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RELATIONSHIP BETWEEN TREE DENSITY AND VISIBILITY IMPROVEMENT FOR HIGHWAY SNOWBREAK WOODS

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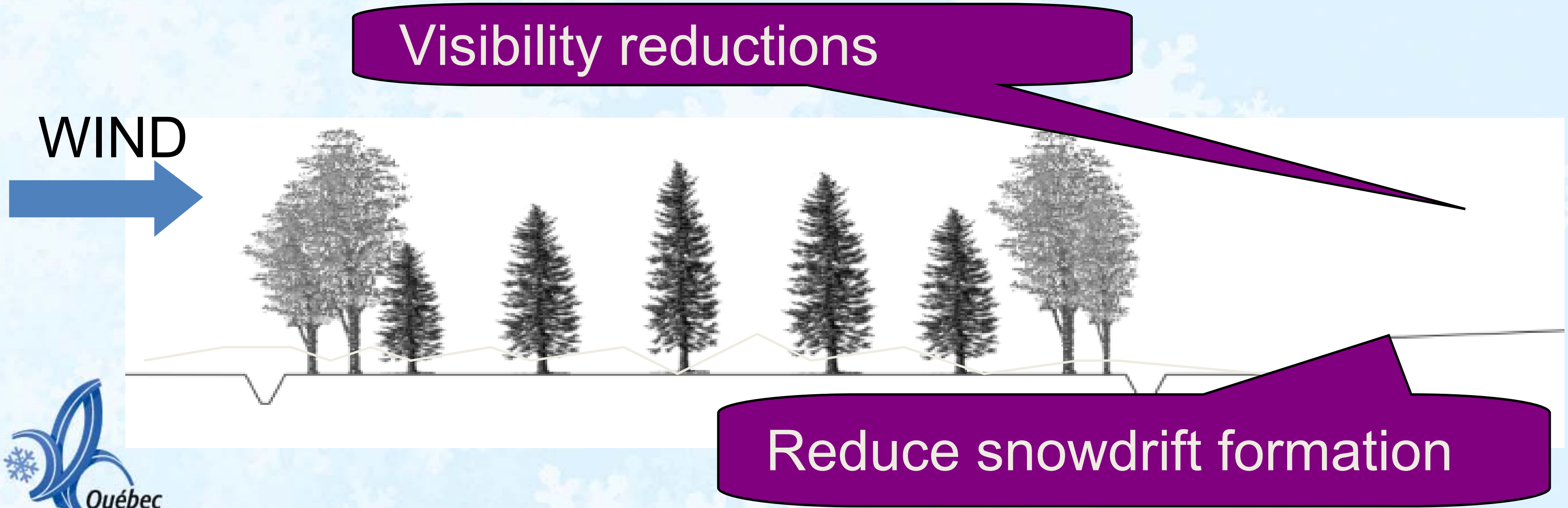
INTRODUCTION
-CHARACTERISTIC OF SNOWBREAK WOODS-

Highway snowbreak woods are formed by planting tree zones either on the side of highways, lowering the wind speed to reduce snowdrift formation and the visibility reductions caused by snowstorms.



INTRODUCTION
HISTORY OF SNOW BREAK WOODS IN JAPAN

1893- Planted on rail sides

wides : 32-96m

Aim: Reduce snowdrift formation

forestry enterprise
(Clearance of wood)

1978- Planted on highway sides

Wides : 10-30m

Aim: Visibility reductions

Reduce snowdrift formation

INTRODUCTION
- THINNING HAS BEEN DELAYED IN SNOWBREAK WOODS -

- In mature highway snowbreak woods, the branches of adjacent trees overlap, contributing to the death of lower branches.
- This allows snow particles to penetrate through the woods, whereby the woods become less effective at improving visibility on the highway.
- To keep lower braches from withering and dying, the planted trees need to be thinned.
- Due to such concerns, there are highway snowbreak woods where thinning has been delayed.

