Shadow Basics by Chris Skellern

This article offers a quick overview to the tree shadow plotting used within ArborShadow software.

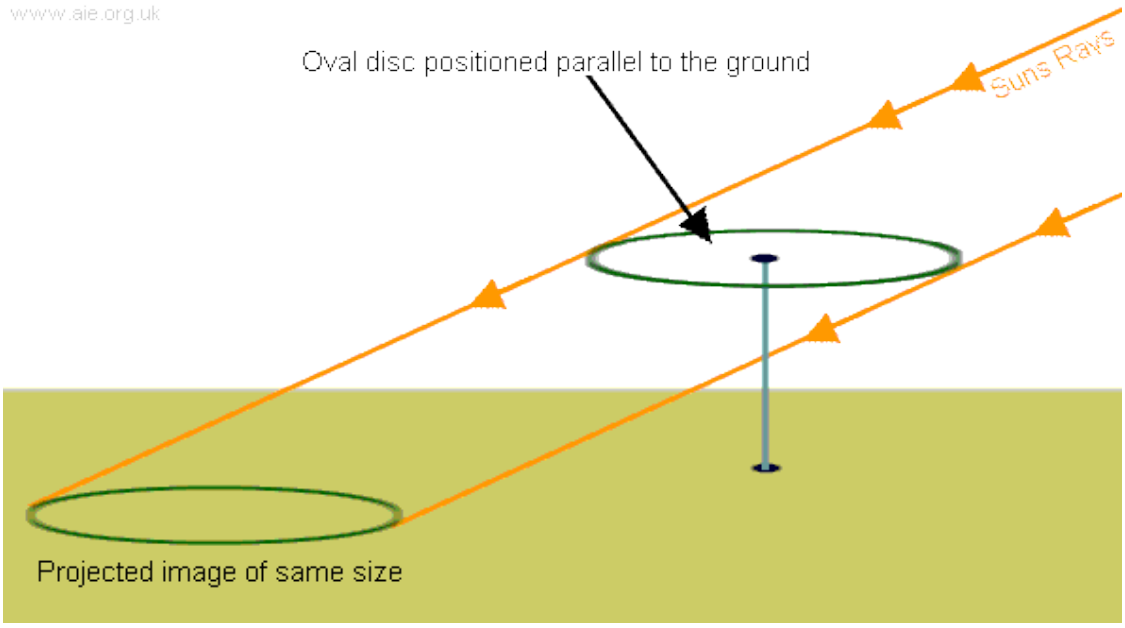
Basic Shadow Calculation

Tree shadow lengths can be calculated by using a right-angled triangle formulae where the trees height is used as the opposite side and the tangent of the altitude of the sun is used as the angle. The result must be modified to allow for canopy spread and the calculation assumes a level terrain.

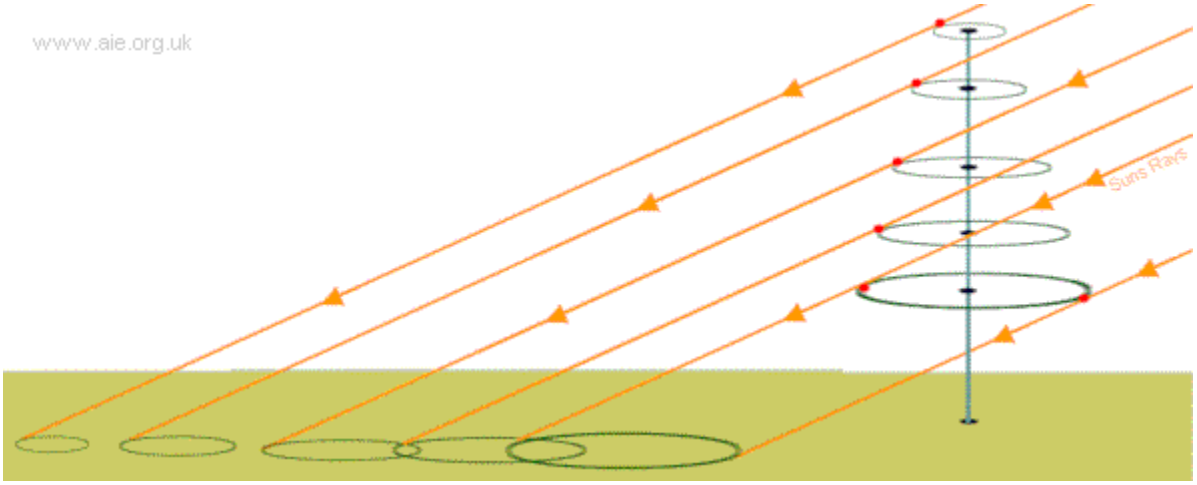
The altitude of the sun is the angle it makes above the horizon from the reference point (the tree). The altitude is based upon a number of factors such as the suns declination, the latitude of reference point and the time displacement from solar noon.The last important factor is the direction of shadow based upon the suns lateral position in the sky. This is called the suns azimuth and is an angle.

