AN ABSTRACT OF THE THESIS OF

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Title: The Development of a Watershed Evaluation Scorecard Based on Data from 17 Lyon County Watersheds

Abstract approved: Thomas A. Eddy

The major objective of this study was to examine the relationship between proper watershed management (including reservoir) and range management in Lyon County. A watershed scorecard (similar to Parker's "range condition scorecard" [1951]) was developed for small watersheds (pastures and prairies) in Lyon County, Kansas.

Seventeen Lyon County watersheds ranging from 5.6 to 39.6 hectares were analyzed using the factors mentioned above. The analysis involved sediment yield (testing a new sampling device which was found to be inadequate) range condition and ground cover sampling (step-loop method. . U.S. Forest Service) and theoretical values derived from observations and recognized sources (consultation with the Soil Conservation Service).

The Watershed Scorecard

A system for evaluating watershed condition was developed from observations and calculations of established watershed data similar to those found in the USLE. Watersheds can be rated excellent to very poor using the following equation: WCRV = RC + GCI + MCPF + SER + TWPEDI; where:

"WCRV" is watershed condition rating value (excellent to very poor).

"RC" is the range condition determined with a modified step-loop method.

"GCI" is the ground cover index rating by modified step-loop method.

"MCPF" is developed from observations of present management practices.

"SER" is the soil erodibility rating derived from the estimated, factored, current soil loss (EFCSL), which is based upon the watershed soil loss equation (WSLE Ly 17) which is derived from the USLE. (See List of Abbreviations.)

"TWPEDI" is the total watershed plant erosion deterrence index which is a measure of variable plant species' ability to deter erosion.

The results of this study indicated that much more research of this nature is needed in this region. Every watershed scorecard factor is reflected in or related to the MCPF (management practices factor). The MCPF is significantly correlated to WCRV (watershed condition rating). Therefore, the MCPF can be used to estimate present watershed condition and could aid in developing future management practices.

THE DEVELOPMENT OF A WATERSHED EVALUATION SCORECARD BASED ON DATA FROM 17 LYON COUNTY WATERSHEDS

A Thesis

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Thomas A. Eddy
Approved for Major Department

James F. Lovell
Approved for Graduate Council

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LIST OF ABBREVIATIONS

AASY - Annual Adjusted Sediment Yield

APDI - Accumulative Plant Desirability Index

ASCE - American Society Civil Engineers

CDI - Composition Desirability Index

CF - Cover factor (used in the USLE, MUSLE and WSLE Ly 17)

csl - Current soil loss using the cover factor for perennials and annuals in the WSLE Ly17

CSL(B) - Current soil loss using the cover factor for bare ground (0.45) in the WSLE Ly17

CSL(C) - Current soil loss using the cover factor for covered areas in the WSLE Ly17

DS - Drainage size (or WSS)

EFCSL - Estimated/factored current soil loss results of the WSLE Ly 17

GCI - Ground cover index (%) by the step-loop method

HE - Hectares eroded

MASY - The AASY using the mean age of ponds

MCPF - Management and conservation practices factor

MPDI - Multiple plant desirability index

MTSL - Mean tolerable soil loss

MUSLE - Modified Universal Soil Loss Equation (Williams 1975 and Smith et al 1984)

NAO - National agricultural organization

P factor - Practices factor used in MUSLE

PA - Pond age

PASY - Predicted adjusted sediment yield using an adjusted "P" and "K" factor (T/K)--MUSLE

PDI - Plant desirability index

PMSY - Predicted sediment yield using the original MUSLE factors of P and K

PSL(A) - Potential soil loss (WSLE Ly17 using 100 % bare ground with the 0.45 cover factor)

R - Rainfall (used in the USLE and WSLE Ly17)

RC - Range condition (%) by the step-loop method

REPF - Relative erosion potential factor...used in watershed scorecard rating

SCS - Soil Conservation Service

SY1 - Gross sediment yield measured by probe

SY2 - Annual sediment yield from the eroded areas only

TGS - Total grams sampled (used when finding SY2)

TWPEDI - Total watershed plant erosion deterrence index

T#S - Total number of samples (used in the categorized evaluation)

T/K - The soil loss tolerability and erodibility

UNESCO - United Nations Education, Science and Cultural Organization

USDA - United States Department of Agriculture

USLE - Universal soil loss equation for estimating mean annual soil loss...=RxKxCxPxSL (Wischmeier and Smith 1960, 1965)

WCRV or WV - Watershed condition rating value

WSLE Ly17 - Watershed soil loss equation for 17 watersheds in Lyon County, Kansas

WSS - Watershed size

% EW - Percent of eroded watershed

% s - percent of slope

s/L - slope length

INTRODUCTION

Past Accounts of Conservation Problems in Land Management

Early ecologists and conservationists recognized the need to identify sources of accelerated erosion and sedimentation in proper watershed management. The following are excerpts from their accounts of past resource conservation problems.

In his book, "Renewable Wild Lands...a Challenge"; about Utah's catastrophic period, Cottom writes, "unpremeditated though they are, man's stupid assaults against the soil resource of high rangelands are insidious, and their damage is cumulative" (Cottam 1961).

Cottam also describes historical accounts of lush, green meadows overgrazed by settlers' livestock. They were transformed into shallow deserts as the grasses were replaced by sagebrush. Deterioration of the plant community advanced and droughts continued for a decade. Ground cover decreased allowing for severe erosion potential. Heavy storms occurred in the spring of 1884 causing flooding and severe gullying. What was once acres of meadow is now dissected by a main wash with gullies scarring the land. Gullies can be devastating to the "overall condition" and basic stability of productivity. This concept will be discussed later in the paper.

Another observation of the effects of man's influences was written by Trimble in 1974. In a Piedmont Area, U.S.A. study, Trimble discovered that historically "geological erosion was slight and man-induced soil erosion was practically nill: at the time of European settlement in the 1700's. After clearing and cultivation of uplands, especially during the latter part of the 1800's and early 1900's, gullies were formed, slopes were severely eroded, channels and ponds were filled with sediments and fertile bottom-lands became back-swamp land" (Trimble 1974).

A third aspect of erosion/sedimentation and their effects on resources is given by A. E. Coleman (1953) who states: "Damage to water supply reservoirs is represented by any reduction of the storage capacity below minimum required to safeguard the continuity of a supply fully adequate for present or estimated future needs...".

