REPORT

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Colour Blindness in the New Zealand Forest Industry

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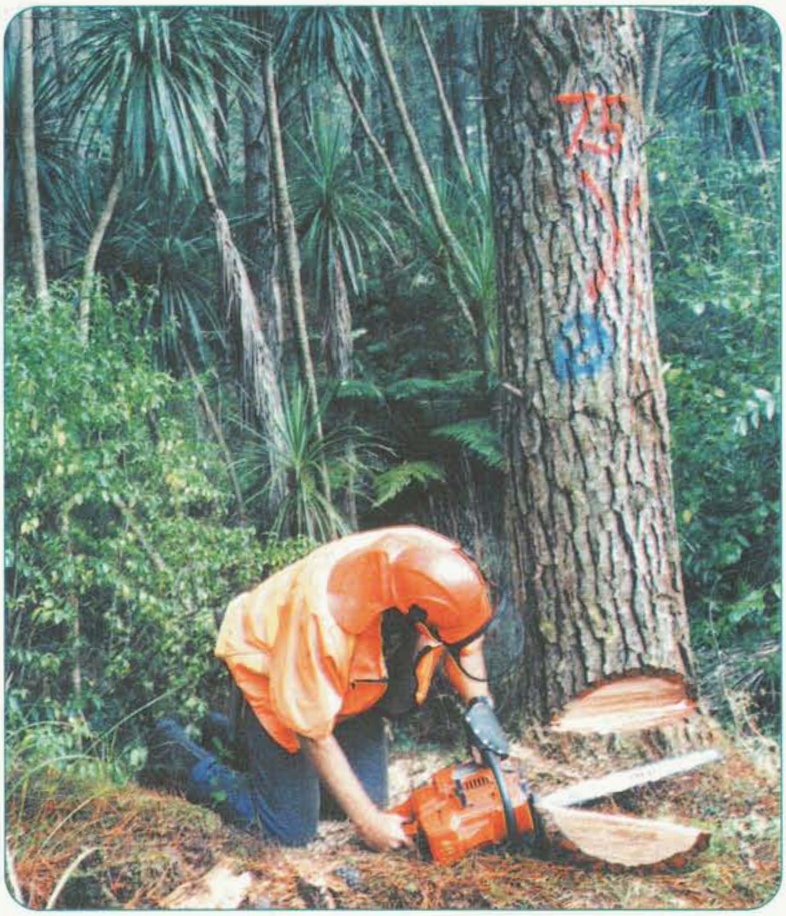

Summary

A sample of 704 forest workers throughout New Zealand were tested for colour blindness using the 38 colour plate Ishihara Test. The study was carried out to determine the prevalence of colour blindness in the New Zealand forest industry workforce. Results showed 3.8% of those tested (all male) exhibited some kind of red-green colour-blindness. This result is lower than overseas findings for the general male population, which indicate colour blindness levels of between 5 and 12%.

To further improve the safety of the forest industry, results from this study indicate that colour blindness should be taken into account when selecting colours for use in the forest. Self reports from colour blind forest workers indicated that the easiest paint colours to see were silver, blue, yellow and fluorescent orange; and the easiest helmet and high visibility colours were fluorescent yellow, fluorescent orange and white.

Important! Self reports from colour blind forest workers indicated that the watermelon fluorescent helmets (pink) were hard to see in all cases.

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Introduction

An inability to perceive and correctly identify colour in the forest environment has the potential to impact negatively on the safety, quality and profitability of a forest operation. A potentially hazardous situation is created when a colour blind worker has difficulty identifying high visibility clothing due to the colour of the clothing or markings, especially against the forest background. A failure to identify paint marks on a standing tree has been anecdotally reported as leading to trees being felled outside of a skid boundary mark, resulting in the contractor having to make compensatory payment to the forest owner. Failing to identify the red paint on extracted stems could also lead to logs being crosscut at the incorrect mark, reducing log value recovery. Incorrect identification of red paint on marker trees has been anecdotally reported as leading to a new road being located in the wrong place in the forest. During forest fire fighting procedures, specific helmet colours are often used to identify the chain of command. Where a firefighter has difficulty identifying particular colours, a state of confusion could result, leading to interruption and possible injury.

