INVESTIGATIONS OF NO-TILLAGE SYSTEMS FOR ESTABLISHING WHEAT ON PREVIOUSLY FARMED AND/OR ABANDONED LAND

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INTRODUCTION

Severe soil erosion and gullying has led to the abandonment of crop production on millions of acres across the state of Oklahoma. In the late 1950's, Harlan (37) found this abandoned farmland to be gullied and washed with most of the topsoil lost to erosion. He concluded that this previously farmed land constituted one of the most serious agricultural problems of the state. As early as 1930, Blackwell (7) reported that more than 1,359,000 acres of land had been abandoned in Oklahoma due to severe erosion.

The major problems associated with attempts to reclaim such land revolve around the dependence on traditional farming techniques. Tillage to destroy undesirable weedy species is usually considered a prerequisite. However, such tillage on this land results in more erosion. Some of these abandoned areas have been seeded or sprigged with improved perennial species in attempts to establish permanent vegetation. However, these perennial species offer poor forage during the winter months and are often not managed for maximum return. Thus, these areas frequently offer very little economic return to the producer and remain largely ignored.

The use of no-till winter wheat as the basis for efforts to improve utilization of our eroded land resources is considered feasible for several reasons. First, most of the indigenous species in these areas are warm season "invader" species whereas wheat is a cool season species. Thus, maximum demands for moisture and nutrients occur during different seasons, or if elimination of such vegetation is desired, nonselective herbicides could be employed. Second, more effective herbicides for annual grass control in wheat are available or are under development. In addition, better seeding equipment for no-till small grain planting is available now than in previous years.

Sod-seeding small grains into bermudagrass has been demonstrated. However, the concept of using sod-seeding systems to increase the productivity of marginal land is relatively new. Seeding wheat into bermudagrass sod combines two of the major crops grown in Oklahoma and is a very desirable cropping system from the standpoint of soil and water conservation (24).

The first objective of this research was to compare the feasibility of using three wheat management systems designed to increase the utilization and productivity of previously cultivated and/or eroded land. Since weedy annual _Bromus_ spp. are known to invade these areas, the second objective was to determine the efficacy and phytotoxicity of herbicides used for control of _Bromus_ spp. in the three wheat management systems. Other objectives of this research were to determine the effects of the various wheat management systems on populations of indigenous species and bermudagrass and to determine whether allelopathy is a factor in no-till wheat stand establishment in indigenous vegetation and bermudagrass.

CHAPTER II

LITERATURE REVIEW

Abandoned, Eroded Cropland in Central Oklahoma

Conventional tillage practices traditionally used for seedbed preparation have led to severe erosion across much of Oklahoma. In the late 1950's, Harlan (37) reported that the settlement of Oklahoma had put 11 million acres into cropland, and a second 11 million was plowed at one time and put into crop production but due to thin erodable soils, was quickly ruined by conventional tillage operations. He found that this abandoned farmland was gullied and washed with most of the topsoil lost to erosion and concluded that this previously farmed land constituted one of the most serious agricultural problems of the state. The loss of topsoil has made it unprofitable to cultivate many fields in Oklahoma. Reports by Blackwell (7) in 1930 indicated that more than 1,359,000 acres of land had been abandoned in Oklahoma due to severe erosion. Much of this abandoned land was in the form of small hillside fields in central Oklahoma, where devastation was particularly severe. By 1965, 38% of the land in Lincoln county was classified as eroded or severely eroded (82).

The Darnell-Stephenville fine sandy loams, 3-12% slopes, are the most prominent soils in several counties in central Oklahoma. For example, in Lincoln county this complex occupies over 59,000 acres or 9.5% of the land area. Of the 192,000 acres occupied by this complex in central Oklahoma, Williams and Bartolina (82) described 72,000 acres as mainly formerly cultivated but now so eroded they are no longer suited for cultivation. In Pawnee county, in central Oklahoma, only one-third of the 80,000 acres in the Dennis-Zaneis soil complex was in cultivation in 1952 (34). About one-fourth of this acreage formerly in cropland was returning to grassland agriculture, due to severe erosion hazards. Nearly 19% of the soils in this complex have been depleted to some extent by erosion. Erosion is serious enough on 3,000 acres of this complex to keep the land out of cultivation permanently. In 1952, one-fifth of the 34,990 acres in the Norge-Teller-Vanoss soil complex in Pawnee county was in some stage of regrassing (34). Most of the old fields being returned to grass are on sloping areas of Teller and Norge, where 18% of the acreage had been depleted by erosion and 1,200 acres were out of crop production because of severe gullying. Retired cropland and abandoned, eroded areas are plentiful in Pawnee County and offer great opportunity for improvement. The usual vegetative growth is needlegrass (common and scientific names of plants are listed in Table I), broomsedge bluestem, silver bluestem and various other bluestems and weeds. Forage production is very low.

The Stillwater Creek Basin, an area of approximately 190,000 acres, represents very well the Red Plains Region of central Oklahoma. The land in this area ranges from creek bottoms to sloping uplands with severe erosion hazards. In 1934 approximately 20% of this total area was in cultivation, 6% was reported to be gullied and washed beyond economic repair but was still being farmed in an attempt to produce crops (84). Approximately 45,600 acres which varied in slope from 2 to 6%, had been abandoned from cultivation in 1934. However, a classification of the soils and their utilization through 1934 indicates that

TABLE I

COMMON AND SCIENTIFIC NAMES OF PLANTS

Common Name	Scientific Name
alfalfa	*Medicago sativa* L.
bahiagrass	*Paspalum notatum* Flugge
barley	*Hordeum vulgare* L.
bermudagrass	*Cynodon dactylon* (L.) Pers.
black-eyed susan	*Rudbeckia hirta* L.
bluegrass	*Poa pratensis* L.
broomsedge bluestem	*Andropogon virginicus* L.
broomweed	*Gutierrezia dracunculoides* (DC.) Blake
cheat	*Bromus secalinus* L.
common sunflower	*Helianthus annus* L.
common yarrow	*Achillea millefolium* L.
coneflower	*Rudbeckia* spp.
corn	*Zea mays* L.
crested wheatgrass	*Agropyron desertorum* (Fisch. ex Link) Schult.
curly dock	*Rumex crispus* L.
downy brome	*Bromus tectorum* L.
hairy crabgrass	*Digitaria sanguinales* (L.) Scop.
heath aster	*Aster ericoides* L.
horseweed	*Conyza canadensis* (L.) Cronq.
Indiangrass	*Sorghastrum nutans* (L.) Nash ex Small
Japanese brome	*Bromus japonicus* Thunb. ex Murr.
ladino clover	*Trifolium repens* L.
little bluestem	*Andropogon scoparius* Michx.

TABLE I (Continued)

Common Name	Scientific Name
needlegrass	*Stipa* spp.
prairie threeawn	*Aristida oligantha* Michx.
ripgut brome	*Bromus rigidus* Roth
rye	*Secale cereale* L.
ryegrass	*Lolium multiflorum* Lam.
sand dropseed	*Sporobolus cryptandrus* (Torr.) Gray
sericea lespedeza	*Lespedeza cuneata* (Dumont) G. Don
sessile tickclover	*Desmodium sessilifolium* (Torr.) T. & G.
showy partridgepea	*Cassia fasciculata* Michx.
sideoats gramma	*Bouteloua curtipendula* (Michx.) Torr.
silver bluestem	*Andropogon saccharoides* SW.
silverleaf nightshade	*Solanum elaeagnifolium* Cav.
shining sumac	*Rhus copallina* L.
switchgrass	*Panicum virgatum* L.
tall wheatgrass	*Agropyron elongatum* (Host) Beaur.
wavy-leaf thistle	*Cirsium undulatum* (Nutt.) Spreng.
wax goldenweed	*Haplopappus ciliatus* (Nutt.) DC. (*Prionopsis*)
western ragweed	*Ambrosia psilostachya* DC.
western wheatgrass	*Agropyron smithii* Rydb.
wheat	*Triticum aestivum* L.
wild buckwheat	*Polygonum convolvulus* L.
woolly croton	*Croton capitatus* Michx.

about 60,800 acres which had a slope of over 6% and was plowed at one time was abandoned through necessity due to soil erosion.

In Payne County, a large part of which is included in the Stillwater Creek Basin, the Coyle soil series, formerly included in the Stoneburg series, is very susceptible to erosion, particularly on slopes equal to or over 3% (33). The Coyle series is a new series that is expected to be found in the new soil surveys of several central Oklahoma counties. The Stoneburg series from which the Coyle series was derived, is presently found only in Osage county in the state of Oklahoma.

Field Succession

Most fields abandoned from cultivation and tillage are generally seriously eroded prior to abandonment. Infertile soils result from the removal of surface soil by erosion. In Oklahoma, these fields are usually low in phosphorus and nitrogen at the time of abandonment (18, 58).

Booth (9) found that succession on abandoned fields in central Oklahoma displayed four stages: (1) ruderal weeds, lasting two to three years; (2) annual grass, predominantly prairie threeawn, lasting from nine to 13 years; (3) perennial bunch grass, predominantly little bluestem, persisting for at least 30 years; and (4) true prairie, in which one of the dominant grasses was switchgrass. The last three stages are in relative order of increasing nitrogen requirements. Rice, Perfound and Rohrbaugh (58) found that the requirements for nitrogen and phosphorus by prairie threawn, little bluestem and switchgrass increase in that order. Harper, Daniel and Murphy (38) found that most annual and perennial weeds present in the ruderal weed stage of succession in abandoned fields had much higher nitrogen and phosphorus requirements than any of the grasses present in latter stages of succession. These forbs are apparently able to root fairly deep and thus utilize minerals from greater depths. These species probably have a marked influence on the availability of mineral matter in the soil. Harper et al. (38) postulates that the weedy species in the first stage of succession may influence succession by increasing the availability of nitrogen and phosphorus in the surface layers of the soil. This enables the plant species in the latter stages of succession with higher requirements for these elements to gradually become established.

Soon after the abandonment of badly eroded soil the weedy stage becomes invaded by annual grasses, predominantly prairie threeawn. Pevino and Risser (57) found that net annual production from the annual grass stage of succession was the lowest of any stage. The economic return from the annual grass stage is negligible (9). These grasses offer only a very limited amount of forage and their palatability is low for all classes of livestock. Many times, burning or excessive grazing is practiced on fields in this stage of succession. Burning not only fails to destroy the prairie threeawn, but also prevents the establishment of other grasses and therefore interferes in the normal succession process. Excessive grazing or burning may allow this stage of succession to remain indefinitely.

Attempts to reseed the prairie threeawn covered land to native grass have been unsuccessful. Elwell, Slosser and Daniel (25) had poor success in establishing native grasses in well-prepared seedbeds on badly eroded soil, even though the soil in their experiments was not considered as poor as that in many of the abandoned fields in central Oklahoma.

The perennial bunch grass stage of succession is also only of moderate economic value (9). In many fields the first perennial bunch grass to appear is silver bluestem. Although this grass is commonly listed as a forage grass, it is actually only of limited value. Since this species is not as palatable as other bunch grass species of this stage, it often becomes the dominant grass for a number of years. Therefore, this stage, like the weedy stage and annual grass stage is very low in productivity and economic value.

Downy Brome Ecology

Downy brome is a dominant species in the weedy stage of field succession and is generally a common species throughout succession (43). Where pure stands of downy brome have developed following abandonment from cultivation or severe grazing, reestablishment of the native grass species is slow, with the downy brome persisting for many years as a dominant (20, 86). Warg (79) found downy brome to be common in abandoned, erodable fields and overgrazed rangelands. Together with other annual bromes, downy brome is most frequent on areas of recent disturbance, such as roadsides or fields recently grazed or cultivated.

Downy brome has been reported to have a marked growth response to nitrogen fertilization, which in turn increases its competitiveness with desirable species. Hulbert (39) demonstrated that root growth more than doubled and height tripled when ammonium nitrate fertilizer was applied at a rate equivalent to 90 kg/ha of actual nitrogen. He also observed that fertilized plants remained greener longer than unfertilized plants, presumably because of a more extensive root system that allowed for water uptake from deeper in the soil profile. Kay and Evans (44) found that under dry conditions, application of nitrogen, especially at higher rates (134 kg/ha) increased downy brome forage production and ground cover at the expense of intermediate wheatgrass. Evans, Eckart and Kay (27) found that without weed control, growth of downy brome preempted the available soil moisture which in turn became the limiting factor for growth of perennial grass seedlings.

Downy brome is reported to be of limited economic importance for forage and to offer some protection against soil erosion (73). Its palatability is somewhat lower than native perennial forage grasses but all classes of livestock readily utilize the young forage. However, forage production from downy brome and other Bromus spp. fluctuates greatly from year to year depending on environmental factors. Stewart and Hull (73) found that in years of drought, forage yields dropped to less than 20% of the average, whereas crested wheatgrass produced 58% of its average forage. Although downy brome may furnish considerable forage in its vegetative stage, its palatability decreases as it reaches the reproductive stage of growth, thus resulting in a short grazing period (45, 72). Because of its inconsistency in forage production, more desirable forage species are often introduced into downy brome areas. However, since it is the principal species on millions of acres of rangeland, it also constitutes the principal competition to the establishment of more desirable perennial grass species in these areas (26, 40).

Downy Brome Control in Rangelands

Residual herbicides are preferred for downy brome control in rangeland because germination of its seed is not always simultaneous (55).

In addition, very high levels of control are necessary if the control is to have a lasting effect. For example, Hulbert (39) demonstrated that up to a point, low density populations of downy brome produced more viable seed than high density populations. Work by Young et al. (87) demonstrated that the stability of downy brome populations is controlled dynamically, meaning that the farther a population size rises or falls, the stronger the tendancy is for that population to return to its original size. For example, paraquat (common and chemical names of herbicides are listed in Table II) has been demonstrated to effectively control emerged downy brome plants (27). However, since downy brome seeds germinate at different times depending on environmental conditions (39, 55), and the seed reservoir in the soil has a tendancy to establish a downy brome population similar in density to the original population, satisfactory control from a single application may not be obtained.

A variety of herbicides have been investigated for their possible use in controlling downy brome and other Bromus spp. Kapusta and Strieker (42), in Illinois, found that cyanazine at 3.4 kg/ha, pronamide at 0.84 and 1.14 kg/ha, simazine at 1.12 kg/ha and terbacil at 0.84 kg/ha provided excellent control of downy brome in alfalfa. These herbicides did not cause any alfalfa injury and yield increases were observed from the downy brome control.

In rangeland, Eckart and Evans (21) found that 0.67 to 1.34 kg/ha of atrazine applied in the fall effectively controlled annual weeds, including downy brome. In his technique, the seedbed was not tilled and remained in a weed-free condition for at least one year prior to seeding of perennial grasses. He considered this a chemical fallow technique. However, the residual activity of atrazine at 1.34 kg/ha damaged the

TABLE II

COMMON AND CHEMICAL NAMES OF HERBICIDES

Common Name	Chemical Name
atrazine	2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine
BAY SSH 0860	1-amino-3-(2,2 dimethylpropyl)-6-(ethylthio)-1,3,5-triazine-2,4-(1H,3H)-dione
BAY SMY 1500	unavailable
bromacil	5-bromo-3-sec-butyl-6-methyluracil
chlorsulfuron	2-chloro-N-[4-methoxy-6-methyl-1,3,5-triazin-2yl) aminol carbonyl] benzenesulforiamide
cyanazine	2-[[4-chloro-6-(ethylamino)-s-triazin-2yl] amino]-2-methylpropionitril
dicamba	3,6-dichloro-o-anisic acid
diclofop	2-[4-(2,4-dichlorophenoxy)phenoxyl] propanoic acid
diphenamid	N,N-dimethyl-2,2-diphenylacetamide
EPTC	S-ethyl dipropylthiocarbamate
glyphosate	N-(phosphonomethyl) glycine
metribuzin	4-amino-6-tert-butyl-3(methylthio)-as-triazin-5 (4H)-one
paraquat	1,1'-dimethyl-4,4'-bipyridinium ion
pronamide	3,5-dichloro(N-1,1-dimethyl-2-propynyl) benzamide
propham	isopropyl carbanilate
simazine	2-chloro-4,6-bis(ethylamino)-s-triazine
terbacil	3-tert-butyl-5-chloro-6-methyluracil
terbutryn	2-(tert-butylamino)-4-(ethylamino)-6-(methylthio)-s-triazine
triallate	S-(2,3,3-trichloroallyl)diisopropylthiocarbamate
trifluralin	a,a,a,-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine

seeded grass. Evans et al. (28) found that a perennial grass stand could not be established on land treated with 1.12 kg/ha of atrazine in the same year as herbicide application. Atrazine at 1.12 kg/ha provided an average of 91% downy brome control one year after herbicide treatment, and perennial grass seeded then was not injured. In established perennial native grass stands (western wheatgrass, sideoats gramma, and sand dropseed) atrazine provided excellent downy brome control with little or no native grass injury (30, 51). This work is also in agreement with Chamberlain et al. (15) who reported near perfect control of downy brome and increased native grass yields with atrazine applied at either 0.84 or 1.12 kg/ha in the northern Great Plains. Three desirable characteristics of atrazine for downy brome control in rangeland are its duration of activity, spectrum of weed control and its preemergence and postemergence activity (28, 51). The current atrazine label in Oklahoma allows 1.1 kg/ha to be applied in late fall or early spring for Bromus spp. control in established perennial range grasses (74). However, certain grazing restrictions may limit the usefulness of atrazine in Oklahoma. Treated areas cannot be grazed within seven months following fall applications or three months following spring applications.

Simazine treatments for downy brome control have produced variable results. When applied at 1.12 kg/ha in the fall to a silty clay loam soil in northwestern Nebraska, simazine appeared to be an effective treatment for downy brome control (51). Forage grass production was significantly increased with this treatment. Other work (28), however, has shown that in drier years, simazine at 1.12 kg/ha provides only marginal downy brome control. The low solubility of simazine may explain its lack of activity under dry conditions. A more soluble triazine, such as atrazine, may be more desirable under dry conditions. With favorable moisture, simazine at 1.12 kg/ha has been demonstrated to cause some injury to established native grass (28). Simazine is currently labeled in Oklahoma for downy brome control in forage bermudagrass at 1.7 to 3.4 kg/ha depending on soil type (36). As with atrazine, grazing and haying restrictions on simazine may limit its usefulness. Treated areas cannot be grazed or cut for hay within 60 days after application.

