



Short Article

Reconciling the community with a concept—The uniformitarian principle in the dendro-sciences



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ARTICLE INFO

Keywords:

Uniformitarianism
Actualism
Dendrochronology
Aggregate tree growth
Principle

ABSTRACT

The uniformitarian principle is one of the most important foundations of all dendro- and paleo-sciences. Without it, no inferences about the past can be made. However, the use of this principle in our community is not consistent and partially incorrect, with the main confusion relating to the understanding of the “uniformitarian principle” as somehow implying a stable relationship between climate and tree growth. To solve this, we look briefly at the history of the term, show how we teach this principle in our textbooks, give some examples of incorrect applications of this principle in the recent literature and close with a simple, logical and straightforward interpretation of this principle to the dendro-community. Applying the principle of aggregate tree growth we show that instable climate-growth relationships and the “no-analogue problem” are not a violation of the uniformitarian principle, but rather reflect our incomplete understanding of tree growth processes. Simply stated: The “uniformitarian principle” is an *a priori* assumption of spatial and temporal invariance of law’s describing nature’s processes. Applied to the dendro-sciences it means that the principle of aggregate tree growth is valid in time and space.

1. Introduction

Most of us would agree that the science of dendrochronology, and its relatives such as dendroarchaeology, dendrogeomorphology, or dendroecology among others, rest on seven basic principles: The Uniformitarian Principle, the Principle of Limiting Factor, the Principle of Aggregate Tree Growth, the Principle of Ecological Amplitude, the Principle of Site Selection, the Principle of Crossdating and the Principle of Replication (Fritts, 1976; Speer, 2010). We all were taught and are teaching these principles to students and newcomers to the field, in university courses, summer schools, workshops and at conferences. We are basing our daily work on these principles.

The uniformitarian principle is usually stated as the first and is considered the most basic principle. Its importance was highlighted by Hal Fritts back in the first edition of his textbook “Tree Rings and Climate” (1976): “The uniformitarian principle is assumed in all dendrochronological inferences, and, as in all sciences of the past, if this principle does not hold, no conclusions regarding the past can be made.” This principle is often stated simplified as “the present is the key to the past” and is also part of “uniformitarianism” or called “actualism” in other sciences.

However, over the years, the authors have noted that our

community uses this term with slightly differing meanings and while on a day-to-day basis this is often neglected – a principle should not leave room for a lot of personal interpretation or risks severe misunderstanding. This communication serves therefore two main purposes: 1) To briefly reiterate the development of the uniformitarian principle from geology to its modern application in dendro-sciences, which is important to understand some disparities, and 2) to propose a simple and straightforward interpretation of this principle to the dendro community.

We do this by looking briefly at the history of the term (“A: The awkward eight syllable word – Uniformitarianism”), show how we teach this principle in our textbooks (“B: The Uniformitarian principle as we teach it”), give some examples of differing interpretations of this principle in the recent literature (“C as Confusion”) and close with a recommendation (“D: The way forward”).

A The awkward eight syllable word – uniformitarianism

James Hutton (1726–1797) is often credited as the person coining the catchy phrase “The presence is the key to the past”. While this is most likely not true (it probably was Sir Archibald Geikie (1905), when writing about Hutton), he is considered by many as one of the main

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Table 1
Definition of the “uniformitarian principle” or reference to “uniformitarianism” in dendro-science textbooks and on webpages.

	Uniformitarian Principle
Fritts, 1976	Applied to dendrochronology, the uniformitarian principle implies that the physical and biological processes which link today's environment with today's variations in tree growth must have been in operation in the past.
Grissino-Mayer, 2017	This principle states that physical and biological processes that link current environmental processes with current patterns of tree growth must have been in operation in the past.
Smith and Lewis, 2007	Applied to dendrochronology, it states that the physical and biological processes that link contemporary environmental processes to current variations in radial tree growth existed in the past.
WSL, 2017 http://www.wsl.ch	Applied to dendrochronology, this principle implies that the physical and biological processes which link today's environment with today's variations in tree growth must have been in operation in the past.
Cardwell, 2004	This statement basically means that the same processes that link biological processes to environmental conditions today also did so in the past.
Bradley, 2011	The relationship between proxy and climate observed today has been similar in the past.
Fritts and Swetnam (1998)	Principle of Uniformitarianism The principle of “uniformity in the order of nature” was first enunciated for geology by James Hutton in 1785....Its dendroecological implications are 1) that the physical and biological processes which link today's environment with today's variations in tree growth were also operating in the past. 2) Tree ring features in a given tree are related to the same environmental conditions as in the past, and 3) environmental conditions associated with present day ring features may be inferred to have existed when that feature occurred in the past.
Sheppard, 2017 www.ltrr.arizona.edu	Physical and biological processes that link current environmental processes with current patterns of tree growth operated similarly in the past
Speer, 2010	This means that the processes occurring today are the same processes that occurred in the past.

