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Task 7

UNIVERSITY OF MARYLAND AT COLLEGE PARK

DEPARTMENT OF AGRONOMY

FINAL REPORT

to

THE MARYLAND DEPARTMENT OF NATURAL RESOURCES

from

THE SOIL CHEMISTRY LABORATORY
UNIVERSITY OF MARYLAND, COLLEGE PARK

Project Title:

RIPARIAN FOREST VEGETATION MANAGEMENT: CONTROL OF NITROGEN DISCHARGE INTO THE CHESAPEAKE BAY FROM GROUNDWATER

Period of Grant:
October 1, 1990 to December 31, 1991

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INTRODUCTION

In accordance with a Memorandum of Understanding between the Maryland Forest, Park, and Wildlife Service and the University of Maryland, research was conducted between January 1 and December 31, 1991 on questions about the efficacy of riparian forest vegetation to lower nitrate concentrations in groundwater flowing from agricultural land to surface waters of the Chesapeake Bay and its tributaries. Specific objectives of the 12-month research project were:

(1) Ascertain the effects of different types of riparian forest vegetation on nitrate concentrations in groundwater, especially regarding differences between non-leguminous and leguminous trees.

(2) Obtain information on the width of riparian buffer strips that is necessary in order to change the concentration of nitrate in groundwater.

(3) Identify seasonal fluctuations in riparian effects on groundwater nitrate concentrations.

(4) Relate results for 1991 with other results for groundwater monitoring beneath riparian zones for the period 1987 through 1990.

SITE DESCRIPTION

The field research was conducted on Wye Island, using riparian forests on the shore of the Wye Narrows. The location of Wye Island makes it ideal for this type of study because it is located approximately in the mid-latitudes of the Chesapeake Bay, where nitrate may become the limiting nutrient for eutrophication (Fig. 1).

Experimental plots of different forest vegetation management practices were established in October, 1988 (Fig. 2), and these included no cutting (controls), cutting just trees and leaving understory vegetation to grow (cut trees), and removal of all natural riparian vegetation (clear cut) and seeding to tall fescue, the grass that was seeded to the 18-ha field around which the riparian zones are located. The plots were replicated two to four times, depending on the constraints of the site.

A detailed soil survey (Fig. 3) was made of the site to establish how soil drainage class and series designation might interact with forest vegetation type and management to affect nitrate concentrations in groundwater. Groundwater depth was related to elevation of individual monitoring wells above sea level (Fig. 4) Monitoring wells were drilled in transects of each transect from the agricultural field into the riparian zone plot, as shown in Figs. 5 to 8). For the 1991 research, two additional wells were placed farther downslope toward the shoreline in transect 1B (Fig. 5) and two others were placed approximately 30 m out into the field from the "field wells" of transects 1C and IF (Fig. 5 and 6) These wells were placed far enough out from the riparian-field boundary to prevent riparian tree roots from having an effect on groundwater in that region of the field. A new, control plot was established in 1D, between plots 1C and 1E. This transect was closely-matched to 1B and 1C, but management treatments were different among the three (1B was clear cut, 1C was a cut-trees plot, and 1D was a control).

Figures 7 and 8 show well positions and soil series for the leguminous zone (zone 4) in which black locust trees dominated the riparian forest. The riparian zone here was shorter in length and width than was the non-leguminous zone, so fewer plots were established here. In addition, only two wells composed a transects, instead of three to five in the non-leguminous zone.

Figure 9 shows the dominant types of trees around the field before treatments were established. The only softwoods, loblolly pine, were found on the north side of the field, where a large gravel pit made it unwise to establish plots and monitoring wells to obtain reliable data.

PRELIMINARY RESULTS OF MONITORING GROUNDWATER

Effects of vegetation treatments on groundwater nitrate concentrations are summarized in Figs 10 to 30. These data provide background context for evaluation of the 1991 data funded specifically by DNR to address the above objectives.

RESULTS OF 1991 SAMPLING AND EXPERIMENTAL WORK

Effects of Different Types of Riparian Vegetation

When mean nitrate-N concentrations were calculated for all wells in different treatments, two patterns in the 1991 data were evident (Table 1). First, nitrate concentrations decreased 58% and 89% in the cut-tree and clear-cut plots, respectively, compared to the uncut controls containing the black locust trees. This result indicated that the black locust trees are acting as a source of NO_3 in groundwater, and their removal may be advisable from a groundwater protection point-of-view. Second, similar vegetation treatments resulted in 57 and 73 % increases in nitrate concentrations in the non-leguminous section. This result indicated that this type of riparian vegetation appeared to lower nitrate concentrations, and its removal may be detrimental to water quality entering the Bay.

These results for 1991 were in agreement with those of earlier years (Fig. 10-30).

Observations of buffer width effects on nitrate concentrations

The most important observation related to the effective width of the buffer strips was that the influence of the riparian vegetation was measured at least 10 m out into the agricultural field from the visible riparian zone-field margin. This was particularly evident in the leguminous zone where cutting the trees resulted in decreases in nitrate in the "field wells" positioned outside of the riparian zone (Table 2). It was also observed that black locust shoots came up and grew rapidly in the field as much as 30 m. from the field margin following cutting of the main stems in the riparian zone. These were particularly evident in 1991, and probably contributed NO_3 when root nodules were sloughed or when leaves were dropped in the fall.

Effects of buffer strip width in 1991 were not as clear as they were in earlier years, perhaps because of high rainfall. The cutting treatments in the non-leguminous zone did raise nitrate concentrations in the field wells (Table 2), as was evident in the riparian wells also. Despite these trends, it was not possible to identify a "minimum width" that would be needed to attenuate nitrate in groundwater. The new wells positioned farther out in the field had mean concentrations of 5.6 and 2.1 mg NO_3-N/L, not far different from those in the field wells closer to the field margin.

There was no riparian effect evident in the leguminous zone, but the nitrate concentrations were lower in the cut treatments than in the controls. Regrowth of black locust trees did raise nitrate concentrations, however, as discussed above.

Seasonal patterns in nitrate concentrations

Although fluctuations were small, seasonal patterns showed a slightly greater effect of the riparian, non-leguminous vegetation during the winter than in the summer. In the treatments in which the vegetation was cut, the variation in the nitrate concentrations increased, so seasonal patterns were not as clear as in the controls. New research is being initiated by injecting nitrate and chloride salts into six wells at the site, and the groundwater concentrations will be monitored over time to identify seasonal effects.

CONCLUSION

Results of this research funded by DNR in 1991 have corroborated earlier patterns in nitrate concentrations in groundwater. The most dramatic effect is shown by the black locust trees acting a source of nitrate. Another effect is that when these trees are cut, nitrate concentrations decrease. When non-leguminous trees are cut, nitrate concentrations increase.

More research needs have been identified as a result of this year's effort:

(1) soil type x vegetation interactions may be central to predicting riparian zone behavior with respect to groundwater

(2) buffer width effects remain unclear, especially with respect to tree root influences.

(3) effects of re-planting trees in riparian areas has not been investigated, and may be an important area for future management of shoreline ecosystems to protect water quality.

(4) seasonal patterns are still unclear, but the data does show that winter may be the most important season for nitrate attenuation in groundwater. This is especially important for Bay water quality because this is also the season when groundwater recharge below agricultural land may leach nitrate downward and toward surface waters.

Table 1. Effects of Non-Leguminous and Leguminous Riparian Vegetation Management on Groundwater Nitrate Concentrations in 1991

	Type of Tree	
	Non-Leguminous	Legume
Cutting Treatment	mg NO_3-N/L (mean ± standard error)	
No cutting	3.0 ± 0.3	3.8 ± 0.6
Cut trees only	4.7 ± 0.8	1.6 ± 0.9
Clear cut/plant fescue	5.2 ± 0.6	0.4 ± 0.1

Table 2. Groundwater nitrate concentrations in field wells (FW: 10 m into field from margin) and in first (RZ1: 5 m from field margin into riparian zone) and second riparian wells (RZ2: 5 m closer to shoreline from first riparian well) of non-leguminous and leguminous sections of riparian zones. Values are means ± standard errors.

	Type of Vegetation							
	Non-Leguminous				Leguminous			
	Well Position							
		FW	RZ1	RZ2		FW	RZ1	RZ2
	mg NO_3-N/L							
Cutting Treatment								
No cutting		3.0	2.8	2.9		2.9	4.8	--*
	±	0.2	0.7	1.0	±	0.4	0.6	--
Cut trees		4.6	4.4	5.8		0.1	0.1	--
	±	1.7	1.6	1.0	±	0.0	0.0	--
Clear cut		6.3	5.3	4.8		0.4	0.4	--
	±	1.8	1.2	2.4		0.2	0.3	--

*no wells at this position

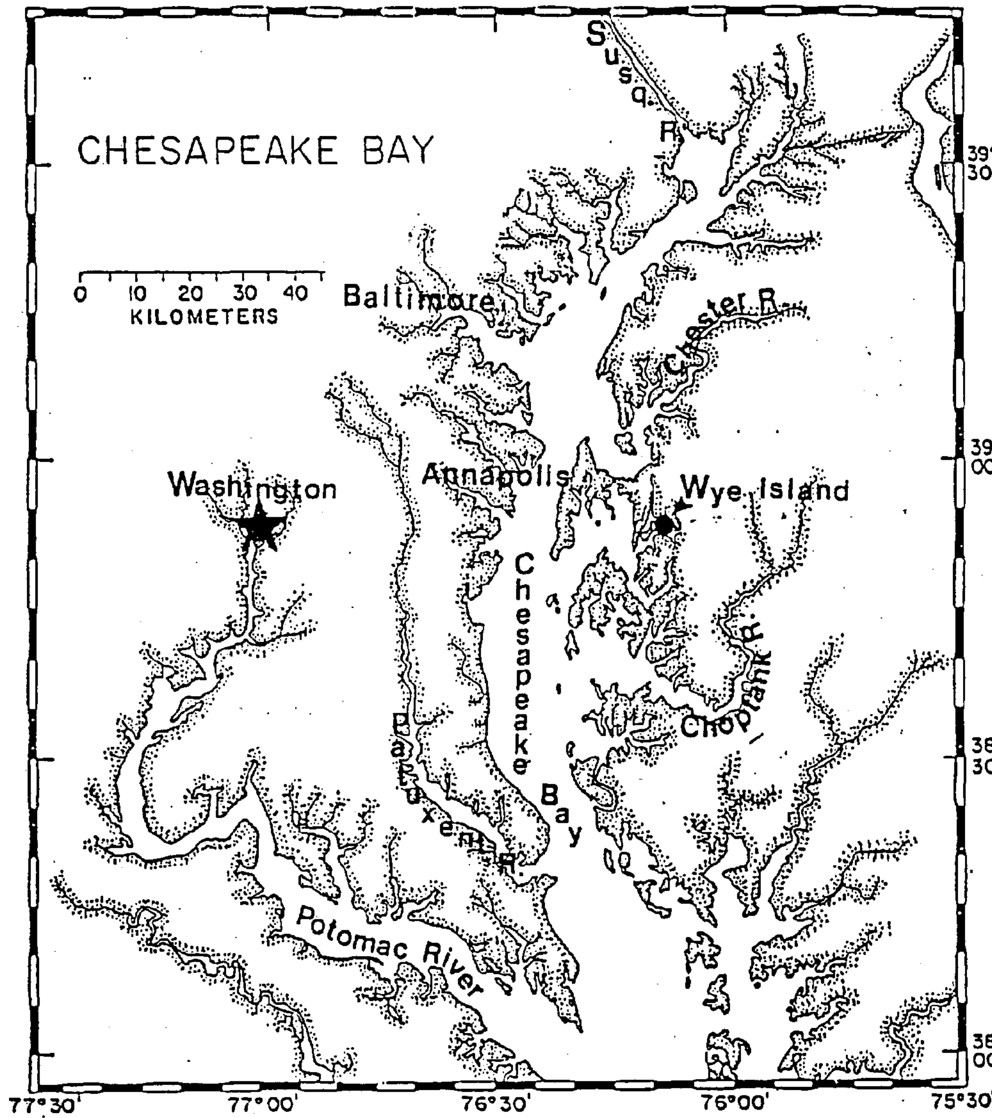

Figure 1. Location of the Wye Island Research Site within the Chesapeake Bay watershed of Maryland.