Canopy Spread Projection

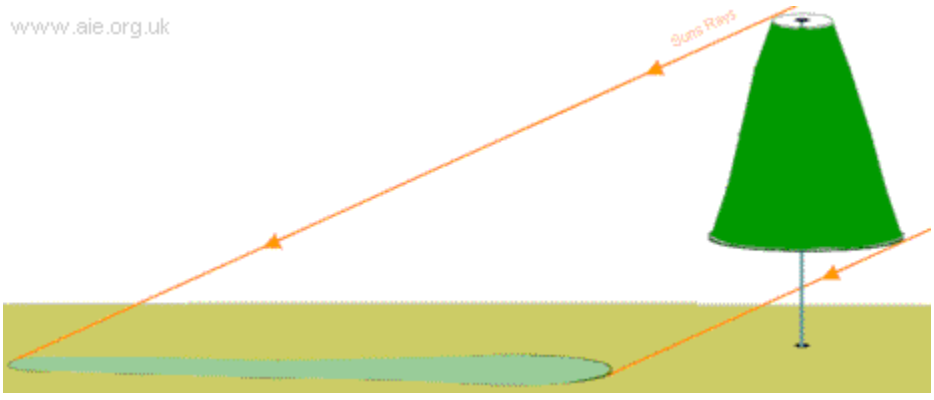
A simple tree canopy is based upon 4 dimensions being measured from a tree centre in the direction of north, south, east and west. Assuming the tree is standing on level ground and the plane of the canopy lies parallel to the ground then each point around the perimeter of the tree canopy will be of the same height but at a different distance from the tree centre. Since light travels in straight lines and the rays of sunlight which strike the earth are considered to be parallel to each other (due to the size of the sun), it follows that an exact 'copy' or shadow of the canopy shape will appear on the ground (see following image).



Imagine this projected disc as being the base of a trees crown. If another disc was defined at a taller height, so it represented another 'slice' through the trees crown then this can also have its shadow projected onto the ground, but would be slightly further away from the tree (and probably be of a smaller diameter in relation to a narrowing tree crown). If the process were continued right to the top of the tree then I would have an irregular representation of the trees shadow on the ground.



If the distance of each 'slice' step was small then I would see an accurate representation of the trees shadow.



However, as you can see, a number of assumptions are made. First the trees is assumed to be straight and vertical. The ground is assumed to be flat and at right angles to the tree. The crown outline won't be an unbroken oval as depicted here.

Although some of these restraints can be overcome such as allowing for a leaning tree and a sloping crown, other factors such as a true crown shape would be impossible to cater for within a program. This is due to the infinite possibilities in actual shape and branch layout, even between trees of the same species and habit.

Tree Dimensions

The necessary dimensions required to calculate a shadow projection is tree height, clear stem height, lower crown dimensions (as north, south, east & west) and upper crown dimensions (although these could be automatically calculated as a percentage of the lower crown).

Day Shadow Trace

ArborShadow can plot a shadow projection to represent the area that would be 'touched' by a trees shadow during the course of a day. Think of this as the above shadow projection being calculated non-stop from 5am in the morning until 10.00pm at night. All the projected shadow images would merge and form a continuous band of varying width and shape as the sun transits across the sky from east to west.