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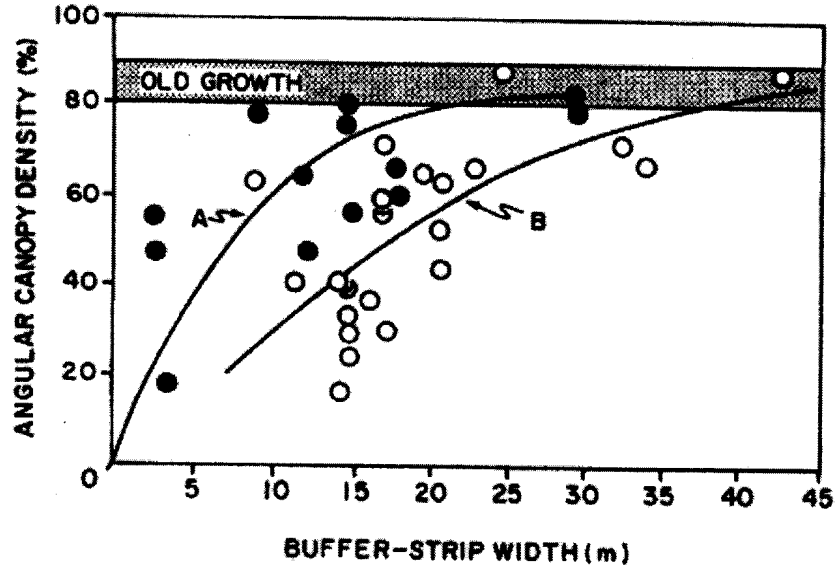

Figure 8. Relation between angular canopy density (ACD) and bufferstrip width in western Oregon. Data for (A) from Brazier and Brown (1973); data for (B) from Steinblums et al. (1984).

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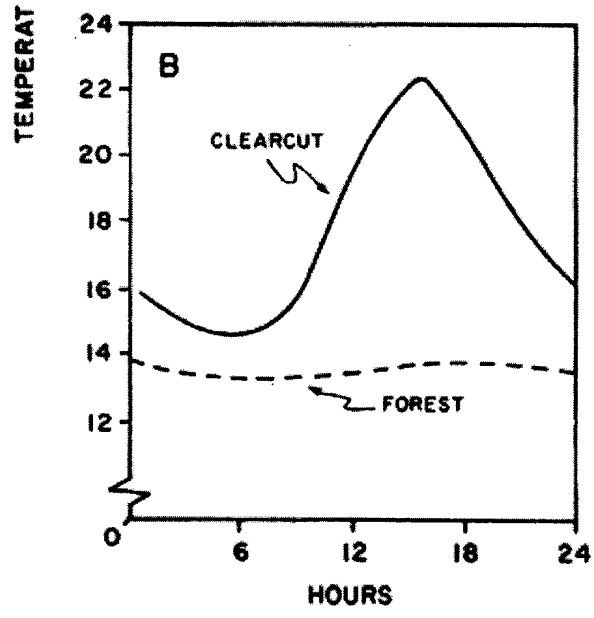

Figure 7. Summertime stream temperatures during clear weather in (A) West Virginia (from Lee 1980), and (B) Coast Range of Oregon (from Brown and Krygier 1967).

Beschta et al. (1987)

Table 2. Summary of summer temperature changes associated with forest management activities on forest watersheds, Pacific Northwest.

Location	Treatment	Stream Temperature Variables	Temperature Change (°C)	Reference
Alaska (Southeast)	Clearcut and natural openings	Δ Temperature per 100 m of channel	0.1 to 1.1°C/100 m Average = 0.7°C/100 m	Meehan (1970)
British Columbia (Vancouver Island)	Logged (Tributary H)	Average June-August diurnal temperature range	0.5° to 1.8°C increase over pre-treatment levels	Holtby and Newcombe (1982)
	Logged and burned (Tributary J)	Average June-August diurnal temperature range	0.7° to 3.2°C increase over pre-treatment levels	Holtby and Newcombe (1982)
Oregon (Cascades)	Clearcut	Average June-August maximum	4.4 to 6.7°C	Levno and Rothacher (1967)
	Clearcut and burning	Average June-August maximum	6.7 to 7.8°C	Levno and Rothacher (1969)
Oregon (Coast Range)	Clearcut	Average July-Sept. maximum	2.8 to 7.8°C	Brown and Krygier (1967)
	Clearcut and burning	Average July-August maximum	9 to 10°C	Brown and Krygier (1970)
Oregon (Cascades)	Mixed clearcut and forested reaches	Δ Temperature per 100 m of channel	0 to 0.7°C/100 m	Brown et al. (1971)
	Tractor striped area	Δ Temperature per 100 m of channel	15.8°C/100 m	Brown et al. (1971)

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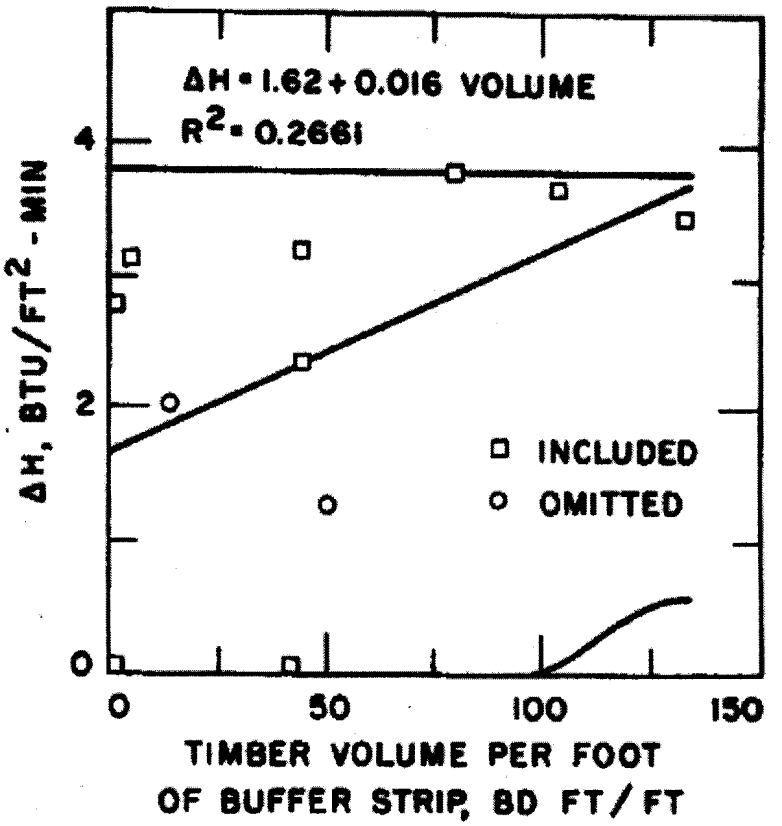


