Evaluation of Grazing Fertilized Native Rangeland Pastures

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Fertilization of native rangeland plot studies showed that application of nitrogen fertilizers increased total herbage yield (Rogler and Lorenz 1957; Whitman 1957, 1963, 1969, 1978; Smika et al. 1965; Power and Alessi 1971; Lorenz and Rogler 1972; Wight and Black 1972, 1979; Taylor 1976) and increased aboveground herbage crude protein content during the early portion of the growing season (Black and Wight 1972, Whitman 1975, Goetz 1975).

A fertilization of native rangeland grazing study with two grazing trials was conducted at the Dickinson Research Extension Center from 1972 to 1982 to test the performance of herbage and livestock on unfertilized native rangeland and fertilized rangeland pastures. Grazing trial I experimented with yearling steers and was conducted from 1972 to 1976 by Dr. Warren C. Whitman and Dr. Harold Goetz. Data from grazing trial I was reported by Nyren et al. 1983. A transition period occurred during 1977. Grazing trial II experimented with cow-calf pairs and was conducted from 1978 to 1981 by Paul E. Nyren and Dr. Harold Goetz and continued during 1981 to 1982 by Dr. Llewellyn L. Manske and Dr. Harold Goetz. Data from grazing trial II was reported by Nyren et al. 1984 and by Manske et al. 1984.

This report reevaluates the original data collected during grazing trials I and II and compares livestock weight gains, ungrazed and grazed total herbage production, and costs and returns on unfertilized and fertilized native rangeland pastures.

Procedure

The nitrogen fertilization of native rangeland grazing study was conducted from 1972 to 1982 as two grazing trials. The research pastures were located on the SW½, sec. 23, T. 140 N., R. 97 W., at the Dickinson Research Extension Center. The native rangeland plant community was strongly rolling upland mixed grass prairie. The soils were Vebar, Parshall, and Flasher fine sandy loams. The control pasture was 18 acres of untreated native rangeland. The fertilized pasture was 12 acres of native rangeland fertilized annually with ammonium nitrate fertilizer (33-0-0) broadcast applied in granular form at a rate of 50 lbs N/ac in early spring, usually around early to mid April, for eleven years from 1972 to 1982.

Steer performance during grazing trial I and cow and calf performance during grazing trial II were determined by mean weight gains or losses. The cattle were weighed upon entering and leaving each pasture.

Aboveground herbage biomass production was sampled by the clipping method. During grazing trial I, herbage samples were collected at the end of each grazing period and during grazing trial II, herbage samples were collected at the beginning and end of each grazing period. Vegetation was hand clipped to ground level in rectangular quadrats located both inside and outside exclosure cages. The plant material was oven dried and weighed. The difference between the aboveground herbage biomass values collected inside and outside the exclosure cages was the forage utilized. The forage use per acre included the forage ingested by the cattle, the loss in vegetation weight caused by senescence, and the loss in vegetation weight caused by parts broken from the plant, soiled by animal waste, consumed by insects and wildlife, and lost to other natural processes.

In 1982, the last year of the fertilization of native rangeland grazing study, the unfertilized and fertilized pasture herbage weight was sampled by clipping to ground level the vegetation from inside and outside exclosure cages during five monthly periods throughout the growing season. The plant material was separated into five categories: warm season grasses, cool season grasses, sedges, introduced grasses, and forbs.

Costs and returns for grazing trial I and grazing trial II were determined from total pasture and forage costs and value of steer and calf weight gain during the grazing periods and followed the methods developed by Manske et al. (2007). Nitrogen fertilizer costs were the actual costs paid during 1982-1985 with ammonium nitrate at $0.24 per pound of nitrogen. Land rent value for grazinglands in North Dakota taken from the North Dakota Agricultural Statistics Service, 1998, was the mean rent in fifteen western counties at $8.76 per acre. Differences between means from treatment years were analyzed by a standard paired-plot t-test (Mosteller and Rourke 1973).

Results

Grazing Trial I (1972-1976)

The precipitation during the growing seasons of 1972 to 1976 was normal or greater than normal (table 1). During 1972, 1973, 1974, 1975, and 1976, 18.57 inches (137.05% of LTM), 11.83 inches (87.31% of LTM), 12.45 inches (91.88% of LTM), 15.26 inches (112.62% of LTM), and 10.84 inches (80.00% of LTM) of precipitation were received, respectively. May, August, and October of 1972 were wet months and each received 217.52%, 167.63%, and 164.21% of LTM precipitation, respectively. April, June, and July received normal precipitation at 88.81%, 120.85%, and 122.52% of LTM, respectively. September was a dry month and received 55.64% of LTM precipitation . Perennial plants were under water stress conditions during September, 1972 (Manske 2009). April and September of 1973 were wet months and each received 224.48% and 167.67% of LTM precipitation, respectively. June received normal precipitation at 85.63% of LTM. May and October were dry months and received 55.56% and 70.53% of LTM precipitation, respectively. July and August were very dry months and received 40.99% and 27.17% of LTM precipitation, respectively. Perennial plants were under water stress conditions during July, August, and October, 1973 (Manske 2009). April and May of 1974 were wet months and each received 197.20% and 177.35% of LTM precipitation, respectively. June, July, August, and October were dry months and received 56.34%, 67.57%, 52.02%, and 54.74% of LTM precipitation, respectively. September was a very dry month and received 42.11% of LTM precipitation. Perennial plants were under water stress conditions during July, August, September, and October, 1974 (Manske 2009). April, May, and October of 1975 were wet months and each received 297.20%, 142.74%, and 149.47% of LTM precipitation, respectively. June received normal precipitation at 120.28% of LTM. September was a dry month and received 60.15% of LTM precipitation. July and August were very dry months and received 28.83% and 31.21% of LTM precipitation, respectively. Perennial plants were under water stress conditions during July, August, and September, 1975 (Manske 2009). April and September of 1976 were wet months and each received 147.55% and 133.08% of LTM precipitation, respectively. June received normal precipitation at 105.35% of LTM. May and October were dry months and received 60.68% and 68.42% of LTM precipitation, respectively. July and August were very dry months and received 33.78% and 23.12% of LTM precipitation, respectively. Perennial plants were under water stress conditions during July and August, 1976 (Manske 2009).

The native rangeland and fertilized rangeland pastures of steer grazing trial I were grazed during one period for an average of 59 days from 30 June to 27 August. The grazing periods varied from 46 to 71 days in length and occurred between 21 June and 3 September. The pastures were grazed by 12 yearling steers of which 50% were Hereford and 50% were Angus-Hereford. The mean stocking rate on the native rangeland pasture was 1.08 acres per animal unit equivalent month (AUEM) with a range from 0.88 acres to 1.24 acres per AUEM. The mean stocking rate on the fertilized pasture was 0.73 acres per AUEM with a range from 0.60 acres to 0.84 acres per AUEM. The stocking rate on the fertilized pasture was 48.9% greater than, and significantly different ($P<0.05$) from, the stocking rate on the native rangeland pasture (table 2).

Post study determination of hindsight stocking rates was made from measured standing herbage biomass and animal unit equivalent of the June steer live weight (table 3). The determined stocking rate on the native rangeland pasture was 0.92 acres per AUEM and was not significantly different ($P<0.05$) from the stocking rate used. The determined stocking rate on the fertilized pasture was 0.64 acres per AUEM and was not significantly different ($P<0.05$) from the stocking rate used (tables 2 and 3). The determined stocking rate on the fertilized pasture was 43.8% greater than, but not significantly different ($P<0.05$) from, the determined stocking rate on the native rangeland pasture (table 3).

Steer performance on the native rangeland and fertilized pastures managed with one grazing period on grazing trial I were compared using gain per head, gain per day, and gain per acre data (table 4). Steer gain per head on the fertilized pasture was 5.6% greater than, but not significantly different ($P<0.05$) from, steer gain per head on the native rangeland pasture. Steer gain per day on the fertilized pasture was 7.9% greater than, but not significantly different ($P<0.05$) from, steer gain per day on the native rangeland pasture. Steer gain per acre on the fertilized pastures was 58.6% greater than, but not significantly different (P<0.05) from, steer gain per acre on the native rangeland pasture (table 4).

Early growing season steer daily gain on the fertilized pasture was greater during mid June to late July than steer daily gain on the native rangeland pasture. Late growing season steer daily gain on the native rangeland pasture was greater during early August to mid September than steer daily gain on the fertilized pasture (table 5).

Aboveground herbage biomass on the native rangeland and fertilized pastures managed with one grazing period on grazing trial I was compared from ungrazed and grazed total herbage production sampled at the end of the grazing period, and by the quantity of forage used per acre during the grazing period (table 6). Ungrazed herbage biomass at the end of the grazing period on the fertilized pasture was 49.8% greater than, but not significantly different (P<0.05) from, the ungrazed herbage biomass at the end of the grazing period on the native rangeland pasture. Grazed herbage biomass remaining at the end of the grazing period on the fertilized pasture was 40.7% greater than, but not significantly different (P<0.05) from, the grazed herbage biomass remaining at the end of the grazing period on the native rangeland pasture. The forage used during the grazing period on the fertilized pasture was 64.7% greater than, but not significantly different (P<0.05) from, the quantity of forage used per acre on the native rangeland pasture (table 6).