A publication obtained from the USDA Soil Conservation Service reads: "Sediment is the number one pollutant (by volume) in large reservoirs and channels" (America's Soil and Water Conservation: Condition and Trends 1980). However, Coleman (1953) points out "silting damages...the smaller reservoirs that contain only channel storage or pondage".

The ideas of Cottam and Coleman may be comparable to the issue of small pasture overgrazing, resulting in erosion and pond sedimentation in Kansas watersheds. In the western states i.e. Utah and Colorado, average slope may be greater. Climates and average watershed sizes may differ. These differences may make comparisons between Kansas and western states impractical. Locally though, the hydrologic processes as well as the outcome of mismanagement or neglect are obvious. The result, however, can be the same as those problems experienced in the western states. Cottam's description of central Utah's main gullying bodies and "the fingers of smaller gullies moving outward from them" (Cottam 1961) is a good example.

The same appears to be true in Lyon County pastures although on a smaller scale. In Utah, gullies cover hundreds of hectares; in Lyon County they may only cover hundreds of feet. Although one may not be able to compare these land conditions from state to state, they appear to have similar methods of origin resulting in similar consequences. Gullies may divide grazing lands, decreasing grazing distribution. They are also illustrative of soil loss and sedimentation through erosion. The end result of severe gullying is the over-all lowering of productive potentials.

Research Objectives

The primary study objective was to determine a relationship between an accepted range condition evaluation and pond sedimentation on selected study sites in Lyon County (including seeded go-back, native pastures and prairies). Through this research a better understanding of the interactions within the ecosystems may be obtained. Another objective was the development of an alternative reservoir sediment sampling method. In addition, it was hoped that a demonstration of a simple, ecological approach to practical resource management (small watersheds) might be used for the managers' benefits. Emphasis was on the "total watershed management concept", including the management of watershed plant communities (especially native grasses and forbs), resource conservation, and sedimentation/erosion control.

The importance of this study is that it represents a first attempt to link range condition/ground cover, to reservoir sedimentation in this region. In this attempt, an accepted range condition evaluation method has been utilized in addition to the development of a crude but practical sedimentation sampling device. A literature search did reveal a study of sediment yield of small watersheds in Kansas (Holland 1971). However, Holland's study did not utilize an acceptable, quantifiable range condition evaluation method. This will be examined later in this paper. The "total watershed management concept" is apparently an infrequently used practice. Most management seems to be land/cattle production oriented in Lyon County. Holland evidently attempted this ("the effects of range condition/ground cover") on the small watershed in Kansas and may have pioneered this concept.

Ecological Concepts in Range Management

Range management, an accepted field in land management, is recognized as a science. Its ultimate goal is to produce forage for maximum livestock growth and production without disturbing the ecological balance. Existing only since the turn of the century, range management has made great advancements (Stoddard et al 1952).

The idea of ecological succession, hydrological influences along with soil and nutrient loss are important "ecological" range management concepts. With the ecological resource being so fragile, range scientists and managers are aware that sustained livestock health/production is the objective. Attention toward natural resources is necessary to maintain production and ecological stability on range and pastureland. To maintain stability (production is slightly less than its potential) a total watershed concept must be accepted because all of the sub-systems of the pastures are intricately related in the ecosystem. Watershed soils (the basis for terrestrial plant life), vegetation, and grazing effects are all related.

In this study pasture and rangeland need not be distinguished, but pastures are usually referred to as planted (one species composition) and fenced-in areas. They may be native or tame (brome). "Rangelands originally dealt with open, broad, unfenced grassland occupied by graxing animals. With more intensive management systems, in general, the differences have become lesser between the two" (Stoddart et al 1952).

Whether referring to pasture or rangeland, management techniques, conservation concepts and other aspects in the overall science of range management may and must be applied for long term success and ecological balance.

Watershed management differs from range management only by the method of land use and the ultimate goal of the user.

Early Research

Ewald Wollney (1888), a German scientist called "the pioneer of soil and water conservation", made extensive investigations in this field. His studies on physical properties of soil that affect runoff and erosion are probably the earliest research of its kind. However, Wollney's research was apparently overlooked by American researchers until the mid 1930's (Meyer 1982).

"The earliest quantitative research measurements of erosion and its influencing factors on American soils was around 1912. These investigations took place on overgrazed rangelands in central Utah. A.W. Sampson, assisted by L.H. Waye, E.W. Storm and C.C. Forsling, sampled two ten acre plots in Manti National Park. Here, factors influencing erosion were studied in all detail for the first time"

(Meyer 1982).

The definitions in this section are general and perhaps the most widely accepted for surface runoff, erosion and sedimentation. Each will be discussed separately although surface runoff is closely related to erosion and sedimentation processes.

Surface Runoff

Satterlune (1972) describes surface runoff as precipitation falling outside the stream channel, flowing overland, which is not stored or absorbed on or by the watershed. Runoff is affected by gravity, slope, storm intensity and amount of precipitation intensity.

A brief description of one genesis of runoff: "Due to land micro-relief ponding occurs. If rainfall persists surface runoff takes place because of the inadequacy of storage of the microtopography" (White 1982).

Runoff can occur only after precipitation demands of the soils are satisfied. These demands include infiltration, interception, evapo-ration and surface storage and channel detention. Although slope may be obvious, the most important factor is the amount and intensity of storm occurrence. On small watersheds, peak flows are more responsibe to rainfall intensity than the amount (Ssatterlund 1972). Although this is a widely accepted theory, a total geological and ecological inventory including soil (physical and chemical characteristics), slope, ground cover and land use must be evaluated, also.

Theoretical situations and models must be used in order to under-stand surface runoff. The combination of the fore-mentioned factors make a practical, rational understanding difficult. As with other general ecological concepts each situation and watershed will be different.

Accompanying surface runoff may be erosion and sedimentation. Control of surface runoff is a necessary part of erosion and sedimentation control (White 1980).

Erosion

Two broad categories of erosion are generally recognized; geologic and accelerated. Geologic erosion is the loss of soil through a natural process of land shaping and climatic phenomena (i.e. wind, precipitaiton). In geologic erosion, soil is developed close to the rate at which it is lost. R. E. Uhland (1934) states: "Mr. H.H. Bennett has often stated that it requires more than four hundred years to produce a single inch of surface soil and he is undoubtedly conservative in his estimate." The erosion which will be dealt with is related to rainfall, although wind and other climatic factors may indirectly effect water erosion.