Figure 2. The observed relation between buffer strip volume and heat blocked (ΔH).

2.

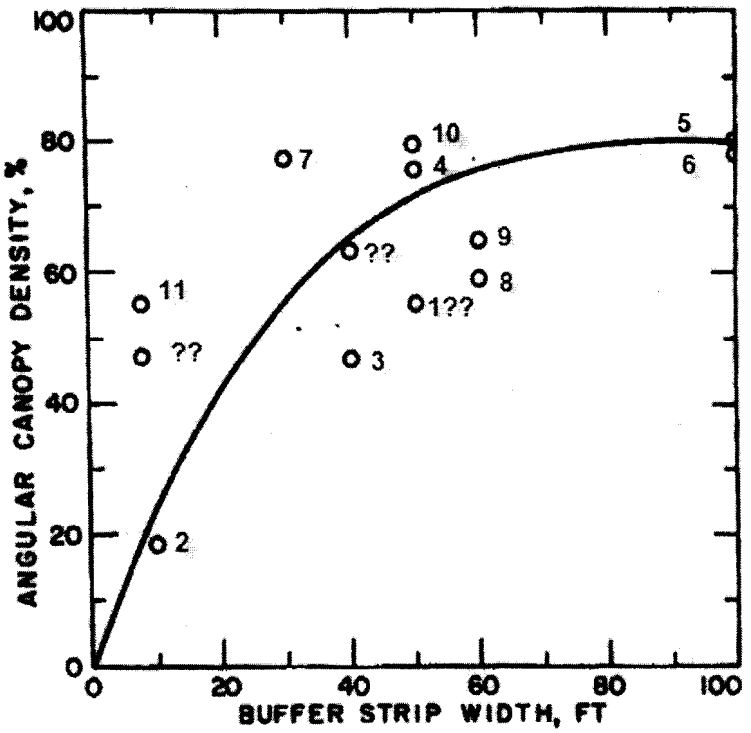
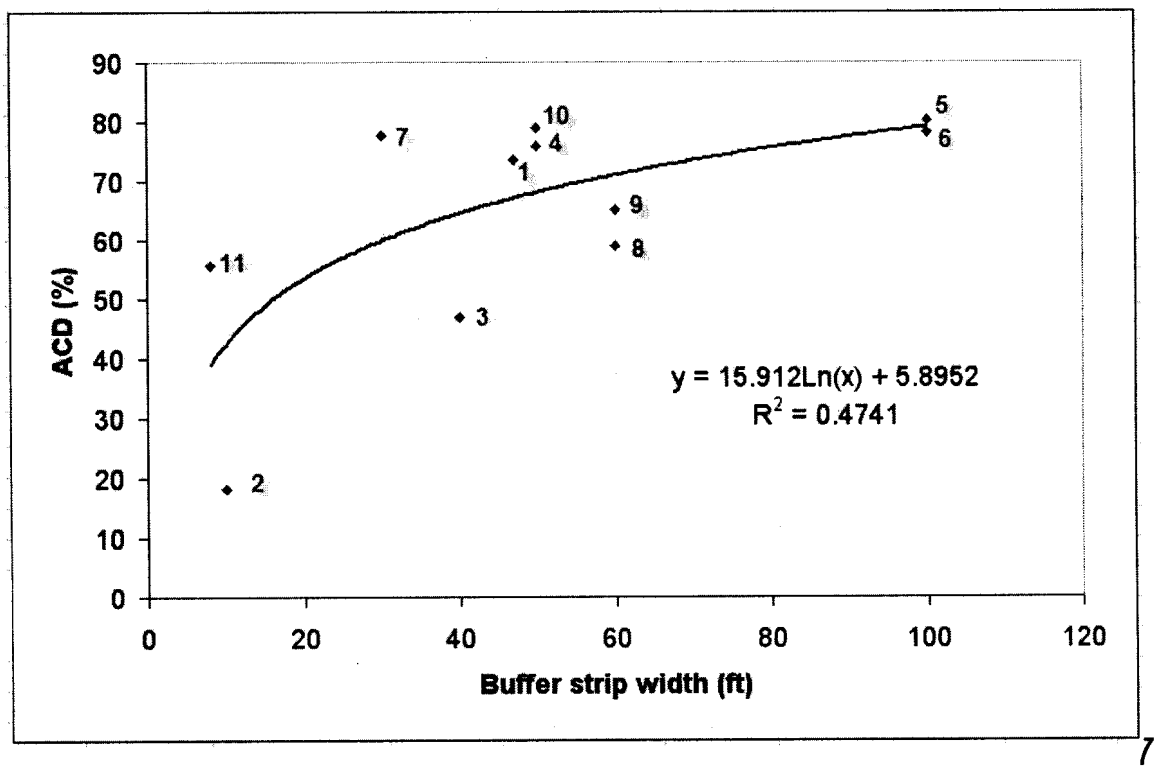


Figure 5. The relation between buffer strip width and angular canopy density.

3.



