

**Final Report to the Oregon Department of
Agriculture from Oregon State University for the
project “Protecting Groundwater While
Optimizing N Applications for Pasture Forage
Production in Oregon”**

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Rationale, background material, and references are contained in the project proposal and will not be included in the final report. Only data and interpretation of the data in provided here

Baker County

The Baker County site was a native or unimproved meadow managed for hay production, a normal practice for the area. Nitrogen as urea was applied at 60 lb N/a on April 2 and at T Sum 200 on April 15. A control plot where no N was added was also included. The results for dry matter yield, protein concentration, and N uptake are presented in Table BA.

Table BA. Mean yield, protein, and N uptake by treatment for Baker County in 1999.

Treatment ¹		Yield	Protein	N Uptake
N rate	Date			
lb/a		lb/a	%	lb/a
0	--	3342	8.9	47
60	4/15	5271	9.2	75
60	4/2	4628	8.9	68
Critical rate for comparison		895	.60	12.3

1-The application on 4/15 was at T-Sum 200

Dry matter yield

This location was deficient in N or an N responsive site as both applications of N significantly increased dry matter production compared to the untreated plot. The critical value for comparison of means is calculated for an alpha level of 0.05. The mean separation does not change if the alpha level is changed to 0.10. However, a change of the alpha level to 0.15 results in all means being different. The application of N on 4/2 increased dry-matter yield an average of 1286 lb/a above the untreated plot. The later application, on 4/15 or at T-Sum 200, increased dry matter yield an average of 1929 lb/a above the untreated plot.

Both N applications were economical. Meadow hay typically sells for \$60/t or \$.03/lb. Assuming the cost of 60 lb N/a and application to be \$25/a, the cost of the additional forage was produced for \$0.0078/lb by the T-Sum 200 treatment and produced for \$0.012/lb by the traditional treatment. Another expression of the data is to say that for the same N cost, growers can gain 650 lb forage/a by applying N approximately 2 weeks earlier than normal.

Application of N did not change protein content of the forage. If palatability and other quality parameters are assumed to be constant, quality was not changed by addition of N. One interpretation of the data is that N supplied at the rate of 60 lb/a was used exclusively for growth requirements and an insufficient amount of N was present to increase protein concentration. Expect increase in protein concentration only after growth requirements of N met.

Forage from the control plot contained an average of 47 lb/a N and the forage from plots receiving N contained 21 and 28 lb N/a more than forage from the control plots. The amount of N in the forage of plots treated with N increased less than half the amount of fertilizer N applied, Table BA. Studies with isotopically labeled N fertilizer typically recover 40 to 60 % of the fertilizer in the current season crop. The apparent recovery of N applied early was less than 40 %. The amount of N taken up by forage from treated plots in other areas was often equal to or greater than the amount applied. The N taken up in forage from this site is lower than expected and without a clear explanation.

The fertilizer N not taken up by the forage did not remain in the top foot of soil in the available form. Composite post harvest soil samples were taken from the site. Ammonium-N concentration, 8.4 ppm, in the control plots was the same as ammonium-N in the T-Sum 200 plots. The nitrate-N concentration, 5.4 ppm in the control plots was the same as the nitrate-N concentration in the plots receiving N on 4/2.

Benton County

The Benton County site was located on the Oregon State University's Soap Creek Ranch, a drainage of the coast range. The Soap Creek ranch consists of approximately 1800 acres of pasture hill ground on which 200 mature cows and 350 stocker cattle graze. Three treatments were established; no N, 60 lb N/a at T-Sum 200 plus 60 lb N/a at the traditional time, and 60 lb N/a at the traditional time that ranchers apply fertilizer, which is usually the first part of April (applied to plots on 4/5). T-Sum 200 occurred late in the first week of February and the T-Sum application of N was made on February 10, 1999. The N source was urea. Plots were clipped on 4/26. Subsequent clipping was planned, but cold wet weather did not produce the desired re-growth, therefore, the plots were not clipped a second time. The results for dry matter yield, protein concentration, and N uptake are presented in Table BE.

