Effects of Different Levels of Canopy Tree Retention on Stocking and Yield of Understory Cohort in the Southern Interior of BC

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Outline

I. Objectives

II. Background

➢ Reported impacts of retained trees (RTs) on yield of understory cohort

III. Estimating impacts of RTs in the Southern Interior of BC

- Objectives
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- Results
- Summary and recommendation

I. Objectives

1. Review the impacts of retained trees on regeneration stocking and yield of understory cohort

2. Quantify the effects of different levels of tree retention on stocking and yield (volume at rotation) of understory cohort in dispersed retention strategy

*3. Develop yield curves and sampling protocols for two-storied stands

II. Background

Variable-retention has become a prominent silvicultural strategy to meet multiple resource management objectives.

Under this strategy, retained trees:

- contribute to structural complexity of subsequent stands
- provide habitat for wildlife, shelter for regeneration and understory vegetation
- promote long-term ecological productivity and biodiversity, etc.

However, recent studies have shown that RTs reduce growth, yield, and value of understory cohorts (Birch and Johnson 1992, Long and Roberts 1992, Hansen et al. 1995, Rose and Muir 1997, Acker et al. 1998, Zenner et al. 1998).

Reduction in yield can be due to:

1. withdrawal of retained area from future timber production and effects of RTs on stocking (% occupancy)

2. competitive influence (e.g., shading) of RTs

Impact of RTs on yield

Varies by:

- spatial pattern of retention
  - dispersed/group/mixed
- edge length and area occupied by RTs
- species composition

Impact of RTs on yield (cont'd)

Varies by:

- attributes of retained trees:
  - size and vigor - size of crown and rate of crown expansion
  - level and duration of retention
  - other factors (e.g., site quality, slope etc)

Impacts of RTs on yield (cont'd)

Methods used to quantify impacts of RTs include:

1. Retrospective studies – paired plots studies (Acker *et al.*1998, Zenner *et al*. 1998)

2. Model extrapolation (Birch & *Johnson* 1992) and simulation techniques (Hansen *et al*. 1995)

Impacts of RTs are reported in terms of effects on:

- Individual tree attributes (e.g., Hansen *et al*. 1995, Wampler 1993)
- Basal area and volume/ha (e.g., Zenner *et al*. 1998, Rose & Muir 1997)
- Mean annual increment (e.g., Acker *et al*. 1998, Birch & Johnson 1992)
- Harvest value (e.g., Hansen *et al*. 1995)
- Stocking (e.g., Kobe and Coates 1996)

Compared to clear cut scenarios, impacts of RTs on yield of understory cohort varied from 5 to 45%

Yield impacts by attributes
% reduction compared to clear cut scenarios

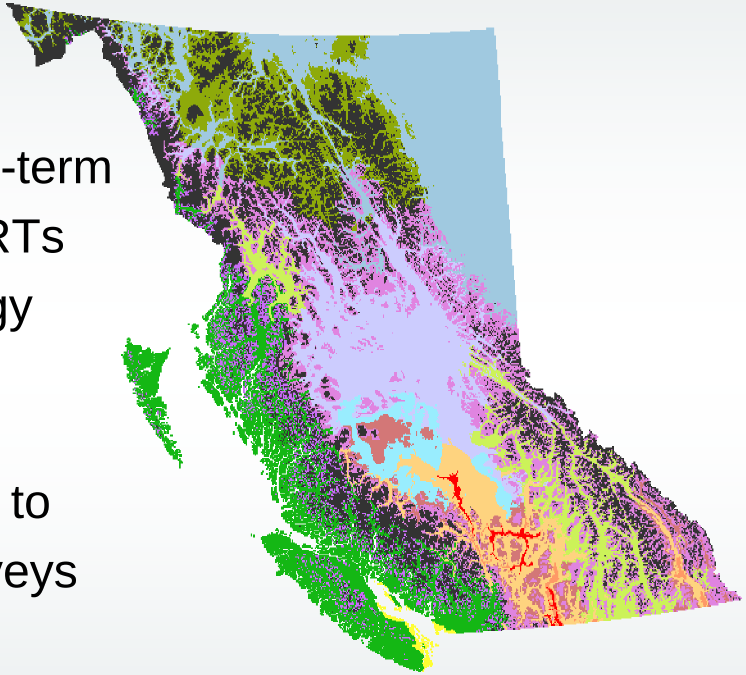
Attribute/Source	% reduction	Comment
Height and diameter		
Hansen *et al*. (1995)	5	Yield loss even at 5 RTs/ha
Wampler (1993)	20	Fir planted under RTs
Basal area		
Rose and Muir (1997)	15	15 RTs/ha
Hansen *et al*. (1995)	18 to 39	5 to 30 RTs/ha
Total Volume		
Long and Roberts (1992)	25 to 35	12 to 86 RTs/ha
Zenner *et al*. (1998)	23 to 45	5 to 50 RTs/ha

