

# WinDENDRO™ 2005

## An Image Analysis System For Tree-Rings Analysis

WinDENDRO has been specifically designed for dendrometrists and dendrochronologists looking for a precise and efficient way to measure annual tree-ring widths and other related parameters (minimum, maximum and average density, earlywood width and more).

In comparison to manual measurement systems, WinDENDRO offers advantages from different points of view. Productivity gain, operator comfort, possibility of archiving the images of the samples with or without their analysis, a working method that encourages and facilitates verifications (like live comparison with known master series during measurement) and easy commands to move back and forth along an analysed sample (without mechanical delays or backlash).



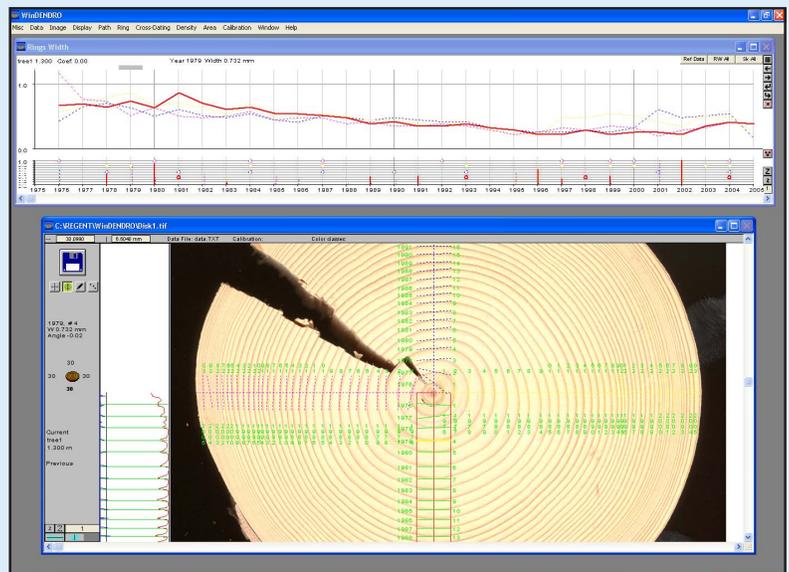
*WinDENDRO can analyse tree-rings from wood disks, cores, X-ray films and images produced by filmless digital X-ray systems.*

The steep increase in scanner and computer performances and prices decrease over the last years has made WinDENDRO systems more than an affordable solution to set up a tree-ring facility. Its cost compares favorably with binocular and positioning table based manual systems.



*Optional accessories to hold cores during their preparation and scanning.*

WinDENDRO is offered as a complete system or software alone. The systems' hardware components goes from low cost (but precise) to faster and more precise high-end models. The WinDENDRO software on its side is offered in four versions differing in functionality and costs.



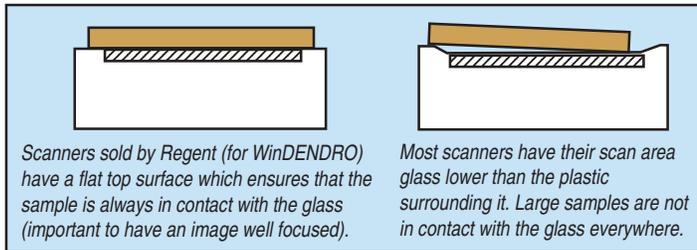
*The WinDENDRO software program runs on modern operating systems like Windows XP. A 64 bit version for the forthcoming Windows XP 64 bits operating system (and Longhorn) should be available soon.*

Since its introduction WinDENDRO has been updated regularly (at least once a year) to make it on par with technological advances in image acquisition hardware (scanners and digital cameras), computers, operating systems and image analysis science. It has also evolved based on suggestions from its large base of experienced users. It is a mature and robust system that has made its proofs in many laboratories worldwide as can be seen from the hundreds of publications made with it (some are listed on [www.regentinstruments.com](http://www.regentinstruments.com)).

WinDENDRO™ has been designed in collaboration with Dr. Rejean Gagnon and Dr. Hubert Morin at the Dendroecology Laboratory at Université Du Québec À Chicoutimi.

## Image acquisition

The first step to analyse the ring-widths of a sample is to get a digital image of it. WinDENDRO can analyse images made with optical scanners, analog or digital cameras and digital filmless x-ray systems. It can open image files produced by these hardware manufacturers programs (provided they are saved in a standard format) but most of the time WinDENDRO is used to acquire images directly from such devices (when they are TWAIN compatible). WinDENDRO offers two methods of image acquisition. One is optimised for ease of use and requires just a mouse click to get an image while the other is more complex and powerful. The latter allows you to get full control over the image acquisition hardware so that you can optimise its parameters to make ring analysis easier.



