IMPROVING LIGHT PENETRATION FOR GOLF GREENS

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SEASONAL SUN ANGLE CHANGES

Definitions

Summer Solstice

- Sun rises and sets farthest away from south
- Sun is highest in the sky
- The longest day of the year

Winter Solstice

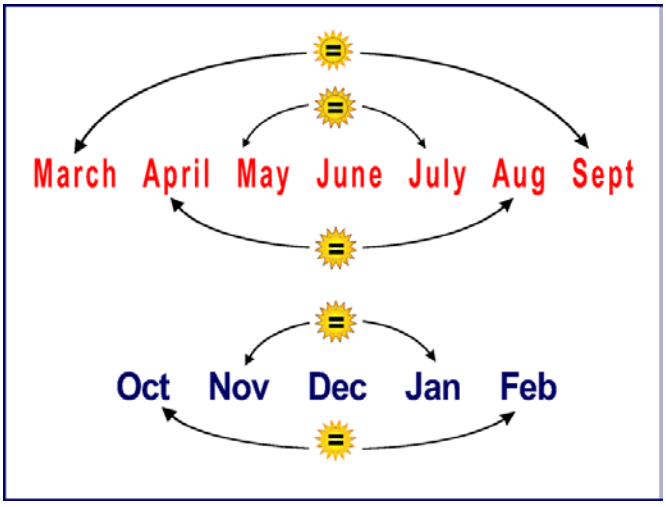
- The shortest day of the year
- Rises and sets closest to south
- Sun is lowest in the sky

Summer Equinox and Winter Equinox

- The Sun rises at true east
- The Sun sets at true west
- Equal length of day and night
- The Sun is at a vertical angle of 45 degrees at local noon

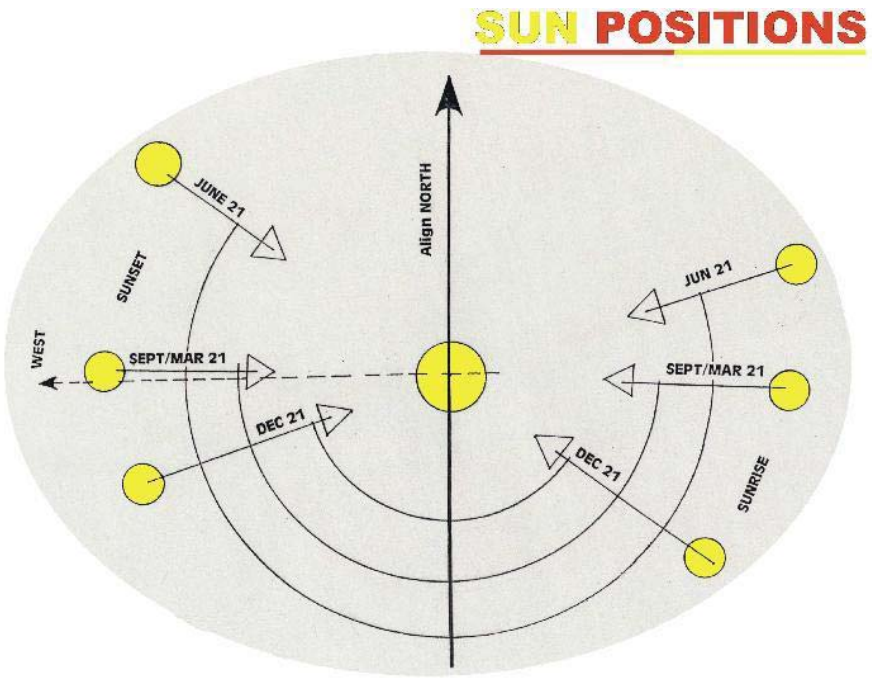
Equivalent Months

The sun is highest in the sky on June 21, the summer solstice. One month before the summer solstice, May 21st, and one month after the summer solstice, July 21st, have almost exactly the same sun positions. The same is true for the winter solstice December 21st. One month before winter solstice, November 21st, and one month after winter solstice, January 21st, have almost exactly the same sun angles.



People working in the north will find the top diagram most useful. People working in the south will find the bottom diagram the most useful.