Costs and returns on the native rangeland and fertilized pastures on grazing trial I were compared using pasture costs and value of steer weight gain (table 7). On the native rangeland pasture managed with one grazing period, a steer required 2.04 acres per period, at a cost of $17.87 for the 59-day period, or $0.30 per day. Steer weight gain was 1.40 lbs per day and 56.18 lbs per acre; accumulated weight gain was 85.70 lbs. When steer accumulated weight was assumed to have a value of $0.70 per pound, the gross return was $59.99 per steer, and the net returns after pasture costs were $42.12 per steer and $20.80 per acre. The cost of steer weight gain was $0.26 per pound. On the fertilized pasture managed with one grazing period, a steer required 1.38 acres per period, at a cost of $29.30 for the 59-day period, or $0.50 per day. Steer weight gain was 1.51 lbs per day and 89.10 lbs per acre; accumulated weight gain was 90.50 lbs. When steer accumulated weight was assumed to have a value of $0.70 per pound, the gross return was $63.35 per steer, and the net returns after pasture costs were $34.05 per steer and $25.10 per acre. The cost of steer weight gain was $0.40 per pound (table 7).

Pasture costs per grazing period on the fertilized pasture was 64.0% greater than, and significantly different (P<0.05) from, pasture costs on the native rangeland pasture. Value of steer weight gain on the fertilized pasture was 5.6% greater than, but not significantly different (P<0.05) from, steer weight gain value on the native rangeland pasture. Net returns per steer on the native rangeland pasture was 23.7% greater than, but not significantly different (P<0.05) from, net returns per steer on the fertilized pasture. Net returns per acre on the fertilized pasture was 20.7% greater than, but not significantly different (P<0.05) from, net returns per acre on the native rangeland pasture. Cost per pound of steer accumulated weight on the fertilized pasture was 53.8% greater than, but not significantly different (P<0.05) from, cost per pound of steer accumulated weight on the native rangeland pasture (table 7).

Grazing Trial II (1978-1982)

The precipitation during the growing seasons of 1978 to 1982 was normal or greater than normal (table 8). During 1978, 1979, 1980, 1981, and 1982, 15.17 inches (111.96% of LTM), 11.12 inches (82.07% of LTM), 10.73 inches (79.19% of LTM), 14.27 inches (105.31% of LTM), and 22.53 inches (166.27% of LTM) of precipitation were received, respectively. April, May, and September of 1978 were wet months and each received 126.57%, 170.51%, and 192.48% of LTM precipitation, respectively. July and August received normal precipitation at 108.56% and 116.18% of LTM, respectively. June was a dry month and received 59.15% of LTM precipitation. October was a very dry month and received 30.53% of LTM precipitation. Perennial plants were under water stress conditions during October, 1978 (Manske 2009). August of 1979 was a wet month and received 127.75% of LTM precipitation. April, June, July, and September received normal precipitation at 89.51%, 86.20%, 100.00%, and 95.49% of LTM, respectively. May and October were very dry months and received 33.89% and 17.89% of LTM precipitation, respectively. Perennial plants were under water stress conditions during October, 1979 (Manske 2009). August and October of 1980 were wet months and each received 191.33% and 253.68% of LTM precipitation, respectively. June received normal precipitation at 75.21% of LTM. July and September were dry months and received 64.41% and 57.14% of LTM precipitation, respectively. April and May were very dry months and received 2.10%

and 5.13% of LTM precipitation, respectively. The April through July precipitation received in 1980 was 44.5% of the LTM precipitation causing drought conditions. Perennial plants were under water stress conditions during April, May, July, and September, 1980 (Manske 2009). August and September of 1981 were wet months and each received 234.10% and 206.77% of LTM precipitation, respectively. June received normal precipitation at 104.51% of LTM. May and July were dry months and received 55.56% and 70.72% of LTM precipitation, respectively. April and October were very dry months and received 46.15% and 24.21% of LTM precipitation, respectively. Perennial plants were under water stress conditions during July and October, 1981 (Manske 2009). April, May, August, September, and October of 1982 were wet months and each received 129.37%, 184.62%, 152.02%, 133.08%, and 685.26% of LTM precipitation, respectively. June and July received normal precipitation at 96.62% and 90.99% of LTM, respectively. Perennial plants did not experience water stress conditions during 1982 (Manske 2009).

The native rangeland pasture of cow-calf grazing trial II was grazed during one period for an average of 45 days from 21 June to 5 August. The grazing periods varied from 28 to 60 days in length and occurred between 19 June and 20 August. The fertilized rangeland pasture of cow-calf grazing trial II was grazed during one period for an average of 51 days from 25 June to 15 August. The grazing periods varied from 28 to 67 days in length and occurred between 17 June and 15 September. The pastures were grazed by 10 commercial crossbred cow-calf pairs. The mean stocking rate on the native rangeland pasture was 1.38 acres per AUEM with a range from 0.91 acres to 1.90 acres per AUEM. The mean stocking rate on the fertilized pasture was 0.82 acres per AUEM with a range from 0.52 acres to 1.25 acres per AUEM. The stocking rate on the fertilized pasture was 67.1% greater than, but not significantly different ($P<0.05$) from, the stocking rate on the native rangeland pasture (table 9).

Post study determination of hindsight stocking rates was made from measured standing herbage biomass and animal unit equivalent of the June cow live weight (table 10). The determined stocking rate on the native rangeland pasture was 1.93 acres per AUEM which was 39.9% lower than, but not significantly different ($P<0.05$) from, the mean stocking rate used. The determined stocking rate on the fertilized pasture was 1.25 acres per AUEM which was 52.4% lower than, but not significantly different ($P<0.05$) from, the mean stocking rate used (tables 9 and 10). The determined stocking rate on the fertilized pasture was 54.4% greater than, but not significantly different ($P<0.05$) from, the determined stocking rate on the native rangeland pasture (table 10).

During the 1980 drought growing season of grazing trial II, the pastures were managed with one grazing period and the stocking rates were reduced greatly. The stocking rate used during drought conditions on the native rangeland pasture was 4.58 acres per AUEM, which was 231.9% lower than the mean stocking rate used during nondrought growing seasons. The determined stocking rate that could have been used during drought conditions on the native rangeland pasture was 2.64 acres per AUEM, which was 91.3% lower than the mean stocking rate used during nondrought growing seasons. The stocking rate used during drought conditions on the fertilized pasture was 3.12 acres per AUEM, which was 280.5% lower than the mean stocking rate used during nondrought growing seasons. The determined stocking rate that could have been used during drought conditions on the fertilized pasture was 2.42 acres per AUEM, which was 195.1% lower than the mean stocking rate used during nondrought growing seasons (tables 9 and 10).

Cow and calf performance on the native rangeland and fertilized pastures managed with one grazing period on grazing trial II were compared using gain per head, gain per day, and gain per acre data (tables 11, 12, and 13). Cow gain per head on the native rangeland pasture was 105.6% greater than, but not significantly different ($P<0.05$) from, cow gain per head on the fertilized pasture. Cow gain per day on the native rangeland pasture was 104.1% greater than, but not significantly different ($P<0.05$) from, cow gain per day on the fertilized pasture. Cow gain per acre on the native rangeland pasture was 109.4% greater than, but not significantly different ($P<0.05$) from, cow gain per acre on the fertilized pasture (tables 11 and 13). Calf gain per head on the native rangeland pasture was 8.4% greater than, but not significantly different ($P<0.05$) from, calf gain per head on the fertilized pasture. Calf gain per day on the native rangeland pasture was 25.2% greater than, but not significantly different ($P<0.05$) from, calf gain per day on the fertilized pasture. Calf gain per acre on the fertilized pasture was 36.8% greater than, but not significantly different ($P<0.05$) from, calf gain per acre on the native rangeland pasture (tables 12 and 13).

Cow and calf performance during the 1980 drought growing season on the native rangeland and fertilized pastures managed with one grazing period on grazing trial II were compared using gain per head, gain per day, and gain per acre data (tables 11, 12, and 13). Cow gain per head on the native rangeland pasture was 1528.6% greater than cow gain per head on the fertilized pasture. Cow gain per day on the native rangeland pasture was 1675.0% greater than cow gain per day on the fertilized pasture. Cow gain per acre on the native rangeland pasture was 2259.3% greater than cow gain per acre on the fertilized pasture (tables 11 and 13). Calf gain per head on the native rangeland pasture was 21.1% greater than calf gain per head on the fertilized pasture. Calf gain per day on the native rangeland pasture was 21.1% greater than calf gain per day on the fertilized pasture. Calf gain per acre on the fertilized pasture was 23.9% greater than calf gain per acre on the native rangeland pasture (tables 12 and 13).