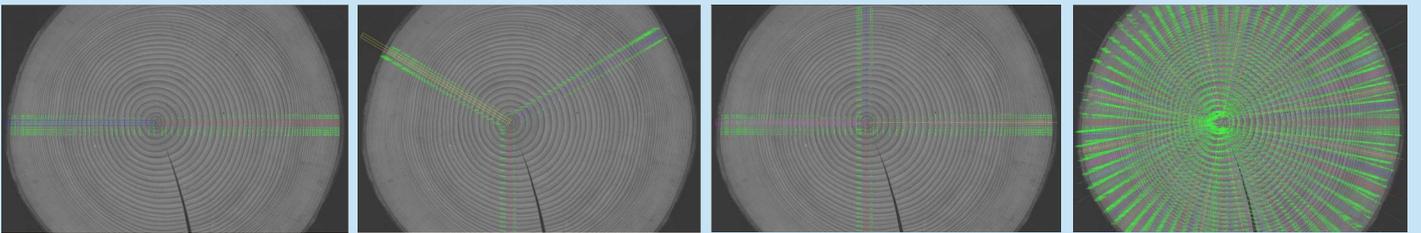
Optical scanners are particularly well adapted for tree-rings analysis. They produce high quality images over large areas. WinDENDRO has been designed to work with scanners in a very efficient way. Time is saved in bypassing the standard "Preview" steps (which can take tens of seconds per sample) and by using positioning accessories which allows you to repetitively place the samples at the right place on the scanner. You can still choose to use the preview step to optimise the scanning parameters.

## Analysis (paths and ring detection)

Once the image of the sample is displayed on the computer screen, you must indicate WinDENDRO where to measure rings on it. This is done by creating ring paths. Paths can have any shape and can be created automatically with a single mouse click (for straight line paths) or manually by tracing them (for paths perpendicular to rings boundary).

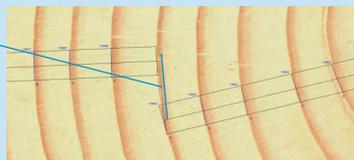


In its simplest form a path can run across a sample (core or disk radius) on a straight line. Up to 128 paths can be created with a single mouse click in pre-defined directions around the clicked position. Paths can also be created by clicking at their beginning and ending points.

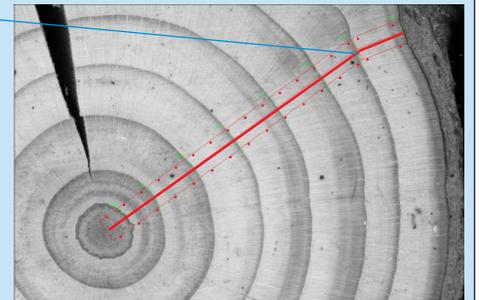


Paths can also change their trajectory to always be perpendicular to ring-widths as done in manual dendrochronological methods.

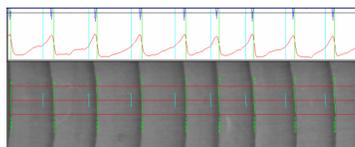
Paths can contain discontinuities to skip crack or missing wood areas on damaged samples or to continue measurements in another direction (to move perpendicular to ring boundaries or avoid damaged areas).



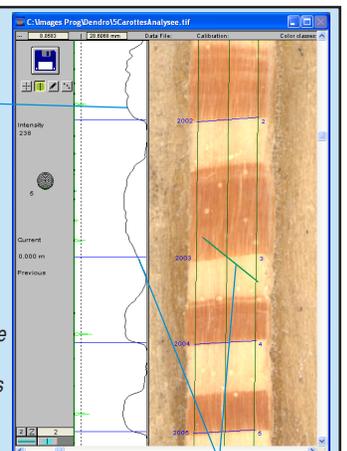
Ring-widths can be measured taking into account their boundary orientation relative to the path. This allows to increase the precision when using straight paths (to achieve similar results as to path made perpendicular to ring widths).



After paths have been created, rings are automatically detected by WinDENDRO and their presence is indicated over the image with lines and text. Lines indicate the rings boundary orientation and the text indicates the year and ring number. Earlywood width can also be displayed along with other ring features (explained next). Close to the image, a profile of the light variations inside the path is also displayed along with ring and earlywood widths. This region is also used to adjust the sensitivity of the automatic ring detection. The sensitivity of this initial detection can be adjusted in function of the rings appearance. Narrow and low contrasts rings require more attention. One or two methods of ring detection are provided in function of the WinDENDRO software model.



