METHODOLOGY OF MEASURING SHELTERBELT OPTICAL POROSITY — A PILOT STUDY

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FOREST & FARM PLANTATION MANAGEMENT COOPERATIVE

EXECUTIVE SUMMARY

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Optical porosity (proportion of light to foliage within the vertical profile) has been shown to be highly correlated with wind-speed reduction of shelterbelts. An 8 mm video camera was used to capture images of several shelterbelts which were then analysed for optical porosity using TNTmips™ computer-based software. The study showed that the technique was relatively straight forward, with an apparently high quality of analysis produced. Recommendations are given involving background, frame size, scale, reflections, and definition, which should ensure high quality images.

Methodology of Measuring Shelterbelt Optical Porosity

A Pilot Study

M A Carter

Introduction

Porosity is an important characteristic of shelterbelts, as it affects wind speed reduction and turbulance. Previous studies have shown a high degree of correlation between optical porosity, and wind speed reduction (Loeffler *et al.*, 1992). These studies have been carried out using still photography which illustrates the optical porosity of the shelterbelt at that instant. The use of video enables a number of individual frames to be captured and the porosity calculated for each frame, so that an average value can be obtained for the belt.This may be useful in assessing porosity in windy conditions, so that a mean porosity, and variance, can be calculated.

Objective

The objective of this study was to;

(a) Develop a methodology for measuing the optical porosity of shelterbelts using a video camera and image processing software, and

(b) Provide porosity data to S Green, Hort Research, for validation of his numerical wind flow model to predict shelterbelt effects on windspeed reductions.(Green, 1994)

Study Sites

This study has been carried out on farm sites near Rotorua and Masterton in the North Island, and Blenheim in the South Island. These sites were chosen because there are existing permanent sample plots established in the shelterbelts on these properties.

On Tihi-Otonga Station, near Rotorua, a shelterbelt spacing trial (see Agroforestry Research Collaborative Report No. 25 for details) which enabled shelterbelts to be videoed with trees at various spacings in both single and twin row configurations, all of the same age class and silvicultural treatment. The other shelterbelts were chosen to introduce different ages and pruning severities.

The following Table summarises the tree data and resulting porosity data for each plot. Not all the shelterbelts videoed are listed below because they were either too similar to one of the chosen belts or the video images were in some way unsuitable for processing.

Table 1 Summary of Shelterbelt Details

Image No	Belt Name	PSP I.D. No.	Optical Porosity (space) %	Mean Height (m)	Pruned Height (m)	Belt Depth (m)	Within row spacing of P.rad (m)	No of rows Total	No of rows P.rad
1	Wiltrun	FR 32 2 3 1	55.0	11.4	3.9	2.0	2.1	2	1
2	Birch Hill	FR 34 5 1 2	46.1	15.0	4.8	4.0	3.0	3	1
3	Armstrong	FR 34 1 1 2	35.7	12.0	2.5	2.0	1.3	2	1
4	Tihiotonga	FR 2 1 1 1	38.1	9.4	4.6	0.5	1.0	2	1
4a	Tihiotonga	FR 2 2 3 2	58.1	9.6	5.2	0.5	2.0	2	1
5	Tihiotonga	FR 2 1 1 4	71.8	9.4	4.7	0.5	4.0	2	1
6	Tihiotonga	FR 2 3 3 4	53.4	9.0	4.6	2.5	4.0	3	2
7	Tihiotonga 45 degree	FR 2 3 3 4	42.0	9.0	4.6	2.5	4.0	3	2
8	Tihiotonga 100% height	FR 2 1 2 5	76.4	9.0	5.2	0.5	5.0	2	1
9	Tihiotonga 75% height	FR 2 1 2 5	73.0	9.0	5.2	0.5	5.0	2	1
10	Tihiotonga 50% height	FR 2 1 2 5	73.8	9.0	5.2	0.5	5.0	2	1
11	Tihiotonga 25% height	FR 2 1 2 5	63.2	9.0	5.2	0.5	5.0	2	1

Field Work Methodology

The videoing was carried out using a Sony CCD-V88E (8mm) video camera recorder set up on a tripod.