Other herbicides that have been evaluated for downy brome control in rangelands include diphenamid, dicamba, trifluralin, EPTC, cyanazine, bromacil, terbacil, and metribuzin. Of this group Evans et al. (28) found that diphenamid, dicamba and tritluralin either did not control downy brome or did so inconsistently. EPTC applied at 4.48 kg/ha in the granular form provided only moderate control of downy brome. Downy brome control was variable with EPTC but in years when satisfactory control was obtained, good stands of either spring or fall seeded perennial grasses were obtained following application. Spring applications of cyanazine at 1.12 kg/ha to established native grass on a silty clay loam provided 95% downy brome control five months after herbicide application and provided an increase in native grass yields of about 672 kg/ha also five months after application (28). Similar results were also observed when applied to a silt loam soil. Studies with bromacil (28) indicate that the long residual activity from this herbicide will not allow seedling establishment of perennial grasses even when a chemical fallow technique is practiced. Terbacil performance in controlling downy brome in rangelands without excessive native grass injury has been inconsistent. Fenster et al. (30) found that terbacil applied at .56

kg/ha provided excellent downy brome control up to five months after application and increased native grass yields by about 615 kg/ha also five months after application. In their work, spring applications of metribuzin and terbacil were the only herbicides that provided consistent downy brome control of 85% or better when applied to a loamy sand.

In other studies in established perennial grasses, metribuzin applied in the fall or spring at 1.12 kg/ha provided excellent downy brome control with significant increases in grass yields (51). Twenty months after application, metribuzin still reduced downy brome stands by 95%. Other work, however, has shown some significant injury to perennial native grass stands from metribuzin applied at either 0.56 or 1.12 kg/ha (30). The injury in these studies resulted in significant grass yield reductions. The differences in effectiveness between herbicides applied to different soil types are apparently related to soil texture, organic matter and amount of annual precipitation. It is important in the evaluation of treatments which increase native grass production to consider not only quantity but also quality of the forage produced since total vegetation may be reduced by some herbicides.

Downy Brome Control in Winter Wheat

Downy brome is one of the most serious weed problems in dryland winter wheat throughout the plains states. In Washington, Rydrych Muzik (66) has shown yield reductions of 28% with only 54 downy brome plants/m². However, in three test years it was demonstrated that downy brome competition is not directly related only to plant populations but also to time of downy brome emergence. Early emergence of downy brome and consequently early weed competition was more detrimental to wheat yields than later emergence of greater densities (66). Even in a winter wheat-fallow rotation system, downy brome is a frequent problem and can markedly reduce yields of the subsequent wheat crop. For example, Massee (50) observed a 1% yield reduction for each 4.25 downy brome plants/m^2. In the past, cultural practices were depended on for downy brome control. Studies have demonstrated that plowing reduces downy brome stands in winter wheat but does not completely eliminate them (29). The use of sweep plows and stubble mulch tillage implements which help control soil erosion results in greater infestations of downy brome than moldboard plowing during the fallow year in a winter wheat-fallow rotation system. The use of stubble mulch farming has provided a niche for downy brome that was not present under the earlier system of plowing (12).

Much research on selective control of downy brome and other *Bromus* spp. has been performed in recent years. Research on downy brome control with propham has had variable results. Rydrych reported that propham applied at 0.84 kg/ha provided consistent downy brome control ($\geq$ 93%) with very little crop injury whether applied preplant incorporated (64, 65) or preemergence (64). However, Schumacher et al. (69) observed no control of ripgut brome, a similar *Bromus* spp. with propham applied preemergence at 1.68 kg/ha. Although Alley et al. (3) found that propham applied postemergence at 2.24 kg/ha provided good downy brome control, he also found that it caused severe wheat injury. It was also found that propham may have different varietal responses (45).

Another herbicide that has had much attention for downy brome control in wheat is diclofop. Diclofop has been demonstrated by several researchers (63, 64, 70, 71) to provide excellent downy brome control when incorporated. When applied preemergence, control has varied from fair (71) to satisfactory (64). Diclofop has also been demonstrated to provide excellent control of downy brome in straw covered seedbeds when applied at 1.12 kg/ha and lightly incorporated (63).

Triallate, another herbicide that has shown promise for selective downy brome control in wheat, was reported by Seder (70) to provide effective downy brome control without substantial wheat injury. However, work by Brewster et al. (10) demonstrated that triallate applied pre-emergence incorporated at 1.4 kg/ha provided no downy brome control. Therefore, herbicides which in the past, have shown some promise of satisfactory downy brome control, have also required incorporation for effective downy brome control; which may not be compatible with reduced tillage systems used for erosion control, particularly on sloping erodable soils.

Downy brome control in a winter wheat-fallow rotation system has been aimed primarily at herbicides with residual activity. Atrazine has received much of this attention. However, the residual activity of atrazine may carry over to injure the next year's crop, particularly in sandy or high pH soils (8). In contrast, other studies have demonstrated that atrazine applied postemergence at 0.67 kg/ha to 2 leaf wheat had activity on downy brome with only minor wheat injury (67). In a chemical fallow system on winter wheat go-back land, Chamberlain and Ally (14) reported that atrazine applied at either 1.12 or 2.24 kg/ha provided 100% downy brome control. Fortino et al. (32) did find atrazine carryover to the subsequent wheat crop when used in a wheat-fallow rotation system at a rate of 0.34 kg/ha.

Performance of Metribuzin and BAY SSH 0860 in Winter Wheat

Both the *as*-triazine metribuzin and the dione-*s*-triazine BAY SSH 0860 have been studied extensively for selective *Bromus* spp. control in winter wheat. Metribuzin has been demonstrated to provide excellent downy brome control in both alfalfa (83) and winter wheat (35). However, studies have indicated that tolerant wheat varieties should be used in order to obtain maximum selectivity (13, 35, 62, 81). Other factors which may affect metribuzin use include soil pH and crop residue on the soil surface at the time of application. Many studies have demonstrated that metribuzin activity increases as soil pH increases (46, 47, 80). However, other studies (5) have shown that the initial activity of metribuzin may not be affected by soil pH. Work by Parrish et al. (56) indicates that as soil moisture increases, metribuzin activity increases. They found that in conservation tillage systems where high levels of crop residue are present, metribuzin activity could be increased on target as well as non-target species, if soil moisture was increased due to the presence of residue on the soil surface. They attributed the increase in activity to greater herbicide micromovement in the soil.

Walker and Crawford (78) found that surface plant residue was not very absorptive of triazine herbicides and thus may not be important in chemically retaining herbicides. However, in other research wheat straw mulch on the soil surface has been found to slow metribuzin penetration and thus reduce its effectiveness (6). A mulch layer would be especially evident where a herbicide was used to kill or surpress existing sod.

Proper applications of metribuzin, according to the product label, are made after the wheat has at least three tillers to avoid possible wheat injury. This postemergence activity is considered important since populations of downy brome often depend on postplanting weather (73).

BAY SSH 0860 has been found to provide selective Bromus spp. control in winter wheat when applied either preplant-incorporated or premergence. Ratliff, Fischer and Peeper (59) found that applications of 1.68 kg/ha provided 100% control of cheat. Schumacher, Thill and Callihan (69) found that BAY SSH 0860 applied preemergence at 2.24 kg/ha effectively controlled ripgut brome with no crop injury. Unlike metribuzin and other triazines, Vaculin (77) found that BAY SSH 0860 was less phytotoxic to wheat as soil moisture increased. Why this occurred, contrary to other triazines is not clear. He also reported that increased phytotoxicity from BAY SSH 0860 due to increases in soil pH should not be a problem.

Sod-Seeding Small Grains

With improved equipment and technology in the no-tillage area, interseeding or sod-seeding could be a useful method of increasing productivity of previously farmed and/or eroded areas. Most past research on interseeding improved species into marginal land has focused on warm-season species.

Corn has been successfully grown in no-tillage systems for many years (1). The success in no-tillage systems with corn has been attributed to herbicides used for sod suppression. Glyphosate is effective in controlling many perennial sods, including bermudagrass (48) and is used in many no-till systems.

Mueller and Chandler (52) were successful in fall interseeding alfalfa and ladino clover. Kalmbacher et al. (41) were also successful in interseeding alfalfa and red clover into bahiagrass in the fall, with the aid of a herbicide for sod suppression. With no herbicide, the legume crop was a failure, indicating that competition from the bahiagrass continued into the fall after legume emergence.

The use of cereal grains in interseeding or sod-seeding systems to increase productivity of marginal land is relatively new. However, interseeding cereal grains into bermudagrass has been demonstrated (17, 19, 22, 23, 75). Seeding wheat into bermudagrass sod combines two of the major crops grown in Oklahoma and is a very desirable cropping system from the standpoint of soil and water conservation (24). Decker (19) was successful in sod-seeding rye into Midland bermudagrass pastures in Maryland. The same technique has been demonstrasted successfully with winter wheat (22, 23, 75). The establishment of small grains in such perennial pastures during dormancy would greatly increase total forage production. Swain et al. (75) found that wheat or barley interseeded into bermudagrass was superior in total forage production to ryegrass. Sod-seeded cereals are generally more productive than other annual pasture grasses at low temperatures (17). Their effectiveness may depend on fertilizer practices (16) and species sown.

In Oklahoma research, Alhagi (2) reported that high seeding rates (136 kg/ha) were very important for the establishment of a uniform stand of wheat seeded into bermudagrass sod. He attributed the need for such high rates to a compensation for non-germinating seeds. However, he used a conventional hoe type drill, not designed for proper seed placement in the sod.

In other Oklahoma research, Woods (85) found that application of 0.28 kg/ha of paraquat to suppress bermudagrass sod significantly increased the number of tillers as well as grain production of sod-seeded wheat. In his unrepeated research, the wheat was planted on October 19 and the bermudagrass remained green until late November. Grain yields of 2937 kg/ha were achieved when paraquat was applied compared to 2203 kg/ha where no paraquat was used.

The overall success of sod-seeding under dryland conditions also depends on the amount and reliability of fall and winter rainfall. Robinson (61) suggests that for successful winter forage production, rainfall in August and September should exceed potential evapotranspiration rates and provide adequate moisture to obtain rapid establishment and growth before cold weather. His research in the Southeastern U.S. suggests that the possibilities of winter grazing sod sown small grains are very limited in parts of the South, and it is only during years of unusually favorable rainfall that sod-seeding can provide substantial winter grazing. He suggests that the first approach to sod seeding in the Southeast is to examine climatological data during critical periods in the fall.

The success of sod-seeding cereals also depends on control of winter annual weeds. Schirman (68) found it necessary to control downy brome with paraquat before sod-seeding spring wheat into herbicide suppressed bluegrass sod. When winter wheat was sod-seeded into the herbicide suppressed bluegrass sod, the downy brome developed such a dense stand that wheat plants failed to tiller, and because of competition from the late developing stands of downy brome, the crop was an economic failure.

Since both downy brome and cheat are common range and waste land species, they should be a substantial threat to sod-seeded wheat in these areas. Because of their phytoxicity to wheat, most herbicides typically used for Bromus spp. control on rangelands cannot be used in conjunction with sod-seeded wheat. Metribuzin, the one herbicide labelled for Bromus spp. control in wheat in Oklahoma, has not been investigated for use in sod-seeded no-till wheat. BAY SSH 0860, another herbicide which has shown promise for Bromus spp. control in wheat, also has not been investigated for use in sod-seeded no-till wheat.

CHAPTER III

METHODS AND MATERIALS

Field studies were conducted on two soils in north central Oklahoma to compare the feasibility of using three wheat management systems designed to increase the productivity of previously cultivated and/or eroded land. Since weedy *Bromus* species (downy brome, japanese brome, cheat) commonly infest such areas these experiments were also designed to determine the efficacy and phytotoxicity of two herbicides applied for *Bromus* spp. control in the three wheat management systems. Fertility treatments were also included in these two experiments to evaluate the effect of fertilization on management system productivity. Field experiments were also conducted at two locations to evaluate herbicides applied in early spring for control of *Bromus* spp. and resultant *Bromus* spp. infestations in subsequent fall seeded no-till wheat. These field experiments will be referred to hereafter as MS-I, MS-II, H-I and H-II respectively. Laboratory experiments were conducted to determine whether allelopathy was a factor in no-till wheat stand establishment in bermudagrass and indigenous vegetation.

All experimental data was analyzed statistically. Treatment effects were compared using protected L.S.D.'s at the 0.05 level of significance. All visual ratings of crop injury or weed control were based on a 0-10 scale, with 0 equal to no effect and 10 equal to complete plant kill. Wheat vigor ratings were based on a 0-100 scale, with 0 equal to complete plant death and 100 equal to maximum plant vigor.

Management System Experiments

Field experiments MS-I and MS-II were initiated in 1982 at the Oklahoma State University Crosstimbers Research Area, Payne County, Oklahoma. Both experiments were conducted as randomized complete blocks with split plot arrangements of treatments replicated four times. The main plot treatments consisted of three wheat management systems and subplots consisted of herbicide treatments, unfertilized controls and unseeded controls. Subplots measured 3.0 m by 7.6 m in MS-I and 3.7 m by 10.7 m in MS-II. Subplot treatments were repeated on the same plots for two years.

MS-I was on a previously farmed, contour terraced Coyle loam (Udic Argiustolls) which had been out of crop production for 13 years. Major vegetation at this site consisted of a variable population of indigenous species (Table III). MS-II was also conducted on a previously farmed Coyle loam; however, this soil was classified as severely eroded (4) and had been out of crop production for 14 years. This area had been sprigged to bermudagrass several years before the initiation of this study. Vegetation at this location consisted primarily of poorly managed bermudagrass but indigenous species were also present (Table IV).

The management systems utilized in both sites were designated: (a) conventional tillage, (b) no-till with glyphosate and (c) no-till hay. In the conventional tillage management system, the soil was plowed with a two bottom, 35.6 cm moldboard plow with scalloped rolling coulters operated at a depth of approximately 18 cm. The second tillage was with a 3 m wide offset disk operated at a depth of approximately 10 cm. A 2.1 m Danish s-tine harrow with rolling baskets operated at a depth of approximately 8 cm was used as the final tillage operation. Dates for tillage operations and herbicide applications were the same in both management system experiments unless otherwise indicated (Table V). An additional tillage implement was deemed necessary to control rhizome bermudagrass in the conventional tillage management system in study MS-II. A 1.8 m wide v-sweep with added rear mounted rolling tines operated approximately 10 cm deep was used. The soil was tilled in both studies just before planting with the s-tine harrow mentioned previously to prepare the seedbed for planting. In 1983, the moldboard plow was not used. The soil was offset disked twice and the final seedbed preparation tillage was with the s-tine harrow.

TABLE III

COMMON SPECIES GROWING AT MANAGEMENT SYSTEM EXPERIMENT MS-I PRIOR TO INITIATION OF MAIN TREATMENTS JULY 23, 1982

Common Name	Estimated Population	Plant Height
	(plants/m^2)	(cm)
coneflower	11-80	10-38
broomweed	11-100	10-20
horseweed	11-80	15-25
silver bluestem	0-22	50-90
shining sumac	0-4	36-122
tall wheatgrass	0-4	75-85
wax goldenweed	0-54	20-30
western ragweed	11-80	25-36

TABLE IV

COMMON SPECIES GROWING AT MANAGEMENT SYSTEM EXPERIMENT MS-II PRIOR TO INITIATION OF MAIN TREATMENTS JULY 23, 1982

Common Name	Estimated Pop.	Plant Height
	(plants/m^2)	(cm)
Indiangrass	0-3	15-36
Korean lespedeza	0-6	10-20
little bluestem	0-3	15-30
horseweed	0-4	10-25
sessile tickclover	0-4	50-90
showy partridgepea	0-8	20-36
wavy-leaf thistle	0-2	20-36
western ragweed	0-12	25-36
bermudagrass	75% ground cover	10-15

In the no-till with glyphosate management system, glyphosate was applied at 4.48 kg a.i./ha in 1982. A conventional tractor mounted boom sprayer equipped with nine 8003 flat fan nozzle tips on 50.8 cm centers was used for applying the glyphosate. The carrier volume was 140 l/ha. Species present at the time of application in 1982 are those listed in Tables III and IV. In 1983, glyphosate was applied at 1.1 kg a.i./ha, again with a tractor mounted hydraulic pump sprayer with a 17 nozzle boom equipped with 9503 flat fan nozzle tips on 50.8 cm centers. Application was in a total volume of 187 l/ha. Major species present at the

TABLE V

FIELD OPERATION DATES USED IN THE THREE MANAGEMENT SYSTEMS

Operation	1982-83			1983-84		
	CT[1]	NT-G	NT-H	CT	NT-G	NT-H
Moldboard Plow	July 22	-	-	-	-	-
Disk	July 31 Sept. 1	-	-	July 6 Sept. 5	-	-
Sweep w/rolling tines [2]	Aug. 27	-	-	-	-	-
Glyphosate application	-	July 23	-	-	July 13	-
Hay harvested	-	-	Aug. 26 (MS-I) Sept. 1 (MS-II)	-	-	Sept. 1
S-tine harrow	Sept. 18	-	-	Sept. 22	-	-
Seeded; SSH 0860 trtmts. applied	Sept. 18	Sept. 18	Sept. 18	Sept. 22	Sept. 22	Sept. 22
Metribuzin trtmts. applied	Nov. 10	Nov. 10	Nov. 10	Nov. 2	Nov. 2	Nov. 2
Grain harvest	June 22	June 22	June 22	June 19	June 19	June 19

(1) CT = conventional tillage, NT-G = no-till w/glyphosate, NT-H = no-till hay management systems

(2) operation used only in experiment MS-II

time of glyphosate application in 1983 are listed in Table VI. Bermudagrass was not present in this management system in 1983.