III. Simulation study
Background

- The Forest Practices Code of BC (FPC) requires that RTs be an integral part of a silvicultural prescription

- In the southern interior of BC, no large-scale, long-term experiment or data exit to quantify the impacts of RTs on stocking and yield in dispersed retention strategy

- A results-based FPC pilot project was established to evaluate silvicultural performance using stand surveys 10-years after stand development and target merchantable volume 80-years after harvest



III. Simulation study
Objectives

To quantify the impacts of RTs on:

1. regeneration stocking after 10-years of stand development

2. understory yield after 80-years of growth

To adjust yield to reflect impacts of RTs for timber supply projections of two-storied stands

Methods
Metadata

- The Tree and Stand Simulator* (TASS, Mitchell 1975) individual tree growth and yield model was used to simulate 268 pure pine and interior spruce stands with varying establishment densities, spatial distributions, and levels of retention.

Attribute	Levels
Planting density (no/ha)	0, 600, 1200
Natural regen. (no/ha)	0, 600, 1200, 3000, 4000
Spatial distribution of naturals	Random, Clumped
No. of RTs/ha	0, 12, 48, 96, and 144
Pattern of RTs	Random

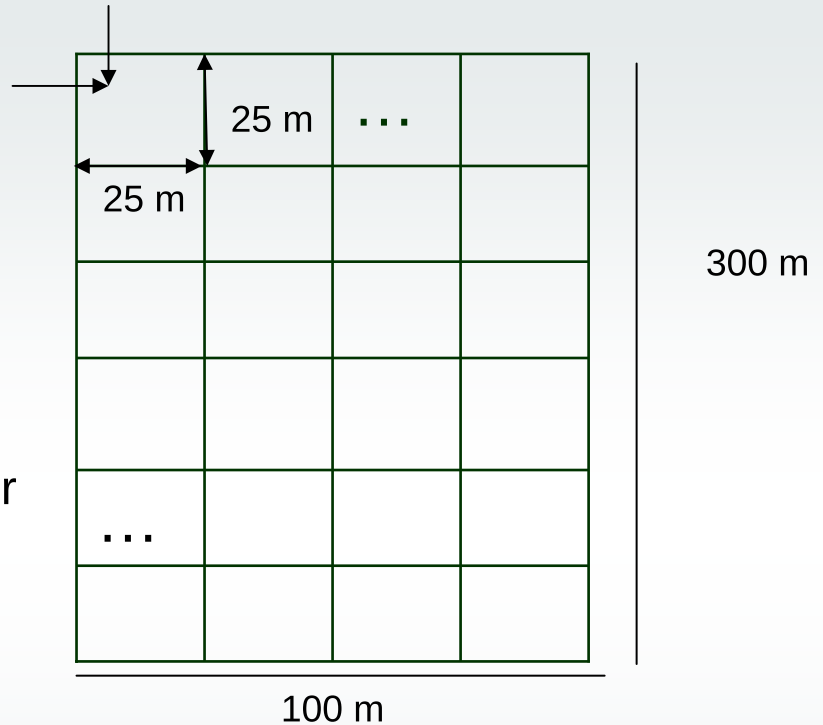
All possible combinations of the factors were not simulated. [SI=20 m]

