FIFTH ANNUAL REPORT

Intermountain Forest Tree
Nutrition Cooperative

April 1985

College of Forestry, Wildlife
and Range Sciences
University of Idaho
Moscow, Idaho 83843

INTERMOUNTAIN FOREST TREE NUTRITION COOPERATIVE

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SUMMARY

Results based on analysis of two-year basal area per acre growth response for all 90 test sites indicate the following:

(a) A majority of the installations showed a substantial (greater than 25%) growth response to both treatments.

(b) There were significant differences in response between geographic regions.

(c) Only Central Washington and North Idaho produced statistically significant response differences between treatments of 200 and 400 lbs of nitrogen per acre, the other regions did not.

(d) Predictive models of response to nitrogen treatments have been developed. Results show that basal area per acre at the time of treatment, pretreatment rate of soil nitrogen mineralization (Min_N), and soil parent material are important predictors of treatment response. As initial basal area increases response decreases, as pretreatment available nitrogen (Min_N) increases response decreases, and there are significant differences in treatment response by soil parent material.

ANALYSIS USING THE EXPERIMENTAL DESIGN

Two-year basal area growth response of the 1981 and 1982 test sites:

Ninety installations were established in managed Douglas-fir stands in 1981 and 1982. The distribution of these installations by geographic region and selected mensurational characteristics are provided in previous annual reports to cooperators. Each installation consists of six one-tenth acre plots. Some plots are larger to include a sufficient number of sample trees. Nitrogen fertilization treatments were applied in the fall and assigned to the plots randomly. The treatments consisted of: (1) two plots with applications of 200 lb. per acre actual nitrogen, (2) two plots with applications of 400 lb. per acre of actual nitrogen, and (3) two control plots. Urea was the nitrogen source. The diameters of all sample trees were measured before treatment and again after two growing seasons. Thus, this analysis is based on diameter (basal area) growth for two years after treatment.

Experimental Design Model: The variables in the model are:

Model: ln (BAI) = Year; Region; Year*Region; Installation (Year Region) Black (Year Region Installation) Treatment; Region*Treatment BA; BA^2; BA*Year; BA^2*Year; BA*Treatment; BA^2*Treatment

where:

BAI	=	two-year basal area per acre increment
ln	=	natural log
Year	=	year of establishment (1981 or 1982)
Region	=	geographic region of the cooperative
Treatment	=	control; 200 lbs/ac of nitrogen; 400 lbs/ac of nitrogen
BA	=	initial basal area per acre at the time of treatment.

Basal area response data are given as smoothed estimates in this section of the report. The estimates are adjusted for initial basal area as derived from the statistical model shown above and described in more detail in Table 1 (The Analysis of Variance Table) of the Technical Documentation Report.

Table 1. Two-year average adjusted basal area per acre increment for all ninety installations by treatment and geographic region.

Region	Treatment		
	Control (ft^2/ac) Mean	200 lb/ac (ft^2/ac) Mean	400 lb/ac (ft^2/ac) Mean
North Idaho	13.1	17.3	17.9
Montana	6.6	8.2	8.4
Central Idaho	8.1	10.0	10.5
Northeast Oregon	5.9	7.4	7.7
Central Washington	8.5	11.7	13.2
Northeast Washington	9.1	11.3	11.5
Overall	8.7	11.1	11.7

The two-year basal area per acre (BA/A) increment for both the 200 and 400 lb treatments were statistically different from the controls across all geographic regions. Except for Central Washington and North Idaho, there was no significant difference between the 200 and 400 lb treatments. The adjusted means (to a common initial basal area of 150 ft^2/ac) for BA/A increment are given for treatment by region in Table 1 and shown in Figure 1. The adjusted differences between average treated growth rates and average untreated growth rates are provided in Table 2. There were significant differences in treatment response between the geographic regions. Note the standard errors for these estimates are very low. The North Idaho region showed the largest absolute response to both the 200 and 400 lb treatments with average increases of 4.2 and 4.8 ft^2/ac, respectively, in the two year period. Central Washington produced the largest relative responses to both treatments, 38 and 54 percent. Northeast Oregon produced the lowest average absolute response, while Northeast Washington showed the lowest relative

FIGURE 1. THE EFFECT OF NITROGEN FERTILIZATION RATE ON TWO-YEAR BASAL AREA RELATIVE RESPONSE FOR THE SIX GEOGRAPHIC REGIONS OF THE IFTNC.

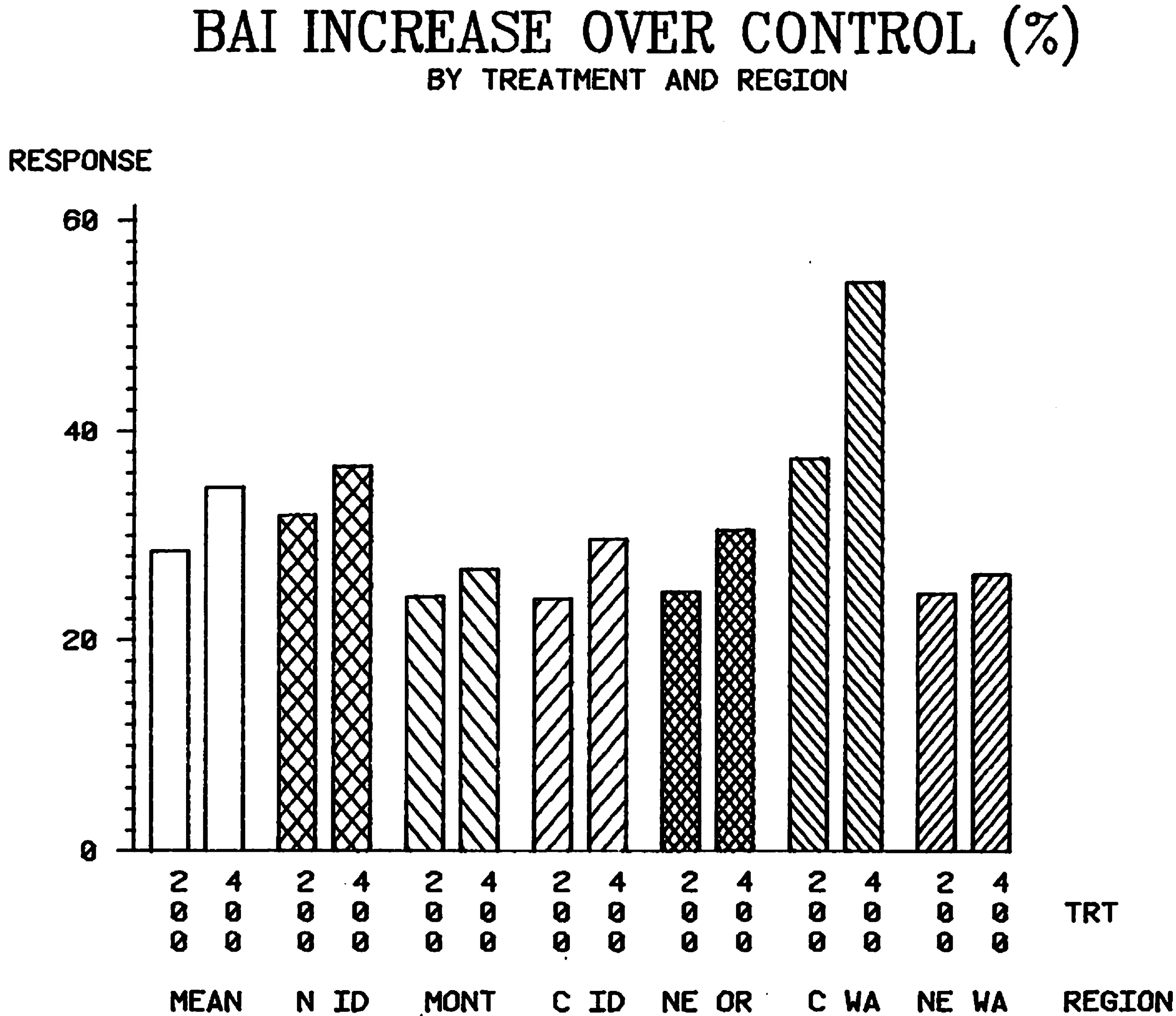


Table 2. Two-year average adjusted basal area per acre increment for all ninety installations by treatment and geographic region.

Region	Treatment							
	200 lb/ac				400 lb/ac			
	ft²/ac	SE	Percent	SE	ft²/ac	SE	Percent	SE
North Idaho	4.2	±.2	32	±1.3	4.8	±.2	35	±1.5
Montana	1.6	±.1	24	±1.0	1.8	±.1	27	±1.1
Central Idaho	1.9	±.1	24	±1.2	2.3	±.1	30	±1.4
Northeast Oregon	1.5	±.1	25	±1.5	1.8	±.1	31	±2.1
Central Washington	3.2	±.1	38	±1.5	4.7	±.2	54	±2.2
Northeast Washington	2.2	±.1	24	±1.0	2.4	±.1	26	±1.1
Overall	2.4	±.05	28	±0.6	3.0	±.1	35	±0.8

response to both nitrogen treatments. By comparison, the average two-year BA/A responses reported for thinned Douglas-fir stands west of the Cascades were 3.74 and 4.03 ft^2/ac for 200 and 400 lb. treatments, respectively (Regional Forest Nutrition Research Project, Biennial Report 1980-82; College of Forest Resources, University of Washington, Seattle). Central Washington, for the 400 lb treatment, and North Idaho for both treatments produced average absolute BA/A responses greater than the "west-side."

Although there are significant differences in treatment response between regions, there is substantial variation within each region. That is, some installations responded very well and others little or not at all in every region. This is illustrated in Table 3 which provides the maximum and minimum response value for each treatment by region. In addition, both the adjusted and unadjusted response values are provided for all 90 installations in Section 1 of the Technical Documentation Report. Can we

Table 3. Maximum and minimum adjusted two-year basal area per acre response for all ninety installations by treatment and geographic region.

Region	Maximum (ft^2/ac)		Minimum (ft^2/ac)	
	200 lb/ac	400 lb/ac	200 lb/ac	400 lb/ac
North Idaho	6.1	10.5	0.4	-1.0
Montana	3.4	5.0	-0.8	-1.0
Central Idaho	5.3	4.5	0.2	0.1
Northeast Oregon	3.2	3.1	0.3	0.1
Central Washington	6.4	10.2	0.6	1.1
Northeast Washington	5.0	4.6	-0.3	0.5

explain this variation between installations? Yes, pretty well. These results are described later in this report in the section describing the development of a predictive model of response.

Significant Covariates: There were two statistically significant covariates in the analysis: year (i.e., a 1981 or 1982 installation) and initial basal area per acre. While year is a significant covariate as a separate term and as an interaction term with initial basal area, it does not interact with treatment! That is, the amount of treatment response does not depend on the year the treatment was applied. However, the magnitude of the within installation adjustment for "normal" growth is significantly different between the 1981 and 1982 installations. There are several possible explanations for differences between the two sets of installations. One possibility is that by design and by chance we sampled somewhat different site and stand conditions in the two years. For example, 1982 installations included several new soil types, and the 1982 installations were more dense (156 ft^2/ac) on the average than 1981 (128 ft^2/ac). Weather is another potential factor that could explain

Table 4. Comparison of long-term average annual precipitation (1948-1978) to recent individual yearly amounts in inches.