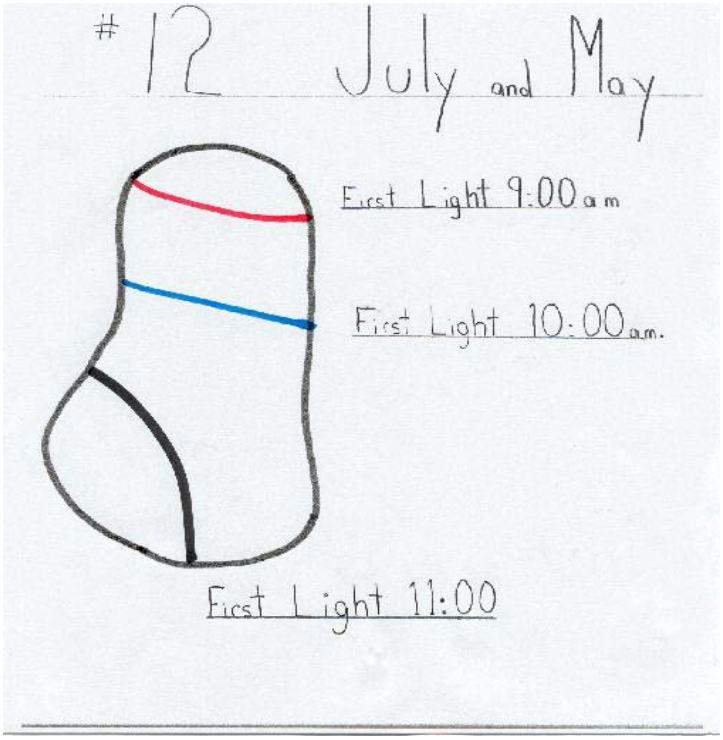
Angle of Sunrise and Sunset



The above diagram shows where the sun rises and sets for different days of the year in Niagara Falls, NY. Notice that the sun rises precisely in the east and sets precisely in the west only two days of the year March 21st and Sept 21st. The sun rises and sets farthest away from south on June 21st thus traveling the farthest. On December 21st it rises and sets closest to south thus traveling the shortest distance.

TIME-LAPSE PHOTOGRAPHY

Time-lapse photography makes a graphic presentation on how much light is reaching a green



The photographs can be summarized in a drawing, like the one above, to emphasize the point.

Methodology

- Start on June 21 and use equivalent months
- Get as high as possible and maintain a constant camera angle
- Take one picture each hour
- Summarize your work

Pros

- Inexpensive
- No special skill required
- No special equipment required
- Very graphic

Cons

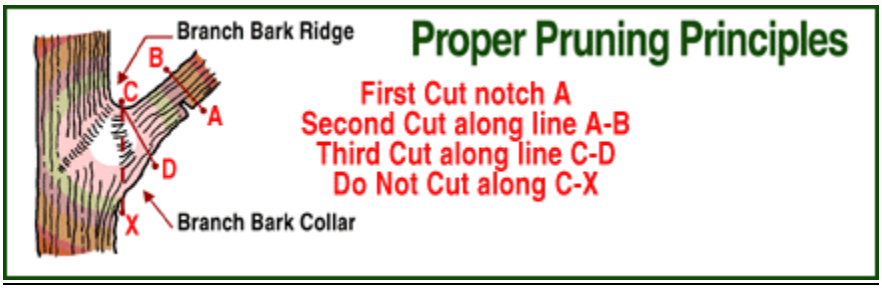
- Proves that there is a problem, but does not determine a solution
- Takes up to 4 months to see results
- Time consuming
- Weather dependent

PRUNING

Rules of Thumb

- Always make proper collar cuts
- Never remove more than 30 % of a trees foliage.
- For the greatest efficacy concentrate your pruning on portions of the tree where there is only one layer of foliage between the sun and green
- Where ever possible use dimension changing pruning instead of crown thinning

Pruning Cuts



THE OBSERVATION METHOD

The observation method is the most common method of developing tree pruning and removal recommendations for shaded greens. Normally this process is quite informal. Usually a Superintendent goes out to a golf green looks at what tree is casting a shadow and comes back later and cuts it down. The aforementioned method does not produce any quantitative data on how individual trees affect the green. As a result, this informal method often falls short when trying to convince committee members to remove trees.

There are a few things that we can do to make the observation method more scientific and quantitative. The following procedure generates undisputable data for committee members and owners.

Procedure

- Use corresponding months
- Number all trees
- Cover the whole green every half hour looking towards the sun and record what trees are between the sun and you. Record all layers
- Summarize your results

Tree Numbering

Number trees with a 9" x 11" card stock so you can easily make notes on what tree is casting shade. Also number with a corresponding, permanent aluminum tag so the tree can be found later.