AIM OF THIS STUDY

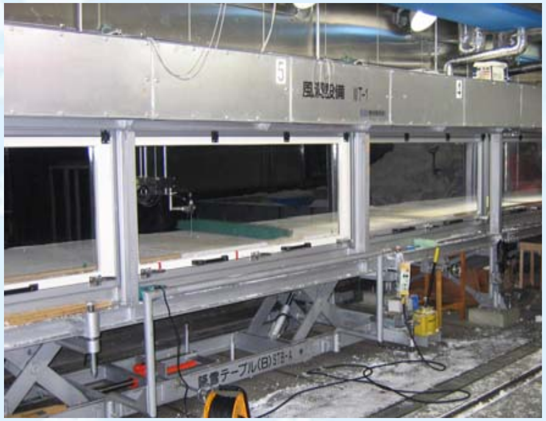
- To clarify the relationship between tree density and the visibility improvement afforded by highway snowbreak woods.

THE METHOD OF THE STUDY

field surveys

- Field surveys of visibility and other data were done for a highway snowbreak woods in Hokkaido, JAPAN.

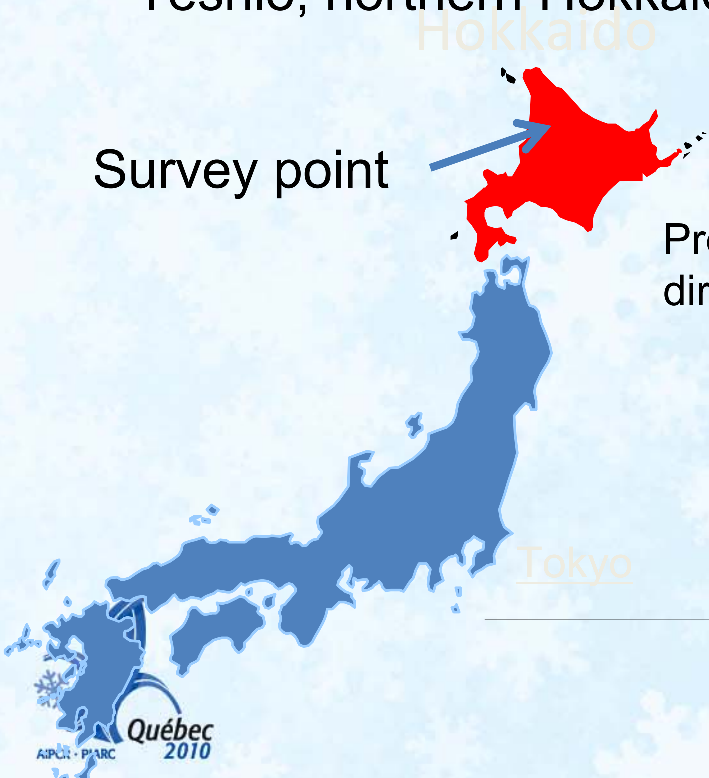
wind tunnel tests

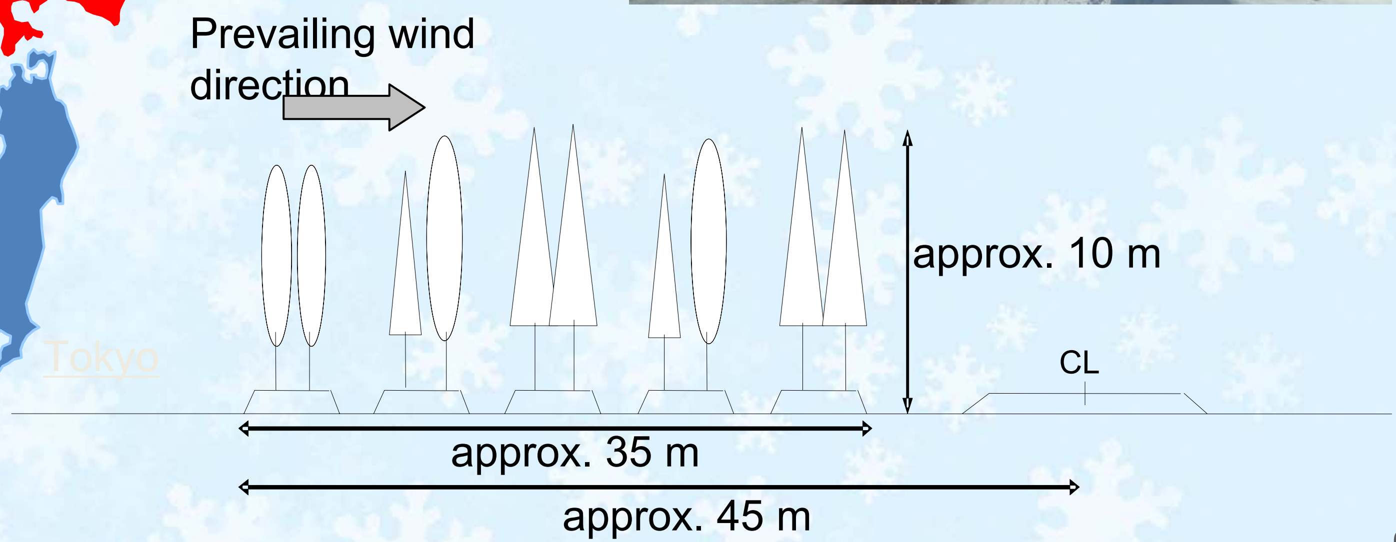


- At the Shinjo Branch of the Snow and Ice Research Center of the National Research Institute for Earth Science and Disaster Prevention

FIELD SURVEYS
- SURVEY LOCATIONS -