Region	Station	Number years	Mean	Standard deviation	Years 1980	1981	1982	1983
North Idaho	Priest River Exp. Sta.	31	32.95	4.83	35.08	31.53	38.72*	39.45*
	Headquarters	17	40.62	6.14	34.42*	40.10	--	40.03
Montana	Missoula	30	13.06	2.52	19.35*	17.35*	15.38	16.71*
	Polson	22	15.40	3.15	24.20*	18.83*	17.80	17.44
Central Idaho	McCall	31	28.24	3.83	34.85*	30.07	36.70*	33.77*
Northeastern Oregon	Enterprise	28	13.44	2.02	16.71*	--	--	17.52*
	Baker	30	10.32	2.24	13.37*	13.86*	12.02	13.36*
Central Washington	Appleton	19	33.09	6.88	39.4	35.5	41.2*	45.5*
	Cle Elum	26	23.20	6.19	24.2	22.7	22.7	22.3
	Conconully	18	14.72	2.65	18.6*	18.2*	20.8*	28.7*
Northeastern Washington	Colville	27	17.37	2.58	25.3*	24.2*	21.27*	27.75*

Table 5. Regional comparison of long-term January average minimum temperatures (1948-1978) to recent individual January average minimums in degrees Fahrenheit.

					Years				
Region	Station	Number years	Mean	Standard deviation	1980	1981	1982	1983	1984
North Idaho	Priest River Exp. Sta.	31	17.67	7.24	12.6	25.6*	18.9	--	21.6
	Headquarters	17	16.89	5.21	10.5*	24.0*	18.2	--	15.5
Montana	Missoula	30	13.15	7.52	8.5	25.1*	13.7	23.5*	18.4
	Polson	24	18.12	7.56	--	28.2*	18.8	27.8*	21.5
Central Idaho	McCall	31	11.54	6.75	12.6	18.9*	12.6	--	9.5
Northeastern Oregon	Enterprise	31	14.0	6.79	10.3	22.0*	--	--	10.7
	Baker	30	16.04	8.14	17.9	27.7	13.5	--	13.7
Central Washington	Appleton	19	23.39	4.19	15.0*	30.0*	24.2	--	24.6
	Cle Elum	29	17.88	7.56	8.5*	30.8*	21.5	--	23.4*
	Conconully	29	12.39	7.84	4.6*	24.5*	13.4	--	23.0*
Northeastern Washington	Colville	30	16.5	7.57	12.9	27.7*	18.9	--	23.0

Table 6. Regional comparison of long-term July average maximum temperatures (1948-1978) to recent individual July average maximums in degrees Fahrenheit.

Region	Station	Number years	Mean	Standard deviation	Years 1980	1981	1982	1983	1984
North Idaho	Priest River Exp. Sta.	31	82.23	2.80	80.1	79.0*	77.0*	--	80.5
	Headquarters	17	81.42	2.33	79.8	79.4	77.6*	--	--
Montana	Missoula	31	84.4	3.37	81.1	88.1*	79.0*	75.9*	85.1
	Polson	25	81.4	3.17	79.5	85.9	--	76.0*	86.0*
Central Idaho	McCall	31	80.72	2.77	78.6	79.7	75.1*	--	81.2
Northeastern Oregon	Enterprise	31	82.67	2.85	79.9	77.5*	75.2*	--	79.2
	Baker	30	85.0	2.40	85.2	84.1	81.3	--	85.8
Central Washington	Appleton	20	79.73	3.0	76.6*	74.0*	76.5*	--	79.8
	Cle Elum	30	81.4	3.68	81.4	78.5	80.8	--	80.3
	Conconully	23	82.3	3.78	83.2	79.6	79.9	--	--
Northeastern Washington	Colville	30	85.5	3.20	82.6	78.3*	79.7*	--	83.5

differences in growth. But there seems to be no real difference in precipitation or temperature between 1981 and 1982 (Tables 4, 5, and 6). Both years generally had higher precipitation than the long-term average (Table 4).

As noted earlier, except for Central Washington and North Idaho, there was no significant difference between the 200 and 400 lb treatments. However, there is a trend for the 400 lb to be higher than the 200 lb treatment. This pattern was not evident in the 1981 installations. Based on only two-year results, 200 lbs/ac is the preferred rate for four of the six regions. Perhaps the 400 lb rate will produce a longer response duration or large future differences in response magnitude.

Another pattern was evident when comparing current results with those obtained from the 1981 installations. The pattern seems to be related to the stand densities sampled in the two years rather than year per se. This is illustrated in Figures 2 through 7 which show the relationships between initial basal area and response to treatment by geographic region. The results based only on the 1981 installations (1984 IFTNC Annual Report) showed much lower relative response for high basal area stands (175 to 225 ft^2/ac) than is predicted based on all ninety installations. Again, we sampled relatively few high density stands in 1981 and relatively more in 1982.

FIGURE 2. THE EFFECT OF INITIAL BASAL AREA PER ACRE ON TWO-YEAR RELATIVE BASAL AREA RESPONSE FOR NORTH IDAHO.

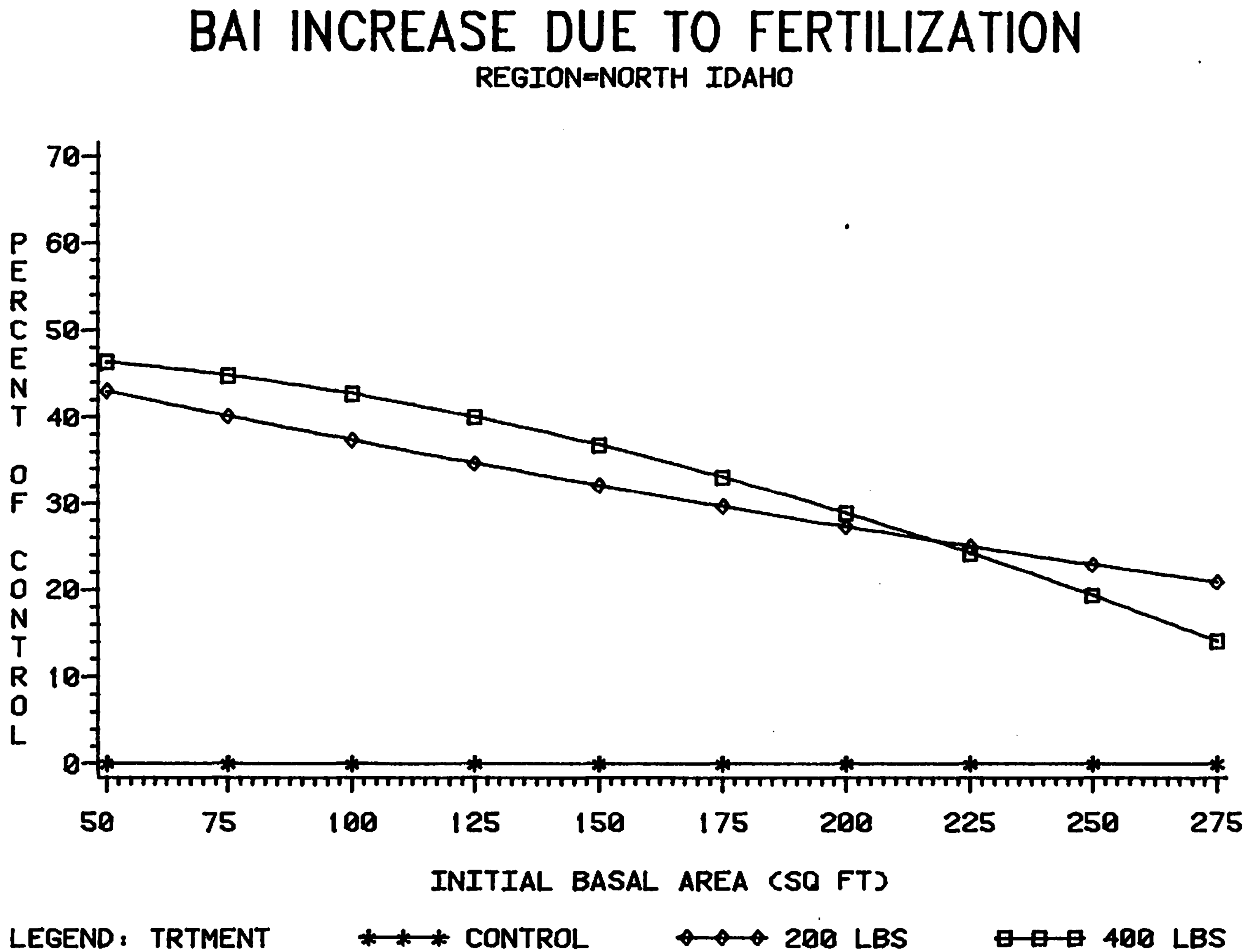


FIGURE 3. THE EFFECT OF INITIAL BASAL AREA PER ACRE ON TWO-YEAR RELATIVE BASAL AREA RESPONSE FOR MONTANA.

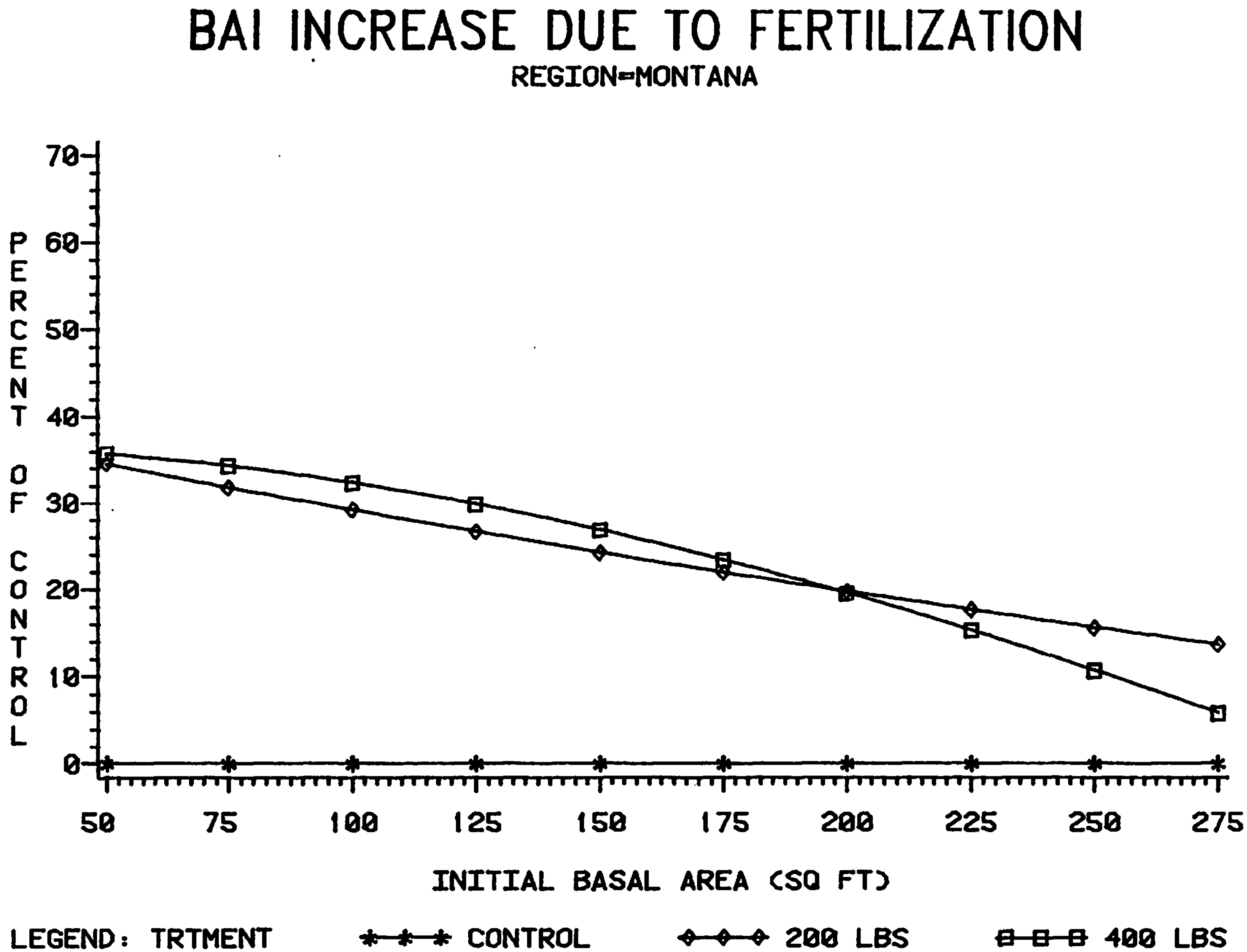


FIGURE 4. THE EFFECT OF INITIAL BASAL AREA PER ACRE ON TWO-YEAR RELATIVE BASAL AREA RESPONSE FOR CENTRAL IDAHO.