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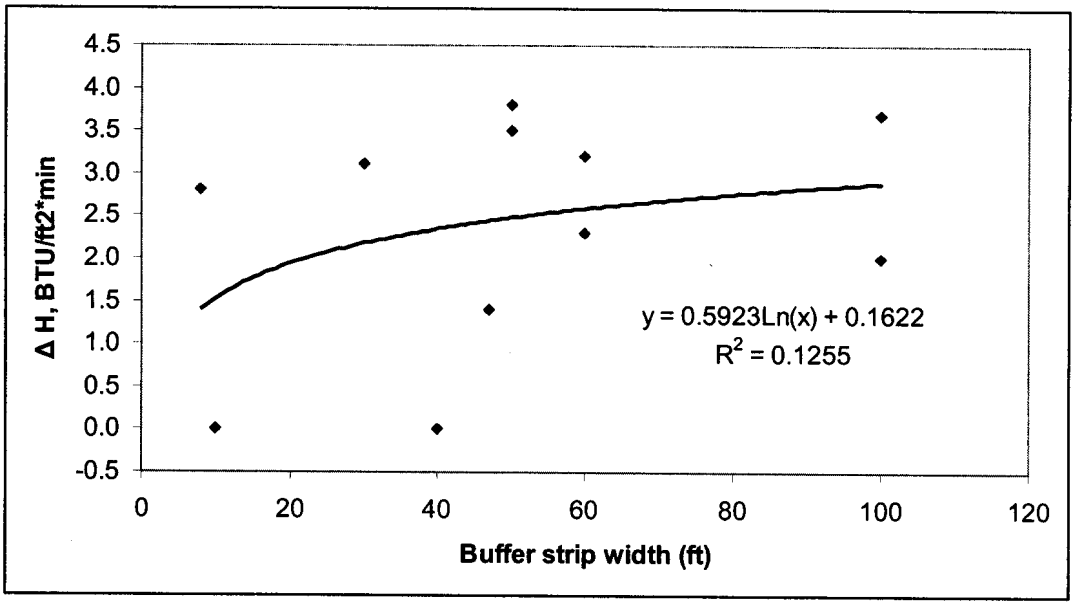
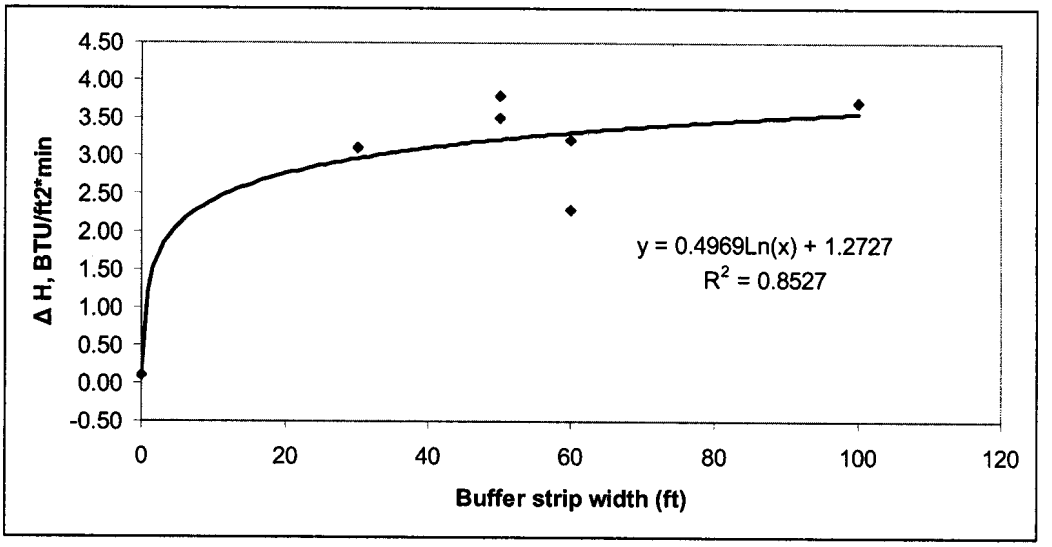
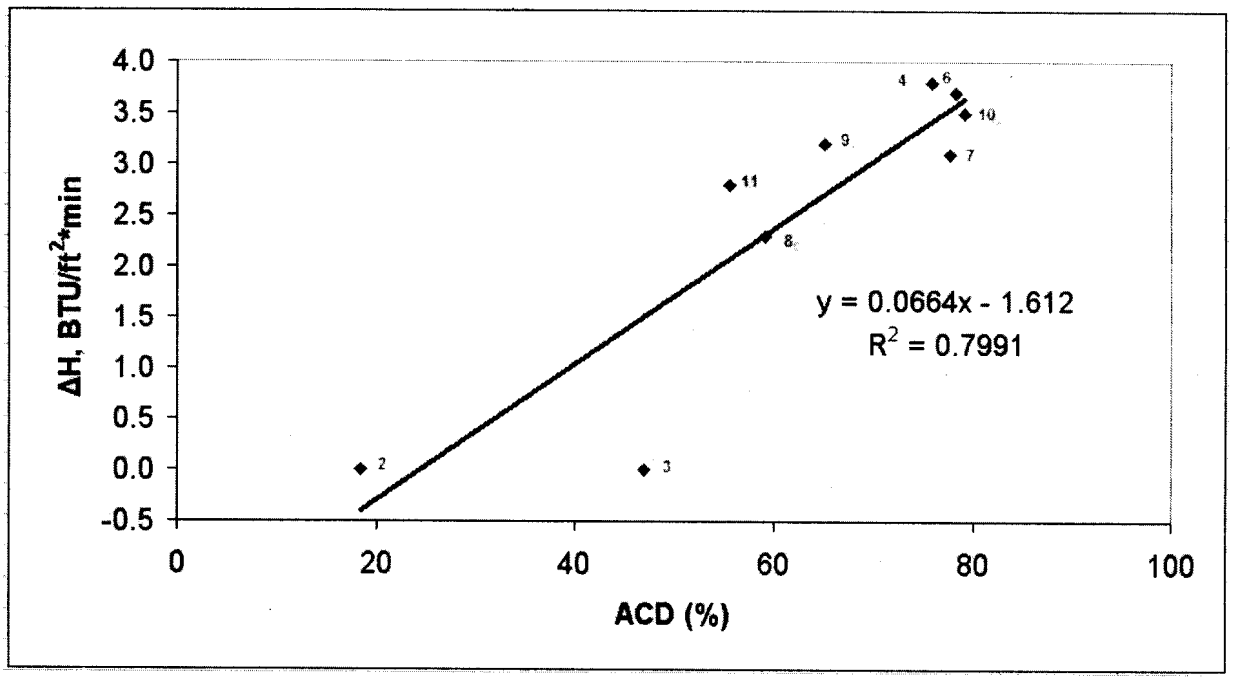

