Estimating Forest Canopy Density

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PREFACE

This RTC-TH publication is part of the RTC-TH AG-2010-4 Basic Recon Line Survey Methods series. Procedures common to all line surveys are contained in the Basic Recon Line Survey paper and are not repeated in subsequent line survey papers. Instead, each subsequent paper in the series provides specific details, insights, and procedures unique to that type of survey.

Canopy density surveys could be used in the following:

- BUGS: to monitor forest "health" relative to watershed management
- SOW / SOS: canopy density affects surface runoff and soil moisture retension which are fundamental to saving water and soil.

Line surveys are often part of a field study. The RTC-TH Publication AG-2010-2 Natural Terrain Study Guide may contain other information that can be used in conjunction with this paper.

RTC-TH Demonstration Farm Programs

Light green shading indicates this lesson can be used in the programs listed above.

Geography: Survey Methods-Biosphere

Estimating Forest Canopy Density

Community-based Environmental Education for the Self-sufficiency and Sustainability of Small Rural Family Farms

1.0 INTRODUCTION

Estimating forest canopy density helps to determine the general condition of the watershed (best if canopy density is >70%), lighting levels under the canopy for agroforesty, monitoring tree thinning operations or reforestation efforts, among other reasons. The data are collected along survey transect lines. The Canopy Densitometer is a binomial instrument so the data collection is rapid with negligible errors (about 6% - 10% error rate). This makes it suitable for fast recon surveys.

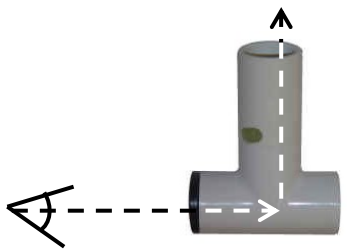
[**Note:** You should have read the RTC-TH publication 2010-4 "Basic Recon Line Survey Methods" before starting a Tree Canopy Density survey.]

2.0 EQUIPMENT

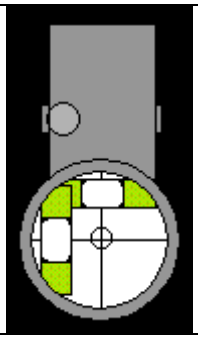
Long measuring tape	Data Log Sheet / Clipboard / pencil-pen
Canopy Densitometer	Flagging
Magnetic Compass / GPS	At least 6 - 10 poles, 3 m tall with flags
Binoculars	GPS unit

2.1 USING THE CANOPY DENSITOMETER

The canopy densitometer provides a single binary (yes or no) estimate of canopy cover at each sample measurement point. It requires you to move through the forested area and measure this binary variable at many points. A sample of 100 points will yield an estimate of vertically projected canopy cover within 6-10 percent of the true canopy cover. Line transects with points every 3.6 – 6 m / 12 -20 ft or so are commonly used. The transect lines may be straight lines or arranged in a triangular or diamond pattern. If 100 points are sampled, the sum of the "1"s is the estimate of canopy cover for the stand.



Side view



Viewfinder View

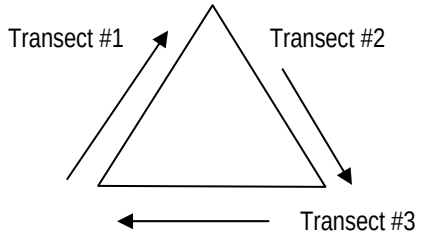
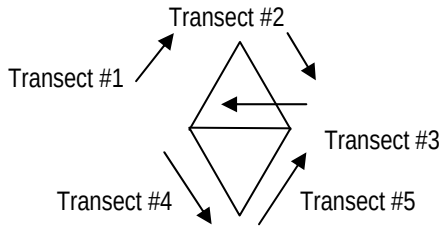
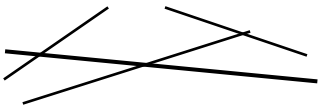
Step 1. Look into one end of the densitometer into a mirror (Figure A below) to get a view of what is directly overhead.

Step 2. Level the 2 bubble levels visible in the viewfinder to be sure the instrument is perpendicular.

Step 3. When the bubbles are leveled, the center of the cross hair will show either open sky (0) or canopy cover (1). Record the data for the survey point and repeat until all transect points have been surveyed.