- Field surveys comparing the visibility improvement afforded by tree zones with differing tree densities were performed at a snowbreak woods on a national highway in the town of Teshio, northern Hokkaido.





FIELD SURVEY
- SURVEY LOCATIONS -

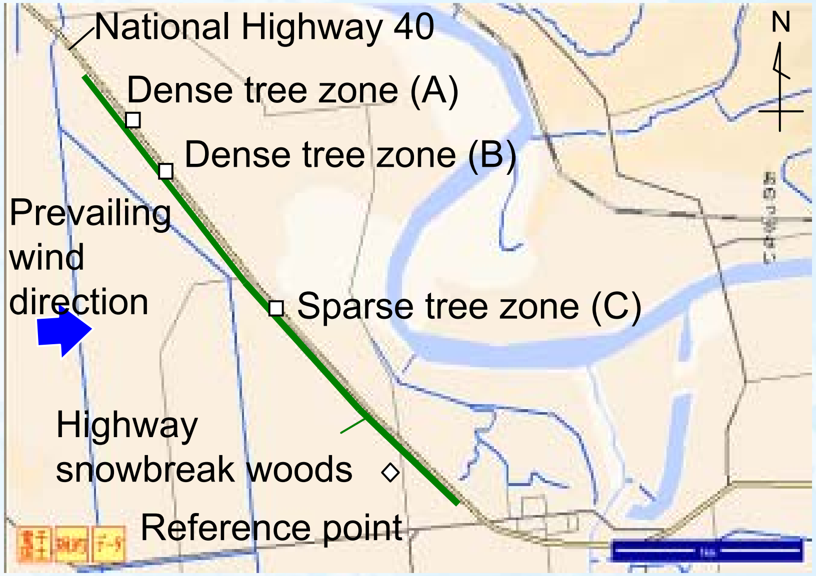


Figure - The survey locations

Tree zone A

Tree zone B

Tree zone C

Reference point

Table - Stand conditions for each survey location

	Planting year	Mean tree height (m)	**Tree density (trees/ha)**	Mean height of lowest branch (m)	Mean branch spread (m)	Mean conifer height (m)	**Mean leaf area index (LAI)**
Tree zone A	1987	6.1	**1733**	1.2	3.4	6.5	**1.2**
Tree zone B	1985	6.7	**1733**	1.3	3.9	7.4	**1.7**
Tree zone C	1982	7.3	**700**	1.4	4.7	8.5	**0.7**

