

Preservation and Conservation concepts in the transdisciplinary perspective of Taphonomy

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Preservation and Conservation concepts in the contemporary perspective of Taphonomy

Contemporary Taphonomy aims not only to study the analysis of the degradation of biological remains and their transformation in deposits from the past (Palaeontology and Archaeology), but also, together with other disciplines such as Forensic sciences and Ecology, the study of depositional and postdepositional events concerning the degradation of biological remains in the present. Due to these interactions, Taphonomy has reached a new status as a transdisciplinary area that supports the interpretations of degradation processes in a broad sense, which would be applicable in the immediate future to other areas as Material sciences or Medicine. But such a wide and complex research panorama requires an agreement on the common terminology. This is crucial in relation with the use of the concepts preservation and conservation, which are widely used in many scientific areas and represent nowadays a dilemma incorporated into Taphonomy. Using Scopus database and network software analysis tools we have explored the relationships between concepts and disciplines implicated in the taphonomical analysis. Our results show that both terms have acquired different nuances through time in each scientific discipline implicated in the study of degradation and, depending on the circumstances and language, are sometimes used as synonymous or even misused.

Keywords: Taphonomy; transdisciplinary; dilemma; Scopus database; network analysis.

Introduction

Surely when John Passmore published the book entitled *Man's responsibility for nature* (Passmore 1974) he never thought that his dissertation could inspire future reflections concerning the use of preservation and conservation concepts in a discipline such as Taphonomy. But the historical development and expansion of Taphonomy has transformed it into a transdisciplinary area which nowadays faces exciting challenges that bring it closer to many other disciplines of study far from Palaeontology, where its origins were established (Efremov 1940).

Contemporary Taphonomy imbricates not only the analysis of biological remains from the past but also from the present, which implies working in conjunction with disciplines such as Forensic sciences and Ecology (Haglund and Sorg 1996, 2002; Swift and Mohan 2017; Olea et al. 2019). Such a complex interaction requires of the maintenance of an agreed common terminology which permits avoiding dilemmas like the one detected in relation with the use of the concepts preservation and conservation (Cambra-Moo et al. 2022), as was recently discussed in the 9th International meeting on Taphonomy and Fossilization (TAPHOS) and 6th ICAZ Taphonomy Working Group Meeting that took place in Spain in June 2022. In addition to being part of a heated debate maintained in Ecology for a long time (Minteer and Corley 2007), both concepts are also used in a large variety of areas. Among them we could name food production and handling (Zeuthen and Bøgh-Sørensen 2003), exploitation of natural resources (e.g., wood) (Goodell et al. 2003), and cultural heritage (architecture, literature, arts and digital information) (Dachs 1984; Borghoff et al. 2003; May and Jones 2006; Madariaga 2021). Even more, due to their interest in degradation, disciplines such as Material sciences (Kutz 2005; Shashoua 2008) and Medicine (Eliaz 2012) are on the brink of being integrated as part of the transdisciplinary scenario of Taphonomy. Therefore, it seems appropriate to critically review this dilemma to correctly face the future of Taphonomy, more so if we consider the

international context where both concepts are frequently used as synonymous or interchangeable (Cambra-Moo et al. 2022).

Passmore philosophy considered that, in Ecology, ‘to conserve’ or the conservation process means ‘to save’, always in the sense of saving natural resources for later consumption. Preservation, on the contrary, is applicable when the saving act is mainly a ‘saving from’ instead of a ‘saving for’ (“saving of species and wildernesses from damage or destruction”, Passmore 1974, p. 73; Norton 1986). But both concepts are also used, with some differences, within Taphonomy. For example, preservation is frequently assimilated as a synonymous of fossilization (Raup and Stanley 2006; also referred as “bone turned to stone”, Wiersma et al. 2021), which is essentially true, but in the context of the new paradigm of Taphonomy explained above, that introduces confusion by the simple fact that not all preserved remains become fossilised (Cambra-Moo et al. 2022). In this sense, decades of experimental taphonomy show that terms such as fossilization and preservation (Sansom 2014; Briggs and McMahon 2016), must be out of any ambiguity and, as Purnell et al. (2018) clairvoyantly referred, fossilization must represent the outcome of the action of different processes that promote information loss (decay process) and/or information retention (preservation process). In the case of conservation, confusion arises when Palaeontologists and even Taphonomists use it indistinctly or as synonymous in relation to preservation (see Cambra-Moo et al. 2022) or use it for example to refer to exceptional preservation deposits (‘conservation deposits’, Sanders and Gee 2021). This last could be cumbersome if the origin of the term is not known (it comes from the German *Konservat-Lagerstätten*; Seilacher 1970, Seilacher et al. 1985; Lyman 1994; Carlton 2021).

Taphonomy has historically been centred in the interpretation of the signals evidenced on preserved remains to unveil how biological entities become incorporated into the lithosphere (Efremov 1940, Behrensmeyer and Kidwell 1985). At the beginning, postdepositional

narrations were built assuming that taphonomical alteration was a destructive process in which, depending on ecological conditions, some types of signals become evidenced on remains (Weigelt 1989; Cadee 1991). Such a destructive (loss of information) point of view also introduced the associated concept of the incompleteness of the fossil record, which would represent a constant bias in the inference-based hypotheses about taphonomic modifications. Beneath this classical taphonomical perception, multiple factors were identified during the taphonomical alteration both before burial: biotic (intrinsic), thanatic (death) and perthotaxic (pre-burial); and after burial: taphic (burial), sullegic (collecting) and threptic (curatorial) (Clark et al. 1967; Fernández-López and Fernández-Jalvo 2002; Marin-Monfort et al. 2018).

During this “classical” period, Taphonomy became a multidisciplinary platform based on a common praxis supported by the development of an important number of methodologies working back from signals discovered on preserved remains (Knüsel and Robb 2016; Shipman 1981). Data concerning location, form, orientation, direction, inclination or the description of biological characteristics (such as the number of elements from each individual and the level of overlapping between elements) was minutely collected in order to infer depositional conditions and taphonomical agents (Behrensmeyer and Hill 1980; Brain 1981; Cambra-Moo and Buscalioni 2003; Shipman 1981; Lyman 1994). Even burial typologies were also described in terms of completeness and quality preservation (Buikstra and Ubelaker 1994; Stojanowski et al. 2002; D’Angelo del Campo et al. 2017; Rascón Pérez et al. 2011).