fathers of modern geology. His dissertation, read in 1785 in front of the Royal Society of Edinburgh, was titled “System of the Earth, its duration and stability” and we have to remember that it was set in a time of geological dispute between Neptunists, Catastrophists and scientists trying to show that the earth was actually older than 6000 years. It is difficult to understand from our viewpoint today, but Hutton seems to have been one of the first paleo-scientists using modern inductive theory and formulating the basis for what was to become known as “uniformitarianism” a little later.

In 1830–1833, Sir Charles Lyell made a mark in geology with a three volume textbook “Principles of Geology”. He constructed a theoretical system to establish geology as a natural science and based his system on three principles (after Camardi, 1999): “1) the Uniformity Principle, which states that past geological events must be explained by the same causes now in operation; 2) the Uniformity of Rate, which states that geological laws operate with the same force as at present; 3) the Steady-state Principle, which states that the earth does not undergo any directional change.” Taken together, these three principles became known as “Uniformitarianism”. Uniformitarians set out to explain the geological record with processes observed in the present day, opposing the “catastrophists” (Scott, 1963) who used “the direct agency of Creative Interference” (Buckland, 1837 in Gould, 1965a), in other words divine intervention, to explain the record. However, Lyell snuck his personal view of “gradualism” into this framework, which implies invariance of rates of change (see principle 2), hampering the science of geology for at least 150 years (Allmon, 1993). Luckily, we don't have to wade through decades of scientific debate (for those interested see Shea, 1982, debunking the concept), but can jump ahead and take a look at the first scientific paper from Steven Jay Gould, the great American paleontologist, evolutionary biologist and popular science writer.

In 1965 Gould published “Is uniformitarianism necessary?” and answered his rhetorical question with a definite “No”. Gould (1965a; b) clearly drives home the point that the term “uniformitarianism” confounds two different concepts: “A testable proposition asserting constancy of rate of change or material conditions through time – substantive uniformitarianism” (Lyell's principles 2 and 3, see above), and “An undemonstrable, though entirely necessary, procedural assumption asserting spatial and temporal invariance of law's describing nature processes – methodological uniformitarianism” (Lyell's principle 1, see above) (Gould, 1965b). He then assessed both concepts and concludes (Gould, 1965b) “the testable proposition is incorrect in any strict formulation” and “the concept embodied in the procedural assumption is

essential, but the term ‘uniformitarianism’ is unnecessary, since the invariance assertion is synonymous with the principle of induction”.

While we can follow Gould's logic in dismissing Lyell's principles 2 and 3 as rejected hypotheses today, we personally see a value in retaining Lyell's principle 1 as a reiterating backbone of our scientific approach, or a specific application of the general inductive concept to paleosciences in general and dendrochronology in particular. Two years before Gould, in 1963, Reyer Hookyaas had discussed Lyell's principles and also retained only the first one. When talking about von Hoff, a contemporary of Lyell, he referred to the “Uniformity Principle” (principle 1) of Lyell as “actualism” (Hookyaas, 1963, page 10): “...he hoped to remain true to the principle that causes now in operation are sufficient to explain the ancient volcanic phenomena, that is, he remained true to ‘actualism’ taken in the literal meaning of admitting none but causes “actually” (at present) in operation...”

This principle, may it be called “Uniformity Principle” or “actualism”, is, in our opinion, closest to the “uniformitarian principle” originally introduced into the dendro-sciences. It is important to note that this principle does not refer to any testable hypotheses and is NOT synonymous with the historical “uniformitarianism” as a concept, but is rather a “procedural assumption” (after Gould, 1965b) of using inductive reasoning (“all small rings today in these pines on sand are a result of drought, so a small ring in a pine of the past which grew on sand most likely was the result of drought as well – all other factors being similar”).

B The uniformitarian principle as we teach it

After this excursion into history, it is time we take a look at our science. The tools for our trade are written down in handbooks, for reference and studying, and more and more ‘somewhere in the net’. This section briefly summarizes how the uniformitarian principle is defined in textbooks of dendrochronology and on random available webpages, which, let us be honest, students would turn to first, if they had to look up the principle (Table 1). The summary contains only the field of dendro-sciences and not examples from other fields – as our goal is here to show how we, as the dendro-community, go about using the principle. Please note: While most researchers refer to the “uniformitarian principle”, some do use the term “uniformitarianism” (see C as Confusion).

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