TRiDaS 1.1: The tree-ring data standard

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Abstract

Tree-ring research and collaboration are currently being hampered by the lack of a suitable data-transfer standard for both data and metadata. This paper highlights the issues currently being faced and proposes a solution that, if adopted by the global dendro community, will open up the possibility of exciting new research collaborations. The solution consists of a data model for dendrochronological data and metadata, and an eXtensible Markup Language (XML) schema as a technical vehicle to exchange this data and metadata. The technology and structure of the standard enables future versions to be developed that will satisfy evolving requirements whilst remaining backwards compatible.

1. Introduction

This article is intended as a starting point for the development of a universal data standard (Tree-Ring Data Standard or TRiDaS) that we hope will be adopted by the dendro community for exchanging dendrochronological data and metadata between applications and users. It is a summary of the discussions to date held by the Dendro Data Standard Forum[1] and members of the Digital Collaboratory for Cultural-Historical Dendrochronology[2] (DCCD). The Dendro Data Standard Forum is an informal open email forum created by Brewer in November 2007 in order to facilitate the discussion about dendrochronological data formats. The DCCD project is directed at building a durable and sustainable data archive for cultural and natural dendrochronological data relevant to cultural-heritage studies in the Low Countries. By the end of 2010 the archive will be accessible on line for data providers, who can individually determine which data they share among each other, researchers from other fields and with members of the public. Some general descriptive metadata such as laboratories and research locations will be publicly available through the DCCD. The development of a tree-ring data standard is part of the project.

1.1. The Challenges

The file formats commonly used today for storing and sharing tree-ring data were established at a time when computing platforms placed considerable restrictions on the designers in terms of file size, naming and structure. These early file formats are typically focused on storing ring-width measurements and have only limited capabilities for storing associated metadata.

The existing data formats used, whilst relatively simple to understand, have not been formally defined. This has led to a number of independent implementations resulting in some applications failing to read files that are reported to be of a compatible format as well as general problems regarding the interchangeability of data.

The most widely used format is the Tucson format, developed at the Laboratory for Tree-Ring Research (University of Arizona). This is a decadal plain-text format required by a wide variety of dendrochronological software and by the International Tree-Ring Data Bank (ITRDB) (Grissino-Mayer and Fritts, 1997). The Tucson format allows for three lines of metadata, such as coordinates, analyst and tree species. However, it does not allow the registration of sapwood numbers and missing rings to the bark (which is a requirement in cultural studies directed at establishing cutting dates of wood) and of annual growth anomalies. In addition it can not accommodate chronologies older than 999BC because it uses a fixed number of digits for the identification of series (first column; six digits) and the year (second column; four digits). A final drawback is that this format reckons with the non-existing year zero, meaning that in chronologically coherent datasets of measurement series that date BC as well as AD, either the BC or the AD intervals of series are shifted one year relative to their actual date.

Another important legacy format is that created by the CATRAS software (Aniol, 1983) which runs in DOS-environments and is still used widely in Europe. It is a binary file format which means that, unlike plain text files, CATRAS files can not be accessed by simple text editors

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[1]The Dendro Data Standard Forum is open to all new participants and can be joined by contacting the corresponding author.

[2]See http://www.dendrochronology.eu for further details.

and standard desktop applications. Using the CATRAS software, it is possible to convert these files to the Tucson-format; however, this introduces a number of issues. With series that date BC, the conversion process adds 8000 years to the date. The CATRAS format requires eight-digit identifiers for series, which clashes with the six-digit identifiers required by the Tucson format. Whilst it does allow for registration of sapwood numbers and a very general registration of growth anomalies (problematic rings), this information is lost when series are converted to the Tucson format. The facility to store descriptions of samples (context etc.) in CATRAS is restricted to one short line.

The use of some other older data formats is restricted to specific collaboration networks and/or research projects. One of these is the decadal plain-text Besançon format(Lambert and Lavier, 1984), developed by Besançon University and the French National Centre for Scientific Research (CNRS) and currently used in France and eastern Belgium.[3] This format again is mostly directed at storing time series (measurement series and chronologies) and hardly allows for metadata. Another is the V-format, a decadal plain-text format developed at Göttingen University (DE) which was used as the prevailing format for measurement series of oak in past EU projects regarding climatic change during the past two to ten millennia.[4] In terms of metadata this format has the same restrictions as the Besançon format.

With the rapid development of computers the restrictions regarding the storage of metadata and within-ring information have largely been removed, leading a number of independent developers to create new formats to enable a more comprehensive form of dendro-data storage. A good example is the decadal plain-text Heidelberg format, created for the commercial software-package TSAP (Rinn, 2008). In this format individual measurement series and their metadata are stored in keyword-value pairs. The number and type of metadata keywords is variable and determined by the author of the series. Another good example is the PAST format created for the PAST commercial software (Knibbe, 2008) which also allows for many types of metadata. These proprietary data formats, however, mean that users are typically tied to specific software. Data sharing between computer programs and/or users is possible only by exporting to one of the more primitive file formats with a subsequent loss of information.

In summary, dendrochronologists are maintaining large amounts of dendrochronological data and metadata in a variety of incompatible formats. Conversion between these formats often requires the renaming of series (changing identifiers) and loss of metadata and chronological precision. These formatting problems are time consuming and the result is that dendrochronologists do not utilise their data to the greatest potential.

As a solution we propose an international registration and archiving standard for dendrochronological data and metadata that is suited for storing metadata regardless of the research domain, complies with established digital data standards such as Dublin Core (see section 2.4), is self-explanatory and can be maintained and updated relatively easily without loss of existing information already stored in this standard. One of the challenges in designing this standard is the wide variety of sub-disciplines within dendrochronology, each with its own requirements.[5] The standard must therefore be flexible enough to deal with a wide variety of data requirements.

1.2. Aims

The primary aim is to produce a specification for a new standard data format that will:

1. facilitate exchange and therefore re-use of data;
2. store metadata to determine the context, provenance and quality of the data;
3. store the wide variety of metadata required by all the disciplines associated with the dendro community, including archaeology, forestry, ecology, art history, building history and palaeo-climatology.

The standard is a data-transfer standard and does not define mechanisms for data storage. Whilst files that conform to the standard could be used for storing data, it is envisaged that many users will choose to store their data in (relational) databases instead, using the standard solely for transferring data. The distinction between a data-transfer standard as opposed to a data-storage standard is minimal but worth emphasising. The proposed TRiDaS format does not specifically include fields that are relevant only to the author (e.g., administrative data such as contact details of the client who commissioned the research). Such information should be stored locally and should not form part of the data transferred to other users.

Many of the concepts described in this document will be directly relevant to the design of a database management system for dendro data, but this is beyond the scope of this document. We are strictly concerned with producing a standard data format that can be used to transfer data between any combination of servers, clients, users and applications.

[3] See for example the Base de Données dendrochronologiques of the Laboratoire de Chrono-Ecologie at Besançon (FR), at http://chrono-eco.univ-fcomte.fr/Public/DataBases/DendroTmp/DData/.

[4] EU projects "Temperature change over Northern Eurasia during the last 2500 years" (EU contract number CV5V-CT94-0050, 1994-1996) and "Analysis of dendrochronological variability and natural climates in Eurasia: the last 10,000 years" (ENV4-CT95-0127, 1996-1998).

[5] For example, the type of metadata stored by a researcher working on modern forest dynamics is dramatically different from the type of metadata recorded by an archaeologist dating hull planks from a shipwreck.