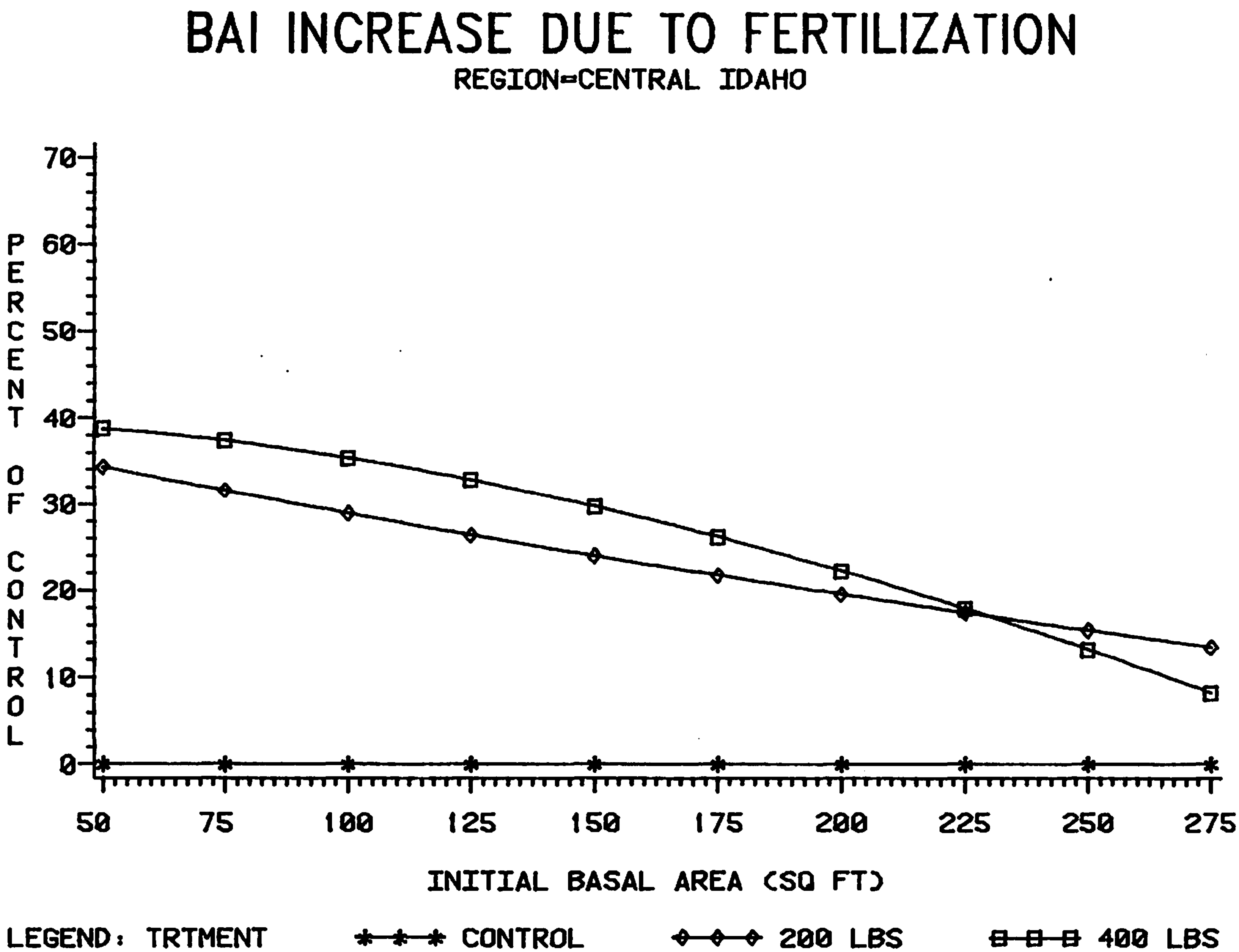


FIGURE 5. THE EFFECT OF INITIAL BASAL AREA PER ACRE ON TWO-YEAR RELATIVE BASAL AREA RESPONSE FOR NORTHEAST OREGON.

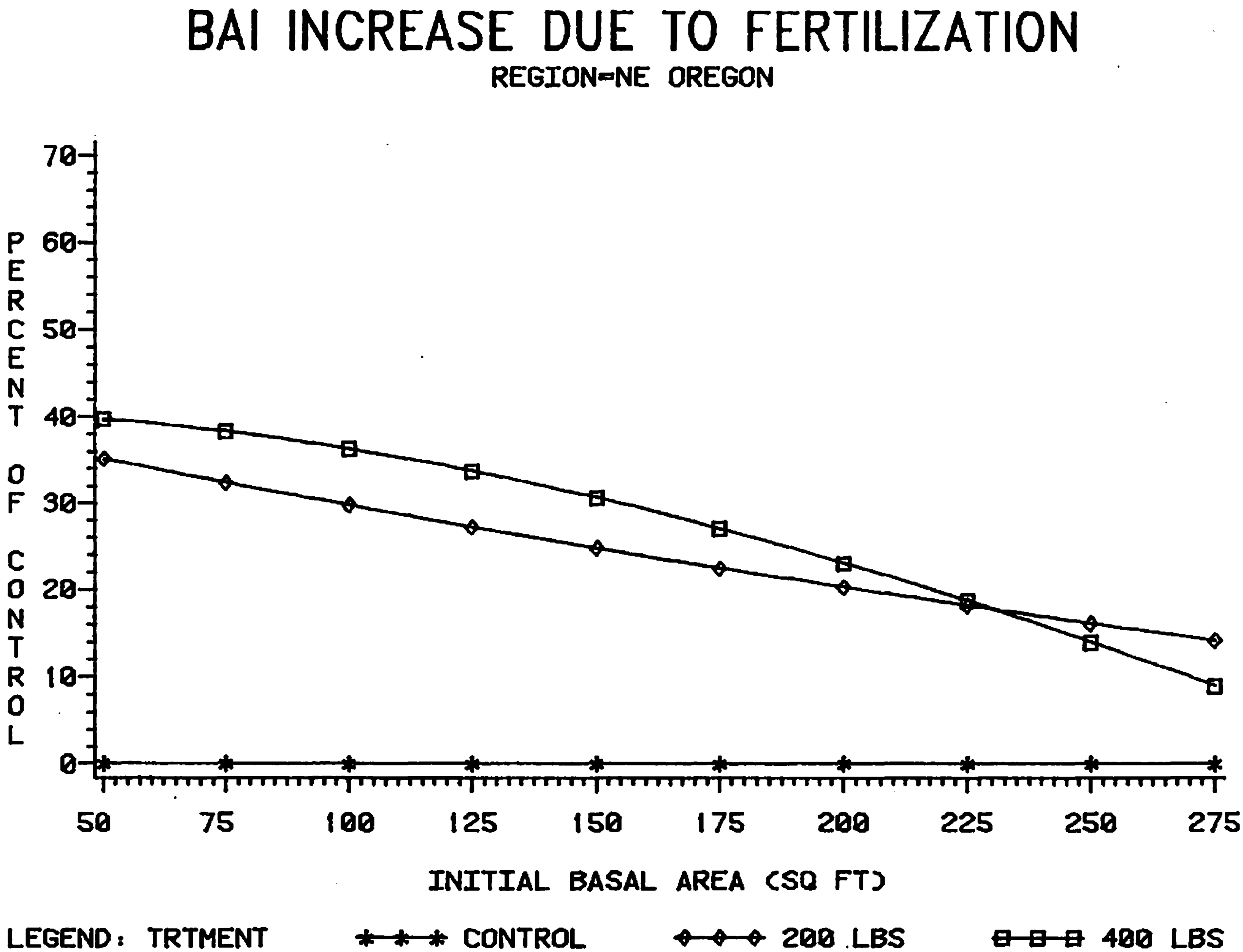


FIGURE 6. THE EFFECT OF INITIAL BASAL AREA PER ACRE ON TWO-YEAR RELATIVE BASAL AREA RESPONSE FOR CENTRAL WASHINGTON.