Note: See Appendix 2 for more information on using the Canopy Densitometer.

2.2 Summary Of Canopy Densitometer Survey Transect Pattern

Triangle	When to use: When survey area isn't big enough for a Diamond pattern	
	Layout: Equilateral triangle; each side 66 m / 216.5 ft, 60° turns to close the triangle; take canopy measurement; total of *3 transects*.	
	Canopy Density Measurement: Every 2 m / 6.5 ft to get 100 measurements; 33-34 samples per transect.	
Diamond	When to use: When survey is too large for a Triangular pattern.	
	Layout: 2 equilateral triangles sharing 1 side; each side 66 m / 216.5 ft, 60° turns to close the triangle; total of *5 transects*.	
	Canopy Density Measurement: every 3.3 m / 10.8 ft to get 100 measurements; 20 samples per transect.	
Typically used to sample the larger areas in which the triangle or diamond shaped transect might provide sample estimates that are too localized and potentially not representative of the sample area.		
Straight Line Transect	Preview area and lay out transect lines to get an aggregated sample for the entire area and minimize sampling bias	
	Layout transect lines to get 100 measurements at least 2 m / 6.5 ft apart. Be sure to specify the transect length and measurement interval.	
Multiple Transects	Layout transect lines randomly or systematically may be used to develop multiple estimates of stand characteristics, as well as stand estimates and variances. Be sure to specify the transect length and measurement interval.	

Notes:
- Each survey must have a minimum of 100 points. Sample points are evenly spaced along a transect or side of a triangle. Survey results have an error rate of about 6% - 10%.
- Data are collected at sample points evenly spaced on transects placed within sample areas.
- The transects are situated so that all the survey points fall within the sample area.
- It is important that a given configuration be applied consistently to avoid any potential bias due to changing the form of the transect.

3.0 GENERAL PROCEDURE

3.1 Survey Location Name: Common name of the survey site.

3.2 Survey ID Code: All Canopy Density surveys are coded "CD" then the date using the format of 4-digits for the year, 3 letters for the month, 2-digits for the day. For example: CD-2005-Jul-31. [**Note:** The survey code is the prefix to all data points collected during that survey.]

3.3 GPS Coordinates: If possible, get GPS coordinates for the starting point of the survey. If this is not possible, try to leave a marker indicating the starting point and survey number/date.

3.4 Survey Time: Record this in 24-hour format to ease the Elapsed Time calculation. Record the start and end time for the actual survey. The Start /End Times are the actual start of the data collection. Elapsed Time is calculated by subtracting the start time from the end time. This data may be helpful when monitoring training and for planning future surveys.

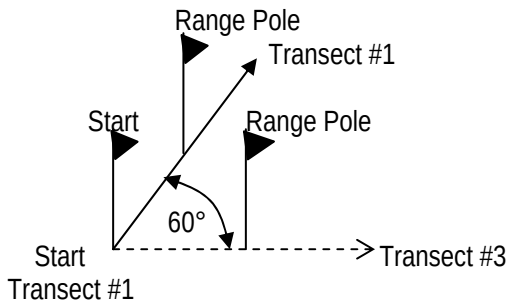
3.5 Layout Survey Transect Pattern: Minimum of 100 survey points are needed. Determine transect pattern. Be sure to specify the transect lengths. The default

value (when no other length is specified, is 66 m / Sketch the pattern in the data block on the survey log form.

Steps 1 – 10 are for a Triangular Pattern.
For a Diamond Survey Pattern, only 20 measurements will be taken at 3.3 m intervals for each transect. Continue with Step 11.

Step 1. Clearly mark the starting point of the survey. Place a pole in the ground and tie a flag to it so you can see this pole. Record the start time of the survey.

Step 2. Use a magnetic compass to determine the azimuth of Transect #1. Mark the azimuth with a Range Pole placed 3 m from the starting point. Record the azimuth on the data log sheet in the space for Azimuth (Az) over the column of numbers labeled 1-01 to 1-34.