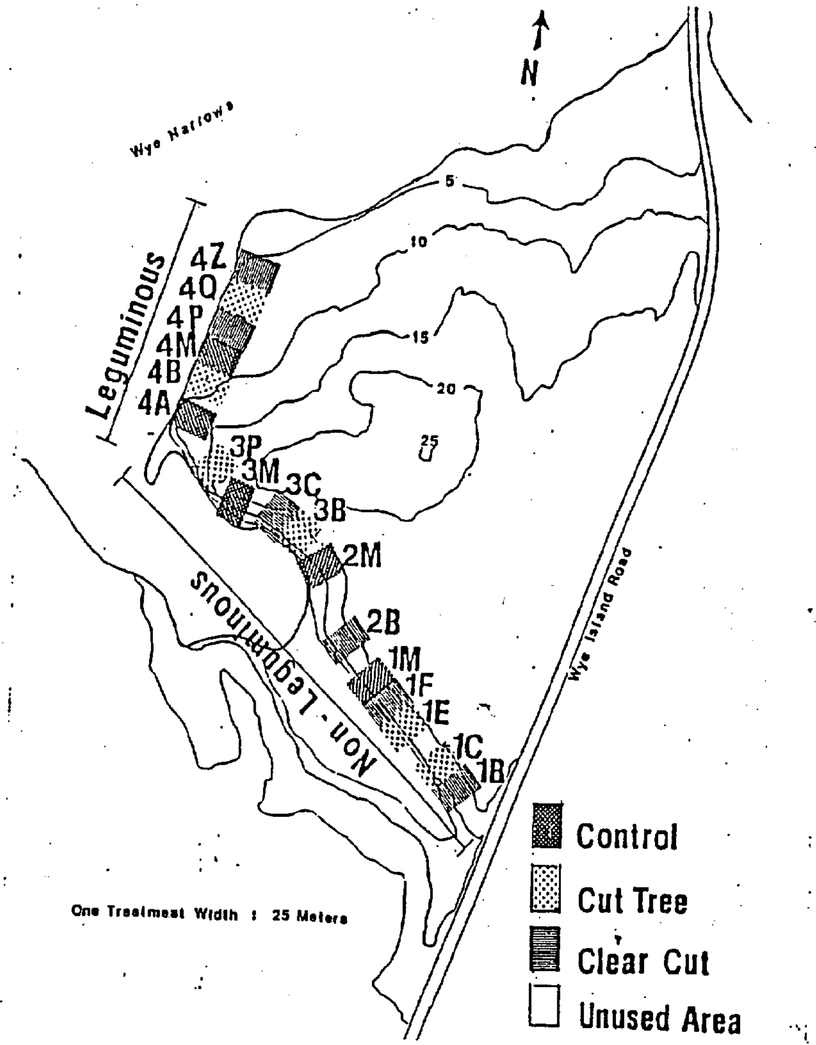

Figure 2. Location of riparian vegetation management treatments (control, clear-cut, cut-tree) for both Non-Leguminous Zones.

Legend for Soil Maps, Closeups of Soil and Well Location, and Well Transect Profiles.

Soil Type

Downner sandy loam

Fallingston sandy loam

Sassafras sandy loam

Bibb silt loam

Woodstown sandy loam

Tidal Marsh

Unnamed sandy loam

Unmapped Land Area

Labels

▲ Well Location

□ Soil Pit

△ Soil Boring

Gravel Pit

Stream

5 Elevation (Interval - 5 ft.)

FE Field Edge

SS Soil Surface

WT Watertable

SL Sealevel

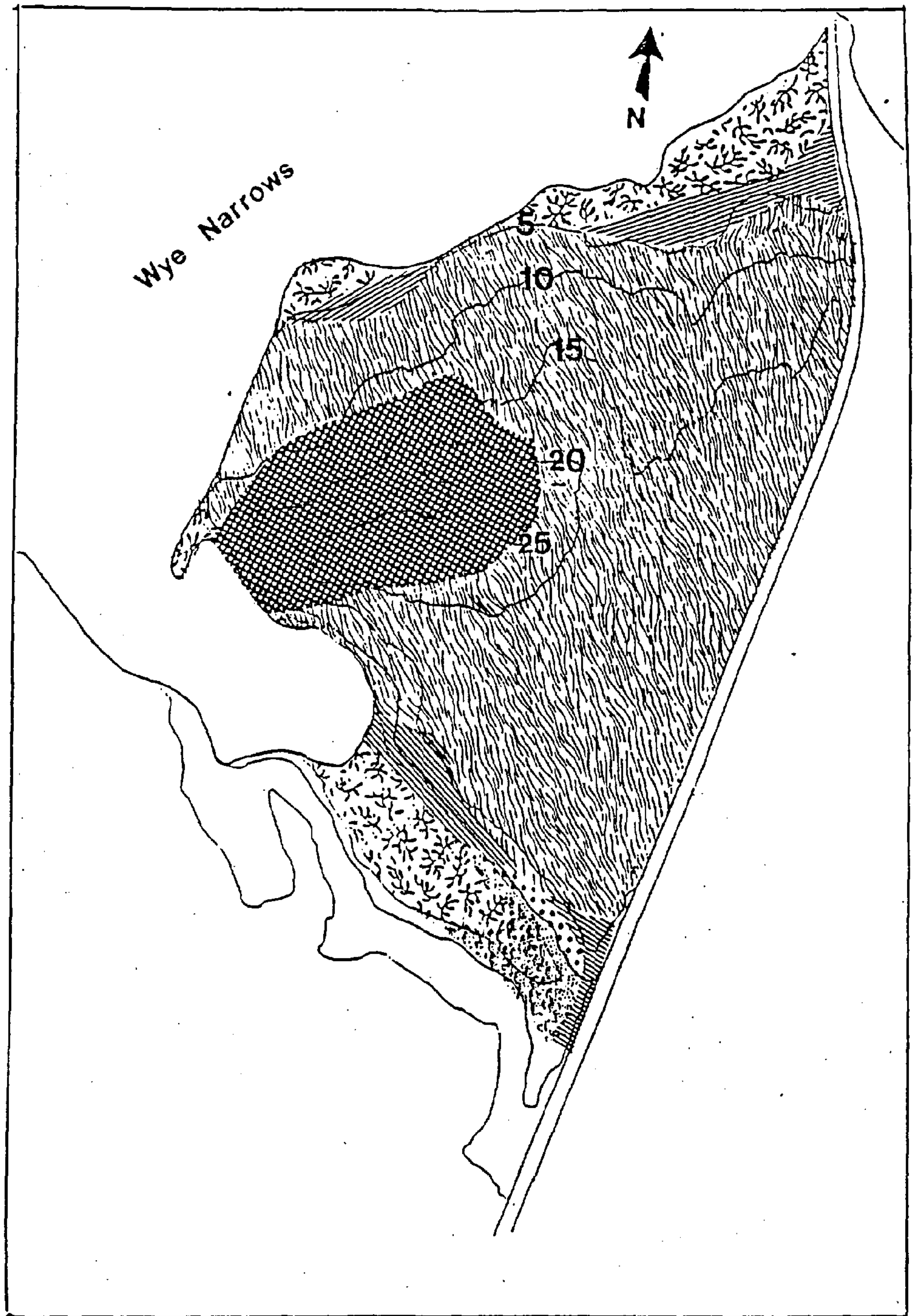

Figure 3. Soil map of the Wye Island Research Site illustrating the diverse soil types present within the riparian and agricultural area. Scale: 1cm = 12 m.

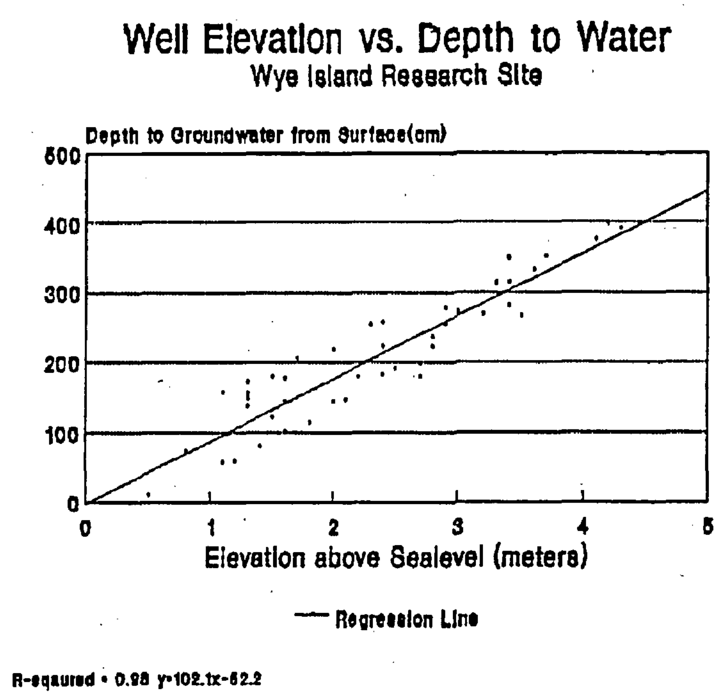

Figure 4. Regression line for groundwater depth from the soil surface in relation to elevation changes in respect to sea level.

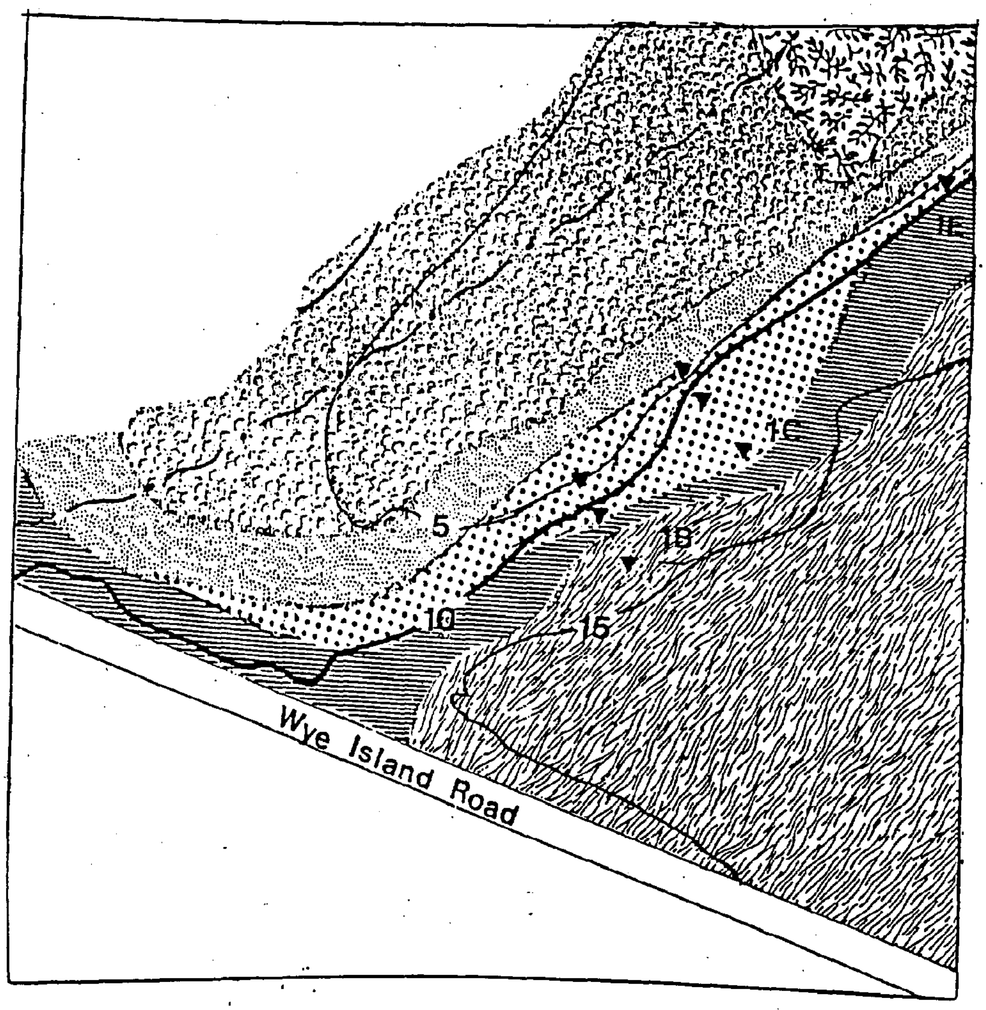

Figure 5. Closeup of riparian well transects IB, IC, and IE, indicating well location, soil type, and elevation (ft). Scale: 1cm - 12m.

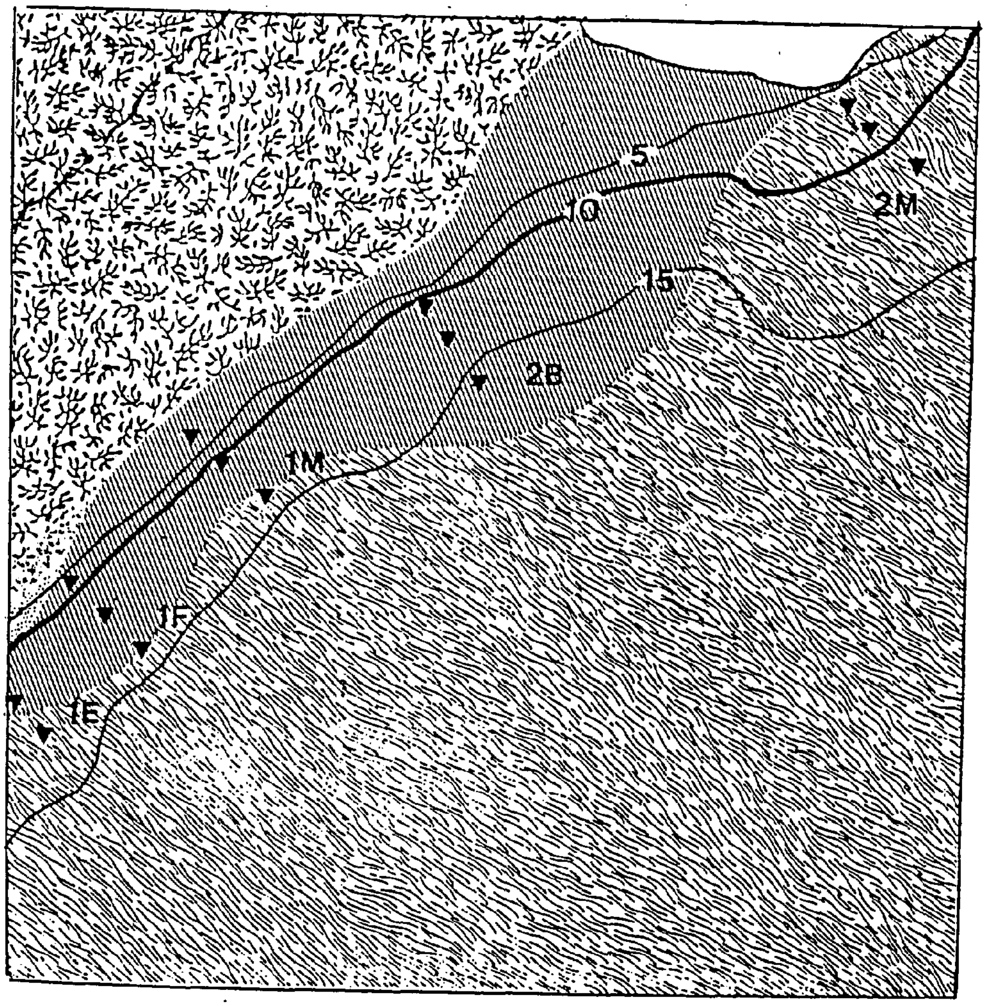

Figure 6. Closeup of riparian well transects IF, IM, IIB, and IIM, indicating well location, soil type, and elevation (ft). Scale: 1cm = 12m.