FIELD SURVEYS
- SURVEY METHOD -

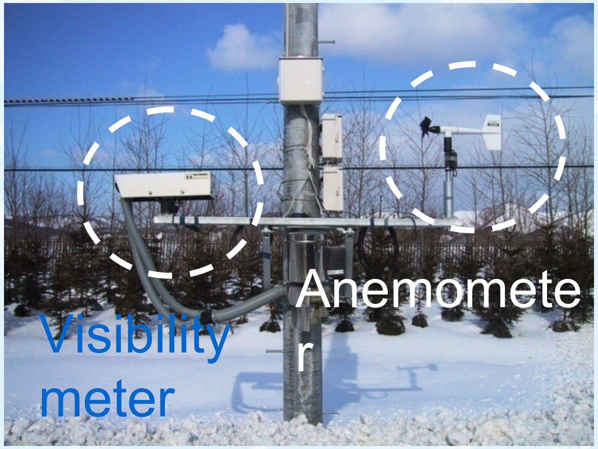
Duration: November 15, 2004 – March 14, 2005 (continuous observation)

Method: reflector-type visibility meters (TZE-4) and
propeller-type anemometers (KADEC21-C)
were placed 2.0 m above the ground at the reference point (the windward side of the forest) and on the roadside (in three sections).

Tree-size and other measurements were made in the forest.

Visibility: calculated using the equation below (taking the wind velocity into consideration).

$$\log(Vis) = -0.870 \log Vo - 0.773 \log V + 2.268$$



Extraction conditions: a temperature of 0°C or higher and a wind velocity of 5 m/s or higher at the reference point (i.e. the windward side of the forest)
← Conditions for the onset of a snowstorm

FIELD SURVEY RESULT
- VISIBILITY RATIOS WITH DIFFERENT DENSITIES -

- regardless of the angle of incidence, the visibility ratio was greater than 1 in all three tree zones.
- Visibilities for the survey points in the tree zones were higher than that for the reference point.
- The visibility improvement was greater in the dense tree zones (A and B) than in the sparse tree zone (C).
- Although zones A and B have equivalent tree density, zone B had a higher visibility ratio and a higher average leaf area index than zone A. This shows that tree density and leaf area index affect the visibility improvement.