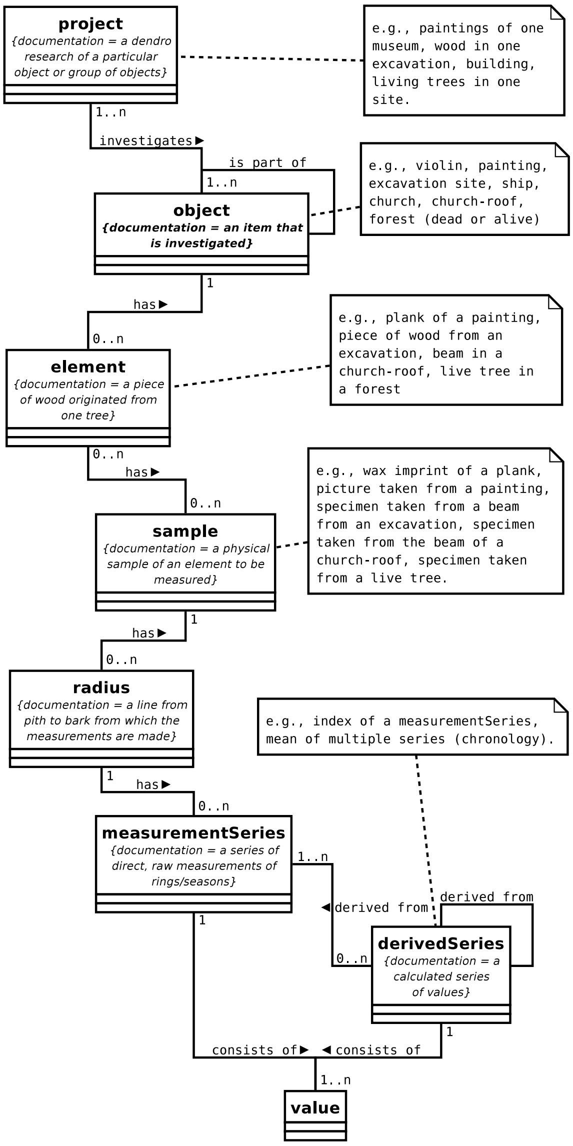

Figure 1: TRiDaS data model showing the relationships between data entities.

2. Design

2.1. Naming conventions

Before discussing the technologies to be used for a dendrochronological data standard, it is necessary to define the primary data entities that are used in the dendro community and to give them consistent names. From discussions held on the Dendro Data Standard Forum it was clear that there are currently no set definitions across the community and that in some cases different labs are using the same name for different concepts. For example, the word "measurement" is used by some to refer to the measurement of a single ring width, whilst others use it to refer to the series of ring-width measurements of an entire piece of wood.

Following discussion, a total of eight data entities and names were decided upon: project, object, element, sample, radius, measurementSeries, derivedSeries and value. Detailed descriptions of each of these entities are given below and their relationships are illustrated in figure 1.

A project is defined by a laboratory and encompasses dendrochronological research of a particular object or group of objects. Examples include: the dating of a building; the research of forest dynamics in a stand of living trees; the dating of all Rembrandt paintings in a museum. What is considered a "project" is up to the laboratory performing the research. It could be the dating of a group of objects, but the laboratory can also decide to define a separate project for each object. Therefore, a project can have one or more objects associated with it.

An object is the item to be investigated. Examples include: violin; excavation site; painting on a wooden panel; water well; church; carving; ship; forest. An object could also be more specific, for example: mast of a ship; roof of a church. Depending on the object type various descriptions are made possible. An object can have one or more elements and can also refer to another (sub) object. For instance a single file may contain three objects: an archaeological site object, within which there is a building object, within which there is a beam object. The list of possible object types is extensible and is thus flexible enough to incorporate the diversity of data required by the dendro community. Only information that is essential for dendrochronological research is recorded here. Other related data may be provided in the form of a link to an external database such as a museum catalogue.

An element is a piece of wood originating from a single tree. Examples include: one plank of a water well; a single wooden panel in a painting; the left-hand back plate of a violin; one beam in a roof; a tree trunk preserved in the soil; a living tree. The element is a specific part of exactly one object or sub object. An object will often consist of more than one element, e.g., when dealing with the staves (elements) of a barrel (object). One or more samples can be taken from an element and an element may be dated using one or more derivedSeries.

A sample is a physical specimen or non-physical representation of an element. Examples include: core from a living tree; core from a rafter in a church roof; piece of charcoal from an archaeological trench; slice from a pile used in a pile foundation; wax imprint of the outer end of a plank; photo of a back plate of a string instrument. Note that a sample always exists and that it can either be physical (e.g. a core) or representative (e.g. a picture). A sample is taken from exactly one element and can be represented by one or more radii.

A radius is a line from pith to bark along which the measurements are taken. A radius is derived from exactly one sample. It can be measured more than once resulting in multiple measurementSeries.

A measurementSeries is a series of direct, raw measurements along a radius. A single measurementSeries can be standardised or a collection of measurementSeries can be combined into a derivedSeries. The measurements themselves are stored separately as values.

A derivedSeries is a calculated series of values and is a minor modification of the "v-series" concept proposed by Brewer et al. (2009). Examples include: index; average of a collection of measurementSeries such as a chronology. A derivedSeries is derived from one or more measurementSeries and has multiple values associated with it.

A value is the result of a single ring measurement. Examples include: total ring width; earlywood width; latewood width. The values are related to a measurementSeries or a derivedSeries. In case of a measurementSeries the variable and its measurement unit (e.g. microns, 1/100th mm etc) are recorded as well.

To place the TRiDaS data model in the context of dendrochronological research, table 1 shows three examples and how they map to the data model. Each example is of a raw measurement series and, for simplicity's sake, includes just three data values each. In reality there would be the same number of values for each example as the recorded number of tree rings.

2.2. Relationship Rules

The relationships between the TRiDaS data entities are shown in figure 1. This is the complete data model design, but not all entities are utilised in all circumstances. Whilst TRiDaS is intended to be as flexible as possible, a number of relationship rules have been defined to ensure that the data remain useful to other users:

1. A minimal file should contain at least one "project," which must include at least one "object." It is therefore not necessary to include actual dendro data in a file. This property allows the use of the standard for storing only the metadata about objects, as well as for storing data.
2. If a derivedSeries has been included in the file, then radius and measurementSeries also need to be present. In certain cases, details regarding radii and/or measurementSeries are not known, in which case empty "placeholder" data entities need to be included. These are XML elements containing no attributes that go in place of the standard radius and measurementSeries sections.
3. If a measurementSeries has *not* been included in the file, then the radius represented by the measurementSeries can not be included either.

2.3. Data Attributes

The data entities described thus far represent the building blocks of the data standard. The majority of the dendrochronological metadata will however be represented by a wealth of attributes associated with these entities. From the examples in table 1, the beam element of example 1 may include the type of joint the carpenter used; the tree element of example 2 may have a diameter at breast height; and the plank element of example 3 may include details of how the plank was cut from the tree.

The type and value of attributes used in the standard will undoubtedly expand over time. However, we would like to define and standardise as many attributes as possible from the outset, to ensure applications can be built that can make use of as much dendrochronological metadata as possible. The current list of proposed attributes for each data entity is shown in tables 2–9. Note the use of medial capitals or "camelCase" in all attribute and data-entity names.

2.4. Utilising Existing Standards

Some of the types of data that need to be stored in the tree-ring data standard are part of already existing data standards. Existing standards will be utilised wherever possible in order to reduce the burden of designing, maintaining and implementing the tree-ring standard. With regards dendrochronological terminology, the standard follows the terms of Kaennel and Schweingruber (1995) wherever possible.

An important established data standard is Dublin Core (DCMI Usage Board, 2008). This standard for sharing metadata across domains is primarily used in the library community. Although Dublin Core does not provide enough flexibility to store all TRiDaS metadata, it is the basis behind the "object" portion of TRiDaS.

All geography data within TRiDaS conform to the Open Geospatial Consortium[6] (OGC) Geography Markup Language (GML) specification (Cox et al., 2004). GML is a well established and very extensive standard for describing geographical features. Only a small portion of the comprehensive GML specification is required in TriDaS. Therefore TriDaS only uses specific GML-elements, in particular gml:Point and gml:Polygon.

Standardisation of the value of attributes is essential if the potential of the data standard is to be fully realised. The vocabulary of the data attributes in TRiDaS should use existing thesauri and databases where appropriate. These include: the Art & Architecture Thesaurus (Getty Vocabulary Program, 2008) and published glossaries of discipline-related terminology for the functional description of objects and elements; Species 2000 and ITIS Catalogue of Life for taxonomy (the naming of tree species and subspecies)(Bisby et al., 2008); national registration systems for the spatial identification of objects, such as the

[6]http://www.opengeospatial.org/

Table 1: Three examples of data that have been transformed to the TRiDaS data model. Note that in these examples a maximum of one sub-object has been shown, but the data model can accommodate any number required by the user. In addition, only three data values are shown for each example whereas in reality there would be the same number of values for each example as the recorded number of tree rings.