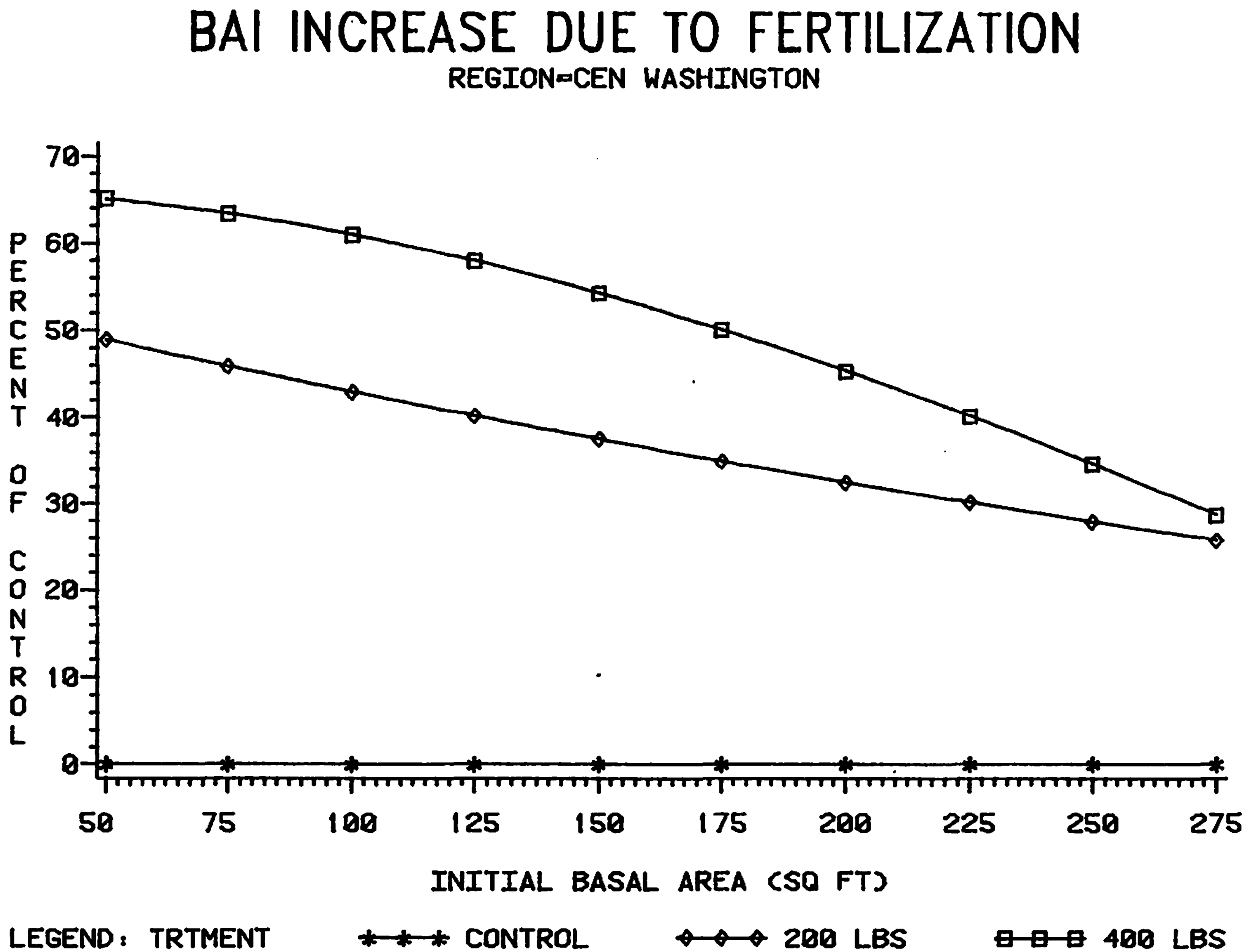
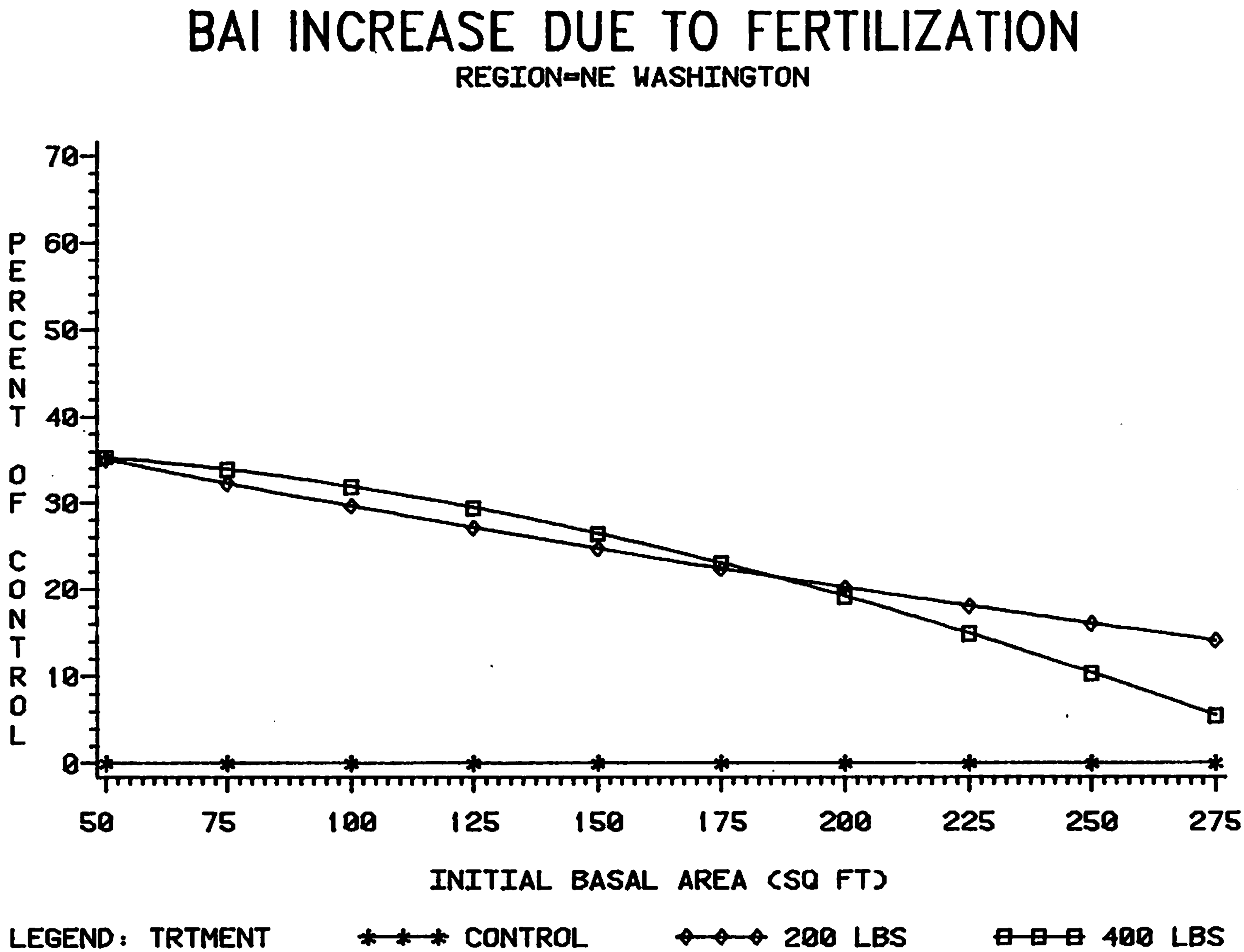


FIGURE 7. THE EFFECT OF INITIAL BASAL AREA PER ACRE ON TWO-YEAR RELATIVE BASAL AREA RESPONSE FOR NORTHEAST WASHINGTON.



Alternative Experimental Design Model

Our results indicate that there is an alternative formulation that performs better statistically than the previous design model.

The alternate model is as follows:

Model: ln(BAI) = Year; Region; Year*Region; Installation (Year Region) Block (Year Region Installation) Treatment; BA; BA^2; BA*Year; BA^2*Year; Min_N; Min_N*Treatment

Where:

Min_N = Rate of nitrogen mineralization before treatment.

All other terms as previously defined.

The statistical details of this model are given in Table 2 of the Technical Documentation Report. The difference between the above model and the first design model is the Min_N term and the fact that the Min_N by treatment interaction has replaced the Region by treatment, BA by treatment, and BA^2 by treatment interactions. The average basal increments and response by treatment are provided in Table 7. The relationship between Min_N and growth response to treatment is shown in Figure 8. As the rate of nitrogen mineralization before treatment increases, response decreases. Sites with low mineralization rates respond better to nitrogen treatments than sites with high mineralization rates. Importantly, the predicted responses to the 200 and 400 lb treatments converge (as well as decline) as pretreatment nitrogen mineralization rate increases. For low Min_N values there is a significant increase from the 400 lb over the 200 lb treatment. Treatment response and Min_N vary together by region (Table 8). Therefore, the Min_N by treatment interaction replaced the region by treatment term (as well as the basal area by treatment interactions) in the model with no loss in accuracy or precision. A soil test to estimate the rate of nitrogen mineralization before treatment shows excellent promise as a screening technqiue in an operational fertilization program.

FIGURE 8. THE RELATIONSHIP BETWEEN NITROGEN MINERALIZATION RATE BEFORE TREATMENT AND TWO-YEAR BASAL AREA RELATIVE RESPONSE TO NITROGEN FERTILIZATION.

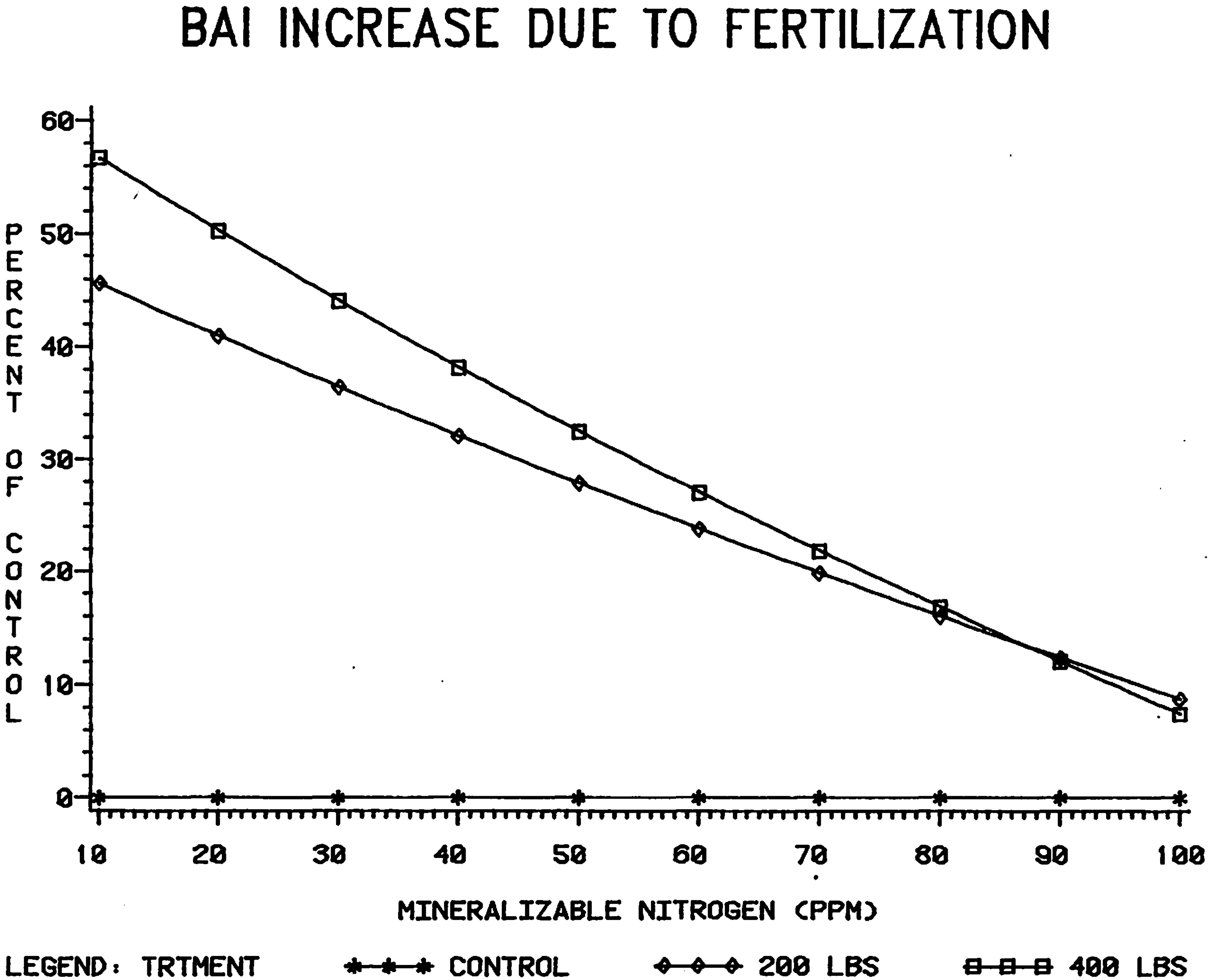


Table 7. Two-year average adjusted[1] basal area per acre increment and response for all ninety installations.

	Treatment				
	Control	200 lb/ac	SE	400 lb/ac	SE
Increment (ft^2/ac)	8.6	11.2		11.7	
Response (ft^2/ac)	-	2.6	±.04	3.1	±.05
Relative response (%)	-	30	±0.5	35	±0.6

[1] Adjusted to an initial basal area of 150 ft^2/ac and a Min_N value of 45 parts per million.

Table 8. Average mineralizable nitrogen rate and average response by geographic region for all ninety installations.

		Treatment response (%)	
Region	Min_N (PPM)	200 lb/ac	400 lb/ac
North Idaho	45.6	32	37
Montana	60.5	24	27
Central Idaho	35.3	24	30
Northeast Oregon	62.4	25	31
Central Washington	30.0	38	54
Northeast Washington	49.5	25	26

DEVELOPING A PREDICTIVE MODEL OF TREATMENT RESPONSE

The use of the previously discussed experimental design models in the statistical analysis allows us to attribute the observed growth responses to the treatments we applied. In addition, including the "installation" term in the analysis allows us to estimate response for each installation. The installation term also "absorbs" (in a statistical sense) the variation between installations, but the use of this analysis approach does not allow a quantitative understanding of why the installations are different. For this reason, we have analyzed the data differently in order to develop a predictive model of response across installations. The following model is a result of that analysis:

$$\ln(BAI) = f(TRT; PMAT; SOILD; ASHD; SI; SLOPE; SLOPE*CASP; SLOPE*SASP; BA; BA*PMAT; BA*ASHD; BA^2; BA^2*PMAT; BA^2*ASHD; PMAT*TRT; BA*TRT; BA^2*TRT)$$

where:

BAI	=	two-year basal area per acre increment
TRT	=	treatment = control or 200 lbs of nitrogen per acre or 400 lbs of nitrogen per acre
PMAT	=	soil parent material = one of the following classes: alluvium ash/loess ash/metasediments basalt colluvium glacial till granite sandstone valley fill
SOLID	=	soil depth = deep if $\geq$ 24" or medium if 12 to 24" or shallow if $\leq$ 12"
ASHD	=	depth of volcanic ash = deep if $\geq$ 12" or = not deep if $\leq$ 12"

Table 9. Two-year average adjusted basal area per acre increment by soil parent material.