Colour blindness is normally described as an inability to differentiate between red and green. Previous overseas research has shown that colour blindness exists in 5 to 12% of males and 0.5% of females (Mollon, 1986, Rollins-Hurley, 1994, Bridger, 1995, Hsia and Graham, 1997). In the human eye, perception of colour is a result of the interaction between rods, which are sensitive to the smallest amount of light, and cones, which sense colour and fine detail. Colour blind individuals have the same number of rods and cones as those with normal colour vision, but somehow the information link to the brain is not activated (Hurley, 1994). Therefore, the colour-sensitive cone cells in the eyes do not collect or send the proper colour signals to the brain. Colour-blindness can be inherited (congenital) or acquired through injury or disease (Hsia and Graham, 1997). Most cases of congenital colour vision deficiency are characterised by a red-green colour deficiency (Ishihara, 1990). The Ishihara Test was designed to detect the most common types of colour blindness (Fisher and Simmonds, 1980).

The sensitivity of the eye to specific wavelengths of light can be affected by drugs such as caffeine, alcohol, tobacco and marijuana, causing an acquired colour deficiency (Knowlton and Woo, 1989). The Ishihara test is clinically proven as the most effective test for red-green colour deficiency (Birch, 1997), providing a quick and accurate assessment of colour vision deficiency of congenital origin. The Ishihara Test is the preferred test of colour vision specialists (Hsia and Graham, 1997). Colour blindness is generally incurable, but in some cases a special red-tinted contact lens (Appendix 1) can be used to aid certain colour deficiencies (American Optometric Association, 1997).

Definition

The term "colour-blind" actually describes the rare condition where only shades of black, white and grey are seen. Alternative terms include: colour vision defect, deficiency, anomaly or abnormality. These more closely identify the type and degree of a colour vision problem. Johnson (1992) defined the condition as "a genetically inherited trait which does not change in type and degree with age, and has no known cure". However, for the purpose of this report, the widely recognised term "colour blind" is used, and denotes a red-green colour deficiency identified by the Ishihara Test.

Method

The 1990 edition of Ishihara's Tests for Colour Blindness was used in this study to determine the prevalence of colour blindness in the forest industry (Figure 1). Forest workers were visited on-site either at the start of the day or during meal breaks so productive work time was not interrupted. Those workers present at the time of the visit were shown the colour plates, and asked to identify the numbers they observed on the plates. The test was immediately able to determine whether a person had normal colour vision, was red-green colour blind, or was totally colour blind. The tests were carried out in accordance with the test procedure specified in the test manual (Ishihara, 1990).

Information on ethnicity was also collected at the time the test was given. Forest harvesting and silviculture crews throughout the North and South Islands of New Zealand were included in the study.

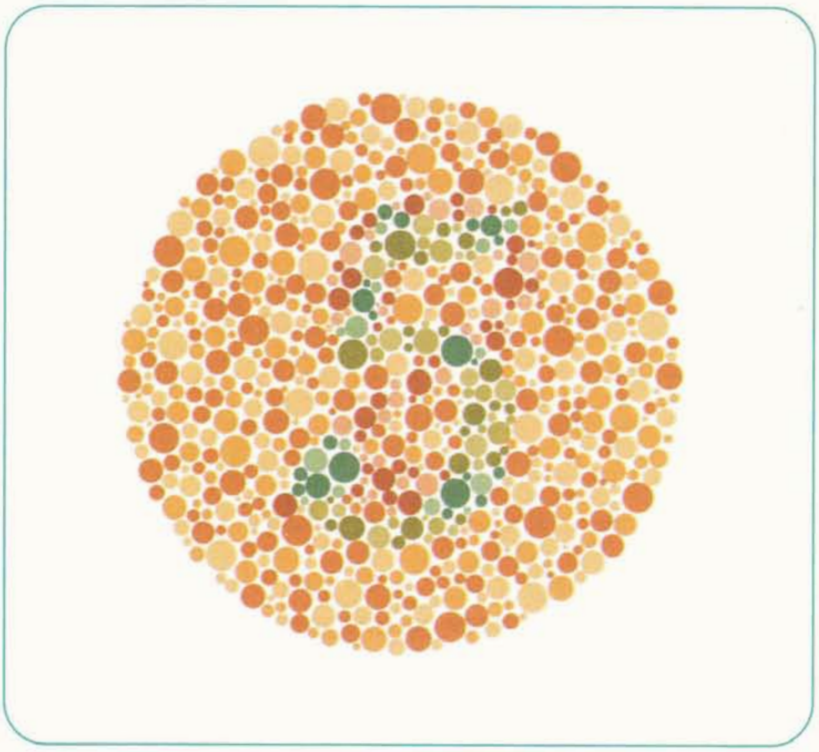

Figure 1 - Colour plate from Ishihara Test for Colour Blindness - 1990 Edition

Results

Ethnicity

The forest workforce included in this study comprised 56% Maori/European Maori, 43% European, and 1% Pacific Islander. The ratio of each group differed according to the different geographical regions of New Zealand (Figure 2). A previous study of the New Zealand forest workforce found just under half identified themselves as Maori/Pacific Islander (Byers, 1995).