Early growing season cow daily gain on the fertilized pasture was greater during early to mid July than cow daily gain on the native rangeland pasture. Late growing season cow daily gain on the native rangeland pasture was greater during early to late August than cow daily gain on the fertilized pasture. Calf daily gain on the native rangeland pasture was greater during mid to late June and during mid July to late August than calf daily gain on the fertilized pasture. Calf daily gain on the fertilized pasture was not greater during any biweekly period than calf daily gain on the native rangeland pasture (table 14).

Cow and calf daily gain during the 1980 drought growing season on the native rangeland pasture was greater during early and late July than cow and calf daily gain on the fertilized pasture (table 14).

Aboveground herbage biomass on the native rangeland and fertilized pastures managed with one grazing period on grazing trial II was compared from pregrazed total herbage biomass sampled at the start of the grazing period, ungrazed and grazed total herbage biomass sampled at the end of the grazing period, and by the quantity of forage used per acre during the grazing period (table 15). Pregrazed herbage biomass on the fertilized pasture was 49.6% greater than, but not significantly different ($P<0.05$) from, pregrazed herbage biomass on the native rangeland pasture. Ungrazed herbage biomass at the end of the grazing period on the fertilized pasture was 60.9% greater than, but not significantly different ($P<0.05$) from, ungrazed herbage biomass at the end of the grazing period on the native rangeland pasture. Grazed herbage biomass remaining at the end of the grazing period on the fertilized pasture was 29.8% greater than, but not significantly different ($P<0.05$) from, grazed herbage biomass remaining at the end of the grazing period on the native rangeland pasture. The forage used during the grazing period on the fertilized pasture was 113.4% greater than, but not significantly different ($P<0.05$) from, the quantity of forage used per acre on the native rangeland pasture (table 15).

Aboveground herbage biomass during the 1980 drought growing season on the native rangeland and fertilized pastures managed with one grazing period on grazing trial II were compared from pregrazed total herbage biomass sampled at the start of the grazing period, ungrazed and grazed total herbage biomass sampled at the end of the grazing period, and by the quantity of forage used per acre during the grazing period (table 15). Pregrazed herbage biomass on the fertilized pasture was 5.5% greater than pregrazed herbage biomass on the native rangeland pasture. Ungrazed herbage biomass at the end of the grazing period on the fertilized pasture was 8.7% greater than ungrazed herbage biomass at the end of the grazing period on the native rangeland pasture. Grazed herbage biomass remaining at the end of the grazing period on the native rangeland pasture was 29.0% greater than grazed herbage biomass remaining at the end of the grazing period on the fertilized pasture. The forage used during the grazing period on the fertilized pasture was 142.6% greater than the quantity of forage used per acre on the native rangeland pasture (table 15).

Costs and returns on the native rangeland and fertilized pastures on grazing trial II were compared using pasture costs and value of calf weight gain (table 16). On the native rangeland pasture managed with one grazing period, a cow and calf required 1.83 acres per period, at a cost of $16.01 for the 45-day period, or $0.36 per day. Calf weight gain was 1.89 lbs per day and 44.93 lbs per acre; accumulated weight gain was 83.98 lbs. When calf accumulated weight was assumed to have a value of $0.70 per pound, the gross return was $58.78 per calf, and the net returns after pasture costs were $42.77 per cow-calf pair and $23.74 per acre. The cost of calf weight gain was $0.21 per pound. On the fertilized pasture managed with one grazing period, a cow and calf required 1.23 acres per period, at a cost of $26.15 for the 51-day period, or $0.51 per day. Calf weight gain was 1.51 lbs per day and 61.45 lbs per acre; accumulated weight gain was 77.45 lbs. When calf accumulated weight was assumed to have a value of $0.70 per pound, the gross return was $54.22 per calf, and the net returns after pasture costs were $28.06 per cow-calf pair and $23.21 per acre. The cost of calf weight gain was $0.39 per pound (table 16).

Pasture costs per grazing period on the fertilized pasture was 63.3% greater than, and significantly different (P<0.05) from, pasture costs on the native rangeland pasture. Value of calf weight gain on the native rangeland pasture was 8.4% greater than, but not significantly different (P<0.05) from, calf weight gain value on the fertilized pasture. Net returns per cow-calf pair on the native rangeland pasture was 52.4% greater than, but not significantly different (P<0.05) from, net returns per cow-calf pair on the fertilized pasture. Net returns per acre on the native rangeland pasture was 2.3% greater than, but not significantly different (P<0.05) from, net returns per acre on the fertilized pasture. Cost per pound of calf accumulated weight on the fertilized pasture was 85.7% greater than, but not significantly different (P<0.05) from, cost per pound of calf accumulated weight on the native rangeland pasture (table 16).

Costs and returns during the 1980 drought growing season on the native rangeland and fertilized pastures on grazing trial II were compared using pasture costs and value of calf weight gain (table 16). On the native rangeland pasture managed with one grazing period, a cow and calf required 2.38 acres per period, at a cost of $20.85 for the 16-day period, or $1.30 per day. Calf weight gain was 2.01 lbs per day and 12.48 lbs per acre; accumulated weight gain was 32.10 lbs. When calf accumulated weight was assumed to have a value of $0.70 per pound, the gross return was $22.47 per calf, and the net returns after pasture costs were $1.62 per cow-calf pair and $0.68 per acre. The cost of calf weight gain was $0.65 per pound. On the fertilized pasture managed with one grazing period, a cow and calf required 1.62 acres per period, at a cost of $34.44 for the 16-day period, or $2.15 per day. Calf weight gain was 1.66 lbs per day and 15.46 lbs per acre; accumulated weight gain was 26.50 lbs. When calf accumulated weight was assumed to have a value of $0.70 per pound, the gross return was $18.55 per calf, and the net returns after pasture costs were a loss of $15.89 per cow-calf pair and a loss of $9.81 per acre. The cost of calf weight gain was $1.30 per pound (table 16).

Pasture costs per grazing period during the 1980 drought growing season on the fertilized pasture was 65.2% greater than pasture costs on the native rangeland pasture. Value of calf weight gain on the native rangeland pasture was 21.1% greater than calf weight gain value on the fertilized pasture. Net returns per cow-calf pair on the native rangeland pasture was 1080.9% greater than net returns per cow-calf pair on the fertilized pasture. Net returns per acre on the native rangeland pasture was 1542.6% greater than net returns per acre on the fertilized pasture. Cost per pound of calf accumulated weight on the fertilized pasture was 100.0% greater than cost per pound of calf accumulated weight on the native rangeland pasture (table 16).

Grazing fertilized native rangeland pastures with steers or with cow-calf pairs did not capture much wealth from the land natural resources because the animal performance responded to the quality of the vegetation. Fertilized plants produced herbage weight at a rapid growth rate over a short period of time that occurred during the early portion of the growing season. Unfertilized plants produced herbage weight at a slower growth rate over a long period of time that continued later into the growing season.

Steers on the fertilized pasture had greater daily gain during mid June to late July than steers on the unfertilized pasture. Steers on the unfertilized pasture had greater daily gain during early August to mid September than steers on the fertilized pasture (table 5).

Cows on the fertilized pasture had similar daily gain to cows on the unfertilized pasture during mid June to mid July. Cows on the fertilized pasture started to lose weight in mid July or early August and lost more weight during the latter portion of the grazing period than they gained during the early portion. Cows on the unfertilized pasture gained weight during mid June to mid August and lost a small amount of weight towards the end of the grazing period. Cows on the unfertilized pasture gained more weight per head than the cows on the fertilized pasture. During drought conditions, cows on the fertilized pasture lost weight and cows on the unfertilized pasture gained weight (table 14).

Calves on the fertilized pasture had similar daily gain to the calves on the unfertilized pasture during mid June to mid July. Calves on the fertilized pasture had lower daily gain after mid July than calves on the unfertilized pasture. Calves on the unfertilized pasture gained more weight per head than the calves on the fertilized pasture. During drought conditions, calves on the unfertilized pasture had greater daily gain than calves on the fertilized pasture (table 14).

Nitrogen fertilization of native rangeland increased the crude protein content of aboveground plant material during early growth stages. Most grass species attained maximum crude protein content in mid May. Crude protein content decreased with advancement of plant maturity. A significant decrease in crude protein was evident on the fertilized treatments during mid June to early July and was not different than that on the unfertilized treatments in early August (Goetz 1975). An accelerated rate of decline progressed rapidly on the fertilized treatments and the crude protein content dropped below livestock requirements earlier in the growing season than the crude protein content of grasses on the unfertilized treatments (Whitman 1975).