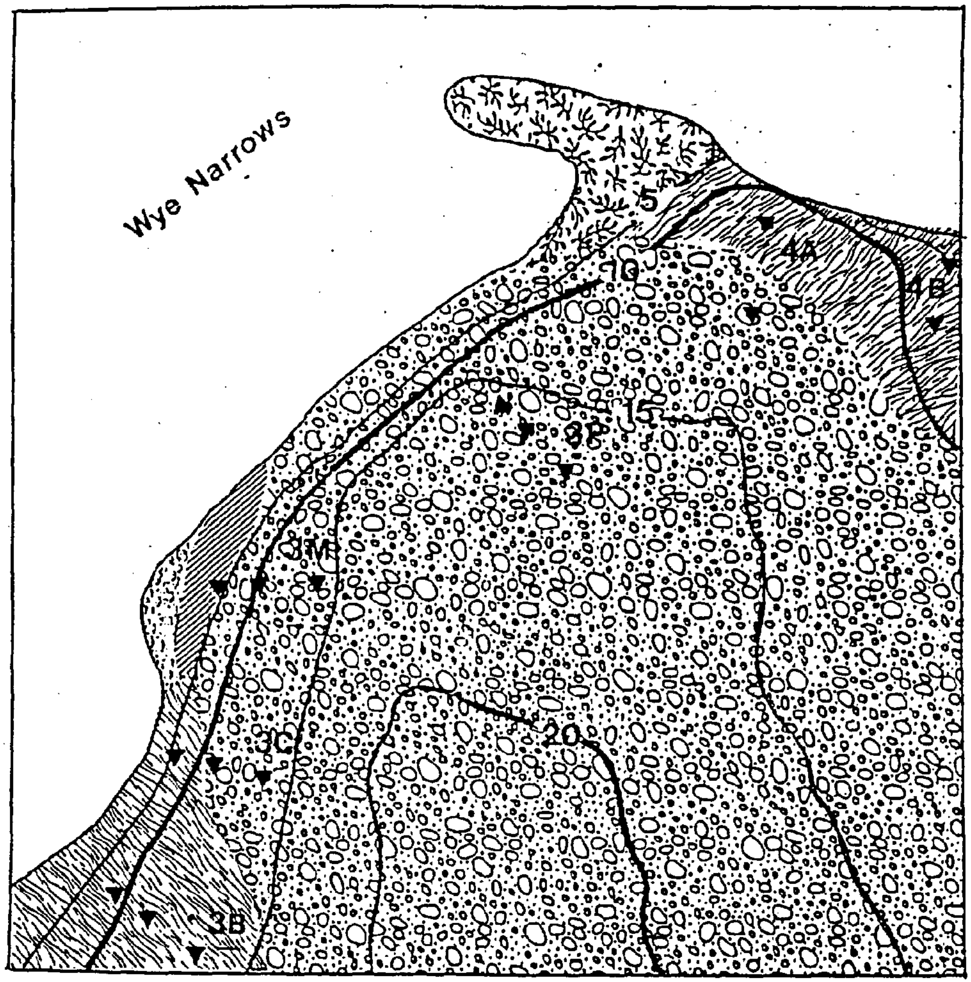

Figure 7. Closeup of riparian well transects IIIB, IIIM, IIIP, IVA, and IVB, indicating well location, soil type, and elevation (ft). Scale: 1cm = 12m.

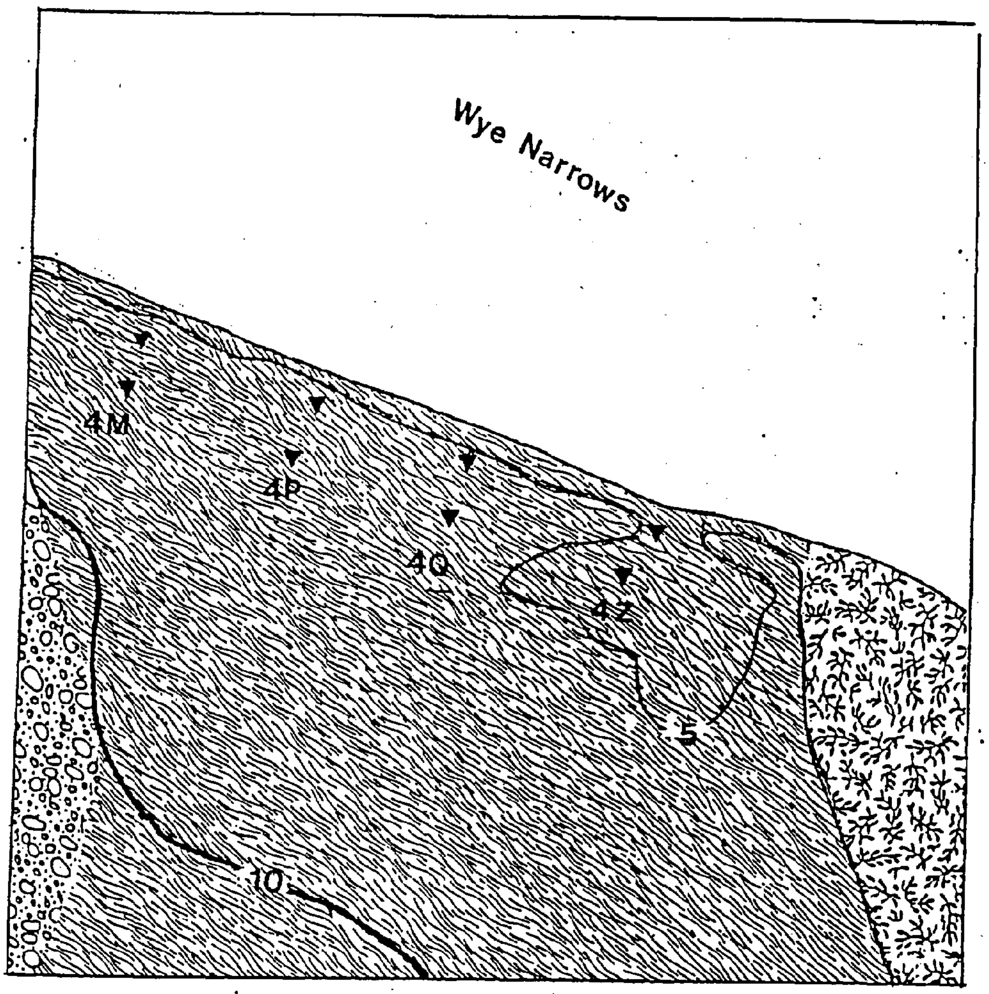

Figure 8. Close up of riparian well transects IVM, IVP, IVQ, and IVZ, indicating well location, soil type, and elevation (ft). Scale: 1cm = 12m.

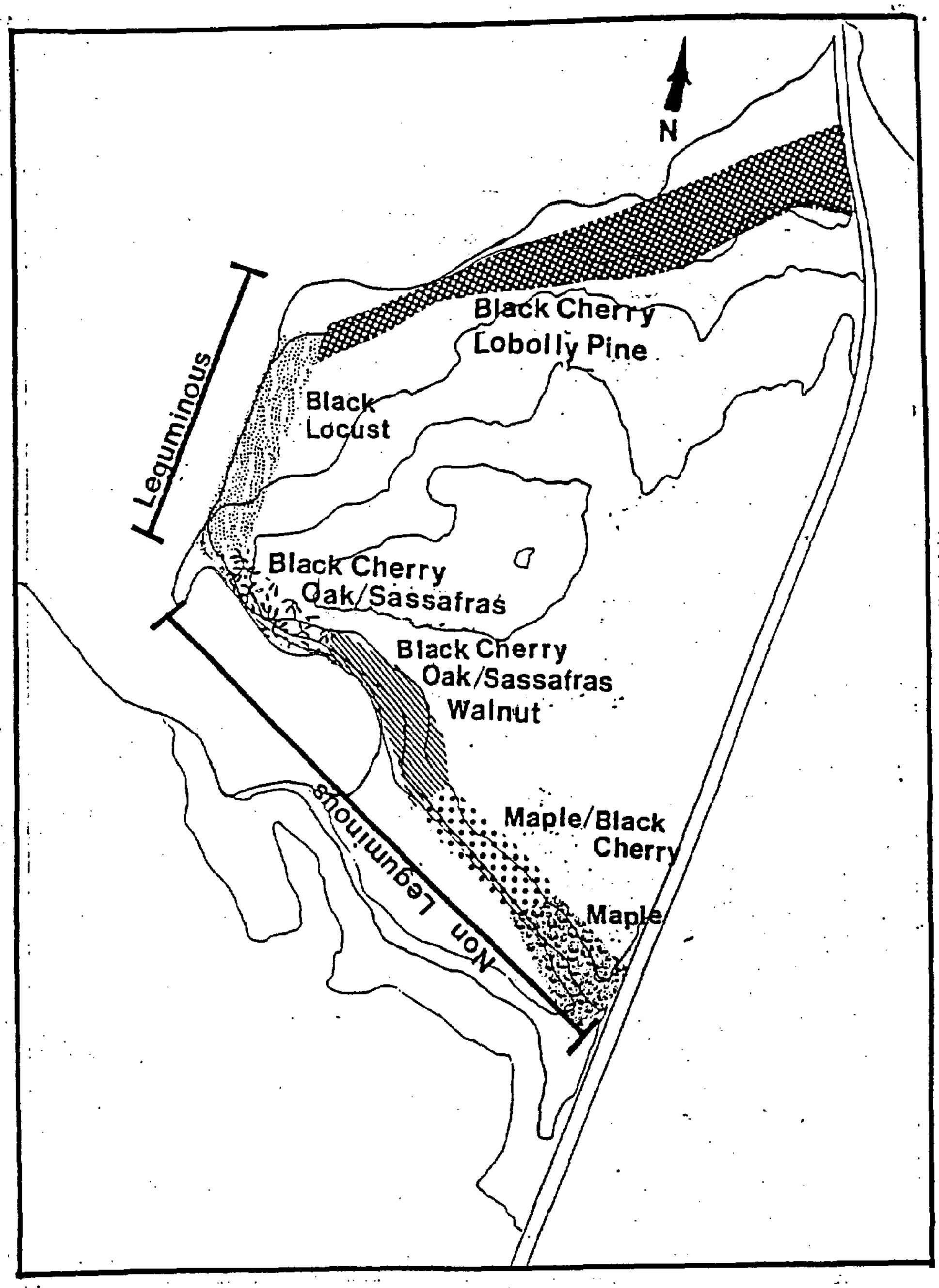

Figure 9. Types of vegetation present before the establishment of riparian vegetation management transect in October, 1898.