A separate category, accelerated erosion, is usually distinguished by man's presence. Due to man's activities , i.e. construction, farming or livestock grazing, erosion rates may be accelerated drastically. Accelerated erosion refers to the inefficient process of soil synthesis. The soil is lost faster than developed. The loss of soil evidently implies the loss of nutrients and water holding capacity. Soil loss is directly related to growth and root support and in addition its loss lowers fertility. Nutrient loss, through erosion, is quantifiable. The importance of nutrient loss accompanying soil loss has been documented "sediment may have an average analysis of 0.15

% nitrogen, 0.15 % P O and 1.50 % K O...more than fifty million tons of primary nutrients are lost from our lands annually with sediment delivers" (Branson et al 1981).

Unlike soil and nutrient loss, erosion is apparently one of the least measureable, most observable phenomena of geomorphology. On rangeland, erosion is even less understandable and predictable than on farmlands. Cropland erosion has been recognized and studied since the formation of the Soil Conservation Service in April of 1935.

Rangeland erosion may not be so obvious but extensive research and new concepts are being recognized (i.e. adaptation of the Universal Soil Loss Equation [USLE] Smith and Wischmeier 1965). Some aspects of rangeland erosion in the western states have been discussed by a number of researchers including "Bryan (1925), Bryan (1940), Bailey (1937, 1941), Peterson (1950), Leopold and Miller (1954)" (Branson et al 1981).

"The erosion process normally begins when raindrops strike the soil surface. The explosive character of impacting raindrops detached soil particles (quantities greater than 100 tons per acre, 225,000 kg/ha have been measured) are splashed in all directions from the impact points with net movement down slope" (Meyer et al 1975). This explosive power's effect may be two fold: (1) The impact can dislodge particles to be carried in overland flow which may follow slope, (2) raindrop impact may seal the soil reducing infiltration, thereby increasing runoff.

There are four factors that have been considered basic determinants of water erosion: (1) climate, largely rainfall and temperature; (2) soil and its inherent resistance to dispersion and its water intake and transmission rates; (3) topography, particularly steepness and length of slope. Slope length affects erosion because runoff increases with distance from the top of the slope (Meyer et al 1975); (4) vegetation cover (Branson et al 1981). Figure 1 illustrates the relationships of water erosion to vegetation and bareground areas (Branson et al 1981).

Three types of erosion are the most common geomorphic land shaping processes related to rainfall and runoff. All can be related to a degree to percent of ground cover or bare ground. Sheet, rill and gully erosion are all associated with cropland, as well as rangeland.

Sheet erosion is commonly most associated with cropland in terms of problem erosion (later, if these problems remain untreated, rill and gully erosion may occur). It may be common in certain specific areas of rangeland according to range site, area and slope. Another possibility are those pastures or grazing areas which are constantly being occupied (i.e., feeding areas).

Rill erosion is the formation of small channels apparently following sheet erosion. A good example is the face of an unseeded dam or a denuded bank (Figure 2). Similar to sheet erosion, rill erosion is usually associated with large "square" areas, unlike gullies originating from narrow denuded areas. Rill erosion may differ from sheet erosion by being associated with a higher percentage of slope. Slope is probably only one of the factors involved when comparing sheet and rill erosion. In addition, the USLE can be used to measure sheet and rill erosion unlike gully erosion. Gully erosion may take more time and field sampling than sheet and rill erosion. It also needs to be observed frequently (after heavy storm) in order to monitor its progress.

Figure 1. Relationship between water erosion and increasing mean annual precipitation for (A) areas of natural vegetation cover (B) areas of bareground (partially after Schumm 1969). (Branson et al 1981).