The growing season of 1982 was the eleventh year with an application of 50 lbs N/ac on the fertilized native rangeland pasture used during the steer grazing trial I (1972-1976) and the cow-calf grazing trial II (1978-1982). The effects from 11 years of fertilization on native rangeland vegetation were determined from herbage weight clipped during 5 monthly periodic dates and separated into 5 categories. Percent herbage growth and senescence of plants during the monthly periods of the growing season were affected by the fertilizer treatment. Fertilized plants have greater herbage growth during a short period in the early portion of the growing season. Unfertilized plants have active growth during about double the length of time of the fertilized plant growth period and have greater herbage growth during the latter portion. Greater total percent herbage senescence occurred during the latter portion of the growing season on the fertilized pasture than on the unfertilized pasture (table 18).

Cool season grasses and upland sedges on the unfertilized and fertilized pastures gained herbage weight during May, June, and July, and then lost aboveground biomass during August and September (table 17). Percent herbage growth of cool season grasses and upland sedges was greater during May and June on the fertilized pasture and was greater during July on the unfertilized pasture. Total percent cool season grass herbage senescence was greater on the fertilized pasture during August and September (table 18 and figure 1).

Warm season grasses on the unfertilized pasture gained herbage weight during May, June, July, and August, and then lost aboveground biomass during September. Warm season grasses on the fertilized pasture gained herbage weight during May, June, and July, and lost aboveground biomass during August and September (table 17). Percent herbage growth of warm season grasses was greater during May and July on the fertilized pasture and was greater during June and August on the unfertilized pasture. Total percent warm season grass herbage senescence was greater on the unfertilized pasture during September (table 18 and figure 2).

Total native grasses on the unfertilized pasture gained herbage weight during May, June, July, and August, and then lost aboveground biomass during September. Total native grasses on the fertilized pasture gained herbage weight during May, June, and July, and lost aboveground biomass during August and September (table 17). Percent herbage growth of total native grasses was greater during May and June on the fertilized pasture and was greater during July and August on the unfertilized pasture. Total percent herbage senescence of total native grasses was greater on the fertilized pasture during August and September (table 18 and figure 3).

Herbage growth of introduced and domesticated grasses occurred during June and July and herbage senescence occurred during August and September on the fertilized pasture and did not occur on the unfertilized pasture (table 18 and figure 4).

Forbs on the unfertilized pasture gained herbage weight during May, June, and July, and then lost aboveground biomass during August and September. Forbs on the fertilized pasture gained herbage weight during May, June, and July, and August, and lost aboveground biomass during September (table 17). Percent herbage growth of forbs was greater during May and June on the unfertilized pasture and was greater during July and August on the fertilized pasture. Almost all of the forb herbage weight on the fertilized pasture was fringed sage. Total percent forb herbage senescence was greater on the fertilized pasture during September (table 18 and figure 5).

Total herbage yield on the unfertilized pasture gained herbage weight during May, June, July, and August, and then lost aboveground biomass during September. Total herbage yield on the fertilized pasture gained herbage weight during May, June, and July, and lost aboveground biomass during August and September (table 17). Percent herbage growth of total herbage yield was greater during May and June on the fertilized pasture and was greater during July and August on the unfertilized pasture. Total percent herbage senescence of total herbage yield was greater on the fertilized pasture during August and September (table 18 and figure 6).

Discussion

Nitrogen fertilization of native rangeland does result in greater production of herbage weight, primarily mid cool season grasses, and a greater crude protein content during early growth stages. These "improvements" in the vegetation, however, do not translate into improved livestock performance throughout the grazing season.

Fertilized rangeland plants have a short period of rapid growth in leaf height and herbage weight during May and June. This rapid increase period is followed by a period of accelerated senescence, with a rapid decline in crude protein content, an increasing rate of leaf drying, and a high rate of loss in aboveground herbage weight during July, August, and September.

Livestock performance responds to the conditions of the vegetation. Yearling steers grazing fertilized rangeland have a high rate of gain during mid June to late July and a poor rate of gain after early August. Cows grazing fertilized rangeland have a good rate of gain during mid June to mid July and have a high loss of weight after mid July or early August. Calves with cows on fertilized rangeland have a good rate of gain during mid June to mid July, have reduced gains during mid July to early August, and have poor gains after early August.

Unfertilized rangeland plants have an active growth period for about 70% of the growing season, which is about double the length of the fertilized plant active growth period. Unfertilized plant growth in leaf height and herbage weight during May and June is slower than the growth rate of fertilized plants. Unfertilized plant growth during July and August is greater than the growth rate of fertilized plants. After mid August, unfertilized rangeland plants have a period of senescence that usually progresses at a slower rate than senescence of fertilized rangeland plants.

Yearling steers grazing unfertilized rangeland have a good rate of gain during mid June to mid September. After early August, the rate of gain by steers on unfertilized rangeland is greater than the rate of gain by steers on fertilized rangeland. Cows grazing unfertilized rangeland have a good rate of gain during mid June to mid August, and after mid August, cows lose a small amount of weight. Calves with cows on unfertilized rangeland have a good rate of gain during mid June to mid August and have a slightly reduced rate of gain after mid August.

Fertilization of native rangeland does produce a short period of rapid plant growth and greater herbage weight, however, fertilization of rangeland does not produce greater livestock performance and does not result in the capture of greater wealth from the native rangeland natural resources.

Acknowledgment

I am grateful to Sheri Schneider for assistance in the production of this manuscript and for development of the tables and figures.

Table 1. Precipitation in inches for growing-season months and the annual total precipitation for 1972-1976, Dickinson, North Dakota.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Growing Season	Annual Total
Long-term mean 1892-2007	1.43	2.34	3.55	2.22	1.73	1.33	0.95	13.55	16.00
1972	1.27	5.09	4.29	2.72	2.90	0.74	1.56	18.57	20.76
% of LTM	88.81	217.52	120.85	122.52	167.63	55.64	164.21	137.05	129.75
1973	3.21	1.30	3.04	0.91	0.47	2.23	0.67	11.83	13.53
% of LTM	224.48	55.56	85.63	40.99	27.17	167.67	70.53	87.31	84.56
1974	2.82	4.15	2.00	1.50	0.90	0.56	0.52	12.45	14.15
% of LTM	197.20	177.35	56.34	67.57	52.02	42.11	54.74	91.88	88.44
1975	4.25	3.34	4.27	0.64	0.54	0.80	1.42	15.26	17.71
% of LTM	297.20	142.74	120.28	28.83	31.21	60.15	149.47	112.62	110.69
1976	2.11	1.42	3.74	0.75	0.40	1.77	0.65	10.84	12.68
% of LTM	147.55	60.68	105.35	33.78	23.12	133.08	68.42	80.00	79.25
1972-1976	2.73	3.06	3.47	1.30	1.04	1.22	0.96	13.78	15.77
% of LTM	191.05	130.77	97.75	58.56	60.12	91.73	101.05	101.70	98.56

Table 2. Mean stocking rates for steers on native rangeland treatments, 1972-1976.

Treatments	Grazing Period Dates	Days in Period	Months in Period	Number of Steers	Number of AUEM	AUEM per Acre	Acres per AUEM
One grazing period 1972-1976							
Unfertilized	30 Jun-27Aug	59	1.92	12	16.95a	0.94a	1.08a
Fertilized	30 Jun-27 Aug	59	1.92	12	16.77a	1.40b	0.73b

Means in the same column and followed by the same letter are not significantly different ($P<0.05$).

Table 3. Stocking rates for steers determined from standing herbage biomass and June animal unit equivalent (AUE), 1972-1976.

Treatments	Mean Standing Herbage (lb/ac)	Mean Forage Available (lb/ac)	June AUE	Forage per Day (lbs)	Forage per Month (lbs)	AUEM per Acre	Acres per AUEM
One grazing period 1972-1976							
Unfertilized	2676.60a	669.15a	0.7657a	19.91a	607.17a	1.10a	0.92a
Fertilized	4010.00a	1002.50a	0.7574a	19.69a	600.65a	1.68a	0.64a

Means in the same column and followed by the same letter are not significantly different ($P<0.05$).

Table 4. Mean steer performance on native rangeland treatments, 1972-1976.

Treatments	Mean Steer initial weight (lbs)	Mean Steer final weight (lbs)	Mean Steer Gain per Head (lbs)	Mean Steer Gain per Day (lbs)	Mean Steer Gain per Acre (lbs)
One grazing period 1972-1976					
Unfertilized	700.92a	786.62a	85.70a	1.40a	56.18a
Fertilized	690.86a	781.36a	90.50a	1.51a	89.10a

Means in the same column and followed by the same letter are not significantly different (P<0.05).

Table 5. Biweekly average daily gain for steers on native rangeland treatments, 1972-1976.

Treatments	1-15 Jun	16-30 Jun	1-15 Jul	16-31 Jul	1-15 Aug	16-31 Aug	1-15 Sep	Mean gain per Day
One grazing period 1972-1976								
Unfertilized		1.28	1.51	1.56	1.40	1.49	1.58	1.40
Fertilized		1.75	1.78	1.67	1.28	1.24	1.31	1.51

Table 6. Herbage biomass production and forage utilization on native rangeland treatments, 1972-1976.