4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
Δ H, BTU/ft2*min
0
20
40
60
80
100
120
Buffer strip width (ft)
y = 0.5923Ln(x) + 0.1622
R2 = 0.1255

5.


4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
Δ H, BTU/ft2*min
0
20
40
60
80
100
120
Buffer strip width (ft)
y = 0.4969Ln(x) + 1.2727
R2 = 0.8527

6.



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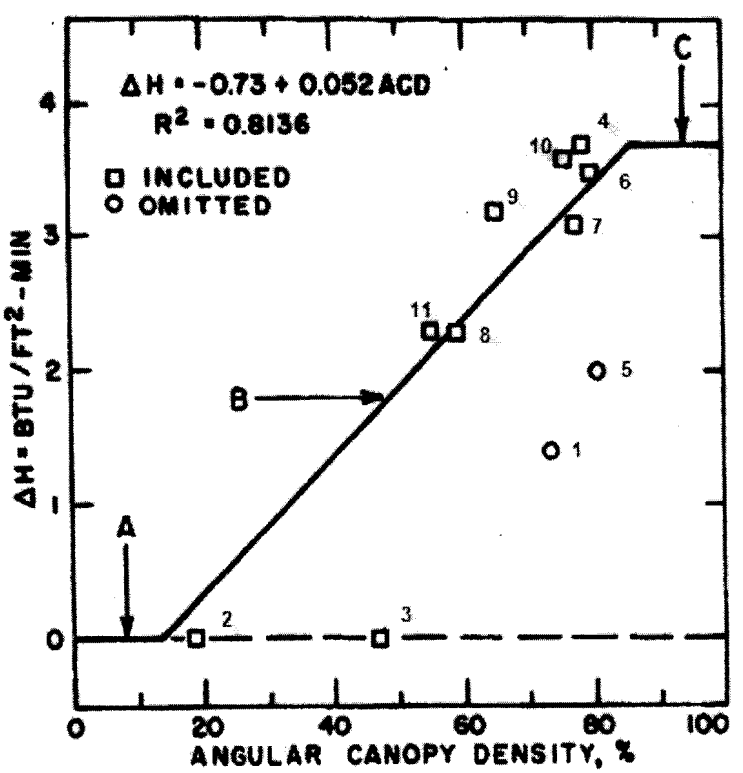
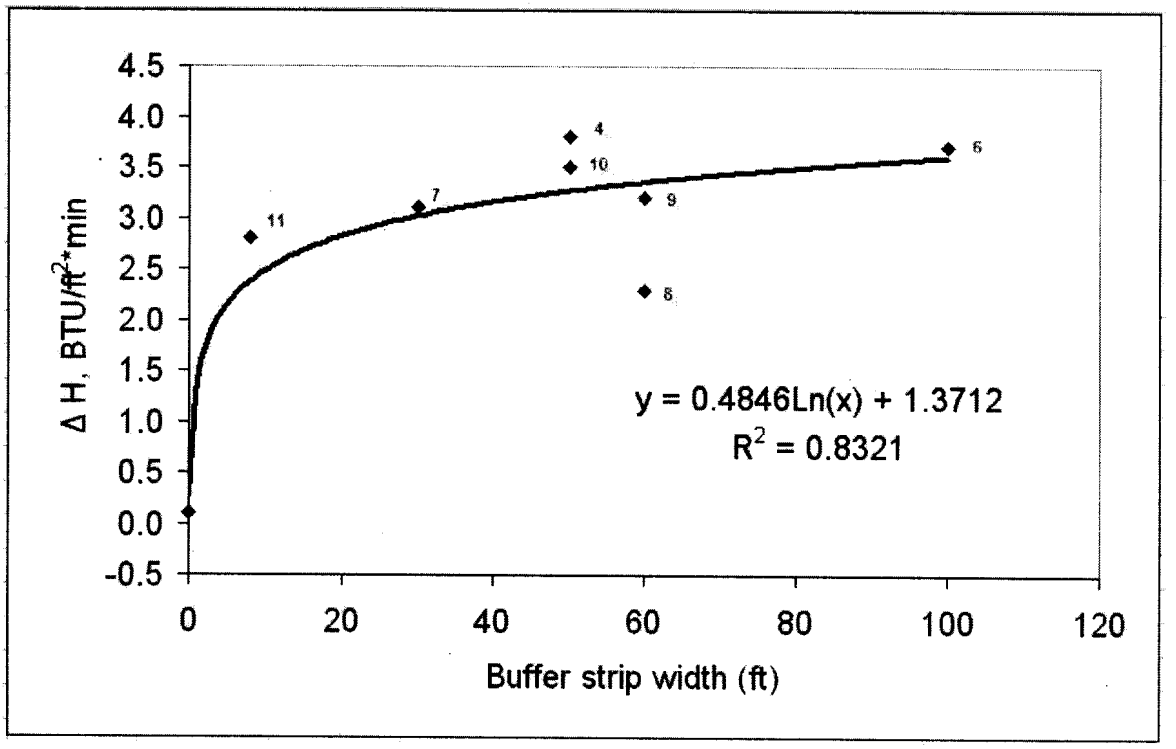


Figure 4. The observed relation between angular canopy density (ACD) and heat blocked (ΔH).