The camera was placed at sufficient distance from the shelterbelt to enable some foreground grass and some sky above the tallest tree to be included in the frame. The distances used in this study ranged from 3.6 to 4.5 tree heights. This was determined by a trial run of transferring the video image into the image processing software where we found the top and bottom of the frame was cropped.
The camera was positioned approximately perpendicular to the belt in the horizontal plane. No attention was paid to the vertical inclination of the camera. The distance from centre of the pinus radiata row of trees to the camera was measured as was the height of the camera above the base of the trees.

Following the preliminary images, a scale board 100mm wide x 2.5m long was included in each shot. The ends of the board were painted black and the middle section, 2.0m long, was painted white. This provided a well defined 2.0 metre length for scaling the image but it needed to be located outside of the area of the porosity calculation. Known tree heights couldn't always be used to scale the frame because the base of the trees was sometimes difficult to define due to pruning slash, tall grass or the shadow cast by the trees.

Each shelterbelt was filmed for approximately one minute. This provided the option of a range of frames to choose from, or multiple frames for processing to obtain an average optical porosity value. One minute of film equates to 1500 frames (@ 25 frames / second).

Some shelterbelts were filmed with the Pinus radiata in the foreground and others with the unpruned supplementary species in the foreground and the Pinus radiata behind. The frames with the Pinus radiata in front of the supplementary species were easier to process simply because the pruned radiata stems were more defined and not obscurred by the unpruned trees.

Image Processing Technique

Video Capture

Before any images could be captured into the image processing system the 8mm video was copied onto a 1/2" VHS cassette for use in the video editing deck.

The software used to process the images is called "Map and Image Processing System" (TNT mips™) produced by MicroImages Inc. Lincoln, Nebraska,USA and is run under Microsoft® Windows™ v3.11.

The captured digitized images are saved as Truevision Advanced Raster Graphics Adapter (TARGA) files. The image resolution was 512 x 576 pixels x 16 bits per pixel with 256 colours. Figure 1 shows the TARGA file of Image 4a (Table 1), the radiata pine are in the foreground and the supplementary species is Cryptomeria japonica. This particular image was the first run through TNT mips™ and shows the tree tops have been cropped.