Treatments	Pregrazed (lbs/acre)	Ungrazed (lbs/acre)	Grazed (lbs/acre)	Forage Utilized (lbs/acre)	Percent Utilization (%)	Forage per steer (lbs/day)
	Aboveground Herbage Biomass					
One grazing period 1972-1976						
Unfertilized		2676.60a	1660.60a	1016.00a	38.21a	27.26a
Fertilized		4010.00a	2337.20a	1672.80a	42.07a	29.48a

Means in the same column and followed by the same letter are not significantly different (P<0.05).

Table 7. Costs and returns after pasture costs for steers on native rangeland treatments, 1972-1976.

Treatments	Land Area per Period (acres)	Production Cost per Acre ($)	Cost per Period ($)	Steer Weight Gain per Period (lbs)	Steer Weight Value @ $0.70/lb ($)	Net Return per Steer ($)	Net Return per Acre ($)	Cost per Pound Steer Gain ($)
One grazing period 1972-1976								
Unfertilized	2.04a	8.76	17.87a	85.70a	59.99a	42.12a	20.80a	0.26a
Fertilized	1.38b	21.26	29.30b	90.50a	63.35a	34.05a	25.10a	0.40a

Means in the same column and followed by the same letter are not significantly different (P<0.05).

Table 8. Precipitation in inches for growing season months and the annual total precipitation for 1978-1982, Dickinson, North Dakota.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Growing Season	Annual Total
Long-term mean 1892-2007	1.43	2.34	3.55	2.22	1.73	1.33	0.95	13.55	16.00
1978	1.81	3.99	2.10	2.41	2.01	2.56	0.29	15.17	17.63
% of LTM	126.57	170.51	59.15	108.56	116.18	192.48	30.53	111.96	110.19
1979	1.28	0.91	3.06	2.22	2.21	1.27	0.17	11.12	12.81
% of LTM	89.51	38.89	86.20	100.00	127.75	95.49	17.89	82.07	80.06
1980	0.03	0.12	2.67	1.43	3.31	0.76	2.41	10.73	12.58
% of LTM	2.10	5.13	75.21	64.41	191.33	57.14	253.68	79.19	78.63
1981	0.66	1.30	3.71	1.57	4.05	2.75	0.23	14.27	15.76
% of LTM	46.15	55.56	104.51	70.72	234.10	206.77	24.21	105.31	98.50
1982	1.85	4.32	3.43	2.02	2.63	1.77	6.51	22.53	26.58
% of LTM	129.37	184.62	96.62	90.99	152.02	133.08	685.26	166.27	166.13
1978-1982	1.13	2.13	2.99	1.93	2.84	1.82	1.92	14.76	17.07
% of LTM	79.02	91.03	84.23	86.94	164.16	136.84	202.11	108.93	106.69

Table 9. Mean stocking rates for cow-calf pairs on native rangeland treatments, 1978-1982.

Treatments	Grazing Period Dates	Days in Period	Months in Period	Number of Cow-Calf Pairs	Number of AUEM	AUEM per Acre	Acres per AUEM
One grazing period 1978-1979, 1981-1982							
Unfertilized	21 Jun-5Aug	45a	1.47a	10a	14.61a	0.82a	1.38a
Fertilized	25 Jun-15 Aug	51a	1.68a	10a	16.49a	1.37a	0.82a
Drought Season 1980							
Unfertilized	7 Jul-23 Jul	16	0.52	7	3.93	0.22	4.58
Fertilized	7 Jul-23 Jul	16	0.52	7	3.84	0.32	3.12

Means in the same column and followed by the same letter are not significantly different (P<0.05).

Table 10. Stocking rates for cow-calf pairs determined from monthly standing herbage biomass and June animal unit equivalent (AUE), 1978-1982.

Treatments	Mean Monthly Standing Herbage (lb/ac)	Mean Forage Available (lb/ac)	June AUE	Forage per Day (lbs)	Forage per Month (lbs)	AUEM per Acre	Acres per AUEM
One grazing period 1978-1979, 1981-1982							
Unfertilized	1718.48a	429.62a	1.0433a	27.13a	827.36a	0.52a	1.93a
Fertilized	2824.41a	706.10a	1.0354a	26.92a	821.05a	0.86a	1.25a
Drought Season 1980							
Unfertilized	1296.45	324.11	1.0799	28.08	856.36	0.38	2.64
Fertilized	1386.85	346.71	1.0557	27.45	837.17	0.41	2.42

Means in the same column and followed by the same letter are not significantly different (P<0.05).

Table 11. Mean cow performance on native rangeland treatments, 1978-1982.

Treatments	Mean Cow initial weight (lbs)	Mean Cow final weight (lbs)	Mean Cow Gain per Head (lbs)	Mean Cow Gain per Day (lbs)	Mean Cow Gain per Acre (lbs)
One grazing period 1978-1979, 1981-1982					
Unfertilized	1058.53a	1087.75a	29.23a	0.74a	15.91a
Fertilized	1047.63a	1045.98a	-1.65a	-0.03a	-1.50a
Drought Season 1980					
Unfertilized	1107.90	1108.60	0.70	0.04	0.27
Fertilized	1075.00	1065.00	-10.00	-0.63	-5.83

Means in the same column and followed by the same letter are not significantly different (P<0.05).

Table 12. Mean calf performance on native rangeland treatments, 1978-1982.

Treatments	Mean Calf initial weight (lbs)	Mean Calf final weight (lbs)	Mean Calf Gain per Head (lbs)	Mean Calf Gain per Day (lbs)	Mean Calf Gain per Acre (lbs)
One grazing period 1978-1979, 1981-1982					
Unfertilized	217.60a	301.58a	83.98a	1.89a	44.93a
Fertilized	234.20a	311.65a	77.45a	1.51a	61.45a
Drought Season 1980					
Unfertilized	287.90	320.00	32.10	2.01	12.48
Fertilized	286.40	312.90	26.50	1.66	15.46

Means in the same column and followed by the same letter are not significantly different (P<0.05).

Table 13. Mean cow and calf performance on native rangeland treatments, 1978-1982.

Treatments	COW Gain per Head (lbs)	COW Gain per Day (lbs)	COW Gain per Acre (lbs)	CALF Gain per Head (lbs)	CALF Gain per Day (lbs)	CALF Gain per Acre (lbs)
One grazing period 1978-1979, 1981-1982						
Unfertilized	29.23a	0.74a	15.91a	83.98a	1.89a	44.93a
Fertilized	-1.65a	-0.03a	-1.50a	77.45a	1.51a	61.45a
Drought Season 1980						
Unfertilized	0.70	0.04	0.27	32.10	2.01	12.48
Fertilized	-10.00	-0.63	-5.83	26.50	1.65	15.46

Means in the same column and followed by the same letter are not significantly different ($P<0.05$).

Table 14. Biweekly average daily gain for cow-calf pairs on native rangeland treatments, 1978-1982.

Treatments	1-15 Jun	16-30 Jun	1-15 Jul	16-31 Jul	1-15 Aug	16-31 Aug	1-15 Sep	Mean gain per Day
One grazing period 1978-1979, 1981-1982								
Cow								
Unfertilized		1.23	1.23	0.22	0.25	-0.25		0.74
Fertilized		1.23	1.27	0.25	-0.88	-1.79	-2.52	-0.03
Calf								
Unfertilized		1.91	1.91	1.89	1.90	1.77		1.89
Fertilized		1.79	1.91	1.72	1.42	0.96	0.46	1.51
Drought Season 1980								
Cow								
Unfertilized			0.04	0.04				0.04
Fertilized			-0.63	-0.63				-0.63
Calf								
Unfertilized			2.01	2.01				2.01
Fertilized			1.65	1.65				1.65

Table 15. Herbage biomass production and forage utilization on native rangeland treatments, 1978-1982.

Treatments	Aboveground Herbage Biomass Pregrazed (lbs/acre)	Ungrazed (lbs/acre)	Grazed lbs/acre)	Forage Utilized (lbs/acre)	Percent Utilization (%)	Forage per Cow-Calf Pair (lbs/day)
One grazing period 1978-1979, 1981-1982						
Unfertilized	1608.18a	1828.78a	1147.63a	681.15a	36.23a	30.94a
Fertilized	2705.60a	2943.23a	1489.53a	1453.70a	51.53a	39.94a
Drought Season 1980						
Unfertilized	1389.10	1203.80	976.50	227.30	18.90	36.53
Fertilized	1465.30	1308.40	756.90	551.50	42.20	59.09

Means in the same column and followed by the same letter are not significantly different (P<0.05).

Table 16. Costs and returns after pasture costs for cow-calf pairs on native rangeland treatments, 1978-1982.

