# John F. Shroder, Jr.'s 1978 and 1980 papers on dendrogeomorphology

David R. Butler and Markus Stoffel

*Progress in Physical Geography* 2013 37: 717
DOI: 10.1177/0309133313501107

Progress in Physical Geography
37(5) 717–721

DOI: 10.1177/0309133313501107
ppg.sagepub.com
SAGE

# John F. Shroder, Jr.'s 1978 and 1980 papers on dendrogeomorphology

**David R. Butler**
Texas State University, USA

**Markus Stoffel**
University of Berne/University of Geneva, Switzerland

**Abstract**
Dendrogeomorphology is the application of tree-ring analysis for the dating of geomorphic processes. Although defined elsewhere, Shroder (1978, 1980) provided the foundation and methodologies for dendrogeomorphology that continue to underpin the discipline more than 30 years after the publication of his research papers. His process-event-response methodology and development of a semi-quantitative index number are techniques employed or discussed in virtually every recent paper within the field of dendrogeomorphology.

**Keywords**
classics revisited, dendrogeomorphology, index number, process-event-response methodology, Shroder

## I Introduction

The field of dendrogeomorphology, the application of tree rings for dating geomorphic processes, has grown tremendously within recent years, and at least 75 papers have been published in the field for the period 2008–2012 (Stoffel and Corona, unpublished data). Tree-ring analysis originated in archeology in the American Southwest, where it was used primarily for the dating of ruins constructed by ancient Native Americans. The initial employment of tree rings was simply as a dating tool (e.g. Douglass, 1941; Stokes and Smiley, 1968) and only rarely exploited other environmental information that could be derived from studies of ring-width variations and records of growth anomalies contained within the tree (Stoffel et al., 2010).

A landmark paper in the field of tree-ring-based analyses of geomorphic processes was published by Alestalo (1971), who first coined the term dendrogeomorphology (p. 7) as the 'application of plant ecology and dendrochronology to research in the field of morphogenic and morphochronological geomorphology'. Moving beyond simply counting annual rings to determine the age of trees, Alestalo described methods based on the scarring ('corrasion'), tilting, exposure, and burial of trees in addition to examining succession in tree communities.

**Corresponding author:**
David R. Butler, Department of Geography, Texas State University, ELA 139, 601 University Drive, San Marcos, TX 78666-4684, USA.
Email: db25@txstate.edu

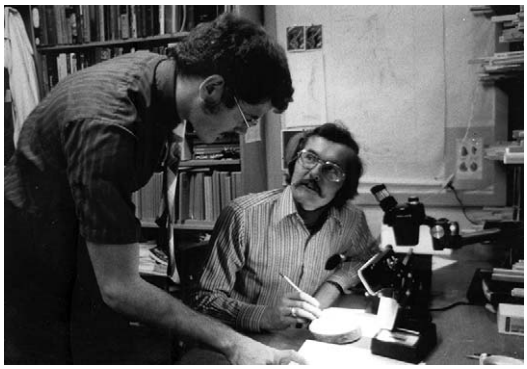

**Figure 1.** Jack Shroder in 1975 (right) teaching principles of dendrogeomorphology to an attentive David Butler.

Although Alestalo's paper is itself a classic worthy of subsequent further examination, our purpose here is to instead examine how Alestalo's paper led to the development of standardized methods and quantitative measures still employed in dendrogeomorphology today, through two classic papers by John F. 'Jack' Shroder, Jr., published in *Quaternary Research* in 1978 and in this journal in 1980 (Shroder, 1978, 1980). We examine these papers in the following discussion.

## II The genesis of process-event-response methodology

Jack Shroder (Figure 1) was well aware of Alestalo's (1971) important paper, and took its methods to heart in his study of slow mass movements on the High Plateau region of south-central Utah, USA. His initial publication summarizing the state of knowledge about dendrogeomorphic analysis of mass movement (Shroder, 1975) was a stepping stone towards developing a semi-quantitative measure for dendrogeomorphic responses in tree rings similar to how dendroclimatologists measured and analyzed ring-width variations (Fritts, 1971). In 1978, Shroder published the first of his two now-classic papers, 'Dendrogeomorphological analysis of mass movement on Table Cliffs Plateau, Utah', in *Quaternary Research*. In that paper, he: (1) published the symbols and methods he had been employing in his research for the first time; (2) published a diagram illustrating how geomorphic mass movement processes trigger events in trees that create datable tree-ring responses, comprising what he referred to as a process-event-response system; and (3) introduced the use of an index value in dendrogeomorphology, defined as a fixed threshold based on the ratio between reacting and sampled trees. The latter two of these contributions continue to form the basis for much of the dendrogeomorphic research of the past 30+ years (Stoffel et al., 2012).

Subsequently in his 1980 paper, 'Dendrogeomorphology: Review and new techniques of tree-ring dating', Shroder created the standardized 'how to' manual for dendrogeomorphology. In that paper, he first provided an overview of structure and growth of tree rings and growth processes relevant to dendrogeomorphology, codified the concepts and principles of dendrogeomorphology that had been presented in his 1978 process-event-response diagram, described the standard methodology for dendrogeomorphology that remained largely unchanged until the mid-2000s (see below), and provided a useful review of the suite of geomorphic processes which could be analyzed using the process-event-response paradigm.