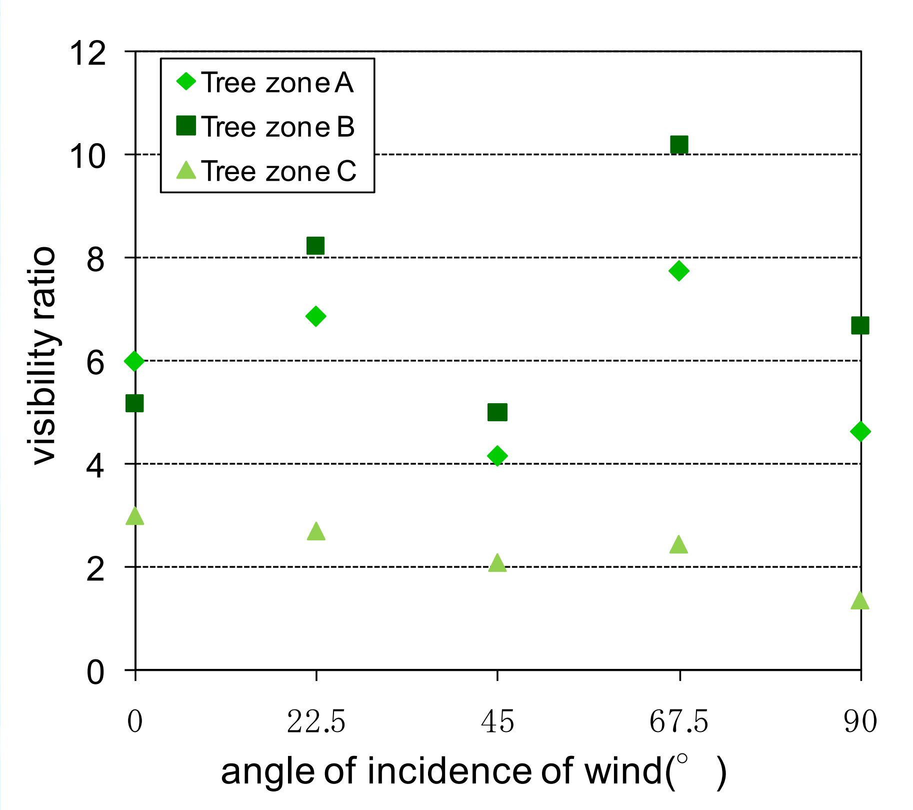


Figure - Visibility ratios of tree zones with different densities

WIND TUNNEL TESTS
- TEST METHOD -

The test was performed using a sealed circulating, low-temperature wind tunnel system at the Shinjo Branch of the Snow and Ice Research Center of the National Research Institute for Earth Science and Disaster Prevention

Upstream end of the survey section of wind tunnel system

WIND TUNNEL TESTS
- MODELS-

The models were prepared by modelling one of the dense tree zones (B) and the sparse tree zone (tree zone C) from the observation data,
and by forming 10 patterns considering thinning according to maturity .
They were modelled to a scale of 1/100.

Table - Model wood materials

Item		Material and product number
Tree (conifer)	Leaf	Moltofilter (INOAC, MF-8)
	Trunk	Hardened stainless steel rods
Tree (deciduous broad-leaf)		Galvanized soft wire (0.28 mm