Treatments	Land Area per Period (acres)	Production Cost per Acre ($)	Cost per Period ($)	Calf Weight Gain per Period (lbs)	Calf Weight Value @ $0.70/lb ($)	Net Return per Cow-Calf Pair ($)	Net Return per Acre ($)	Cost per Pound Calf Gain ($)
One grazing period 1978-1979, 1981-1982								
Unfertilized	1.83a	8.76	16.01a	83.98a	58.78a	42.77a	23.74a	0.21a
Fertilized	1.23b	21.26	26.15b	77.45a	54.22a	28.06a	23.21a	0.39a
Drought Season 1980								
Unfertilized	2.38	8.76	20.85	32.10	22.47	1.62	0.68	0.65
Fertilized	1.62	21.26	34.44	26.50	18.55	-15.89	-9.81	1.30

Means in the same column and followed by the same letter are not significantly different (P<0.05).

Table 17. Monthly dry matter weight in pounds per acre for treatments on the evaluation of native rangeland pasture fertilization trial, 1982.

Plant Categories Treatments	15 May	15 Jun	15 Jul	15 Aug	15 Sep
Unfertilized					
cool season	429.6	834.9	1506.1	1232.0	1147.7
warm season	9.3	178.1	520.2	965.9	404.4
total native grass	438.9	1013.0	2026.3	2197.9	1552.1
introduced grass	0.0	0.0	0.0	0.0	0.0
forbs	31.4	199.5	231.6	222.6	203.4
total yield	470.3	1212.5	2257.9	2420.5	1755.5
Fertilized					
cool season	1085.4	2690.6	3260.0	2332.8	2233.6
warm season	54.2	71.0	229.8	162.7	126.1
total native grass	1139.6	2761.6	3489.8	2495.5	2359.7
introduced grass	0.0	201.2	895.9	707.1	264.0
forbs	10.7	205.5	480.3	638.0	133.2
total yield	1150.3	3168.3	4866.0	3840.6	2756.9

Table 18. Percent herbage growth and senescence of plant categories for treatments on the evaluation of native rangeland pasture fertilization trial, 1982.

Plant Categories Treatments	15 May	15 Jun	15 Jul	15 Aug	15 Sep
Unfertilized					
cool season	28.52	26.91	44.57	-18.20	-5.60
warm season	0.96	17.48	35.42	46.14	-58.13
total native grass	19.97	26.12	46.10	7.81	-29.38
introduced grass	0.0	0.0	0.0	0.0	0.0
forbs	13.56	72.58	13.86	-3.89	-8.29
total yield	19.43	30.66	43.19	6.72	-27.47
Fertilized					
cool season	33.29	49.24	17.47	-28.44	-3.04
warm season	23.59	7.31	69.10	-29.20	-15.93
total native grass	32.66	46.48	20.87	-28.49	-3.89
introduced grass	0.0	22.46	77.54	-21.07	-49.46
forbs	1.68	30.53	43.07	24.72	-79.12
total yield	23.64	41.47	34.89	-21.07	-22.27

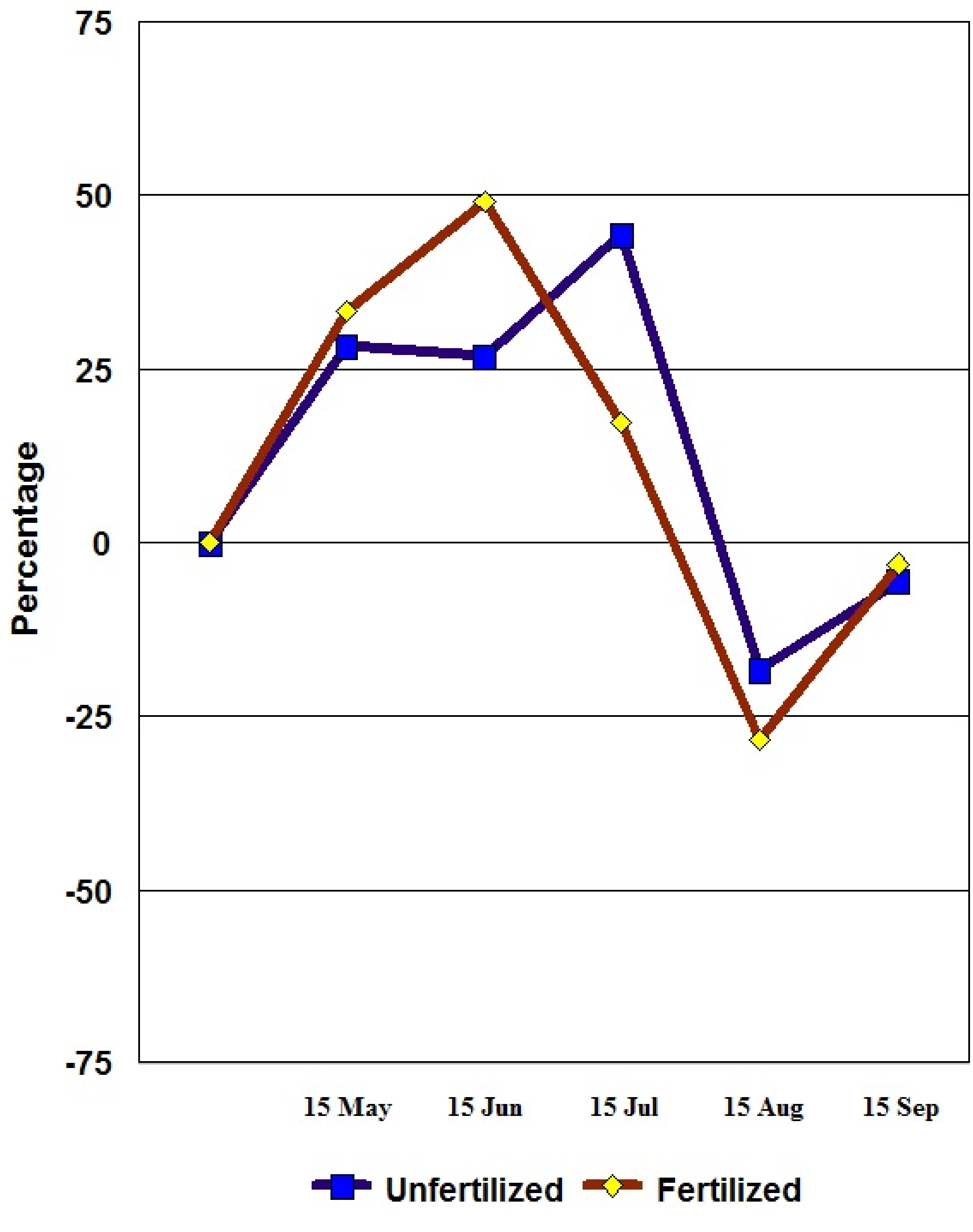

Figure 1. Percent herbage growth and senescence of cool season grasses for treatments on the evaluation of native rangeland pasture fertilization trial, 1982.