	Example 1	**Example 2**	**Example 3**
laboratory	Cornell Tree-Ring Laboratory	Laboratory of Tree-Ring Research, Arizona	The Netherlands Centre for Dendrochronology RING
project	Aegean Dendrochronology	NSF Paleoclimatology ATM-0551986	Western Australian Museum
object	White Tower, Thessaloniki	Sheep Mountain	VOC ship *Batavia*
(sub) object	Fourth Floor	-	Hull
element	Rafter 15S	Tree SHP910	Plank
sample	Section TWT-65	Core A	BAT6068B
radius	A	1	1
measurementSeries	Ring widths in 1/100mm units	Ring widths in micron units	Ring widths in 1/100mm units
values	1001 = 54 1002 = 111 1003 = 71 ...	1001 = 354 1002 = 414 1003 = 284 ...	1001 = 98 1002 = 98 1003 = 91 ...

Dutch systems ARCHIS (which identifies and geographically records all archaeological research in the Netherlands) and the “Objectendatabank” (which identifies and describes all national monuments (buildings)). For subject areas where suitable multi-lingual glossaries do not currently exist, they will be developed further as part of the DCCD project (cultural terms) and released to the community as part of TRiDaS.

2.5. Identification of Dendro Data Instances

Identification codes within and between files will enable a researcher to identify homologous data instances. For instance in table 1 example 1, a second file containing the data for a second beam would include the identifying code for the floor, allowing the researcher to keep track of the fact that the two files contain data from the same building. To cope with the possibility that different labs may use the same identifier to represent different data entities, a domain or namespace attribute is used that uniquely identifies the laboratory that produced this data.

3. Implementing TRiDaS in an XML-file

The data standard needs to meet the requirements of dendrochronology, as well as some more technical requirements. TRiDaS should be:

1. adaptable, in order to accommodate future data-storage needs which at this point in time are not yet envisaged or required;
2. simple and open, to ensure that all users and developers can access the data and produce tools capable of reading and manipulating the data;
3. capable of using any character sets, so that users can store metadata in the language of their choosing;
4. accessible to computers running any operating system.

Discussions held in early 2008 soon led to the consensus that eXtensible Markup Language (XML) was the logical choice for the new data standard. XML has been widely adopted by both the research community and computing industry as the most suitable language for data sharing. It enables data to be stored in a highly structured way whilst at the same time remaining “human readable,” as it is just a specialised form of text file. As its name suggests it is extensible, allowing the community to update the specification of the format whilst maintaining both forward and backward compatibility with applications. Examples of TRiDaS XML files are available in electronic form at http://www.tridas.org.

An important issue when implementing a new file format is how to ensure that files comply to the new standard. Fortunately, this is a relatively simple task with XML files, thanks to XML schemas. Schemas are machine-processable specifications which define the structure and syntax of metadata specifications in a formal schema language. Hence XML schemas are documents that programmatically describe the structure, attributes and rulesets of the format and can be used to automatically validate files. Such a schema includes the names of the data entities (as described in section 2.1), the rules governing the relationships between these entities (as described in section 2.2 and figure 1), the attributes that are mandatory (as listed in tables 2–9), and restrictions on the types of data stored in each attribute. The complete TRiDaS XML schema is shown in appendix B.

3.1. Future development, flexibility and extensibility

Whilst we are confident that the standard fields outlined in the tables of appendix A will encompass the needs of many dendrochronologists, it is inevitable that additional fields will be necessary. These may include fields not identified by the authors as well as future requirements that have not yet been envisaged. Attempts have been made to include representatives from all sub disciplines of dendrochronology in the design process, however, the majority of contributors (see section 5) are from an archaeological and cultural dendrochronology background. This has resulted in this first version of TRiDaS being more complete for these sub disciplines than for others. It is hoped that over time, additional contributors will join this initiative and help develop the standard in these under-represented areas. The inherent extensibility of XML makes this evolution of the standard possible, but requires users to propose new fields, make agreements and wait for a new version of the schema to be published, a process that is likely to take some time.

Whilst users wait for new standard fields to be agreed upon, they can make use of the genericField tags that are provided within the TRiDaS standard. These fields encode the field name and type of data as attributes in the XML tag which makes it easy for software to access the data even if the precise meaning of the data is not clear.

An additional purpose of the genericField tag is to guide the future development of the TRiDaS standard. Users are encouraged to submit their genericField definitions to the TRiDaS website. Generic fields that are used by multiple members of the community will be promoted to full standardised fields periodically when updates to the TRiDaS schema are released. Therefore, in most cases these generic tags will be a temporary solution that can be used until the schema is updated and the data can be stored in a standardised and more transparent form.

3.2. From TRiDaS 1.0 to TRiDaS 1.1

The first test of TRiDaS' flexibility was encountered after submitting this article for review. Studying the comments of the reviewer gave us the opportunity to evaluate what was then called "TRiDaS 1.0". It being an open standard, TRiDaS was then altered, taking into account ideas from the Dendro Data Standard Forum and first experiences implementing the standard. We therefore present version 1.1 in this paper.

4. Conclusion

Dendrochronological research at present is hampered by the existence of many different digital data formats and the resulting need for data conversion when accessing specific analytical software. In addition it is hampered by a lack of uniform registration of metadata as well as by the non-sustainability of metadata during conversion.

The XML-based standard TRiDaS has been designed to fill this gap. It is an internationally approved registration and archiving standard for dendrochronological data and metadata that complies with established digital data standards such as Dublin Core, is suited for storing metadata regardless of the research domain, is self-explanatory and can be maintained and upgraded without loss of data and metadata already stored in this format. The presented version 1.1 is the first of what over time will develop into a series of consecutive TRiDaS versions. Based on input from the dendrochronological community TRiDaS will be developed further. We invite all dendrochronologists to evaluate TRiDaS 1.1 through the Dendro Data Standard Forum (see footnote [1]) in the light of their specific research and archiving practices.

The current version will be used both by the DCCD and its participating laboratories (see acknowledgements) and The Malcolm and Carolyn Wiener Laboratory for Aegean and Near Eastern Dendrochronology at Cornell University. This ensures that in 2010, after completion of the DCCD, these US- and Europe-based data archives can be linked and in theory (depending on the access restrictions defined by the data owners) become searchable through the internet. We are confident that this will stimulate research collaborations across national borders and even continents, will improve international funding of such research and will stimulate the development of software applications based on the new digital standard.

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- University of Liège, Centre Européen d'Archéométrie, Laboratoire de Dendrochronologie (Liège, BE)
- Vlaams Instituut voor het Onroerend Erfgoed (VIOE; Brussels, BE)
- The Royal Institute for Cultural Heritage (IRPAKIK; Brussels, BE)
- Centre de Recherche et de Restauration des Museés de France (C2RMF; Paris, FR)
- Dendronet (Freiburg, DE)
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A. Data Attribute Dictionaries

Table 2: Details of the attributes available for projects.

	Definition	Mandatory	Repeatable	Usage Notes
title	Name of the project	Y	N	
identifierValue	Laboratory project identification such as a report number	Y	N	Must be unique in combination with laboratory
createdTimestamp	Date and time that this record was created	N	N	
lastModifiedTimestamp	Date and time that this record was last modified	N	N	
type	Examples include: dating, provenance, wood-technology, vegetation reconstruction, climate study	Y	Y	Ideally value should be taken from a controlled vocabulary. Examples are given in section 2.4
description	More information about purposes of the dendrochronological research	N	N	
file	Results of the project in digital files	N	Y	Link to separate file(s)
laboratory	Name of the dendrochronological research laboratory	Y	Y	
category	Former vegetation, archaeology, building history, ship's archaeology, art/furniture, actual vegetation	Y	N	Ideally value should be taken from a controlled vocabulary. Examples are given in section 2.4
investigator	Principal investigator	Y	N	If unknown then value must be stated explicitly 'unknown'
period	When the dendrochronological project took place	Y	N	Could consist of a start- and end-date. If unknown it should be estimated
requestDate	Date of the request for dendrochronology	N	N	If unknown it should be estimated.
commissioner	Commissioner	N	N	Person and/or institute
reference	Dendrochronological publications	N	Y	Bibliographical description of publication
researchIdentifierDomain	National or international system in which the research project is registered	N	Y	Must be unique in combination with research_id
researchIdentifierValue	National or international registration of research: registration number	N	Y	Must be unique in combination with researchIdentifierDomain

Table 3: Details of the attributes available for objects.