Methods

- *TASS is spatially-explicit and generates stem map data. Each TASS simulation was conducted for a 3 ha (300m*100m) area

- In each simulated stand, 50 m^2 (3.99 m radius) plots were established on randomly oriented 25 m grid, resulting in ~ 48 plots for each survey

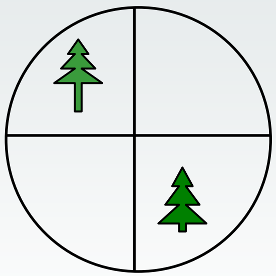
- For each of the 268 stands, 30 surveys were simulated 10-year after harvest, resulting in 8040 simulated surveys



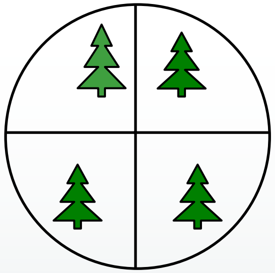
[Not to scale]

Methods (cont'd)
Stand survey

- Each 50 m^2 circular plot was split into quadrants along the north-south and east-west axes.



- In each quadrant, species and height of each tree were recorded, and a quadrant was classified as stocked (if it contains at least one healthy free-growing tree) or not stocked



- For each plot, the number of stocked quadrant was counted [0, 1, 2,3,4]

Methods (cont'd)
Stand survey

- For each survey, mean number of stocked quadrant was calculated from ~ 48 plots

- Subsequently, each stand was grown for 80- years using TASS

- Mean number of stocked quadrant values were related to merchantable volume 80-years after harvest

Summary of Attributes for overstory and understory trees at start and end of simulation [n=134 pine stands]

Attribute	Overstory at start	Overstory after 80-years	Understory after 80-years
# of tree/ha	12 -144	12 -144	189-1351
Basal area (m^2/ha)	1.1-14	1.4-16.3	9.8-47.1
Merch. volume (m^3/ha)	8-110	11-139	67-340
Average height (m)	22.2-23.6	24.4-25.9	17.2-19.3
Diameter (cm)	32.6-36.3	35.9-39.2	18.4-28.4
Crown width (m)	5.3-6.0	5.5-6.1	2.5-4.6

Similar ranges were observed for interior spruce

Mean stocked quadrant by levels of retention
Pine stands

- For both pine and spruce, mean number of stocked quadrant (MSQ) decreased with increasing number and basal area of RTs

No. RTs (no./ha)	No. of stands	MSQ±SD pine	MSQ±SD spruce
0	26	3.68±0.39	3.68±0.40
12	27	3.58±0.63	3.66±0.41
48	27	3.57±0.61	3.44±0.71
96	27	3.55±0.58	3.43±0.64
144	27	3.52±0.55	3.41±0.62

Basal area class (m^2/ha)	No. of stands	MSQ±SD pine	MSQ±SD spruce
2	53	3.63±0.52	3.67±0.40
6	27	3.57±0.61	3.46±0.71
10	27	3.55±0.58	3.45±0.66
12+	27	3.52±0.55	3.44±0.61