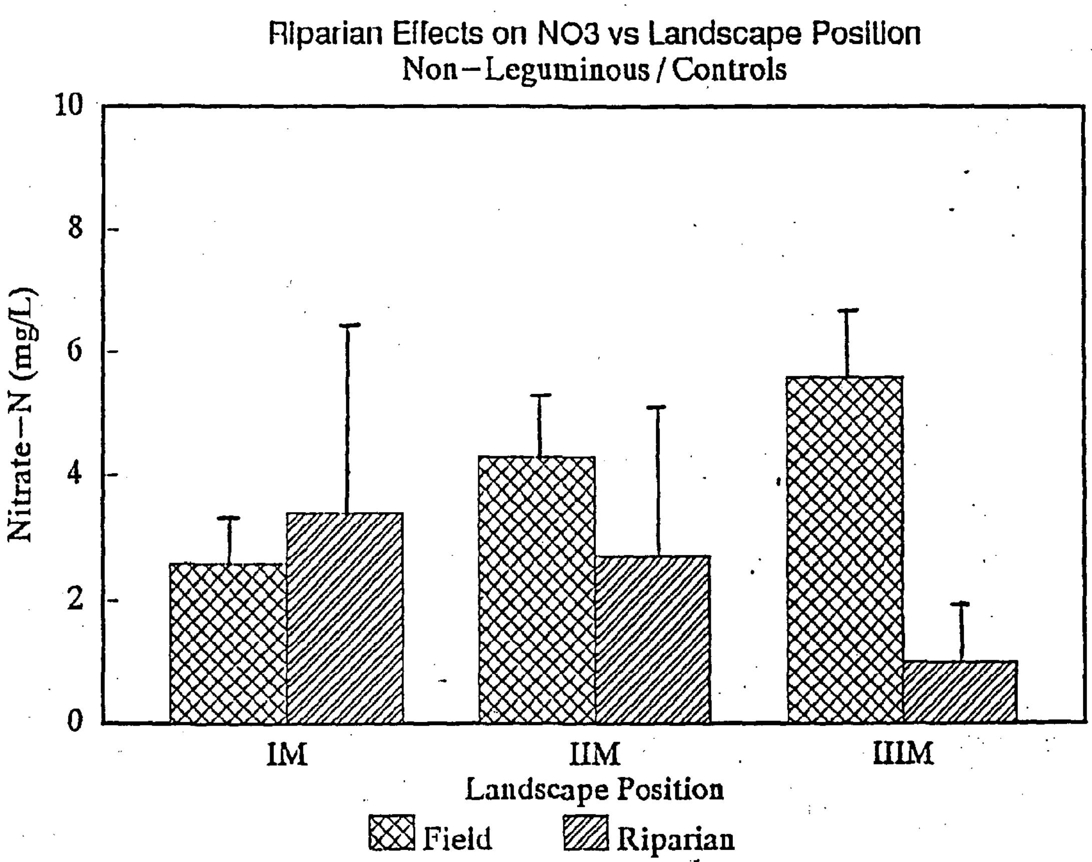

Figure 10. Mean NO_3 concentration in Non-Leguminous control transect, IM, IIM, and IIIM as a function of management treatment and well landscape position.

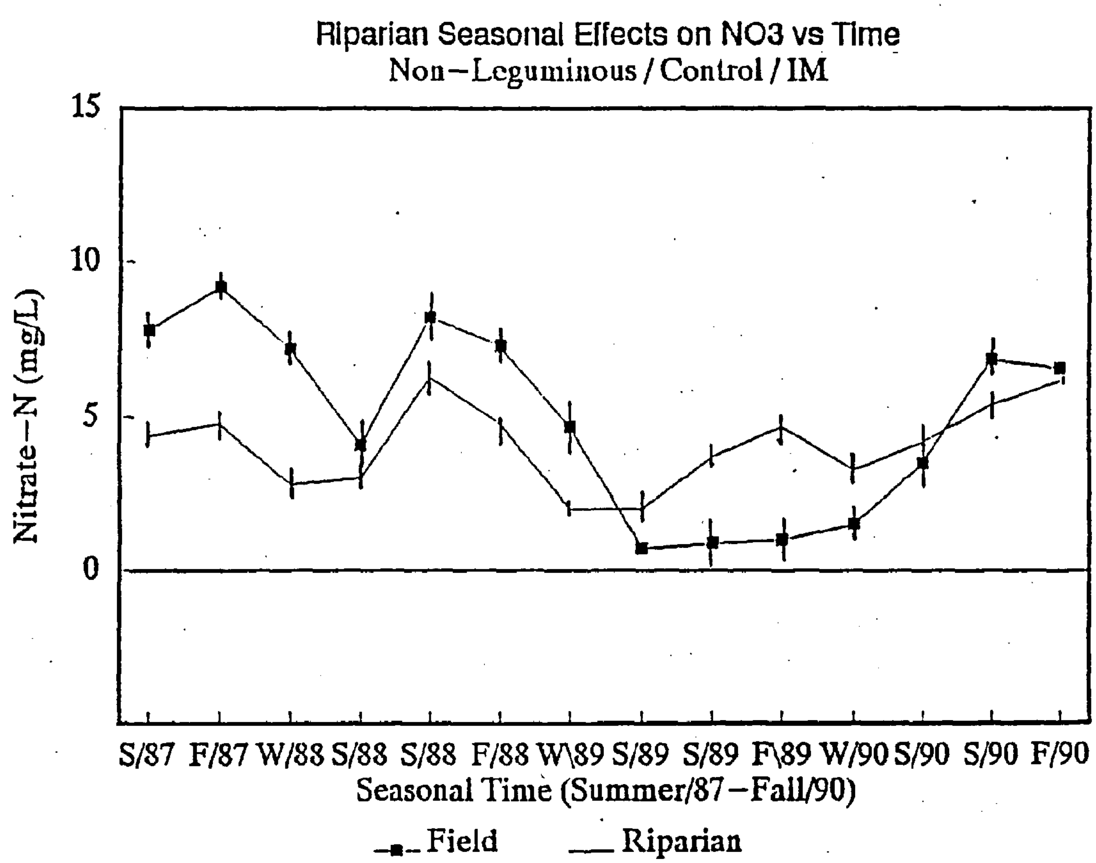

Figure 11. Mean seasonal riparian effects on NO_3 concentration in Non-Leguminous, control transect IM from Summer/87 to Fall/90.

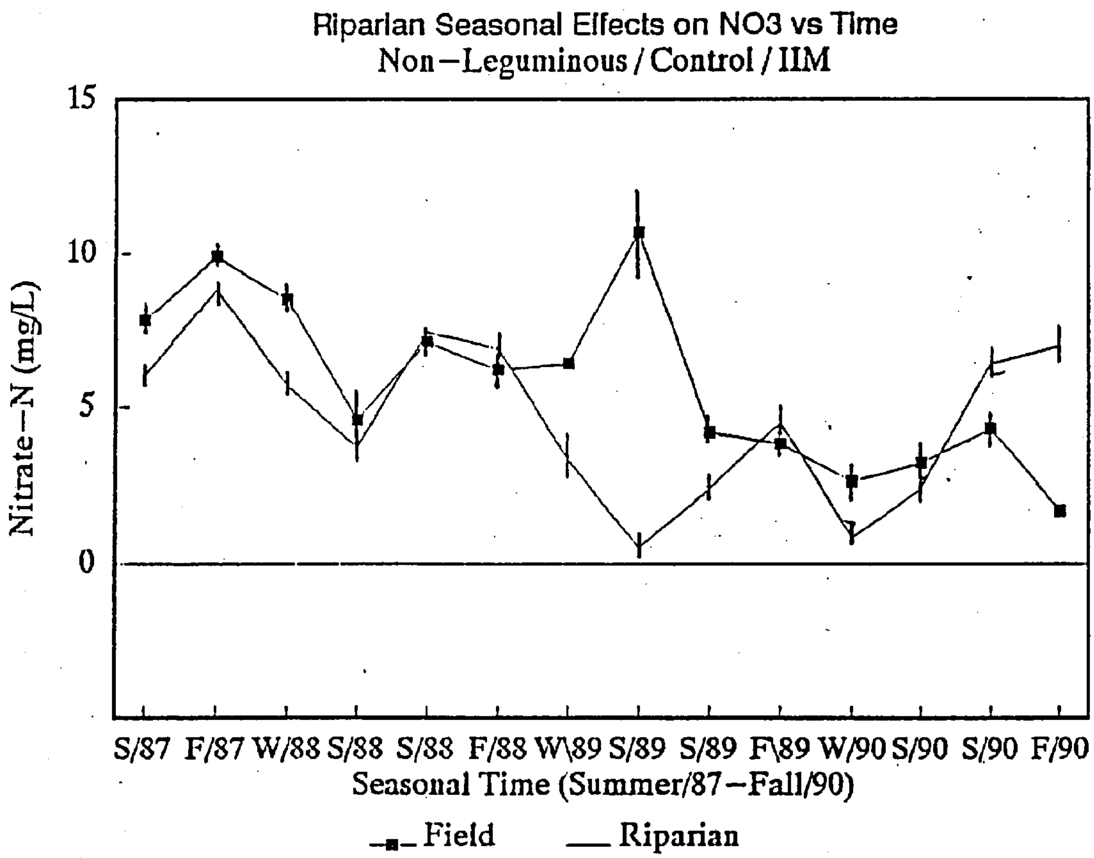

Figure 12. Mean seasonal riparian effect on NO_3 concentration in Non-Leguminous, control transect IIIM from Summer/87 to Fall/90.

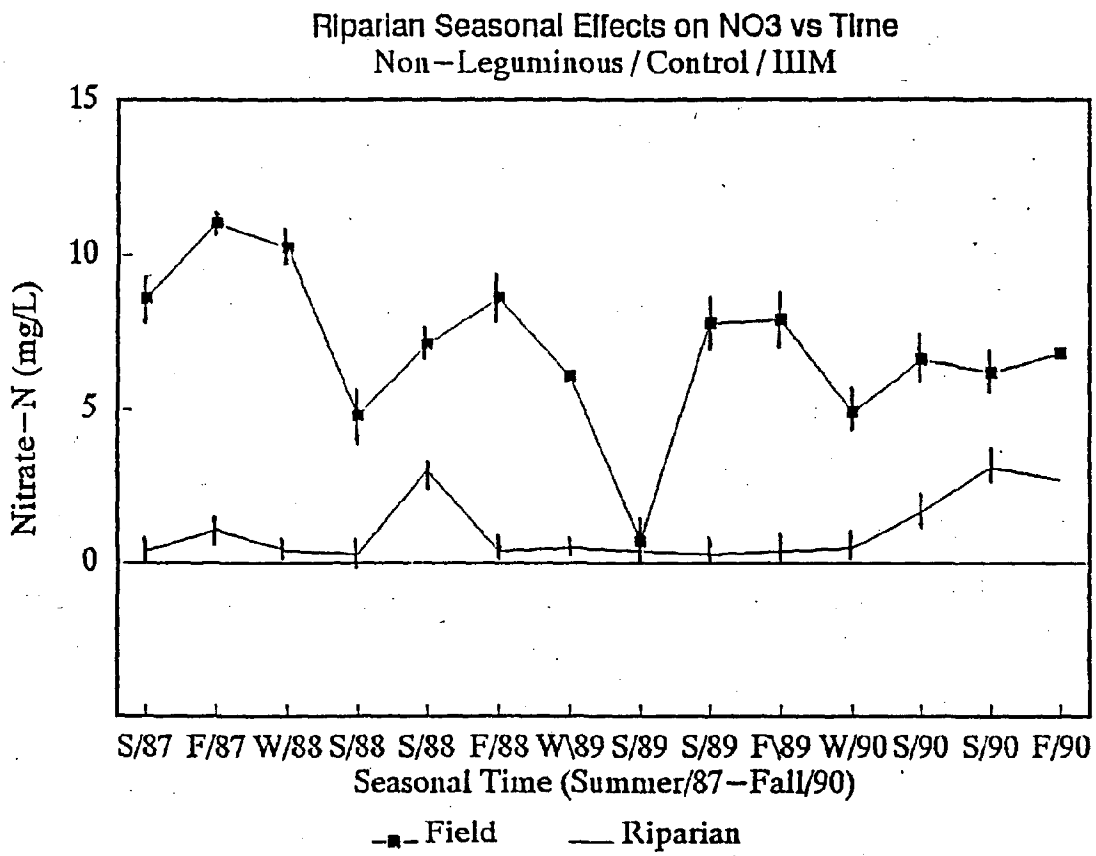

Figure 13. Mean seasonal riparian effects on NO_3 concentration in Non-Leguminous, control transect IIIM from Summer/87 to Fall/90.