But a brand new taphonomical perspective raised from original ideas, such as those proposed by Sixto Fernández López, which supported the establishment of a novel paradigm for Taphonomy based on the idea of a non-exclusively destructive taphonomical process (Cambra-Moo et al. 2022). Under this constructive approach, fossils became not necessarily formed from organic matter or retain any of their original characteristics (Fernández-López 1991, 2000), and taphonomical reasoning could also investigate the taphonomical process

itself. This new paradigm led to finally recognise Taphonomy as an independent discipline with its own hypotheses and methodologies, and from which biological and taphonomical interpretations became equally inferred (Fernández-López 1991, 2000; Domínguez-Rodrigo et al. 2011).

Under the constructive premises established by the new paradigm of Taphonomy, organic and inorganic entities both pass through taphonomical processes and can be analysed under similar hypotheses and methodologies. It is precisely from this transdisciplinary perspective that we have reviewed the use of the concepts of preservation and conservation in the different disciplines related to Taphonomy aiming to unveil which are the main challenges that must be overpassed to reach a consensus on their use. For that purpose, we set the following objectives:

- to explore the most relevant definitions related with both concepts considering the etymology of the terms and different languages,
- to explore the literature in order to analyse the evolution of concepts and disciplines related to the taphonomical analysis,
- to create a database with the most important nodes (referred to concepts and disciplines) that allow us to deeply understand its imbrication and relationships with the historical development of Taphonomy,
- to identify the establishment of important hubs during the evolution of the concept-network of Taphonomy.

Material and Methods

To explore the utilisation of the concepts of preservation and conservation from an etymological point of view (i.e., as acts and nouns derived from the verbs ‘to preserve’ and ‘to conserve’), we explored and collected most common definitions found in current general and

specific vocabularies, glossaries, and dictionaries of different languages. Table 1 collects the Latin source for both terms considering their prefixes, Table 2 and 3, definitions from dictionaries and glossaries from British, American and other English sources, and Table 4, definitions from dictionaries of Romance languages (French and Italian) close to Spanish, the authors' native language.

[Place Table 1, 2, 3 and 4 here]

After that, we explored the Scopus database (Elsevier B.V., Amsterdam, Netherlands) publications of the last 120 years (from 1900 to 2020) that include in their title, abstract and keywords concepts and disciplines shown in Table 5 or combinations of them. The exploration of the data was carried out using basic Boolean search commands “AND”, “OR” and “NOT” that were combined in the search tool of the Scopus webpage (<https://www.scopus.com/>; Elsevier B.V.). The experiment was carried out under the institutional access to Scopus database offered by the *Universidad Autónoma de Madrid* through *Fundación Española para la Ciencia y la Tecnología* (FECYT) Spanish institution.

[Place Table 5 here]

Raw data referring to multiple search combinations between concepts and disciplines were used to build up a database using Excel software (Microsoft ©). The combinations were later analysed with the free licensed Gephi network analysis software (Gephi.org, 2022). The 12 concepts and disciplines (see Table 5) were investigated over a timespan of 120 years representing them as nodes or vertices of a network. The interactions between them, that is, the number of publications in which each pair of nodes appeared interconnected every year, were

interpreted and represented as edges or links of the network (Oulas et al. 2019). Gephi software allowed us to explore network structural variation established by the nodes and edges during the lapse of time analysed. For that, first we transformed the Excel database in two different data files, one with nodes timeseries and another one with information from the edges. Both files were imported into Gephi software to construct an undirected graph, a spatial representation in which there was no order between nodes (Cherven 2013). After the data were imported, we processed graph representation considering weighed nodes (number of publications that each node accumulated in each moment) and the distance between them, adjusting the graph spatial representation using algorithms that calculate repulsion forces between them and assumes nodes as springs. In this case, we used “Yifan Hu Proportional” layout algorithm to modulate optimal distance (which permits controlling the graph density) and theta (which permits adjusting the accuracy of the graph) parameters, which allowed us to explore graph structure under controlled conditions (Khokhar 2015). In the resulting graph, similar nodes occupied the same subspace and the repulsion forces between nodes were calculated by the specific algorithm using pairs of adjacent nodes, which reduced complexity making the process faster. Lastly, a modularity class analysis was performed to investigate the strength of the network as a whole and to detect communities in the network. Modularity classes were represented with different colours in the graphical representation of the network (see below Figures 2 and 3) (Khokhar 2015).

Results

Attending to their etymological roots, preservation and conservation concepts are configured by the union of the Latin verb *Servō*, which means to maintain something intact either animate or inanimate, with the prefixes *Prae-* or *Con-* (Table 1). When *Prae-* accompanies the verb *Servō*, it indicates temporal precedence. On the contrary, when *Con-* accompanies *Servō*, it

means simultaneously or together (Glare 2012). Different nuances of English language denote some important variations in the meaning of both concepts. Firstly, in English, both American and British (see Table 2 and 3), preservation mainly maintains the same meaning as in its Latin origin, which also correlates with Passmore's proposition (1974; Norton 1986), 'saving from' (mainly from damage or decay). However, the definitions for conservation seem not to be so clearly defined. They appear to be usually oriented to the protection of natural resources for their potential use (i.e., the 'saving for' sense), but sometimes the concept also appears related with protecting nature from damage, which is confusing because this meaning aligns better with preservation rather than with conservation.

When we explore other sources as definitions provided by UNESCO (UNESCO 2022), descriptions become more complex and both seem to correlate with the 'saving for' sense, as it occurs with the, or even both become closer in their meaning as it occurs in the example of the Dictionary of Ecology (see Table 3). The exploration of Romance languages derived from Latin (Spanish, French and Italian) evidences that preservation is used according to Passmore's sense (Passmore 1974). But surprisingly, conservation meanings related with 'saving for' are again confusing. Conservation meanings are related with the maintenance of the durability of something, and even the verb 'to preserve' is used to explain the conservation concept (Table 4).

After the examination of preservation and conservation multiple definitions, we explored Scopus database to quantify the number of publications in which both concepts appear in the specialised literature. In general, more than 76,000 records from Scopus database concerning publications between years 1900 and 2020 were obtained. As it can be seen in Figure 1, conservation and preservation concepts were significantly more abundant in the specialised literature than the others (see left axis in Figure 1A); diagenesis and fossilization were the next in number of publications, but their numbers are lower by several magnitudes

(right axis in Figure 1A). Biostratinomy and fossildiagenesis were so poorly represented that they were not plotted in the graph. When all concepts are explored in combination with Taphonomy, we observed that preservation was the most represented followed by diagenesis, fossilization, conservation and biostratinomy (Figure 1B). Fossildiagenesis is apparently barely used in relation to Taphonomy.

Concerning the analysis of the relationships among nodes, we performed combinations between concepts and disciplines defining relationships or edges. We identified publications with pairs of concepts for each year for the last 120 years. Table 6 represents the amount of publications in which each pair of concepts appear together (intensity pattern of edges). A total of 66 edges were recognised, being the most intense those between conservation and Ecology (C-E in Table 6) and between preservation and conservation (P-C).