	Definition	Mandatory	Repeatable	Usage Notes
title	Individual name (such as the name of a ship, building or painting)	Y	N	
identifier	Inventory number. Equivalent to Dublin Core element “identifier”	N	N	
identifierDomain	Inventory system	N	N	
createdTimestamp	Date and time that this record was created	N	N	
lastModifiedTimestamp	Date and time that this record was last modified	N	N	
type	Functional description: building (church, house etc.) water well, painting, musical instrument (and type), ship (and type), type of forest	Y	N	Ideally value should be taken from a controlled vocabulary. Examples are given in section 2.4
description	More elaborate description of the object itself; this could include important characteristics which are mainly domain specific. For example in building history “type of joints” or dimensions of the object	N	N	
linkSeries	Reference to a derivedSeries which is a combination of measurements of this object	N	Y	
file	Digital pictures; word-docs; excelsheets; maps; files with geo-measurements	N	Y	
creator	Name, place of the workshop/wharf	N	N	
owner	Owner of object	N	N	
coverageTemporal	If the date is already known in more or less detail: historical period (broad). Equivalent to Dublin Core term “temporal”	N	N	When an object can not be dated, a date can be estimated using for instance stylistic properties or stratigraphy
coverageTemporal-Foundation	Dating support (e.g. archive sources, inscriptions, stratigraphic context, associated finds, typology, stylistic aspects, carpenter marks, radiocarbon, OSL, other methods)	N	N	
locationGeometry	Objects in situ: coordinates point or polygon. Equivalent to Dublin Core term “spatial”	N	N	Point or polygon ideally in WGS84.
locationType	One of: Growth location; Location of use (static); Location of use (mobile); Current location; Manufacture location	N	N	For example, point taken from center or corner of area, which corner
locationPrecision	Stores potential difference; number of meters difference, so 0 is exact.	N	N	
locationComment	Extra information	N	N	For example, point taken from center or corner of area, which corner

Table 4: Details of the attributes available for element.

	Definition	Mandatory	Repeatable	Usage Notes
title	Name of the element	Y	N	
identifier	External registration-number, find number, code	N	N	
identifierDomain	Domain from which the identifierValue was issued	N	N	
createdTimestamp	Date and time that this record was created	N	N	
lastModifiedTimestamp	Date and time that this record was last modified	N	N	
type	Functional term of the part of the object	N	N	
description	Other information about the element	N	N	
linkSeries	Reference to a derivedSeries which is a combination of measurements of this element	N	Y	
file	drawings or pictures of the element; position in the object	N	Y	
taxon	The most detailed taxonomic name known: species, genus, family etc	Y	N	Ideally the value should be taken from the Catalogue of Life. See section 2.4
shape	Shape of element - used primarily for beams	N	N	Ideally value should be taken from a controlled vocabulary. Examples are given in section 2.4
dimensions	Dimensions of element. Depending on the type of element this can include one or more of the following: diameter; height; width; depth	N	N	When the element is a tree, this would likely contain height and diameter but in most other cases it is likely to contain height, width and depth
unit	SI-units used for the dimensions	N	N	
authenticity	Original/repair/later addition	N	N	
locationGeometry	See table 3	N	N	
locationType	See table 3	N	N	
locationPrecision	See table 3	N	N	
locationComment	See table 3	N	N	
processing	Processing (carved, sawn etc.) rafting marks	N	N	
marks	Carpenter marks, inscriptions	N	N	
altitude	Altitude in metres if this element is a live tree in situ	N	N	
slopeAngle	Angle of slope from horizontal in degrees	N	N	
slopeAzimuth	Angle in degrees from north along which the slope lies	N	N	
soilDescription	General description of soil type	N	N	
soilDepth	Depth of soil in centimetres	N	N	
bedrockDescription	General description of the underlying bedrock	N	N	

Table 5: Details of the attributes available for sample.

	Definition	Mandatory	Repeatable	Usage Notes
title	Name of the sample	Y	N	
identifier	Unique sample identifier	N	N	
identifierDomain	Domain from which the identifier-value was issued	N	N	
createdTimestamp	Date and time that this record was created	N	N	
lastModifiedTimestamp	Date and time that this record was last modified	N	N	
type	Method that was used to take a sample from the element	Y	N	
description	More information about the sampling	N	N	
file	Digital photo or scanned image	N	Y	
samplingDate	Year of dendrochronological sampling	N	N	
samplingDateCertainty	Certainty of the date of sampling	N	N	
position	Position of sample in element	N	N	
state	State of material (dry/wet/conserved/burned, woodworm, rot, cracks) things that indicate the quality of the measurements.	N	N	
knots	Presence of knots	N	N	

Table 6: Details of the attributes available for radius.

	Definition	Mandatory	Repeatable	Usage Notes
title	Name of the radius	Y	N	
identifier	Unique radius identifier	N	N	
identifierDomain	Domain from which the identifierValue was issued	N	N	
createdTimestamp	Date and time that this record was created	N	N	
lastModifiedTimestamp	Date and time that this record was last modified	N	N	
pith	Whether pith is present or absent	Y	N	
heartwood	Whether present of absent			
missingHeartwoodRings-ToPith	Estimated number of missing heartwood rings to the pith	N	N	
missingHeartwoodRings-ToPithFoundation	Description of the way the estimation was made and certainty	N	N	
sapwood	One of: n/a; absent; complete; incomplete	Y	N	
missingSapwoodRings-ToBark	Estimated number of missing sapwood rings to the bark	N	N	
missingSapwoodRings-ToBarkFoundation	Description of the way the estimation was made and certainty	N	N	
nrOfSapwoodRings	Number of measured sapwood rings	N	N	
lastRingUnderBark	Information about the last rings under the bark	N	N	If the last ring under the bark is present, include information about the completeness of this ring and/or season of felling.
bark	Bark present/absent	Y	N	
azimuth	Angle in degrees from north along which this radius lies	N	N	

Table 7: Details of the attributes available for measurementSeries.

	Definition	Mandatory	Repeatable	Usage Notes
title	Name of the measurementSeries	Y	N	
identifier	Unique measurementSeries identifier	N	N	
identifierDomain	Domain from which the identifierValue was issued	N	N	
createdTimestamp	Date and time that this record was created	N	N	
lastModifiedTimestamp	Date and time that this record was last modified	N	N	
analyst	Name of the analyst that made the series	N	N	
dendrochronologist	Name of the dendrochronologist that oversaw the analyst	N	N	
measuringMethod	What method was used to measure	Y	N	
comments	More information about the series	N	N	
usage	How the series is used, for instance in which chronology	N	N	
usageComments	Comments by later users on quality of series	N	Y	
variable	Measured variable (ring-width, earlywood, latewood etc)	Y	N	
firstYear	Year of the first measured ring. This is derived from the chronology that was used to date this series	N	N	Not to be confused with sproutYear. A suffix of BC, AD or BP should be used.
datingReference	Chronology used to interpret the measurement	N	N	
statValue	Statistical value used to support match with chronology	N	Y	
statType	Type of statistic used to support match with chronology	N	Y	
significanceLevel	Significance of statistical match with the chronology	N	Y	
sproutYear	Estimated year that the tree sprouted	N	N	A suffix of BC, AD or BP may be used otherwise value is assumed to be a signed integer representing BC/AD year.
usedSoftware	Software used to perform the statistical match with the chronology	N	Y	
deathYear	Estimated year of death of the tree	N	N	A suffix of BC, AD or BP may be used otherwise value is assumed to be a signed integer representing BC/AD year.
provenance	Estimated provenance derived from the matching chronology	N	N	

Table 8: Details of the attributes available for derivedSeries.

	Definition	Mandatory	Repeatable	Usage Notes
title	Name of the derivedSeries	Y	N	
identifier	Unique derivedSeries identifier	N	N	
identifierDomain	Domain from which the identifierValue was issued	N	N	
createdTimestamp	Date and time that this record was created	N	N	
lastModifiedTimestamp	Date and time that this record was last modified	N	N	
type	Type, e.g. chronology, object curve	Y	Y	
linkSeries	Series from which this series was derived	Y	Y	
objective	The reason/rationale why this series was made	N	N	
standardizingMethod	Numerical method used to standardise the series	N	N	
author	Author	N	N	
version	Version number	N	N	
comments	See table 7	N	N	
usage	See table 7	N	N	
usageComments	See table 7	N	Y	
firstYear	See table 7	N	N	
datingReference	See table 7	N	N	
statValue	See table 7	N	Y	
statType	See table 7	N	Y	
significanceLevel	See table 7	N	Y	
sproutYear	See table 7	N	N	
usedSoftware	See table 7	N	Y	
deathYear	See table 7	N	N	
provenance	See table 7	N	N	
extentGeometry	Geographical extent that the derivedSeries covers	N	N	
extentComment	Comments on the geographical extent	N	N	

Table 9: Details of the attributes available for value.