Table BE. Mean yield, protein, and N uptake by treatment for Benton County in 1999.

Treatment		Yield	Protein	N Uptake
N rate	Date			
lb/a		lb/a	%	lb/a
0	--	2553	13.0	53
60	4/5	2156	12.3	42
60 + 60		5267	14.7	123
Critical rate for comparison		574	1.7	11

This location was deficient in N or an N responsive site as the N application at T-Sum 200 significantly increased dry matter production compared to the untreated plot. The cool wet conditions did not allow forage growth to take advantage of the N applied early in April. Plots treated with 60 lb N/a on 4/5 were not different from the control plots where no N was applied as shown in Table BE.

The increase in dry matter production from the application of N at T-Sum 200 and on 4/5 did not influence forage protein concentration.

The doubling of dry matter production was logically followed by more than a doubling of the N in the above ground forage. The average of T-Sum 200 treatment for N uptake was higher than either of the other treatments, 70 lb N/a more than the control plot. Since the N application on 4/5 did not increase forage dry matter or N uptake, we can assume that the second application of N on the plots receiving N at the T-Sum 200 time was not taken up by the forage. The N found in the forage came from the N application at T-Sum 200. The data from Benton County presented in table BE shows that approximately the same amount of N applied at T-Sum 200 was taken into the additional growth produced. The untreated plots contained an average of 53 lb N/a and the plots treated with 60 lb N/a at T-Sum 200 contained an average of 123 lb N/a or 70 lb N/a more than the untreated plots.

Coos County

In contrast to the single harvest reported for Baker and Benton Counties, five harvests were made in Coos County. The regime simulated multiple grazing events. Forage production at the Coos County site was exceptional in amount and quality during 1999. Cool moist weather provided adequate growing conditions throughout the summer. The site responded to N application of 60 lb/a by producing slightly more than a ton/a of forage dry matter more than plots receiving no N as shown in Table CO. Treatments were: a control or no N added, 60 lb N/a on 2/15 as the T-Sum 200 treatment, and 60 lb N/a on 4/2 as the traditional application time.

Table CO. Mean cumulative forage dry matter yield and N uptake from Coos County in 1999.

N Application ¹		Yield lb/a	N Uptake lb/a
lb/a	Date		
0	--	11945	326
60	2/19	14327	403
60	4/2	14373	470

¹ The 2/19 application was slightly after T-Sum 200 was reached.

Both N treatment produced the same amount of forage but the distribution and protein content of the forage differed by date. Significant differences in forage yield were measured for the interaction of date and N treatment at an alpha of 0.11. Figure 1 illustrates the interaction. One the first clipping date 4/26, forage yield for the plots receiving N at T-Sum 200 produced twice the forage from the plots not receiving N early. Forage yield was not significantly different for either of the treatments receiving N for the remainder of the season. The no N or control plots produced significantly less forage for the first three dates, but were not different from either of the treatments receiving N at the last two dates. This data clearly illustrates the advantage of N application at T-Sum 200 for early forage production. The additional forage produced for the first clipping cost \$0.02/lb or \$40/t, less than the price of hay. Both N treatments produced additional forage for the season at a cost of \$0.006/lb.