[Place here Figure 1]

[Place here Table 6]

In relation to the ensembled analysis of nodes and edges we present relevant data of the temporal development of the graphical representation of the resulting network in Figures 2 y 3. At the beginning, nodes were clearly isolated from each other. Preservation and conservation, as well as Palaeontology and Archaeology, were quickly established as interconnected nodes (1908, Figure 2A). After 1940 preservation links to Ecology, and Archaeology also becomes linked to conservation (Figure 2B). In 1945 Ecology started to be an important hub thanks to its interconnection with conservation (Figure 2C), and after 1955 Palaeontology started appearing in relation to conservation, preservation, and Palaeoecology (Figure 2D). Around 1967 Palaeontology reached an important expansion in the number of edges and became an

important hub. At the same time, Forensic sciences appeared in networks in connection to preservation, Archaeology and conservation concepts (Figure 2E). In 1971, the database collects the first record related to Taphonomy (Figure 2E), that will continue accumulating edges until becoming an important Hub in the network around the 90's (Figure 3A-C). From about 2009 to current days, the Forensic sciences experienced a significant growth in relation to the other analysed concepts (Figure 3E-F).

[Place here Figure 2]

[Place here Figure 3]

Discussion

What can we interpret from data?

The exploration of the definitions of preservation and conservation has evoked interesting and unexpected revelations. Historically, both terms are clearly interconnected in their use on science, but their utilization differs or even becomes confused when different disciplines are included in the analysis. It seems that major controversy concerns the use of the concept of conservation (Table 2-4). As we see in Figure 2, from the beginning this concept was close to Ecology and related with saving natural resources “for” (Passmore 1974), and this, as we have evidenced, introduced some distortions when the concept is used outside the umbrella of Ecology (Table 3). In this sense, we considered highly recommendable to review all possible meanings and ways of utilization of both terms and to focus our efforts into establishing a consensus that helps differentiating when conservation is used in relation to the exploitation of natural resources (which have veiled commercial interests) from when it is used in relation to the archaeological or paleontological record and cultural heritage (where commercial interests

should not be present). In the same sense, a revision of the definitions of conservation in Romance languages seems likewise advisable (Table 4), because most of them are far away from the etymological source. All of these factors introduce difficulties in a contemporary paradigm of Taphonomy that entwines multiple disciplines apart from Palaeontology.

The representation of concepts and disciplines as nodes, and the number of publications shared by these nodes as edges, has helped us to explore the complexity reflected in the literature related to the taphonomical analysis (and Taphonomy) in a broad sense. The analysis of the temporal behaviour of the network built considering publications collected from Scopus database (Figure 1) helped us to quantify the relationships between nodes and edges (Figures 2 and 3). This has been crucial to better understand the present use of all concepts in the transdisciplinary perspective of contemporary Taphonomy. During the early twentieth century, preservation and conservation were largely represented and established the first important link that marks the starting point of the network. The Palaeontology and Archaeology nodes also established early interactions, but they were initially isolated from other concepts (Figure 2A). In the 40's the network was clearly polarised between preservation and conservation nodes (Figure 2B). This is the result of an important discussion established in Ecology between conservationists and preservationists and coincides in time with the development of discussions for a new ethic perspective regarding the relation of man with nature. As Passmore explains, the idea that man was superior to nature based in religious beliefs needed to be deeply questioned and reoriented (Passmore 1974). What was unexpected in the evolution of the network around the 40's is that the efforts made by pioneers of Taphonomy like Efremov (1940) among others was not registered in Scopus database (Figure 2B). This is evidenced in the fact that Taphonomy would take 30 more years to appear in the scene (Cadee 1991). Around 1945 Ecology was the most important hub in the network (Figure 2C), but at this time we can also recognise the starting point of the Palaeontology “golden age”, which will reach its zenith

at the end of the 60's. During this time Palaeontology linked to the concepts of conservation and preservation, and this could be assumed to be the moment in which the meanings of both concepts started to differentiate from those established in Ecology. At the same time Paleoecology appeared in the network and quickly linked the subspace between Palaeontology and Ecology (1955, Figure 2D-E). During the 60's fossil diagenesis and diagenesis were incorporated into the network as well (1967, Figure 2E). Forensic sciences appeared also at this time, and in 1971 Taphonomy appeared for the first time in the network linked to preservation (Figure 2F).

From the 70's Taphonomy acquired relevance in the network, and it would remain an important hub for thirty years. The translation of Weigelt's work in 1989 (originally published in 1927) promoted the expansion of Taphonomy that started to be based in a new perspective in which the empirical observations under natural or controlled degradation conditions (developing systematic experiments, Allison and Bottjer 2011) led to new hypotheses and the incorporation of new methodologies. In 1978 Taphonomy became linked to many nodes and the number of related publications substantially increased (Figure 3A). This period could be described as a multidisciplinary scenario in which Taphonomy started being imbricated in all studies that analysed remains not only from paleontological but also from archaeological sites. After that, Taphonomy started also to progressively be linked to Ecology, conservation and finally to Forensic sciences (1997, Figure 3B-D). From there on, Taphonomy started to abandon its multidisciplinary status to be transformed into a transdisciplinary area (Nicolescu, 2014) not only dedicated to the analysis of biological remains in a retrospective way but also in a prospective sense. This important transformation in Taphonomy was also accompanied with the progression of Forensic sciences, which became an important hub in the network around 2009 when it reached a substantial increase in the number of publications (Figure 3E-F).

Which is our proposal?

The current scenario of Taphonomy enables the proposition of new hypotheses concerning degradation in a much broader sense, not necessarily associated exclusively with biological remains. In this sense, degradation is a time dependent universal process that determines the transformation of the original information of something that lost its original characteristics (information loss as Purnell et al. 2018 proposed for organisms' degradation). During the taphonomical process, preservation and conservation agents could intervene regulating degradation intensity or avoiding it (stabilization in Figure 4). Unlike degradation's universality, preservation and conservation are partially or totally influenced by human activity, and that is what has made both concepts to acquire different meanings that must be agreed on in order to permit their transdisciplinary use.