Light Penetration Spread Sheet

The trees that are blocking light can be recorded on a form like this.

BACK LEFT GREEN QUADRANT

APRIL 21

TIME	% OF GREEN RECEIVING LIGHT	TREE OR PORTION RESPONSIBLE
7:30 to 8:30 A.M.	0	# 9 whole crown, # 10 whole crown, # 11 suckers, # 12 suckers.
8:30 to 9:30 A.M.	0	# 10 12:00 to 6:00 quadrant, # 12 suckers, # 13 6:00 to 12:00 quadrant, # 14 6:00 to 12:00 quadrant, # 17 10:00 to 12:00 quadrant, # 21 3:00 to 9:00 quadrant.
9:30 to 10:30 A.M.	10	# 12 12:00 to 6:00 quadrant, # 13 whole crown, # 14 whole crown, # 21 whole crown, # 40 10:00 to 2:00 quadrant.
10:30 to 11:30 A.M.	10	# 13 and # 14 whole crown, # 21 whole crown, # 22 6:00 to 12:00 quadrant.
11:30 A.M. to 12:30 P.M.	10	# 13 and # 14 whole crown, #21 and #22 whole crown.
12:30 to 1:30 P.M.	10	# 21 overhanging branches, # 22 whole crown.
1:30 to 2:30 P.M.	20	# 21 overhanging branches, # 22 12:00 to 6:00 quadrant.
2:30 to 3:30 P.M.	30	# 22 12:00 to 6:00 quadrant, # 28 whole crown, # 29 6:00 to 12:00 quadrant.
3:30 to 4:30 P.M.	0	# 28 and # 29 whole crown.
4:30 to 5:30 P.M.	20	# 28 12:00 to 6:00 quadrant, # 29 whole crown, # 31 6:00 to 12:00 quadrant.
5:30 to 6:30 P.M.	10	# 29 suckers, # 31 whole crown.

MAY 21

Tree 12 Spread Sheet

BACK LEFT GREEN QUADRANT

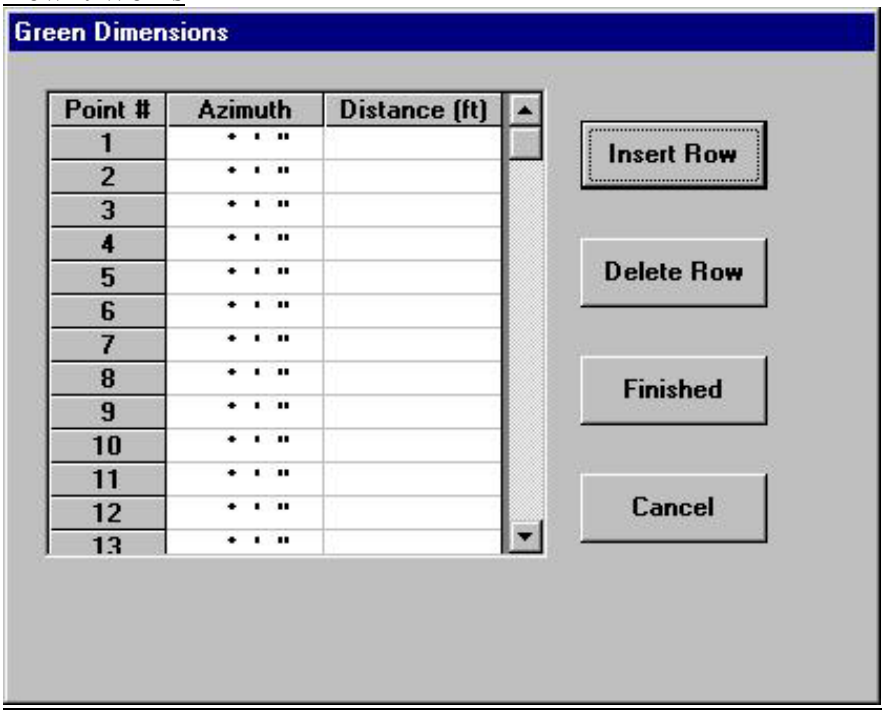
DATE	TIME	PORTION OF TREE BLOCKING LIGHT
June 21	8:45 A.M.	Whole crown
June 21	9:45 A.M.	Whole crown
June 21	10:45 A.M.	Whole crown
May/July 21	8:00 A.M.	Whole crown
May/July 21	9:00 A.M.	Whole crown
May/July 21	10:00 A.M.	Whole crown
Sept.21	8:30 A.M.	Suckers
Sept. 21	9:30 A.M.	Suckers

A spread sheet like the one above shows how individual trees block light on the green. It makes a powerful case for the removal of Tree12. The tree spreadsheet is extrapolated from the light penetration survey.