8.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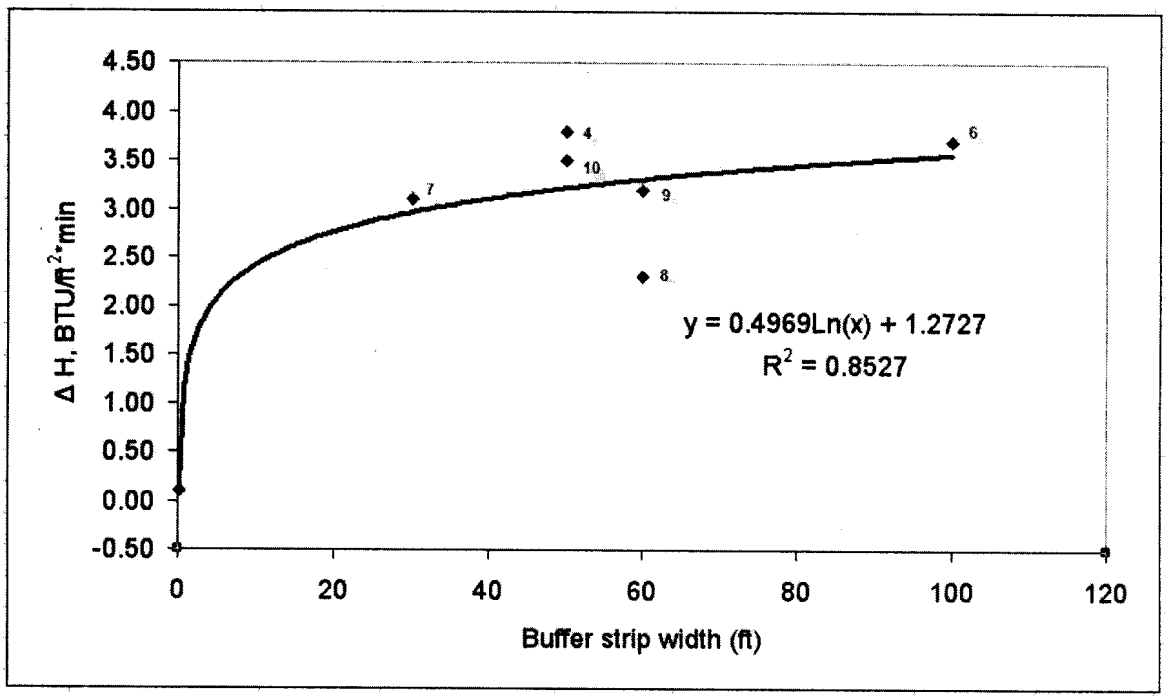
2.0
1.5
1.0
0.5
0.0
-0.5
Δ H, BTU/ft²*min
0
20
40
60
80
100
120
Buffer strip width (ft)
4
10
6
7
11
9
8
y = 0.4846Ln(x) + 1.3712
R² = 0.8321

9.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1.50
1.00
0.50
0.00
-0.50
Δ H, BTU/ft²*min
0
20
40
60
80
100
120
Buffer strip width (ft)
4
10
6
7
9
8
y = 0.4969Ln(x) + 1.2727
R² = 0.8527

10.

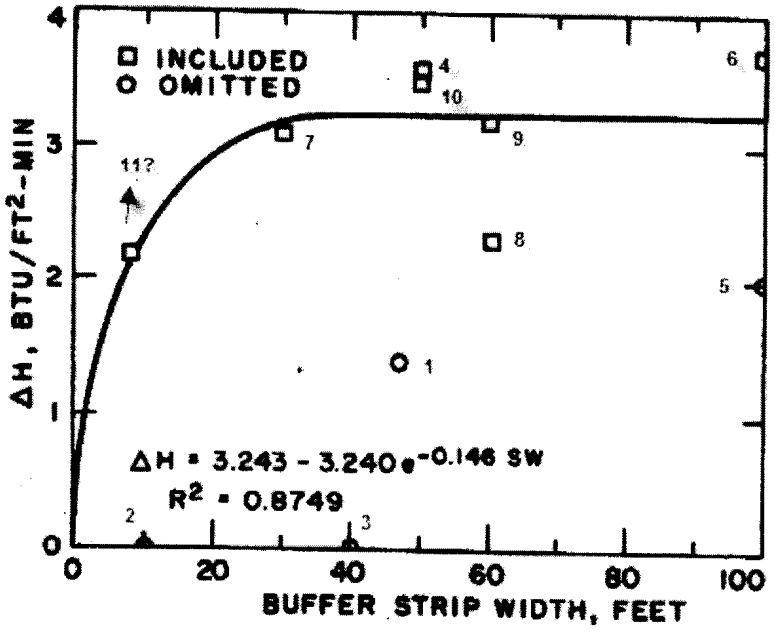


Figure 3. The observed relation between buffer strip width (SW) and heat blocked (ΔH).

11.

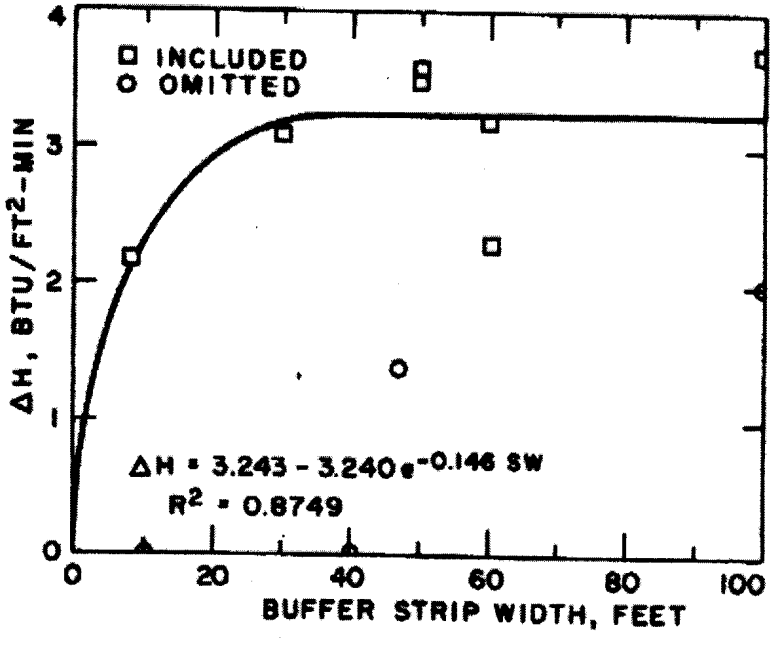


Figure 3. The observed relation between buffer strip width (SW) and heat blocked (ΔH).