[Place here Figure 4]

Under our point of view the use of the concepts of preservation and conservation must be based in their original etymology from the Latin verb *Servō* that means to maintain something intact (see results section). Taking this as a reference, preservation (agents and process) acts saving something from degradation (promoting information retention, Purnell et al. 2018), that is, keeping the major quantity of the original characteristics of something and reaching a stage in which we can recognise or infer that information (preservation stage in Figure 4). On the contrary, conservation (agents or process) acts saving something with the aim of maintaining the characteristics that it has at a particular time, which seems to be appropriate in relation to those situations in which at least some original characteristics are no longer present (something has been altered or transformed due to degradation). With this

interpretation, preservation could be produced by natural or non-natural causes, but conservation must be restricted to non-natural causes (anthropologically influenced) (Figure 4). For example, preservation of biological remains could be naturally or anthropologically induced. A forest could be naturally preserved as a petrified forest but also maintained intact protecting it from fire or exploitation. In the same way, organisms (as in the case of mummies) or foods could be preserved by natural anoxia, extreme low or high temperature, or by similar processes induced by humans (e.g., evisceration, salting, drying, smoking). Both modes of preservation result in the maintenance of a large amount of original information. However, to ensure the state of preservation reached, conservation actions are mandatory to avoid the progress of the degradation process (e.g., replant trees in an exploited forest, controlling temperature in a museum showcase or inside our freezer). The same reasoning could be applied to non-biological remains. For example, information has been historically registered and/or stored in multiple formats, from simple rock engravings or paintings, to books, compact disks, USB drives, or even cloud storages. While these storages are in use, they permit preserving information by simply replicating contents in the most appropriate support depending on the nature of the information. But when those storages become obsolete or are abandoned, conservation actions become again crucial to avoid the loss of information (e.g., protect rock art from degradation, restoration of a book, etc.).

Conclusions

The use of preservation and conservation varies between the different disciplines and languages that utilise these concepts. Under our point of view, the time has come to assume that Taphonomy has overpassed its classical definition and now supports the analyses of the degradation process in a much broader sense. Taphonomy can be used not only to describe the degradation of biological remains or the fossilization process but can also be applied to the

analysis of buildings, materials, or even digital data whose degradation needs to be evaluated. In this sense, it seems necessary to revisit the use of preservation and conservation concepts, since as has been demonstrated, there is an important dilemma in their use that urgently needs to reach a consensus.

We propose that, in general, preservation must be used with the ‘saving from’ sense, which links with its Latin root (before or in advance of something), therefore permitting to establish that the preservation process can be associated with natural and non-natural actions or agents that act promoting the maintenance of the original status or characteristic of something.

In contrast, conservation must be used in the sense of ‘saving for’, which also links to its etymological meaning (together) and implies that the original characteristics of something are not completely available any longer (or at least there is uncertainty about it) and some level of transformation (structure, composition, location, etc.) has happened and must be assumed. In this case, contrary to Preservation, the human influence is clear in the action of saving, so conservation must be assumed exclusively as a non-natural process.

Efforts made by taphonomists during the last 120 years in the transformation of Taphonomy from a classical to a modern perspective have finally permitted us to describe Taphonomy from a new transdisciplinary perspective, which must necessarily be accompanied by a consensus in the use of preservation and conservation concepts.

Future work will be oriented on the one hand to continue looking for consensus in the use of both terms in different scientific disciplines. On the other hand, we will try to investigate deeply into the relationships between concepts and disciplines during the first years of the development of Taphonomy in which different scientific groups from different countries were involved (Cadee, 1991). Finally, it is important to continue working to incorporate the works

of pioneers in the most relevant databases and in the analysis of the historical Taphonomy evolution.

Acknowledgements

The authors want to thank specially the participants of the 9th International Meeting on Taphonomy and Fossilization (TAPHOS) and the 6th ICAZ Taphonomy Working Group Meeting carried out in July of 2022 in Spain for the interesting interchange concerning the ideas herein discussed. We also deeply thank the organizing committee of the meeting for inviting us to deliver a special talk honoring Prof. Sixto Fernández López. This study was supported by research projects SBPLY/21/180501/000242 (Administration of Education, Culture and Sports of Castilla-La Mancha), PGC2018-099405-B-I00, HAR2017-82755-P, PID-2019-105546GB-I00 (Spanish Ministry of Science, Innovation and Universities), HAR2016-78036-P (Spanish Ministry of Economy and Competitiveness), Grant ref. 38360 (The Leakey Foundation), BIOUAM02-2019 (Department of Biology, Universidad Autónoma de Madrid).

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Tables and Figure captions

Table 1. Etymological roots for preservation and conservation terms.

Table 2. Current use of terms preservation and conservation from American and British dictionaries.

Table 3. Use of terms preservation and conservation from different English references. Other related references as Robert L. Carlton Palaeontology Dictionary (Carlton 2019) have also been analysed but no definitions were found concerning Preservation and Conservation.

Table 4. Current definitions of terms preservation and conservation from non-English dictionaries.

Table 5. Concepts and disciplines names and abbreviations used in the exploration of publications in the Scopus database.

Table 6. Number of publications in the timespan analysed representing edges between nodes. Colour gradient filling cells indicates the intensity of the relations from black (lowest) to white (highest). Concepts and disciplines abbreviation as in Table 2.

Figure 1. Raw data referring to multiple searches in Scopus database. A) Number of publications during last 120 years that include the six concepts analysed, excluding biostratinomy and fossildiagenesis, due to their underrepresentation. Note that the left axis represents the values for preservation and conservation, and is 40 times larger than the right axis, which represents the values for diagenesis and fossilization. B) Number of publications where each of the concepts appear in relation with Taphonomy. Left axis represents the values for preservation, conservation, diagenesis and fossilization (note that axis is six times larger). Right axis represents the values for biostratinomy.

Figure 2. Network graphs representing nodes and edges until the 70's. From A (1908) to F (1971). Black arrows signal to important events in the evolution of the network. Node colours represent node communities found in the graph. Concepts and disciplines abbreviations as in Table 2.

Figure 3. Network graphs representing nodes and edges analysed from the 70's to current days. From A (1978) to F (2020). Node colours represent node communities found in the graph. Red dotted arrows from A (1978) to C (1988) denote the Taphonomy multidisciplinary scene expansion. Red dotted double-headed arrows in D (1997) represent the initial step to the transdisciplinary status reached in Taphonomy. Red dotted arrows in E (2009) identifies the Forensic sciences expansion. Concepts and disciplines abbreviations as in Table 2.

Figure 4. Consensus terminology proposal describing degradation under the transdisciplinary point of view of Taphonomy. General taphonomical process includes two subprocesses, preservation and conservation, and both present phases of active degradation and stabilization (something avoids degradation). Note that something that has been well preserved could be well or badly conserved (black arrows). Figure modified from Cambra-Moo et al (2022).

Table 1. Etymological roots for preservation and conservation terms.