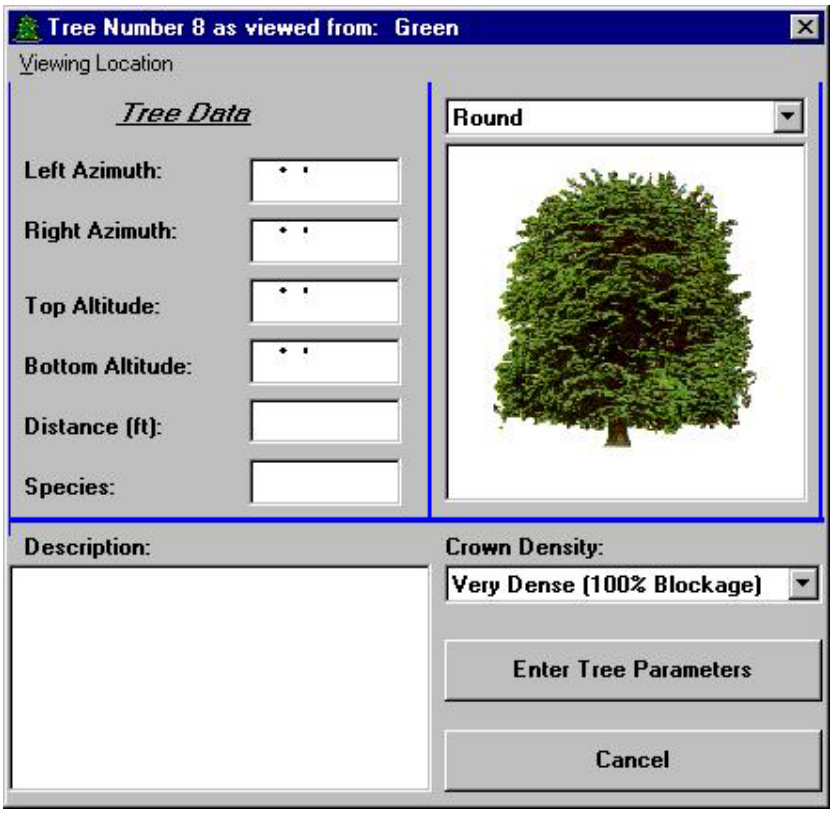
COMPUTER MODELING

Computer modeling has been used for over 5 years to help develop tree pruning and removal programs. And more importantly, through graphic calculations convince boards and owners to implement the removal and pruning program.