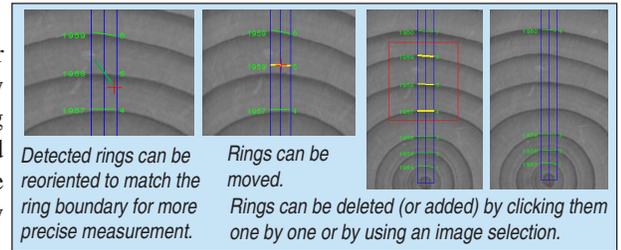
All the image content inside the path (not only the central line) is used to calculate the intensity profile displayed parallel to the path. The path width is adjustable so that you can choose what the profile is made of (paths should only contain valid tree-rings information, they should not encompass the core holder for example). The WinDENDRO Density version also uses ring orientation to produce more precise profiles. Each time a ring is moved or reoriented, the intensity profile is recalculated using a virtual slit that matches the rings boundary.



Light variations transitions are less sharp for rings with a wrong orientation.

## Analysis (ring validation)

After the initial automatic rings detection, a validation must be done to consider the possibility of the presence of false, frost, locally absent rings or simply misclassifications done by WinDENDRO. This validation is done by browsing the image and clicking to make corrections. Rings (and earlywood-latewood boundaries) can be added, deleted, moved and reoriented with simple mouse clicks. As modifications are done, the rings' number and year are automatically updated in the image and the ring-widths graphic.



### Regarding wood species, narrow rings and ring contrasts

When rings are well contrasted, such as with medium to large rings (0.5 mm and over) of coniferous species, the automatic detection rate is close to 100% requiring little modifications from the operator so the productivity gain over manual methods is very high. Rings with lower contrasts such as those from deciduous (hardwood) species or narrow rings, require more attention to preparation, scanning and analysis settings. The more time is spent on obtaining a good image, the less time is spent on their analysis (this is true for manual methods also). Low contrast samples can be analysed with WinDENDRO but the productivity gain over manual methods is lower than with conifers because more operator corrections are needed. Low contrasted rings requires paying attention to:

**1) Sample preparation.** It has a great influence on the automatic detection rate. As rings get narrower, the finer the preparation has to be (0.01 mm rings require a finer method than 1.0 cm rings). Visible mechanical marks (like scratches) should be avoided as they tend to be more visible in digitized images than to the naked eye. They can trigger false ring detections or wrong orientations. There are no universal method accepted for preparation but sanding is very popular for dry samples.

**2) Scanning.** Contrasts enhancements done during scanning or after in WinDENDRO allows to see the rings more easily. Narrow rings require higher resolution (DPI) than large rings. As a rule the practical minimum number of pixels per ring is four and this number increases (up to ten typically) as ring contrasts lower. A good quality scanner is also mandatory. Good quality is not only related to the theoretical dpi claimed by its manufacturer, it is also a matter of good optics and electronics. Regent Instruments tests and compares all scanner models it sells. It also ensures they are compatible with WinDENDRO and its accessories. Regent Instruments can take the time to look at your samples before recommending a system, so do not hesitate to contact us.

**3) Analysis settings.** They must also be fine tuned for low contrasts rings. You can experiment with the two methods of ring detection provided and adjust their parameters to optimise the automatic detection. Some samples are better done in the complete manual mode.

## The Ring-Widths Graphic

A graphic of ring-widths in function of the year is displayed during the analysis and is automatically updated as rings are edited during the validation phase. This graphic is also used for visual and numerical cross-dating. It can display simultaneously master chronologies and the ring widths of the sample under analysis and correlate some of them to help find mistakes in the analysis. Ring-width series can be detrended (converted to indices) using the smoothing spline method.

The smoothing spline can be displayed to help determine its filtering strength.

Skeleton plots can be displayed during the measurements of one or more series simultaneously with master chronologies. These are used by dendrochronologists to identify rings that are smaller or larger than their neighbors for visual cross-dating.

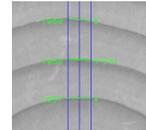
Ring widths can be displayed unmodified (as measured in millimeters) or as index values (ring widths for which long term non-climatic variations such as those due to tree aging have been removed) and can also be converted to a logarithm scale to increase the effects of narrow rings variations.

There are many interactive commands associated with the graphic. For example, when you click a year on it, the image is scrolled to display the part of the image where that ring is. The ring-width series can be splitted and shifted at different places (and the correlation updated) to help find missing or false rings. Modifications done by adding rings at splits points can be ported to the analysed sample by activating a command.