Language/ Reference	Concept and Definitions	
	<i>Prae- + Servō</i>	<i>Con- + Servō</i>
Latin/ Glare 2012	<i>Prae-</i> . indicates position in front of. Before . To exhibit in one's demeanour, display, in comparison with, faced with.	<i>Con-</i> . Expressing collocation or simultaneity , joint action, connection or partnership, enclosure or containing, intensity of action, completeness.
	<i>Servō</i> . To maintain in existence, preserve intact (animate or inanimate things). To preserve (perishable objects). To watch over, guard, mind, look after. To keep under observation, watch.	

Table 2. Current use of terms preservation and conservation from American and British dictionaries.

Language	Reference	Concept and Definitions	
		Preservation	Conservation
English (American)	Merriam Webster Dictionary 2022	1. Activity or process of keeping something valued alive, intact, or free from damage or decay. 2. Preparation of food for future use (canning, pickling, freezing, salt) to prevent spoilage.	1. Preservation and protection of something (management of a natural resource to prevent exploitation, destruction, or neglect). 2. Preservation of a physical quantity during transformations or reactions.
	The American Heritage Dictionary of the English Language 2022	1. Act or process of conserving. Preservation or restoration from loss, damage, or neglect: manuscripts saved from deterioration under the program of library conservation. 2. The protection, preservation, management, or restoration of wildlife and of natural resources such as forests, soil, and water. 3. The maintenance of a physical quantity, such as energy or mass, during a physical or chemical change.	1. The act or process of conserving. 2. a. Preservation or restoration from loss, damage, or neglect: manuscripts saved from deterioration under the program of library conservation. b. The protection, preservation, management, or restoration of wildlife and of natural resources such as forests, soil, and water. 3. The maintenance of a physical quantity, such as energy or mass, during a physical or chemical change.
English (British)	Cambridge Dictionary 2022	1. Act of keeping something the same or of preventing it from being damaged. 2. Act of protecting something so that it is not damaged or destroyed.	Protection of plants, animals, natural areas, structures and buildings, and supplies from the damaging effects of human activity.

Table 3. Use of terms preservation and conservation from different English references. Other related references as Robert L. Carlton Palaeontology Dictionary (Carlton 2019) have also been analysed but no definitions were found concerning Preservation and Conservation.

Language	Reference	Concept and Definitions	
		Preservation	Conservation
English (British)	Hine 2019 (Dictionary of Biology)	The sensible management of the earth's natural resources in order to avoid degradation and impoverishment of the environment.	Defined in "food preservation". Prevention of the spoilage of food, which is achieved by a variety of techniques. These aim to prevent bacterial and fungal decay and contamination of food, which can cause *food poisoning.
	Lincon et al. 1982, 1998 (Dictionary of Ecology)	1. The maintenance of individual organism, populations or species by planned management and breeding programmes; <i>cf. conservation</i> . 2 (added in second edition). The preservation of biodeterioration of materials or products by the use of chemical or physical means to kill or prevent the growth of microorganism.	1. The planned management of natural resources; the retention of natural balance, diversity and evolutionary change in the environment; <i>cf. preservation</i> . 2. A taxonomic procedure to conserve a scientific name which would otherwise contravene the provisions of the Code and thus be unavailable; conserved name. 3. (added in second edition) The preservation through time of some bases in the polynucleotide sequence of an evolving gene or of some amino acids in the sequence of an evolving protein.
English (Canada)	UNESCO Institute for Statics 2022	To obviate damage liable to be caused by environmental or accidental factors, which pose a threat in the immediate surroundings of the object to be conserved. Accordingly, preventive methods and measures are not usually applied directly but are designed to control the microclimatic conditions of the environment with the aim of eradicating harmful agents or elements, which may have a temporary or permanent influence on the deterioration of the object.	Measures taken to extend the life of cultural heritage while strengthening transmission of its significant heritage messages and values. In the domain of cultural property, the aim of conservation is to maintain the physical and cultural characteristics of the object to ensure that its value is not diminished and that it will outlive our limited time span.

English (Switzerland)	Kipfer 2021	(Category: Technique) The planned management of a natural resource to prevent exploitation, destruction, or neglect.	(Category: Term) The protection of artifacts and archaeological sites through activities that minimize deterioration and damage and that prevent loss of context and content.
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Table 4. Current definitions of terms preservation and conservation from non-English dictionaries.