	Definition	Mandatory	Repeatable	Usage Notes
index	Alphanumeric code to identify the sequential position of the value, e.g. nr1001, nr1002 etc.	Y	N	To avoid confusion with years, the index should have a prefix of "nr"
value	The actual value being recorded	Y	N	
remark	Remark about this ring. A controlled vocabulary can be used to standardise important remarks such as 'fire damage', 'frost damage' etc	N	N	
count	Number of underlying values that contribute to this value	N	N	Only applicable to values associated with derivedSeries

B. TRiDaS XML Schema

```
<?xml version="1.0" encoding="UTF-8"?>
<!--
TRiDaS 1.1: Tree-Ring Data Standard for dendrochronology
See http://www.tridas.org/ for:
- more information
- contact information
- latest version

Version date: 2009-03-17

This XML Schema is available under LGPLv3
more information on http://www.gnu.org/licenses/lgpl.html

***********************************************-->
<xs:schema xmlns="http://www.tridas.org/1.1" xmlns:xs="http://www.w3.org/2001/XMLSchema" xmlns:xlink="
    http://www.w3.org/1999/xlink" xmlns:gml="http://www.opengis.net/gml" targetNamespace="http://www.
    tridas.org/1.1" elementFormDefault="qualified" attributeFormDefault="unqualified">
  <!--
%%%%%%%%%%%%%%
%       EXTERNAL SCHEMAS
%%%%%%%%%%%%%% -->
  <xs:import namespace="http://www.w3.org/1999/xlink" schemaLocation="xlinks.xsd"/>
  <!-- download-location: http://www.tridas.org/1.1/xlinks.xsd -->
  <!-- original location: http://schemas.opengis.net/xlink/1.0.0/xlinks.xsd -->
  <xs:import namespace="http://www.opengis.net/gml" schemaLocation="gmlsf.xsd"/>
  <!-- download-location: http://www.tridas.org/1.1/gmlsf.xsd -->
  <!-- original location: http://schemas.opengis.net/gml/3.1.1/profiles/gmlsfProfile/1.0.0/gmlsf.xsd
      -->
  <!--

%%%%%%%%%%%%%%
%       GLOBAL TYPES
%%%%%%%%%%%%%% -->
  <!-- controlledVoc -->
  <xs:complexType name="controlledVoc">
    <xs:simpleContent>
      <xs:extension base="xs:string">
        <xs:attribute name="normalStd"/>
        <xs:attribute name="normalId"/>
        <xs:attribute name="normal"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
  <!-- date and time -->
  <xs:simpleType name="certainty">
    <xs:restriction base="xs:string">
      <xs:enumeration value="unknown"/>
      <xs:enumeration value="exact"/>
      <xs:enumeration value="approximately"/>
      <xs:enumeration value="after"/>
      <xs:enumeration value="before"/>
    </xs:restriction>
  </xs:simpleType>
  <xs:complexType name="dateTime">
    <xs:simpleContent>
      <xs:extension base="xs:dateTime">
        <xs:attribute name="certainty" type="certainty" use="optional"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
  <xs:element name="createdTimestamp" type="dateTime"/>
  <xs:element name="lastModifiedTimestamp" type="dateTime"/>
  <xs:complexType name="date">
    <xs:simpleContent>
      <xs:extension base="xs:date">
        <xs:attribute name="certainty" type="certainty" use="optional"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
```

```
<xs:complexType name="year">
  <xs:simpleContent>
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      <xs:attribute name="certainty" type="certainty" use="optional"/>
      <xs:attribute name="suffix" use="required">
        <xs:simpleType>
          <xs:restriction base="xs:string">
            <xs:enumeration value="AD"/>
            <xs:enumeration value="BC"/>
            <xs:enumeration value="BP"/>
          </xs:restriction>
        </xs:simpleType>
      </xs:attribute>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>
<!-- linkSeries -->
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  <xs:complexType>
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        <xs:complexType>
          <xs:attribute name="ref" type="xs:IDREF"/>
        </xs:complexType>
      </xs:element>
      <xs:element name="xLink" maxOccurs="unbounded">
        <xs:complexType>
          <xs:attribute ref="xlink:href"/>
        </xs:complexType>
      </xs:element>
      <xs:element ref="identifier" maxOccurs="unbounded"/>
    </xs:choice>
  </xs:complexType>
</xs:element>
<!-- type -->
<xs:element name="type" type="controlledVoc"/>
<!-- description -->
<xs:element name="description" type="xs:string"/>
<!-- title -->
<xs:element name="title" type="xs:string"/>
<!-- identifier -->
<xs:element name="identifier">
  <xs:complexType>
    <xs:simpleContent>
      <xs:extension base="xs:string">
        <xs:attribute name="domain" use="required"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>
</xs:element>
<!-- extent -->
<xs:element name="extent">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="extentGeometry"/>
      <xs:element ref="extentComment" minOccurs="0"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<xs:element name="extentGeometry">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="gml:Polygon"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<xs:element name="extentComment" type="xs:string"/>
<!-- location -->
<xs:element name="location">
  <xs:complexType>
    <xs:sequence>
```

```
        <xs:element ref="locationGeometry"/>
        <xs:element ref="locationType" minOccurs="0"/>
        <xs:element ref="locationPrecision" minOccurs="0"/>
        <xs:element ref="locationComment" minOccurs="0"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
  <xs:element name="locationGeometry">
    <xs:complexType>
      <xs:choice>
        <xs:element ref="gml:Point"/>
        <xs:element ref="gml:Polygon"/>
      </xs:choice>
    </xs:complexType>
  </xs:element>
  <xs:element name="locationType" type="xs:string"/>
  <xs:element name="locationPrecision" type="xs:string"/>
  <xs:element name="locationComment" type="xs:string"/>
  <!-- file -->
  <xs:element name="file">
    <xs:complexType>
      <xs:attribute ref="xlink:href" use="required"/>
    </xs:complexType>
  </xs:element>
  <!-- generic field -->
  <xs:element name="genericField">
    <xs:complexType>
      <xs:simpleContent>
        <xs:extension base="xs:string">
          <xs:attribute name="name" use="required"/>
          <xs:attribute name="type" use="optional"/>
        </xs:extension>
      </xs:simpleContent>
    </xs:complexType>
  </xs:element>
  <!--
%%%%%%%%%%%%
%       ROOT
%%%%%%%%%%%% -->
  <xs:element name="tridas">
    <xs:complexType>
      <xs:sequence>
        <xs:element ref="project" maxOccurs="unbounded"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
  <!--
%%%%%%%%%%%%
%       PROJECT
%%%%%%%%%%%% -->
  <xs:element name="project">
    <xs:complexType>
      <xs:sequence>
        <xs:element ref="title"/>
        <xs:element ref="identifier" minOccurs="0"/>
        <xs:element ref="createdTimestamp" minOccurs="0"/>
        <xs:element ref="lastModifiedTimestamp" minOccurs="0"/>
        <xs:element ref="type" maxOccurs="unbounded"/>
        <xs:element ref="description" minOccurs="0"/>
        <xs:element ref="file" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element ref="laboratory" maxOccurs="unbounded"/>
        <xs:element ref="category"/>
        <xs:element ref="investigator"/>
        <xs:element ref="period"/>
        <xs:element ref="requestDate" minOccurs="0"/>
        <xs:element ref="commissioner" minOccurs="0"/>
        <xs:element ref="reference" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element ref="research" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element ref="genericField" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element ref="object" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element ref="derivedSeries" minOccurs="0" maxOccurs="unbounded"/>
```

```
            </xs:sequence>
        </xs:complexType>
    </xs:element>
    <!-- PROJECT.title (global type)-->
    <!-- PROJECT.identifier (global type) -->
    <!-- PROJECT.createdTimestamp (global type) -->
    <!-- PROJECT.lastModifiedTimestamp (global type) -->
    <!-- PROJECT.laboratory -->
    <xs:element name="laboratory">
        <xs:complexType>
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                <xs:element ref="place"/>
                <xs:element ref="country"/>