Mean stocked quadrant by establishment density Pine stands

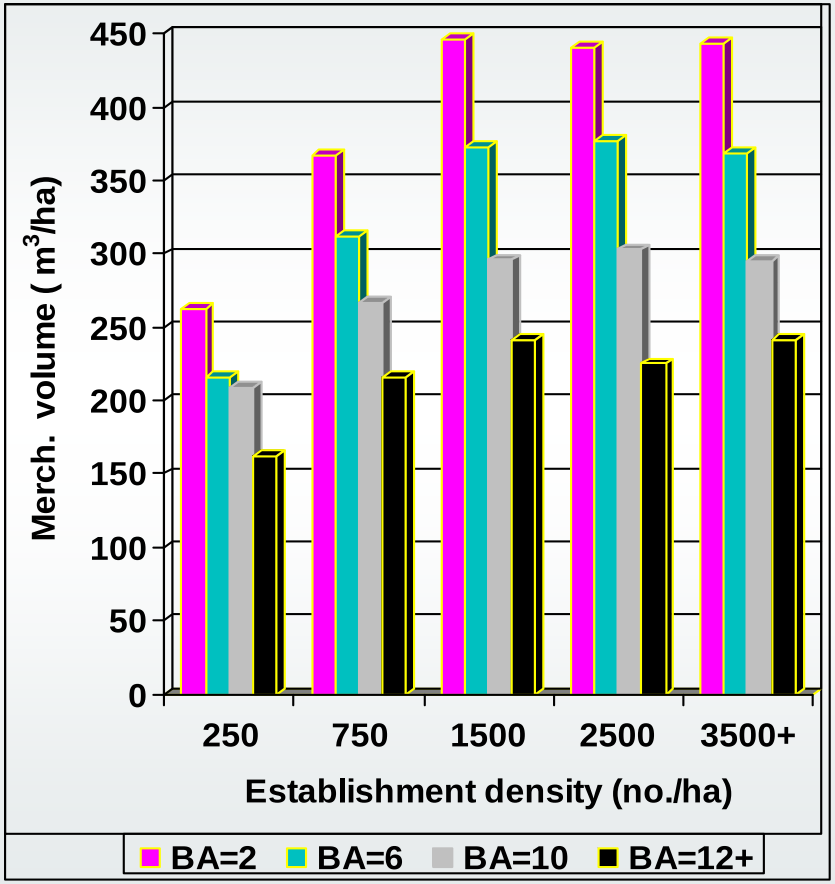
- As expected, mean number of stocked quadrant (MSQ) increased with increasing establishment density

Establishment density (no./ha)	No. of stands	MSQ±SD Pine	MSQ±SD Spruce
250	18	2.47±0.77	2.41±0.80
750	24	3.48±0.30	3.41±0.29
1500	36	3.80±0.07	3.69±0.48
2500	22	3.84±0.04	3.81±0.04
3500+	34	3.85±0.02	3.84±0.03

Merch. volume 80-years after harvest over establishment density

- At each level of establishment density, merchantable volume 80-years after harvest decreased with increasing basal area of RTs, indicating the effects of RTs on understory yield