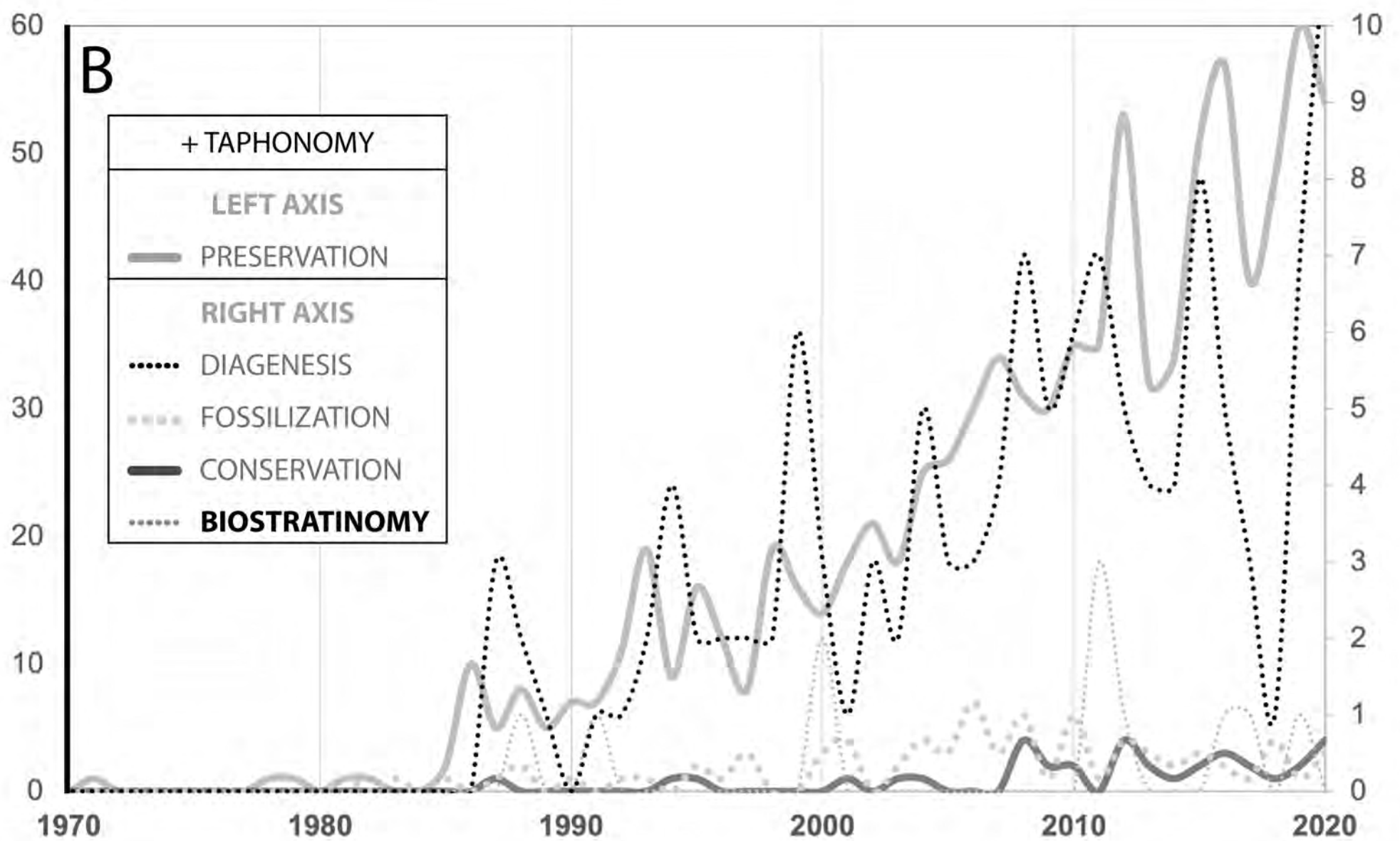
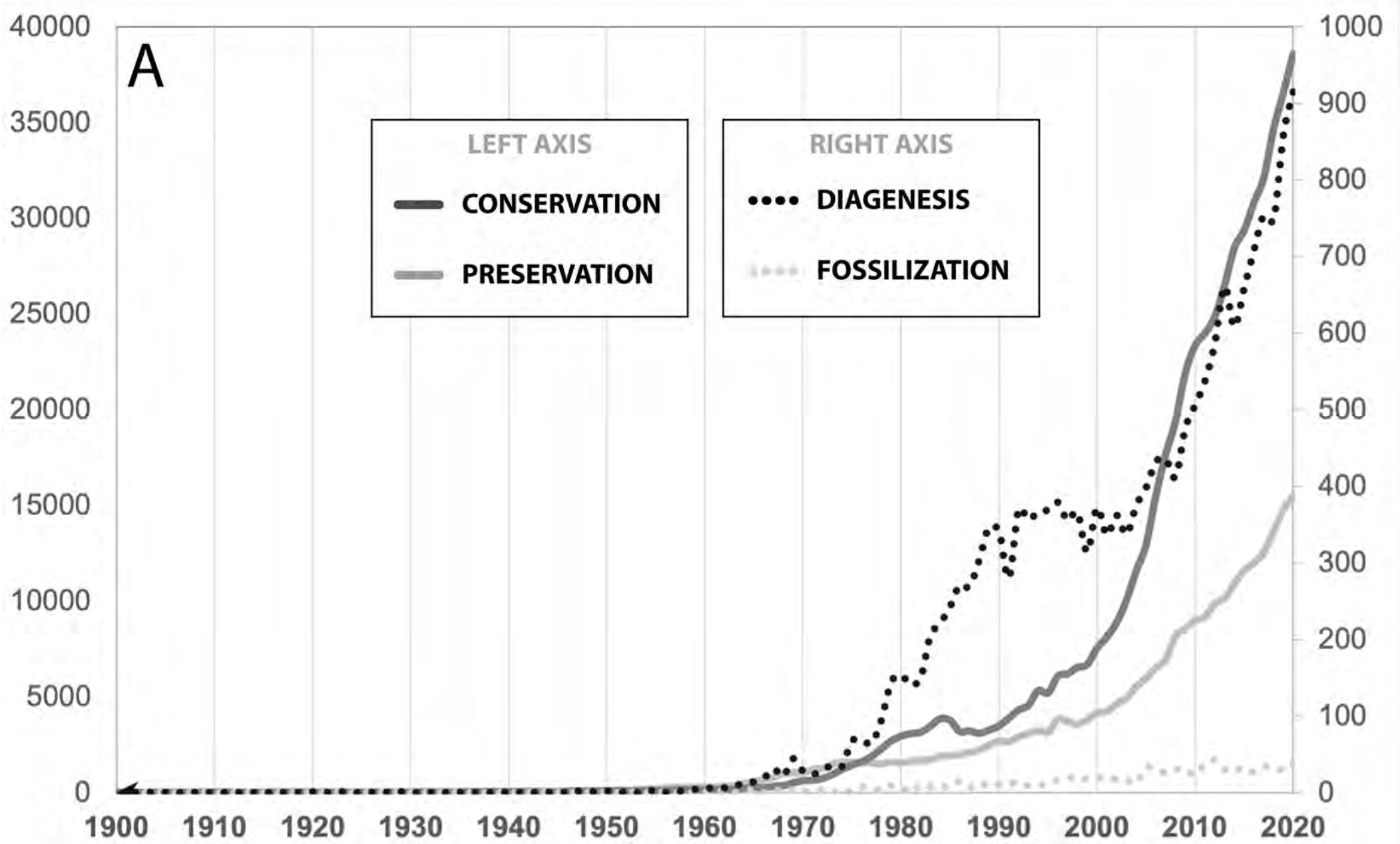
Language/ Reference	Concept and Definition	
	<i>Preservación</i>	<i>Conservación</i>
Spanish/ <i>Real Academia de la Lengua Española (RAE) 2022</i>	<i>Acción y efecto de proteger, resguardar anticipadamente a alguien o algo, de algún daño o peligro.</i>	<i>Acción y efecto de mantener o cuidar de la permanencia o integridad de algo o de alguien; mantener vivo y sin daño a alguien, continuar la práctica de hábitos y costumbres, guardar con cuidado algo, preservar un alimento en un medio adecuado.</i>
	<i>Préservation</i>	<i>Conservation</i>
French/ <i>Larousse Dictionnaire 2022</i>	<i>- Action de protéger quelqu'un, quelque chose, le mettre à l'abri d'un mal éventuel; empêcher l'altération, la perte de quelque chose.</i>	<i>Action de maintenir des denrées, des produits en bon état, les préserver de toute altération; maintenir, garder quelque chose, quelqu'un dans un certain état; rester dans un certain état, continuer d'avoir une certaine qualité; continuer d'avoir quelque chose, quelqu'un, ne pas les perdre ni s'en dessaisir; garder quelque chose à sa disposition, ne pas s'en séparer; prendre soin de quelque chose en l'absence de quelqu'un, le garder pour lui.</i>
	<i>Preservazione</i>	<i>Conservazione</i>
Italian/ <i>Grande Dizionario Hoepli Italiano 2001-2022</i>	<i>Azione e risultato del preservare. Preservare: Difendere, proteggere da possibile danno fisico o morale: p. le piante dal gelo; p. un quadro dall'umidità; p. qualcuno dall'inganno.</i>	<i>Azione, risultato e modo di mantenere qualcosa in buono stato in modo che non si guasti, non si corrompa; tenere da parte, mantenere in serbo; custodire; non aver perso, avere ancora; raro Proteggere, preservare.</i>

Table 5. Concepts and disciplines names and abbreviations used in the exploration of publications in the Scopus database.