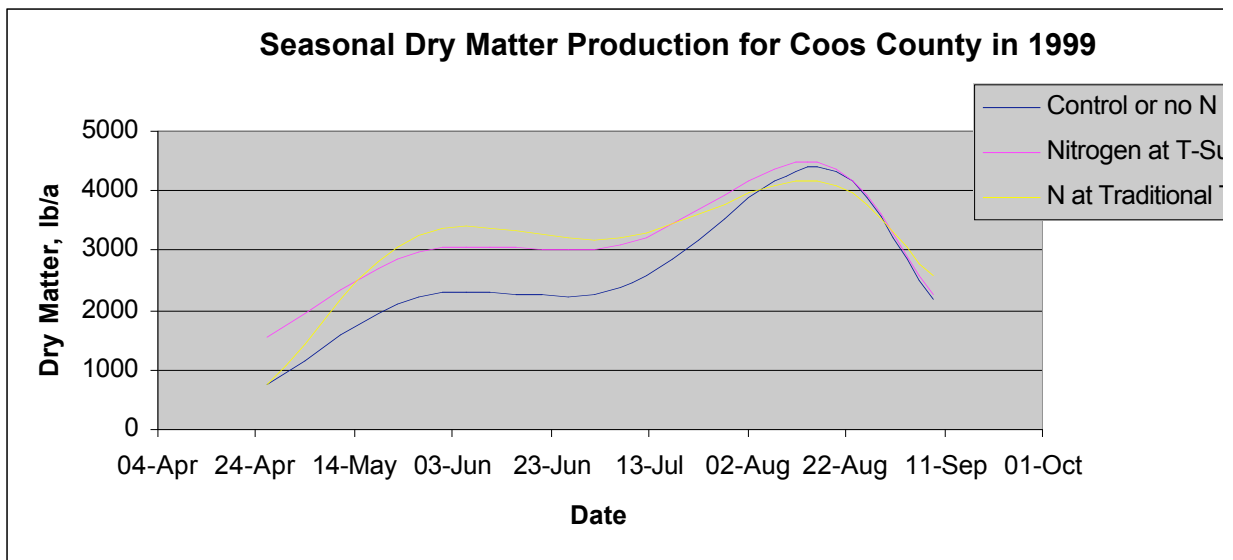
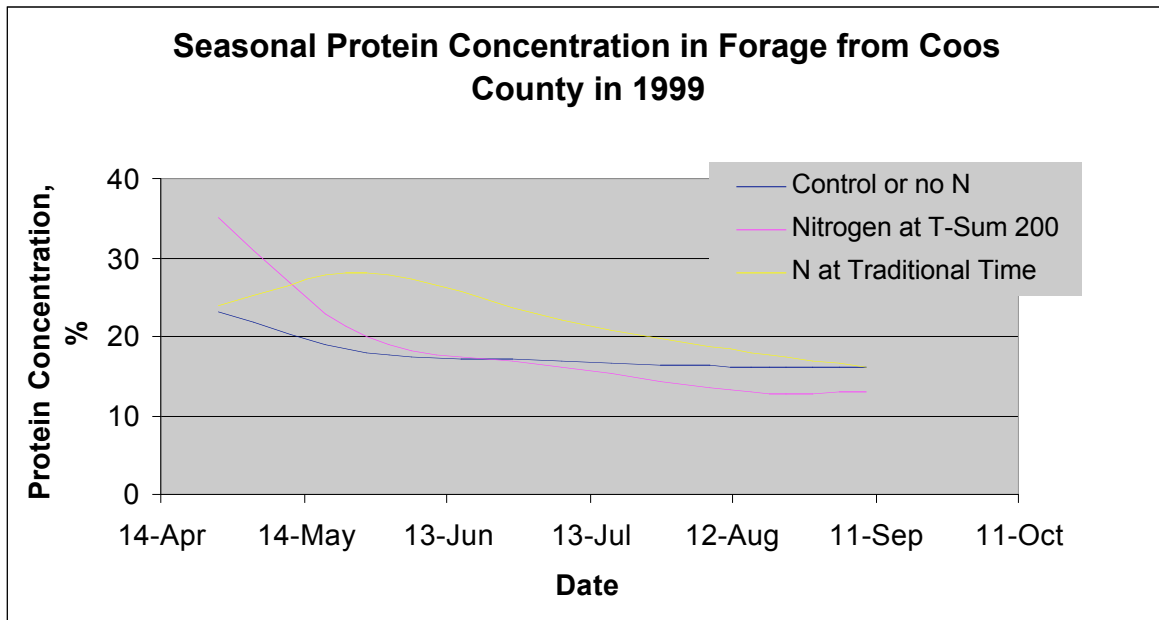


Figure 2 shows the timing of N treatments is evident in forage protein concentration. Nitrogen applied at T-Sum 200 produced forage with exceptionally high protein concentration for the first cutting. The protein concentration of the plots supplied N at a later time, 4/2, increased significantly from the date of the first clipping to the date of the second clipping.