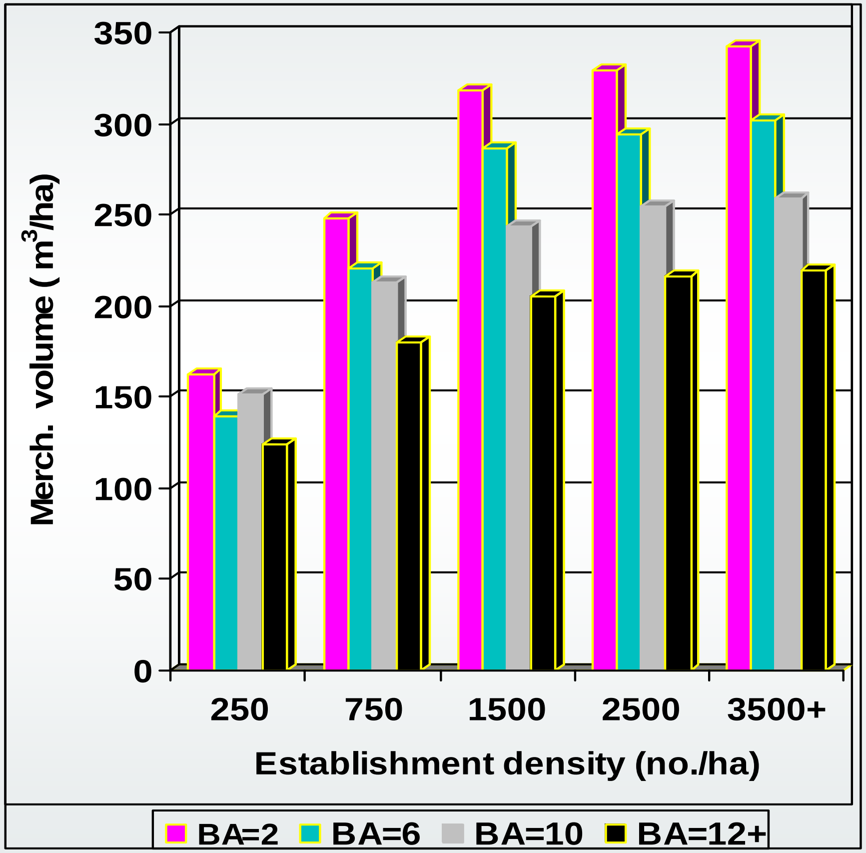
Spruce



Merch. volume 80-years after harvest over establishment density

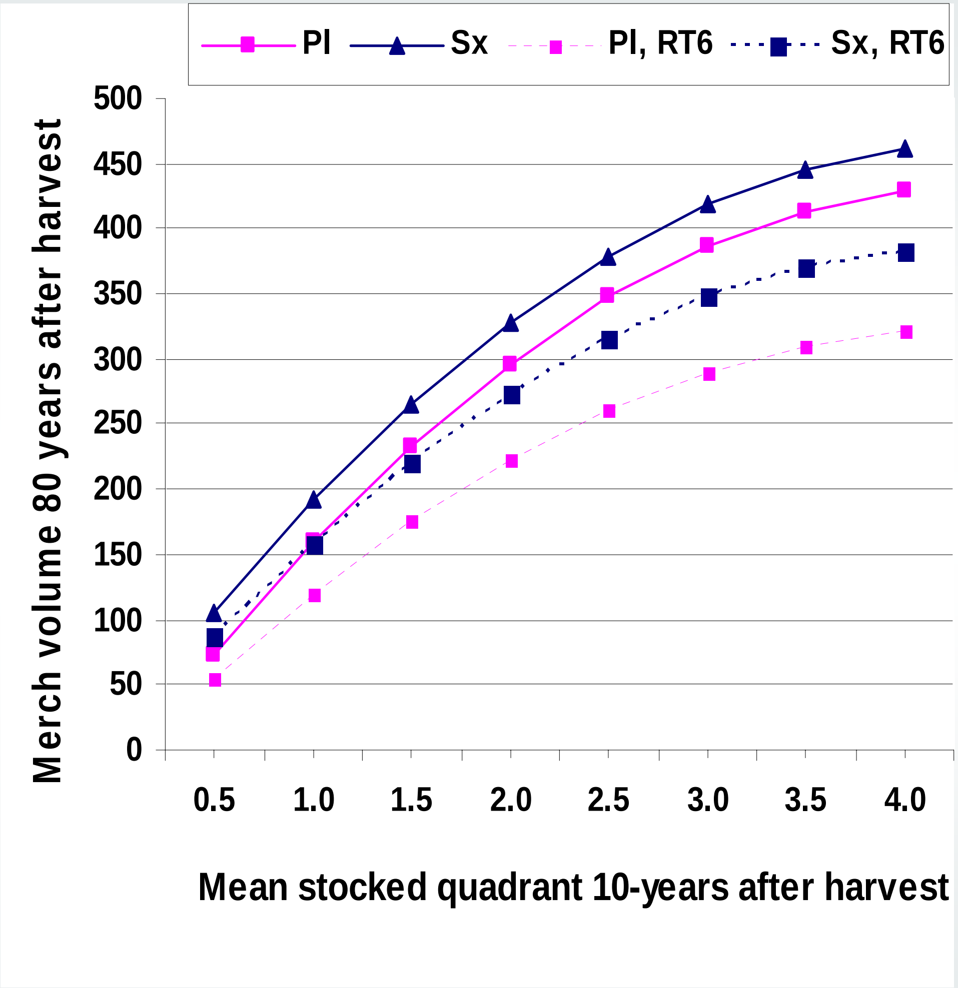
- For establishment density >250 trees/ha, merchantable volume 80-years after harvest decreased with increasing basal area of RTs, indicating the effects of RTs on understory yield

