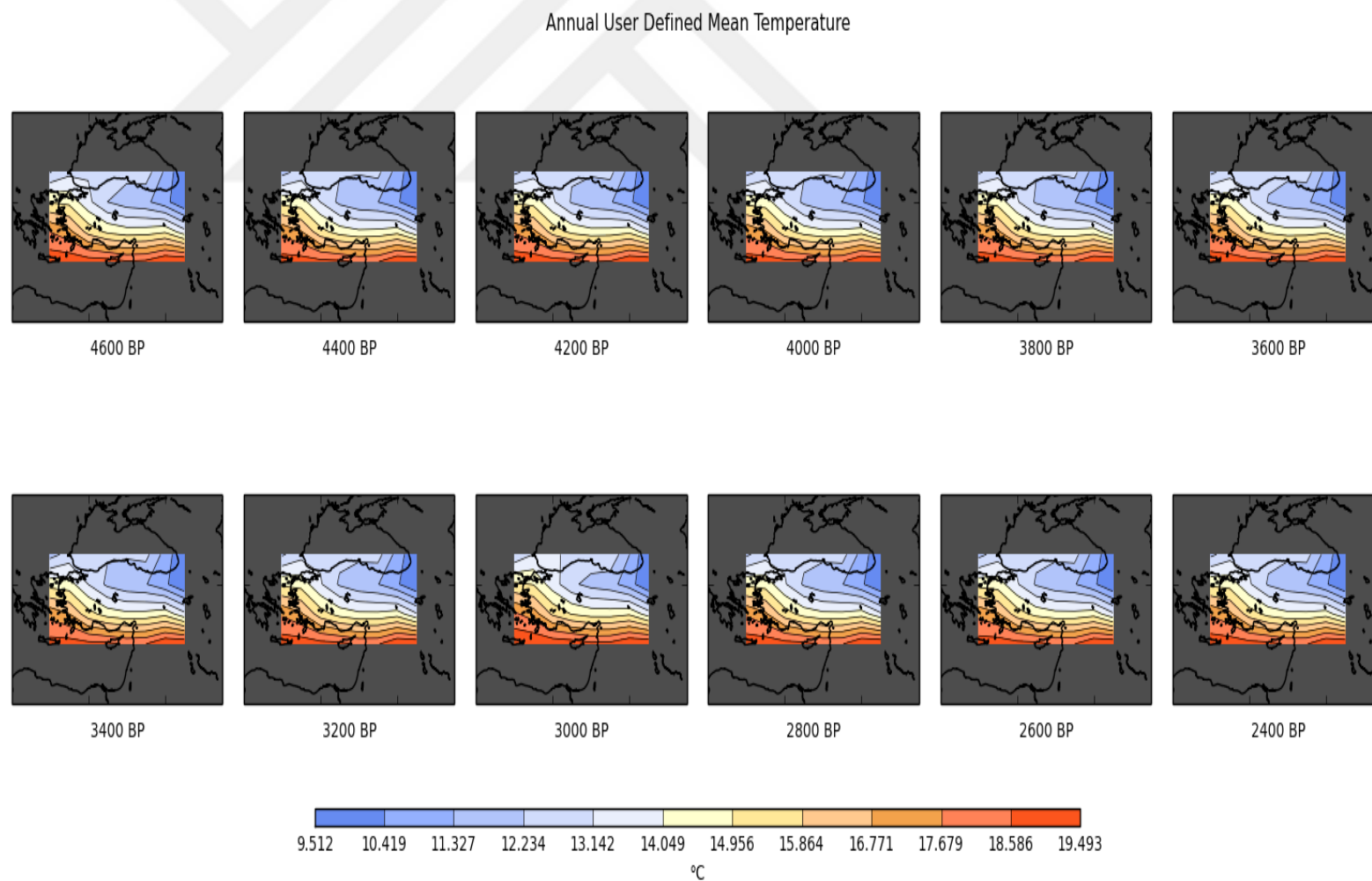


Figure B.1 (continued): PaleoView Temperature values per 200 years.