		Treatment		
Parent material	Number of installations	Control ft^2/ac	200 lb/ac ft^2/ac	400 lb/ac ft^2/ac
Granite	10	8.0	9.7	10.6
Ash/loess	9	6.0	8.3	8.7
Basalts	19½	9.2	11.8	12.0
Glacial till	23½	9.3	11.8	12.3
Ash/metasediments	12	10.5	13.4	14.8
Valley fill	6	7.4	7.2	7.3
Colluvium	4	5.5	8.1	9.6
Alluvium	3	6.6	9.2	8.4
Sandstone	3	8.0	13.1	13.9
Overall	90	7.7	10.1	10.6

SI	=	Douglas-fir site index (Monserud 1984)
SLOPE	=	percent slope
CASP	=	cosine of aspect
SASP	=	sine of aspect
BA	=	basal area per acre at the time of treatment.

The model parameters were estimated using least-squares regression. The predictor variables accounted for 70 percent of the variation in two-year basal area growth per acre. The parameter estimates and other statistical details are given in Table 3 of the Technical Documentation Report. Most of the variables in the model do not directly influence response to nitrogen fertilization, but they do account for differences in the underlying basal area growth rates between installations. These variables are: soil depth, depth of an ash layer (if present), Douglas-fir site index, slope, and aspect. Two-year basal area increment increases as soil depth, ash depth, and site index increase. Slope and aspect are combined as interaction terms in the model as suggested by Stage (1976). The optimum aspect in our data for basal area growth is south-southeast (159°).

Basal area per acre at the time of treatment and soil parent material also account for differences in the underlying basal area growth rate. In addition they significantly interact with treatment, i.e., they are important in predicting treatment response! The relative responses by soil parent material are shown in Figure 9 and the adjusted (to a basal area of 142 ft^2/ac) absolute basal area increments and number of plots for each of the nine parent materials are provided in Table 9. Absolute and relative responses are given by parent material in Table 10. Large differences in response are apparent between the parent materials. Valley fills don't respond to fertilization and colluviums and sandstones show very large

FIGURE 9. TWO-YEAR RELATIVE BASAL AREA RESPONSE BY SOIL PARENT MATERIAL.

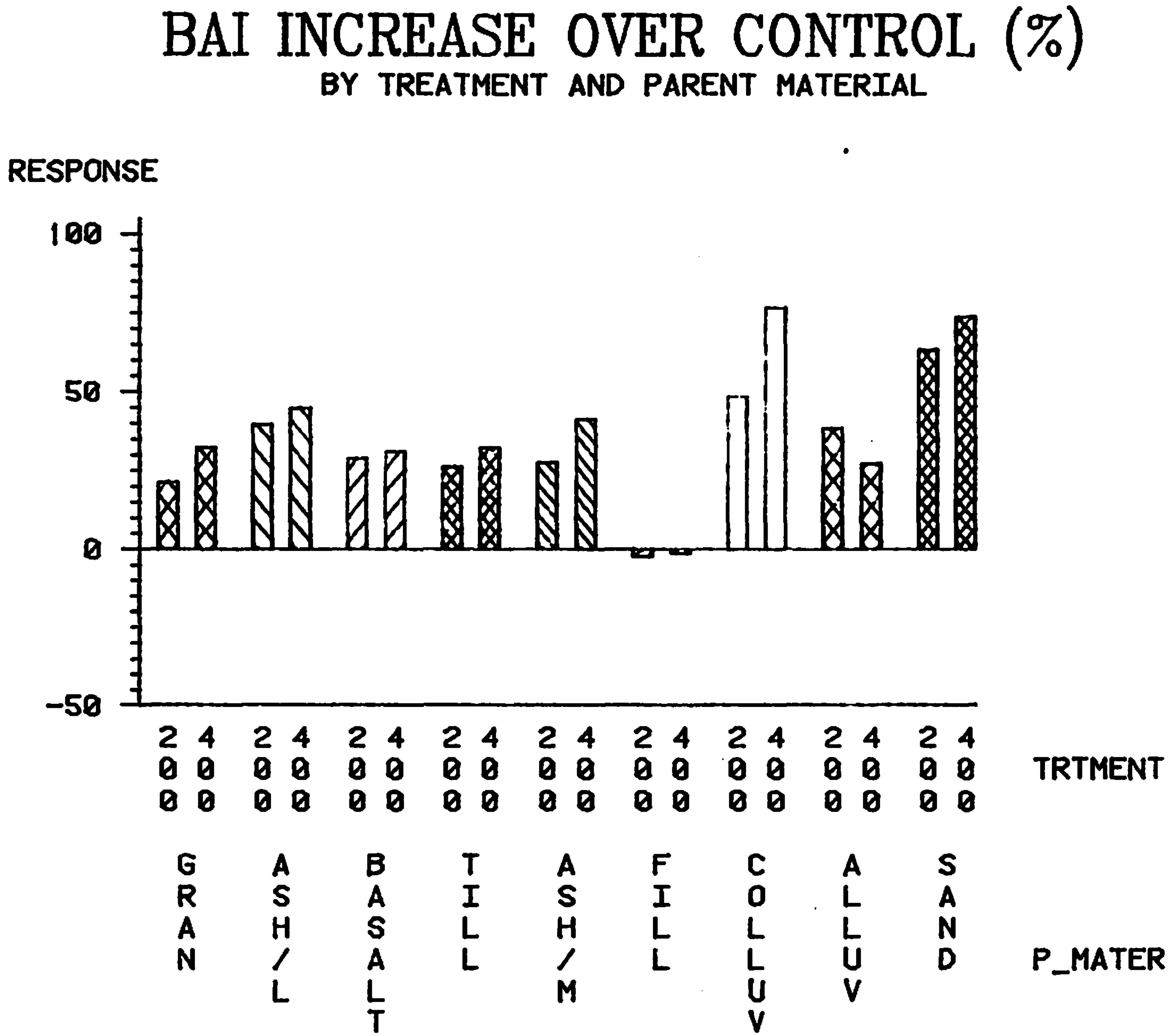


Table 10. Two-year average adjusted basal area per acre response by soil parent material.

	Treatment			
	200 lb/ac		400 lb/ac	
Parent material	ft^2/ac	percent	ft^2/ac	percent
Granite	1.7	21	2.6	32
Ash/loess	2.3	40	2.7	45
Basalts	2.6	29	2.8	31
Glacial till	2.5	27	3.0	32
Ash/metasediments	2.9	28	4.3	41
Valley fill	-0.2	-3	-0.1	-1
Colluvium	2.6	48	4.1	77
Alluvium	2.6	39	1.8	27
Sandstone	5.1	63	5.9	74
Overall	2.4	31	2.9	38

relative response, and sandstone shows a very high absolute response as well. However, we had only 4 installations on colluviums and 3 on sandstones. The alluvium soils showed a decrease in response for the 400 lb treatment compared to the 200 lb treatment. The ash/loess parent material produced the highest responses of the more common soils. The relationships between initial basal area and treatment response for each of the nine parent materials are illustrated in Figures 10 through 18. As initial basal area increases, predicted response decreases more quickly for the 200 lb than the 400 lb treatment. The predicted response for the 200 lb treatment levels off as basal area continues to increase. One caution, the relationships portrayed on these graphs do not extrapolate well outside the range of basal areas presented (i.e., 75 to 225 ft^2/ac). The relationships between response and initial basal area by parent material are very informative. One easy way to compare treatment response by parent material is to pick a substantial relative response, say 30 percent, and determine the basal area that predicts that response by parent material (Table 11). For the common parent materials, the ranking in terms of the maximum amount of basal area that can be supported (in descending order) and still produce a substantial response (30%) is as follows: (1) ash/loess, (2) ash/metasediments, (3) basalt, (4) glacial till, (5) granite, and (6) valley fills (these soils don't respond to nitrogen treatments). These relationships seem logical from many biological viewpoints, particularly regarding the moisture holding capacities of these soils. Fertilization guidelines based on the interaction of parent material and stand density seem entirely feasible.

FIGURE 10. THE RELATIONSHIP BETWEEN INITIAL BASAL AREA PER ACRE AND RELATIVE BASAL AREA RESPONSE BY TREATMENT FOR GRANITIC PARENT MATERIALS.

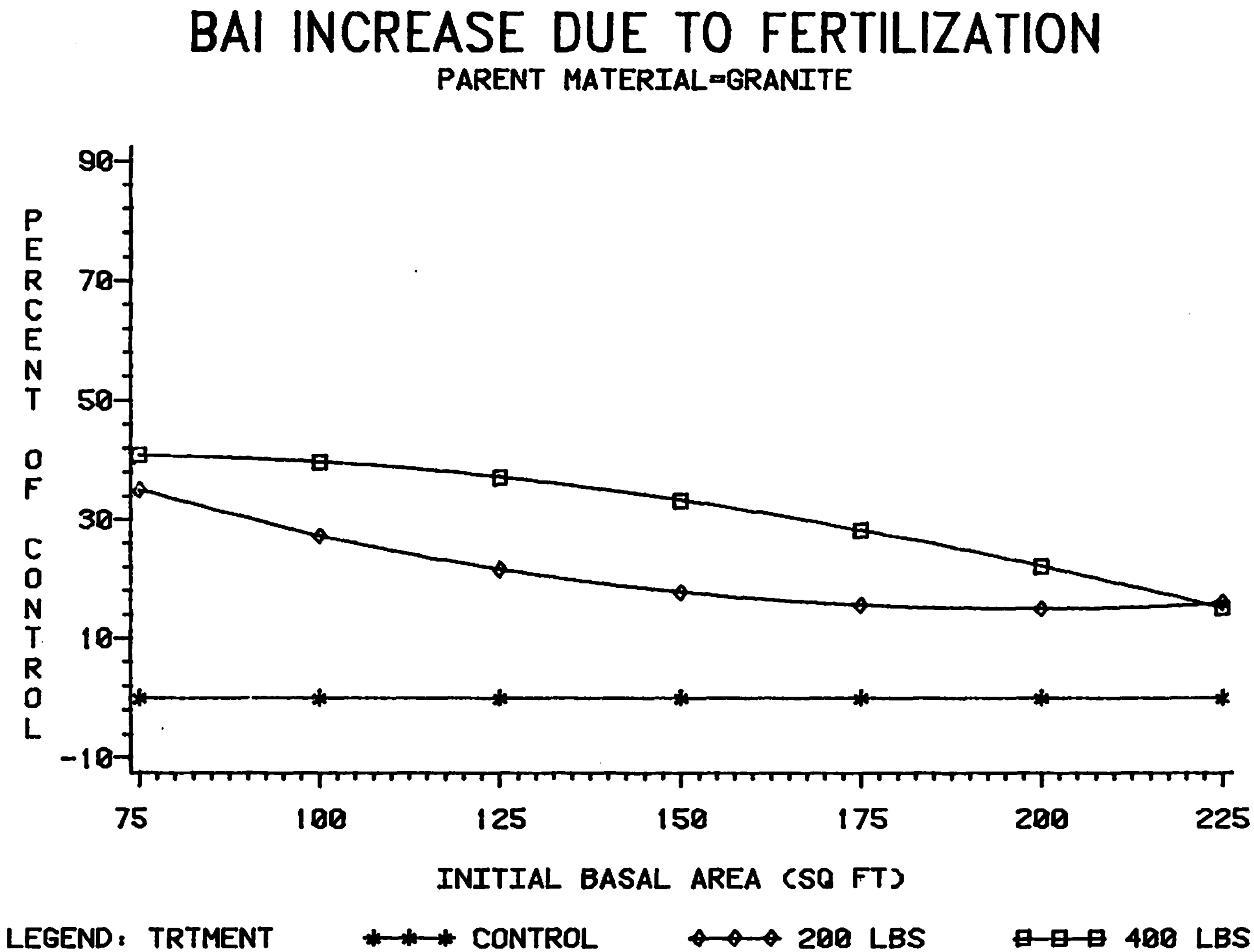


FIGURE 11. THE RELATIONSHIP BETWEEN INITIAL BASAL AREA PER ACRE AND RELATIVE BASAL AREA RESPONSE BY TREATMENT FOR ASH/LOESS PARENT MATERIALS.