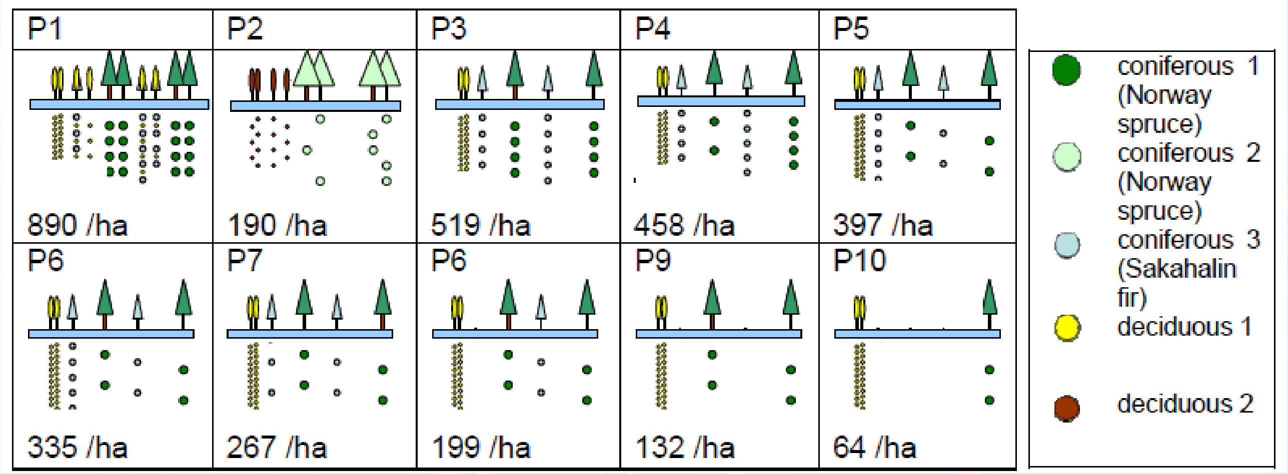


Figure - Arrangement of test patterns

WIND TUNNEL TESTS RESULTS
- CORRECTING RATIO OF MASS FLUX OF SNOW -

- The snowbreak woods effectiveness was assessed using the ratio of mass flux of snow (*RMf*).
- This is the ratio of the mass flux of snow at the survey point to the mass flux of snow at a distant point.
- First, the mass flux of snow in the wind tunnel test *(RMfe)* and the mass flux of snow in the field survey (*RMfo)* were compared, verifying the reproducibility of the scaled-down model.
- a proportional relationship was hypothesized, and Equation was obtained.

$$RMf_o = 1.68\ Rmf_e \quad . \ . \ . \ . \ . \ (1)$$

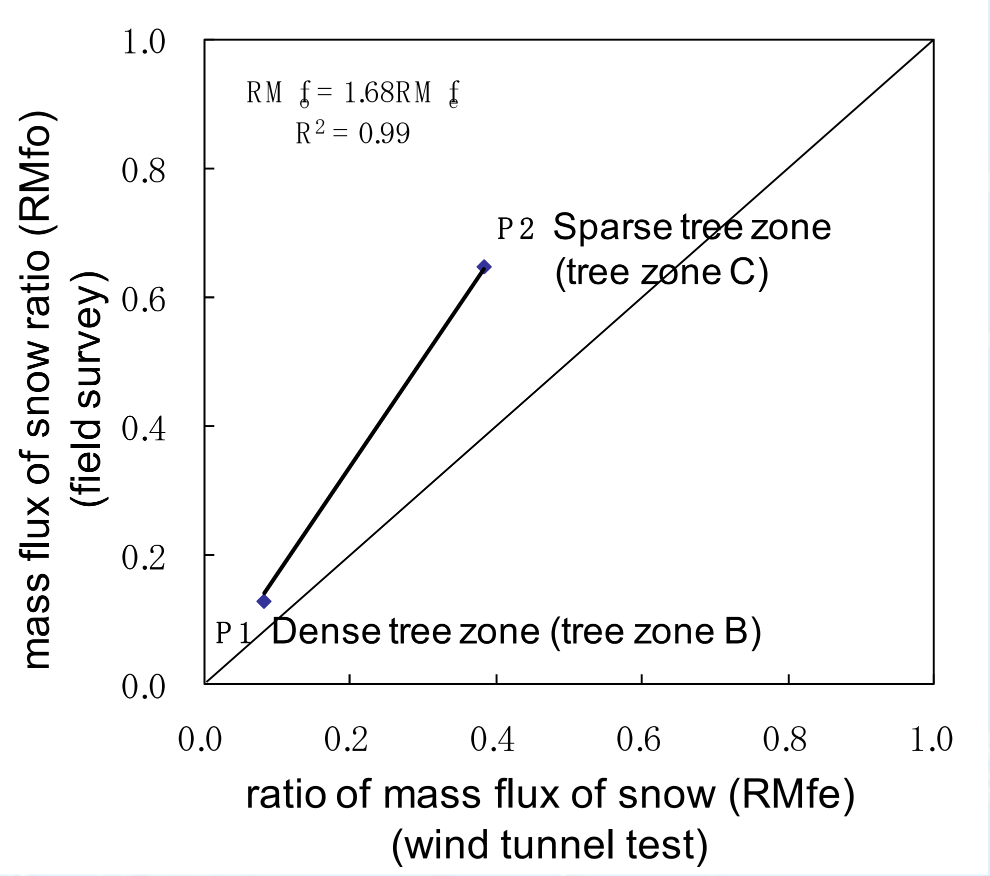


Figure - Relationship of ratios of mass flux of snow in the wind tunnel test to that in the field survey

WIND TUNNEL TESTS RESULTS - RELATIONSHIP BETWEEN TREE DENSITY AND RATIO OF MASS FLUX OF SNOW -

- *RMfo'* is a theoretical value of the ratio of mass flux of snow of the field survey, by solving Equation (1).
- This figure shows that *RMfo* near the road increases as ρ_t decreases. From P1 to P6, the increase in *RMfo'* is small, but then it increases remarkably beginning at P7.
- From This figure, the relationship between *RMfo'* and ρ_t was approximated by a secondary regression equation, obtaining Equation (2).