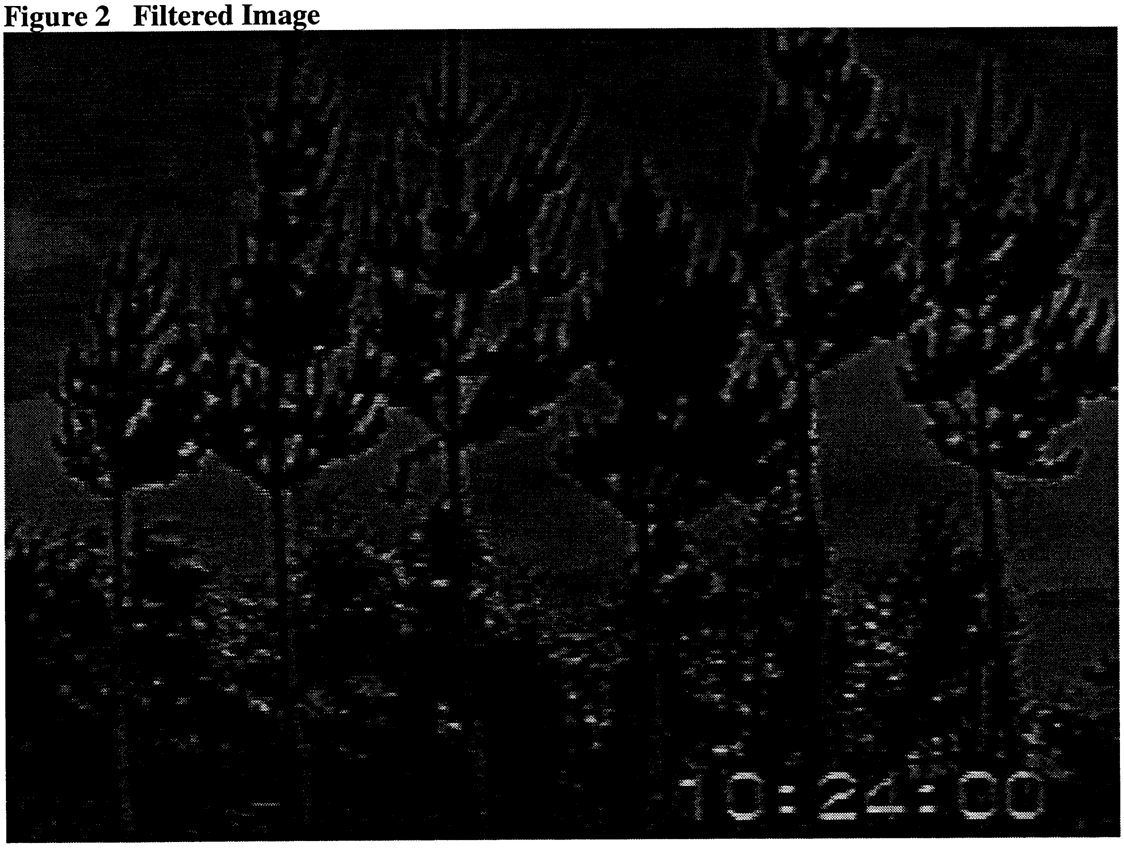
Figure 1 Captured Video Image

Filtering

A filter is a numeric matrix that is applied to data around the processing cell. Filtering alters the selected cell's value to more nearly agree with, or more strongly contrast with, the cells around it.

TNT mips™ has a range of filter processing options included with the software. Through a process of trial and error we selected a 9x9 matrix high boost filter, with a modified boost factor of 1.4 which resulted in sharpening all features in the image.

Figure 2 Filtered Image



The filtered image shows greater contrast between the trees and the background simplifying classification of the features. The same filter type was applied to all the images.