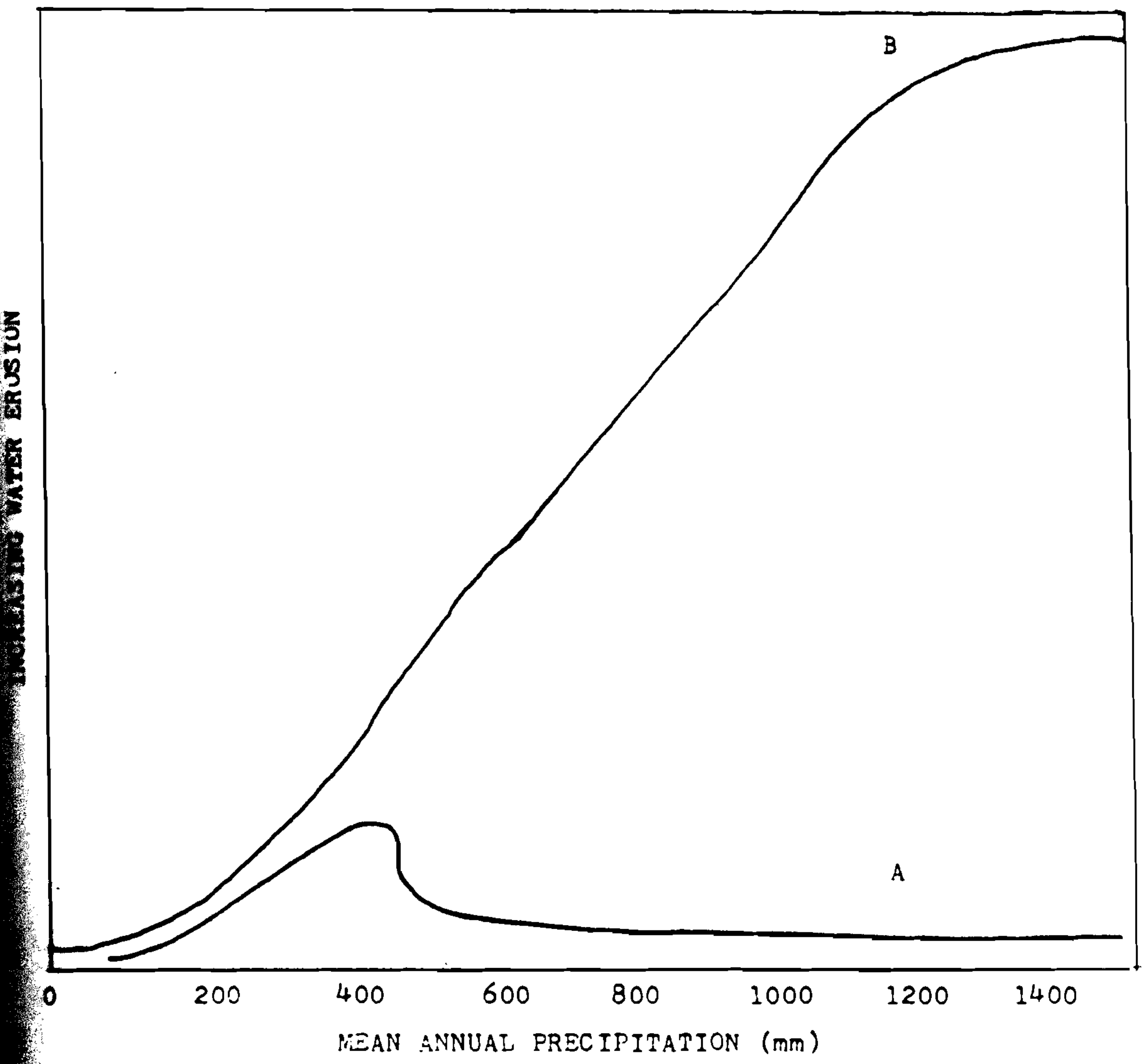
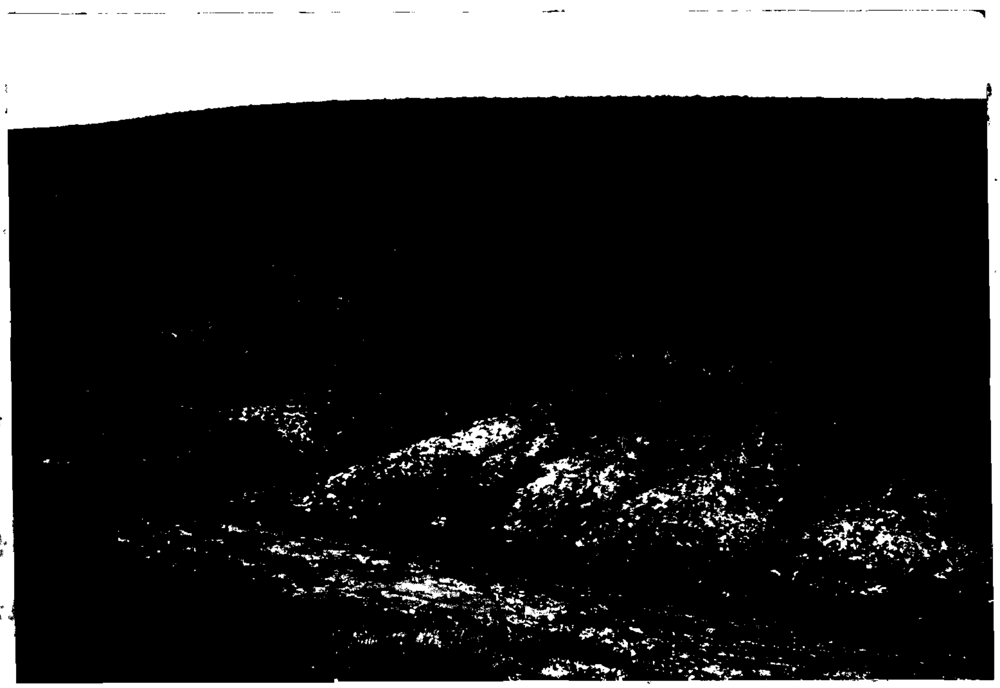

B
A
INCREASING WATER EROSION
0
200
400
600
800
1000
1200
1400
MEAN ANNUAL PRECIPITATION (mm)

Figure 2. Showing rilling on denuded banks (H-5).



Gully erosion is the least understood of the erosive conditions. According to the Sedimentation Task Committee (1977) of the Hydraulic Division of the American Society of Civil Engineers, the gully erosion process has been "admirably described in several regions of the United States (Ireland et al 1939; Brice 1966), but the cause-effect interrelationships of gully formation have never been put into proper perspective. Methods are, therefore, not available for any given locality and under any set of existing or assumed conditions, for accurately predicting rates of gully erosion or gully advance."

Gully development is usually associated with severe climatic events, improper land use, or changes in stream base levels (Sedimentation Task Committee 1977). Unlike sheet and rill erosion, gully erosion does not require a large square area of bare ground to begin. A prime example (and maybe a major most common problem in terms of overall soil stability) is cattle trailing on grazed lands. A study by members of the American Society of Civil Engineers (ASCE), on a small summer-grazed watershed in Idaho showed that cattle trailing was the major cause for erosion/sedimen-tation on grazed watersheds. In their paper they explain: "Cattle trails intercept runoff and may eventually end up causing small gullies, contributing a substantial amount of sediment into channels" (Frontier et al 1980).

Several stages of gullying are recognized. The first stage is slight gullying where a small channel is formed (similar to a cow path). The second stage is the intermediate stage, where the ridge is widened and deepend. Exposed roots are noticeable along the edge of the gully. A wash area and soil displacement is obvious to a careful observer. This stage is evidently the most crucial. This is the stage

Figure 3a. Photograph of severe active gullying down to limestone shelf on watershed 0-16.

Fig. 3b. Photograph illustrating pedestalling at the head of a severe gully on watershed G-12.

in which the problem can be controlled (Schlechtl 1980). The third stage is probably the most severe. It is identified by deep and widened areas of soil displacement; even down to rock or other impervious layers such as a limestone shelf (Figure 3a). Pedestalling is a good indicator of the severe gullying stage (Figure 3b). Its occurrence is isolated where grass or other equivalent ground cover is absent. The effects of gullying on the range conditions will be discussed later. Gullying may also be the major contributor of sediment in certain areas. Heede (1975), a hydraulic engineer, gives an adequate explanation of how and why gullies are formed.

Soil Erodibility

When speaking of erosion, soil erodibility factors must be considered. These are, soil parent material, depth and chemistry. Soil erodibility is closely linked with soil parent material. "In general, soils derived from sandstone are the least erodible. Mixed sandstone and shale are intermediate with the most erodible soil originating from marine shale" (Branson et al 1981).

Another important factor of erodibility is soil depth. In six studies of Utah watersheds ranging from 253 to 7,349 ha (6,221 to 18,147 acres), "the most obvious relationship between accelerated erosion and soils concerned the depth of the friable material (all soil materials that are readily permeable to water over bedrock or tight subsoils)" (Branson et al 1981). "Although these friable soils underlain by clay or bedrock at shallow depth occupied only one-fifth the total area studies, 85 % of the severe erosion occurred on them" (Branson et al 1981).