TABLE VI

COMMON SPECIES FOUND IN THE NO-TILL WITH GLYPHOSATE MANAGEMENT SYSTEM PRIOR TO GLYPHOSATE APPLICATION IN 1983

Common Name	Estimated Population(m^2)	Plant Height (cm)
MS-I		
black-eyed susan	0-10	10-20
hairy crabgrass	0-30	8-12
heath aster	0-3	40-45
silverleaf nightshade	0-5	15-27
sunflower	0-1	40-48
wooly croton	0-3	20-37
MS-II		
hairy crabgrass	0-20	8-12
wavy-leaf thistle	0-2	40-50
wooly croton	0-3	30-37

In the no-till hay management system, the existing vegetation was removed as hay with a flail type harvester similar to one described by Buker (11) on August 26, 1982 (MS-I) or September 1, 1982 (MS-II). The stubble height was approximately 9 cm. The soil was left undisturbed.

On September 1, 1983 the forage yields were determined in the no-till hay management system from both experiments on September 1, again using the flail type harvester. A sample was again retained for protein analysis in the laboratory. The remaining vegetation was harvested with a 2.7 m wide pull type swather, baled and removed from the area.

In both 1982 and 1983, fertilizer was applied to all but the unfertilized treatments according to soil test recommendations for winter wheat from the Oklahoma State University Soil Testing Laboratory with a yield goal of 3360 kg/ha (Table VII). On August 11, 1982, 336 kg/ha of ammonium nitrate was applied to MS-I with a 2.4 m Barber spreader. In MS-II, 336 kg/ha of ammonium nitrate was applied on September 10, 1982 and 95.2 kg/ha of potassium chloride was applied on September 11, 1982, again through the previously mentioned fertilizer spreader. An additional 112 kg/ha of diammonium phosphate was applied through the grain drill to all fertilized plots at the time of planting. In 1983, 61.6 kg/ha of diammonium phospate was applied through the grain drill at the time of planting to both studies. On January 31, these plots received 336 kg/ha of ammonium nitrate broadcast with a 3 m Gandy spreader.

On September 18, 1982, both studies were planted with TAM W 101 hard red winter wheat at 101 kg/ha using a model EZ1010 hoe type drill with 25.4 cm drill row spacings. The drill had been modified and converted to a no-till drill by lengthening the frame to accommodate two tool bars so that rolling coulters (50.9 cm diameter) and additional weights could be added. The conventional shoes on the drill had been replaced by specially designed narrow shoes for easier soil penetration and minimum soil disturbance. In 1983 both locations were planted on September 22 using the same methods used in 1982.

TABLE VII

SUMMARY OF SOIL TEST RESULTS [1]

Experiment	Texture	Year	pH	Surface NO_3-N (kg/ha)	Soil test index (kg/ha) P	K	Organic Matter (%)
MS-I	Silty clay loam	1982-83	6.2	9.0	140.0	370.7	0.3
		1983-84	6.2	15.7	85.1	457.0	1.7
MS-II	Silt loam	1982-83	6.7	16.8	16.8	222.9	0.6
		1983-84	5.8	30.2	37.0	350.6	2.0
H-I	Loam	1983-84	5.5	0	114.2	375.2	0
H-II	Clay loam	1983-84	5.8	1.1	25.8	420.0	2.7

(1) Soil analyzed by the Oklahoma State University Soil and Water Service Laboratory, prior to fertilizer applications in the respective years

All subplot herbicide treatments for Bromus spp. control were applied with a tractor mounted compressed air plot sprayer with water carrier and total spray volume of 280 l/ha. BAY SSH 0860 was applied preemergence at 0.83, 1.26, and 1.68 kg/ha (active ingredient) in all management systems in both experiments immediately after planting each year. Metribuzin was applied at 0.28, 0.42, and 0.56 kg/ha (active ingredient) when the wheat had three to four tillers on November 10, 1982 and on November 2, 1983. Heavy populations of downy brome were encountered both years and size varied from 8 cm to 10 cm at the time of metribuzin application. Visual ratings of both downy brome control and wheat injury were made on December 21, 1982; April 22, 1983; and May 20, 1983 in the first year and on December 8, 1983; April 19, 1984 and May 16, 1984 in the second year of both experiments. A wheat vigor rating was also taken on May 16 in the second year of both experiments.

Additional treatments were added to evaluate the effect of fertilization alone on Bromus spp. populations, forage production, and wheat grain yield in each management system. Treatments included: (1) unplanted, unfertilized; (2) unplanted, fertilized; (3) planted, unfertilized; and (4) planted, fertilized. The latter treatment was also utilized as the no herbicide check for visual ratings of downy brome control and wheat vigor. In the unplanted, fertilized plot, diammonium phosphate fertilizer was applied through the grain drill as previously mentioned. However, the shoes of the drill were not down, and the soil was left undisturbed.

Wheat stands/densities were measured on November 9, 1982 (MS-I and MS-II) and November 22, 1983 (MS-I) or November 21, 1983 (MS-II). Three drill rows were selected in the middle of each plot and the percent stand determined by measuring the areas of missing wheat plants in a 1.6 m length. An area of missing wheat was determined to exist when leaf blades from consecutive wheat plants did not overlap. Bromus spp. populations were determined by counting the number of plants in two 7.6 cm by 33.0 cm areas in each plot on October 8, 1982 and on November 8, 1983 (MS-I) or November 10, 1983 (MS-II). Each year, just before harvest, weed populations were determined by counting the weeds present in either the entire plot or in a 75.4 cm by 7.6 m quadrat (MS-I) or a 75.4 cm by 10.6 m quadrat (MS-II).

Wheat and Bromus spp. forage production was determined by clipping a 0.1 m^2 area from each plot in all management systems on March 8, 1983 at both locations. Forage was cut to a height of 4 cm, separated by species and placed in brown paper bags. The samples were dried in a forced air oven dryer at 70 C and data recorded as dry matter production. The second year, forage was clipped in MS-I on March 13 and in MS-II on March 9.

Wheat yields were obtained by harvesting a 1.5 m by 7.6 m area (MS-I) or a 1.5 by 10.7 m area (MS-II) of each plot with a small plot combine on June 22, 1983. In 1984 experiment MS-II was harvested on June 19. Experiment MS-I was harvested on June 19 (replications one and two) and June 22 (replications three and four) due to interruption by rainfall. Dockage, obtained by recleaning the grain with a small seed cleaner, was primarily due to large amounts of downy brome seed present in the wheat grain at harvest. Test weight of clean grain and the weight of one thousand seeds from each plot were used as measures of grain quality. Grain samples were also taken from each subplot for protein analysis throught the Udy (76) procedure in 1983. Straw samples were collected immediately behind the combine, placed in brown paper bags and weighed in the field on an electronic balance. Straw moisture was determined after drying in a forced air oven dryer at 70 C.

Herbicide Screening Experiments

Two field experiments were initiated on previously farmed, naturally revegetating land in the spring of 1983 to compare herbicides applied in early spring for Bromus spp. control and phytotoxicity to wheat (TAM W 101) and barley (Post) seeded no-till the following fall. One experiment was located at the Crosstimbers Range Research Area on a Coyle loam (H-I) and the other approximately seven miles north of Stillwater on an eroded Norge loam (Udic Paleustoll) (H-II).

In experiment H-I, fourteen herbicide treatments were applied in experiment H-I to 2.1 m by 10.7 m plots in a randomized complete block design with four replications on March 11, 1983. The treatments were applied with a compressed air bicycle sprayer equipped with four 11005 flat fan spray tips spaced 51 cm apart. The total spray volume was 280 l/ha. Primary species present at the time of herbicide application in H-I included crested wheatgrass, 0-4/m^2, 10-13 cm tall; prairie threeawn (residue), 15-100/m^2, 12-18 cm tall; silver bluestem, 0-2/m^2, 15-18 cm tall; horseweed, 8-15/m^2, 10-15 cm tall and downy brome, 100-200/m^2, 10-12 cm tall. The existing forage at this site was removed from the plot area on September 6, 1983 with a 2.7 m wide swather to avoid interference with the planting operation. On September 22, 1983 wheat at 100.8 kg/ha and barley at 84 kg/ha were planted across the herbicide treatments, with each species occupying half of each plot. Fertilizer was applied according to soil sample recommendations determined by the

Oklahoma State University soil testing laboratory for winter wheat with a yield goal of 3360 kg/ha (Table VII). Diammonium phosphate was applied at 61.6 kg/ha through the grain drill at the time of planting. An additional 336 kg/ha of ammonium nitrate was applied on February 3, 1984 with a 3 m wide Gandy spreader. On December 1 when the crops had three to four tillers three postemergence treatments were applied. The primary species present at the time these treatments were applied was downy brome, 100-200/m², 8-10 cm tall. Weed control visual ratings were made on April 22, 1983; February 3, 1984; and April 19, 1984. Wheat and barley yields were obtained from clean grain harvested from each plot with a small plot combine on June 15, 1984.

Experiment H-II was conducted in a similar manner as experiment H-I on once farmed, terraced land on which bermudagrass had been sprigged several years previously. Plot size and experimental design were the same as in experiment H-I. Fourteen herbicide treatments were applied on April 7, 1983 with the previously mentioned bicycle sprayer. The primary vegetation at this location was a thin stand of bermudagrass. Other vegetation present when the April 7 treatments were applied included horseweed, 1-6/m², 8-10 cm tall; common yarrow, 1-6/m², 12-18 cm tall and downy brome, 100-200/m², 10-12 cm tall. Before planting vegetation at this site was also removed to avoid interference with the planting operation. The site was planted with wheat and barley on November 8 across herbicide treatments. Fertilizer was applied according to soil sample recommendations determined by the Oklahoma State University soil testing laboratory for winter wheat with a yield goal of 3360 kg/ha (Table V). This diammonium phosphate was applied at 112 kg/ha through the grain drill at the time of planting. An additional 336 kg/ha of ammonium nitrate was applied on March 4, 1984 with a centrifugal broadcast applicator. This experiment had three additional herbicide treatments which were applied immediately after planting on November 8, with the previously mentioned bicycle sprayer. Three postemergence treatments were also applied to the established wheat and barley on March 7, 1984 when the crops had three to four tillers. The primary species present at the time these postemergence treatments were applied was Bromus spp., 0-100/m², 3-5 cm tall. Visual weed control ratings were made on May 27, 1983 and May 16, 1984. Wheat yields were obtained from clean grain harvested from each plot with a small plot combine on June 15, 1984.

Allelopathy Experiments

Experiments were conducted to determine whether allelopathy was a factor in wheat stand establishment in the three management systems. Three, 7 cm diameter soil cores, 9 cm deep, were taken from the fertilized, no herbicide treatment plots in each management system. The three samples were then combined and mixed thoroughly. One 325 g sample from each plot was placed in a 473 ml plastic pot to which 150 ml of distilled water was added. After thorough mixing, the pots were left undisturbed for 24 hours. The mixture was filtered gravimetrically through Whatman 41 ashless rapid filter paper and 5 ml of the filtrate were placed in a 9 cm petri dish lined with the previously mentioned filter paper. Twenty-five wheat seeds were placed on the saturated filter paper in each petri dish. The petri dishes were then placed in a controlled environment germinator set to provide 25 C, 12 hour days and 18 C, 12 hour nights. Seventy-two hours later the radicle and coleoptile lengths of each germinated seed were measured and recorded. The percent germination in each petri dish was also recorded. The five longest radicles and coleoptiles were selected from the recorded measurements and used as subsamples in data analysis utilizing a randomized complete block design.

A similar study was conducted to determine if allelopathy from indigenous vegetation was a factor in no-till wheat establishment. Several indigenous species common to experiment MS-I were selected for this study. Four plants were selected at random near the experimental area. Three 7 cm diameter samples were taken 9 cm deep from the soil directly beneath the target species on December 12. The samples were combined and thoroughly mixed. One 325 g sample was taken from the mixture for use in the allelopathy experimental procedure mentioned in the previous experiments. Radicle and coleoptile lengths were recorded from the germinated wheat seeds and the five longest measurements were selected for use as subsamples in data analysis utilizing a randomized complete block experimental design with four replications. The percent germination was also calculated and analyzed statistically.

CHAPTER IV

RESULTS AND DISCUSSION

Management System Experiment MS-I

The July glyphosate applications in the no-till with glyphosate management system effectively controlled 97 to 100% of all existing vegetation in both 1982 and 1983. Tillage operations in the conventional tillage system controlled vegetation effectively. In the no-till hay system, very little regrowth of indigenous species occurred after the mowing operation.

In 1982, wheat stand establishment was better in both no-till systems than in the conventional tillage system (Table VIII). The no-till drill tended to plant too deep in the conventional tillage and consequently poor stands resulted. Also, when rainfall occurred, soil in the conventional tillage system tended to crust and thus impair seedling emergence. The SSH 0860 treatments had no effect on stand establishment, nor was there a significant management system by herbicide treatment interaction.

In contrast to 1982, in 1983 excellent stands were obtained in all management systems. The unfertilized treatment did have a slightly poorer stand in both no-till systems than in the conventional tillage system.

In 1982, higher _Bromus_ spp. populations were found within the SSH 0860 treatments in the no-till with glyphosate system than in either

TABLE VIII

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE AND FERTILIZER COMBINATIONS ON THE PERCENT OF ROW LENGTH OCCUPIED BY WHEAT FOLIAGE (MANAGEMENT SYSTEM EXPERIMENT MS-I)

Treatment	Herb. Rate (kg/ha)	November 9, 82			November 22, 83		
		NT-H[1]	NT-G	CT	NT-H	NT-G	CT
1. Fertilized, SSH 0860	0.83	71	88	73	99	99	100
2.	1.26	81	85	66	99	100	100
3.	1.68	82	93	56	100	100	100
4. Fertilized, Metribuzin	0.28	-	-	-	99	100	100
5.	0.42	-	-	-	99	100	100
6.	0.56	-	-	-	100	100	100
7. Fertilized, No herb.	-	78	90	54	99	99	100
8. Unfertilized, No herb.	-	82	86	51	97	96	100
Mean		79	88	60			
LSD 0.05 [2]			(18)			3	

(1) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems

(2) The LSD 0.05 in ( ) is for comparing management system means. The LSD without ( ) is an interaction LSD for comparing any two values within the November 22 data.

other system, probably due to the dead thatch layer on the soil surface which would tend to conserve moisture and thus promote seed germination (Table IX). Bromus spp. plant counts were made 21 days after seeding and application of the SSH 0860 treatments. Sufficient rainfall for SSH 0860 activation had not occurred and consequently, no herbicide treatment reduced Bromus spp. populations below those in the herbicide treatment control (trtmt. 7) in any management system. The application of fertilizer alone (trtmt. 9) did not effect Bromus spp. populations in any management system. However, the planting operation alone (trtmt. 8) reduced Bromus spp. in the no-till with glyphosate system but not in the other systems. The displacement or destruction of much of the thatch layer with the drill probably accounts for this reduction. In 1982, the metribuzin treatments were not applied until after the Bromus spp. plant counts were taken and therefore were not included in data analysis.

In contrast to 1982, in 1983 metribuzin treatments were applied six days prior to the Bromus spp. plant counts and a significant amount of rainfall occurred within a few hours after application. Metribuzin activity on Bromus spp. was evident at the time the estimates were made; and plants with severe herbicide injury were not counted. All rates of both SSH 0860 and metribuzin decreased Bromus spp. populations in all management systems. Among the treatments with no herbicide, the seeded, fertilized treatment (trtmt. 7) had higher Bromus spp. populations than the other treatments in both no-till systems. However, this was not evident in the conventional tillage system, because Bromus spp. populations were lower.

Visual ratings on December 21, 1982, 96 days after treatment (DAT), indicate that SSH 0860 provided no Bromus spp. control in either no-till

TABLE IX

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE, FERTILIZER AND PLANTING COMBINATIONS ON *BROMUS* SPP. POPULATIONS (MANAGEMENT SYSTEM EXPERIMENT MS-I)

Treatment	Herb Rate (kg/ha)	October 8, 82			November 8, 83		
		NT-H[1]	NT-G	CT	NT-H	NT-G	CT
		(plants/m²)					
1. Planted, Fertilized, SSH 0860	0.83	149	770	298	3209	2752	830
2.	1.26	204	636	383	3090	1803	512
3.	1.68	303	830	283	2196	2002	343
4. Planted, Fertilized, Metribuzin	0.28	-	-	-	3011	2901	522
5.	0.42	-	-	-	2718	2976	810
6.	0.56	-	-	-	1679	2742	288
7. Planted, Fertilized, No herb. (herbicide trtmt. control)	-	606	775	447	5197	4029	1495
8. Planted, Unfertilized, No herb.	-	90	371	155	1067	1067	262
9. Unplanted, Fertilized, No herb.	-	106	1048	209	2251	2251	837
10. Unplanted, Unfertilized, No herb.	-	98	1242	579	1356	1546	557
LSD 0.05 [2]		475; 604			1537; 1782		

(1) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems

(2) The LSD's are interaction LSD's. The first LSD is for comparing values within a single management system and the second LSD is for comparing any two values in one year.

system, and only moderate control in the conventional tillage system (Table X). However, on April 22, 1983, some Bromus spp. control with SSH 0860 was evident in both no-till systems. Metribuzin at 0.56 kg/ha provided good to excellent Bromus spp. control in all management systems. Metribuzin at 0.28 kg/ha provided better control in the conventional tillage system than in either no-till system on all rating dates. In the last rating, averaged over all herbicide treatments, Bromus spp. control was better in the conventional tillage system than in either no-till system. This indicates that higher rates of these herbicides are probably required for effective control in no-till systems, possibly due to the surface residue found in the no-till systems which may interfere with herbicide penetration. Metribuzin at 0.56 kg/ha provided better Bromus spp. control than SSH 0860 in all management systems throughout the 1982-83 season.

Despite greater rainfall in the fall of 1983, visual ratings of Bromus spp. control for the 1983-84 season (Table XI) are similar to those from the 1982-83 season. SSH 0860 provided essentially no visible control in either no-till system through April. However, control was better in the conventional tillage system. By mid May, visible control with SSH 0860 varied from poor to good in the no-till and conventional tillage systems respectively. Metribuzin at 0.56 kg/ha provided excellent Bromus spp. control in all management systems on all rating dates. However, at lower rates, its performance differed significantly in both no-till systems on all rating dates. In the conventional tillage system, the performance of metribuzin was very good throughout the season. This again indicates a need for higher metribuzin rates in the no-till systems.