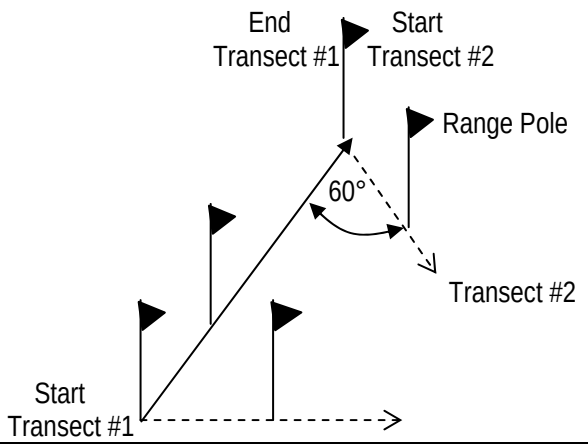
Note: The range pole is used with the Starting Marker Flag as a visual sighting aid to keep the survey line straight. The person with the tape measure walks away from the Start point past the Range pole. Looking back, the range pole and the starting point should line up to make a single image.

Step 3. Use a magnetic compass and turn an angle 60° in a clockwise direction from Transect #1. Mark the azimuth with a stake placed 3 m from the starting point. [Note: For a Triangular Survey Pattern, this would be Transect #3.]

Step 4. Use a tape measure to measure the length of Transect #1. [Note: Unless otherwise specified, the length of the transect = 66 m and the sampling points will be every 2 m along the transect.] Record the Transect length in the space for Distance (Dist) over the column of numbers labeled 1-01 to 1-34.

Step 5. At the end of Transect #1, mark the point.

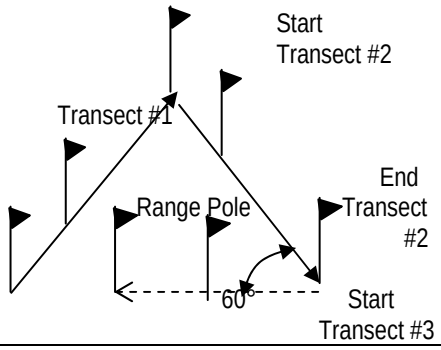
Step 6. Use a magnetic compass and sight back along Transect #1. Turn an angle 60° in a counterclockwise direction from Transect #2. Mark the azimuth with a Range Pole placed 3 m from the starting point. [Note: For a Triangular Survey Pattern, this would be Transect #2.] Record the azimuth on the data log sheet in the space for Azimuth (Az) over the column of numbers labeled 2-01 to 2-34.



Step 7. Repeat Steps 4 & 5 until reaching the end of Transect #2. [Note: If you are able to see the starting range pole and the range pole for Transect #3 set close to the starting pole, you can use these two range poles to determine the end point of Transect #2 / start point for Transect #3.

Step 8. Mark the end of Transect #2 with a flag.

Step 9. Use a magnetic compass and sight back along Transect #2. Turn an angle 60° in a counterclockwise direction from Transect #3. Mark the azimuth with a stake placed 3 m from the starting point. [Note: For a Triangular Survey Pattern, this would be Transect #3.] Record the azimuth on the data log sheet in the space for Azimuth (Az) over the column of numbers labeled 3-01 to 3-34.



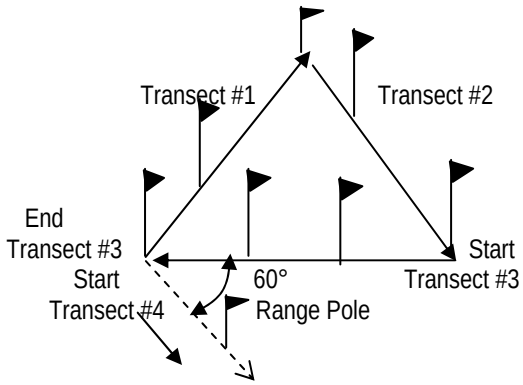
Step 10. Repeat Steps 4 & 5 until reaching the end of Transect #3. You should be back at the starting point of the survey. Record the Stop time for the survey.

Step 10 is the last step for a Triangular Survey Pattern.
If using a Diamond Survey Pattern, Continue with Step 11. Remember, in a Diamond Pattern, take ONLY ***20 measurements at 3.3 m intervals*** *for each transect.*

Step 11. At the end of Transect #3, use a magnetic compass and sight back along Transect #3. Turn an angle 60° in a clockwise direction from Transect #3. Mark the azimuth with a stake placed 3 m from the starting point.