Table 1. A Comparison of Various Measured and Calculated Parameters for the Study Streams.

Stream	Temperature change: Predicted	Temperature change: Observed	Heat blocked, ΔH	Angular canopy density, ACD	Average strip width	P-O[1]	Timber volume/ foot of strip	Maximum temperature: Observed	Maximum temperature: Predicted
	F	F	BTU / ft² min	Percent	Ft	F	Bd ft	F	F
Little Rock	10.1	6.0	1.4	73.6	47	4.0	50	72.0	76.0
Upper Reynolds	4.8	7.5	0.0	18.3	10	-2.7	0	74.5	72.0
Lower Reynolds	1.6	3.0	0.0	46.9	40	-1.4	42	71.5	70.0
Upper Francis	41.9[2]	2.0	3.8	75.9	50	39.9	78	62.0	101.9
Upper Deer	7.6	4.0	2.0	80.3	100	3.6	11	57.0	60.5
Lower Deer	9.0	1.0	3.7	78.3	100	8.0	102	56.0	64.0
Lake	12.5	3.0	3.1	77.7	30	9.5	2	61.0	70.5
Upper Grant	4.4	2.0	2.3	59.1	60	2.4	42	55.0	57.5
Lower Grant	4.3	1.0	3.2	65.2	60	3.3	42	55.0	58.5
Griffith	21.7	3.0	3.5	79.1	50	18.7	137	62.0	80.5
Upper Needle Branch	32.0[2]	9.0	2.8	55.6	8	23.0	0	67.0	90.0

[1]The predicted temperature change minus the observed temperature change.
[2]Predicted from the equilibrium temperature calculation.

Table 2. A Comparison of the Commercial Volume of the Buffer Strips in Conifers and the Percentage of Shade Contributed by the Conifers.

Stream	Commercial volume in conifers[1]	Shade contributed by conifers
	Bd ft	*Percent*
Little Rock	75,000	87.5
Lower Reynolds	25,118	33.0
Upper Francis	187,885	79.2
Lower Francis	55,145	83.3
Lower Deer	138,830	25.0
Upper Grant	36,073	10.0
Lower Grant	36,073	10.0
Griffith	411,625	74.2
Savage	194.980	0.0

[1]The other buffer strips were composed entirely of hardwood and brushy species of vegetation.

Brosofske, K.D., J. Chen, R.J. Naiman and J.F. Franklin. 1997.

Effects of harvesting on microclimate from small streams to uplands in western Washington. Ecological Applications 7:1188-1200.

1.

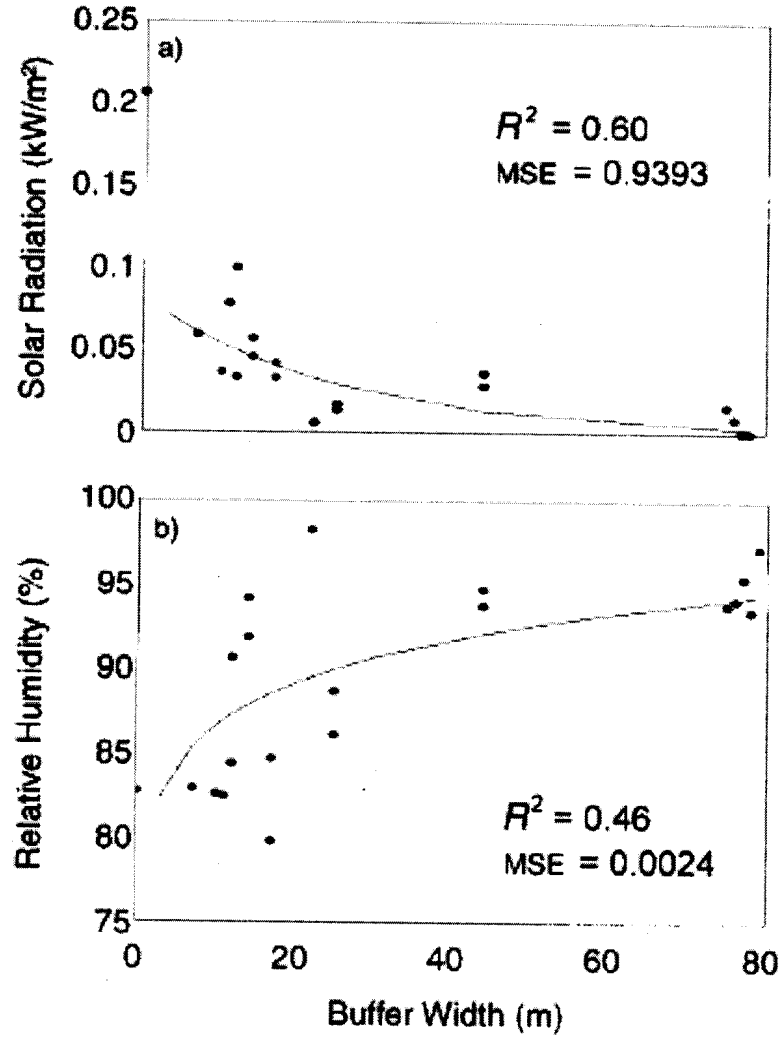


FIG. 8. Effects of buffer width on relative humidity and solar radiation at the stream. All 20 transects were used in analyses; the points grouped around 80 m represent pre-harvest data. Best-fit regression models are: $R_t = \exp[-2.5186 - 0.0409 \times (\text{buffer width})]$, $R^2 = 0.60$; and $h = \exp[4.3671 + 0.0412 \times \ln(\text{buffer width})]$, $R^2 = 0.46$.