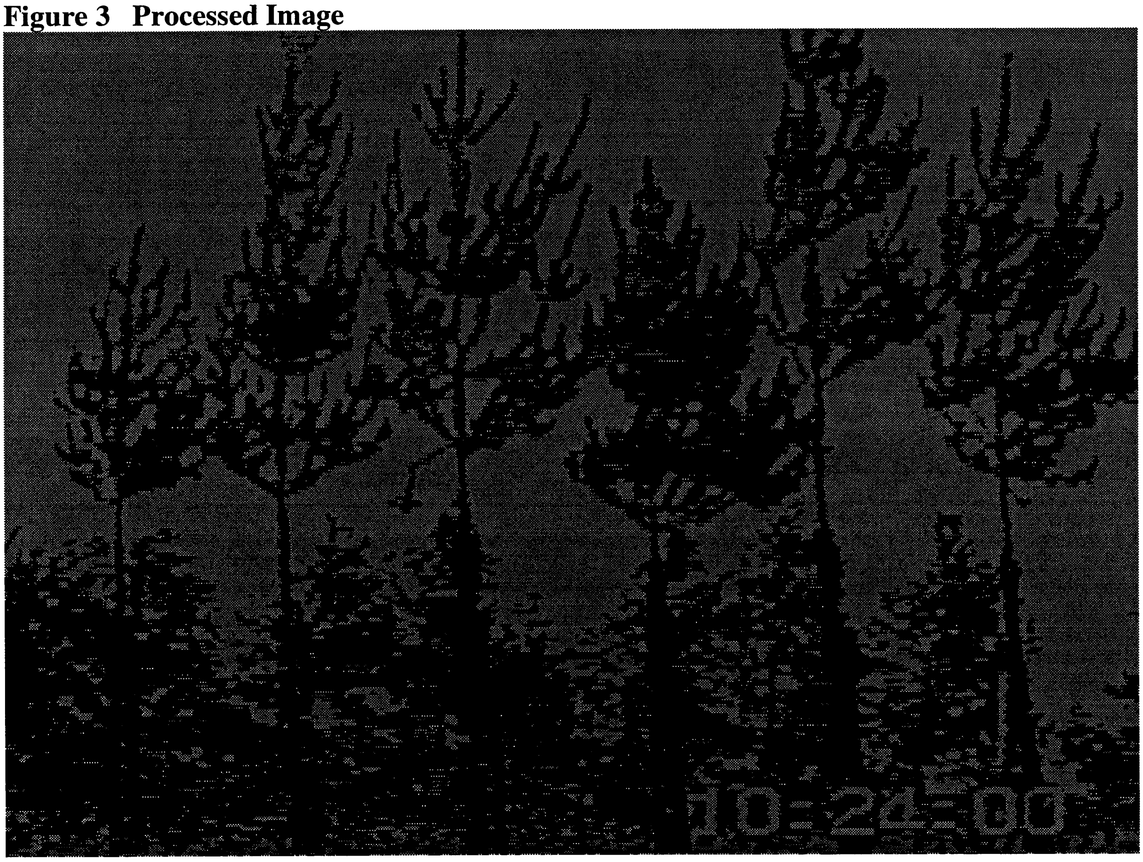
Feature Classifying

This process is refered to in TNT mips™ as Feature Mapping.

The interactive feature mapping process requires the operator to identify sample pixels which relate to a selected feature class. The processing system then classifies all cells with identical attributes to the single sample (or range of sample cells) within the image and displays them as a prototype for the operator to judge the accuracy of the classification. If the fit is acceptable then the prototype cells are classified and removed from further processing consideration.

The image was divided into two classifications; Solid for the trees and Space for the background. As they appear on the screen, the trees reflect a range of colours, some of which are also present in the background. The aim is to make the trees all one classification (see Figure 3), in this case dark blue, and the background a single contrasting colour. This is best done using the video frame displayed on a monitor next to the computer screen so feature definitions can be readily compared.

Figure 3 Processed Image



When the feature map is complete the 'region of interest' (ROI) is defined by drawing a rectangular box to encompass the trees and exclude excess foreground and sky.
The ROI defines the area of the feature map raster for which the statistical report is required. The report function then calculates the number of blue and grey pixels in the ROI and expresses them as a percentage of the total number of pixels in that area. The percentage of space (or background) for each image is listed in Table 1.

Recommendations

- The ideal frame for imaging is to have a complete sky background, or at least no trees behind the selected shelterbelt. The pruned species should be in the front, and the camera settings set to give maximum contrast between the trees and the background beyond the belt.
- Light reflection off the pruned stems and the foliage can cause those portions of the tree to show up in the porosity calculation, as space rather than as solid, therefore consideration needs to be given to the position of the sun especially on cloudless days.
- Some of these problems may be overcome by filming directly onto SVHS video hence removing the copying step and capturing the images at a higher resolution of 768 x 576 x 16 bit pixels.
- Mount camera at half tree height on a platform or cherrypicker to avoid distortion of tree tops.

Conclusions

The pilot study conducted demonstrates that it is possible to identify with acceptable accuracy the solid and space in a shelterbelt using video imaging and image processing techniques. TNT mips™ is easy to use, taking approximately one hour to fully process an image from capturing the image through to producing the statistical report. The time involved videoing in the field is on average 15 minutes per site where 1 minute of video would be recorded. Porosity data, tree growth data, and a general description of three shelterbelt sites was supplied to Dr S. Green, HortResearch, for processing through the numerical model to examine the influence of shelterbelt structure on windspeed reduction. These results have been published in HortResearch Report No. 94/132.

References

Loeffler A E, Gordon A M, and Gillespie T J, 1992. Optical porosity and windspeed reduction by coniferous windbreaks in Southern Ontario.
Agroforestry Systems 17 : 119 - 133, 1992.

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