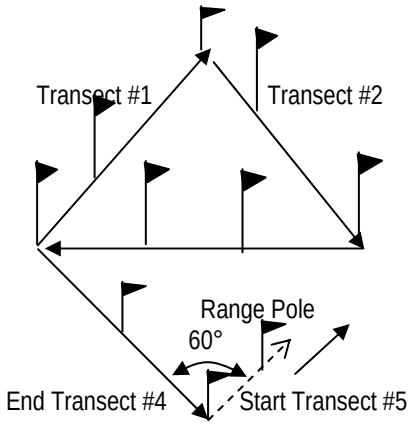
For a Diamond Survey Pattern, this would be Transect #4. Record the azimuth on the data log sheet in the space for Azimuth (Az) over the column of numbers labeled 4-01 to 4-20.

Step 12. Repeat Steps 4 & 5 until reaching the end of Transect #4.



Step 13. At the end of Transect #4, use a magnetic compass and sight back along Transect #4. Turn an angle 60° in a clockwise direction from Transect #4. Mark the azimuth with a Range pole placed 3 m from the starting point. This is Transect #5. Record the azimuth on the data log sheet in the space for Azimuth (Az) over the column of numbers labeled 5-01 to 5-20.

Step 14. Repeat Steps 4 & 5 until reaching the end of Transect #5. You should be back at the End Point for Transect #2 / Start Point for Transect #3. Record the Stop Time of the survey.



For environmental monitoring purposes, leave the Transect corner marker poles in place. This will make it easier to do follow-up surveys along the same route to assess changes of canopy density over time.

Canopy Density Survey Data Processing Procedure	Term	Density
Step 1. At the end of the survey, count all of the "1"s. If the survey had 100 data points, the total number of "1"s is the estimated % canopy density. Step 2. The estimated canopy density could be off by 6-10%. Step 3. *When canopy density is less than 70%, the watershed is NOT in good condition.* Since the error could be 6-10%, canopy density values of 70 - 80% should be set as trigger an alert to carefully inspect and monitor the condition of watershed.	Closed	100%
	Dense	75% - 99%
	Thin	50% - 74%
	Open	Less than 50%
Post Processing • All canopy density data should be entered into a spreadsheet and archived (digital data and hard copy). • Annual summaries should be tabulated to develop a historical log of the watershed health. • Canopy density survey data should be used when planning any agroforestry activities in the survey area.		

4.0 CHANGES OVER TIME

- **Base-line surveys** should be done at the end of the rainy season, and near the end of the dry season. This may show the annual range of canopy density.
- **Special surveys** should be done at the time of any significant changes (e.g. after a fire or some harvesting / clearing / thinning of the forest that may affect canopy density.
- **Trigger Point Monitoring:** To adequately protect the watershed's water catchment ability, the overall canopy density should not be less than 70%. When canopy densities are in the 70-75% range, reforestation or planting efforts must be started.

APPENDIX 1:
MAKING A SIMPLE CANOPY DENSITOMETER

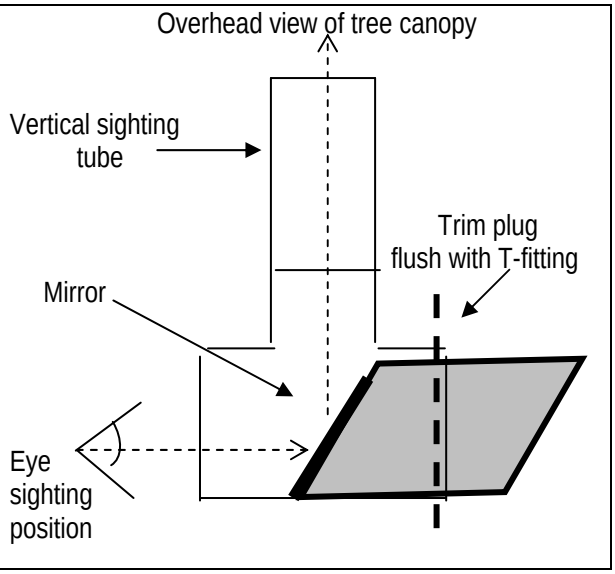
This simple canopy densitometer is made using PVC pipe (1 T-fitting, a short length of pipe), a Styrofoam plug, a small mirror, a small bubble level, a sharp nail, black thread, a fishing lead weight, electrical tape, clear tape, black marking pen, and a hacksaw.