Concepts	Abbreviation	Disciplines	Abbreviation
Preservation	P	Taphonomy	T
Conservation	C	Paleontology/Palaeontology	PAL
Fossilization	F	Paleoecology/Palaeoecology	PALECO
Biostratinomy	B	Archeology/Archaeology	A
Fossildiagenesis	FO	Ecology	E
Diagenesis	D	Forensic sciences	FS

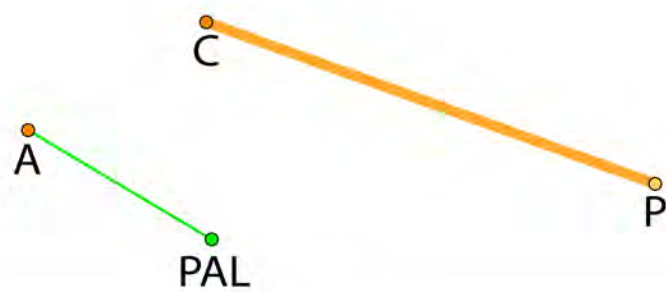
Table 6. Number of publications in the timespan analysed representing edges between nodes. Colour gradient filling cells indicates the intensity of the relations from black (lowest) to white (highest). Concepts and disciplines abbreviation as in Table 5.

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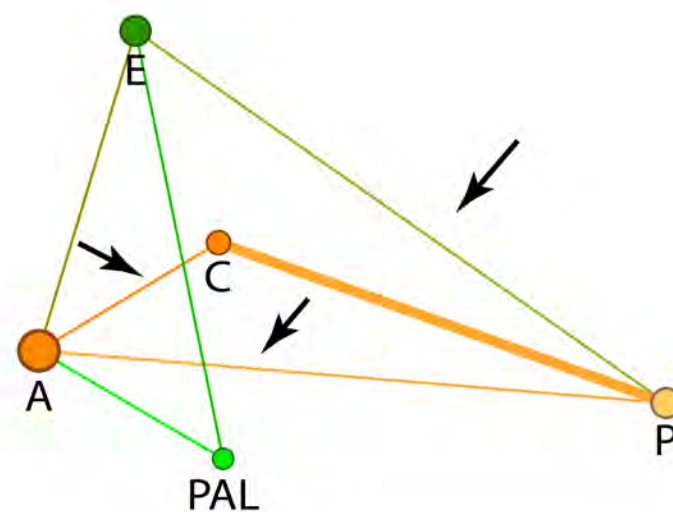