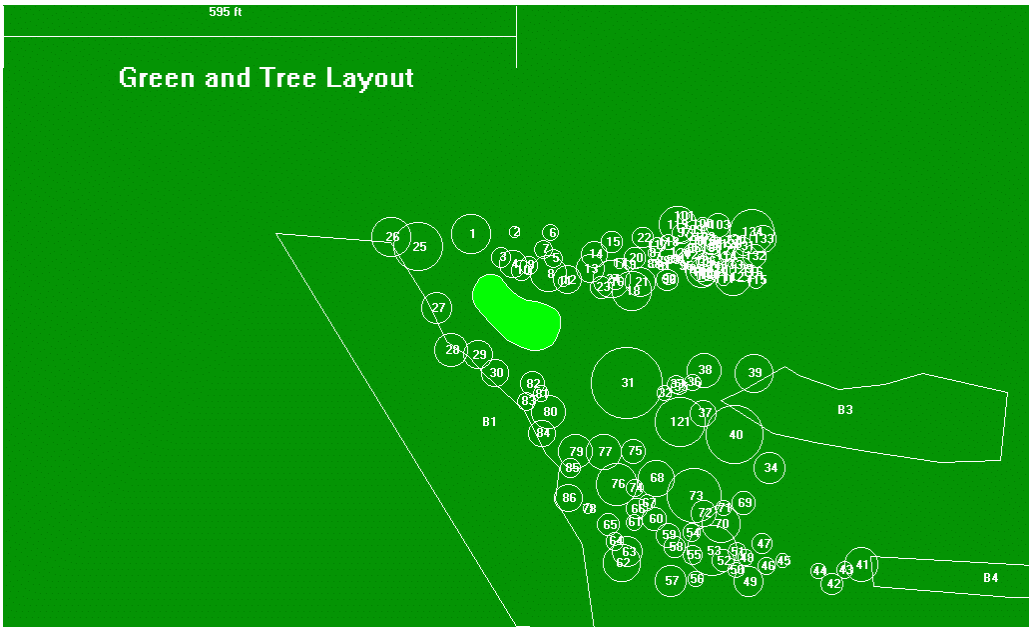
How it Works



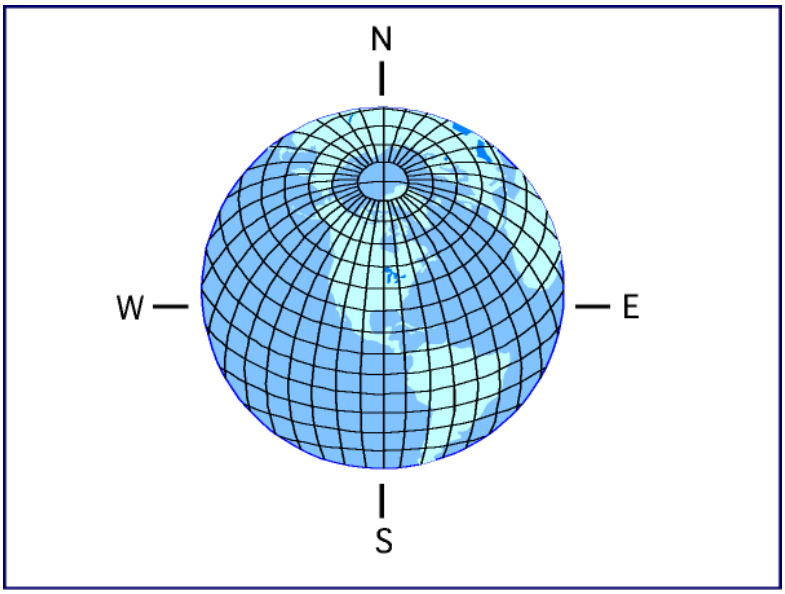
The position of the green is entered into specialized software by enter 60 points around the edge of the green.



The three dimensional position of all trees effecting light on the green are entered by a series of angles and distances.



This is a two dimensional picture of a three dimensional data bank. It is similar to an aerial picture. The green is light green, the trees are represented by the circles, and the shapes B1 B3 and B4 are groups of trees represented by a three dimensional block.



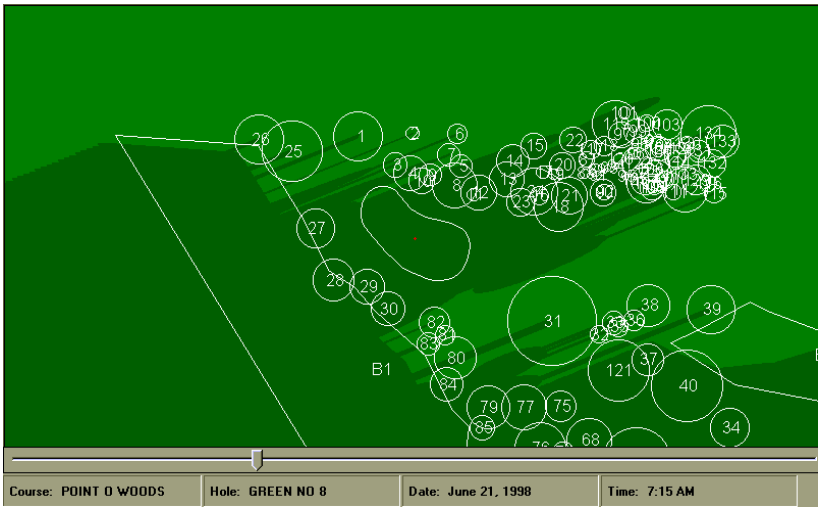
The exact position of the golf green on the earth's surface is entered into the software by entering the longitude and latitude of the golf green. The longitude and latitude enter into a formula that calculates exact sun angles.