Step 1. Prepare / Mount the Mirror.

- Cut the Styrofoam into a cylindrical shape to fit inside the PVC T-fitting.
- Bevel 1 end at a 45° angle and glue a small mirror here. The plug and mirror are glued inside the T-fitting so the mirror is aligned with both the vertical and the horizontal sighting end of the T-fitting.
- Trim the Styrofoam block flush with the end of the T-Fitting.

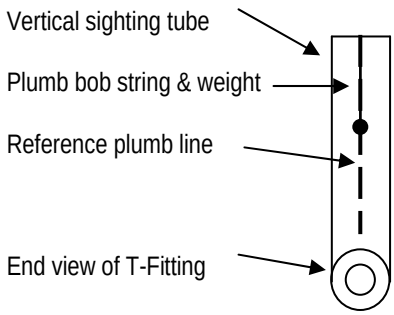
Step 2. Prepare the Sighting Tube.

- Get a straight piece of PVC pipe 15 cm long.
- Insert 1 end into the vertical tube of the T-fitting.



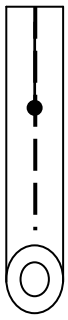
Step 3. Preparing the Vertical Plumb Line.

- On 1 side of the vertical tube, use a sharp nail to scribe a deep vertical line from the top of the tube to the bottom. This side should face you when you are looking into the sighting end of the T-fitting. Fill the groove with black ink—but clean off the excess so you only see the black plumb line.
- Extend a thread half way down the vertical tube and put the fishing weight on the end.
- Tape the top pf the thread in place. Be sure the plumb line string is directly over the scribed plumb reference line.



APPENDIX 2:
USING A SIMPLE CANOPY DENSITOMETER

Using the Densitometer



Properly aligned for use

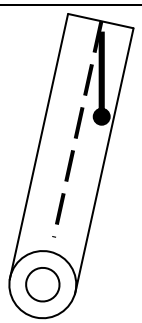
Taking Measurements

All canopy densitometer measurements are binary. They can only be 1 of 2 possibilities: no canopy cover (clear sky = 0) or canopy cover (tree branches / leaves = 1).

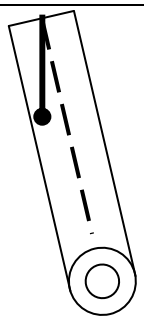
Step 1. Properly align the instrument so the plumb line string lines up with the vertical plumb reference line.

Step 2. Looking into the horizontal sighting hole.

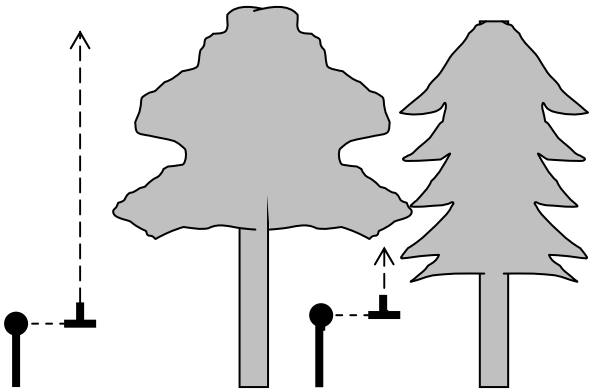
Step 3. When the view is directly overhead, notice if you see clear sky, record a measurement of 0 (zero). If you see tree branches, record a measurement of 1 (one).



Leaning to the right



Leaning to the Left



Clear sky above. Record a measurement "0"

Tree canopy above Record a measurement "1"

Processing The Data

Step 1. At the end of the survey, count all of the "1"s. If the survey had 100 data points, the total number of "1"s is the estimated % canopy density.

Step 2. Look up the canopy density term associated with the % canopy. (See table of terms on the top of page 3 and on the back of the survey form.

Step 3. The estimated canopy density could be off by 6-10%.

Alert: When canopy density is less than 70%, the watershed is NOT in good condition. Since the error could be 6-10%, canopy density values of 70 - 80% should be set as trigger an alert to carefully inspect and monitor the condition of watershed.