Chan, S., P. Anderson, J. Cissel, L. Larson,and C. Thompson. 2004.
Variable density management in Riparian Reserves: lessons learned from an operational study in managed forests of western Oregon, USA.
For. Snow Landsc. Res. 78(1/2):151-172.

1.

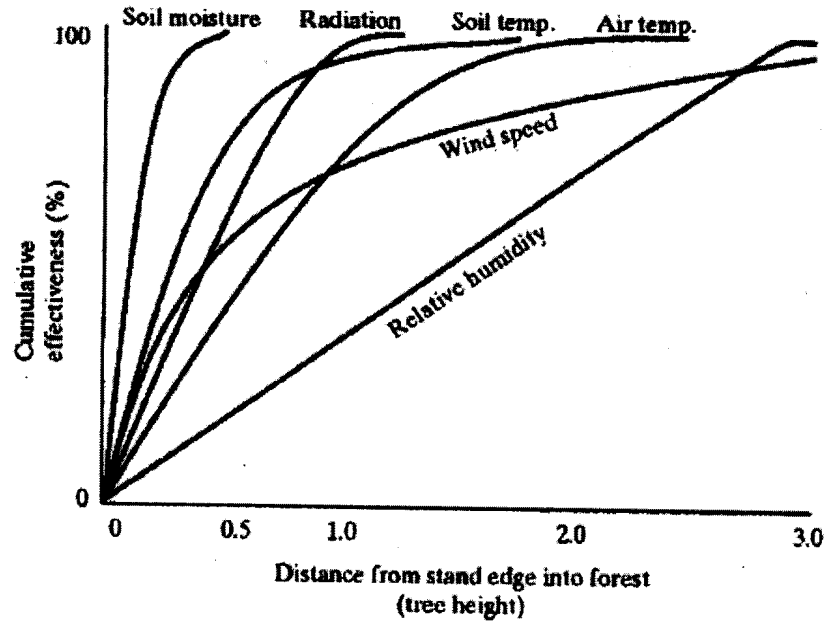


Fig. 1. Generalized curves indicating effectiveness of residual stand in moderating microclimate gradients between a clearcut and the interior of a residual old-growth stand. Percent effectiveness refers to the percentage deviation in observed microclimate values relative to measurements made in the undisturbed interior of the old-growth stand as a function of distance from clearcut edge towards the forest interior (generalized after CHEN 1991 and adapted from FEMAT 1993).

Teti, P.A. and R.G. Pike. 2005.

Selecting and testing an instrument for surveying stream shade. BC J. Ecosyst. Manage. 6: 1-16

1.

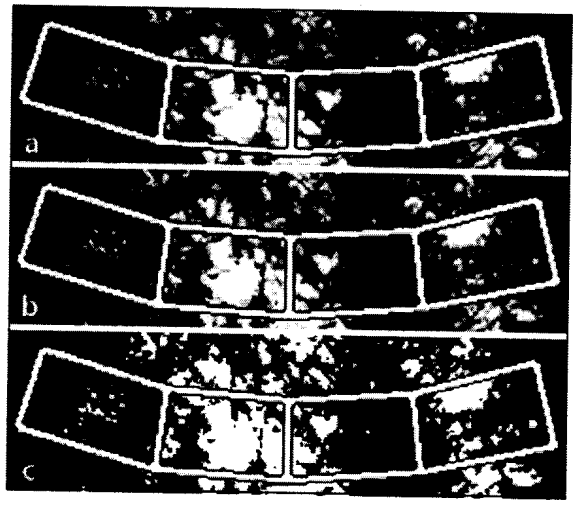
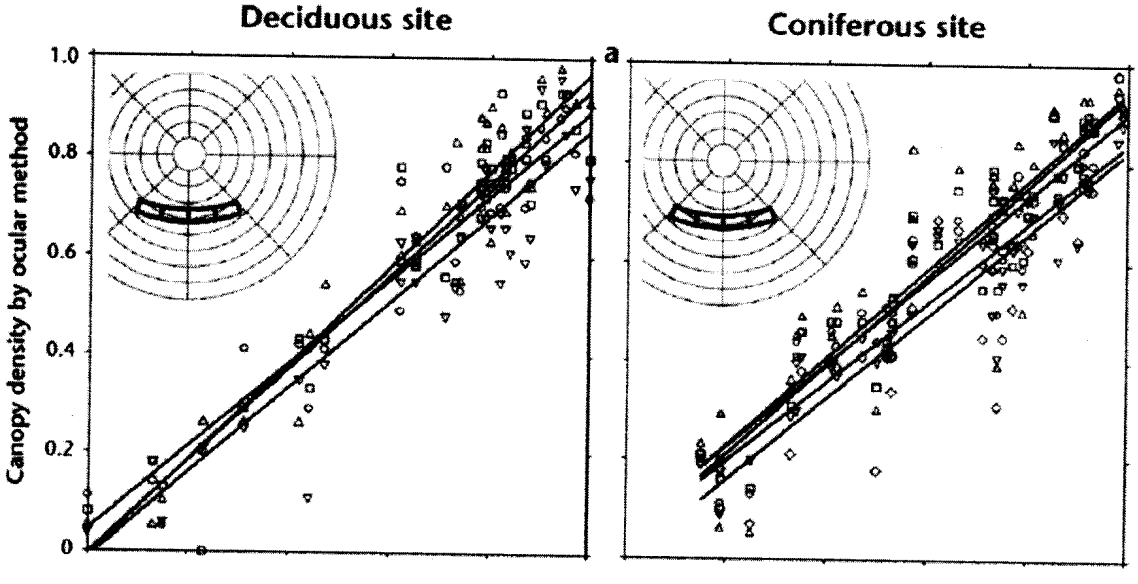


FIGURE 5. Enlarged segment of a fisheye image showing ACD area: (a) at original resolution, (b) after subsampling, and (c) after pixel classification.