Verifying Model Accuracy

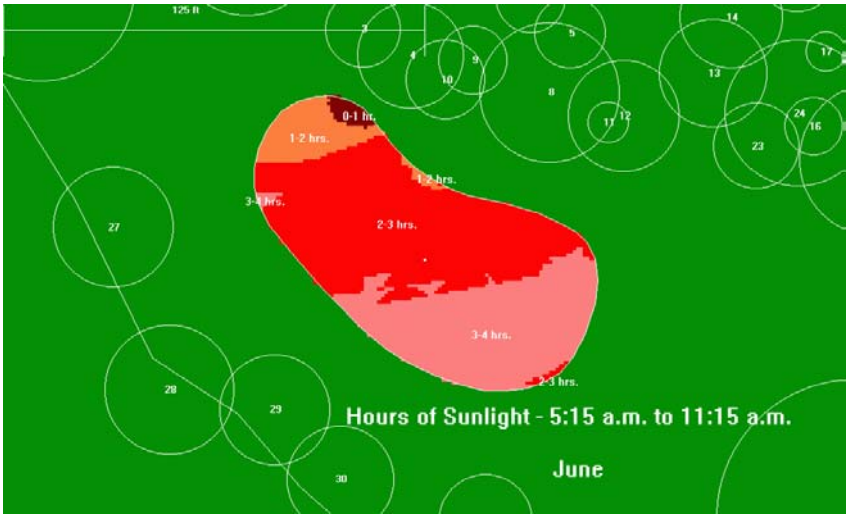
Computer Model

Actual

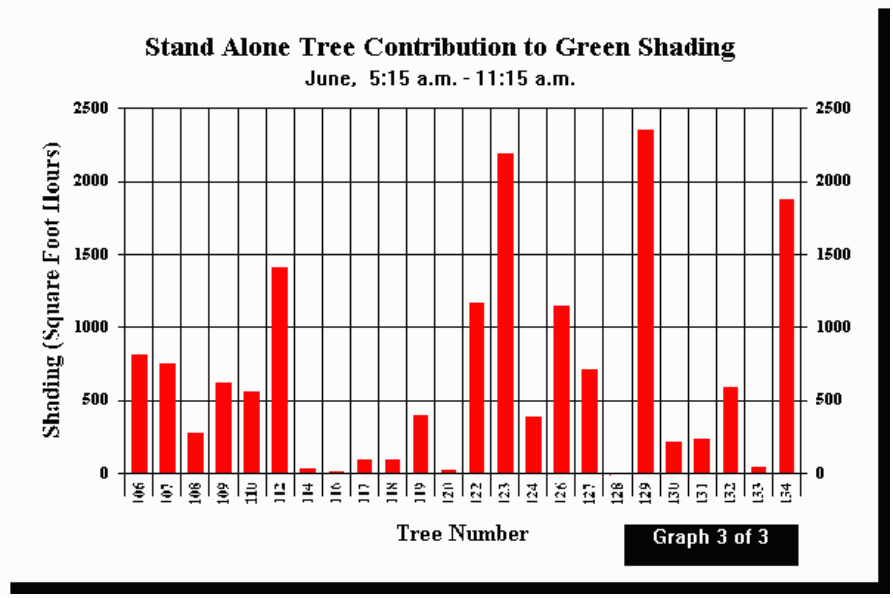
The top diagram shows a computer simulated shadow pattern. The bottom diagram shows the actual shadow pattern. The computer draws an oval half way between the peaks and valleys of the actual shadow pattern. The computer simulated shadow pattern is accurate to within 6 inches of the actual shadow pattern.



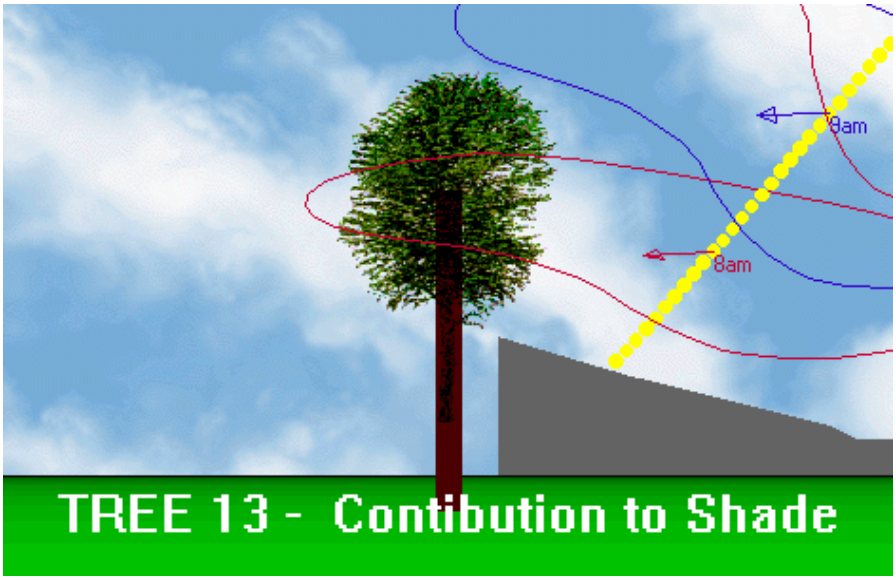
After the model has been constructed, shadow patterns can be animated for any moment in time. *(Sorry, we haven't figured out a way to animate on paper yet!!)*