Wheat injury was not evident from any herbicide treatment on any rating date in the 1982-83 season. In the 1983-84 season, slight wheat

TABLE X

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE COMBINATIONS ON VISUAL *BROMUS* SPP. CONTROL RATINGS (MANAGMENT SYSTEM EXPERIMENT MS-I 1982-83)

Herbicide Treatment	Rate (kg/ha)	December 21, 82			April 22, 83			May 20, 83			
		NT-H(1)	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	Mean
		(% control)									
1. SSH 0860	0.83	5	0	8	0	0	15	18	13	24	18
2.	1.26	0	0	45	0	0	58	14	4	58	25
3.	1.68	0	3	58	35	13	58	30	26	66	41
4. Metribuzin	0.28	15	5	55	30	10	93	24	25	78	42
5.	0.42	15	20	88	53	70	98	41	61	98	67
6.	0.56	60	53	96	85	88	100	83	85	100	89
7. Untreated	-	0	0	0	0	0	0	0	0	0	0
Mean		-	-	-	-	-	-	30	31	60	
LSD 0.05 (2)		23; 25			27; 30				(14)		⌊18⌋

(1) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems

(2) The LSD's without ( ) or ⌊ ⌋ are interaction LSD's. The first LSD is for comparing values within a single management system and the second LSD is for comparing any two values within one date. The LSD in ( ) is for comparing management system means and the LSD in ⌊ ⌋ is for comparing herbicide treatment means averaged over management systems from the May 20 rating date.

TABLE XI

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE COMBINATIONS ON VISUAL *BROMUS* SPP. CONTROL RATINGS (MANAGEMENT SYSTEM EXPERIMENT MS-I 1983-84)

Herbicide Treatment	Rate (kg/ha)	December 12, 83			April 19, 84			May 16, 84		
		NT-H[(1)]	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT
		(% control)								
1. SSH 0860	0.83	5	0	40	10	0	39	11	23	77
2.	1.26	0	0	60	0	8	59	5	40	84
3.	1.68	3	1	66	10	13	80	23	34	90
4. Metribuzin	0.28	58	63	88	18	25	88	28	50	93
5.	0.42	83	88	96	60	56	95	65	63	99
6.	0.56	94	96	93	87	78	99	97	90	100
7. Untreated	-	0	0	0	0	0	0	0	0	0
LSD 0.05 [(2)]		14; 19			22; 25			25; 27		

(1) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems

(2) LSD's are interaction LSD's. The first LSD is for comparing values within a single management system and the second LSD is for comparing any two values within one date.

injury from metribuzin was observed (Table XII). This is possibly due to the higher amount of rainfall received in the fall of 1983 and subsequent increased herbicide activity. On December 12 (41 DAT), injury was primarily in the form of dead or chlorotic wheat plants. By April 19 (172 DAT), injury was recorded as stand reduction. Averaged over management systems, metribuzin at 0.56 kg/ha caused wheat injury of only 2 and 3% in the first and second ratings respectively.

The wheat vigor rating from May 16, 1984 (Table XII) generally reflects the level of Bromus spp. control obtained with each treatment. Wheat in plots with very low or no Bromus spp. infestation appeared to have a dark green color and a vigorous appearance and rated high in vigor, whereas wheat in plots with heavy Bromus spp. infestations generally was stunted and more yellow. Wheat in the conventional tillage management system was generally more vigorous than wheat in either no-till system. Wheat in plots treated with the high rate of SSH 0860 (1.68 kg/ha) in both the no-till with glyphosate and conventional tillage systems appeared as vigorous as wheat in plots treated with the high rate of metribuzin (0.56 kg/ha). In contrast, wheat in plots treated with the high rate metribuzin (0.56 kg/ha) in the no-till hay system was more vigorous than wheat in plots treated with the high rate of SSH 0860 (1.68 kg/ha), presumably due to better Bromus spp. control.

In the winter forage production data for 1983 (Table XIII), all treatments except SSH 0860 at 0.83 kg/ha increased wheat forage production over that of the herbicide treatment control (trtmt. 7). Metribuzin at 0.28 and 0.56 kg/ha increased wheat forage more than the high rate of SSH 0860 (1.68 kg/ha). The unfertilized treatment (trtmt. 8) produced significantly less wheat forage than any other treatment. No differences

TABLE XII

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE COMBINATIONS ON HERBICIDE PHYTOXICITY AND WHEAT VIGOR
(MANAGEMENT SYSTEM EXPERIMENT MS-I 1983-84)

Herbicide Treatment	Rate (kg/ha)	Wheat Injury: December 12, 83: NT-H[1]	NT-G	CT	Mean	Wheat Injury: April 19, 84: NT-H	NT-G	CT	Mean	Wheat Vigor: May 16, 84: NT-H	NT-G	CT
		(%)										
1. SSH 0860	0.83	0	0	0	0	0	0	0	0	55	56	89
2.	1.26	0	0	0	0	0	0	0	0	46	73	93
3.	1.68	0	0	0	0	0	0	0	0	59	75	90
4. Metribuzin	0.28	0	0	0	0	0	0	0	0	58	79	89
5.	0.42	0	1	1	1	0	0	0	0	76	78	95
6.	0.56	3	3	0	2	4	4	0	3	86	86	93
7. Untreated	-	0	0	0	0	0	0	0	0	30	41	70
LSD 0.05[2]					[2]				[2]		16	

(1) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems
(2) The LSD's in [ ] are used for comparing herbicide treatment means averaged over management systems within their respective rating date. The LSD for wheat vigor without [ ] is an interaction LSD for comparing any two values.

TABLE XIII

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE, FERTILIZER AND PLANTING COMBINATIONS ON WINTER FORAGE PRODUCTION (MANAGEMENT SYSTEM EXPERIMENT MS-I; MARCH 8, 1983)

Treatment	Herb. Rate (kg/ha)	Wheat				Bromus Spp.				Total[1]			
		NT-H[2]	NT-G	CT	Mean	NT-H	NT-G	CT	Mean	NT-H	NT-G	CT	Mean
		(g dry weight/m²)											
1. Planted, Fertilized, SSH 0860	0.83	90	90	110	97	65	91	22	59	155	181	132	156
2.	1.26	76	102	126	102	56	119	15	63	132	221	141	165
3.	1.68	95	76	133	101	32	65	2	33	127	142	134	134
4. Planted, Fertilized, Metribuzin	0.28	92	118	167	125	27	54	0	27	119	172	167	152
5.	0.42	90	123	112	108	20	7	0	9	110	130	112	117
6.	0.56	113	118	146	126	7	4	0	4	120	122	146	129
7. Planted, Fertilized, No herb. (herbicide trtmt. control)	-	63	89	78	77	69	105	103	92	132	194	181	169
8. Planted, Unfertilized, No herb.	-	40	44	63	49	15	8	25	16	55	52	88	65
9. Unplanted, Fertilized, No herb.	-	-	-	-	-	126	212	125	154	126	212	125	154
10. Unplanted, Unfertilized, No herb.	-	-	-	-	-	33	35	63	44	33	35	63	44
Mean		82	95	117		45	70	36		111	146	129	
LSD 0.05[3]			(NS)		[22]		(23)		[32]		(NS)		[38]

(1) Total forage = wheat forage + Bromus spp. forage
(2) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems
(3) The LSD in ( ) is for comparing management system means. The LSD's in [ ] are for comparing treatment means averaged over management systems.

in wheat forage production were found between the three management systems when averaged over treatments.

Bromus spp. forage production is generally inversely related to wheat forage production. All herbicide treatments reduced *Bromus* spp. forage production compared to the herbicide treatment control (trtmt. 7). However, the high rate of metribuzin (0.56 kg/ha) did not differ significantly in *Bromus* spp. forage from the high rate of SSH 0860 (1.26 kg/ha). The unfertilized treatments (trtmts. 8 and 10) produced less *Bromus* spp. forage than treatments fertilized but without herbicide (trtmts. 7 and 9). When treatments were fertilized but without herbicide (trtmts. 7 and 9), the unplanted treatment produced significantly more *Bromus* spp. forage than the planted treatment indicating that the planting operation destroyed a substantial amount of *Bromus* spp. However, when treatments were not fertilized and without herbicide (trtmts. 8 and 10), the planting operation had no effect on *Bromus* spp. forage production. Averaged over treatments, the no-till with glyphosate system produced significantly more *Bromus* spp. forage than either the no-till hay or conventional tillage systems. This data would agree with *Bromus* spp. populations data in which higher populations occurred in the no-till with glyphosate system than in either other system.

Metribuzin at 0.42 kg/ha was the only herbicide treatment that produced significantly less total forage than the herbicide treatment control (trtmt. 7). It is unclear as to why this middle rate had this reduction. Even though total forage available in March was not increased with the herbicide treatments, if late spring grazing was desired, the grazing period would have been extended by replacing the *Bromus* spp. forage with wheat forage. Treatments that were not fertilized (trtmts.

8 and 10) produced less total forage whether planted with wheat or not planted with wheat. No differences existed between management systems in total forage production when averaged over herbicide treatments.

The 1984 wheat forage data (Table XIV) is similar to that of 1983. SSH 0860 at 1.26 kg/ha and metribuzin at 0.28 and 0.56 kg/ha increased wheat forage production over that of the herbicide treatment control (trtmt. 7). The unfertilized treatment again produced substantially less wheat forage than any other treatment. However, averaged over treatments, significantly more wheat forage was available in 1984 in the conventional tillage system than in either no-till system and the no-till hay system produced less wheat forage than either other system.

In contrast to 1983, in 1984 interactions were found in both the Bromus spp. and total forage data. All SSH 0860 treatments reduced Bromus spp. forage production in the no-till with glyphosate system but only the high rate reduced Bromus spp. forage in the no-till hay system. None of the SSH 0860 treatments reduced Bromus spp. forage in the conventional tillage system. Metribuzin effectively reduced Bromus spp. forage production in all management systems at all rates. In both no-till systems, unfertilized treatments produced less Bromus spp. forage than other treatments that were fertilized but without herbicide application whether planted with wheat or not planted with wheat Bromus spp. forage in the unplanted, unfertilized treatments in the no-till with glyphosate and conventional tillage systems was greater than in the no-till hay system. This could indicate that nutrient release from killing the existing vegetation with glyphosate or by tillage was similar. Without fertilizer, the unplanted treatment in the conventional tillage system yielded more Bromus spp. forage than the planted treatment which

TABLE XIV

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE, FERTILIZER AND PLANTING COMBINATIONS ON WINTER FORAGE PRODUCTION (MANAGEMENT SYSTEM EXPERIMENT MS-I; MARCH 13, 1984)

Treatment	Herb. Rate (kg/ha)	Wheat				*Bromus* spp.			Total(1)		
		NT-H(1)	NT-G	CT	Mean	NT-H	NT-G	CT	NT-H	NT-G	CT
		----------------(dry weights; grams/m²)----------------									
1. Planted, Fertilized, SSH 0860	0.83	76	132	220	143	55	80	23	131	213	242
2.	1.26	67	142	233	147	67	67	12	134	209	244
3.	1.68	85	154	229	156	53	86	13	138	241	242
4. Planted, Fertilized, Metribuzin	0.28	87	131	242	153	20	69	3	107	199	245
5.	0.42	73	110	219	134	25	32	0	98	142	219
6.	0.56	105	154	277	179	1	12	0	105	166	277
7. Planted, Fertilized, No herb. (herbicide trtmt. control)	-	47	109	186	114	95	145	52	143	253	238
8. Planted, Unfertilized, No herb.	-	11	33	114	53	10	58	16	22	91	130
9. Unplanted, Fertilized, No herb.	-	-	-	-	-	165	195	138	165	195	138
10. Unplanted, Unfertilized, No herb.	-	-	-	-	-	36	92	94	36	92	94
Mean		69	121	215	-	-	-	-	-	-	-
LSD 0.05 (3)			(28)		[36]		41			61	

(1) Total forage = wheat forage + *Bromus* spp. forage
(2) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems
(3) The LSD's without ( ) or [ ] are interaction LSD's used for comparing any two values. The LSD in ( ) is for comparing management system means and the LSD in [ ] is for comparing herbicide treatment means averaged over management systems.

may indicate that wheat is an effective competitor with *Bromus* spp. when nutrients are limited. With fertilizer the unplanted treatment produced more *Bromus* spp. forage than any other treatment in all management systems, which simply indicates the tremendous ability of *Bromus* spp. to respond to nitrogen.

Only the 0.42 and 0.56 kg/ha rates of metribuzin in the no-till with glyphosate system produced less total forage than the herbicide treatment control. The unfertilized treatments (trtmts. 8 and 10) produced less total forage than any other treatment without herbicide in both no-till systems. When wheat was planted and fertilizer was applied (trtmt. 7), total forage was increased over that of the unfertilized treatments.

In 1983, no differences were observed in the wild buckwheat populations present at harvest (Table XV), even though a trend towards higher populations in the metribuzin treatments that provided good *Bromus* spp. control was evident in the no-till systems. The lack of statistical significance in this data may be due to the scattered populations of wild buckwheat which were present only in two replications of the experiment. Curly dock, common yarrow, and serecia lespedeza were found in all replications of the experiment; however, populations did not differ statistically between management systems or between herbicide treatments. Tall wheatgrass, a common species both years, had higher populations in the no-till hay than in the no-till with glyphosate or conventional tillage systems. Heath aster, a species common to pastures and rangeland in Oklahoma, was common in the no-till hay system but was not found in the other systems. Without a herbicide or tillage for its control, this species became very evident in the no-till hay system. When all

TABLE XV

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE COMBINATIONS ON WEED POPULATIONS BEFORE WHEAT HARVEST
(MANAGEMENT SYSTEM EXPERIMENT MS-I; JUNE 22, 1983)

Herbicide Treatment	Herb. Rate (kg/ha)	WB[1]			TW			CD			CY			HA			SL			TPB		
		NT-H[2]	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT
		(plants/100 m²)																				
1. SSH 0860	0.83	0	0	0	453	93	13	1	0	0	16	0	0	8	0	0	3	0	0	28	0	0
2.	1.26	0	0	0	520	67	40	4	0	0	11	0	0	0	0	0	9	0	1	24	0	1
3.	1.68	0	0	0	467	40	67	3	1	0	15	0	0	0	1	0	4	0	0	21	3	0
4. Metribuzin	0.28	13	0	0	440	53	27	21	4	0	68	0	0	19	0	0	33	0	0	141	4	0
5.	0.42	133	120	13	573	67	27	0	5	0	8	3	0	3	0	0	33	0	0	44	8	0
6.	0.56	120	80	0	693	133	0	13	1	0	7	39	0	9	0	0	0	0	0	29	40	0
7. Untreated	-	0	0	0	240	27	53	0	0	4	4	0	0	1	0	0	1	0	0	7	0	4
Mean		38	29	2	484	69	32	6	2	1	18	6	0	6	0	0	12	0	0	-	-	-
LSD 0.05[3]			(NS)			(311)			(NS)			(NS)			(4)			(NS)			34	

(1) WB = wild buckwheat, TW = tall wheatgrass, CD = curly dock, CY = common yarrow, HA = heath aster, SL = sericea lespedeza, TPB = total perennial broadleaf weeds

(2) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems

(3) The LSD's in ( ) are used for comparing management system means. The LSD for total perennial broadleaf weeds without ( ) is an interaction LSD used for comparing any two values.

perennial broadleaf weeds were added together (curly dock, common yarrow, heath aster, serecia lespedeza), significant management system by herbicide treatment interactions resulted. Perennial broadleaves were then found to be uncommon in the conventional tillage management system but were found in both no-till systems. In the no-till with glyphosate system, common yarrow, which is difficult to control with glyphosate, was the major perennial broadleaf weed present. In the no-till hay system, higher perennial broadleaf weed populations were found in the low rate of metribuzin treatment than in any other treatment. Since no herbicides were used for control of perennial species in this system, perennial broadleaves were probably established in this system prior to herbicide application for Bromus spp. control. Higher rates of metribuzin in this system may have had some activity on these established perennials and thus reduced their populations. In general, the no-till hay system had higher weed populations than the other systems, which indicates a need for a postemergence broadleaf control herbicide in this system.

In June, 1984, before the wheat was harvested, weed populations (Table XVI) were generally lower and more eratic than at the same time in 1983. Wild buckwheat populations were very sparse and therefore were not counted. As in 1983, crested wheatgrass was more common in the no-till hay system than in either other system. There were no significant differences in curly dock, common yarrow, heath aster or Korean lespedera between management systems when analyzed separately. However, when these species were analyzed together as total perennial broadleaf weeds, higher populations were again found in the no-till hay system than in the other systems. This again indicated a need for a postemergence broadleaf control herbicide in this system.

TABLE XVI

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE COMBINATIONS ON WEED POPULATIONS BEFORE WHEAT HARVEST (MANAGEMENT SYSTEM EXPERIMENT MS-I; JUNE 18, 1984)

Herbicide Treatment	Herb. Rate (kg/ha)	TW[1]			CD			CY			HA			SL			TPB		
		NT-H[2]	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT
		(plants/100 m²)																	
1. SSH 0860	0.83	168	7	0	0	0	0	11	0	0	0	0	0	0	0	0	11	0	0
2.	1.26	194	0	0	3	0	0	4	0	0	2	0	0	14	0	0	24	0	0
3.	1.68	271	19	0	1	0	0	10	0	0	0	0	0	13	0	0	24	0	0
4. Metribuzin	0.28	142	13	0	3	0	0	1	0	0	0	0	0	12	0	0	16	0	0
5.	0.42	213	7	0	0	1	0	28	0	0	0	0	0	3	0	0	31	1	0
6.	0.56	174	19	0	0	0	0	4	5	0	0	0	0	7	0	0	11	5	0
7. Untreated	-	123	7	0	0	0	0	9	0	0	18	0	0	18	0	0	45	0	0
Mean		184	10	0	1	0	0	10	1	0	3	0	0	10	0	0	23	1	0
LSD 0.05[3]		(74)			(NS)			(NS)			(NS)			(NS)			(10)		

(1) TW = tall wheatgrass, CD = curly dock, CY = common yarrow, HA = heath aster, SL = sericea lespedeza, TPB = total perennial broadleaf weeds

(2) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems

(3) The LSD's in ( ) are used for comparing management system means.