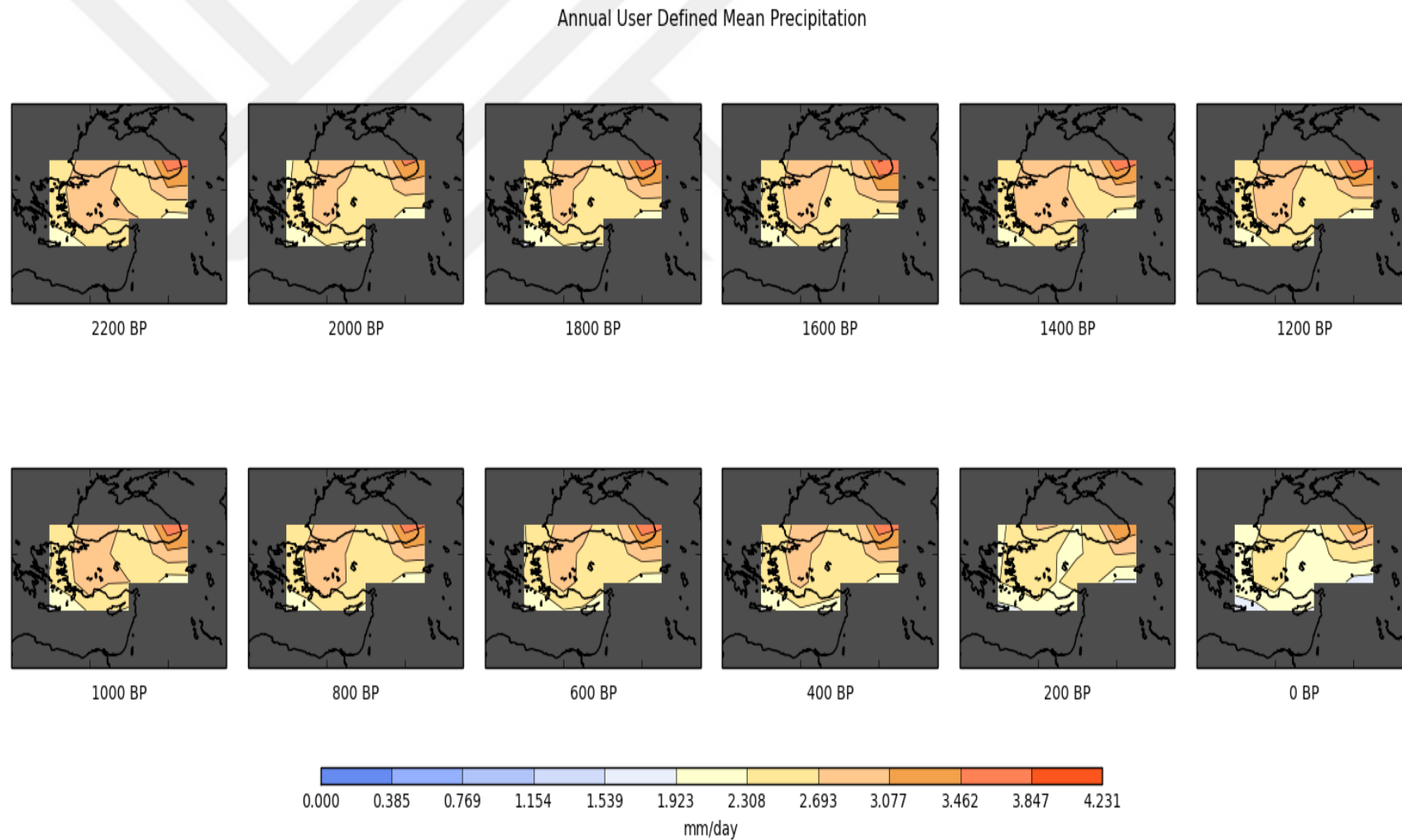


Figure B. 2 : PaleoView Precipitation values per 200 years.