The protein concentration of the T-Sum 200 treatment was significantly higher than the protein concentration of the other two treatments only at the first cutting. For the second clipping date, the protein concentration of the T-Sum 200 treatment was the same as the protein content of the later N treatment. By the third clipping date, the protein content of the T-Sum 200 treatment was the same as the protein content of the control treatment the last two clipping dates, the protein concentration of the T-Sum plots was significantly lower than the protein concentration of the control plots.



As expected, forage from the N treated plots contained more N than forage from the control plots. The amount of N in the plots receiving N at T-Sum 200 was 403 lb/a, and the N in the forage from the control treatment was 326 lb/a. The difference in forage N between these two treatments was slightly more than the rate of N used. In contrast, the difference in Forage N between the control and the later N application treatment was more than double the amount applied.

Crook and Jefferson Counties

Nitrogen was applied at three times to an irrigated orchard grass pasture. The T-Sum 200 application was made on March 3rd at the Powell Butte (Crook County) and on February 20th at the Madras (Jefferson County) site. To adequately follow the range of traditional N timing, two applications were made at each site. N was applied on April 5th and 23rd at Powell Butte and on March 21st and April 12th at Madras. A treatment receiving no N was included at both sites. Plots were clipped on May 7th and June 6th at Madras and May 26th and June 16th at Powell Butte to simulate grazing.

Forage yield for the Powell Butte site is presented in Table CR. The interaction of clipping date and treatment was significant. Forage yield for all treatments except the T-Sum 200 N timing increased from the first clipping date to the second. Forage yield for the N application at T-Sum 200 did not change with clipping date. The significant interaction illustrates the increase in early forage production from the application of N at T-Sum 200.

Forage yield for the Madras site is presented in Table J. Forage yield increased with the application of N. The interaction of clipping date and treatment was significant. Forage yield for treatments receiving N on April 5th and 23rd increased from the first clipping date to the second. Forage yield for the treatment receiving no N and N application at T-Sum 200 did not change with clipping date. The significant interaction illustrates the increase in early forage production from the application of N at T-Sum 200. Table J. Mean and total forage yield from Madras for 1999. Means followed by the same letter are not different alpha 0.05.

N Treatment	Date	Clipping		Total
		1	2	
lb/a		lb/a		
0		624f	754def	1378
60	3/3	940bc	910bcd	1850
60	4/5	810cde	988ab	1798
60	4/23	740ef	1136a	1876

Even though forage yield was increased by N application at both sites, the magnitude of response was small. Treatments receiving N application produced an average of approximately 475 lb/a more forage than the treatment receiving no N.

Table CR. Mean and total forage yield from Powell Butte for 1999. Means followed by the same letter are not different alpha 0.05.

N Treatment	Date	Clipping		Total
		1	2	
lb/a		lb/a		
0		570g	725ef	1295
60	3/3	947b	919bc	1866
60	4/5	716f	835bcd	1551
60	4/23	824cde	1088a	1912

Protein concentration was generally high and not influenced by either treatment or cutting date at the Powell Butte site and only affected by cutting date at the Madras site. The average protein concentration at Powell Butte was 18%, a relatively high value and indication that N was not limiting yield. Protein concentration at Madras for the first cutting was 14% and 19 % fore the second cutting. The higher protein concentration for the second clipping date is an indication the N was not limiting at harvest.

In spite of the high protein concentration, the N recovered in the forage was low. The treatment receiving no N at Madras contained an average of 38 lb/a and 18 lb/a at Powell Butte. The treatments receiving N contained an average of 48 lb/a N at Madras and an average of 26 lb N/a at Powell Butte. Soil at both sites was able to supply much of the N required by the forage. Little, approximately 15%, of the amount of fertilizer N was recovered in the forage.

Even with the modest forage yield, an application of N at T-Sum 200 produced a significant increase in forage for the first clipping at both sites.