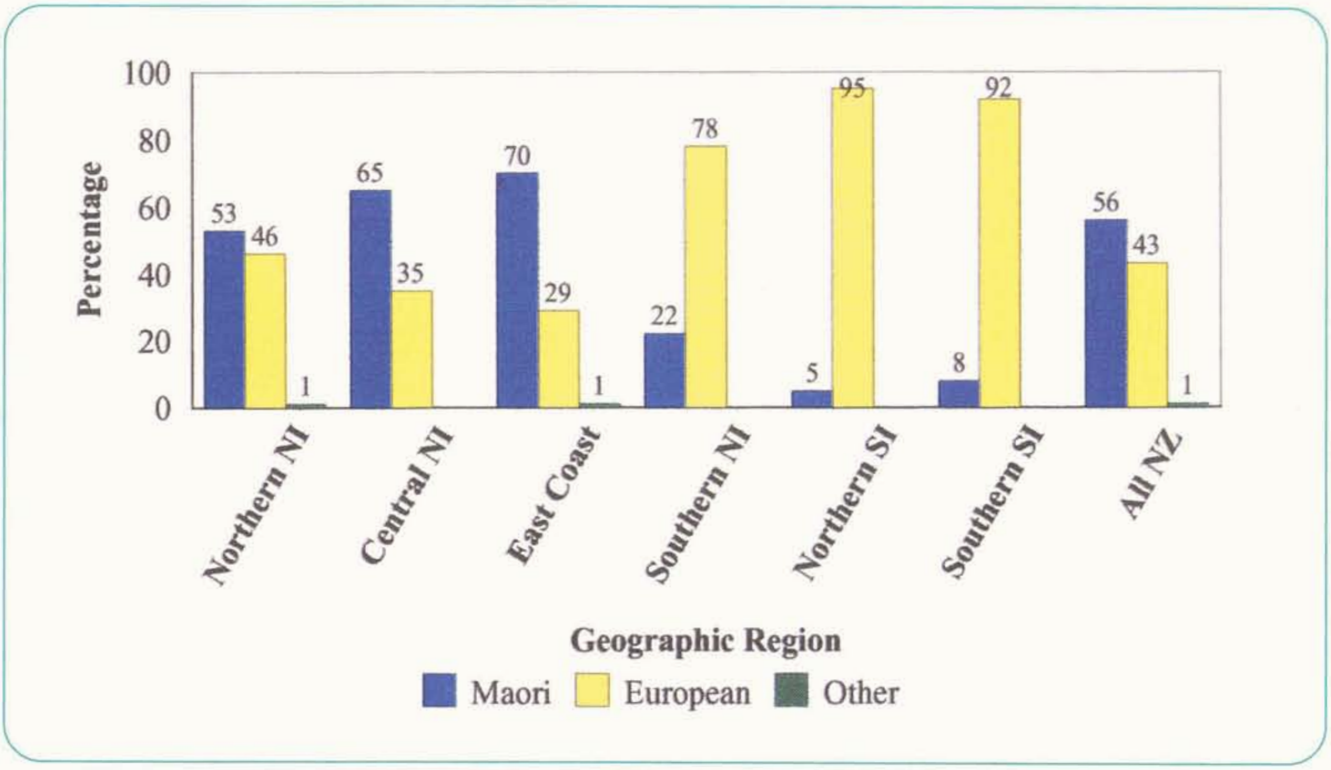

Figure 2 - Regional ethnic distribution

Prevalence of colour blindness

A total of 704 male forest workers were tested for colour deficiency. No females were present at the time of the researchers' visit. Overall, 3.8% of the forest workforce showed red-green colour blindness.

The percentage of people with colour blindness found in the New Zealand forest industry was lower than the 5 to 12% previously identified in overseas studies for the general male population. This New Zealand finding is lower than expected, given the extent of overseas research, but may not be lower than the general New Zealand male population. This finding may also indicate workers were self-selecting themselves.

Ethnicity and colour blindness

There were more European forest workers with colour blindness (5.3%) than Maori/European Maori (3%). Although there was a trend that Maori suffered less from colour blindness, this finding was not statistically significant. Previous research into colour blindness in different ethnic populations revealed lower incidences of colour blindness in Negro and Indian males (2 to 4%) and Chinese (5 to 7%), than was found in white males (8 to 9%). In this same study, Cook Island males showed zero colour blindness (Fisher and Simmons, 1980). However, another study of colour vision in Polynesian Tongans found colour blindness in 7.5% of the sample (Beaglehole, 1939).