## III The rapid acceptance of Shroder's process-event-response and Index value methodologies

Shroder's (1978) process-event-response methodology and index value were quickly adopted and extended from the study of slow mass movements to processes such as snow avalanches, debris flows, rockfall avalanches, and numerous other geomorphic processes (for extensive bibliographies of published works

utilizing these techniques, see Bollschweiler and Stoffel, 2010; Stoffel and Bollschweiler, 2008; Stoffel et al., 2010). Modified versions of Shroder's (1978) process-event-response diagram were recently presented by Stoffel and Bollschweiler (2009) and Bollschweiler and Stoffel (2010). These new diagrams incorporate advances in the use of tangential rows of traumatic resin ducts (TRD) (see also Schneuwly et al., 2009; Stoffel et al. 2008) within annual rings, in addition to the morphological responses described by Shroder (1978). These updated process-event-response diagrams reflect advances in the discipline within the past 10 years in the use of TRD in dating geomorphic processes to the year (and in several cases to within a several-week period during the growing season; cf. Schneuwly-Bollschweiler and Stoffel, 2012, and references therein; Stoffel, 2006; Stoffel and Bollschweiler, 2009), but clearly are outgrowths from Shroder's 1978 diagram and 1980 concepts. Recent papers emphasize the use of datable responses with the highest-quality evidence, i.e. corrasion scars, TRD, strong reaction wood, and intense growth suppression (Bollschweiler and Stoffel, 2010; Stoffel et al., 2012), and the value in weighting some responses more heavily than others (Corona et al., 2012; Germain et al., 2005; Reardon et al., 2008), but these papers all nonetheless remain the intellectual descendants of Shroder's two papers.

Shroder's (1978, 1980) publications have also spawned widespread discussion concerning whether minimum thresholds for individual geomorphic processes should be identified, and if so what those cut-off levels should be (Butler et al., 1987). Several authors have used quantitative approaches based on the proportion of disturbed versus existing trees (index value/number) to date events to a given year (Butler and Sawyer, 2008), with thresholds used ranging from 10% (e.g. Dubé et al., 2004) to 40% (e.g. Butler and Malanson, 1985) for studies that date snow avalanche occurrence, and between 2% (Lopez Saez et al., 2012a, 2012b) and 30% (Corominas and Moya, 1999; Stefanini, 2004) for studies of landslide occurrence. Index values in snow avalanche studies were also used by Germain et al. (2005), Reardon et al. (2008), and Corona et al. (2012), who also added a minimal number of trees showing growth disturbances in a specific year (generally 10) to render dating more accurate. The ongoing debate of which index value threshold to use to invoke the presence of a geomorphic process nonetheless reflects the significance and legacy of the introduction of the index number/value concept by Shroder.

## IV The continuing significance of Shroder's 1978 and 1980 papers

New techniques for using tree rings to date geomorphic processes continue to develop, for both coniferous and deciduous trees (e.g. Arbellay et al., 2010a, 2010b, 2012a, 2012b, 2013; Stoffel et al., 2010; Trappmann and Stoffel, 2012), but virtually all of these new techniques still depend intellectually upon the concepts and methodologies elucidated in Shroder's papers. Most papers in the field of dendrogeomorphology are cited some few to a few dozen times. In Google Scholar, Shroder's 1978 paper has been cited 176 times, and the 1980 paper 155 times as of 12 June 2013. The modern field of dendrogeomorphology has grown dramatically since the late 1970s, and new approaches have been developed in the recent past. However, this growth is inarguably and intellectually linked to the research, publications, and lasting legacy of Jack Shroder and his two milestone publications on dendrogeomorphology. The development of process-event-response and index value methodologies remains the solid foundation of the field of dendrogeomorphology today.

## References

Alestalo J (1971) Dendrochronological interpretation of geomorphic processes. *Fennia* 105: 1–140.

Arbellay E, Corona C, Stoffel M, et al. (2012a) Defining an adequate sample of earlywood vessels for retrospective injury detection in diffuse-porous species. *PLoS One* 7: e38824.

Arbellay E, Fonti P, and Stoffel M (2012b) Duration and extension of anatomical changes in wood structure after cambial injury. *Journal of Experimental Botany* 63: 3271–3277.

Arbellay E, Stoffel M, and Bollschweiler M (2010a) Dendrogeomorphic reconstruction of past debris-flow activity using injured broad-leaved trees. *Earth Surface Processes and Landforms* 35: 399–406.

Arbellay E, Stoffel M, and Bollschweiler M (2010b) Wood anatomical analysis of *Alnus incana* (L.) Moench and *Betula pendula* Roth injured by a debris flow. *Tree Physiology* 30: 1290–1298.

Arbellay E, Stoffel M, and Decaulne A (2013) Dating of snow avalanches by means of wound-induced vessel anomalies in subarctic *Betula pubescens*. *Boreas* 42: 568–574.