Douglas County

The Douglas County site was established in the central region of the county on level bottom ground near the South Umpqua River, on a loam soil. An initial soil test showed that adequate levels of phosphorus, potassium, calcium and magnesium, as well as a moderate pH, were present for good forage production on this site. Forage consisted predominantly of Annual and Perennial Ryegrass, Orchard Grass and White Clover, but also contained some Tall Fescue and Subterranean Clover. Weeds were present in moderate levels at the beginning of the test period, but increased over the growing season. The site was a non-irrigated pasture. However, livestock were excluded from grazing the area during the experimental period.

Nitrogen applications, 60 lb N/a as urea, were made on February 5th for T-Sum 200 and on April 4th for the traditional timing. Data is presented graphically in the figure with this section. The seasonal distribution of forage at this site is typical of western Oregon. Forage production is low at the beginning and end of the season with a sharp increase in forage during the spring. The spring forage production is typically beyond

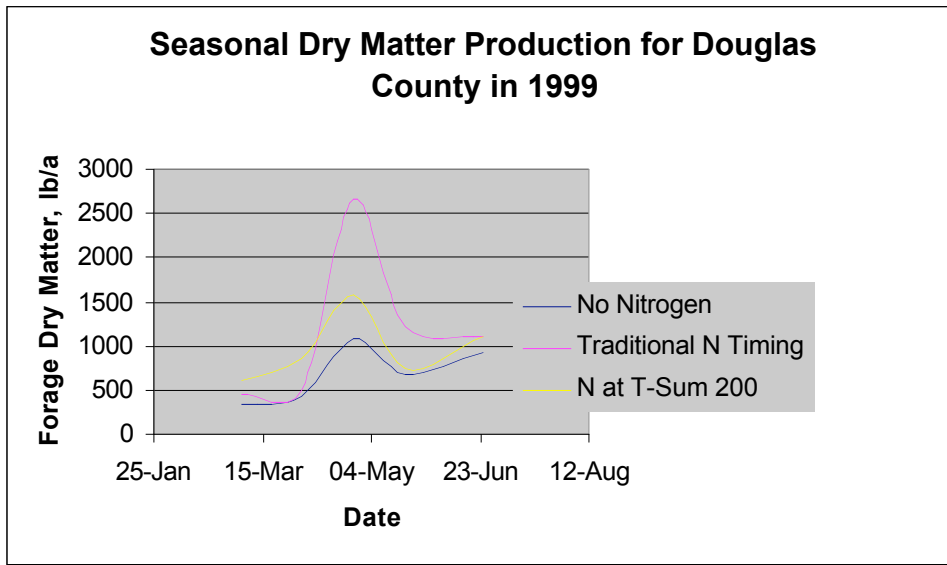
the ability of animals to utilize the forage. Forage production in the winter can be critical as the supply of conserved forage is generally low and the price of purchased forage is high. Any management choices that will economically provide forage during this time would be extremely beneficial to the livestock industry. The figure with this section shows that N application at T-Sum 200 was successful in producing early-season forage. Statistical analysis of the data supports the interpretation of the graph as the interaction of N application and date of forage harvest was significant. The T-Sum N application produced significantly more forage than the other treatments for the first two harvest dates, March 5 and April 2. By the third sampling date, April 26th, the forage yield from the traditionally timed N application produced the highest amount of forage for any treatment regardless of harvest date. The N application at T-Sum 200 produced a significantly lower forage yield than the traditional application, but higher than the no N treatment at any harvest date. At the fifth harvest date, June 24th, no differences were measured among treatments for forage yield.

Forage yield was relatively low at this site, and only a modest yield increase was measured in response to N fertilization. Cumulative production from the treatment receiving no N produced an average of 3841 lb/a, the T-Sum treatment produced an average of 4881 lb/a, and the traditional N treatment produced an average of 5945 lb/a. Protein concentration from the T-Sum treatment at the first harvest date, March 5th, was 19.72% and from the plots receiving no N, 15.4%. The protein concentration was much higher in these plots than for the same treatments in Benton County. The high protein concentration is an indication that N was not the primary limitation to growth at this site. By the end of the season the protein concentration, as with yield, was the lowest for any clipping date, an indication that both the fertilizer N and mineralizable N were depleted or limited by a lack of moisture.