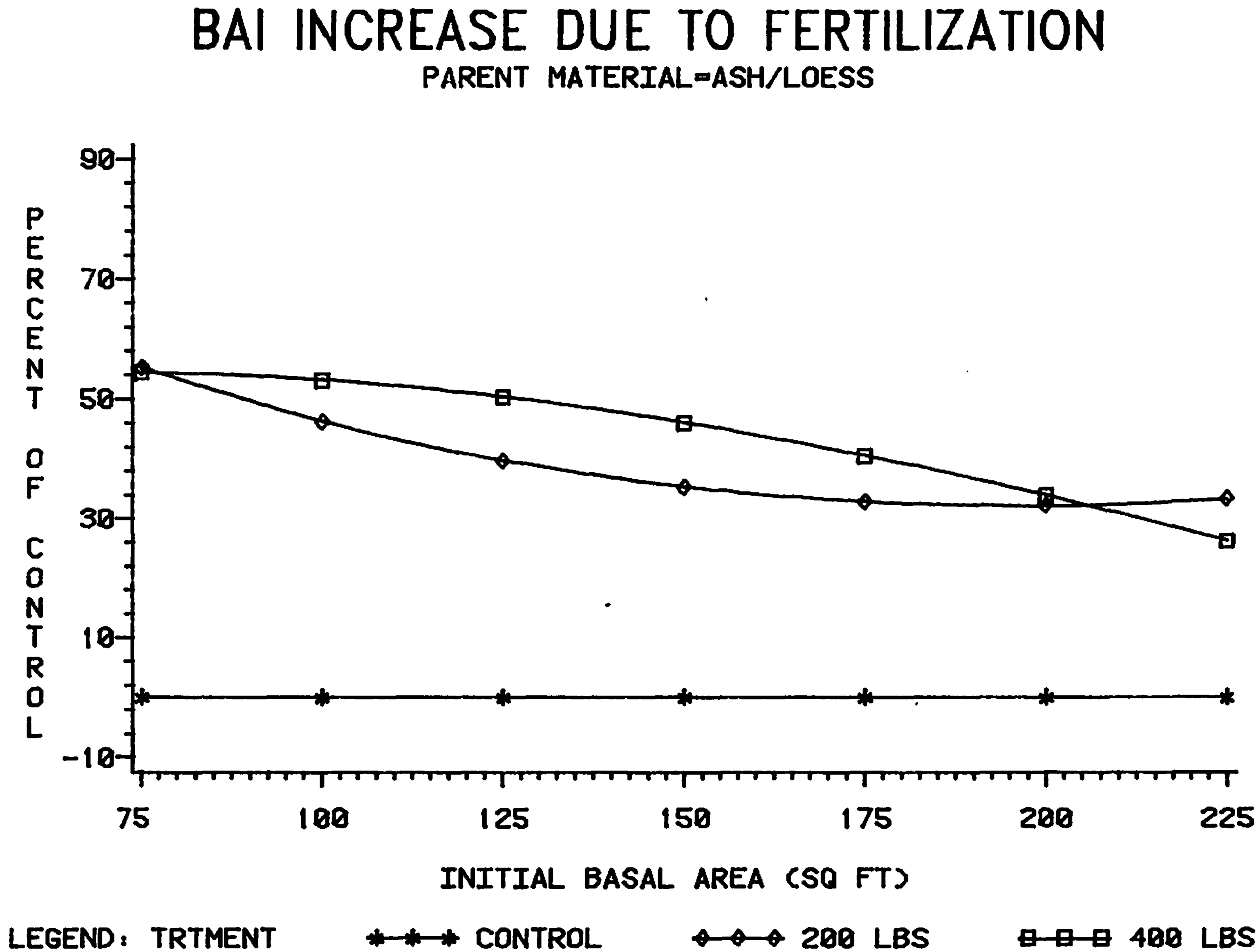


FIGURE 12. THE RELATIONSHIP BETWEEN INITIAL BASAL AREA PER ACRE AND RELATIVE BASAL AREA RESPONSE BY TREATMENT FOR BASALTIC PARENT MATERIALS.

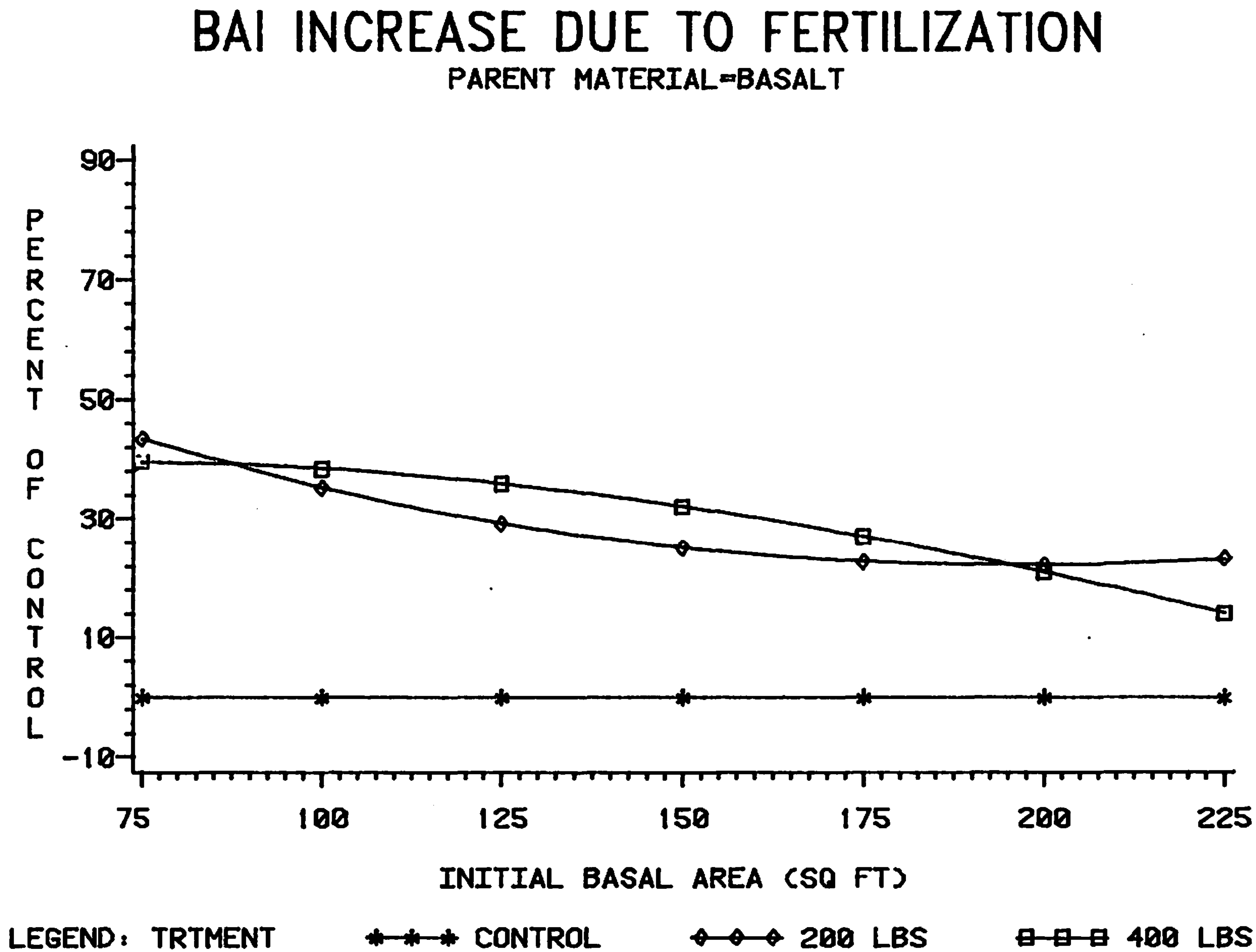


FIGURE 13. THE RELATIONSHIP BETWEEN INITIAL BASAL AREA PER ACRE AND RELATIVE BASAL AREA RESPONSE BY TREATMENT FOR GLACIAL TILL PARENT MATERIALS.

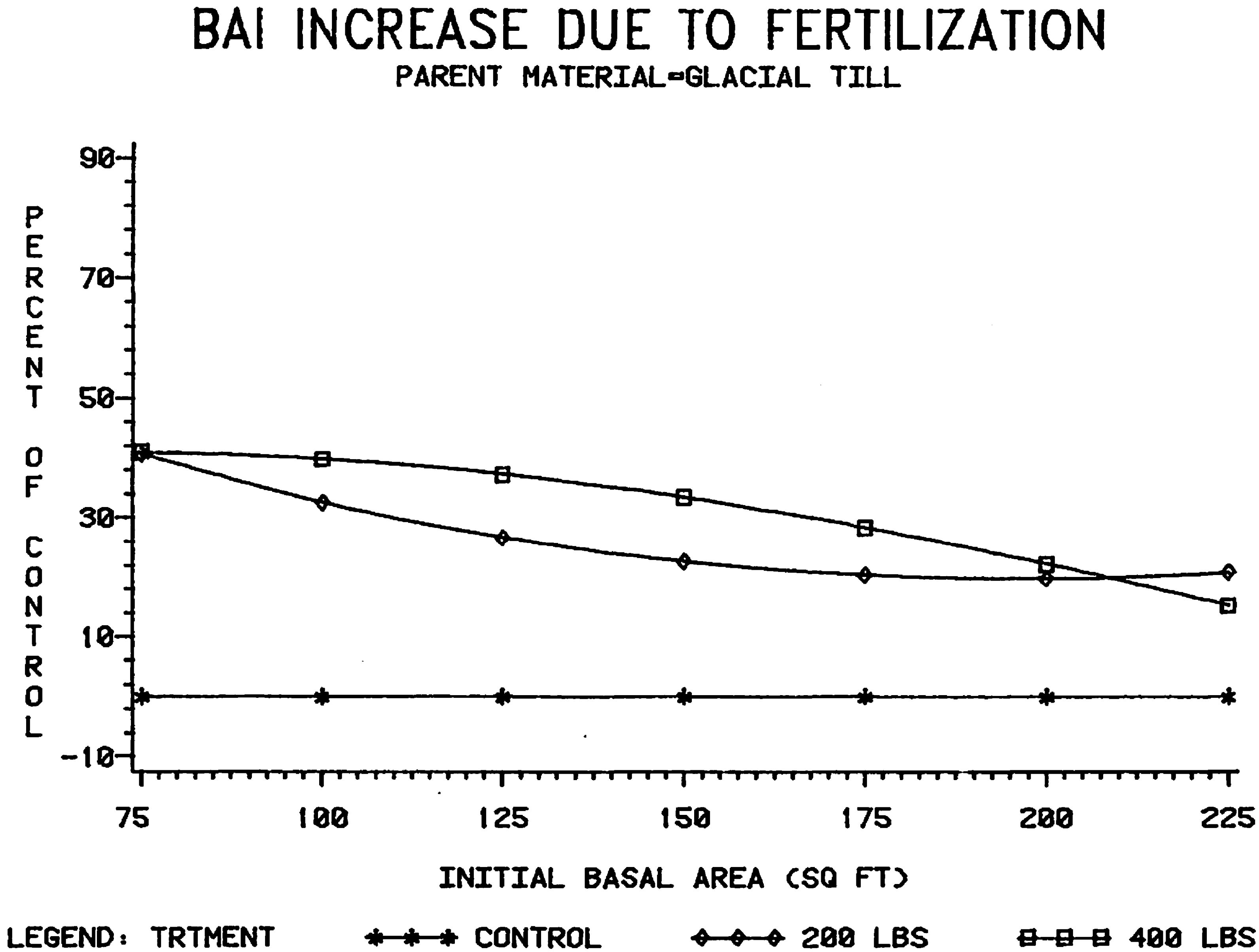


FIGURE 14. THE RELATIONSHIP BETWEEN INITIAL BASAL AREA PER ACRE AND RELATIVE BASAL AREA RESPONSE BY TREATMENT FOR ASH/METASEDIMENTS PARENT MATERIALS.