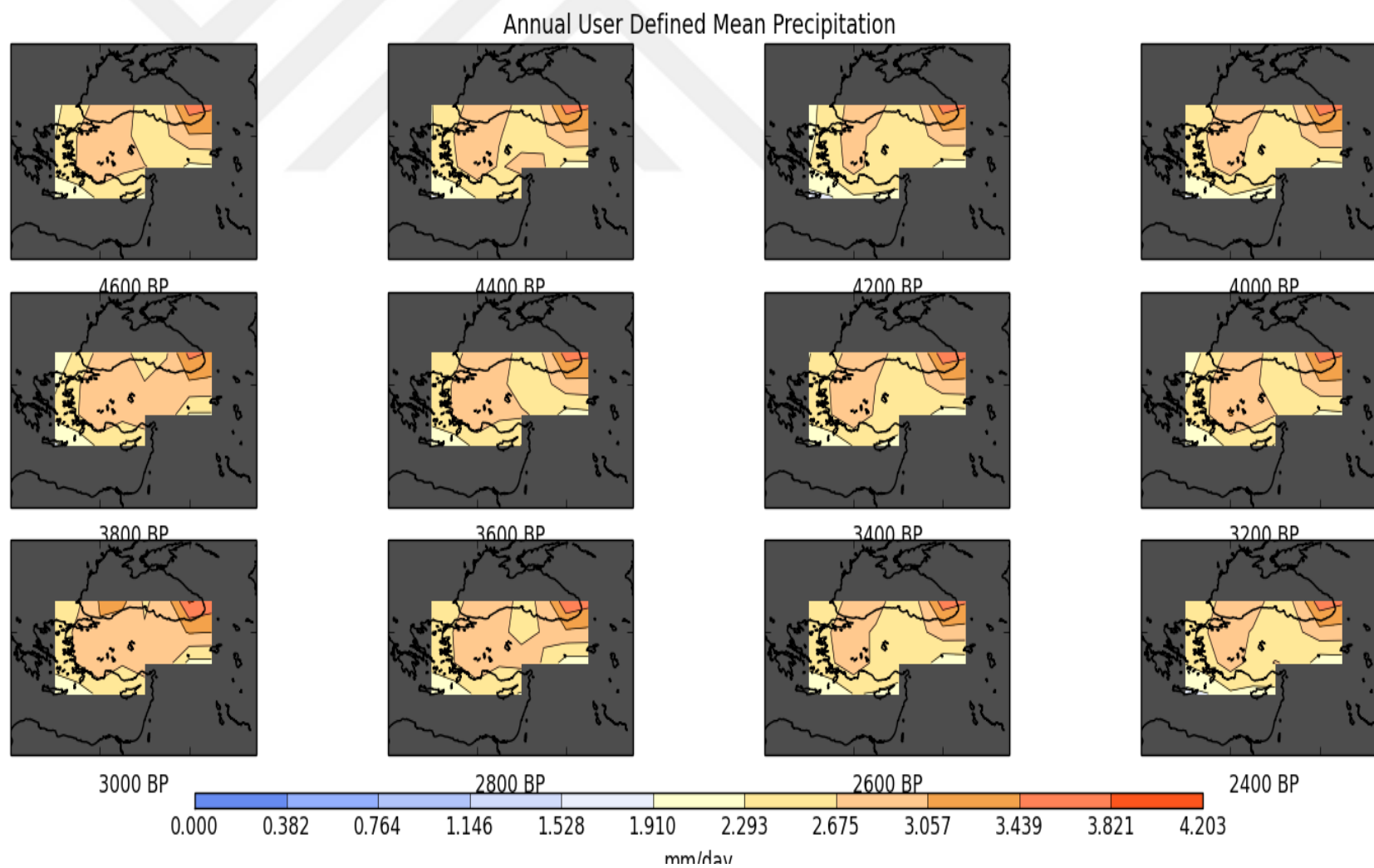
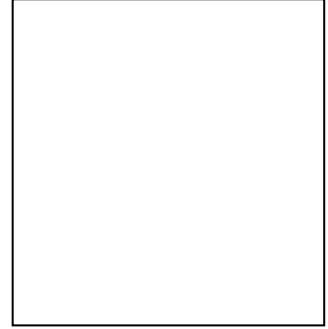


Figure B.2 (continued): PaleoView Precipitation values per 200 years.



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