The cumulative N uptake by forage from treatments with no N application contained an average of 92 lb N/a, forage from the late traditional N treatment contained an average of 169 lb N/a, and forage from the T-Sum 200 treatments contained an average of 128 lb N/a.

Both the forage production and the cumulative amount of N measured at the Douglas County site are comparable to the forage yield and N uptake from the Benton County site. The Benton County site was harvested a single time, the Douglas County site 5 times. The combination of the modest forage yield, high protein concentration, and N uptake provide basis that a limitation to yield other than N existed at this site.

Both N application treatments produced forage economically. The traditional application produced an average of 2464 lb/a forage above the no N treatment for a cost of \$0.006/lb. The T-Sum treatment produced an average of 1400 lb/a more forage than the treatment receiving no N for a cost of \$0.01 lb of forage which is less than half the cost per pound of minimal quality grass hay.



Lake County

Meadow foxtail was produced with flood irrigation at both Lake County sites. These sites are sometimes grazed before hay is cut, but generally hay is cut in July before the parcels are grazed in September and October. Normal application of N would be made in the second week of May. The T-Sum 200 N applications were made on April 27th for Site 1 and April 16th for Site 2. The data provided in Tables LA-1 and LA-2 is from two simulated grazing events for Site 1 and haying for Site 2.

Table LA-1. Mean forage dry matter yield and protein concentration for Site 1 from Lake County in 1999.

N Application		Protein %	Forage Yield	
Rate lb/a	Date		6/21 lb/a	8/10 lb/a
0	--	15.60	2921	732
60	5/13	14.75	2703	925
70	4/27	13.35	3260	1021
Critical value for comparison		0.8045	NS	NS

Table LA-2. Mean forage dry matter yield for Site 2 from Lake County in 1999.

N Application Rate lb/a	Date	Forage Yield lb/a
0	--	837
60	5/5	808
70	4/16	730
Critical value for comparison		NS

Neither the application of N nor the timing of N application influenced forage yield in either Lake County Site for 1999. The yield data supported visual observations as no differences in treatment could be seen throughout the growing season. At Site 1, the lack of an increase in yield from the application of N fertilizer is probably attributable to the amount of N present in the soil at the beginning of the year. A soil sample taken before treatments were implemented showed approximately 50 lb available N/a in the surface foot of soil. The forage from the first cutting contained between 65 and 80 lb N/a. The amount in the soil before any N was added could easily supply most of the crop need, therefore, the fertilizer N produced no increase in forage yield.

In contrast to the forage yield, protein concentration at Site 1 was affected by N application. The mean protein concentration for the late treatment was 15.6%, Table LA-1, significantly higher than the mean protein concentration of 13.35% from the plots receiving no N. The mean protein concentration from the T-Sum 200 treatment was not different from either of the other treatments. The elevated protein in the treatment receiving N later is an indication that N beyond requirements for growth was present.

For the second cutting, neither forage yield or protein concentration was significantly influenced by the addition or timing of N application at Site 1. The data in table LA shows the mean forage yield increasing with an increase in N application, although significant at $p=0.18$. This data indicates that the soil supply of N is diminishing and the fertilizer application is beginning to have an influence on forage yield.