            </xs:sequence>
        </xs:complexType>
    </xs:element>
    <xs:element name="name">
        <xs:complexType>
            <xs:simpleContent>
                <xs:extension base="xs:string">
                    <xs:attribute name="acronym" use="optional"/>
                </xs:extension>
            </xs:simpleContent>
        </xs:complexType>
    </xs:element>
    <xs:element name="place" type="xs:string"/>
    <xs:element name="country" type="xs:string"/>
    <!-- PROJECT.type (global type) -->
    <!-- PROJECT.category -->
    <xs:element name="category">
        <xs:complexType>
            <xs:complexContent>
                <xs:extension base="controlledVoc">
                    <xs:attribute name="normalTridas">
                        <xs:simpleType>
                            <xs:restriction base="xs:string">
                                <xs:enumeration value=""/>
                            </xs:restriction>
                        </xs:simpleType>
                    </xs:attribute>
                </xs:extension>
            </xs:complexContent>
        </xs:complexType>
    </xs:element>
    <!-- PROJECT.investigator -->
    <xs:element name="investigator" type="xs:string"/>
    <!-- PROJECT.period -->
    <xs:element name="period" type="xs:string"/>
    <!-- PROJECT.description (global type) -->
    <!-- PROJECT.requestDate -->
    <xs:element name="requestDate" type="date"/>
    <!-- PROJECT.commissioner -->
    <xs:element name="commissioner" type="xs:string"/>
    <!-- PROJECT.reference -->
    <xs:element name="reference" type="xs:string"/>
    <!-- PROJECT.file (global type) -->
    <!-- PROJECT.research -->
    <xs:element name="research">
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            <xs:sequence>
                <xs:element ref="identifier"/>
                <xs:element ref="description"/>
            </xs:sequence>
        </xs:complexType>
    </xs:element>
    <!-- PROJECT.genericField (global type) -->
    <!--
%%%%%%%%%%%%
%       OBJECT
```

```
%%%%%%%%%%%%%-->
    <xs:element name="object">
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                <xs:element ref="identifier" minOccurs="0"/>
                <xs:element ref="createdTimestamp" minOccurs="0"/>
                <xs:element ref="lastModifiedTimestamp" minOccurs="0"/>
                <xs:element ref="type"/>
                <xs:element ref="description" minOccurs="0"/>
                <xs:element ref="linkSeries" minOccurs="0" maxOccurs="unbounded"/>
                <xs:element ref="file" minOccurs="0" maxOccurs="unbounded"/>
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                <xs:element ref="genericField" minOccurs="0" maxOccurs="unbounded"/>
                <xs:element ref="object" minOccurs="0" maxOccurs="unbounded"/>
                <xs:element ref="element" minOccurs="0" maxOccurs="unbounded"/>
            </xs:sequence>
        </xs:complexType>
    </xs:element>
    <!-- OBJECT.title (global type) -->
    <!-- OBJECT.identifier (global type) -->
    <!-- OBJECT.createdTimestamp (global type) -->
    <!-- OBJECT.lastModifiedTimestamp (global type) -->
    <!-- OBJECT.type (global type) -->
    <!-- OBJECT.description (global type) -->
    <!-- OBJECT.linkSeries (global type) -->
    <!-- OBJECT.file (global type) -->
    <!-- OBJECT.creator -->
    <xs:element name="creator" type="xs:string"/>
    <!-- OBJECT.owner -->
    <xs:element name="owner" type="xs:string"/>
    <!-- OBJECT.coverage -->
    <xs:element name="coverage">
        <xs:complexType>
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                <xs:element ref="coverageTemporal"/>
                <xs:element ref="coverageTemporalFoundation"/>
            </xs:sequence>
        </xs:complexType>
    </xs:element>
    <xs:element name="coverageTemporal" type="xs:string"/>
    <xs:element name="coverageTemporalFoundation" type="xs:string"/>
    <!-- OBJECT.location (global type) -->
    <!-- OBJECT.genericField (global type) -->
    <!--
%%%%%%%%%%%%%
%       ELEMENT
%%%%%%%%%%%%%-->
    <xs:element name="element">
        <xs:complexType>
            <xs:sequence>
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                <xs:element ref="identifier" minOccurs="0"/>
                <xs:element ref="createdTimestamp" minOccurs="0"/>
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                <xs:element ref="type" minOccurs="0"/>
                <xs:element ref="description" minOccurs="0"/>
                <xs:element ref="linkSeries" minOccurs="0" maxOccurs="unbounded"/>
                <xs:element ref="file" minOccurs="0" maxOccurs="unbounded"/>
                <xs:element ref="taxon"/>
                <xs:element ref="shape" minOccurs="0"/>
                <xs:element ref="dimensions" minOccurs="0"/>
                <xs:element ref="authenticity" minOccurs="0"/>
                <xs:element ref="location" minOccurs="0"/>
                <xs:element ref="processing" minOccurs="0"/>
                <xs:element ref="marks" minOccurs="0"/>
                <xs:element ref="altitude" minOccurs="0"/>
                <xs:element ref="slope" minOccurs="0"/>
```

```
         <xs:element ref="soil" minOccurs="0"/>
         <xs:element ref="bedrock" minOccurs="0"/>
         <xs:element ref="genericField" minOccurs="0" maxOccurs="unbounded"/>
         <xs:element ref="sample" minOccurs="0" maxOccurs="unbounded"/>
      </xs:sequence>
   </xs:complexType>
</xs:element>
<!-- ELEMENT. title (global type) -->
<!-- ELEMENT. identifier (global type) -->
<!-- ELEMENT. createdTimestamp (global type) -->
<!-- ELEMENT. lastModifiedTimestamp (global type) -->
<!-- ELEMENT. type (global type) -->
<!-- ELEMENT. linkSeries (global type) -->
<!-- ELEMENT. file (global type) -->
<!-- ELEMENT. taxon -->
<xs:element name="taxon">
   <xs:complexType>
      <xs:complexContent>
         <xs:extension base="controlledVoc">
            <xs:attribute name="normalTridas">
               <xs:simpleType>
                  <xs:restriction base="xs:string">
                     <xs:enumeration value=""/>
                  </xs:restriction>
               </xs:simpleType>
            </xs:attribute>
         </xs:extension>
      </xs:complexContent>
   </xs:complexType>
</xs:element>
<!-- ELEMENT. shape -->
<xs:element name="shape">
   <xs:complexType>
      <xs:complexContent>
         <xs:extension base="controlledVoc">
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                  <xs:restriction base="xs:string">
                     <xs:enumeration value=""/>
                  </xs:restriction>
               </xs:simpleType>
            </xs:attribute>
         </xs:extension>
      </xs:complexContent>
   </xs:complexType>
</xs:element>
<!-- ELEMENT. dimensions -->
<xs:element name="dimensions">
   <xs:complexType>
      <xs:sequence>
         <xs:element ref="unit"/>
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            <xs:sequence>
               <xs:element name="diameter" type="xs:decimal"/>
               <xs:element name="height" type="xs:decimal"/>
            </xs:sequence>
            <xs:sequence>
               <xs:element name="height" type="xs:decimal"/>
               <xs:element name="width" type="xs:decimal"/>
               <xs:element name="depth" type="xs:decimal"/>
            </xs:sequence>
         </xs:choice>
      </xs:sequence>
   </xs:complexType>
</xs:element>
<!-- ELEMENT. authenticity -->
<xs:element name="authenticity" type="xs:string"/>
<!-- ELEMENT. location (global type) -->
<!-- ELEMENT. description (global type) -->
<!-- ELEMENT. processing -->
<xs:element name="processing" type="xs:string"/>
```

```
<!-- ELEMENT.marks -->
<xs:element name="marks" type="xs:string"/>
<!-- ELEMENT.altitude -->
<xs:element name="altitude" type="xs:double"/>
<!-- ELEMENT.slope -->
<xs:element name="slope">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="angle" type="xs:integer" minOccurs="0"/>
      <xs:element name="azimuth" type="xs:integer" minOccurs="0"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<!-- ELEMENT.soil -->