Soil chemistry is one of the more quantifiable factors of soil erodibility. The following excerpt is from "Rangeland Hydrology"... "Wallis and Steven (1961) reported soil erodibility indices that were related to amount and kind of cations present in the soil" (Branson et al 1981). Twenty soils were indexed for their erodibility utilizing Milldeton's (1930) dispersion ratios and Anderson's (1951) surface-aggregation ratio. Four major cations were studied including Ca, Mg, K, Na. When predicting an erosion index, linear and curvilinear terms involving Ca and Mg were significant (Branson et al 1981).

A multifactor study by Andre and Anderson in 1961, added to the soil forming factors perviously mentioned. These are geology, vegetation type, elevation and geographic zone to compute an erosion index. Results included the improved predictability of soil erodibility, vegetation and cover comparisons. Three types of cover vegetation, brush, trees and grass, were studied. Of these, soils under brush were the most erodible, the next highest under trees and the least erodible soils under grass. "No clear-cut relation between erodibility and elevation was found" (Branson et al 1981). These studies demonstrate the importance of understanding erosion processes in range management.

The difficulty of measuring erosion has long been recognized. Erosion measurements on rangeland are even more difficult than on croplands, because rangeland soils are more complex. Problems include the measuring of gullys. Measuring rangeland erosion may be more difficult than row cropland. This is why it has been difficult to efficiently modify the original Universal Soil Loss Equation (USLE) to accommodate rangeland situations. Row crops are planted with a linear distribution whereas range plants are randomly distributed.

Identifying the interrelationship between erosion-estimating-techniques (USLE and WSLE Ly17) and sediment yield estimating techniques (MUSLE) is the basis for this research (see Methods and Materials).

Satterlund (1972) states: "Sediment is derived primarily from erosion of the watershed and channel cutting. All watersheds produce sediment, for erosion is a geologic process." The relationship between erosion and sedimentation studies is evident from Satterlund's statement. Sediment yield may actually give an estimate of erosion in certain situations. Therefore, sediment yield measurement is important in terms of soil and nutrient loss research. The effect of erosion on the total watershed (including pond) might be identified through erosion/sedimentation studies. (Sediment yield and the measurement of sedimentation will be discussed together.)

Sedimentation and Sediment Yield

For over one hundred years, sediment problems in channels and reservoirs have been a concern in the U. S. (Branson et al 1981).

The distinction between sediment yield and sedimentation must be made. Sediment yield is the actual measurement of sediment loss from a watershed. It is defined as the total amount of sediment transported out of a watershed or drainage basin, as measured at a specific location over a specified period of time (Woodhiser and Blinco 1975).

Reservoir sedimentation is defined as the process in which soil particles influenced by a transport mechanism are carried down a slope through runoff. Deposition occurs when runoff slows, allowing the particles to "settle out".

Sedimentation can also be influenced by the amount of sediment regardless of slope. The transport mechanism carries as much sediment as its physical capabilities allow (White 1982). Deposition is relative to the capabilities of the mechanism. In this case the sediment may or may not be "unloaded" at a point where the velocity decreases or increases. An example is the development and maturation of old streams. "Meandering" streams' banks and bottoms erode resulting in constant soil deposition. Where the stream "winds", water velocity decreases on the inside and increases on the outside due to the resistance of the stream bank. The decrease in velocity allows for a heavier particles to "settle out" or be dropped at that point.

Factors Influencing Sedimentation

The amounts of runoff, sediment and nutrient discharge from small watersheds are greatly affected by rainfall. Reductions in rainfall of reduce in sediment and nutrient transport. During years of below average runoff, the effect of land use on sediment yields are important. During years of above average rainfall, slope is clearly the dominant factor affecting sediment yields (Environmental Protection Agency 1977).

Ritter (1978) explains the realization of the complexity of sedimentation problems. Their solutions were illustrated by a researcher approximately twenty years ago. Douglas (1967) suggested that the problems induced by man may be enough to invalidate the practice of applying present rates in studies of long-term landscape effects. "Evidence also indicated that these activities may increase detrital loads by at least an order of magnitude" (Ritter 1978).

Sedimentation problems can range from a "life and home threatening" situation to a decrease in volume of a 1/4 hectare recreation park lake (mentioned later).

The Importance of Sedimentation Studies

Glymph (1975) defines sediment adequately. His views also reflect the necessity and importance of sediment identification. In addition, he addresses source identification and its control as he states: "Sediment is the product of a selective process in which the finer and lighter particles are preferentially removed and carried away by runoff. Sediments, therefore, are generally higher in clay, silt and organic matter than the soils from which they are derived... The particles and organic substances have great capacity for adsorption of pathogens, viruses, plant nutrients, pesticides and other chemicals. Thus, the need for identification and control of pollutants (referring to large reservoirs; sediment is the number one pollutant by volume). Understanding the physical and chemical properties of sediment in respect to specific erosion sites is necessary." In conclusion, Satterlund (1972) stated: "Sediment has direct effect at its source, in transit and wherever deposited."

Methods of Measuring and Predicting Sediment Yield

One of the first sampling methods, used in the 1920's, was developed by C.S. Howard of the U. S. Geological Survey. "A special sampling ring consisting of a pint milk bottle suspended in a frame was used to measure quantities of sediment in the Colorado River. The bottle has an ordinary cap with a 5/8 inch hole covered by paper. The paper is cut by a knife actuated by a weight that slides down the nding cable. All samples were filtered in the field through r papers which were dried, packed and shipped to Washington where weighing was carried out" (Howard 1925).

Today these basic concepts are still used but with more sophistion. Perhaps the most common sampling methods are the sediment and stream sampler. The stream sampler is probably used the most se stream sampling seems to be more applicable. In a study done northern Idaho watershed, members of the American Society of Civil ers (ASCE) measured sediment yields of 41, 488 and 618 kg/ha in 1978 and 1979, respectively, using the PS-69 sampler method. The sampler was placed inside v-notched wiers in designated areas ier et al 1980).

olland (1971) used a sediment trap to sample drainages in Kansas will be discussed later.

Reservoir deposition surveys probably come closest to being a e of the total sediment delivery. However, this is true only if servoir or pond is large enough to insure 100 % efficiency by ng all of the incoming sediment. This method involves measureby field survey of the volume of sediment accumulated in the pond ervoir. (This method is referred to as the 'sediment trap '.) The sediment is weighed and expressed as an accumulation ing to the age of the pond" (Glymph 1975).

ard (1980) agrees with Glymph and also cites other uses of the t trap method by explaining that the sediment trap method is ble for measurements. It is necessary to realize that these tes can be utilized to relate sediment yield to drainage area. roach provides good information on magnitude and variation of e annual sediment yield over a relatively short period of time.