Bornstein reported this phenomenon may be due to an increase in exposure to ultraviolet radiation which occurs at higher altitudes and closer to the equator. This increases the density of yellow pigmentation in the eye and decreases sensitivity to blue and green (in Fisher and Simmonds, 1980). The sample of forest workers in the present study contained 56% Maori/European Maori, and one percent Pacific Islander. This could have contributed to the finding that the overall prevalence of colour blindness in the New Zealand forest workforce was lower than that found in overseas research.

Recommendations

Paint Colours

Self reports of the colour blind individuals at the time of the study indicated the following paint colours were visible in all types of colour blindness. Therefore, these colours are recommended for use in the forest industry:

- Silver
- Blue
- Yellow
- Fluoro Orange

Purple was visible only to those with one type of red/green colour blindness (Protan type). In all types of colour blindness, red and green paints were the hardest colours to see in the forest environment. The problem was most apparent when red or green was viewed against a dark background, such as tree bark or the forest. In these situations, a colour blind worker had the most difficulty identifying red or green paint colours.

Helmet Colour

In almost all cases of identified colour blindness, the workers reported that they had difficulty identifying the fluorescent watermelon (pink) coloured helmets in the forest environment. Rather than being highly visible, they appeared dull to the colour blind individual. Conversely, fluorescent yellow and white helmets were the easiest to detect against a forest background (Figure 3).

Figure 3 - Fluorescent yellow was visible to colour blind forest workers; fluorescent pink (watermelon) was not.

High Visibility Colour

Fluorescent yellow high visibility markings against a black or blue background were self reported by colour blind workers as being most easily recognised (Figure 4). Research into the conspicuity of safety garments in road workers found fluorescent yellow and orange to be the two most conspicuous colours in four trials which also included fluorescent green, white, and blue (Isler et. al., 1997).

The brighter fluorescent yellow was more conspicuous against darker backgrounds, while fluorescent orange was more visible when seen against a brighter background. Fluorescent red was not recommended due to the inability of colour blind people to detect the colour. In another study of high visibility clothing in forest workers, fluorescent yellow was the most highly visible colour against the pine forest background (Bradford et. al, 1992).

A dramatic reduction in the number of "not seen" injuries reported to the forest industry Accident Reporting Scheme (ARS), was noted after the introduction of high visibility equipment (Sullman, Kirk and Parker, 1996). This indicates that visibility is a key safety issue in the forest industry. As a result, the effect of colour blindness needs to be specifically addressed in order to avoid lost time injuries in not seen accidents.