Pine



Merch Volume 80-year after harvest under clear cut scenarios (solid lines) and at 6m^2/ha BA retention

- At each level of retention, merchantable volume 80-years after harvest increased with increasing MSQ, indicating the effects of stocking on understory yield



Impacts of RTs on understory yield 80-years after harvest by BA retention

- Ratio of merch. volume under RTs and clear cut scenarios
- Yield in regeneration layer was reduced by 8 to 42%, varying by the level of retention

Species	Retained basal area/ha (m^2/ha)						
	0	2	4	6	8	10	12
Pine	1	0.92	0.83	0.75	0.66	0.60	0.58
Spruce	1	0.94	0.89	0.83	0.78	0.72	0.68

Note: merch. Volume of RTs was not included in the analysis

Results Summary

- Merchantable volume 80-years after harvest increased with increasing MSQ and decreasing level of retention

- Compared to clear cut scenarios, retained trees reduced regeneration stocking by 0.27 to 6.52% on a stocked quadrant basis

- Depending on the level of retention (2 to 12 m^2/ha), RTs reduced the final yield of understory cohort by 8 to 42%

- Negative correlations were observed between average crown width of RTs and merch. volume 80-years after harvest

Recommendations

- To obtain actual impacts of RTs on growth and yield of understory cohort, large-scale and long-term experiments are required
- Impacts of RTs on tree species composition of future forest should be examined

References

Acker, S.A., E.K. Zenner, and W.H. Emmingham. 1998. Structure and yield of two-aged stands on the Willamette National Forest, Oregon: implications for green tree retention. Can. J. For. Res. 28: 749-758.

Andreassen, K. 1994. Development and yield in selection forest. Medd. Skogforsk 47(5): 1-37.

Assmann, E. 1970. The Principles of Forest Yield Studies. Pergamon Press. Oxford, 506 pp.

Birch, K.R. and K.N. Johnson. 1992. Stand-level wood production costs of leaving live, mature trees at regeneration harvest in coastal Douglas-fir stands. West. J. Appl. For. 7:65-68.

Hansen, A.J., S.L. Garman, J.F. Weigand, D.L. Urban, W.C. McComb, and M.G. Raphael. 1995. Alternative silvicultural regimes in the Pacific Northwest simulations of ecological and economic effects. Ecol. Appl. 5: 535-554.

Kobe, R., and Coates, D. 1996. Models of sapling mortality as a function of growth to characterize interspecific variation in shade tolerance of eight tree species of northwestern British Columbia. Can. J. For. Res. 27: 227–236.

Long, J.N. and S.D. Roberts. 1992. Growth and yield implications of a “New Forestry” silvicultural system. West. J. Appl. For. 7: 6-9.

Mitchell, K.J. 1975. Dynamics and simulated yield of Douglas-fir. For. Sci. Monogr. 17. 39 pp.

Rose, C.R. and P.S. Muir. 1997. Green tree retention: consequences for timber production in forests of the Western Cascade Oregon. Ecol. Appl. 7: 209-217.

Wampler, M. 1993. Growth of Douglas-fir under partial overstory retention. M.Sc. Thesis. U.W. College of Forest Resources. 97 pp.

Zenner, E.K., S.A. Acker, and W.H. Emmingham. 1998. Growth reduction in harvest-age, coniferous forests with residual trees in the west central Cascade Range of Oregon. For. Ecol. & Mgmt. 102: 75-88.

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