Therefore, reservoir-deposition surveys may be more helpful in research on the sedimentation process on the reservoir (in terms of storage capacity decrease, etc.). Occasionally, however, sediment yield is estimated of soil loss, not the amount deposited.

A number of methods for sampling and measuring sediment yield have been documented. In an erosion/sediment yield estimation study, Renard (1980) used several techniques including reservoir deposition surveys, the sediment rating-curve/flow duration method, and the aforementioned PS-69; some of these utilized stream flow and others sampling the reservoir inflow. He states: "the study cannot be accurate without sophisticated and permanent equipment." He continues by stating that "bedload relationships and field measurements of erosion and deposition are applicable; however, the uncertainty of both measurements can lead to large error" (Renard 1980).

Theoretical Methods of Estimating Sediment Yield

Branson et al (1981) suggests that most of the erosion-estimating techniques were developed using data from cultivation agriculture (Pacific Southwest Inter-agency Committee 1974). The PSIAC method used nine variable factors and assigned values universal to each, which upon summation would give an erosion class. High values were assigned to factors which would cause significant sediment yields. Once the erosion classes were established, sediment yields could be estimated graphically (Branson et al 1981). Although widely accepted, the PSIAC method may be less applicable to small watersheds due to smaller measurements.

Sediment Yield Prediction

Sediment yield estimation methods are expressed in terms of amount per year per time and concentrates on the sediment itself. Sediment yield predicting refers to soil loss. It concentrates on the variable factors involved. The methods most accepted are PSIAC (described earlier) and the Universal Soil Loss Equation (USLE). These methods may also be used to estimate erosion (some separate sediment loss and erosion estimates).

The Universal Soil Loss Equation (USLE) and Its Modifications

The USLE was first developed by Wischmeier and Smith in 1965. It was intended for agricultural purposes. The equation is RxCxKxPxSL whereas: R = rainfall, C = cover factor, K = erodibility, P = conservation and practices factor and SL - slope length. Field data is applied to the variables and the equation is solved illustrating the estimated average annual soil loss.

Since its development, the USLE has been examined and researched thoroughly. Modifications have been investigated as new ideas and theories appear. The "C" or cover and management factor has been objectively adjusted and manipulated for specific regions and land uses (Wischmeier 1975). Williams (1975) adjusted the "P" or practices factor to include certain conservation practices (terracing, etc.). Williams (1975) explains that the Modified Universal Soil Loss Equation (MUSLE) was developed by replacing the rainfall factor of the USLE (Wischmeier and Smith 1960) with a runoff energy factor. Definitions and equations for the USLE and MUSLE are found in Appendix A. Designated study area data will be used to compare the WSLE Ly17 (Watershed

Soil Loss Equation for 17 Watersheds in Lyon County, Kansas) to the MUSLE. These changes widen the applicability and increase accuracy of the USLE.

Parker (1954) and Ellison (1956) stressed the application of ecological concepts in range condition and trend by emphasizing the importance of soil stability, site potential and long term productivity.

An important step in the ecological concept of range management was the modification of the USLE to apply to rangeland. In the last five years, the question of rangeland applicability in the use of the USLE was evident. Several researchers cited in this cited in this study including: G.R. Foster, D.K. McCool, J.M. Lafflin and K.G. Renard have all contributed to the rangeland/USLE concept.

Educated assumptions and modifications are recognized as a necessity for accurate results. One researcher that has used these modifications is G. R. Foster, a hydraulic engineer at Purdue University. Foster acknowledged special problems for application to rangeland. These problems include, the key influential factors of erosion mechanical treatments and grazing erosion pavement, cover, soil disturbance, roots, physical soil characteristics and burning just to name a few. He states: "These problems illustrate the need for expanded research in the west to validate existing theories and to develop new values for the USLE "C" and "P" factors (cover and practices) (Foster 1982). Gebhart (1982) diagrams the USLE "C" factor for typical range-lands adapted from Wischmeier and Smith (1978).

Another problem in rangeland erosion estimation is gullying. Gullying must be measured (volume, length and width) before soil loss can be estimated. The development of an accurate, "gully" soil loss estimate or measurement has been established by Iowa researchers, but only for cropland. The need for development of such an estimate was stated by B.H. Heede. He states: "Watershed managers would have a useful tool if gully stages could be expressed in terms of erosion rates and sediment yield" (Heede 1975).

Sedimentation and Turbidity

A factor which may or may not be involved with sedimentation is turbidity. Very little research has been done on the direct relationship between sediment yield/sedimentation and turbidity in lentic environments (ponds and reservoirs) in Kansas. Variable factors including wind exposure, soil type and particle size may have discouraged research. Other factors that apparently effect turbidity are the activities of benthic (bottom dwelling) fauna including bullhead, carp and crayfish if overpopulation occurs. These organisms probably play a major role in keeping larger particles suspended.

The effects on sight feeding organisms are clear. Gabelhouse (1982) speaks of Kansas ponds: "If the water visibility is less than one foot, fish production will be decreased due to water turbidity". Meehan and Platts (1978) adds that large quantities of fine sediment alter the structure of aquatic communities, decrease productivity and reduce the water permeability of channel materials used by spawning fish. In lentic (i.e. lakes) environments, spawning grounds probably will either be covered by silt or exposed to water recession by a decrease in volume due to sedimentation and climatic factors.

Although studies of the correlation between sediment and turbidity are lacking in Kansas, stream studies in Oregon have been carried out.

Creeks sampled demonstrated there was a significant correlation between turbidity and sediment concentration for 24 of 26 storm events. "This confirmed that suspended sediment was the most important factor influencing turbidity of Oregon Coast range streams" (Beschta 1980). Beschta continues by explaining that relationships differ from watershed to watershed.

Watershed Management in Kansas

Potential watershed management problems in Kansas differ from the western states in at least four ways. Climate, ecology (including vegetation), topography and the average watershed size. However, erosion/sedimentation problems are still important for small Kansas (grazed) watersheds.

Although the aforementioned variables are natural, man can be the major source of a problem. The following is an account of man's interaction with nature on the high plains of Kansas: "This year parts of Kansas were picked clean due to a combination of drought and heavy grazing. Occasionally the gentle slopes have shown erosion channels but these channels have been filled immediately with Russian thistle...there is little danger of erosion on the high plains" (Schantz 1934). Today it appears there is danger of erosion on the high plains.