2.



Ocular estimates of three canopy density parameters versus measurements by the computer-fisheye method: (a) ACD (each point represents the average of four estimates.

Lessard, J.L. and D.B. Hayes. 2003.

Effects of elevated water temperature on fish and macroinvertebrate communities below small dams. River Research and Application 19(7):721-732.

20. Lessard, J.L. and D.B. Hayes. 2003. Effects of elevated water temperature on fish and macroinvertebrate communities below small dams. River Research and Application 19(7):721-732.

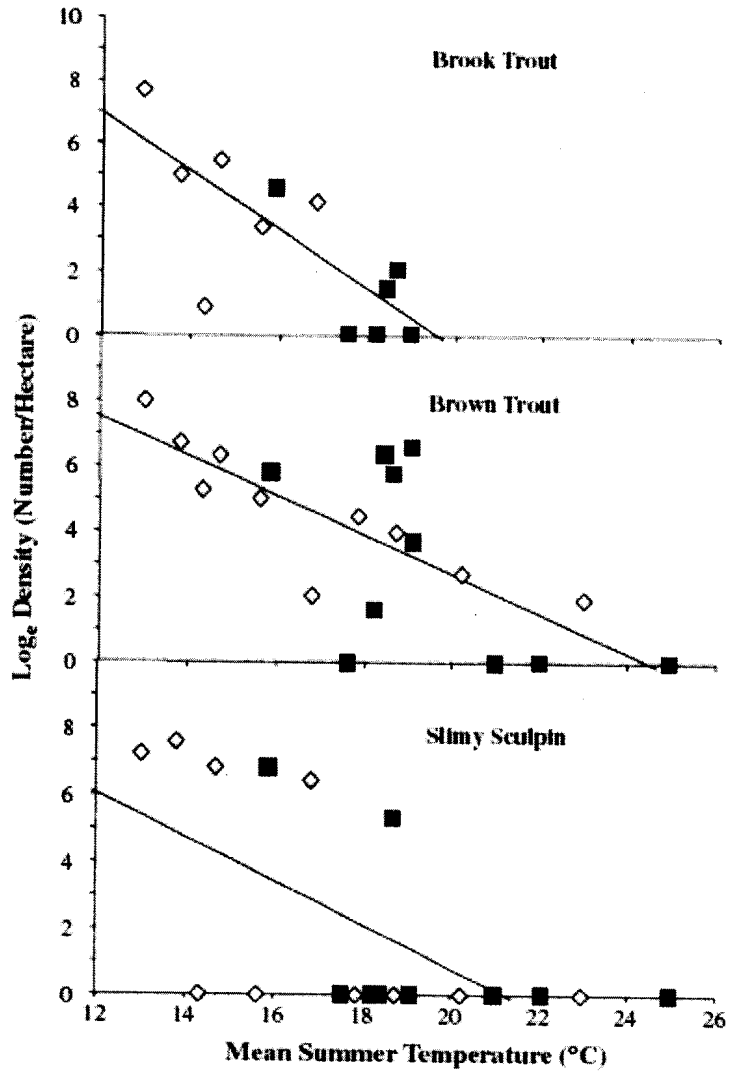


Figure 3. Mixed modelling analysis relating the log$_e$ transformed brook trout, brown trout and slimy sculpin population densities to mean summer temperature (°C). Upstream (open diamonds) and downstream (closed squares) samples are indicated, but position was not significant. Brook trout model is based on the six streams that contained brook trout and the brown trout and slimy sculpin models are based on all ten study streams

Li, H.W., G.A. Lamberti, T.N. Pearsons, C.K. Tait, J.L. Li, and J.C. Buckhouse. 1994.

Cumulative effects of riparian disturbances along high desert trout streams of the John Day Basin, Oregon. Trans. Am. Fish. Soc. 123:627-640.

1. Li, H.W., G.A. Lamberti, T.N. Pearsons, C.K. Tait, J.L. Li, and J.C. Buckhouse. 1994. Cumulative effects of riparian disturbances along high desert trout streams of the John Day Basin, Oregon. Trans. Am. Fish. Soc. 123:627-640.

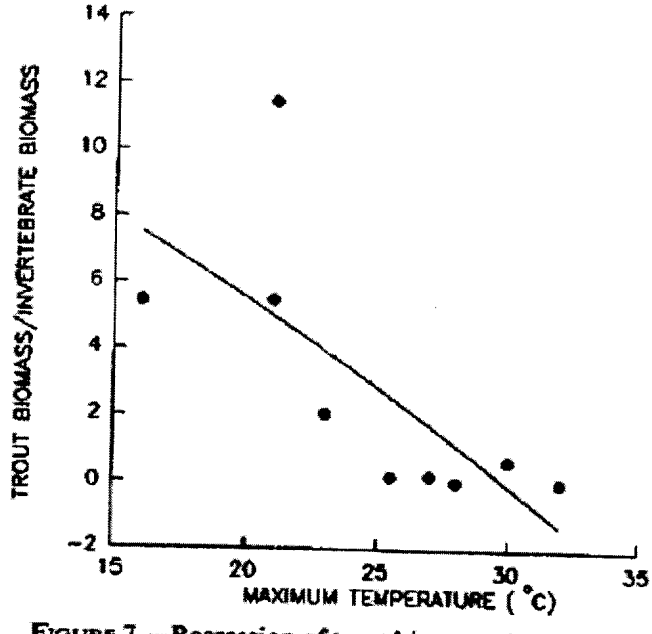


FIGURE 7.—Regression of trout biomass : invertebrate biomass ratio on maximum daily temperature for all reaches combined; $r = -0.71$, $P < 0.05$.