Yield responses also differed between management systems similar to Bromus spp. control with SSH 0860 varied between management systems (Table XVII). In the no-till hay system the middle and high rates of SSH 0860 increased wheat yields above that produced by the herbicide treatment control. In the no-till with glyphosate system only the high rate of SSH 0860 (1.68 kg/ha) increased yields over that of the herbicide treatment control and in the conventional tillage system all rates of SSH 0860 increased wheat yields. Metribuzin at all rates in all management systems increased wheat yields over that of each system's respective herbicide treatment control. The unfertilized treatment yields were not lower than the fertilized without herbicide treatment yields in all management systems. Without a herbicide for effective Bromus spp. control, yields between management systems were not different. However, with effective control, obtained with the high rate of metribuzin (0.56 kg/ha), grain yields in the conventional tillage system were higher than yields in the no-till hay system.

Although there were no interactions in the test weight data, all rates of both herbicides except the low rate of SSH 0860 increased the clean grain test weight. The addition of fertilizer without a herbicide did not increase test weight. No differences were observed between management systems when averaged over treatments in the test weight data.

Thousand seed weight data are very similar in some aspects to the test weight data. As with the test weight data, all rates of both herbicides increased seed weights except the low rate of SSH 0860. The addition of fertilizer without a herbicide did not increase seed weights. However, in contrast to the test weight data, when averaged over treat-

TABLE XVII

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE AND FERTILIZER COMBINATIONS ON VARIOUS HARVEST PARAMETERS (MANAGEMENT SYSTEM EXPERIMENT MS-I 1982-83)

Treatment	Herb. Rate (kg/ha)	Yield(1)			Test Weight(1)				1000 Seed Weight				Grain Protein			
		NT-H(2)	NT-G	CT	NT-H	NT-G	CT	Mean	NT-H	NT-G	CT	Mean	NT-H	NT-G	CT	Mean
		------(kg/ha)-----			---------(kg/hl)----------				----------(grams)---------				-----------(%)----------			
1. Fertilized, SSH 0860	0.83	765	684	1497	68	70	71	70	34.1	34.0	37.4	35.2	10.1	11.2	10.4	10.6
2.	1.26	893	856	1776	72	73	75	73	35.6	34.9	37.8	36.1	9.8	10.4	10.5	10.2
3.	1.68	1234	1167	1686	75	73	76	75	35.6	34.8	38.5	36.3	9.7	10.5	10.6	10.3
4. Fertilized, Metribuzin	0.28	1055	1323	2075	72	73	78	74	34.0	35.2	38.6	35.9	10.0	10.6	10.7	10.4
5.	0.42	967	1619	2073	75	75	78	76	34.0	35.9	38.2	36.0	9.8	10.7	10.8	10.4
6.	0.56	1242	1763	2057	76	77	76	76	36.3	36.5	36.7	36.5	10.5	11.3	11.6	11.2
7. Fertilized, No herb. (herbicide trtmt. control)	-	369	569	835	69	68	70	69	32.4	33.6	37.1	34.4	9.9	10.2	10.7	10.2
8. Unfertilized, No herb.	-	352	174	651	69	69	69	69	33.6	31.0	35.9	33.5	9.5	10.2	9.9	9.9
Mean		-	-	-	72	72	74		34.5	34.5	37.5		9.9	10.6	10.7	
LSD 0.05(3)			521; 558			(NS)		[2]		(1.7)		[1.4]		(0.6)		[0.5]

(1) Yield and test weight of clean grain
(2) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems
(3) The LSD's without ( ) or [ ] are interaction LSD's. The first LSD is for comparing values within one management system and the second LSD is for comparing any two values under one heading. The LSD in ( ) is for comparing management system means and the LSD in [ ] is for comparing treatment means averaged over management systems.

ments, grain from the conventional tillage system was heavier than grain from either no-till system.

Metribuzin at 0.56 kg/ha was the only treatment that increased grain protein compared to the herbicide treatment control. However, all rates of metribuzin and the low rate of SSH 0860 (0.83 kg/ha) increased grain protein over that of the unfertilized, no herbicide treatment (trtmt. 8). Averaged over treatments, grain from the no-till hay system had lower protein than grain from the no-till with glyphosate or the conventional tillage system.

All rates of both herbicides decreased dockage compared to the herbicide treatment control (Table XVIII). Metribuzin at the two higher rates (0.42 and 0.56 kg/ha) was more effective than SSH 0860 at any rate. The unfertilized treatment (trtmt. 8) had less dockage than the fertilized without herbicide treatment (trtmt. 7). Averaged over treatments, the conventional tillage system had less dockage than either no-till system.

The Bromus spp. seed weight data generally reflect the amount of Bromus spp. control obtained in each management system. SSH 0860 decreased seed production compared to the herbicide treatment control (trtmt. 7) in the conventional tillage system but not in the two no-till systems. A rate response with SSH 0860 was also observed in the conventional tillage system, whereby the two higher rates (1.26 and 1.68 kg/ha) reduced Bromus spp. seed production more than the low rate (0.83 kg/ha). All rates of metribuzin reduced Bromus spp. seed production in both the no-till with glyphosate and conventional tillage systems. However, in the no-till hay system only the two higher rates of metribuzin reduced Bromus spp. seed production. The unfertilized treatment (trtmt. 8)

TABLE XVIII

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE AND FERTILIZER COMBINATIONS ON DOCKAGE, *BROMUS* SPP. SEED WEIGHT AND STRAW MOISTURE (MANAGEMENT SYSTEM EXPERIMENT MS-I 1982-83)

Treatment	Herb. Rate (kg/ha)	Dockage NT-H[3]	Dockage NT-G	Dockage CT	Dockage Mean	*Bromus* Seed Weight[1] NT-H	*Bromus* Seed Weight NT-G	*Bromus* Seed Weight CT	Straw Moisture[2] NT-H	Straw Moisture NT-G	Straw Moisture CT	Straw Moisture Mean
		(%)				(kg/ha)			(%)			
1. Fertilized, SSH 0860	0.83	41.4	56.6	31.1	43.4	481	842	579	47.9	32.3	40.0	40.1
2.	1.26	44.8	50.0	18.6	37.8	565	813	305	44.1	27.5	30.6	34.1
3.	1.68	26.8	38.1	14.3	26.4	343	692	205	39.8	31.9	23.5	31.7
4. Fertilized, Metribuzin	0.28	32.6	35.9	6.7	25.1	457	661	109	42.7	29.6	24.0	32.1
5.	0.42	20.9	14.6	4.6	13.3	227	217	56	48.5	24.6	28.1	33.7
6.	0.56	10.3	7.7	2.9	7.0	70	70	49	35.3	30.0	19.3	28.2
7. Fertilized, No herb. (herbicide trtmt. control)	-	64.6	65.0	54.4	61.3	612	1019	902	44.7	37.3	40.1	40.7
8. Unfertilized, No herb.	-	46.3	69.0	38.5	51.3	374	443	383	52.8	30.0	24.5	35.8
Mean	-	36.0	42.1	21.4		-	-	-	44.5	30.4	28.8	
LSD 0.05[4]			(13.6)		[8.5]		274; 328			(8.9)		[NS]

(1) *Bromus* spp. seed cleaned from wheat grain

(2) Straw collected behind combine

(3) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems

(4) The LSD's without ( ) or [ ] are interaction LSD's. The first LSD is for comparing values within a single management system and the second LSD is for comparing any two values under one heading. LSD's in ( ) are for comparing management system means and LSD's in [ ] are for comparing treatment means averaged over management systems.

produced less Bromus spp. seed than the fertilized without herbicide treatment (trtmt. 7) in both the no-till with glyphosate and conventional tillage systems. The fertilized, no herbicide treatment produced as much or more Bromus spp. seed than wheat seed.

The straw moisture data reflects the amount of green material present in the wheat at harvest. It could also be an indication of wheat and Bromus spp. maturity, but the wheat was ripe. The no-till hay system had higher straw moisture than the no-till with glyphosate or the conventional tillage system. The data probably reflects the higher populations of perennial species in the no-till hay system. The higher straw moisture in this system could interfere in harvesting operations and could indicate a disadvantage to use of this sytem compared to the no-till with glyphosate system. However, application of a broadleaf control herbicide might have reduced the straw moisture. When averaged over management systems no differences were observed between herbicide treatments.

Even though Bromus spp. control with SSH 0860 was poor in both no-till systems, no interactions were present in the 1983-84 yield data (Table XIX). All herbicide treatments increased grain yields over that produced by the herbicide treatment control. Metribuzin at 0.42 and 0.56 kg/ha increased yields more than SSH 0860. The unfertilized treatment (trtmt. 8) produced less wheat grain than any other treatment. Yields from the no-till hay system were lower than yields from the other systems. However, yields in the conventional tillage systems were the highest of the three management systems.

Grain test weights and 1000 seed weights were slightly higher in the conventional tillage system than in either no-till system. No

TABLE XIX

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE AND FERTILIZER COMBINATIONS ON VARIOUS HARVEST PARAMETERS (MANAGEMENT SYSTEM EXPERIMENT MS-I 1983-84)

Treatment	Herb. Rate (kg/ha)	Yield(1)				Test Weight(1)			1000 Seed Weight			
		NT-H(2)	NT-G	CT	Mean	NT-H	NT-G	CT	NT-H	NT-G	CT	Mean
		(kg/ha)				(kg/hl)			(grams)			
1. Fertilized, SSH 0860	0.83	1423	1530	3132	2028	76	75	77	35.0	35.1	36.2	35.4
2.	1.26	1220	1867	3486	2191	74	76	75	35.1	34.4	36.5	35.3
3.	1.68	1498	1955	3314	2256	75	77	76	34.7	34.6	37.9	35.7
4. Fertilized, Metribuzin	0.28	1709	2205	3420	2378	73	76	76	35.0	33.6	38.2	35.6
5.	0.42	2034	2374	3504	2637	74	73	77	34.1	33.3	37.4	34.9
6.	0.56	2464	2770	3749	2994	74	74	76	33.1	35.0	36.6	34.9
7. Fertilized, No herb. (herbicide trtmt. control)	-	685	1102	2205	1331	76	76	76	34.0	34.5	37.1	35.2
8. Unfertilized, No herb.	-	65	130	914	370	75	74	75	30.8	30.7	35.5	32.3
Mean		1387	1717	2966		75	75	76	34.0	33.9	36.9	
LSD 0.05(3)			(326)		[287]		(1)			(1.9)		[1.[illegible]]

(1) Yield and test weight of clean grain
(2) NT-H - no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems
(3) The LSD's in ( ) are for comparing management system means and LSD's in [ ] are for comparing treatment means averaged over management systems.

herbicide treatment increased seed weight over that produced by the herbicide treatment control. However, without fertilizer, seed weights were significantly less than with fertilizer.

Although no herbicide treatment in the no-till hay system reduced dockage below that of the herbicide treatment control, a trend towards reduced dockage with the higher rates of metribuzin is evident (Table XX). The two higher rates of metribuzin reduced dockage in the no-till with glyphosate system, and all rates reduced dockage in the conventional tillage system. SSH 0860 did not reduce dockage in either no-till system but at the high rate did reduce dockage in the conventional tillage system. Without herbicide application, the unfertilized treatment had higher dockage than any other treatment in both no-till systems. In the conventional tillage system, however, the unfertilized treatment was not different from the fertilized treatment.

In contrast to the 1983 harvest, in 1984 treatments that were not planted with wheat were also harvested to obtain Bromus ssp. seed production and straw moisture data from these treatments as well as from the planted treatments. In the no-till hay system, only metribuzin at 0.56 kg/ha reduced Bromus spp. seed production below that produced by the herbicide treatment control. In the no-till with glyphosate system, no herbicide treatment significantly reduced Bromus spp. seed production below that of the herbicide treatment control. SSH 0860 at 1.26 and 1.68 kg/ha and metribuzin at all rates reduced Bromus spp. seed production in the conventional tillage system. Without herbicide application, the addition of fertilizer without planting increased Bromus spp. seed production in the no-till hay and no-till with glyphosate management systems. However, the addition of fertilizer alone did not effect

TABLE XX

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE AND FERTILIZER COMBINATIONS ON DOCKAGE, *BROMUS* SPP. SEED WEIGHT AND STRAW MOISTURE (MANAGEMENT SYSTEM EXPERIMENT MS-I 1983-84)

Treatment	Herb. Rate (kg/ha)	Dockage			*Bromus* Seed Weight (1)			Straw Moisture (2)		
		NT-H (3)	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT
		(%)			(kg/ha)			(%)		
1. Planted, Fertilized, SSH 0860	0.83	16.1	19.2	8.0	198	221	121	20.1	10.9	4.6
2.	1.26	19.1	15.1	5.6	224	209	82	26.1	7.2	7.2
3.	1.68	16.1	12.9	4.4	175	206	33	25.2	4.0	9.2
4. Planted, Fertilized, Metribuzin	0.28	15.0	11.7	4.8	199	140	46	16.1	4.6	8.1
5.	0.42	9.8	10.1	4.6	110	118	37	23.5	7.3	10.3
6.	0.56	9.7	6.5	4.3	56	67	31	28.4	4.7	7.3
7. Planted, Fertilized, No herb. (herbicide trtmt. control)	-	11.9	21.3	15.9	190	188	235	22.6	5.1	6.2
8. Planted, Unfertilized, No herb.	-	60.0	59.8	21.0	113	194	185	49.2	14.4	9.8
9. Unplanted, Fertilized, No herb.	-	-	-	-	417	324	451	19.8	8.6	9.3
10. Unplanted, Unfertilized, No herb.	-	-	-	-	122	150	564	54.7	30.9	8.0
LSD 0.05 (4)		11.1; 13.0			122; 122			10.2; 13.2		

(1) *Bromus* spp. seed cleaned from plot sample.
(2) Determined from straw and residue collected behind combine.
(3) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage
(4) LSD's are interaction LSD's. The first LSD is for comparing values within a single management system and the second LSD is for comparing any two values under one heading.

Bromus spp. seed production in the conventional tillage system. Instead, the planting operation significantly reduced Bromus spp. seed production in this system whether fertilized or not.

In 1984 herbicides did not affect straw moisture in any management system when compared to the herbicide treatment control, perhaps because straw moisture was lower than the previous year. However, the planting operation and fertilizer application did effect the percent moisture in the samples collected behind the combine in both no-till systems. No differences from any treatment were observed in the conventional tillage system. Of all treatments that did not receive a herbicide application, straw and combine residue from the treatments receiving only fertilizer generally had lower moisture than other treatments. In the no-till hay system the unfertilized treatments had higher straw and combine residue moisture percentages than any other treatments. Moisture percentages were generally lower in the fertilized treatments than in the unfertilized treatments because vegetation in these treatments was primarily mature Bromus spp. In unfertilized treatments, however, Bromus spp. were not as robust and therefore did not account for a large percentage of the sample harvested. In these treatments the higher moisture was due to green indigenous species.

Hay was harvested from the no-till hay management system on September 1, 1983, approximately one year after the initiation of the experiment (Table XXI). The fact a wheat crop was grown in combination with no fertilizer singificantly reduced hay yields. Herbicide application had no effect on hay yields. Since this experimental area was in the weedy stage of field succession, primary vegetation consisted of weedy species. Therefore reducing yields from these species may be beneficial, especially

TABLE XXI

INFLUENCE OF PLANTING, HERBICIDE AND FERTILIZER COMBINATIONS ON HAY YIELD AND PROTEIN CONTENT IN THE NO-TILL HAY MANAGEMENT SYSTEM (MANAGEMENT SYSTEM EXPERIMENT MS-I)

Treatment	Herb. Rate (kg/ha)	Yield(1)	Crude Protein
		(MT/ha)	(%)
1. Planted, Fertilized, SSH 0860	0.83	5.6	4.1
2.	1.26	6.5	4.7
3.	1.68	5.8	5.2
4. Planted, Fertilized, Metribuzin	0.28	6.4	4.1
5.	0.42	5.5	4.9
6.	0.56	6.4	3.8
7. Planted, Fertilized, No herb. (herbicide trtmt. control)	-	5.4	4.1
8. Planted, Unfertilized, No. herb.	-	4.4	5.0
9. Unplanted, Fertilized, No. herb.	-	9.4	3.8
10. Unplanted, Unfertilized, No. herb.	-	6.6	6.4
LSD 0.05		2.5	NS

(1) Yield of undried hay

if over a period of several years, a more desirable species became dominant. However, the long-term effects of no-till wheat planting on field succession are not known. No differences were observed between treatments in hay crude protein content.

Management System Experiment MS-II

As in experiment MS-I, glyphosate applied in the no-till with glyphosate management system effectively provided 97 to 100% control of all species, including the bermudagrass in both 1982 and 1983. Initial tillage operations in the conventional tillage systems were not successful in controlling bermudagrass. However, by later using the V-blade sweep with rolling tines the remaining bermudagrass was controlled. The mowing operation performed in the no-till hay system appeared to stimulate bermudagrass growth and approximately 5 cm of regrowth was present at the time the wheat was planted.

In 1982, stand establishment was poorer in the no-till hay system than either other system (Table XXII). This was attributed to bermudagrass regrowth after the August mowing operation in this system which led to moisture depletion and poor conditions for the germinating wheat seedlings. In 1983, with more fall precipitation, excellent stands were obtained in all management systems, but stands in the conventional tillage system were still slightly better than stands in the other systems.