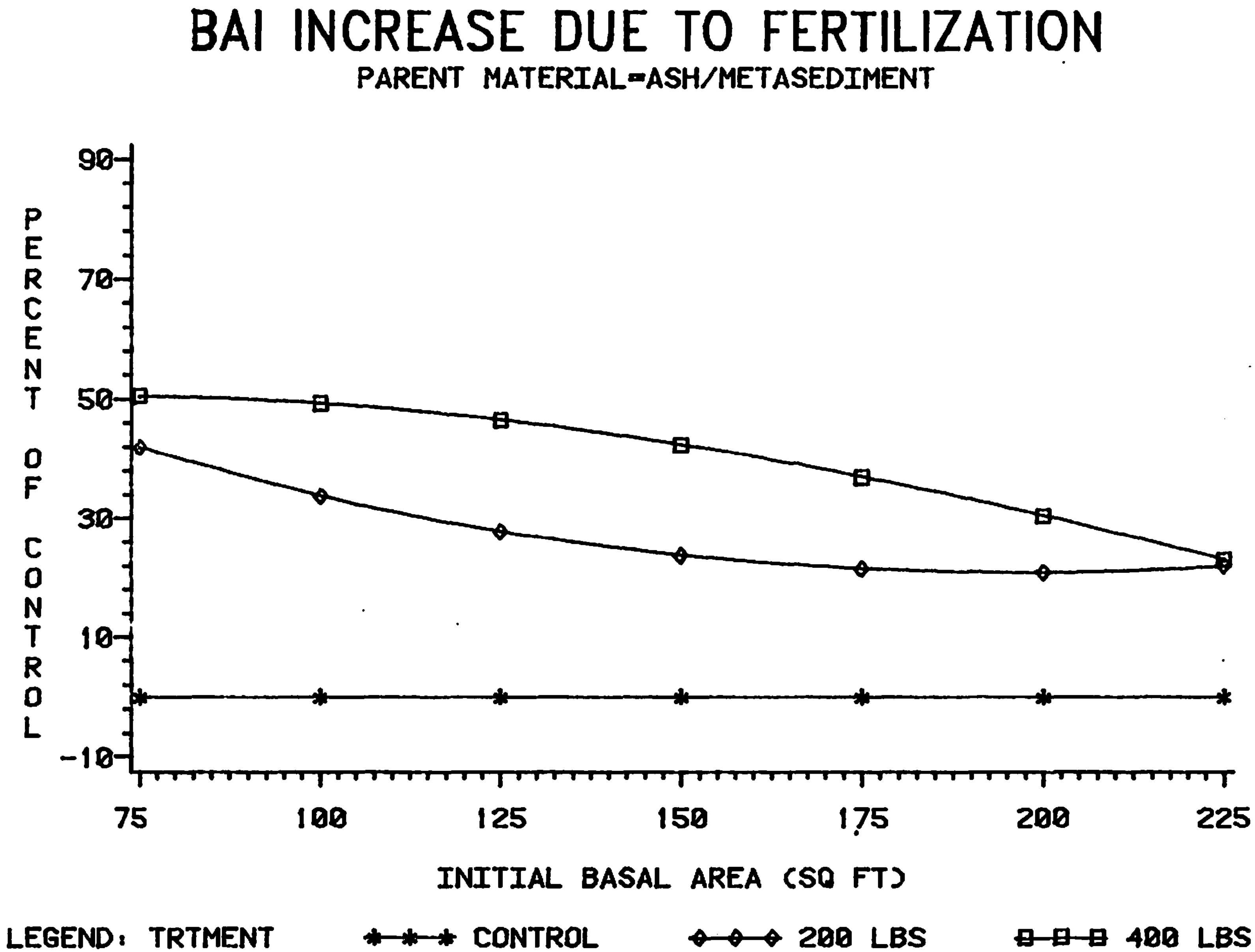


FIGURE 15. THE RELATIONSHIP BETWEEN INITIAL BASAL AREA PER ACRE AND RELATIVE BASAL AREA RESPONSE BY TREATMENT FOR VALLEY FILL PARENT MATERIALS.

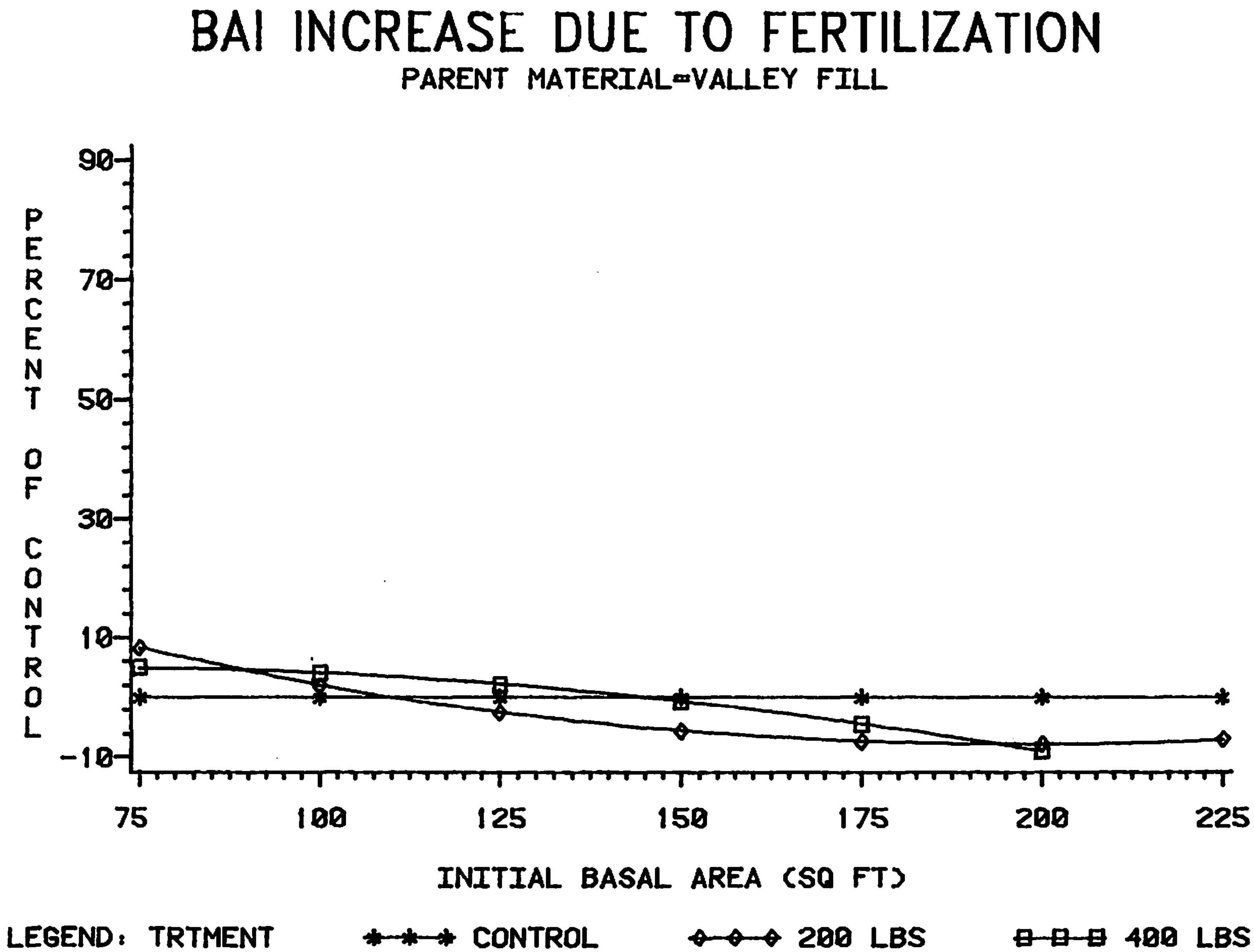


FIGURE 16. THE RELATIONSHIP BETWEEN INITIAL BASAL AREA PER ACRE AND RELATIVE BASAL AREA RESPONSE BY TREATMENT FOR COLLUVIUM PARENT MATERIALS.

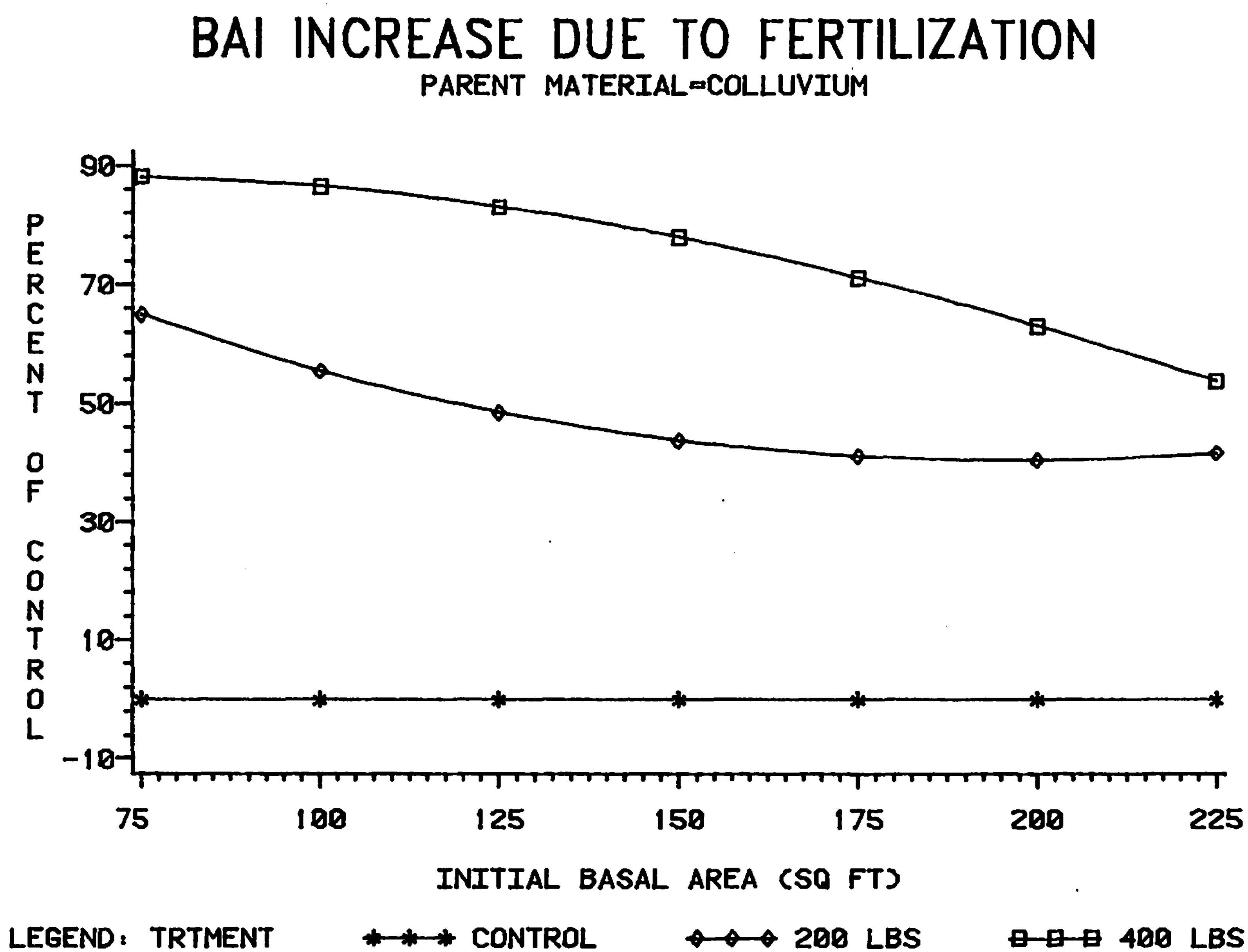


FIGURE 17. THE RELATIONSHIP BETWEEN INITIAL BASAL AREA PER ACRE AND RELATIVE BASAL AREA RESPONSE BY TREATMENT FOR ALLUVIUM PARENT MATERIALS.