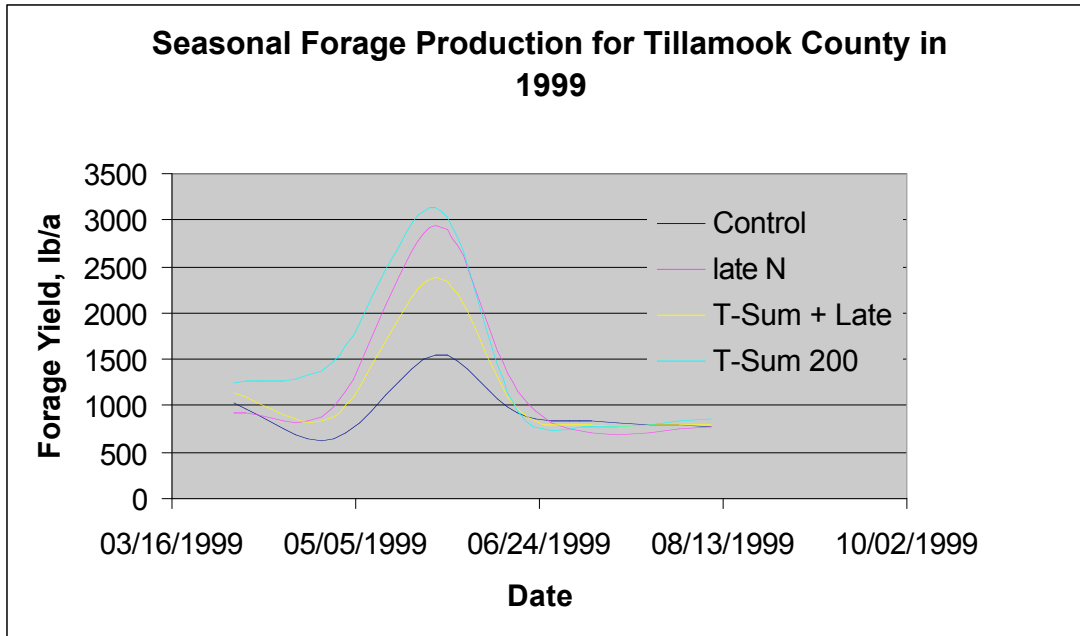
Site 2 had a low soil test for available N before N application, low forage yield, low protein concentration, and no change in protein concentration with N application, all indicators that a limit to yield other than N was present. Observation of the site condition suggests that over stocking in a wet period may have caused compaction to a point where it limits growth.

Tillamook County

The treatments at the Tillamook site included a control plot that received no N, the application of 60 lb N/a at T-Sum 200, the same N rate later, and 60 lb N/a at T-Sum 200 plus 60 lb N/a later. To simulate grazing, the plots were clipped on 4/2, 4/29, 5/27, 6/18, 7/8, and 8/10. The graphical presentation of forage yield data with this section provides a dry matter distribution and yield response to N that is similar to the one from Douglas County. Significant differences in forage yield were measured for the first three harvest dates but no differences in forage yield were found for the last three harvest dates. Even though the mean forage yield of the treatments receiving N at the T-Sum timing for the first clipping date produced 220 lb/a more forage than plots receiving no N, the increase in yield was not significant. Forage production from the treatment receiving N only at T-Sum 200 was significantly higher than other treatments on the second clipping date. The lack of production from plots receiving N at T-Sum plus later has no explanation.

Protein concentration in forage from all treatments clipped on the first two dates was 20 to 26%, not significantly different for the dates or treatments, but different from the protein measured in all other dates and treatments. Protein concentration from forage clipped on the last two dates was lowest of all protein measured, but still 13 to 17%.

The forage in the control plot contained 165 lb N/a. The plots receiving N at T-Sum 200 accumulated only 35 lb N/a more than the control plots. Plots receiving only late N accumulated 60 lb N/a more than the control, the amount applied as fertilizer. The difference in N in forage from the control treatment and the treatment receiving N only at T-Sum 200 is the same in Tillamook and Douglas Counties. The T-Sum application stimulated early forage production, but did not apparently recover the amount of N applied as fertilizer. In contrast, the plots receiving N later, seemingly recovered an amount of N similar to the amount applied as fertilizer.



Summary

Application of N at T-Sum 200 was generally increased early forage production at sites where N was limiting production. This data is in agreement with reports from northern Europe and coastal British Columbia. In addition, the data from Baker, Crook and Jefferson counties shows that the T-Sum 200 approach to N timing increases early season forage production in cold high elevation settings. The amount of forage produced from the T-Sum 200 application is site specific. Only a modest increase in forage was measured at some sites. Application of N at T-Sum 200 should be used on sites where N is clearly limiting and sufficient early growth will be produced to use the N supplied.

Forage was economically produced by the early N application, generally at half or less the cost of comparable hay. At most sites, the amount of N recovered in excess of the control treatment was more than the amount of N applied for the T-Sum 200 treatment. The exception was for sites with little early forage production from the T-Sum 200 application.