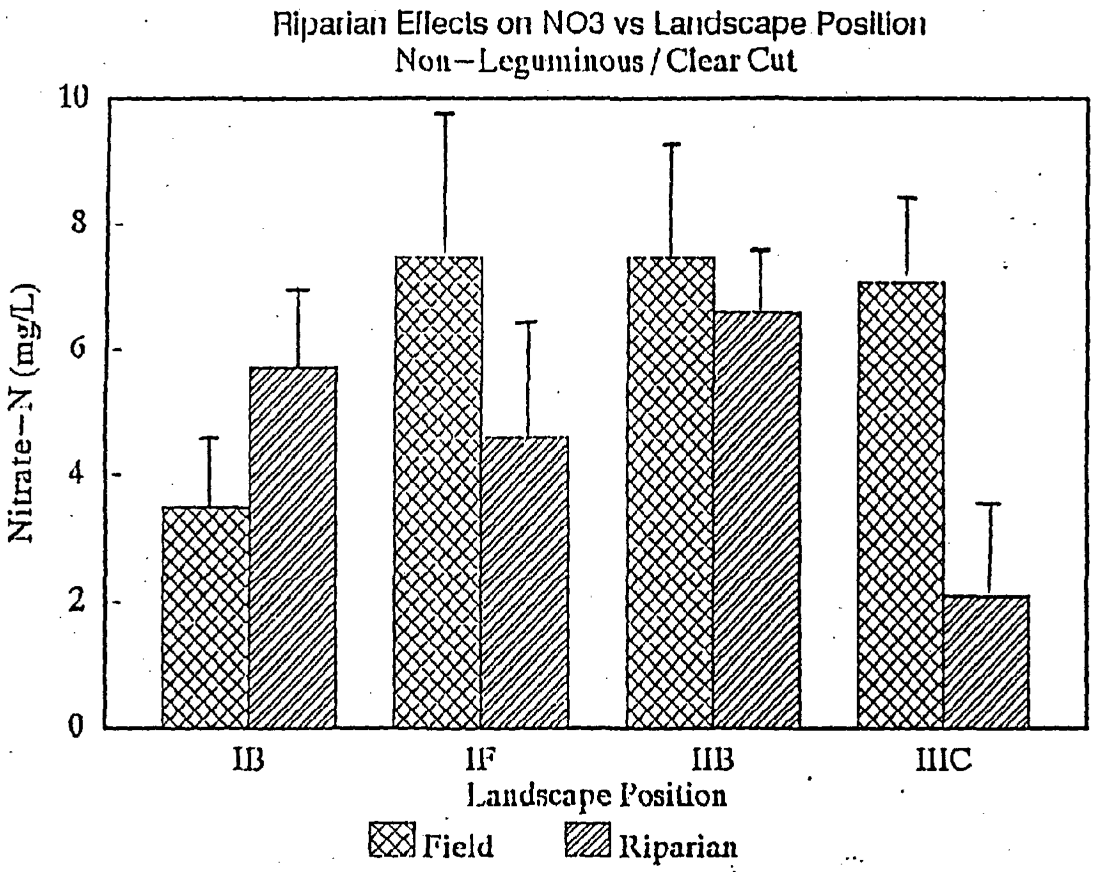

Figure 14. Mean NO_3 concentration in Non-Leguminous clear cut transect, IB, IF, IIB, and IIIC as a function of managements treatments and well landscape position.

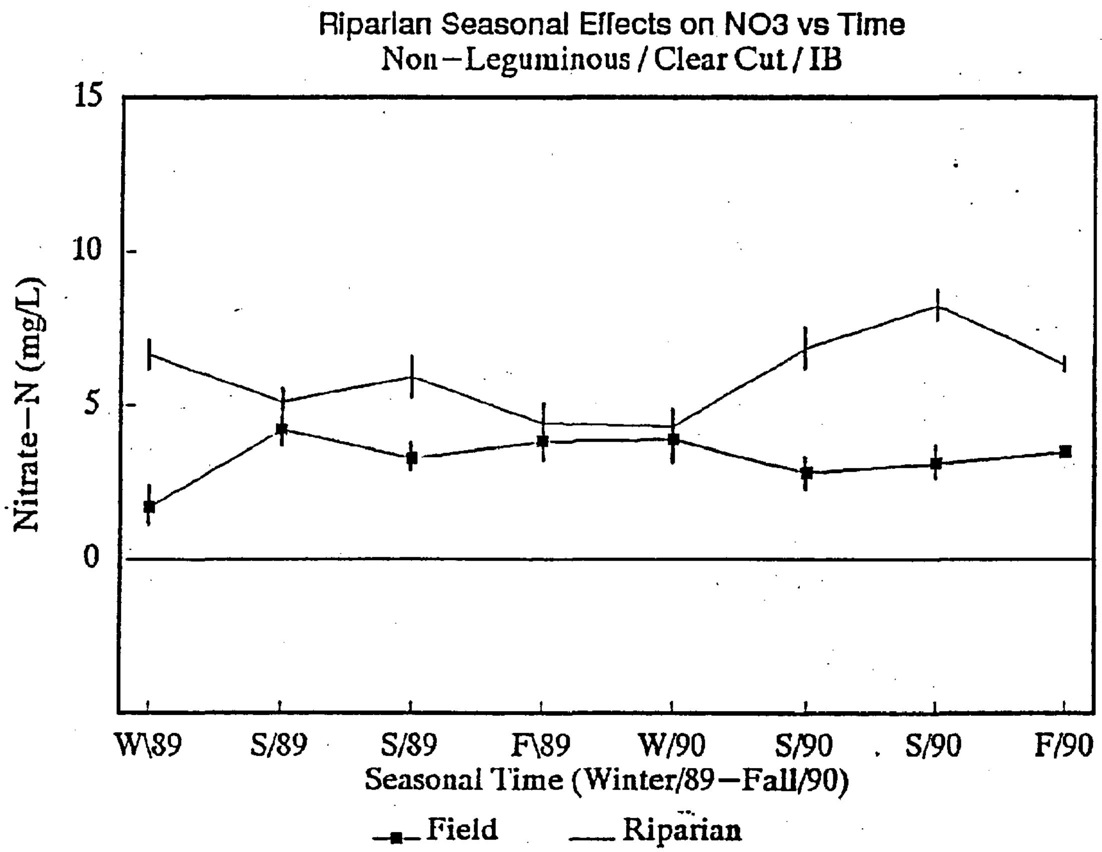

Figure 15. Mean seasonal riparian effects on NO_3 concentration in Non-Leguminous, clear cut transect IB from Winter/89 to Fall/90.

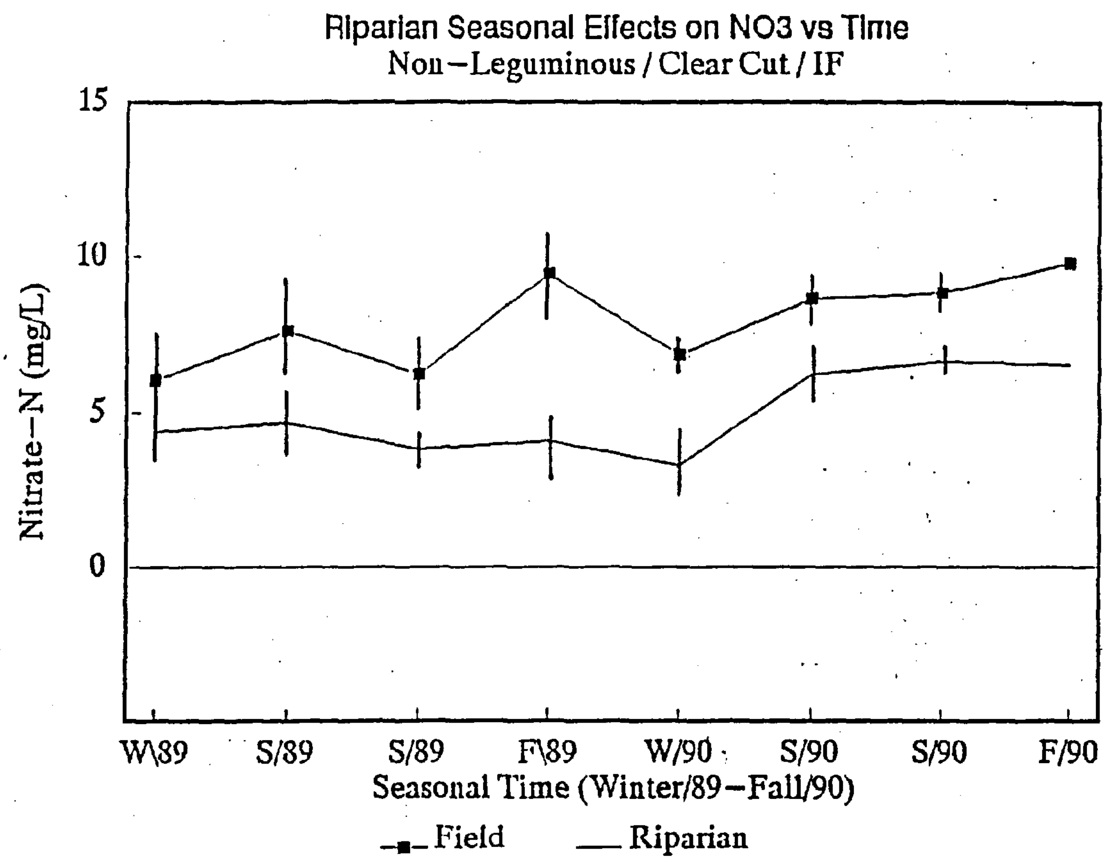

Figure 16. Mean seasonal riparian effect on NO_3 concentration in Non-Leguminous, clear-cut transect IF from Winter/89 to Fall/90.

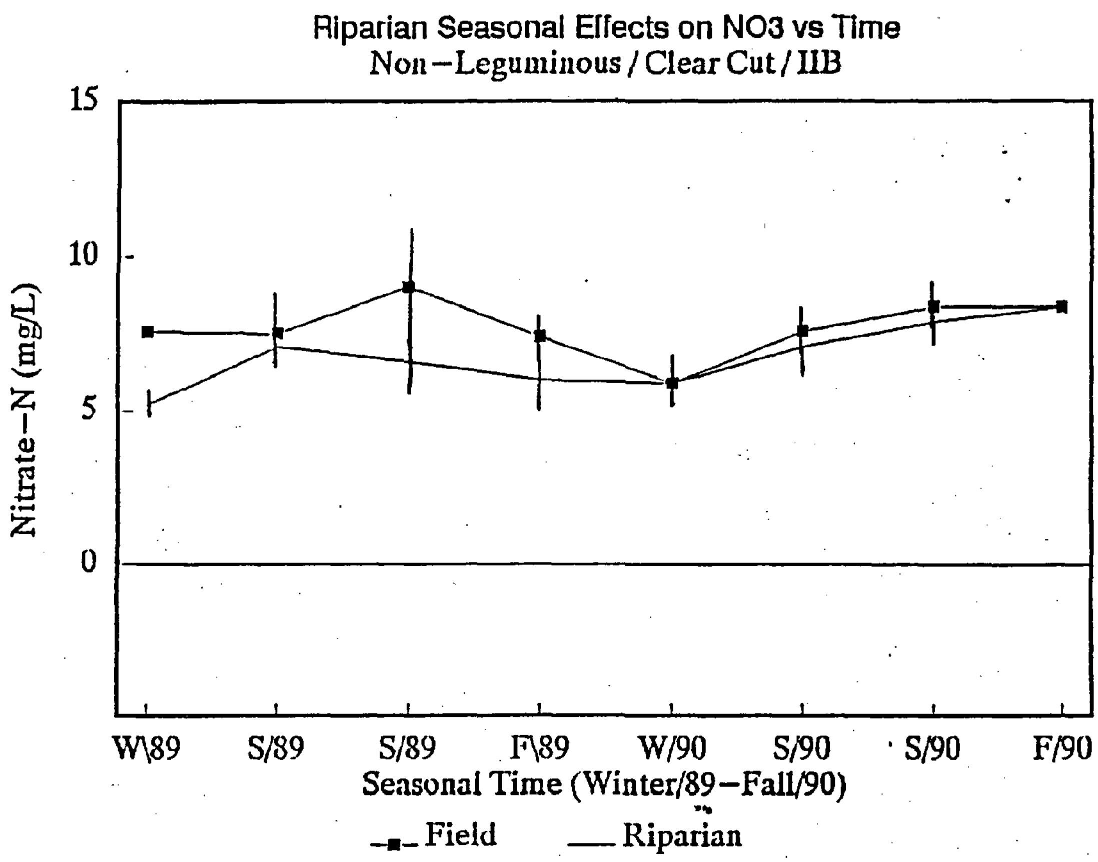

Figure 17. Mean seasonal riparian effects on NO_3 concentration in Non-Leguminous, clear-cut transects IIB from Winter/89 to Fall/90.

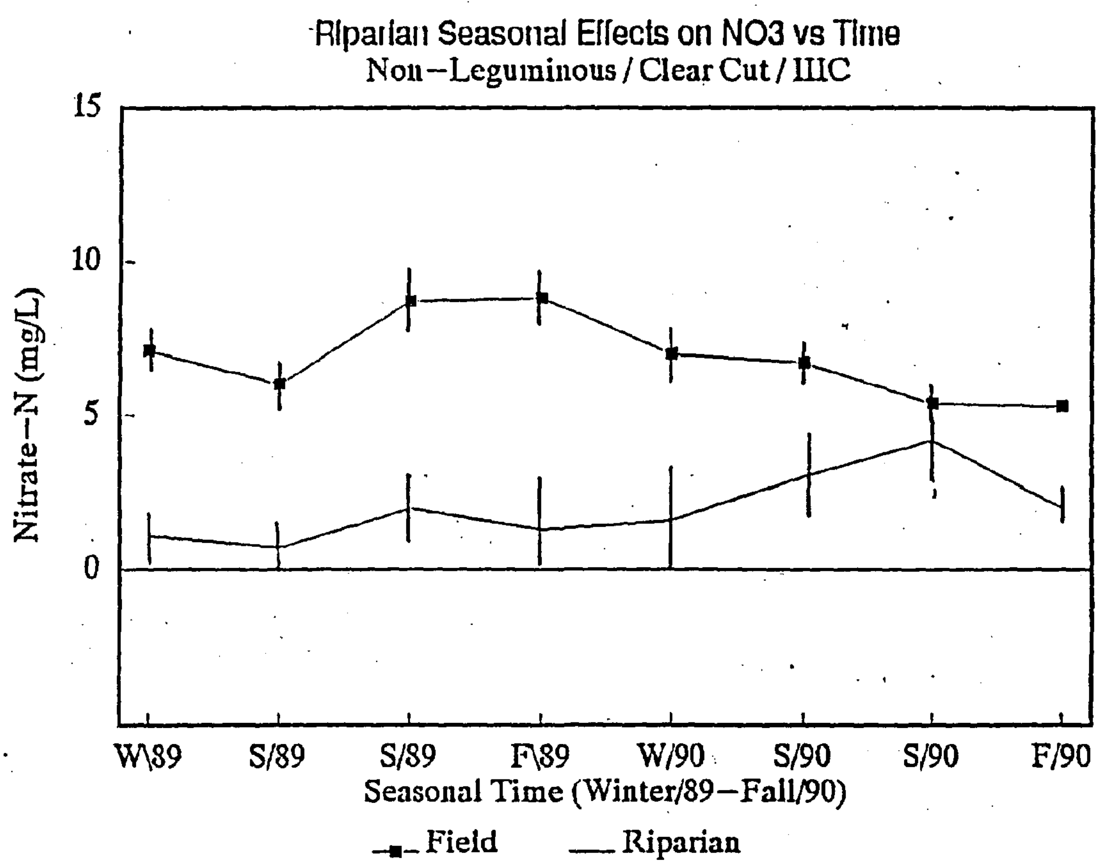

Figure 18. Mean seasonal riparian effect on NO_3 concentration in Non-Leguminous, clear-cut transects IIIC from Winter/89 to Fall/90.