Biosphere

Tree Canopy Density Data Log

Community-based Environmental Education for Families and Sustainable Neighborhoods

Location:				Canopy Density	Stop Time
CD	YYYY	MMM	DD		Start Time
Surveyor:					Elapsed time
Survey Origin GPS Coordinates:	Lat			Long	Alt

Survey Pattern	☐ Line Pattern	Total # measurements	Note: Sketch the Survey Pattern in the space at the bottom of the form.
	☐ Triangle; 3 transects; 66 m; 2 m interval	Transect length	
	☐ Diamond; 5 transects;66 m; 3.3 intervals	Measurement interval	

Az		Az		Az		Az		Az	
Dist		Dist		Dist		Dist		Dist	
Pt #	Rdg	Pt #	Rdg	Pt #	Rdg	Pt #	Rdg	Pt #	Rdg
1-01		2-01		3-01		4-01		5-01	
1-02		2-02		3-02		4-02		5-02	
1-03		2-03		3-03		4-03		5-03	
1-04		2-04		3-04		4-04		5-04	
1-05		2-05		3-05		4-05		5-05	
1-06		2-06		3-06		4-06		5-06	
1-07		2-07		3-07		4-07		5-07	
1-08		2-08		3-08		4-08		5-08	
1-09		2-09		3-09		4-09		5-09	
1-10		2-10		3-10		4-10		5-10	
1-11		2-11		3-11		4-11		5-11	
1-12		2-12		3-12		4-12		5-12	
1-13		2-13		3-13		4-13		5-13	
1-14		2-14		3-14		4-14		5-14	
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1-16		2-16		3-16		4-16		5-16	
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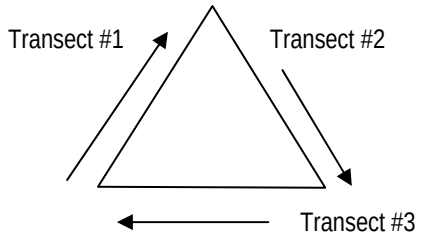
1-19		2-19		3-19		4-19		5-19	
1-20		2-20		3-20		4-20		5-20	
1-21		2-21		3-21					
1-22		2-22		3-22					
1-23		2-23		3-23					
1-24		2-24		3-24					
1-25		2-25		3-25					
1-26		2-26		3-26					
1-27		2-27		3-27					
1-28		2-28		3-28					
1-29		2-29		3-29					
1-30		2-30		3-30					
1-31		2-31		3-31					
1-32		2-32		3-32					
1-33		2-33		3-33					
1-34		2-34		3-34					

Sketch Survey Transect Layout

Reference notes are on the back of this form.

SUMMARY OF CANOPY DENSITOMETER SURVEY TRANSECT PATTERNS

Triangle	When to use: When survey area isn't big enough for a Diamond pattern	
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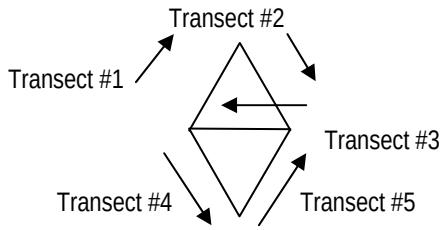
Diamond	When to use: When survey is too large for a Triangular pattern.	
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In large areas where the triangle or diamond shaped transects might provide sample estimates that are too localized and potentially not representative of the sample area, use these line survey patterns.

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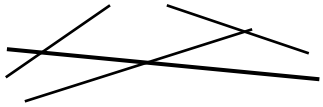
Multiple Transects	Layout transect lines randomly or systematically to develop multiple estimates of forest stand characteristics, as well as stand estimates and variances. Be sure to specify the transect length and measurement interval.	

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Step 3. *When canopy density is less than 70%, the watershed is NOT in good condition.* Since the error could be 6-10%, canopy density values of 70 - 80% should be set as trigger an alert to carefully inspect and monitor the condition of watershed.	Thin	50% - 74%
	Open	Less than 50%

Post Processing

- All canopy density data should be entered into a spreadsheet and archived (digital data and hard copy).
- Annual summaries should be tabulated to develop a historical log of the watershed health.
- Canopy density survey data should be used when planning any agroforestry activities in the survey area.