Bollschweiler M and Stoffel M (2010) Tree rings and debris flows: Recent developments, future directions. *Progress in Physical Geography* 34: 625–645.

Butler DR and Malanson GP (1985) A history of high-magnitude snow avalanches, southern Glacier National Park, Montana, USA. *Mountain Research and Development* 5: 175–182.

Butler DR and Sawyer CF (2008) Dendrogeomorphology and high-magnitude snow avalanches: A review and case study. *Natural Hazards and Earth System Science* 8: 303–309.

Butler DR, Malanson GP, and Oelfke JG (1987) Tree-ring analysis and natural hazard chronologies: Minimum sample sizes and index values. *The Professional Geographer* 39: 41–47.

Corominas J and Moya J (1999) Reconstructing recent landslide activity in relation to rainfall in the Llobregat River basin, eastern Pyrenees, Spain. *Geomorphology* 30: 79–93.

Corona C, Lopez Saez J, Stoffel M, et al. (2012) How much of the real avalanche activity can be captured with tree rings? An evaluation of classic dendrogeomorphic approaches and comparison with historical archives. *Cold Regions Science and Technology* 74–75: 31–42.

Douglass AE (1941) Crossdating in dendrochronology. *Journal of Forestry* 39: 825–831.

Dubé S, Filion L, and Hétu B (2004) Tree-ring reconstruction of high-magnitude snow avalanches in the northern Gaspé Peninsula, Québec, Canada. *Arctic, Antarctic, and Alpine Research* 36: 555–564.

Fritts HC (1971) Dendroclimatology and dendroecology. *Quaternary Research* 1: 419–449.

Germain D, Filion L, and Hétu B (2005) Snow avalanche activity after fire and logging disturbances, northern Gaspé Peninsula, Quebec, Canada. *Canadian Journal of Earth Sciences* 42: 2103–2116.

Lopez Saez J, Corona C, Stoffel M, et al. (2012a) Probability maps of landslide reactivation derived from tree-ring records: Pra Bellon landslide, southern French Alps. *Geomorphology* 138: 189–202.

Lopez Saez J, Corona C, Stoffel M, et al. (2012b) Dendrogeomorphic reconstruction of past landslide reactivation with seasonal precision: the Bois Noir landslide, southeast French Alps. *Landslides* 9: 189–203.

Reardon BA, Pederson GT, Caruso CJ, et al. (2008) Spatial reconstructions and comparisons of historic snow avalanche frequency and extent using tree rings in Glacier National Park, Montana, USA. *Arctic, Antarctic, and Alpine Research* 40: 148–160.

Schneuwly DM, Stoffel M, and Bollschweiler M (2009) Formation and spread of callus tissue and tangential rows of resin ducts in *Larix decidua* and *Picea abies* following rockfall impacts. *Tree Physiology* 29: 281–289.

Schneuwly-Bollschweiler M, and Stoffel M (2012) Hydrometeorological triggers of periglacial debris flows – a reconstruction dating back to 1864. *Journal of Geophysical Research – Earth Surface* 117: F02033.

Shroder JF Jr (1975) Dendrogeomorphological analysis of mass movement. *Proceedings of the Association of American Geographers* 7: 222–226.

Shroder JF Jr (1978) Dendrogeomorphological analysis of mass movement on Table Cliffs Plateau, Utah. *Quaternary Research* 9: 168–185.

Shroder JF Jr (1980) Dendrogeomorphology: Review and new techniques of tree-ring dating. *Progress in Physical Geography* 4: 161–188.

Stefanini M (2004) Spatio-temporal analysis of a complex landslide in the northern Apennines (Italy) by means of dendrochronology. *Geomorphology* 63: 191–202.

Stoffel M (2006) A review of studies dealing with tree rings and rockfall activity: The role of dendrogeomorphology in natural hazard research. *Natural Hazards* 39: 51–70.

Stoffel M and Bollschweiler M (2008) Tree-ring analysis in natural hazards research – an overview. *Natural Hazards and Earth System Sciences* 8: 187–202.

Stoffel M and Bollschweiler M (2009) What tree rings can tell about earth-surface processes. Teaching the principles of dendrogeomorphology. *Geography Compass* 3: 1013–1037.

Stoffel M, Bollschweiler M, Butler DR, et al. (eds) (2010) *Tree Rings and Natural Hazards – A State of the Art*. Dordrecht: Springer.

Stoffel M, Bollschweiler M, Leutwiler A, et al. (2008) Large debris-flow events and overbank sedimentation in the Illgraben torrent (Valais Alps, Switzerland). *Open Geology Journal* 2: 18–29.

Stoffel M, Butler DR, and Christophe C (2012) Mass movements and tree rings: A guide to dendrogeomorphic field sampling and dating. *Geomorphology*. doi: 10.1016/j.geomorph.2012.12.017.

Stokes MA and Smiley TL (1968) *An Introduction to Tree-Ring Dating*. Chicago, IL: University of Chicago Press.

Trappmann D and Stoffel M (2012) Counting scars on tree stems to assess rockfall hazards: A low effort approach, but how reliable? *Geomorphology* 180–181: 180–186.