<xs:element name="soil">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="description" type="xs:string" minOccurs="0"/>
      <xs:element name="depth" type="xs:double" minOccurs="0"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<!-- ELEMENT.bedrock -->
<xs:element name="bedrock">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="description" type="xs:string" minOccurs="0"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<!-- ELEMENT.genericField (global type) -->
<!--
%%%%%%%%%%%%%%%
%      SAMPLE
%%%%%%%%%%%%%%%-->
<xs:element name="sample">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="title"/>
      <xs:element ref="identifier" minOccurs="0"/>
      <xs:element ref="createdTimestamp" minOccurs="0"/>
      <xs:element ref="lastModifiedTimestamp" minOccurs="0"/>
      <xs:element ref="type"/>
      <xs:element ref="description" minOccurs="0"/>
      <xs:element ref="file" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="samplingDate" minOccurs="0"/>
      <xs:element ref="position" minOccurs="0"/>
      <xs:element ref="state" minOccurs="0"/>
      <xs:element ref="knots" minOccurs="0"/>
      <xs:element ref="genericField" minOccurs="0" maxOccurs="unbounded"/>
      <xs:choice>
        <xs:element ref="radius" minOccurs="0"/>
        <xs:element ref="radiusPlaceholder" minOccurs="0"/>
      </xs:choice>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<!-- SAMPLE.title (global type) -->
<!-- SAMPLE.identifier (global type) -->
<!-- SAMPLE.createdTimestamp (global type) -->
<!-- SAMPLE.lastModifiedTimestamp (global type) -->
<!-- SAMPLE.type (global type) -->
<!-- SAMPLE.description (global type) -->
<!-- SAMPLE.file (global type) -->
<!-- SAMPLE.samplingDate -->
<xs:element name="samplingDate" type="date"/>
<!-- SAMPLE.position -->
<xs:element name="position" type="xs:string"/>
<!-- SAMPLE.state -->
<xs:element name="state" type="xs:string"/>
<!-- SAMPLE.knots -->
```

```
    <xs:element name="knots" type="xs:boolean"/>
    <!-- SAMPLE.genericField (global type) -->
    <!--
%%%%%%%%%%%%
%       RADIUS
%%%%%%%%%%%%-->
    <xs:element name="radius">
        <xs:complexType>
            <xs:sequence>
                <xs:element ref="title"/>
                <xs:element ref="identifier" minOccurs="0"/>
                <xs:element ref="createdTimestamp" minOccurs="0"/>
                <xs:element ref="lastModifiedTimestamp" minOccurs="0"/>
                <xs:element ref="pith"/>
                <xs:element ref="heartwood"/>
                <xs:element ref="sapwood"/>
                <xs:element ref="bark"/>
                <xs:element ref="azimuth" minOccurs="0"/>
                <xs:element ref="genericField" minOccurs="0" maxOccurs="unbounded"/>
                <xs:element ref="measurementSeries" minOccurs="0" maxOccurs="unbounded"/>
            </xs:sequence>
        </xs:complexType>
    </xs:element>
    <!-- RADIUS.title (global type) -->
    <!-- RADIUS.identifier (global type) -->
    <!-- RADIUS.createdTimestamp (global type) -->
    <!-- RADIUS.lastModifiedTimestamp (global type) -->
    <!-- RADIUS.pith -->
    <xs:element name="pith">
        <xs:complexType>
            <xs:attribute name="presence" use="required">
                <xs:simpleType>
                    <xs:restriction base="xs:string">
                        <xs:enumeration value="present"/>
                        <xs:enumeration value="absent"/>
                    </xs:restriction>
                </xs:simpleType>
            </xs:attribute>
        </xs:complexType>
    </xs:element>
    <!-- RADIUS.azimuth -->
    <xs:element name="azimuth" type="xs:decimal"/>
    <!-- RADIUS.heartwood -->
    <xs:element name="heartwood">
        <xs:complexType>
            <xs:sequence>
                <xs:element ref="missingHeartwoodRingsToPith" minOccurs="0"/>
                <xs:element ref="missingHeartwoodRingsToPithFoundation" minOccurs="0"/>
            </xs:sequence>
            <xs:attribute name="presence" use="required"/>
        </xs:complexType>
    </xs:element>
    <xs:element name="missingHeartwoodRingsToPithFoundation" type="xs:string"/>
    <xs:element name="missingHeartwoodRingsToPith" type="xs:string"/>
    <!-- RADIUS.sapwood -->
    <xs:element name="sapwood">
        <xs:complexType>
            <xs:sequence>
                <xs:element ref="nrOfSapwoodRings" minOccurs="0"/>
                <xs:element ref="lastRingUnderBark" minOccurs="0"/>
                <xs:element ref="missingSapwoodRingsToBark" minOccurs="0"/>
                <xs:element ref="missingSapwoodRingsToBarkFoundation" minOccurs="0"/>
            </xs:sequence>
            <xs:attribute name="presence" use="required">
                <xs:simpleType>
                    <xs:restriction base="xs:string">
                        <xs:enumeration value="not applicable"/>
                        <xs:enumeration value="absent"/>
                        <xs:enumeration value="complete"/>
                        <xs:enumeration value="incomplete"/>
                    </xs:restriction>
```

```
            </xs:simpleType>
         </xs:attribute>
      </xs:complexType>
   </xs:element>
   <xs:element name="nrOfSapwoodRings" type="xs:string"/>
   <xs:element name="lastRingUnderBark" type="xs:string"/>
   <xs:element name="missingSapwoodRingsToBarkFoundation" type="xs:string"/>
   <xs:element name="missingSapwoodRingsToBark" type="xs:string"/>
   <!-- RADIUS.bark -->
   <xs:element name="bark">
      <xs:complexType>
         <xs:attribute name="presence" use="required">
            <xs:simpleType>
               <xs:restriction base="xs:string">
                  <xs:enumeration value="present"/>
                  <xs:enumeration value="absent"/>
               </xs:restriction>
            </xs:simpleType>
         </xs:attribute>
      </xs:complexType>
   </xs:element>
   <!-- RADIUS.genericField (global type) -->
   <!-- RADIUS-PLACEHOLDER -->
   <xs:element name="radiusPlaceholder">
      <xs:complexType>
         <xs:sequence>
            <xs:element ref="measurementSeriesPlaceholder"/>
         </xs:sequence>
      </xs:complexType>
   </xs:element>
   <!--
%%%%%%%%%%%%%
%       MEASUREMENTSERIES
%%%%%%%%%%%%%-->
   <xs:element name="measurementSeries">
      <xs:complexType>
         <xs:sequence maxOccurs="unbounded">
            <xs:element ref="title"/>
            <xs:element ref="identifier" minOccurs="0"/>
            <xs:element ref="createdTimestamp" minOccurs="0"/>
            <xs:element ref="lastModifiedTimestamp" minOccurs="0"/>
            <xs:element ref="analyst" minOccurs="0"/>
            <xs:element ref="dendrochronologist" minOccurs="0"/>
            <xs:element ref="measuringMethod"/>
            <xs:element ref="comments" minOccurs="0"/>
            <xs:element ref="usage" minOccurs="0"/>
            <xs:element ref="usageComments" minOccurs="0" maxOccurs="unbounded"/>
            <xs:choice minOccurs="0">
               <xs:element ref="interpretation"/>
               <xs:element ref="interpretationUnsolved"/>
            </xs:choice>
            <xs:element ref="genericField" minOccurs="0" maxOccurs="unbounded"/>
            <xs:element ref="values" minOccurs="0" maxOccurs="unbounded"/>
         </xs:sequence>
         <xs:attribute name="id" type="xs:ID"/>
      </xs:complexType>
   </xs:element>
   <!-- MEASUREMENTSERIES.title (global type) -->
   <!-- MEASUREMENTSERIES.identifier (global type) -->
   <!-- MEASUREMENTSERIES.createdTimestamp (global type) -->
   <!-- MEASUREMENTSERIES.lastModifiedTimestamp (global type) -->
   <!-- MEASUREMENTSERIES.analyst -->
   <xs:element name="analyst" type="xs:string"/>
   <!-- MEASUREMENTSERIES.dendrochronologist -->
   <xs:element name="dendrochronologist" type="xs:string"/>
   <!-- MEASUREMENTSERIES.measuringMethod -->
   <xs:element name="measuringMethod">
      <xs:complexType>
         <xs:complexContent>
            <xs:extension base="controlledVoc">
               <xs:attribute name="normalTridas">
```

```
                <xs:simpleType>
                    <xs:restriction base="xs:string">