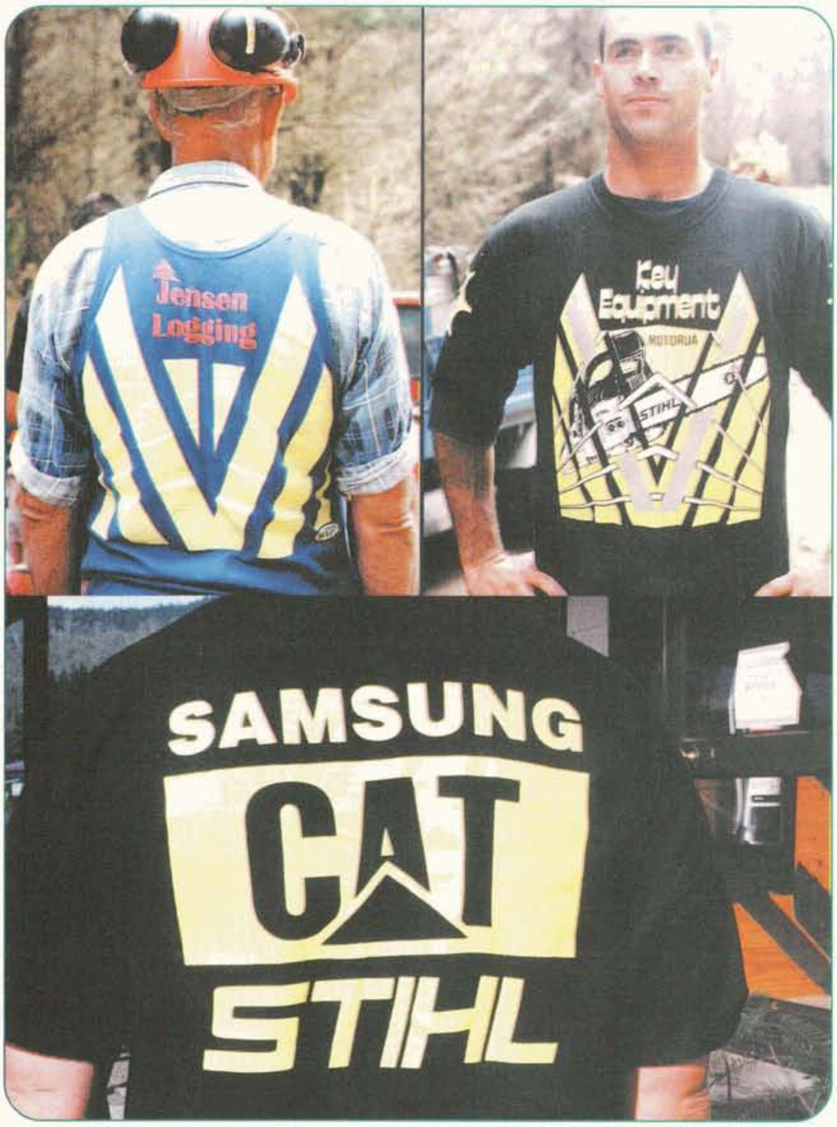

Figure 4 - Fluorescent yellow on a black or blue background was most easily seen by colour blind forest workers.

Summary

Results from this study show that the prevalence of colour blindness in male forest workers was lower than that shown in previous overseas studies. However, colour blindness still appears to be an important issue in the New Zealand forest industry, and should be taken into account when determining the recommended paint colours and high visibility colours. Anecdotal evidence from colour blind forest workers and data from the forest industry Accident Reporting Scheme (ARS) indicates that colour blindness can have an impact on the safety and profitability of a forest operation. It is also recommended that testing for colour blindness be part of a pre-employment medical. Once identified, colour blindness is easily managed in the forest environment by selecting colours which are clearly visible to all forest workers.

References

American Optometry Association (1997): Answers to questions about color deficiency. Http://www.aoanet.org/cvc-color-deficiency.htm

Beaglehole, E. (1939): Tongan colour vision. Man, Vol. 39, 170.

Birch, J. (1997): Efficiency of the Ishihara test for identifying red-green colour deficiency. Ophthalmic and Physiological Optics, Vol. 17 (5), 403-408.

Bradford, S., Isler, R., Kirk, P. and Parker, R. (1992): Conspicuous colours for logger's safety clothing. Liro Report Vol. 17, 11.

Bridger, R.S. (1995): *Introduction to ergonomics*. McGraw-Hill, Inc.

Byers, J. (1995): New Zealand Forest Owners' Association forestry workforce census 1994. Liro Project Report 57.

Fisher, C. J. and Simmonds, M. B. (1980): A note on the incidence of colourblindness on Cook Island males. New Zealand Psychologist, Vol. 9 (1), 34.

Hsia, Y. and Graham, C. H. (1997): Color Blindness. Readings on Color, Vol. 2:The science of color, 201-229. Cambridge, MA, USA: The Mit Press.

Hurley, S. (1994): Colour vision deficits and literary acquisition. Reading psychology, Vol. 15 (3), 155-163.

Ishihara, S. (1990): Ishihara's tests for colour blindness. 38 plates edition. Kanehara and Co., Ltd, Tokyo, Japan.

Isler, R. B., Parsonson, B. S., Connelly, M.L., (1997): Testing the relative conspicuity of road worker's safety garments. Transfund New Zealand Research Report No. 69.

Johnson, D. (1992): The Ishihara test: on the prevention of job discrimination. Journal of the American Optometric Association, Vol. 63 (5), 352-360.

Knowlton, M. and Woo, I. (1989): *Functional colour vision* deficits and performance of children on an educational task. Education of the visually handicapped, Vol. 20 (4), 156-162.

Mollon, J. (1986): Understanding colour vision. Nature, Vol. 321 (6065), 12-13.

Rollins-Hurley, S. (1994): Color vision deficits and literacy acquisition. Reading Psychology, Vol. 15 (3), 155-163.

Sullman, M., Kirk, P. and Parker, R., (1996): The accident reporting scheme: What happens to the data and why. Liro Report Vol. 21, No. 32.

Appendix 1

The "*ChromaGen*" lens is available as a soft contact lens or sunglasses, and is prescribed for either one or both eyes depending on the type and severity of the defect. The lenses use a carefully controlled filter which is hidden over the black pupil of the eye and allows through a specific wavelength of light. For many people with colour vision deficiencies this has produced a dramatic improvement in their perception of colours.

For additional information, contact the Australian distributor: Mr Cameron Graco, phone +61 9682 8646, fax +61 3958 08181, email:mbscolor@lexicon.net