The following will discuss the application of these concepts to Kansas pasturelands (watersheds).

The Validity of the Step-Loop Method in Kansas

Wilk (1984) gives an adequate historical account of past research in range sampling and evaluation methods including the step-loop method. The question of the applicability of the step-loop method for the tallgrass prairies of the Flinthills rangelands and surrounding pastureland has been established. Wilk compared the clip-plot method (currently used by the Soil Conservation Service) to the step-loop method on selected sites in the Flinthills. In Wilk's study it was shown that as "the number of step-loop hits on decreaser species and increaser species increased, so did the lbs/acre dry-weight production and the basal density. This suggests that the step-loop method was a reliable index to vegetation composition and density" (Wilk 1984).

Sediment Yield Studies in Kansas

The need for sediment yield studies was obvious. Premature sedimentation of ponds could be significant if the minimum pond depth is less than that recommended by the USDA and SCS. The USDA Handbook #387 (1971) recommends a minimum pond depth of seven to eight feet to insure an adequate yearly water supply in Lyon County, Kansas.

Sediment yield/erosion studies using range condition or ground cover on small, grazed, watersheds are almost entirely lacking in Kansas. However, one study was done in Kansas (Holland 1971). Holland used the reservoir sediment deposition survey method by sediment trapping. One of his study sites was located in Lyon county.

The range condition/ground cover was estimated by observation only. No quantifiable method was used. This is not to say the study was not meaningful. However, without an accepted sampling method, it appears to be less valid. An excerpt from the glossary states: "Good range condition - Good vegetation cover without appreciable evidence of erosion" (Holland 1971). Holland's awareness of relationships between sedimentation, vegetation cover and grazing is reflected in this statement as he explains, "The differences in sediment yield within physiographics region are primarily dependent upon the kinds and amounts of vegetation which is directly influenced by the degree of livestock utilization. Undisturbed rangeland across the state yields significantly less sediment than land utilized for crops or livestock forage. Rangeland with poor vegetal cover may yield twice as much sediment as rangeland with fair vegetal cover" (Holland 1971).

When comparing drainages, Holland used the terms pastureland and rangeland (Figure 4). He defined pastureland as "land used primarily for production of introduced forage plants (i.e., brome, fescue). Rangeland is all land which produces native forage plants" (Holland 1971). It is obvious that pastureland and rangeland sediment yields differed. Pastureland sediment yield exceeded sediment yield from rangeland in poor condition (Figure 4).

In his study of 44 areas, Holland reported the average annual sediment deposit ranged from 130 to 2,930 tons per square mile per year. These figures are dependent on size of drainage and periods of sediment deposits. Holland's study showed poor rangeland can lose 1,680 T/Sq. Mi/Y (tons/square mile/year). Range in good condition can lose less than 330 T/Sq. Mi/Y (Figure 4) (Table 1). In addition, sediment yield from rangeland with gullys, Lyon County, appears to be comparable to poor range condition (Table 1).

Two Accounts of Sedimentation Problems in Kansas

As in the rest of the states, man's effects on sediment yield/erosion can be devastating to a watershed (including the impoundment). There may simply be an awareness problem.

Figure 4. Pasture and rangeland sediment yield in Eastern Kansas (Holland 1971)

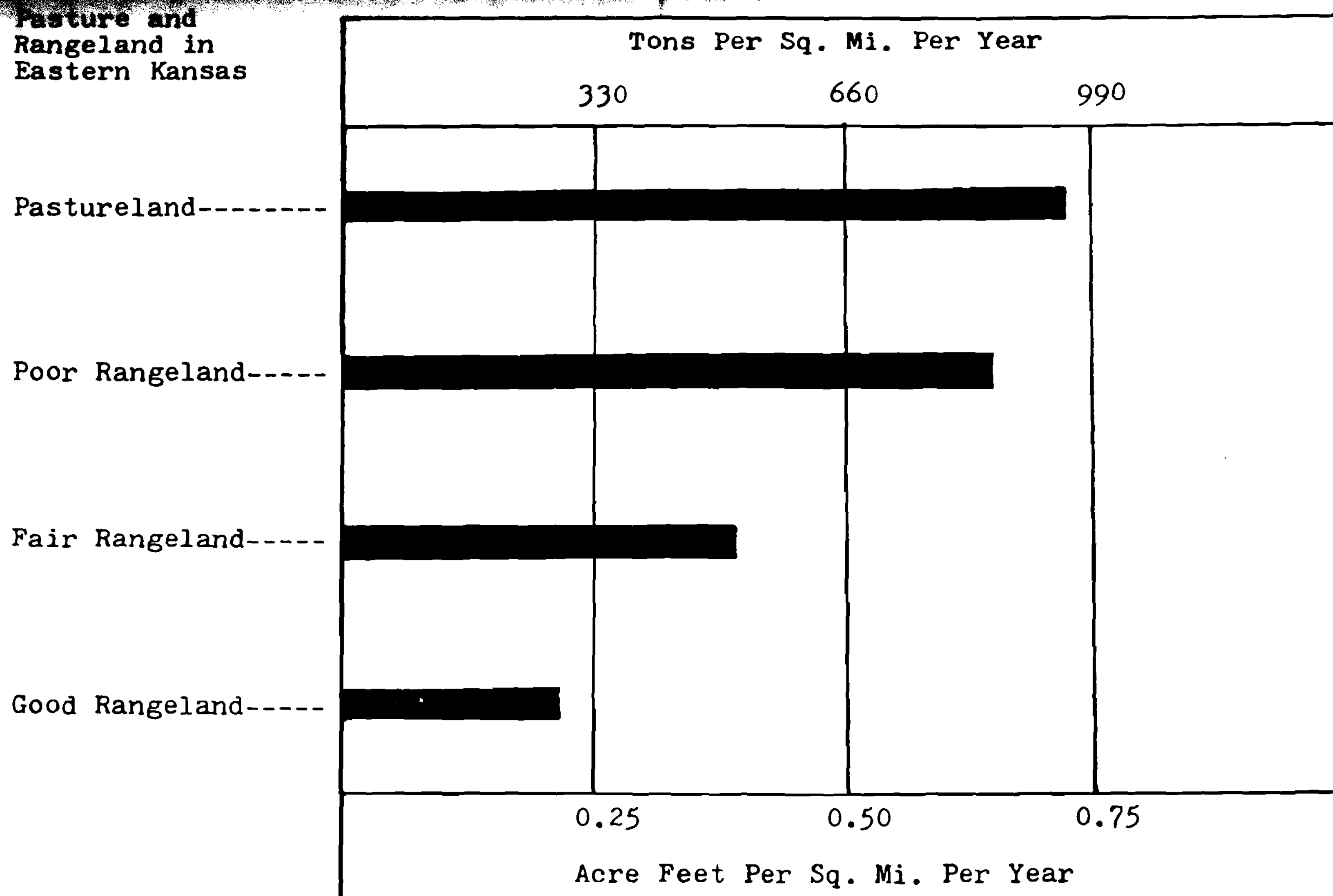

Pasture and
Rangeland in
Eastern Kansas
Tons Per Sq. Mi. Per Year
330
660
990
Pastureland--------
Poor Rangeland-----
Fair Rangeland-----
Good Rangeland-----
0.25
0.50
0.75
Acre Feet Per Sq. Mi. Per Year