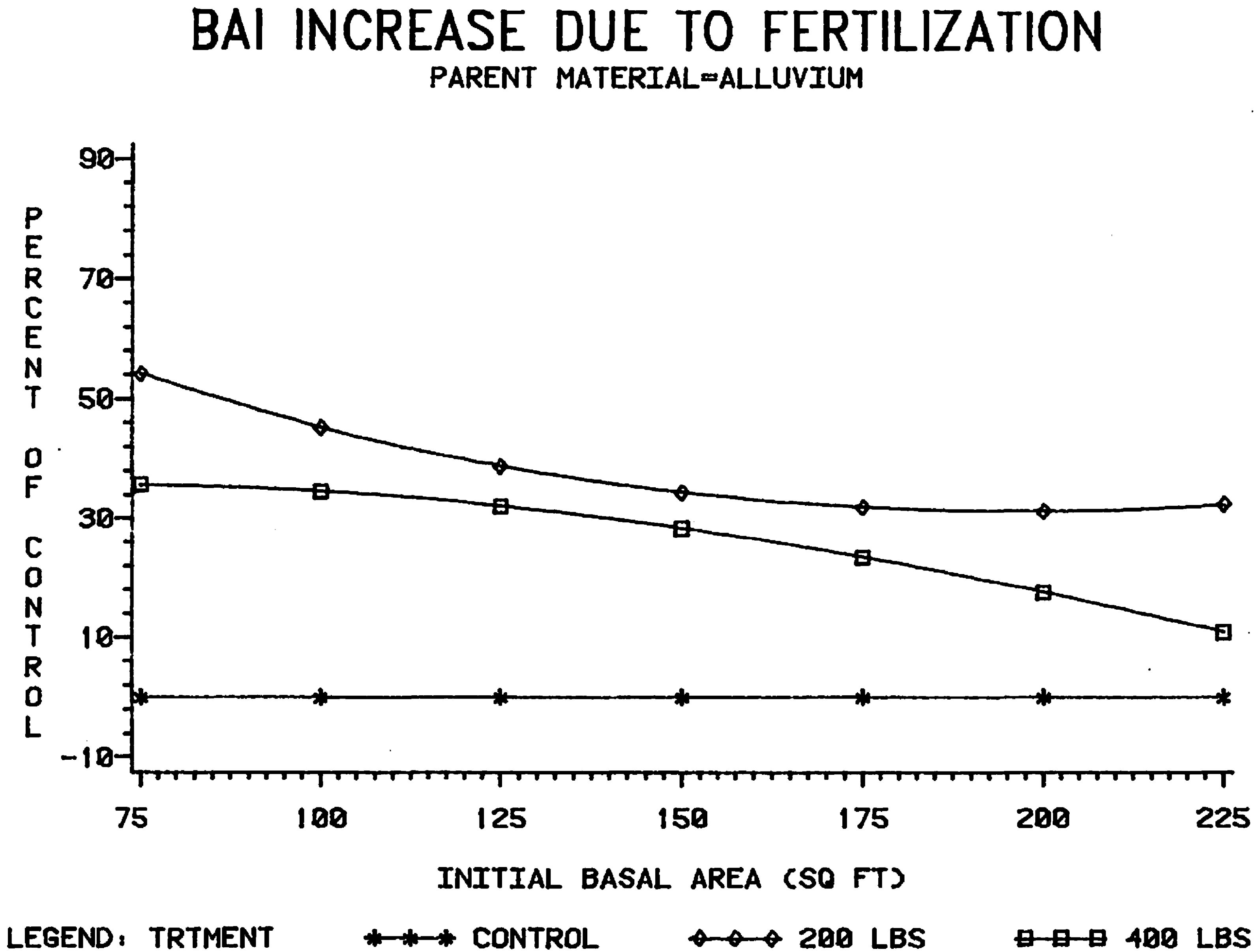


FIGURE 18. THE RELATIONSHIP BETWEEN INITIAL BASAL AREA PER ACRE AND RELATIVE BASAL AREA RESPONSE BY TREATMENT FOR SANDSTONE PARENT MATERIALS.

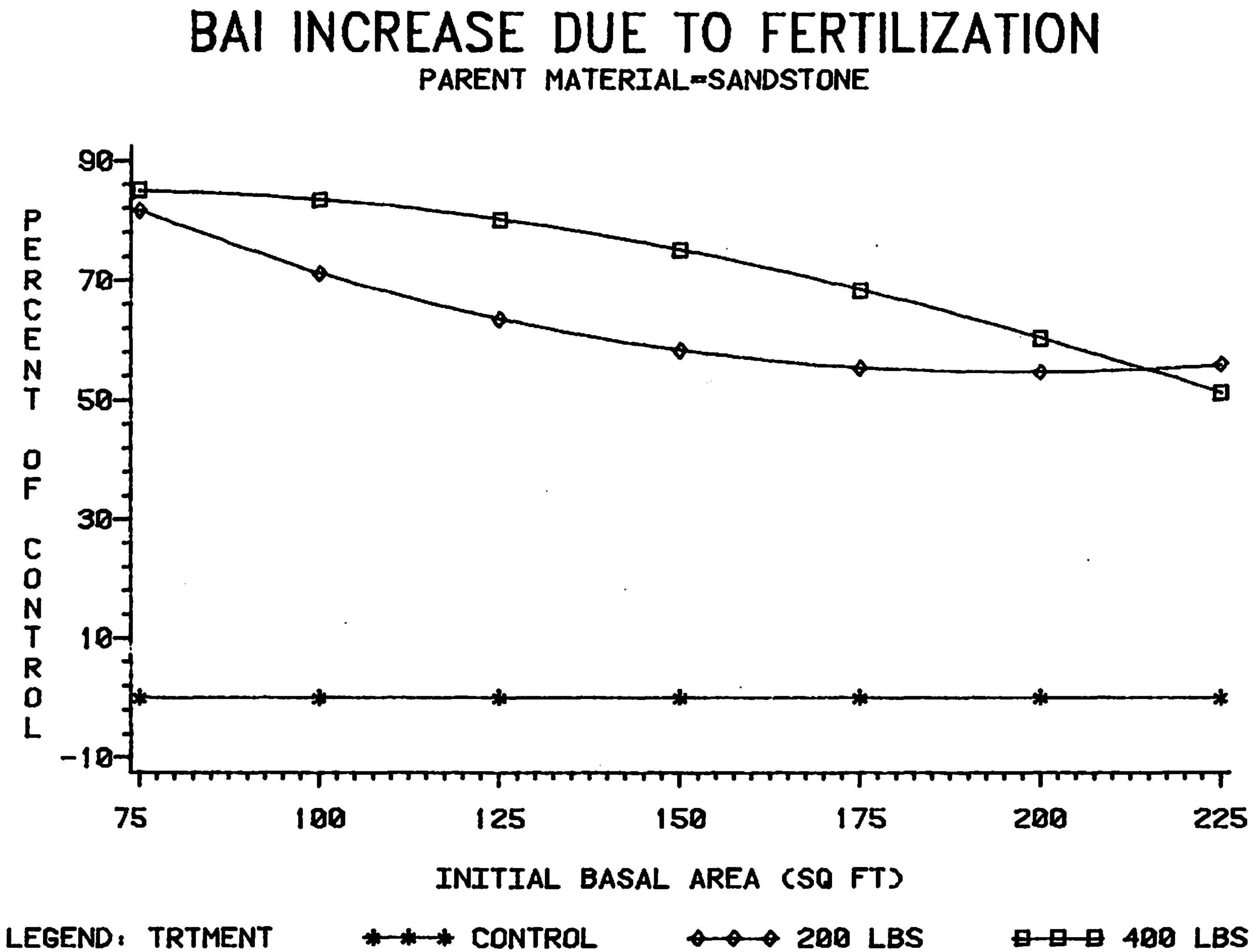


Table 11. Stand densities that predict a thirty percent two-year basal area growth response by treatment and soil parent material.

Parent material	Initial Basal Area (ft^2/ac) Treatment 200 lb/ac*	400 lb/ac*
Granite	91	172
Ash/loess	Exceeds	211
Basalts	122	163
Glacial till	109	169
Ash/metasediments	117	204
Valley fill	Below	Below
Colluvium	Exceeds	Exceeds
Alluvium	195	135
Sandstone	Exceeds	Exceeds
Overall		

* Exceeds indicates that response was greater than 30 percent across the basal areas sampled.
Below indicates that response was less than 30 percent across the basal areas sampled.

Development of an alternative predictive model of response:

As of this writing, we are working on a predictive model of response using mineralizable nitrogen (Min_N) as a predictor variable. Preliminary results are very encouraging. Hopefully, the results will be presented at the annual meeting of the Cooperative.

Results of the "Weetman" Foliar Diagnostic Technique for the 1982 installations:

In 1984 we made predictions of growth response for each 1982 installation based on new foliage collected one year after the fertilizer treatments were applied. The nitrogen/needle weight graphs are included in section III of the Technical Documentation Report. The predictions were based on interpreting graphs showing change in needle weight versus change in nitrogen content of the needles (Weetman 1981). Based on these graphs, each installation was categorized as: yes--a responder to treatment; no--a nonresponder; or maybe. The average adjusted (for density) two-year basal area growth response of installations predicted to be in the three response classes were compared. There was no statistically significant difference in the average growth response for the three predicted classes. The average adjusted basal area responses for both the 200 and 400 lb treatments for the three classes are given in Table 12. The average for the "maybe" category was lower than the other two, almost significantly lower. However, this is not a particularly useful finding. As with the previous analysis for the 1981 installations, the 1982 stands were not correctly classified using the "nitrogen/needle weight" graphs based on two-year growth response. The technique is based on two factors, the change after nitrogen treatment in foliar nitrogen concentrations and change in needle weight one year after treatment. Responding stands should theoretically have both an increase in nitrogen and in needle weight. Just as for the 1981 stands, essentially all of the 1982 installations showed substantial increases in foliar nitrogen concentrations, including "nonresponders." This again indicates that a failure of the trees to take up the nitrogen was not a factor in explaining the nonresponse.

Table 12. Two-year average adjusted basal area per acre increment by treatment and nitrogen/needle weight predicted response class for the 1982 installations.

Predicted response class	Treatment	
	200 lb/ac (ft^2/ac)	400 lb/ac (ft^2/ac)
Yes	3.01	3.70
No	2.99	5.05
Maybe	2.07	1.70

Change in needle weight is the most important factor in the prediction of response. The technique is based on a direct relationship beteeen increasing needle weight for first year foliage collected one year after treatment and increasing growth response to treatment. The 1982 stands showed the same relationships as the 1981 stands: many of the installations that had the largest growth response had no change in needle weight, and conversely, many installations had large increases in needle weight and showed no growth response. Clearly, there are other factors in addition to foliar nitrogen concentrations and needle weights, that are operating to determine treatment response. Soil characteristics are indicated as being important for predicting response in results presented earlier in this report. The implications are that, on some soil types, the availability of other mineral nutrients or moisture interact with change in needle weights and nitrogen concentrations to explain response. The possible interactions will be discussed more fully at the annual meeting of the cooperative.

LITERATURE CITED

Monserud, R.A. 1984. Height growth and site index curves for inland Douglas-fir based on stem analysis data and forest habitat type. Forest Sci. 30:943-965.

Stage, A.R. 1976. An expression for the effect of slope, aspect, and habitat type on tree growth. Forest Sci. 22:457-460.

Weetman, G.F. and R.M. Fournier. 1981. Forest fertilization screening trials, interior of British Columbia: 1980 lodgepole pine, Douglas-fir and white spruce. Project report on file Faculty of Forestry University of British Columbia. 387 pp.