The animated shadow patterns are run internally and a calculation like this can be generated. The above calculation is the result of over 35,000 trigonometry calculations. It shows how much light is reaching green between 5:15 am and 11:15 am on June 21st. The back two thirds of the green are deficient in light.



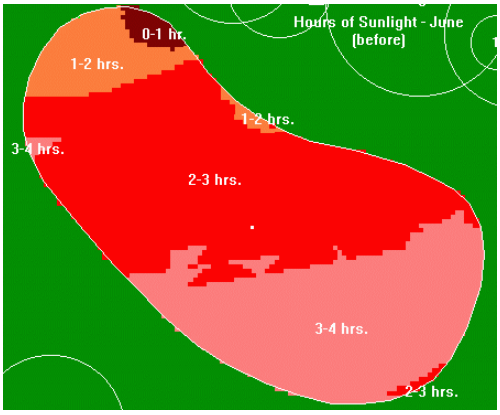
The horizontal axis of this graph represents tree number. The vertical axis of the graph represents square foot hours of shade. The bigger the bar the more shade the corresponding tree is shading.



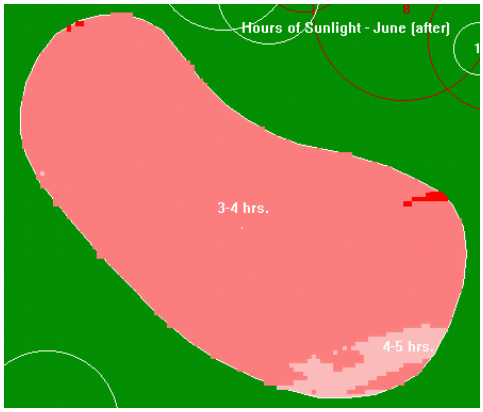
This diagram shows what portion of the tree is blocking light reaching the green. The software reverses the shadow process. It takes an image of the golf green skews it based on sun angle and projects it into the image of the tree. Any portion of the tree image that overlaps with the golf green image is blocking light reaching the green. Almost the whole crown is shading the green. Therefore it was recommended for removal.