When _Bromus_ spp. populations were counted in 1982, 21 DAT, sufficient rainfall for SSH 0860 activation had not occurred and the metribuzin treatments had not yet been applied. Consequently, these herbicide treatments had no effect on _Bromus_ spp. populations. When wheat was

TABLE XXII

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE AND FERTILIZER COMBINATION ON THE PERCENT OF ROW LENGTH OCCUPIED BY WHEAT FOLIAGE (MANAGEMENT SYSTEM EXPERIMENT MS-II)

Treatment	Herb Rate (kg/ha)	November 9, 82			November 21, 83		
		NT-H[1]	NT-G	CT	NT-H	NT-G	CT
1. Fertilized, SSH 0860	0.83	39	88	71	99	98	100
2.	1.26	37	78	88	99	99	100
3.	1.68	35	89	85	99	99	100
4. Fertilized, Metribuzin	0.28	-	-	-	97	99	99
5.	0.42	-	-	-	97	98	100
6.	0.56	-	-	-	98	98	100
7. Fertilized, No herb.	-	31	88	68	98	99	100
8. Unfertilized, No herb.	-	38	79	78	96	97	100
Mean		36	85	78	98	98	100
LSD 0.05 [2]			(25)			(1)	

(1) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems

(2) LSD's in ( ) are used for comparing management system means averaged over treatments.

seeded and fertilizer applied, Bromus spp. populations in the no-till with glyphosate system were much higher than in the other management systems. The application of fertilizer alone (trtmt. 9) did not effect Bromus spp. populations in any management system. However, in the no-till with glyphosate system, the planted, fertilized treatment had much higher Bromus spp. populations than the planted unfertilized treatment.

In contrast to the 1982 data, in 1983, metribuzin treatments were applied six days prior to the Bromus spp. plant counts and a substantial amount of rainfall occurred a few hours later. Metribuzin activity on Bromus spp. was very evident at the time and plants with severe herbicide injury were not counted. Even though metribuzin activity was evident at the time the counts were made (6 DAT), Bromus spp. populations in these treatments were not lower than populations in the herbicide treatment control. SSH 0860, again did not significantly affect Bromus spp. populations in any management system. Planting and fertilizer combinations (trtmts. 7, 8, 9, and 10) affected Bromus spp. populations differently in each management system. In the no-till hay system, fertilizing alone (trtmt. 9) resulted in higher Bromus spp. populations than planting and adding fertilizer (trtmt. 7), planting and not fertilizing (trtmt. 8) or not planting and not fertilizing (trtmt. 10). The no-till with glyphosate system, however, had higher Bromus spp. populations in the treatment consisting of not planting or fertilizing (trtmt. 10). It is not clear why the addition of fertilizer in the unplanted treatments actually decreased Bromus spp. populations. Since the plant counts were made approximately one month later in 1983 than in 1982, the unplanted, fertilized treatment (trtmt. 9) may have had a lower population due to

TABLE XXIII

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE, FERTILIZER AND PLANTING COMBINATIONS ON *BROMUS* SPP. POPULATIONS (MANAGEMENT SYSTEM EXPERIMENT MS-II)

Treatment	Herb Rate (kg/ha)	October 8, 82 NT-H(1)	NT-G	CT	November 10, 83 NT-H	NT-G	CT
		---(plants/m²)---					
1. Planted, Fertilized, SSH 0860	0.83	378	2111	894	1206	517	385
2.	1.26	969	1774	1471	945	690	377
3.	1.68	576	2082	879	848	420	218
4. Planted, Fertilized, Metribuzin	0.28	-	-	-	737	619	207
5.	0.42	-	-	-	514	568	170
6.	0.56	-	-	-	599	597	147
7. Planted, Fertilized, No herb. (herbicide trtmt. control)	-	368	2568	929	844	754	505
8. Planted, Unfertilized, No herb.	-	164	509	195	805	845	333
9. Unplanted, Fertilized, No herb.	-	166	713	226	1594	858	1157
10. Unplanted, Unfertilized, No herb.	-	131	729	293	744	1409	794
LSD 0.05 (2)			944; 967			486; 514	

(1) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems

(2) The LSD's are interaction LSD's. The first LSD is for comparing values within a single management system and the second LSD is for comparing any two values in one year.

competition between more vigorous Bromus spp. plants. The unplanted, unfertilized treatment may have had a higher population simply because the plants were smaller. In the conventional tillage system, the planted, unfertilized treatment (trtmt. 8) had lower Bromus spp. populations than the unplanted treatments (trtmts. 9 and 10) but not lower than populations found in the planted and fertilized treatment without herbicide (trtmt. 7). This would indicate that the planting operation had more of an effect on Bromus spp. populations than the addition of fertilizer.

Visual ratings of Bromus spp. control on December 21 (96 DAT) in the 1982-83 season (Table XXIV) also indicate that SSH 0860 did not provide any Bromus spp. control in any system. By April 22 (201 DAT), some control was visible in the conventional tillage system and by the last rating (230 DAT), Bromus spp. control with SSH 0860 had increased to 44% in the no-till hay system. However, Bromus spp. control with SSH 0860 remained essentially zero throughout the 1982-83 season in the no-till with glyphosate system. At 42 DAT, metribuzin at 0.56 kg/ha was providing significantly better control in the no-till with glyphosate and conventional tillage systems than in the no-till hay system. However, by May 10 this treatment was providing excellent Bromus ssp. control in all management systems. With lower metribuzin rates, better Bromus spp. control was obtained in the conventional tillage system than in either no-till system. No wheat injury was observed with any treatment at any date in the 1982-83 season.

Similar Bromus spp. control was observed in the 1983-84 season (Table XXV). SSH 0860 at the high rate (1.68 kg/ha) provided poor control in both no-till systems and only moderate control in the conventional tillage system as the season progressed. By mid-May, Bromus spp.

TABLE XXIV

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE COMBINATIONS ON VISUAL *BROMUS* SPP. CONTROL RATINGS (MANAGEMENT SYSTEM EXPERIMENT MS-II 1982-83)

Herbicide Treatment	Rate (kg/ha)	December 21, 83			April 22, 83			May 20, 83		
		NT-H(1)	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT
		(% control)								
1. SSH 0860	0.83	0	0	8	5	0	8	21	5	4
2.	1.26	3	0	10	18	0	25	21	0	28
3.	1.68	0	0	5	18	0	35	44	8	54
4. Metribuzin	0.28	5	0	25	20	5	73	54	15	59
5.	0.42	48	30	75	73	68	93	63	66	96
6.	0.56	33	68	88	73	85	95	84	88	100
7. Untreated	-	0	0	0	0	0	0	0	0	0
LSD 0.05 (2)		18, 21			24, 24			22, 23		

(1) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems

(2) LSD's are interaction LSD's. The first LSD is for comparing values within a single management system and the second LSD is for comparing any two values within one date.

TABLE XXV

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE COMBINATIONS ON VISUAL BROMUS SPP. CONTROL RATINGS (MANAGEMENT SYSTEM EXPERIMENT MS-II 1983-84)

Herbicide Treatment	Rate (kg/ha)	December 7, 83			April 19, 84			May 16, 84		
		NT-H[1]	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT
		(% control)								
1. SSH 0860	0.83	3	0	38	0	0	36	4	20	75
2.	1.26	3	0	53	3	4	55	6	19	94
3.	1.68	24	5	55	8	10	70	29	50	88
4. Metribuzin	0.28	79	89	83	40	58	76	35	74	86
5.	0.42	88	97	90	69	84	89	78	85	98
6.	0.56	96	98	94	84	95	97	93	96	99
7. Untreated	-	0	0	0	0	0	0	0	0	0
LSD 0.05[2]		22; 22			16; 15			16; 17		

(1) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems

(2) LSD's are interaction LSD's. The first LSD is for comparing values within a single management system and the second LSD is for comparing any two values within one date.

control with SSH 0860 was considered good with the two higher rates (1.26 and 1.68 kg/ha) in the conventional tillage system. In the no-till systems at this date, only poor to moderate control was observed even with the high rate of SSH 0860 (1.68 kg/ha).

Metribuzin provided good Bromus spp. control at all rates in all management systems by 36 DAT. However, by April control with the low rate was generally lower in all management systems. By the last rating, 200 DAT, control continued to be considered poor with the low rate of metribuzin (0.28 kg/ha) in the no-till hay system. Control in the conventional tillage system was excellent with all rates on May 16. In the no-till with glyphosate system at this date, metribuzin provided good Bromus spp. control with the two higher rates (0.42 and 0.56 kg/ha). Unlike the 1982-83 data, control with the high rate of SSH 0860 and metribuzin in the conventional tillage system did not differ significantly by May 20. The data indicates that higher metribuzin rates were needed for Bromus spp. control in the no-till systems than in the conventional tillage systems.

Some minor wheat injury from metribuzin was evident in the 1983-84 season, possibly due to greater rainfall after treatment than during the previous year. Injury was confined to the no-till systems and particularly to the no-till with glyphosate system (Table XXVI). On December 7 (36 DAT), injury was primarily in the form of dead or chlorotic wheat plants. In April, injury was recorded as stand reduction. The only wheat injury observed in the no-till hay system was with the high rate of metribuzin (0.56 kg/ha) on December 7.

The wheat vigor rating on May 16, 1984 (Table XXVI) generally reflects the level of Bromus spp. control obtained with each treatment.

TABLE XXVI

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE COMBINATIONS ON HERBICIDE PHYTOXICITY AND WHEAT VIGOR (MANAGEMENT SYSTEM EXPERIMENT MS-II 1983-84)

Herbicide Treatment	Rate (kg/ha)	Wheat Injury						Wheat Vigor		
		December 7, 84			April 19, 84			May 16, 84		
		NT-H[1]	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT
		(%)								
1. SSH 0860	0.83	0	0	0	0	0	0	51	68	88
2.	1.26	0	0	0	0	0	0	55	79	90
3.	1.68	0	0	0	0	0	0	70	79	88
4. Metribuzin	0.28	0	5	1	0	1	0	75	80	95
5.	0.42	0	10	1	1	11	0	81	85	93
6.	0.56	8	13	1	3	11	0	84	89	95
7. Untreated	-	0	0	0	0	0	0	40	40	36
LSD 0.05[2]		3; 4			4; 4			12; 13		

(1) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems

(2) LSD's are interaction LSD's. The first LSD is for comparing values within a single management system and the second LSD is for comparing any two values within one date.

Wheat in plots with very low or no Bromus spp. infestations appeared to have a dark green color and vigorous appearance and rated high in vigor, whereas wheat in plots with heavy Bromus spp. infestations generally was stunted and lighter green in color. All herbicide treatments except the low rate of SSH 0860 increased vigor compared to the no herbicide control in all management systems. The lower vigor ratings with five of the six herbicide treatments in the no-till hay system than the conventional tillage system reflect the greater difficulty in controlling Bromus spp. in the no-till hay system.

SSH 0860, at the high rate increased spring 1983 wheat forage over that of the herbicide treatment control (trtmt. 7) in both the no-till with glyphosate and conventional tillage systems but not in the no-till hay system (Table XXVII). Two of the three metribuzin treatments increased wheat forage compared to the herbicide treatment control in both the no-till with glyphosate and conventional tillage systems but not in the no-till hay system. The addition of fertilizer without herbicide (trtmt. 7) increased wheat forage over that produced by the unfertilized treatment in both no-till systems but not in the conventional tillage system. More wheat forage was produced in the no-till with glyphosate system with the high rates of both SSH 0860 and metribuzin than in any other system.

No herbicide treatment significantly reduced Bromus spp. forage production compared to the herbicide treatment control (trtmt. 7) in any management system. However, a trend of decreased Bromus spp. forage with increased herbicide rates was observed with both herbicides in all management systems. In the planted treatments without herbicide (trtmts. 7 and 8) the addition of fertilizer had no significant effect on Bromus

TABLE XXVII

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE, FERTILIZER AND PLANTING COMBINATIONS ON WINTER FORAGE PRODUCTION

(MANAGEMENT SYSTEM MS-II, MARCH 8, 1983)

Treatment	Herb. Rate (kg/ha)	Wheat			Bromus spp.			Total[1]		
		NT-H[2]	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT
		(dry weights; grams/m²)								
1. Planted, Fertilized, SSH 0860	0.83	60	119	85	21	48	74	81	168	159
2.	1.26	76	114	86	47	47	46	123	161	132
3.	1.68	94	200	145	22	34	7	116	234	153
4. Planted, Fertilized Metribuzin	0.28	58	150	138	17	36	17	74	186	155
5.	0.42	60	131	156	3	16	0	63	147	156
6.	0.56	53	189	130	6	4	0	59	192	130
7. Planted, Fertilized, No herb. (herbicide trtmt. control)	-	60	96	87	45	49	44	105	145	130
8. Planted, Unfertilized, No herb.	-	8	34	63	5	18	18	13	52	81
9. Unplanted, Fertilized, No herb.	-	-	-	-	111	307	83	111	307	83
10. Unplanted, Unfertilized, No herb.	-	-	-	-	5	38	33	5	38	33
Mean										
LSD 0.05 [3]			46; 50			51; 58			63; 77	

(1) Total forage = Wheat forage + *Bromus* spp. forage

(2) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems

(3) LSD's are interaction LSD's. The first LSD is for comparing values within a single management system and the second LSD is for comparing any two values under one species.

spp. forage production in any management system. Planting wheat had no effect on Bromus spp. forage production in the unfertilized treatments (trtms. 8 and 10). However, in treatments that were fertilizied but without herbicide, the planting operation decreased Bromus spp. forage production in both no-till systems. When wheat was not planted (trtmts. 9 and 10) the addition of fertilizer increased Bromus ssp. forage in both no-till systems.

The high rate of SSH 0860 increased total forage compared to the herbicide treatment control in the no-till with glyphosate system. However, in the no-till hay and conventional tillage systems total forage yields were not affected by any herbicide treatment even though the wheat to Bromus spp. ratio was increased. With the herbicide treatments, more forage was generally produced in the no-till with glyphosphate and conventional tillage systems than in the no-till hay system, probably because of the poorer wheat stand in the no-till hay system. In the fertilized, no herbicide treatments (trtmts. 7 ad 9) in the no-till with glyphosate system, more total forage was present when wheat was not planted (trtmt. 9) than when wheat was planted (trtmt. 7). However, both other managment systems had no differences between these two treatments. Without added fertilizer (trtmts. 8 and 10), planting wheat had no effect on total forage production regardless of the management system. Without herbicide application, when wheat was planted (trtmts. 7 and 8) the addition of fertilizer had no affect on total forage production regardless of the management system.

When forage production was determined in March, 1984, no herbicide treatment by management system interactions were found (Table XXVIII). Averaged over management systems, all herbicide treatments except the

TABLE XXVIII

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE, FERTILIZER AND PLANTING COMBINATIONS ON WINTER FORAGE PRODUCTION (MANAGEMENT SYSTEM EXPERIMENT MS-II; MARCH 9, 1984)

Treatment	Herb. Rate (kg/ha)	Wheat NT-H[1]	Wheat NT-G	Wheat CT	Wheat Mean	*Bromus* spp. NT-H	*Bromus* spp. NT-G	*Bromus* spp. CT	Total[1] NT-H	Total[1] NT-G	Total[1] CT
		(dry weights; grams/m²)									
1. Planted, Fertilized, SSH 0860	0.83	44	159	144	116	74	94	20	118	253	164
2.	1.26	38	152	166	119	84	66	7	121	218	173
3.	1.68	45	116	121	94	53	57	8	98	173	129
4. Planted, Fertilized, Metribuzin	0.28	41	165	175	127	14	21	2	55	186	178
5.	0.42	60	138	177	125	3	4	0	63	142	177
6.	0.56	46	117	136	99	0	0	1	46	117	137
7. Planted, Fertilized, No herb. (herbicide trtmt. control)	-	28	95	133	85	52	158	40	80	254	173
8. Planted, Unfertilized, No herb.	-	9	44	85	46	12	63	21	21	107	107
9. Unplanted, Fertilized, No herb.	-	-	-	-	-	81	134	169	80	134	169
10. Unplanted, Unfertilized, No herb.	-	-	-	-	-	11	116	34	11	116	84
Mean		39	123	142	-	-	-	-	-	-	-
LSD 0.05 [3]			(36)		[27]		40; 43			55; 58	

(1) Total forage = wheat forage + *Bromus* spp. forage
(2) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems
(3) The LSD's without ( ) or [ ] are interaction LSD's. The first LSD is used for comparing values within one management system and the second LSD is for comparing any two values under one species. The LSD in ( ) is for comparing management system means and the LSD in [ ] is for comparing herbicide treatment means averaged over management systems.

high rates of OSH 0860 and metribuzin increased wheat forage compared to the herbicide treatment control. The wheat injury observed in wheat treated with metribuzin at 0.56 kg/ha obviously reduced wheat growth compared to lower rates of the herbicide. The unfertilized treatment (trtmt. 8) produced less forage than any other treatment. Averaged over treatments, significantly less wheat forage was produced in the no-till hay system than in the no-till with glyphosate or conventional tillage systems.

In the *Bromus* spp. forage data, when fertilizer was applied and no herbicide was used (trtmt. 7), significantly less forage was produced in the no-till hay and conventional tillage systems than in the no-till with glyphosate system. In the no-till with glyphosate system all rates of both herbicides reduced *Bromus* spp. forage compared to the herbicide treatment control. However, in both other systems, this reduction was not observed. In planted treatments with no herbicide (trtmts. 7 and 8), adding fertilizer increased *Bromus* spp. forage in both no-till systems but had no effect in the conventional tillage system. This may have been due to nutrient release from the plowed under sod. In general, fertilization increased *Bromus* spp. forage production whether wheat was planted or not.

The total forage data indicates that from the standpoint of early season forage availability there is no benefit from controlling *Bromus* spp. As with the individual species, the total forage data shows a marked response to fertilization.