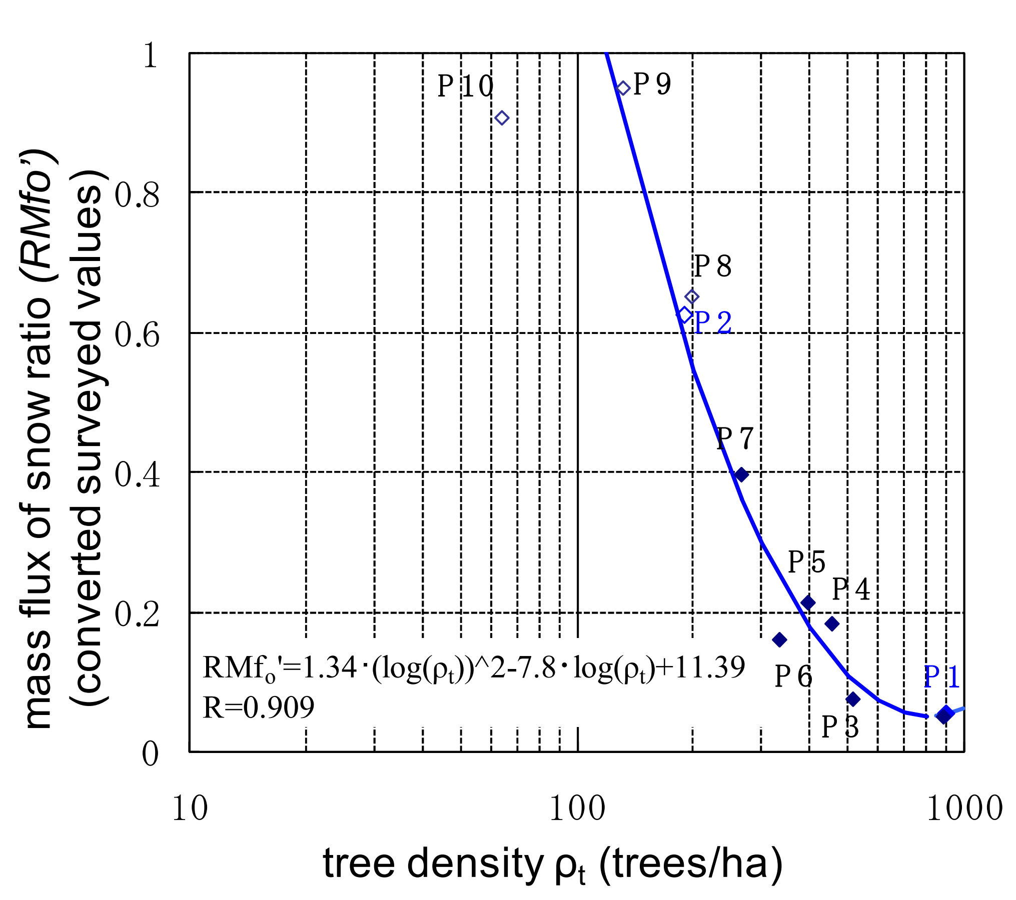


Figure - Relationship between tree density and ratio of mass flux of snow

- $RMf_o' = 1.34 \cdot \log^2 \rho_t - 7.80 \cdot \log \rho_t + 11.39 \cdots\cdots (2)$

WIND TUNNEL TESTS RESULTS
- ELATIONSHIP BETWEEN TREE DENSITY AND VISIBILITY IMPROVEMENT-

- Figure shows that the visibility improvement differs according to ρ_t.
- When visibility at the upwind side of a snowbreak woods is less than 50 m (Vis_w <50 m), driving is extremely difficult (Kajiya et al.).
- However, if the tree density of the snowbreak woods exceeds 400 trees/ha (ρ_t >400 trees/ha), then the visibility on the road improves to 200 m (Vis_r >200 m). Visibility of 200 m on the road allows normal driving.
- Therefore, the ρ_t that can maintain visibility sufficient for normal driving is about 400 trees/ha.