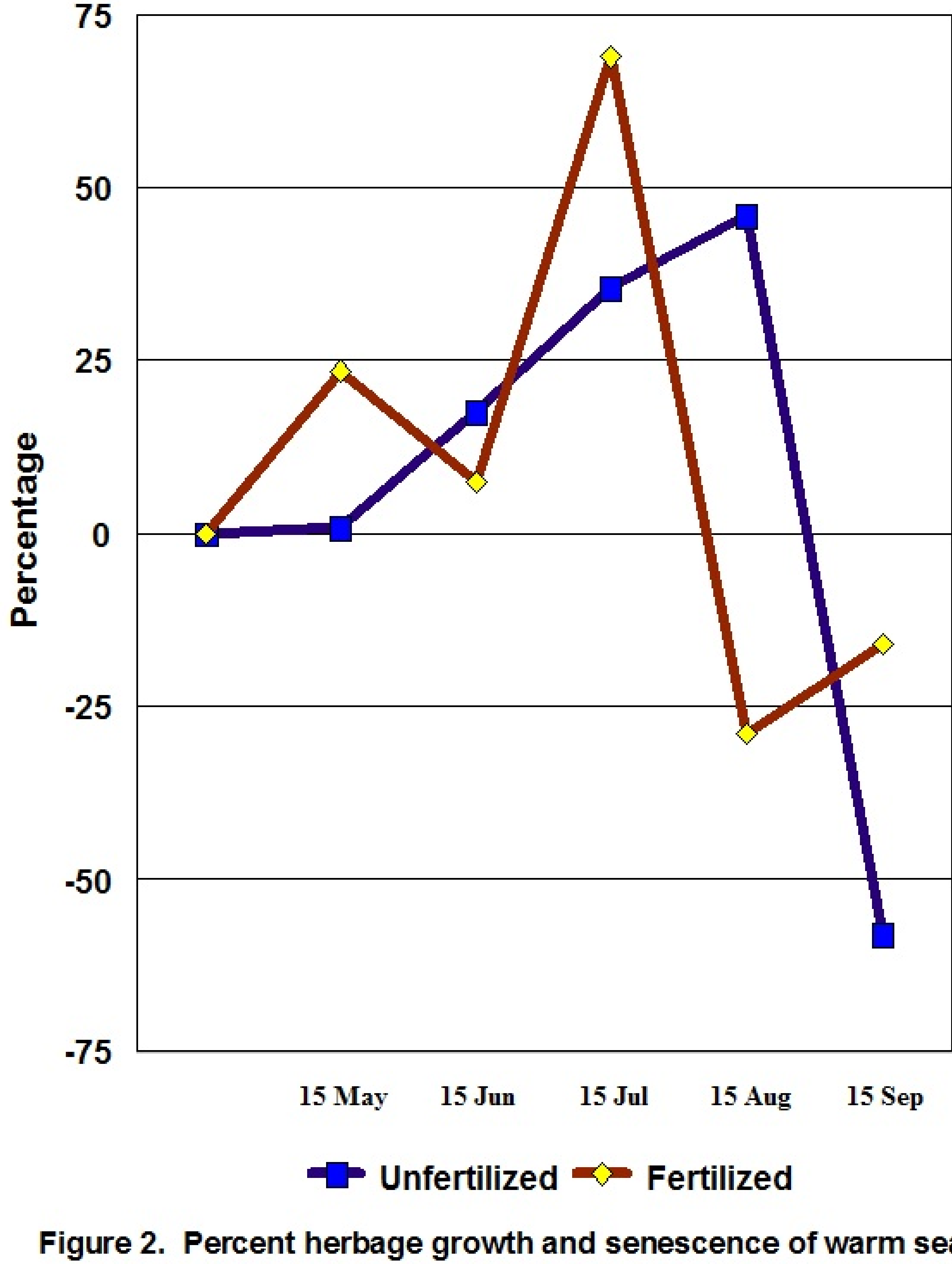

Figure 2. Percent herbage growth and senescence of warm season grasses for treatments on the evaluation of native rangeland pasture fertilization trial, 1982.

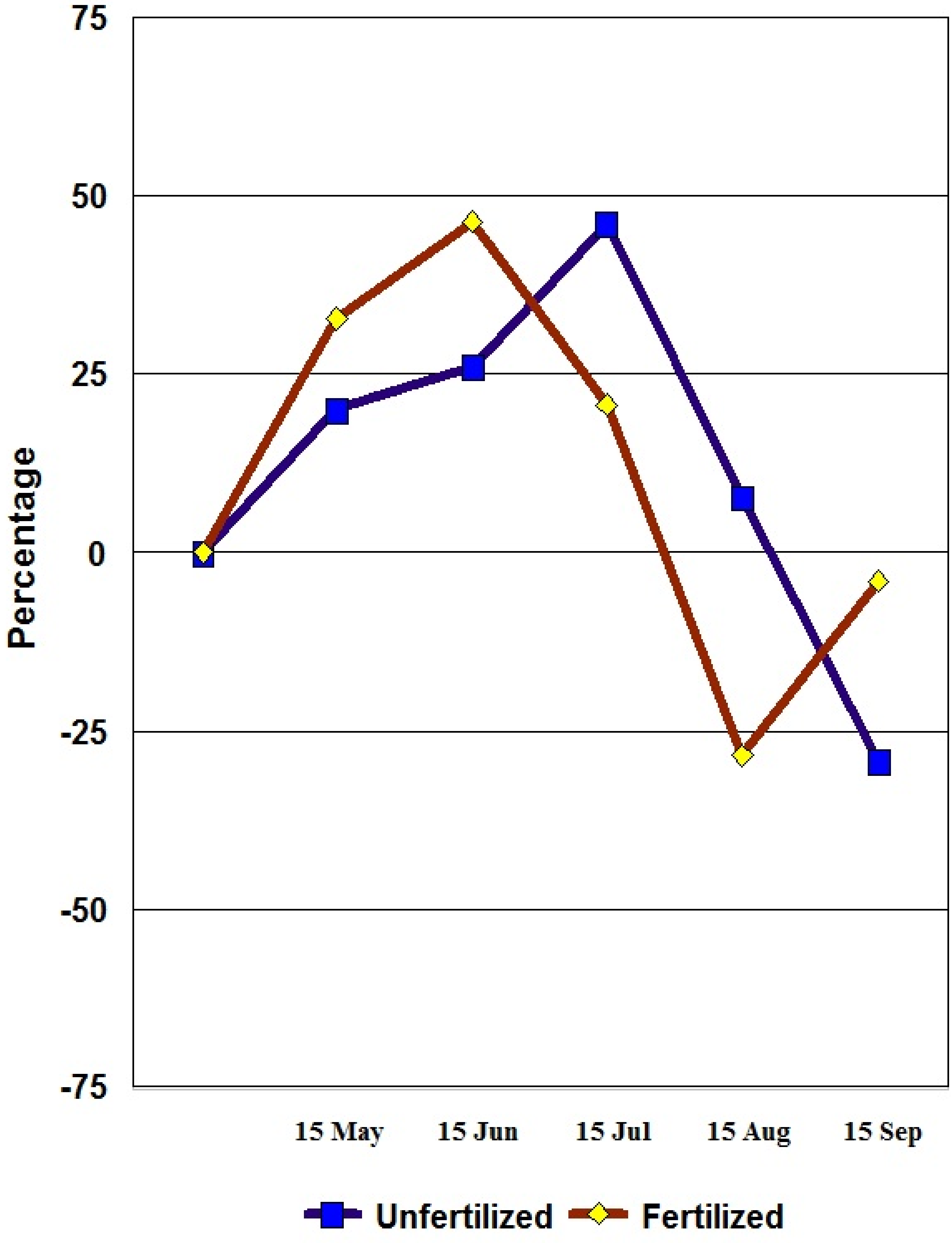

Figure 3. Percent herbage growth and senescence of total native grasses for treatments on the evaluation of native rangeland pasture fertilization trial, 1982.

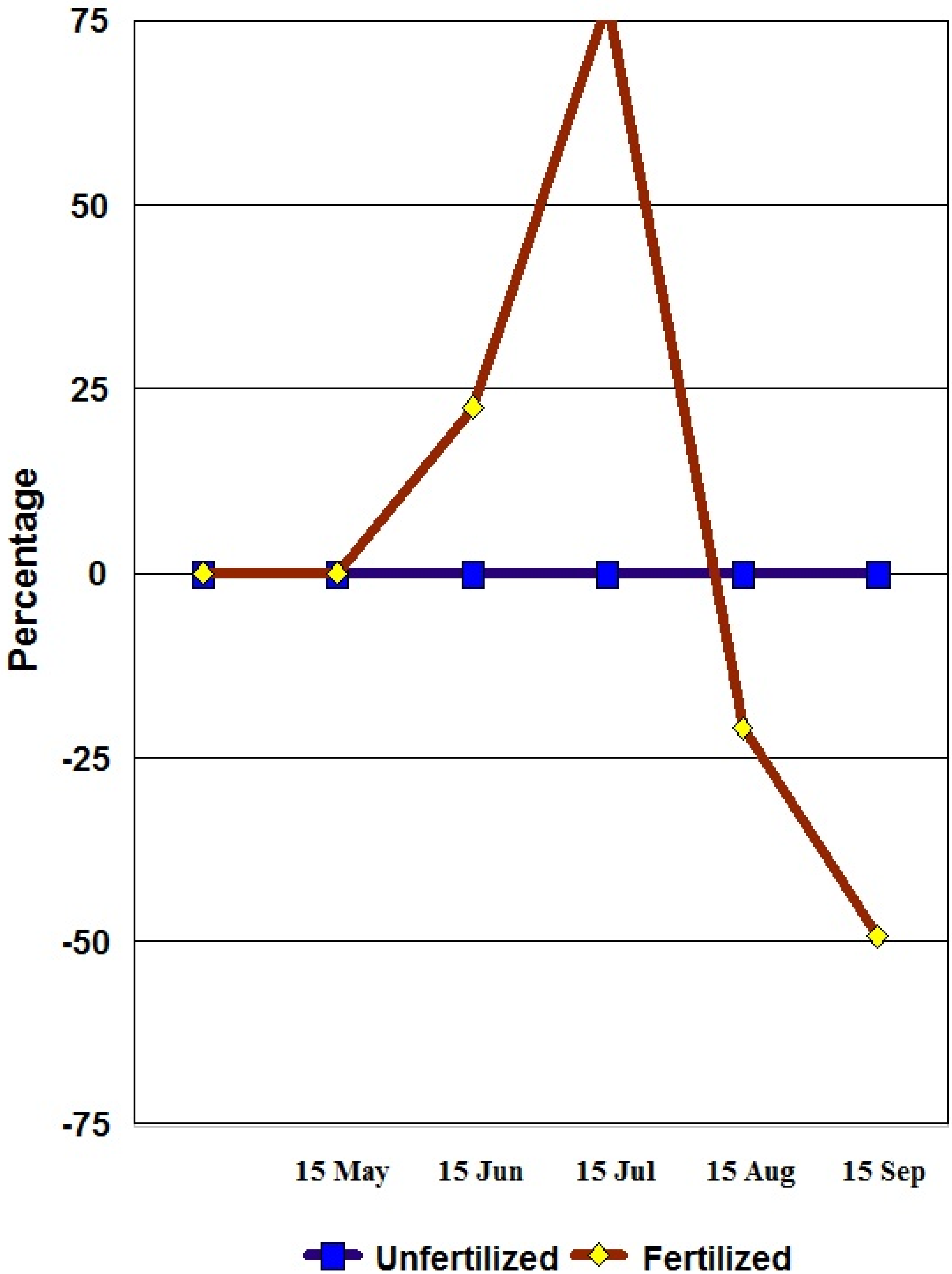

Figure 4. Percent herbage growth and senescence of introduced grasses for treatments on the evaluation of native rangeland pasture fertilization trial, 1982.