Weed populations of various dominant weeds were determined on June 22, 1983 before wheat harvest (Table XXIX). Wavy leaf thistle, sessile tickclover, serecia lespedeza and horsenettle were present in

TABLE XXIX

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE COMBINATIONS ON WEED POPULATIONS BEFORE WHEAT HARVEST (MANAGEMENT SYSTEM EXPERIMENT MS-II; JUNE 22, 1983)

Herbicide Treatment	Herb. Rate (kg/ha)	WLT[1]			SL			ST			WB				HN			WR		
		NT-H[2]	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	Mean	NT-H	NT-G	CT	NT-H	NT-G	CT
		(plants/100 m²)													(stems/100 m²)					
1. SSH 0860	0.83	15	8	6	0	0	0	0	8	13	10	0	38	16	0	2	3	943	29	0
2.	1.26	11	5	22	0	0	0	1	4	4	0	0	19	6	0	0	1	819	48	19
3.	1.68	10	37	23	30	0	0	3	0	15	0	10	200	70	3	0	20	1286	29	0
4. Metribuzin	0.28	7	22	15	1	0	0	18	0	9	0	48	381	143	2	0	0	857	29	48
5.	0.42	11	34	10	0	0	0	31	3	3	86	248	667	333	0	0	0	1619	0	10
6.	0.56	26	19	8	5	0	0	22	2	17	0	143	476	206	0	0	2	1819	86	48
7. Untreated	-	19	10	12	0	0	0	36	7	13	0	0	38	13	0	0	6	429	48	10
Mean		14	19	14	5	0	0	16	3	11	14	64	260		1	0	5	1110	38	19
LSD 0.05[3]			(NS)			(NS)			(NS)			(165)		[182]		(NS)			(585)	

(1) WLT = wavy-leaf thistle, SL = sericea lespedeza, ST = sessile tickclover, WB = wild buckwheat, HN = horsenettle, WR = western ragweed

(2) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems

(3) The LSD's in ( ) are used for comparing management system means and the LSD in [ ] is used for comparing herbicide treatment means averaged over management systems.

the experiment; however, due to their erratic distribution, populations did not differ statistically between managment systems or between herbicide treatments. Western ragweed was the dominant perennial weed and significantly higher populations of it were found in the no-till hay system than in the other systems. Thus, either tillage or glyphosate was very effective in controlling this species.

Significantly higher populations of wild buckwheat were found in the conventional tillage system than in the no-till systems. Wild buckwheat populations also exhibited a herbicide treatment effect with higher populations found in plots treated with the two higher rates of metribuzin (0.42 and 0.56 kg/ha). This may be due to decreased competition with Bromus spp. since these two treatments generally provided good Bromus spp. control.

As in 1983, wavy leaf thistle, serecia lespedeza, and horsenettle were present in the experiment in 1984, but populations did not differ statistically between management systems or between herbicide treatments (Table XXX). Sessile tickclover, however, was more common in the no-till hay system than in other systems. Western ragweed was again the dominant perennial weed. Unlike the 1983 data, in 1984, populations of western ragweed did not differ statistically between management systems. However, averaged over management systems, significantly higher populations were found in plots treated with the high rate of metribuzin. This again is probably due to decreased competition with Bromus spp. since this treatment provided good Bromus spp. control.

Wild buckwheat populations exhibited managment system by herbicide treatment interactions. Although no significance was observed between herbicide treatments in the no-till hay system, a definite trend towards

TABLE XXX

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE COMBINATIONS ON WEED POPULATIONS BEFORE WHEAT HARVEST (MANAGEMENT SYSTEM EXPERIMENT MS-II; JUNE 18, 1984)

Herbicide Treatment	Herb. Rate (kg/ha)	WLT(1)			SL			ST			WB			HN			WR			
		NT-H(2)	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	Mean
		(plants/100 m²)												(stems/100 m²)						
1. SSH 0860	0.83	12	6	3	0	0	0	2	0	1	0	0	32	0	5	10	5	7	6	6
2.	1.26	10	3	5	0	0	0	0	1	0	0	0	19	1	0	0	5	9	0	5
3.	1.68	17	4	10	1	0	1	3	0	1	0	0	60	4	0	0	0	13	0	4
4. Metribuzin	0.28	5	6	10	2	0	0	1	0	0	37	46	78	0	0	0	7	11	4	7
5.	0.42	12	12	12	6	0	0	3	0	0	65	157	406	1	0	0	7	13	0	7
6.	0.56	29	8	5	1	0	0	5	0	0	171	272	743	0	0	0	12	31	0	14
7. Untreated	-	8	7	11	0	0	0	5	0	0	0	0	0	0	0	0	2	3	1	2
Mean		13	6	8	2	0	0	3	0	0	-	-	-	1	1	1	5	13	2	
LSD 0.05(3)			(NS)			(NS)			(2)			195; 192			(NS)			(NS)		[7]

(1) WLT = wavy-leaf thistle, SL = sericea lespedeza, ST = sessile tickclover, WB = wild buckwheat, HN = horsenettle, WR = western ragweed
(2) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems
(3) The LSD's without ( ) or [ ] are interaction LSD's. The first LSD is for comparing values within a single management system and the second LSD is for comparing any two values under wild buckwheat. LSD's in ( ) are for comparing management system means and the LSD in [ ] is used for comparing herbicide treatment means averaged over management systems.

higher wild buckwheat populations in plots treated with the higher rates of metribuzin was observed. In the no-till with glyphosate and conventional tillage systems, higher buckwheat populations were found in plots treated with the high rate of metribuzin. By eliminating the Bromus spp., this treatment decreased the competition with the wild buckwheat, therefore creating a better environment for its germination and growth.

In 1983, SSH 0860 increased wheat yields in the no-till hay system at the high rate (1.68 kg/ha) and in the conventional tillage system at the two higher rates (1.26 and 1.68 kg/ha) (Table XXXI). However, since SSH 0860 did not control the Bromus spp. in the no-till with glyphosate system, yields were not increased. All rates of metribuzin increased grain yields in all management systems. Within metribuzin treatments, yields were higher in the no-till glyphosate than in the no-till hay system. The unfertilized treatment produced less grain than the fertilized treatments. Yields in the conventional tillage system were generally higher than yields produced by either no-till system.

As in the yield data, management system by treatment interactions were present in the clean grain test weight data. In the no-till hay system, only the high rate of SSH 0860 (1.68 kg/ha) increased test weight over that of the herbicide treatment control (trtmt. 7). In the no-till with glyphosate system, all test weights were higher than in the no-till hay system; however, only the two high rates of metribuzin (0.42 and 0.56 kg/ha) increased test weights compared to the herbicide treatment control. All rates of metribuzin and the two higher rates of SSH 0860 increased test weights in the conventional tillage system. The addition of fertilizer alone did not increase test weights in any management system.

TABLE XXXI

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE AND FERTILIZER COMBINATIONS ON VARIOUS HARVEST PARAMETERS (MANAGEMENT SYSTEM EXPERIMENT MS-II 1982-83)

Treatment	Herb. Rate (kg/ha)	Yield[1]			Test Weight[1]			1000 Seed Weight			Grain Protein			
		NT-H[2]	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	Mean
		(kg/ha)			(kg/hl)			(grams)			(%)			
1. Fertilized, SSH 0860	0.83	971	1279	1093	69	74	73	32.1	32.7	34.3	8.6	9.8	9.5	9.3
2.	1.26	762	1189	1993	69	75	75	32.5	32.5	34.5	8.5	9.9	8.9	9.1
3.	1.68	1225	1222	2063	73	75	75	34.6	32.8	34.5	8.6	9.8	9.5	9.3
4. Fertilized, Metribuzin	0.28	1097	1592	2598	69	76	77	33.8	33.6	34.8	8.9	10.1	8.8	9.2
5.	0.42	1298	1836	2792	69	78	78	34.1	34.7	35.1	9.5	10.0	9.5	9.7
6.	0.56	1111	2079	2818	69	78	78	34.5	34.8	36.7	8.7	9.2	9.6	9.2
7. Fertilized, No herb. (herbicide trtmt. control)	-	647	1014	1180	68	74	69	32.1	32.5	33.7	9.2	9.3	9.7	9.4
8. Unfertilized, No herb.	-	83	217	676	60	72	70	29.8	31.0	34.0	8.1	9.7	8.9	8.9
Mean		-	-	-	-	-	-	-	-	-	8.8	9.7	9.3	
LSD 0.05[3]		438; 499			4; 5			1.4; 1.8			(NS)			[NS]

(1) Yield and test weight of clean grain

(2) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems

(3) The LSD's without ( ) or [ ] are interaction LSD's. The first LSD is for comparing values within one management system and the second LSD is for comparing any two values under one heading. The LSD in ( ) is for comparing management system means and the LSD in [ ] is for comparing treatment means averaged over management systems.

Interactions were also found in the 1000 seed weight data. SSH 0860 only increased seed weights in the no-till hay system, and only the highest rate in that system caused an increase. Metribuzin, however, increased seed weights in the no-till hay system at all rates and in the no-till with glyphosate and conventional tillage systems at the two higher rates. Seed weights in treatments without herbicide were higher in the conventional tillage. The addition of fertilizer alone (trtmt. 7) increased seed weights in both no-till systems but had no effect in the conventional tillage system. No differences between management systems or between treatments were observed in grain protein data from this experiment.

No interactions were found in the dockage data (Table XXXII). However, averaged over treatments, dockage was higher in the no-till systems than in the conventional tillage system. Averaged across management systems, all rates of both herbicides except the low rate of SSH 0860 decreased dockage. However, the two higher rates of metribuzin reduced dockage more than other treatments. The unfertilized treatment (trtmt. 8) had higher dockage than the fertilized, no herbicide treatment.

The Bromus spp. seed weight data indicate that all rates of both herbicides, except the low rate of SSH 0860 (0.83 kg/ha) decreased Bromus spp. seed production. The two higher rates of metribuzin decreased Bromus spp. seed production more than SSH 0860 treatments did. The unfertilized treatment (trtmt. 8) produced less Bromus spp. seed than the fertilized without herbicide treatment (trtmt. 7).

The straw moisture data reflects the amount of green material present in the wheat at harvest. No herbicide treatment reduced straw

TABLE XXXII

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE AND FERTILIZER COMBINATIONS ON DOCKAGE, *BROMUS* SPP. SEED WEIGHT AND STRAW MOISTURE (MANAGEMENT SYSTEM EXPERIMENT MS-II 1982-83)

Treatment	Herb. Rate (kg/ha)	Dockage				Bromus Seed Weight[1]				Straw Moisture[2]		
		NT-H[3]	NT-G	CT	Mean	NT-H	NT-G	CT	Mean	NT-H	NT-G	CT
		(%)				(kg/ha)				(%)		
1. Fertilized, SSH 0860	0.83	44.4	40.9	49.8	45.0	605	686	651	647	43.3	29.3	40.5
2.	1.26	41.2	41.2	26.9	36.4	415	653	546	538	47.2	23.7	28.2
3.	1.68	31.2	33.2	24.8	29.7	411	453	470	445	41.9	23.8	31.1
4. Fertilized, Metribuzin	0.28	35.1	25.7	15.7	25.5	352	388	282	341	44.4	20.6	23.6
5.	0.42	26.4	15.0	4.7	15.4	247	201	197	215	44.7	16.9	19.5
6.	0.56	23.2	7.3	4.5	11.7	182	72	34	96	46.6	10.1	20.1
7. Fertilized, No herb. (herbicide trtmt. control)	-	59.7	46.5	49.3	51.9	704	645	873	741	48.3	27.6	37.9
8. Unfertilized, No herb.	-	72.3	68.0	48.5	62.9	161	377	514	351	56.3	46.5	30.5
Mean		41.7	34.7	28.0		385	434	446		-	-	-
LSD 0.05 [4]			(8.8)		[7.7]		(NS)		[128]		9.1; 11.6	

(1) *Bromus* spp. seed cleaned from wheat grain
(2) Straw collected behind combine
(3) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems
(4) The LSD's without ( ) or [ ] are interaction LSD's. The first LSD is for comparing values within a single management system and the second LSD is for comparing any two values under one heading. LSD's in ( ) are for comparing management system means and the LSD in [ ] is for comparing treatment means averaged over management systems.

moisture below that of the herbicide treatment control (trtmt. 7) in the no-till hay system. In the no-till with glyphosate system only the two higher rates of metribuzin reduced straw moisture lower than the herbicide treatment control (trtmt. 7). However, in the conventional tillage system, straw moisture was reduced by SSH 0860 at one rate (1.26 kg/ha) and by metribuzin at all rates compared to the herbicide treatment control. The unfertilized treatment (trtmt. 8) had higher straw moisture than the fertilized without herbicide treatment (trtmt. 7) in the no-till with glyphosate system. Higher straw moisture in the no-till hay system than in the other systems indicates that without better weed control, grain harvesting would be somewhat more difficult in this system than in the other systems.

In 1984 all herbicide treatments increased grain yields in all management systems (Table XXXIII). Metribuzin at 0.56 kg/ha increased grain yields more than SSH 0860 treatments in the no-till hay system. However, in both the no-till with glyphosate and conventional tillage systems, the high rate of SSH 0860 increased grain yields as much as the high rate of metribuzin. With the high rate of metribuzin, yields were as good in the no-till hay system as they were in the no-till with glyphosate system. However, the conventional tillage system had higher grain yields than either no-till system. Without fertilizer, yields were significantly less than any other treatment in all management systems.

Averaged over treatments clean grain test weights clean grain test weights did not differ between management systems. The seed weight data also indicates that grain was heavier in the conventional tillage system than in either no-till system. This data also indicates that without fertilizer seed weights are lower than in any other treatment.

TABLE XXXIII

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE AND FERTILIZER COMBINATIONS
ON VARIOUS HARVEST PARAMETERS
(MANAGEMENT SYSTEM EXPERIMENT MS-II 1983-84)

Treatment	Herb. Rate (kg/ha)	Yield[1]			Test Weight[1]			1000 Seed Weight			
		NT-H[1]	NT-G	CT	NT-H	NT-G	CT	NT-H	NT-G	CT	Mean
		------(kg/ha)-----			------(kg/hl)----			---------(grams)--------			
1. Fertilized, SSH 0860	0.83	835	1704	2388	75	77	76	32.7	33.5	34.1	33.4
2.	1.26	1059	1489	3097	76	76	77	30.7	32.6	34.1	32.5
3.	1.68	1226	1947	3166	76	76	76	33.5	33.4	34.4	33.8
4. Fertilized, Metribuzin	0.28	1505	2354	2791	76	76	74	32.9	32.6	33.7	33.1
5.	0.42	2077	2152	3222	75	73	76	33.6	31.3	33.9	33.0
6.	0.56	2299	2046	3228	74	74	74	32.6	30.6	33.9	32.4
7. Fertilized, No herb. (herbicide trtmt. control)	-	467	1014	1472	76	77	77	32.4	33.0	34.1	33.1
8. Unfertilized, No herb.	-	24	161	832	74	74	74	26.8	29.5	32.1	29.5
Mean		-	-	-	75	75	76	31.9	32.1	33.8	
LSD 0.05 [3]		378; 426			(NS)			(1.5)			⌊1.3⌋

(1) Yield and test weight of clean grain
(2) NT-H = no-till hay, NT-G = no-till w/glyphosate, CT = conventional tillage management systems
(3) The LSD's without ( ) or ⌊ ⌋ are interaction LSD's. The first LSD is for comparing values within one management system and the second LSD is for comparing any two values under yield. LSD's in ( ) are for comparing management system means and the LSD in ⌊ ⌋ is for comparing treatment means averaged over management systems.

All herbicide treatments reduced dockage compared to the herbicide treatment control (Table XXXIV). Without fertilizer and herbicide applications dockage was significantly higher than any other treatment. No differences were observed between management systems in the dockage data.

The Bromus spp. seed weight data again reflects the amount of Bromus spp. control achieved by each herbicide treatment. In the no-till hay system, only the two higher rates of metribuzin decreased Bromus spp. seed production and in the no-till with glyphosate system only the highest rate of metribuzin decreased seed production. However, in the conventional tillage system, all rates of both herbicides decreased Bromus spp. seed weights. Unplanted but fertilized treatments yielded more Bromus spp. seed than any other treatment in both no-till systems. However, this was not evident in the conventional tillage system, probably due to some nutrient release from the plowed under sod.

Straw moisture was not affected by herbicide treatment in any management system when compared to the herbicide treatment control. The unfertilized treatments generally had higher straw moisture because a higher percentage of vegetation in these treatments was green, warm season indigenous species. However, in fertilized treatments, winter annual Bromus spp. growth was stimulated and therefore samples from these treatments consisted primarily of mature, dry Bromus spp. straw with lower moisture percentages.

Hay was harvested from the no-till hay management system on September 1, 1983, approximately one year after the initiation of the experiment (Table XXXV). Without a herbicide, the planting operation significantly reduced hay yields whether fertilized or not fertilized. However,

TABLE XXXIV

EFFECT OF MANAGEMENT SYSTEM - HERBICIDE AND FERTILIZER COMBINATIONS ON DOCKAGE, BROMUS SPP. SEED WEIGHT AND STRAW MOISTURE (MANAGEMENT SYSTEM EXPERIMENT MS-II 1983-84)

Treatment	Herb. Rate (kg/ha)	Dockage NT-H[1]	Dockage NT-G	Dockage CT	Dockage Mean	Bromus Seed Weight[1] NT-H	Bromus Seed Weight NT-G	Bromus Seed Weight CT	Straw Moisture[2] NT-H	Straw Moisture NT-G	Straw Moisture CT
		(%)				(kg/ha)			(%)		
1. Planted, Fertilized, SSH 0860	0.83	20.7	11.7	7.4	13.3	153	139	85	16.8	7.3	3.9
2.	1.26	14.0	9.8	5.3	9.7	105	98	59	15.5	6.5	5.2
3.	1.68	8.8	7.7	4.0	6.8	68	77	40	15.9	8.4	8.3
4. Planted, Fertilized, Metribuzin	0.28	10.5	6.4	9.0	8.6	76	66	118	14.8	9.2	7.1
5.	0.42	6.6	6.6	4.7	6.0	26	63	46	13.8	9.9	6.4
6.	0.56	3.6	6.1	4.3	4.7	20	43	35	14.3	6.8	7.7
7. Planted, Fertilized, No herb. (herbicide trtmt. control)	-	29.8	22.1	49.6	26.3	175	166	343	14.9	8.5	6.9
8. Planted, Unfertilized, No herb.	-	55.4	45.2	49.6	50.1	30	96	237	53.0	27.8	24.9
9. Unplanted, Fertilized, No herb.	-	-	-	-	-	139	286	424	45.7	11.4	7.2
10. Unplanted, Unfertilized, No herb.	-	-	-	-	-	20	112	478	56.2	20.1	9.5
Mean		18.7	14.5	13.9	-	-	-	-	-	-	-
LSD 0.05 [3]			(NS)		[7.3]		107; 109			10.3; 11.4	

(1) Determined from Bromus spp. seed cleaned from the plot sample.
(2) Determined from straw and residue collected behind combine.
(3) The LSD's without ( ) or [ ] are interaction LSD's. The first LSD is for comparing values within a single management system and the second LSD is for comparing any two values under one heading. The LSD in [ ] is for comparing treatment means averaged over management systems.