                        <xs:enumeration value=""/>
                    </xs:restriction>
                </xs:simpleType>
            </xs:attribute>
        </xs:extension>
    </xs:complexContent>
  </xs:complexType>
</xs:element>
<!-- MEASUREMENTSERIES.measuringDate -->
<xs:element name="measuringDate" type="date"/>
<!-- MEASUREMENTSERIES.comments -->
<xs:element name="comments" type="xs:string"/>
<!-- MEASUREMENTSERIES.usage -->
<xs:element name="usage" type="xs:string"/>
<!-- MEASUREMENTSERIES.usageComments -->
<xs:element name="usageComments" type="xs:string"/>
<!-- MEASUREMENTSERIES.genericField (global type) -->
<!-- MEASUREMENTSERIES.interpretation -->
<xs:element name="interpretation">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="firstYear" minOccurs="0"/>
      <xs:element ref="datingReference" minOccurs="0"/>
      <xs:element ref="statFoundation" minOccurs="0" maxOccurs="unbounded"/>
      <xs:element ref="sproutYear" minOccurs="0"/>
      <xs:element ref="usedSoftware" minOccurs="0"/>
      <xs:element ref="deathYear" minOccurs="0"/>
      <xs:element ref="provenance" minOccurs="0"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<xs:element name="datingReference">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="linkSeries"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<xs:element name="firstYear" type="year"/>
<xs:element name="statFoundation">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="statValue"/>
      <xs:element ref="type"/>
      <xs:element ref="significanceLevel" minOccurs="0"/>
      <xs:element ref="usedSoftware"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<xs:element name="statValue" type="xs:decimal"/>
<xs:element name="significanceLevel" type="xs:decimal"/>
<xs:element name="usedSoftware" type="xs:string"/>
<xs:element name="sproutYear" type="year"/>
<xs:element name="deathYear" type="year"/>
<xs:element name="provenance" type="xs:string"/>
<!-- MEASUREMENTSERIES.interpretationUnsolved -->
<xs:element name="interpretationUnsolved" type="xs:string"/>
<!-- MEASUREMENTSSERIES-PLACEHOLDER -->
<xs:element name="measurementSeriesPlaceholder">
  <xs:complexType>
    <xs:attribute name="id" type="xs:ID" use="required"/>
  </xs:complexType>
</xs:element>
<!--
%%%%%%%%%%%%
%       DERIVEDSERIES
%%%%%%%%%%%% -->
<xs:element name="derivedSeries">
  <xs:complexType>
```

```
      <xs:sequence>
        <xs:element ref="title"/>
        <xs:element ref="identifier" minOccurs="0"/>
        <xs:element ref="createdTimestamp" minOccurs="0"/>
        <xs:element ref="lastModifiedTimestamp" minOccurs="0"/>
        <xs:element ref="type"/>
        <xs:element ref="linkSeries" maxOccurs="unbounded"/>
        <xs:element ref="objective" minOccurs="0"/>
        <xs:element ref="standardizingMethod" minOccurs="0"/>
        <xs:element ref="author" minOccurs="0"/>
        <xs:element ref="version" minOccurs="0"/>
        <xs:element ref="comments" minOccurs="0"/>
        <xs:element ref="usage" minOccurs="0"/>
        <xs:element ref="usageComments" minOccurs="0" maxOccurs="unbounded"/>
        <xs:choice minOccurs="0">
          <xs:element ref="interpretation"/>
          <xs:element ref="interpretationUnsolved"/>
        </xs:choice>
        <xs:element ref="extent" minOccurs="0"/>
        <xs:element ref="genericField" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element ref="values" minOccurs="0" maxOccurs="unbounded"/>
      </xs:sequence>
      <xs:attribute name="id" type="xs:ID"/>
    </xs:complexType>
  </xs:element>
  <!-- DERIVEDSERIES.title (global type) -->
  <!-- DERIVEDSERIES.identifier (global type) -->
  <!-- DERIVEDSERIES.createdTimestamp (global type) -->
  <!-- DERIVEDSERIES.lastModifiedTimestamp (global type) -->
  <!-- DERIVEDSERIES.type (global type) -->
  <!-- DERIVEDSERIES.objective -->
  <xs:element name="objective" type="xs:string"/>
  <!-- DERIVEDSERIES.standardizingMethod -->
  <xs:element name="standardizingMethod" type="xs:string"/>
  <!-- DERIVEDSERIES.author -->
  <xs:element name="author" type="xs:string"/>
  <!-- DERIVEDSERIES.version -->
  <xs:element name="version" type="xs:string"/>
  <!-- DERIVEDSERIES.linkSeries (global type) -->
  <!-- DERIVEDSERIES.derivationDate -->
  <xs:element name="derivationDate" type="date"/>
  <!-- DERIVEDSERIES.usedSoftware (defined at MEASUREMENTSERIES.interpretation) -->
  <!-- DERIVEDSERIES.genericField (global type) -->
  <!-- DERIVEDSERIES.interpretation (defined at MEASUREMENTSERIES) -->
  <!-- DERIVEDSERIES.interpretationUnsolved (defined at MEASUREMENTSERIES) -->
  <!--
  %%%%%%%%%%%%
  %     VALUES
  %%%%%%%%%%%% -->
  <xs:element name="values">
    <xs:complexType>
      <xs:sequence>
        <xs:choice>
          <xs:sequence>
            <xs:element ref="variable"/>
            <xs:element ref="unit"/>
          </xs:sequence>
          <xs:element ref="unitless"/>
        </xs:choice>
        <xs:element ref="value" maxOccurs="unbounded"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
  <!-- VALUES.variable -->
  <xs:element name="variable">
    <xs:complexType>
      <xs:complexContent>
        <xs:extension base="controlledVoc">
          <xs:attribute name="normalTridas">
            <xs:simpleType>
              <xs:restriction base="xs:string">
```

```
                    <xs:enumeration value="Ring width"/>
                    <xs:enumeration value="Earlywood width"/>
                    <xs:enumeration value="Latewood width"/>
                    <xs:enumeration value="Ring density"/>
                    <xs:enumeration value="Earlywood density"/>
                    <xs:enumeration value="Latewood density"/>
                    <xs:enumeration value="Maximum density"/>
                    <xs:enumeration value="Latewood percent"/>
                </xs:restriction>
            </xs:simpleType>
        </xs:attribute>
    </xs:extension>
  </xs:complexContent>
 </xs:complexType>
</xs:element>
<!-- VALUES.unit -->
<xs:element name="unit">
 <xs:complexType>
  <xs:complexContent>
    <xs:extension base="controlledVoc">
        <xs:attribute name="normalTridas">
            <xs:simpleType>
                <xs:restriction base="xs:string">
                    <xs:enumeration value="micrometres"/>
                    <xs:enumeration value="1/100th millimetres"/>
                    <xs:enumeration value="1/10th millimetres"/>
                    <xs:enumeration value="millimetres"/>
                    <xs:enumeration value="centimetres"/>
                    <xs:enumeration value="metres"/>
                </xs:restriction>
            </xs:simpleType>
        </xs:attribute>
    </xs:extension>
  </xs:complexContent>
 </xs:complexType>
</xs:element>
<!-- VALUES.unitless (is empty by definition) -->
<xs:element name="unitless">
 <xs:complexType/>
</xs:element>
<!-- VALUES.value -->
<xs:element name="value">
 <xs:complexType>
  <xs:sequence>
    <xs:element ref="remark" minOccurs="0" maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="value" type="xs:string" use="required"/>
  <xs:attribute name="index" type="xs:string" use="required"/>
  <xs:attribute name="count" type="xs:integer" use="optional"/>
 </xs:complexType>
</xs:element>
<!-- VALUES.remark -->
<xs:element name="remark">
 <xs:complexType>
  <xs:complexContent>
    <xs:extension base="controlledVoc">
        <xs:attribute name="normalTridas">
            <xs:simpleType>
                <xs:restriction base="xs:string">
                    <xs:enumeration value="Fire damage"/>
                    <xs:enumeration value="Frost damage"/>
                    <xs:enumeration value="Crack"/>
                    <xs:enumeration value="False ring(s)"/>
                    <xs:enumeration value="Compression wood"/>
                    <xs:enumeration value="Tension wood"/>
                    <xs:enumeration value="Traumatic ducts"/>
                    <xs:enumeration value="Unspecified injury"/>
                </xs:restriction>
            </xs:simpleType>
        </xs:attribute>
    </xs:extension>
```

```
            </xs:complexContent>
        </xs:complexType>
    </xs:element>
</xs:schema>
```