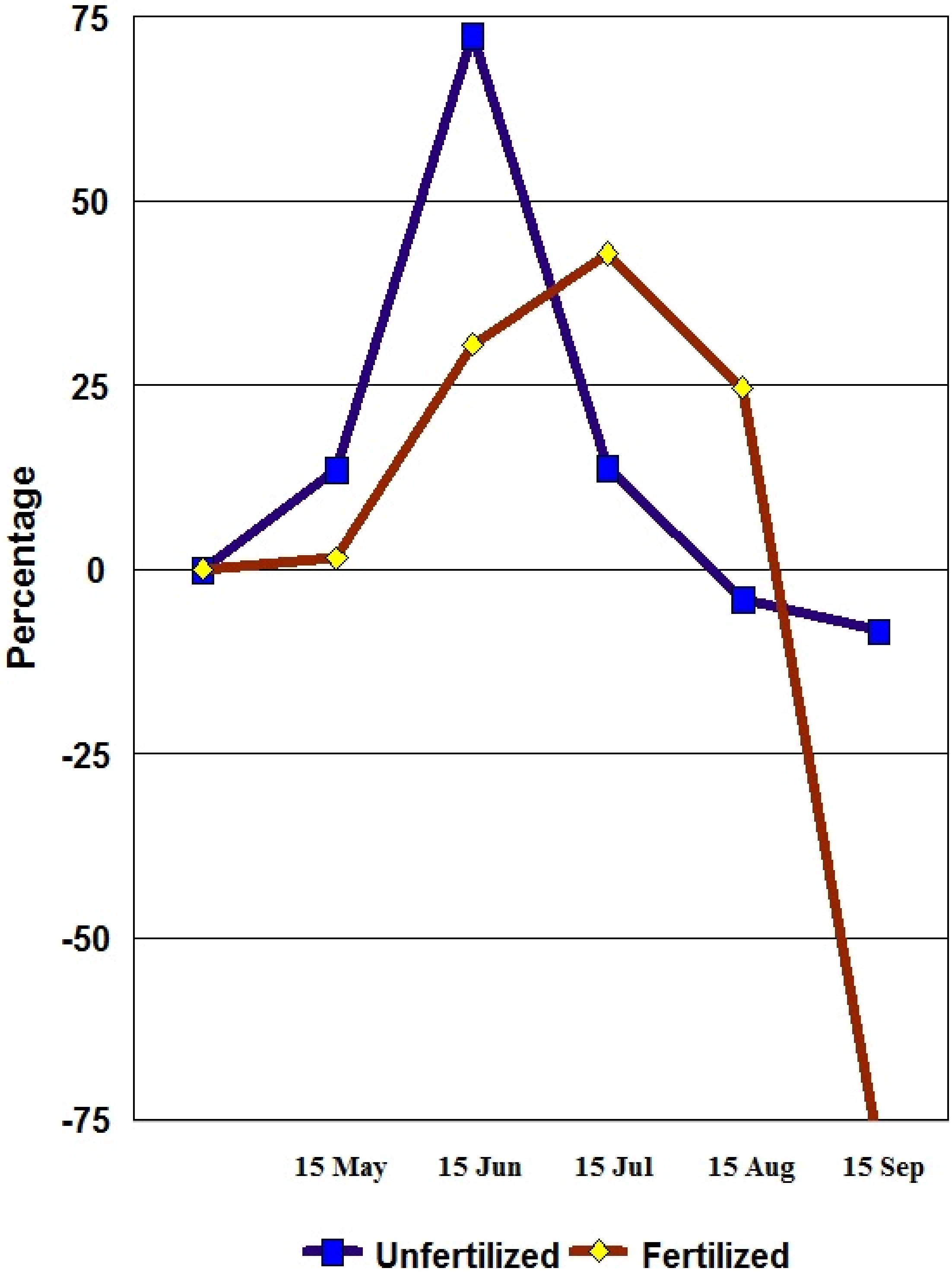

Figure 5. Percent herbage growth and senescence of forbs for treatments on the evaluation of native rangeland pasture fertilization trial, 1982.

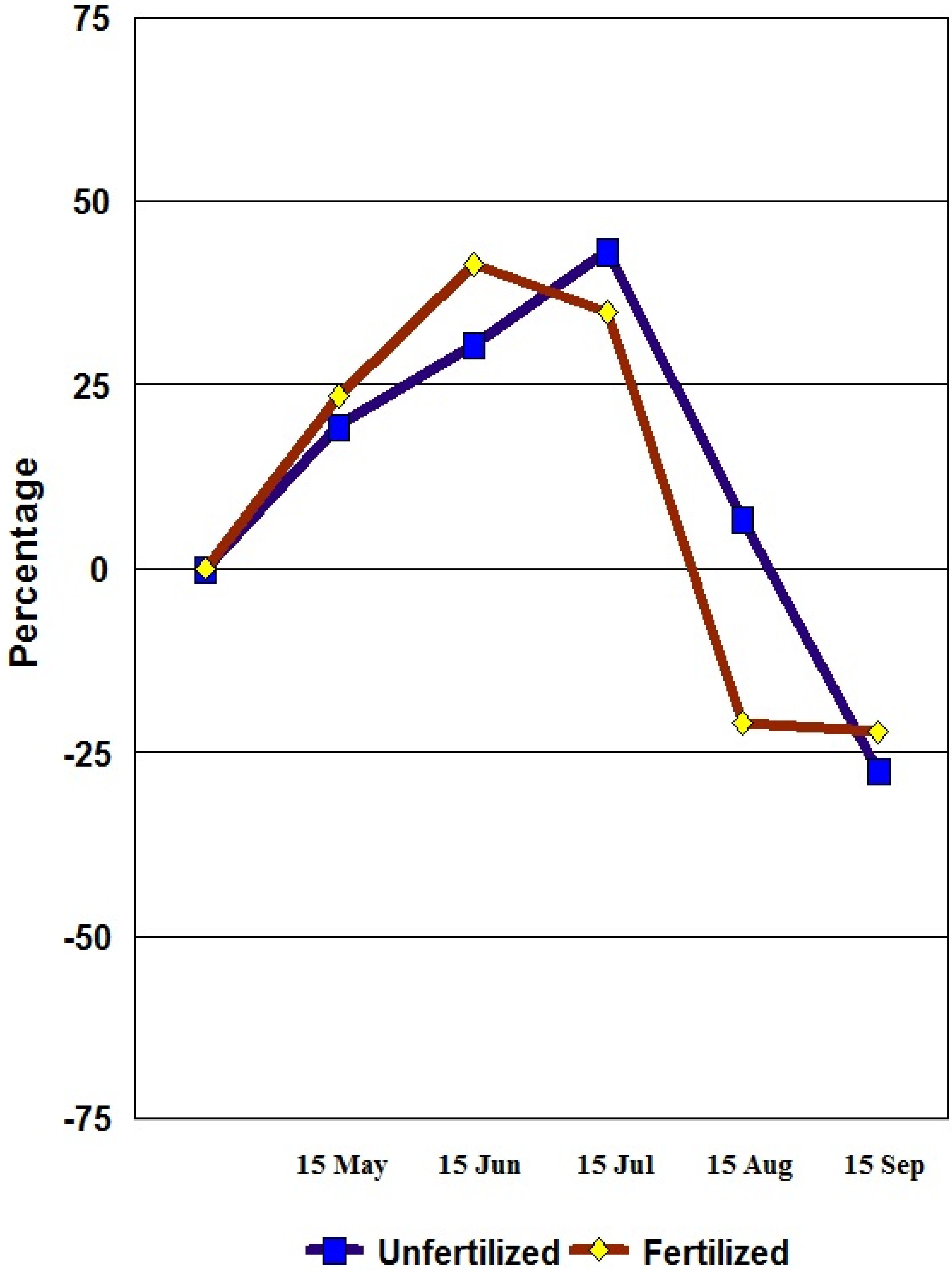

Figure 6. Percent herbage growth and senescence of total yield for treatments on the evaluation of native rangeland pasture fertilization trial, 1982.

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