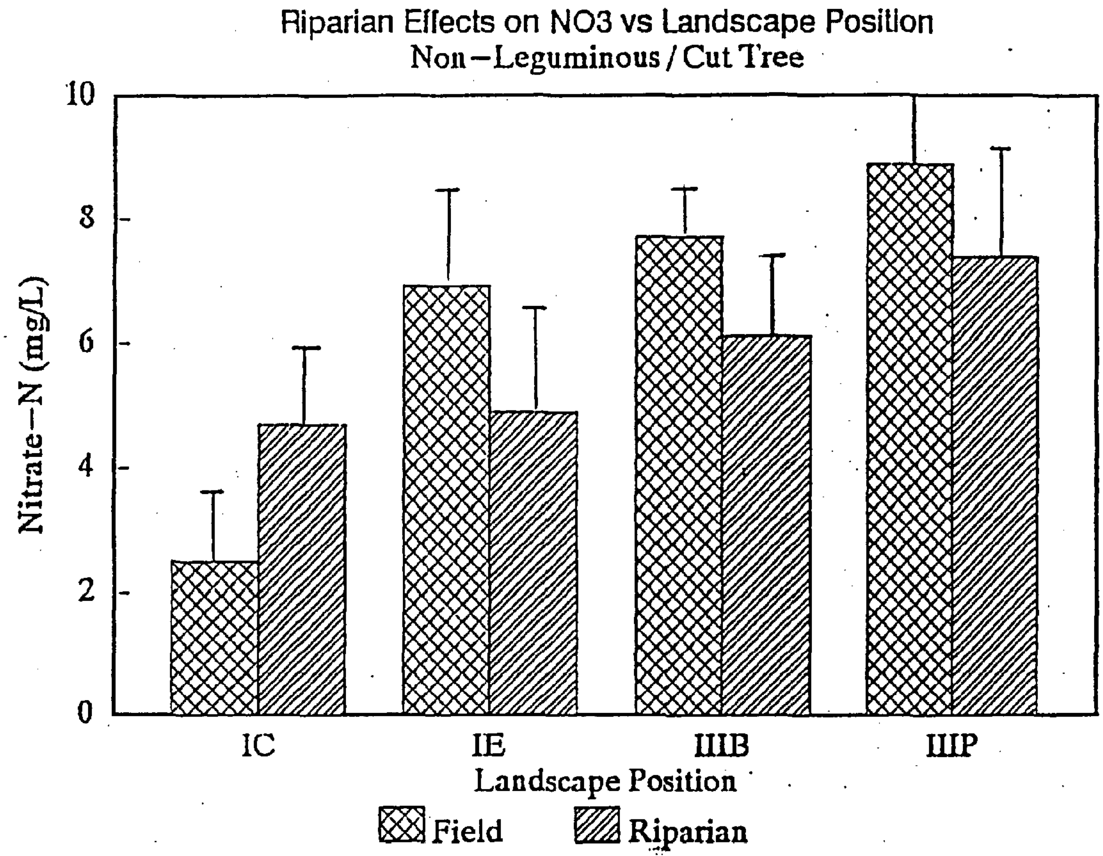

Figure 19. Mean NO_3 concentration in Non-Leguminous cut tree transects, IC, IE, IIIB, and IIIP as a function of management treatments and well landscape position.

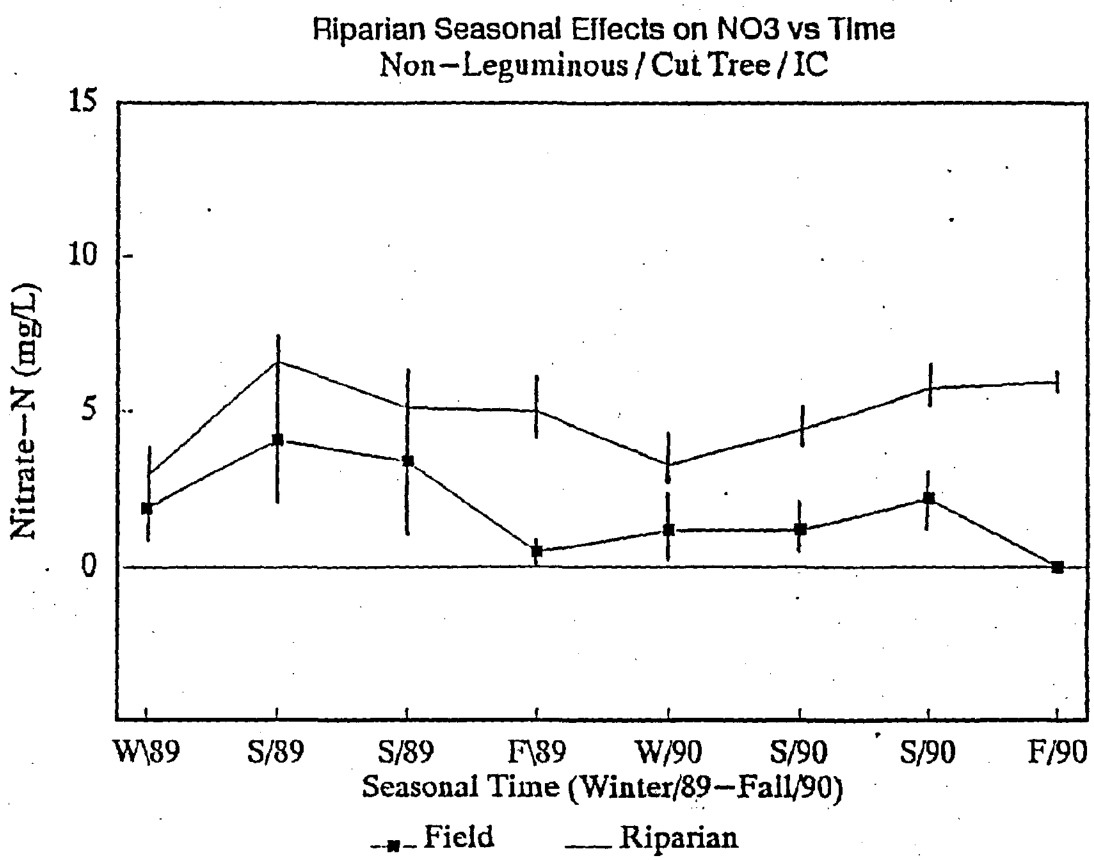

Figure 20. Mean seasonal riparian effects on NO_3 concentration in Non-Leguminous, cut tree transect IC from Winter/89 to Fall/90.

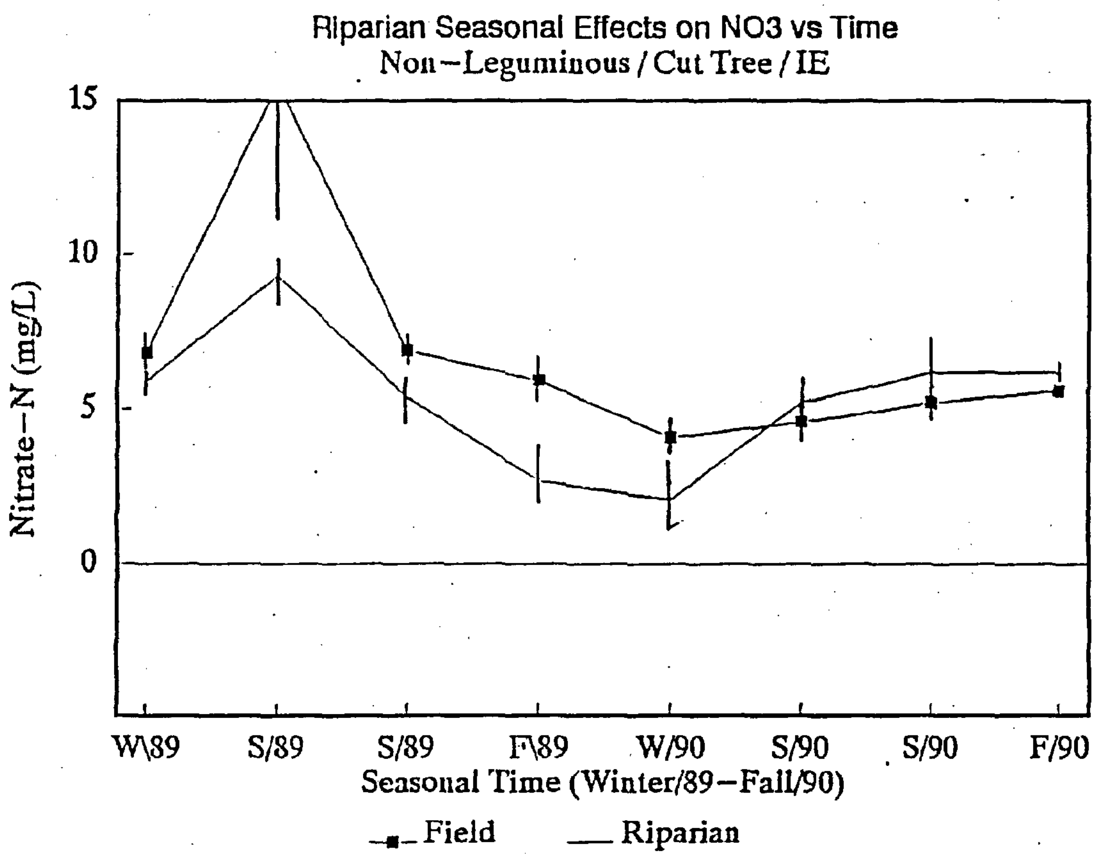

Figure 21. Mean seasonal riparian effects on NO_3 concentration in Non-Leguminous, cut tree transect IE from Winter/89 to Fall/90.

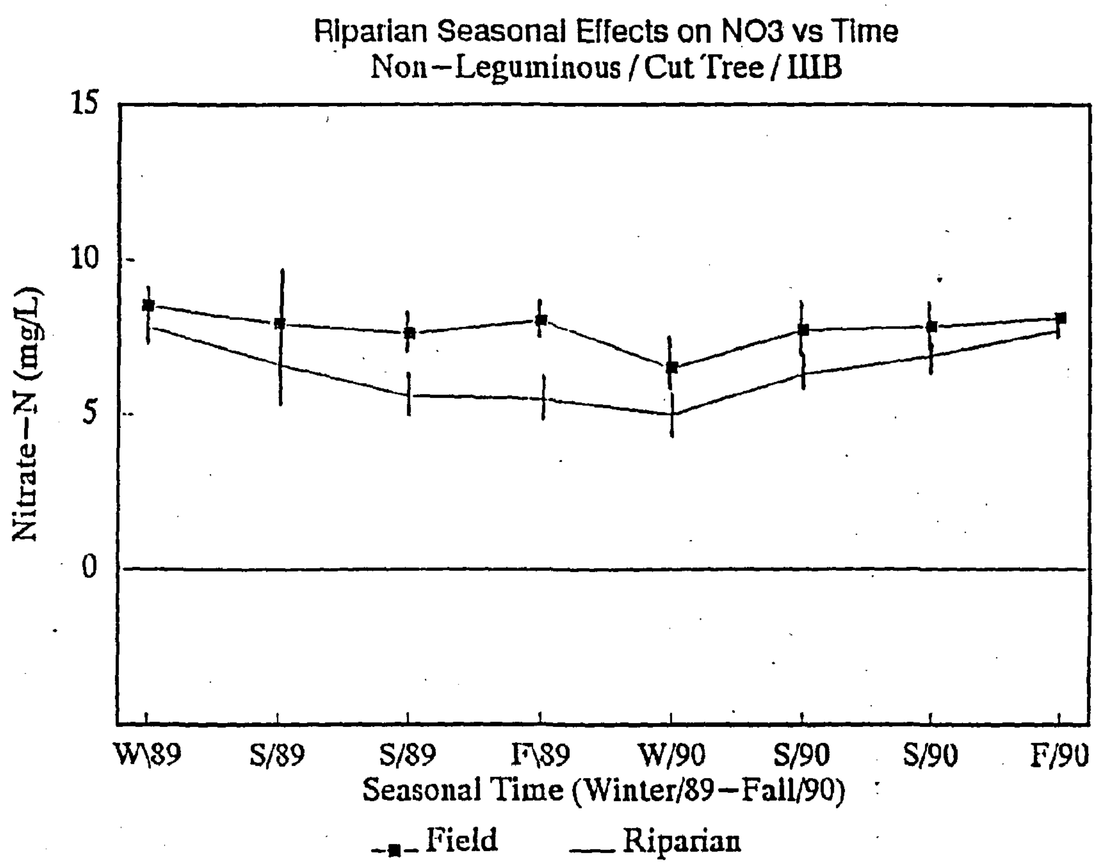

Figure 22. Mean seasonal riparian effects on NO_3 concentration in Non-Leguminous, cut tree transect IIIB from Winter/89 to Fall/90.