Three split points where the data series can be independently shifted. More points can be added or removed.

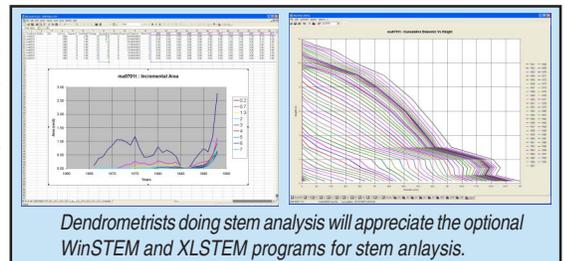
The screenshots show the 'Ring Widths' software interface. The top plot shows a blue line representing the ring width series with a red smoothing spline overlaid. Below it is a 'Skeleton Plot' showing individual ring widths as vertical bars. The bottom plot shows a zoomed-in view of a specific year (Year 1507) with three split points marked by vertical lines, allowing for independent shifting of the data series.

Rings can be tagged with observations that you define (you choose their name, meaning and the symbol used to indicate their presence close to a ring). For example you could define two features called *narrow* and *frost* and select which rings have these characteristics. These ring features are then displayed on the graphic and in the image close to rings which have these features.



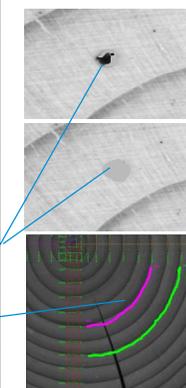
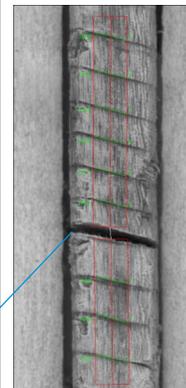
## Data

When an analysed image is saved to a file, the analysis is automatically saved with it. This analysis can later be retrieved, validated or modified simply by loading the image in WinDENDRO. The analysis data such as ring width, minimum density etc, are also saved to standard text files that can be read by many programs including spreadsheet style software like Microsoft's Excel. WinDENDRO has its own format (documented in its user guide) to store ring analysis data but can also convert those files to the decadal (Tucson) format used by dendrochronologists (the old format precise up to 1/100 of a mm and the new one precise up to 1/1000 of a mm). Unlike the decadal format, the WinDENDRO format allows to store the analysis settings, date and time, image information along with the rings measurements.