TABLE XXXV

INFLUENCE OF PLANTING, HERBICIDE AND FERTILIZER COMBINATIONS ON HAY YIELD AND PROTEIN CONTENT IN THE NO-TILL HAY MANAGEMENT SYSTEM (MANAGEMENT SYSTEM EXPERIMENT MS-II)

Treatment	Herb Rate (kg/ha)	Yield(1)	Crude Protein
		(MT/ha)	(%)
1. Planted, Fertilized, SSH 0860	0.83	7.9	3.8
2.	1.26	8.5	4.1
3.	1.68	9.4	3.6
4. Planted, Fertilized, Metribuzin	0.28	8.4	4.3
5.	0.42	7.5	3.8
6.	0.56	8.7	4.9
7. Planted, Fertilized, No herb. (herbicide trtmt. control)	-	6.4	3.8
8. Planted, Unfertilized, No herb.	-	2.8	4.4
9. Unplanted, Fertilized, No herb.	-	9.1	3.8
10. Unplanted, Unfertilized, No herb.	-	4.4	4.7
LSD 0.05		1.6	NS

(1) Yield of undried hay

with any rate of either SSH 0860 or metribuzin, the planting operation did not reduce hay yields lower than that produced by the unplanted but fertilized treatment (trtmt. 9). Two rates of both SSH 0860 (1.26 and 1.68 kg/ha) and metribuzin (0.28 and 0.56 kg/ha) increased hay yields over that produced by the herbicide treatment control (trtmt. 7). The control of Bromus spp. by these treatments in the wheat crop may have conserved soil moisture for the subsequent bermudagrass hay crop in this system, therefore increasing hay yields. Controlling the Bromus spp. also allowed more sunlight to penetrate the wheat canopy and be utilized by the bermudagrass. No differences were observed in hay crude protein data.

Herbicide Screening Experiment H-I

When applied to Bromus spp. in March, 1983, atrazine at 1.12 and 2.24 kg/ha and metribuzin at 0.34 and 1.12 kg/ha provided 100% control of the Bromus spp. and 72 to 93% control of the existing horseweed (Table XXXVI). However, elimination of the Bromus spp. growing in the Spring of 1983 did not result in Bromus spp. free plots in the fall. By April, 1984, the effect of these treatments on the Bromus spp. was hardly evident. The barley and wheat harvested from these treatments did yield more than the untreated check but dockage was near 50% and yields were poor. The other treatments applied the spring before the wheat and barley was seeded failed to adequately control the sprayed Bromus spp. and consequently grain seeded in these treatments performed poorly.

The best treatments were the metribuzin treatments applied in the fall after the wheat and barley was in the early tilling stage of growth.

TABLE XXXVI

EFFECT OF HERBICIDE APPLICATION ON WEED CONTROL AND WHEAT AND BARLEY PRODUCTION (HERBICIDE SCREENING EXPERIMENT H-I)

Herbicide Treatment	Herb. Rate (kg/ha)	Trtmt. Date	Visual Ratings: Apr. 83 HW[1]	Apr. 83 BR	Feb. 84 BR	Apr. 84 BR	Harvest Data: Barley Yield[2]	Barley Dockage	Wheat Yield[2]	Wheat Dockage
			-------(% control)			---------	(kg/ha)	(%)	(kg/ha)	(%)
1. Atrazine + AG98	0.56 + ½%	March 11, 83	78	65	41	5	483	63	386	60
2.	1.12 + ½%		72	100	78	18	731	51	583	48
3.	2.24 + ½%		80	100	60	8	577	52	448	56
4. Metribuzin + AG98	0.56 + ½%	March 11, 83	68	83	44	3	452	63	427	61
5.	0.84 + ½%		75	100	64	13	582	60	677	49
6.	1.12 + ½%		93	100	75	18	648	55	538	54
7. Atrazine + cyanazine + AG98	0.56 + 1.68 + ½%	March 11, 83	20	32	44	0	518	61	384	63
8. Atrazine + terbutryn + AG98	0.56 + 1.68 + ½%		45	75	48	5	620	51	355	65
9. Atrazine + chlorsulfuron + AG98	0.56 + 0.02 + ½%		65	65	25	0	216	74	363	60
10. Cyanazine + AG98	2.24 + ½%	March 11, 83	53	71	29	0	327	73	364	61
11. Terbutryn + AG98	2.24 + ½%		8	15	23	0	323	66	197	67
12. Paraquat	0.28	March 11, 83	0	8	18	0	157	78	290	61
13. Glyphosate	1.12		83	73	24	0	288	68	502	58
14. Metribuzin	0.28	Dec. 1, 83	-	-	48	33	749	40	660	32
15.	0.42		-	-	31	79	1254	26	1160	26
16.	0.56		-	-	58	84	1392	15	1081	27
17. Untreated	-	-	0	0	0	0	199	77	206	76
LSD 0.05			27	33	44	14	269	12	342	18

(1) HW = horseweed, BR = *Bromus* spp.
(2) Yield of clean grain

These treatments controlled Bromus spp. longer into the season and therefore reduced dockage and increased yields more. It is apparent from this experiment that completely controlling the growing Bromus spp. in the spring prior to seeding wheat or barley in the fall did not eliminate the Bromus spp. problem in the seeded crops. However, with the relatively small plots used, it is possible that seed movement from untreated areas may have reduced the effectiveness of the spring applied treatments.

Herbicide Screening Experiment H-II

When applied to indigenous vegetation in early April, 1983, atrazine plus susfactant at 1.12 kg/ha provided excellent common yarrow and heath aster control, but even the higher rate did not kill all of the Bromus spp. (Table XXXVII) With these two higher rates of atrazine, some control of Bromus spp. was still evident in May, 1984. None of the atrazine treatments significantly increased barley or wheat yields. However, some reductions in dockage were noted.

Control with April, 1983 applied metribuzin was similar to control with atrazine; however, by May, 1984, Bromus spp. control was poor. The barley and wheat yields from these treatments were not higher than yields from the checks but the two higher rates reduced dockage in both crops. Among the other treatments applied in April before the wheat and barley were seeded, atrazine plus cyanazine, atrazine plus chlorsulfuron, cyanazine and glyphosate provided excellent control of the perennial broadleaves present. However, these treatments failed to control the sprayed Bromus spp. and no grain yeild increases were found. Atrazine plus cyanazine reduced dockage in wheat and atrazine plus chlorsulfuron reduced dockage in barley.

TABLE XXXVII

EFFECT OF HERBICIDE APPLICATION ON WEED CONTROL AND WHEAT AND BARLEY PRODUCTION (HERBICIDE SCREENING EXPERIMENT H-II)

Herbicide Treatment	Herb. Rate (kg/ha)	Trtmt. Date	Visual Ratings May 27, 83 CY[1]	HA	BR	May 16, 84 BR	Harvest Data Barley Yield[2]	Dockage	Wheat Yield[2]	Dockage
			--------(% control)--------				(kg/ha)	(%)	(kg/ha)	(%)
1. Atrazine + AG98	0.56 + ½%	April 7, 83	50	28	0	0	2169	9	2125	5
2.	1.12 + ½%		98	95	58	54	2135	8	1933	7
3.	2.24 + ½%		100	95	92	71	2341	7	2111	5
4. Metribuzin + AG98	0.56 + ½%	April 7, 83	38	60	58	29	2209	6	1854	7
5.	0.84 + ½%		93	93	83	48	2389	8	2194	5
6.	1.12 + ½%		98	98	80	54	2326	7	1943	5
7. Atrazine + cyanazine + AG98	0.56 + 1.68 + ½%	April 7, 83	98	93	65	41	2112	9	2211	5
8. Atrazine + terbutryn + AG98	0.56 + 1.68 + ½%		95	78	78	38	1845	9	2187	6
9. Atrazine + chlorsulfuron + AG98	0.56 + 0.02 + ½%		100	98	58	49	2239	6	2234	8
10. Cyanazine + AG98	2.24 + ½%	April 7, 83	100	98	50	20	1680	11	1827	12
11. Terbutryn + AG98	2.24 + ½%		0	0	0	0	1646	12	1640	12
12. Paraquat	0.28	April 7, 83	0	0	0	8	1523	10	1979	8
13. Glyphosate	1.12		98	98	18	0	1859	9	1594	8
14. SMY 1500	0.84	Nov. 8, 83	-	-	-	90	2552	4	2726	3
15.	1.26		-	-	-	90	2031	5	2790	2
16.	1.68		-	-	-	100	2324	3	2907	1
17. Metribuzin	0.28	March 7, 84	-	-	-	10	1917	8	2129	8
18.	0.42		-	-	-	76	2252	5	2174	6
19.	0.56		-	-	-	90	2278	4	2175	4
20. Untreated	-	-	0	0	0	0	1629	13	1834	10
LSD 0.05			24	19	28	30	NS	5	401	5

(1) CY = common yarrow, HA = heath aster, BR = *Bromus* spp.
(2) Yield of clean grain

The best treatments were the SMY 1500 treatments applied immediately after planting in November. These treatments provided _Bromus_ spp. control, increased wheat yields substantially and reduced dockage. _Bromus_ spp. control from application of metribuzin to the tillered crops in March, 1984, increased with rate, but none of the treatments increased yields. Grain dockage was decreased by the higher rates. The lack of yield response to spring _Bromus_ spp. control in winter grain is in agreement with Fischer (31).

Unlike wheat yields, treatment differences were not observed in the barley yields. This perhaps indicates that barley is more competitive with _Bromus_ spp. than wheat. Barley yields have been found to be reduced less than wheat yields by wild oat infestations (52).

As in experiment H-I, satisfactory _Bromus_ spp. control and increased grain yields were not obtained with herbicides applied in the spring preceding wheat and barley seeding. However, with the relatively small plots used, it is possible that seed movement from untreated areas may have reduced the effectiveness of the spring applied treatments.

The excellent control of common yarrow and heath aster obtained with several of the treatments applied in the spring before planting may indicate a good way to eliminate problems with these species such as those noted in the management system experiments.

Allelopathy Experiments

Filtrates from soil containing roots and surface residue of western ragweed, silver bluestem, and prairie threeawn, common on eroded abandoned land, reduced wheat germination considerably compared to the distilled water control (Table XXXVIII). These results would be in agreement with the work of Neill and Rice (53) who found that western ragweed inhibited the germination of several species. Such reduction in germination may indicate that in areas where these species proliferate wheat germination and subsequent wheat strands may be reduced. However, after germination, radicle and coleoptile growth were not affected.

Filtrates from soil collected from plots in the three management systems in experiments MS-I and MS-II did not have an allelopathic effect on radicle growth or coleoptile extension of wheat (Table XXXIX). However, filtrates from the no-till systems of MS-I appeared to inhibit wheat germination, and the filtrate from the no-till with glyphosate plots of MS-II did inhibit wheat germination. To clarify the effect of the filtrates from the no-till systems on wheat germination, data from both experiments were pooled. A significant reduction in germination was then evident with filtrates from both no-till systems. This research did not determine whether the decrease in seed germination would be overcome with time or would require compensating measures such as higher seeding rates as suggested by Alhagi (2).

TABLE XXXIX

EFFECT OF SOIL SOLUTION FILTRATES COLLECTED FROM SOIL FROM THE THREE MANAGEMENT SYSTEMS IN EXPERIMENT MS-I AND MS-II ON THE GERMINATION AND EARLY GROWTH OF WHEAT

Seed Moistening Solution Source	Radicle Length(1)		Coleoptile Length(1)		Germination(1)		
	MS-I	MS-II	MS-I	MS-II	MS-I	MS-II	Pooled
	---------------(% of control (2))---------------						
No-till hay	88	103	91	89	83	89	85
No-till w/glyphosate	96	97	102	86	83	78	81
Conventional tillage	82	126	94	102	86	101	94
LSD 0.05	NS	14	NS	NS	NS	13	14

(1) 72 h after addition of moistening source
(2) control = distilled water

CHAPTER V

SUMMARY AND CONCLUSIONS

Two field experiments were conducted for two years to determine the feasibility of using no-till wheat to increase the productivity of previously farmed and/or eroded land. Although grain yields from the no-till hay system were lower than yields from the conventional tillage system, some advantages of this no-till system may offset its lower grain yield. Erosion control is a definite advantage with this system that should not be overlooked. Another advantage of the no-till hay system, particularly on areas with desirable warm season species, such as bermudagrass, is that it is a double cropping system. Grain from the wheat is harvested in the spring and then a hay crop from the warm season grass can be taken in the summer. Thus, the land on which this system is employed is in constant crop production. Some disadvantages are also evident with this system. Fall moisture is essential for adequate wheat stands. Warm season spp. generally have depleted all available moisture and consequently the seeded wheat is dependent on rainfall after planting. Rainfall is also essential in early spring at the grain filling period since warm season spp. generally are also actively growing at this time. From this research it is evident that Bromus spp. control is a major factor with this system. Bromus spp. populations were higher in this system than in conventional tillage and were also less easily controlled with available herbicides. Very little

Bromus spp. activity was obtained with SSH 0860 at the rates used. However, metribuzin at 0.56 kg/ha provided good Bromus spp. control and subsequent yield responses. It was apparent that higher rates of metribuzin were needed in the no-till hay system than with conventional tillage. Perennial weed species were also more common in this system than in conventional tillage. These species could interfere in the harvesting operation, causing yield losses and dockage increases. However, application of a postemergence broadleaf control herbicide in the spring should eliminate this problem. Thus, the no-till hay system is the most logical choice of the no-till systems if maintenance of an improved perennial grass species is desired along with grain production.

The other no-till system investigated used July applied glyphosate to kill all existing warm season vegetation. This system may be especially desirable on marginal land where vegetation consists primarily of weedy species. In dry falls this system has a definite advantage over the no-till hay system in its moisture conserving capability. Bromus spp. populations were also higher in this system than in the conventional tillage system. However, metribuzin at 0.56 kg/ha did provide effective Bromus spp. control. This system may be desirable to use in rotation, the year before desirable warm season grasses are seeded. After the warm season grasses are established, the no-till hay system could be employed for grain production. It may also be the most desirable system where destruction of the natural vegetation and monoculture cropping is desired.

Two other experiments were conducted to evaluate herbicides applied in the spring preceding fall no-till seeding of wheat and barley. From these experiments it was apparent that controlling the growing Bromus spp. in the spring prior to seeding did not eliminate the *Bromus* spp. problem after the wheat and barley were planted. However, with the relatively small plots used, it is possible that *Bromus* spp. seed movement from the untreated areas may have reduced the effectiveness of these treatments. Metribuzin, applied to the tillered wheat and barley provided good *Bromus* spp. control and yield responses. SMY 1500 applied at the time of planting also provided effective *Bromus* spp. control and yield responses. Barley performed as good as wheat in this type of no-tillage situation, indicating that it may be another option to no-till wheat planting.

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TABLE XL

RAINFALL DATA - AGRONOMY RESEARCH STATION, STILLWATER, OKLAHOMA
(JUNE 1, 1982 - MAY 31, 1984)

Date	Centimeters	Date	Centimeters
June 2, 1982	.5	December 28	.4
June 3	.1	January 19, 1983	.4
June 4	.3	January 22	.5
June 11	1.1	February 1	4.1
June 12	.6	February 5	.3
June 15	1.5	February 9	.1
June 16	.2	February 10	.1
June 19	1.7	February 20	1.8
June 21	.4	February 21	.8
June 24	.3	February 22	.6
June 25	4.5	March 4	1.7
June 27	.1	March 5	.5
July 6	.1	March 20	.5
July 7	.5	March 23	.3
July 10	.7	March 24	.3
July 13	.1	March 26	3.1
July 28	.1	March 27	.5
July 29	2.8	March 29	.2
July 30	.8	March 30	.9
August 8	3.1	April 2	.4
August 16	.1	April 4	.7
August 30	.1	April 5	2.2
September 13	.6	April 8	.1
September 14	1.1	April 9	.1
September 15	3.8	April 10	.1
September 19	.1	April 13	.2
September 20	.2	April 20	.1
October 2	.2	April 22	.3
October 3	.1	May 11	.7
October 9	.1	May 13	3.4
October 12	.3	May 14	3.4
October 28	1.6	May 18	2.6
October 29	.2	May 21	3.0
November 11	.8	May 28	1.7
November 12	1.3	May 29	2.7
November 22	.3	May 31	1.4
November 26	2.3	June 6	.2
November 27	1.9	June 11	2.9
November 28	.6	June 14	.7
December 1	.6	June 18	.2
December 5	.8	June 25	.3
December 10	.9	June 26	.6
December 11	.2	June 29	2.9
December 24	1.9	August 20	2.2
December 27	1.2	September 5	.2

TABLE XL (Continued)

Date	Centimeters	Date	Centimeters
September 13	2.8	January 15	.1
September 14	.1	January 17	.2
September 16	.5	February 9	.8
September 20	1.5	February 27	.9
September 26	.2	March 4	.9
October 5	.3	March 12	1.0
October 7	.9	March 17	.3
October 8	.4	March 19	.9
October 11	.9	March 23	3.8
October 12	.4	March 24	2.6
October 17	.9	March 28	2.0
October 18	.1	March 29	.2
October 19	1.1	March 31	1.3
October 20	6.1	April 3	.2
October 21	8.2	April 8	2.4
October 22	.1	April 10	.2
November 1	.2	April 11	1.3
November 2	.3	April 16	.1
November 7	.4	April 20	.4
November 9	.5	April 21	.9
November 10	.2	April 27	1.7
November 19	1.6	April 30	.1
November 23	1.7	May 4	.1
November 27	.8	May 7	2.4
December 3	.4	May 20	1.6
December 19	.6	May 26	2.1
January 10, 1984	.2	May 27	.6

VITA

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