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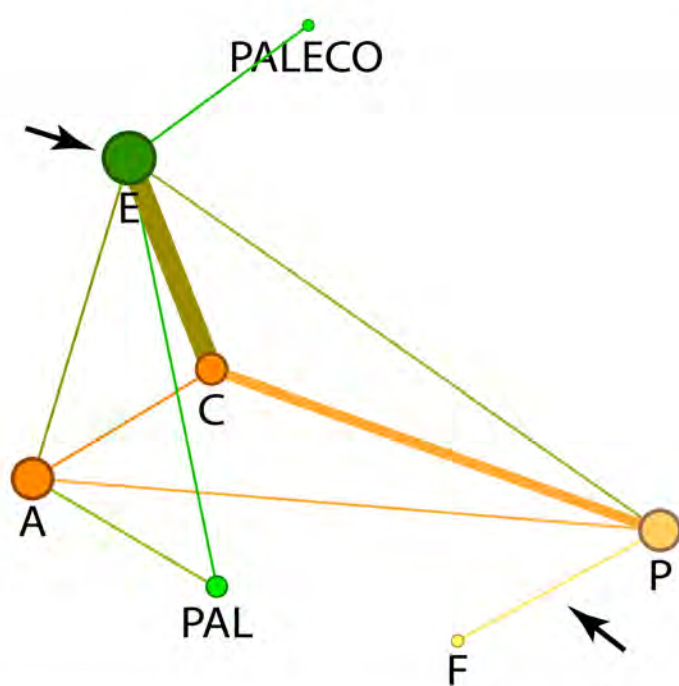
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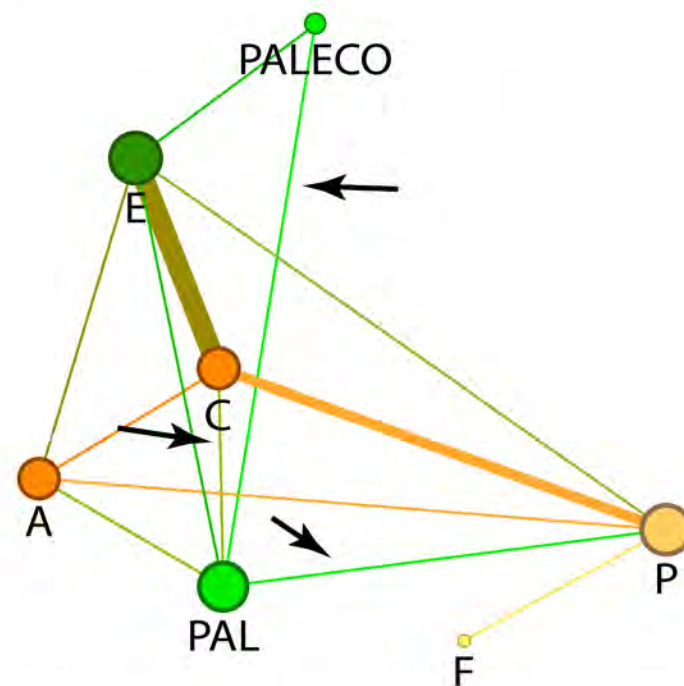
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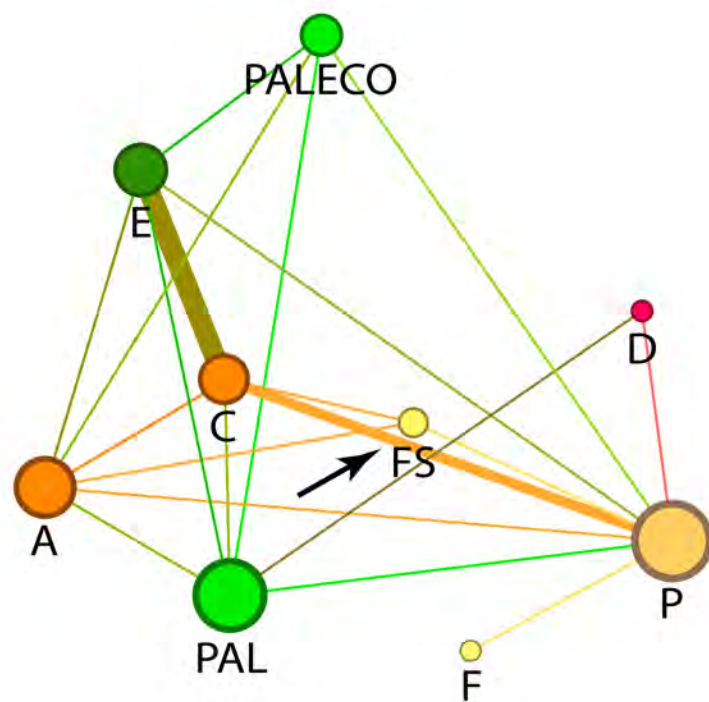
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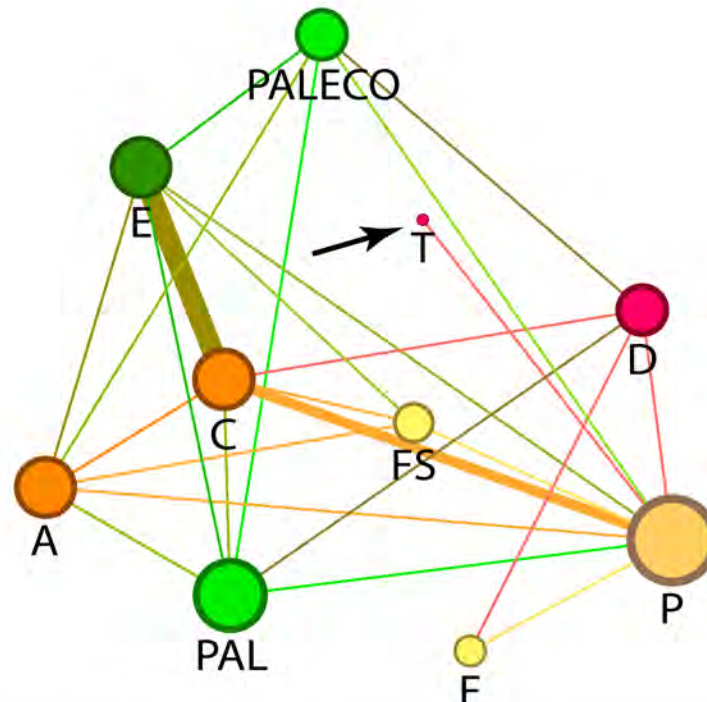
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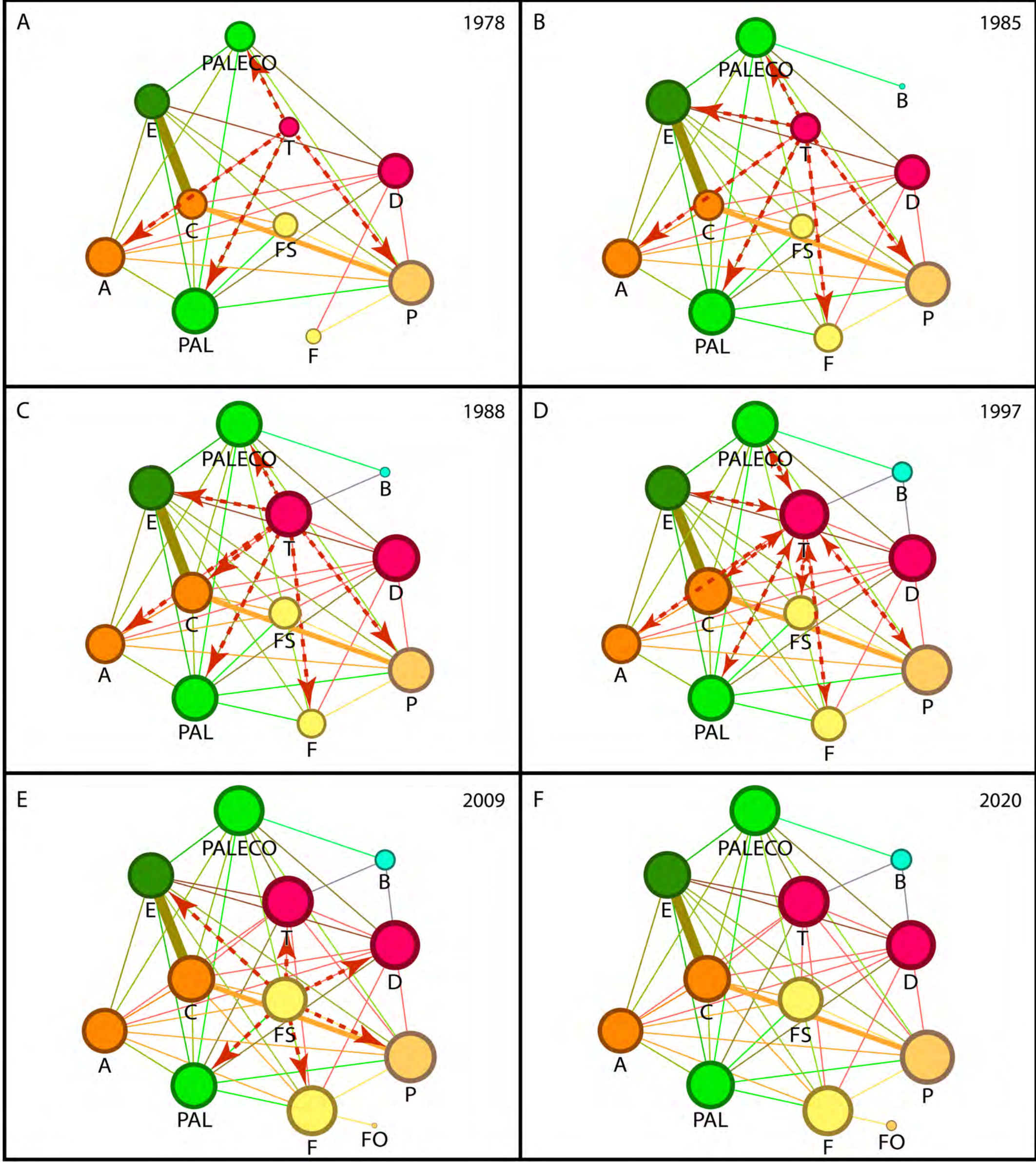
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Taphonomical Process

**PRESERVATION
PROCESS**

**CONSERVATION
PROCESS**