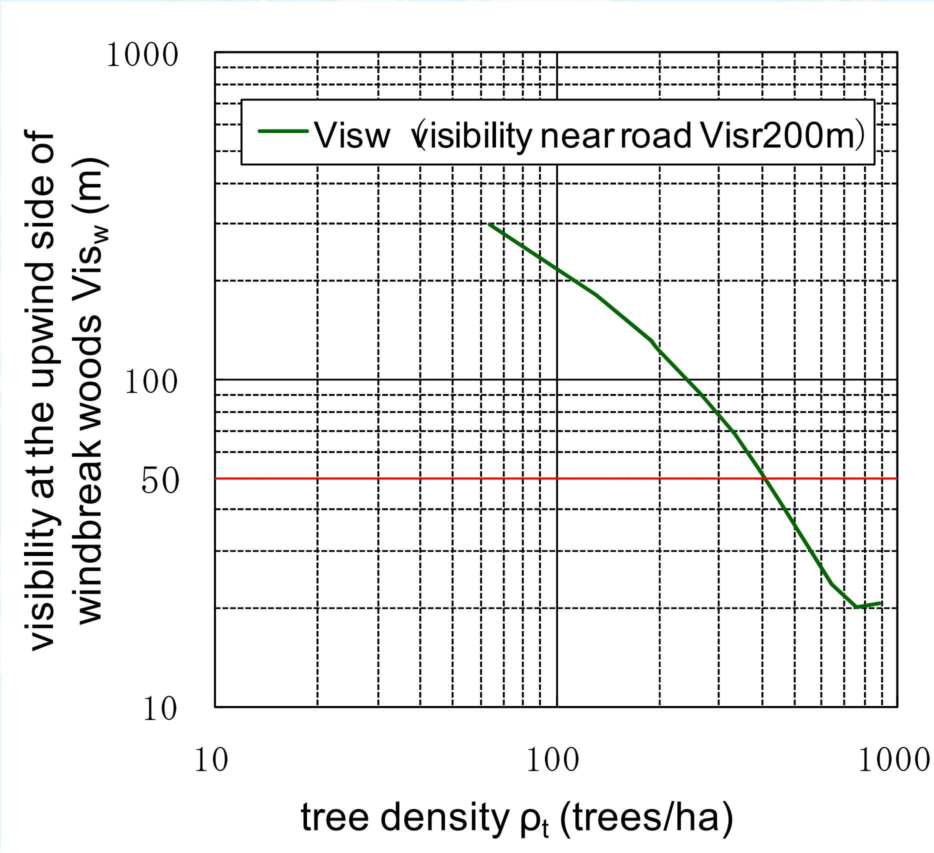


Figure - Tree densities that achieve visibility of 200 m on the road

SUMMARY

In the field survey, the following results were obtained.

1. Highway snowbreak woods improve visibility under snowstorm conditions.
2. The tree density of a snowbreak woods greatly influences the visibility improvement afforded by the woods.
3. Leaf-area index influences visibility improvement.

In wind tunnel testing, the following results were obtained.

1. When the visibility on the upwind side of a 32-m-wide snowbreak woods is less than 50 m, in order to maintain a visibility of 200 m on the road, the tree density the woods should to be at least 400 trees/ha.

ACKNOWLEDGMENTS

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THANK YOU FOR YOUR KIND ATTENTION