## WinDENDRO Features Per Software Model

Feature	WinDENDRO Software Model				Description
	Mini	Basic	Reg	Density	
<b>Paths</b>					
Number of automatic ring detection methods	1	1	2	2	All versions have the intensity differences method. The Reg and Density versions have an alternative method called Teach&Show method which is sometimes better for deciduous (but can also work with conifers). Two methods gives more options for low contrasted rings.
Paths per image (max)	1	4	128	128	The mini version only work with one path at a time. The Basic can work with 1 to 4
Vertical or horizontal paths	Y	Y	Y	Y	Paths in the same direction as the image edges.
Paths in any direction	N	N	Y	Y	Paths in directions other than horizontal and vertical
Multi-segments paths	N	N	Y	Y	Paths that have more than one segments and can change direction between segments
Tangent to ring boundary	Y	Y	Y	Y	Ring widths are more precise when they are oriented to follow the ring boundary direction.
Skip gaps (cracks, void)	N	Y	Y	Y	To exclude void areas (such as cracks due to wood drying) from the ring widths measurements. With the <i>Mini</i> version, gaps can be removed by cropping the image in another program (not included). In the other versions, gaps are simply indicated to WinDENDRO with a few mouse clicks.
<b>Measurements</b>					
Earlywood and latewood width measurement	N	N	Y*	Y*	* The density version will produce more precise earlywood width measurement when density analysis is turned on (even if no light calibration is done).
Sapwood width	N	Y	Y	Y	Must be indicated manually by the operator.
Ring features	N	N	Y	Y	For each ring, you can set up to five features or observations that you define (frost ring, wide, missing...) plus add textual comments. Features are displayed in the image, the ring-widths graphic and are saved with the analysis data.
Log/Area module	*	*	*	*	This module is optional and can be added to any version of WinDENDRO. It adds the following: •:Compression (reaction) wood and voids (cracks) areas measurement. This is done manually by tracing them in the image. •Disk area, shape (form coefficient), perimeter, average radius, ring density per inch or cm in function of distance to pith.This is done semi-automatically.
Light reflection analysis	N	N	Y*	Y*	Export the path intensity profile to text files (on a pixel basis). The density version will produce more precise measurements when density analysis is turned on (even if no light calibration is done).
Density analysis	N	N	N	Y	From x-ray films or images from digital filmless x-ray systems. Measurements per ring include: minimum density, maximum density, average ring density, average earlywood density, average latewood density and ring orientation. More information about density analysis can be found on an addendum to this brochure or on our web site.
<b>Image Sources</b>					
Analyse tiff, jpeg or bmp files	Y	Y	Y	Y	Tiff uncompressed is recommended for precision.
Acquire images from TWAIN compatible scanner and cameras	N	Y	Y	Y	The mini version can only open tiff, bmp and jpeg files.
Calibration for images which come from a camera	Y	Y	Y	Y	Calibration of images from a camera can be done with a single mouse click when Regent's new calibration targets are included in the image.
<b>Image Processing And Analysis</b>					
9 to 16 bits per pixel grey levels	N	N	N	Y	Grey levels images with more than 8 bits per pixels of information (typically 10, 12 or 16 bits/pixel) can be visualized and analysed in a user selectable bandwidth range of information. For example you can view and utilize only the 8 most significant bits, the least significant or any range in between. You can also use the whole range as before. As the range is changed, the paths intensity profile and density values for each ring (min, max, average) are recalculated after a modification is done to a path.
Color channel selection	N	N	N	Y	Color images can be visualized and analysed on one of its three color channels (Red, Green, or Blue) or using the three of them (a regular color image). If the color channel is changed while an analysis is displayed, the paths intensity profile and density values for each ring (min, max, average) are recalculated automatically.
Image edition	N	N	Y	Y	You can edit the image (modify its content) with any color present in it (by picking it up interactively) or by defining your own colors. This allows to remove defects that prevent ring analysis from being done accurately. It can also be used to remove artefacts for density analysis (on x-ray films or wood). Any modifications done to the image are permanent and are saved with it (if you save the image after edition).
Image Temporary Markers	N	N	Y	Y	You can draw temporary markers over the image (to help you keep track of rings along a disk to find missing ones for example). Markers appearance (thickness, color) can be changed after they have been created and can have an identification name.
Background light variations removal	N	N	N	Y	Mostly used with camera images.
<b>Graphic</b>					
Ring-width graphic, cross-dating, skeleton plots, detrending	N	N	Y	Y	Refer to the Graphic section of this brochure.
<b>Misc.</b>					
Save data in ascending/descending order	Y/N	Y/N	Y/Y	Y/Y	From pith to bark or bark to pith.
Possibility to save only the last few rings of a path	N	N	Y	Y	For stem analysis mostly. To study growth of only some years of interests.
Customisable sample identification	N	N	Y	Y	Choose the meaning and type of some variables used to identify a sample before its analysis. This information is saved with the data.
WinCELL Regular included	N	N	Y	Y	A program for wood cell anatomical analysis. It shares the same look and feel as WinDENDRO. Can also be used to analyse the morphology and area of other objects (leaf area for example).
Printed manual	N	Y	Y	Y	Printed manual has plenty of color illustrations and utilisation examples.
Free updates (years)	0	1	3	3	Number of years of free updates that you will get after purchasing (at least one per year).



## Misc.

WinDENDRO comes with a printed color illustrated manual and prompt and competent technical support (via e-mail). Although it is done by e-mail it is as responsive as telephone could be. The typical answering time is within one hour and most of the time it is shorter than that. It is also done by competent persons, people close to and which can rely on WinDENDRO programmers for technical advices.

WinDENDRO is not copy protected, does not require any activation (such as an Internet connection or a password), does not limit the number of installations and uninstalls but a single license limit the number of user to one at a time. Multiple users licence agreements are available.

WinDENDRO is a member of a family of related products for plant science research and production. Among them you will find;  
**WinCELL** for wood anatomical cell analysis (free with WinDENDRO Reg and Density)  
**WinRHIZO** and **WinRHIZO Tron** for root analysis (extracted and in-soil),  
**WinSCANOPY** for canopy and radiation analyses from fish-eye hemispherical images,  
**WinCAM** for color analysis,  
**WinFOLIA** for broad leaf analysis,  
**WinSEEDLE** for seed and needle analysis.

Specifications subject to modifications.

For more information visit our web site at [www.regentinstruments.com](http://www.regentinstruments.com) or contact our sales department at [sales@regentinstruments.com](mailto:sales@regentinstruments.com)

Regent Instruments is a Canadian company serving its customers worldwide since 1991

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