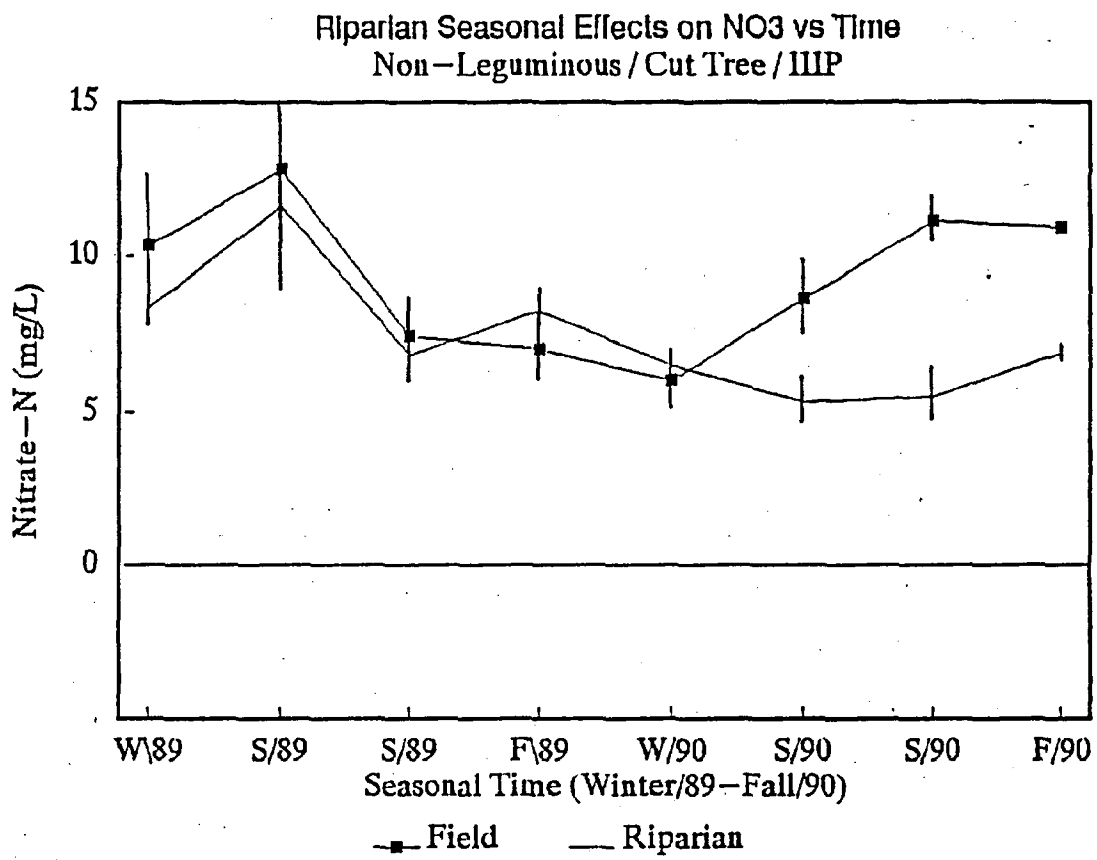

Figure 23. Mean seasonal riparian effect on NO_3 concentration in Non-Leguminous, cut tree transect IIIP from Winter/89 to Fall/90.

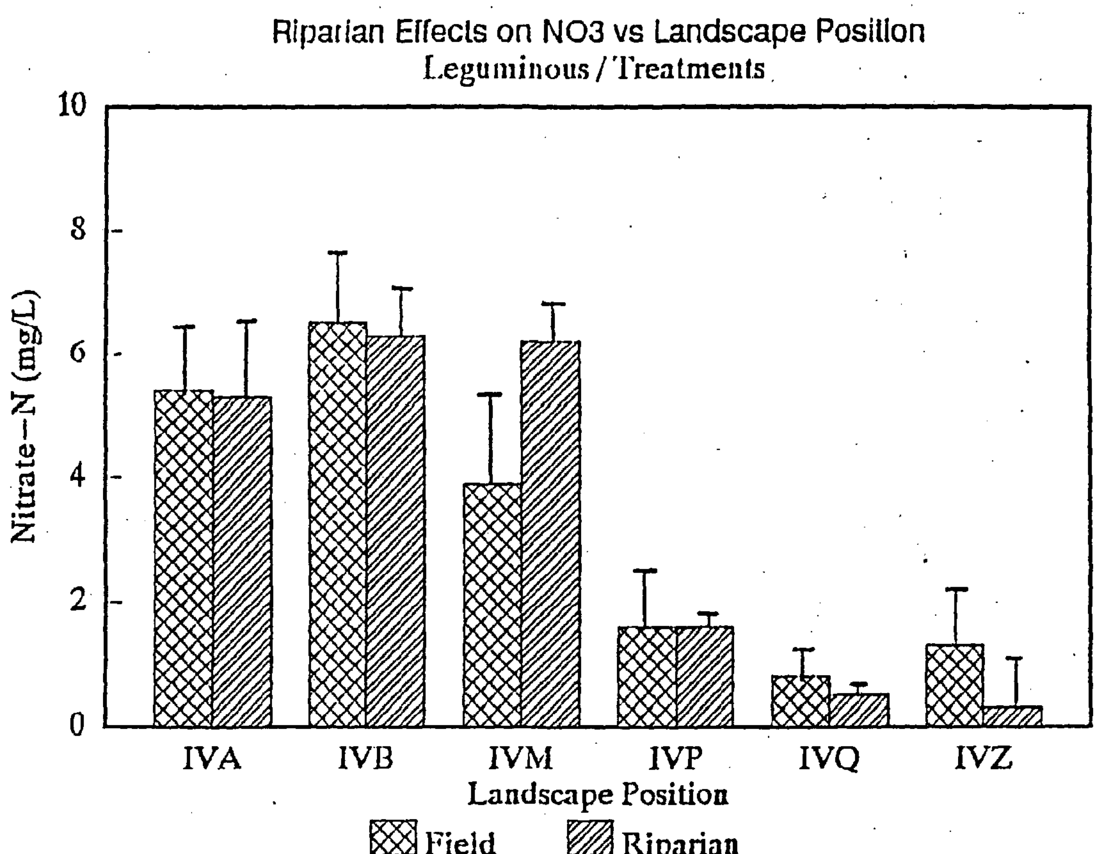

Figure 24. Mean NO_3 concentration in Leguminous vegetation treatments transect IVA, IVB, IVM, IVP, IVQ, and IVZ as a function of management treatment and well landscape position.

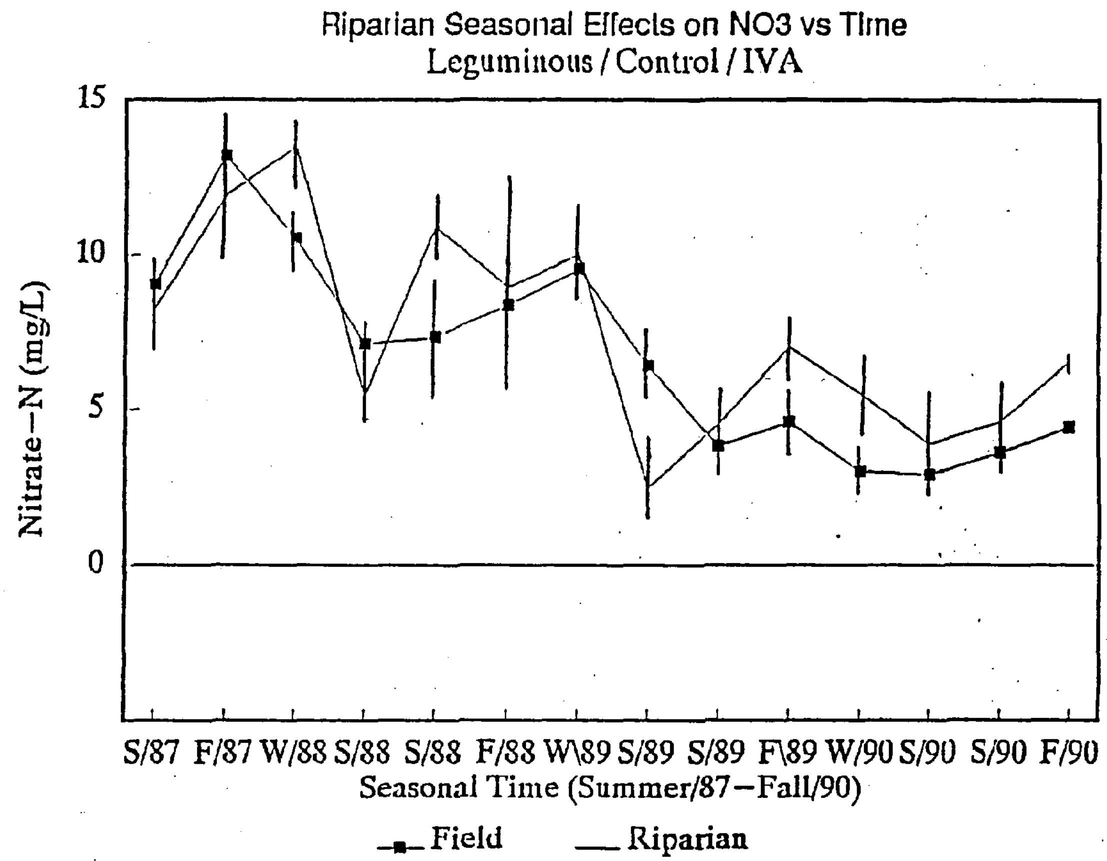

Figure 25. Mean seasonal riparian effects on NO_3 concentration in Leguminous, central transect at IVA from Summer/87 to Fall/90.

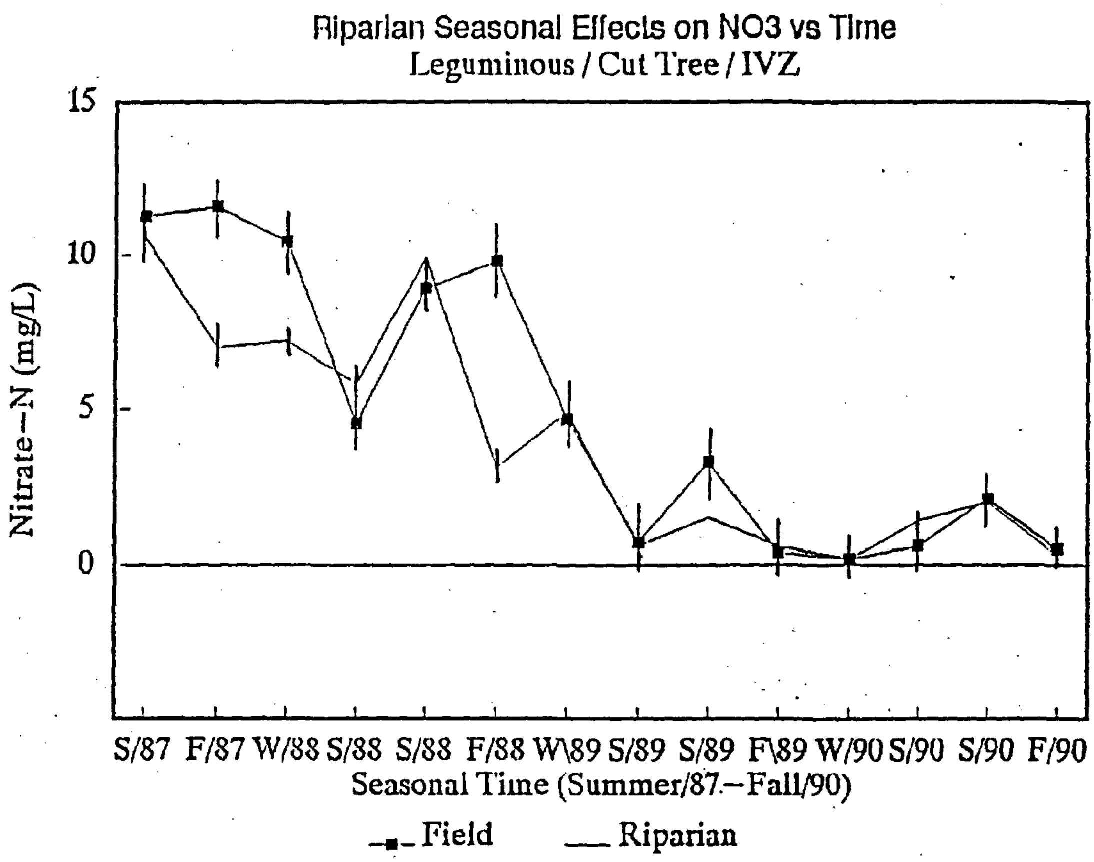

Figure 26. Mean seasonal riparian effects on NO_3 concentration in Leguminous, central transect IVZ from Summer/87 to Fall/88, and clear cut from Winter/89 to Fall/90.