Before & After Hours of Sunlight Diagrams for June

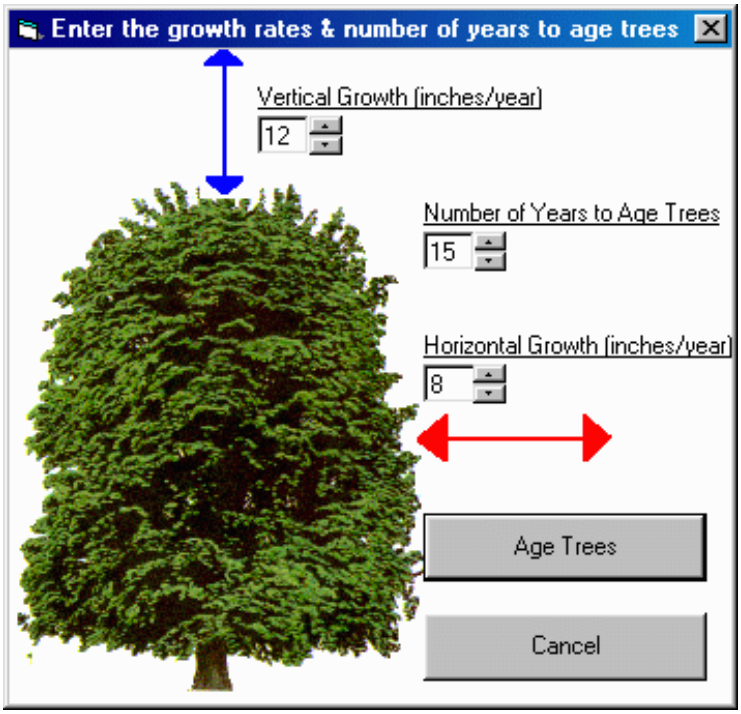
Before



After



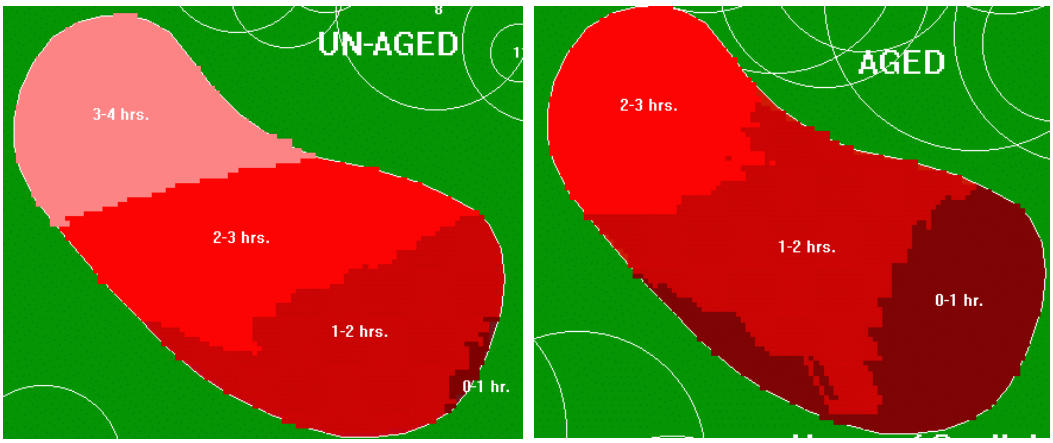
Using both tree ranker graphs and hours of sunlight diagrams, pruning and removal recommendations were developed. The calculation on the left shows how much light is currently reaching the green. The calculation on the right shows how much light will reach the green if removal recommendations are implemented.



Computer modeling can tell us what light conditions will be like in the future. The average growth rate of trees surrounding the green is inputted into the software. The software then adds that much growth to all of the trees for the specified number of years. In this case 15.

Comparison of Hours of Sunlight Diagrams

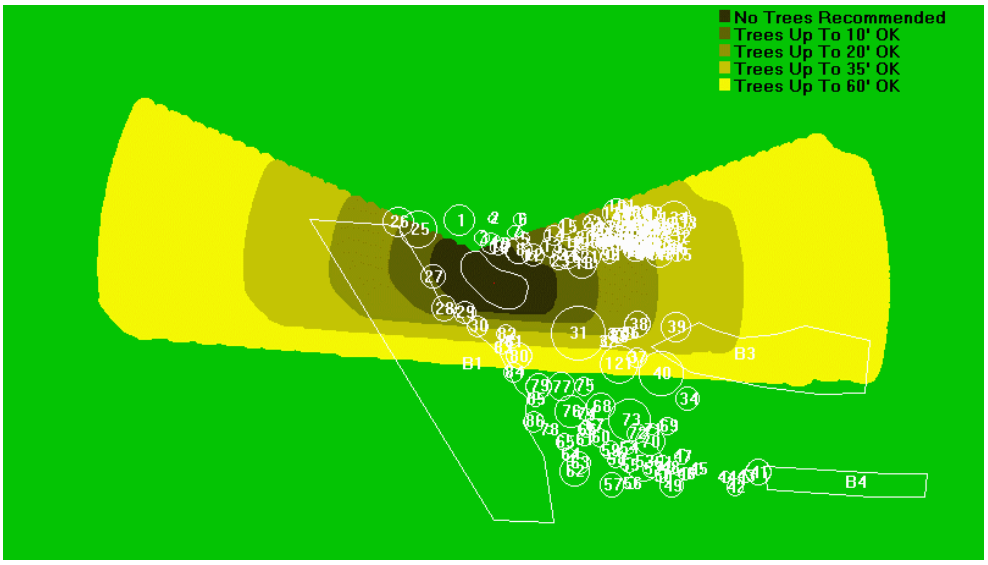
Un-Aged *Aged*



The diagram on the left shows what light conditions are like currently. The diagram on the right shows what light conditions will be like in 15 years if no tree work is done.

Allowable Tree Height

May 1 - Sept 21
7:00a.m. to 7:00p.m.



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After trees have been removed people often want to replant with lower growing trees and shrubs. This calculation shows how high trees can be before they block light reaching the green.