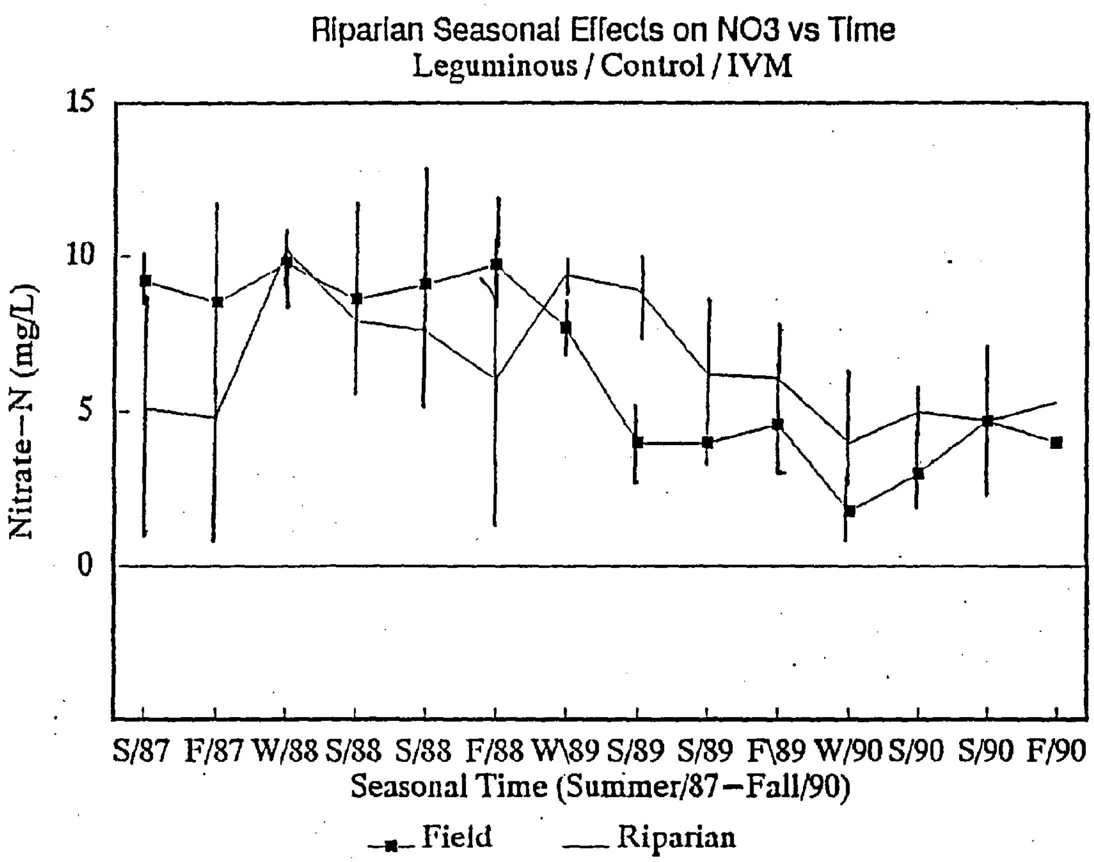

Figure 27. Mean seasonal riparian effects on NO_3 concentration in Leguminous, central transect of IVM from Summer/87 to Fall/90.

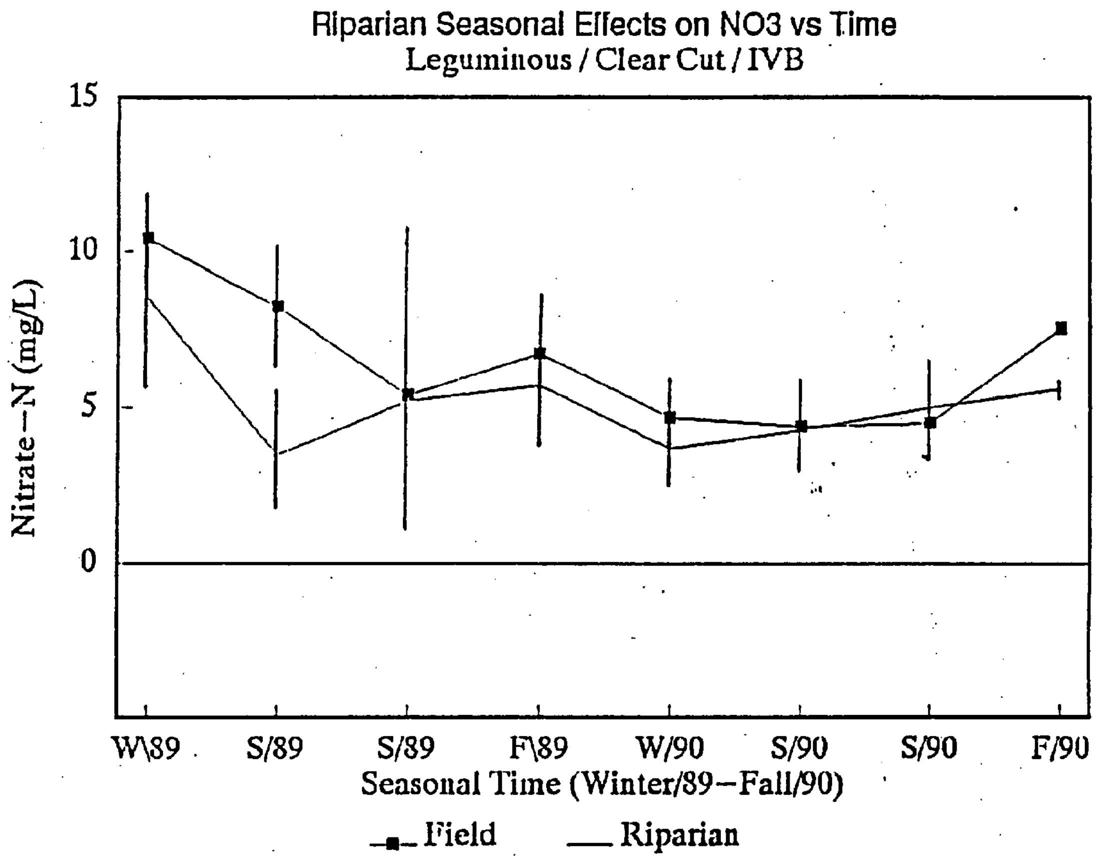

Figure 28. Mean seasonal riparian effects on NO_3 concentration in Leguminous, cut tree transect IVB from Winter/89 to Fall/90.

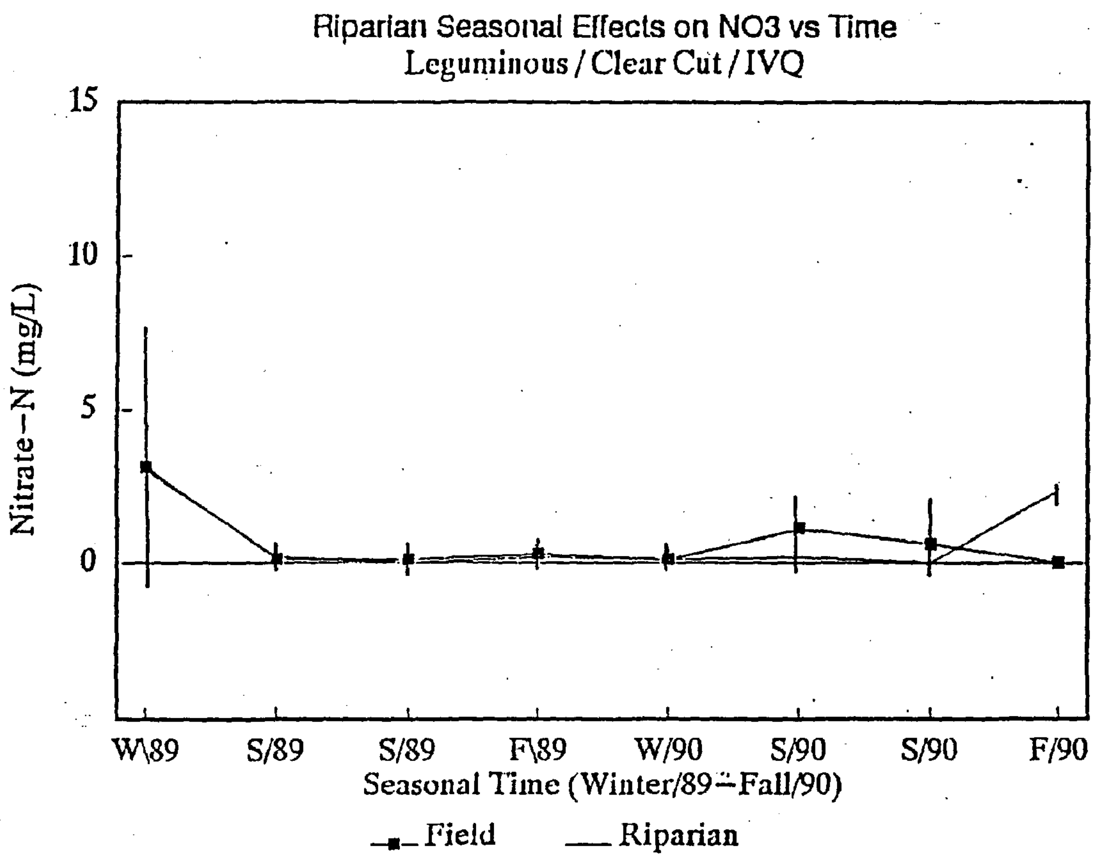

Figure 29. Mean seasonal riparian effects on NO_3 concentration in Leguminous, cut tree transect IVQ from Winter/89 to Fall/90.

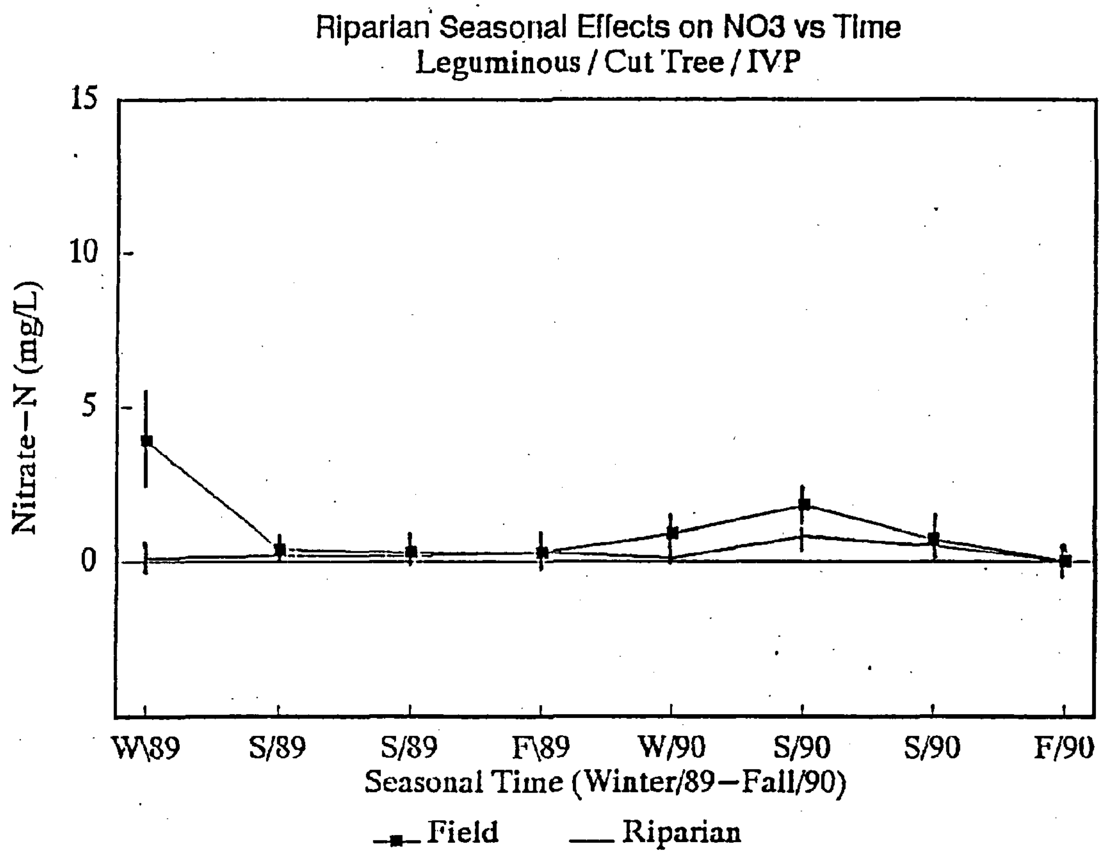

Figure 30. Mean seasonal riparian effects on NO_3 concentration in Leguminous, clear cut transect IVP from Winter/89 to Fall/90.