Table 1. Reservoir survey data condensed from "Sediment yield from small drainage areas in Kansas" (Holland 1971).

W#	County	DA Sq. Mi.	POD Yrs.	Range. %	%s	Crop. s%	%c	AASD T/SM/Y	Remark (obs.)
1	Chatauqua	0.49	17.8	93	6	2	-	590	---------
2	Chatauqua	2.25	9.5	98	6	2	-	360	G range
3	Chatauqua	0.25	24.0	90	6	3		300	---------
4	Coffey	0.18	18.0	100	1.5	-	-	695	F range
5	Greenwood	2.08	13.3	100	6	2	2	130	E range
6	Lyon	0.70	18.8	87	6	4	-	1550	g range
7	Johnson	6.20	12.1	20	6	4	-	2930	---------
8	Greenwood	0.13	8.3	62	6	4	-	1680	P range

DA - Drainage area
POD - Period of deposit
Range. - Percentage of drainage area used as rangeland
Crop. - Percentage of drainage area used as cropland
AASD - Average annual sediment deposit
Percentage of conservation applied
Percent of slope
Percent of land use
Excellent range
Good range
Fair range
Poor range
Gullied range

A documented account of these effects were investigated in a report by an environmental company, F.X. Browne, Inc.

The Brown County State Lake, a 27 hectare state owned/managed impoundment, was projected to decrease in depth from a ten feet mean depth in 1953 to a two feet mean depth in 2083 without management or prevention measures. (The drainage is mostly farmland. The soils are loess of glacial origin and therefore more topsoil was present in the early farming days.) This may have slowed the application of "conservation practices."

Another prediction was that without management, four hectares of the lake would be greater than two feet deep (Browne 1984). This effects the productivity from primary producers to the large consumers including man. These interactions may be complex.

In as much as these effects are important to the ecological productivity a brief description of these effects will be attempted.

At the first few trophic levels, plankton and algae may be reduced due to a decrease of sunlight. This may cause a reduction of photosynthesis, increasing the biological oxygen demand. (This next theory would only be true if sedimentation and turbidity were somehow proportional.) If turbidity increased, the whole ecological balance might be upset reducing overall productivity.

A personal account of Kansas sedimentation problems occurred in the early 1980's. A quarter hectare impoundment, in the Lenexa area, was built for recreation and esthetics. Located in a "roadside park", the 12 to 16 hectare drainage contained some lawn grasses, a horse-grazed pasture and building sites. The biologists estimated that sediment from surface runoff of heavy spring rains in 1981 and 1982 decreased the volume of the pond by some 50 % in one year. The sources were identified as the building site which was denuded for leveling purposes and the horse-grazed pasture which appeared to be over-used.

Economically as well as recreationally, the effects were detrimental. The city paid to stock this pond for an urban fishing program. When channel catfish were delivered and stocked, these fish were put unknowingly into an estimated 18 inches of water. Fish harvest probably decreased due to lack of interest as well as a result of the "quick fill-in process."

DESCRIPTION OF STUDY AREAS

All 17 study areas were classified according to the Soil Survey Map (after page 96) of the Lyon County Soil Survey of Kansas (Neill 1981). Three classifications of soil type associations included in the study were Kenoma-Martin-Elmont (III), Kenoma-Ladysmith (IV) and Tully-Florence (V) associations. There will be a brief description of each association taken from Soil Legend of the Soil Survey Map. Brief descriptions of several of the study areas and their legal descriptions follow. Tables of physical characteristics of each watershed are in Appendix A. Descriptions of watershed condition are detailed in the RESULTS AND DISCUSSION part of this paper.

Kenoma-Martin-Elmon (III) Association

This association exhibits "deep, gently sloping and moderately sloping, moderately well drained soils that have a silty clay or silty clay loam subsoil on uplands" (Neil 1981). In terms of potential the soil survey says "this association has good potential for cultivated crops, range and openland wildlife habitat. Water erosion is a hazard on gently and moderately sloping areas. Controlling erosion and maintaining soil tilth and fertility are the main concerns of management."

Watershed I-6

(Legal description: Southeast quarter, Section 19, Range 11 East, Township 16 South (SE 1/4, S19, R11E, T16S).

Located approximately 14 miles northwest of Emporia (between Allen and Bushong), this watershed contains seeded go-back and native rangeland. It drains approximately 11 and three-tenths hectares (ha) into a three-tenths ha pond.

Soil types present include: 44 % of 5-20 % sloped Clime-Sogn, 11 % of 1-6 % sloped Labette, 11 % of 1-6 % sloped; eroded Labette, 28 % of 4-7 % sloped; eroded Martin and 6 % of 1-3 % sloped Kenoma. Soils around the pond periphery are predominantly eroded 4-7 % sloped Martin.

The watershed was sampled in January 1983. At that time vegetation composition was dominated by native plants including big bluestem (*Andropogon gerardii*) (Vitman), Indian grass (*Sorghastrum nutans* L.) Nash and side-oats grama (*Bouteloua curtipendula* M.) Torrey. These native areas were away from the pond (towards the top of the drainage). Planted brome grass (*Bromus* spp.) and three-awn (*Aristida* spp. L.) dominated the areas closer to the ponds (according to grazing). Ragweed (*Ambrosia* spp. L.) seemed to dominate towards the end of the summer. I-6 appeared to be early-intensively grazed from April to early July. In April of 1984, cattle were observed grazing on sprouts of less than five inches in height. There appeared to be a considerable amount of bareground and little soil cover.

The pond was approximately three-tenths of a hectare and 12 years old. It had two inflow areas. It was built for stock water supply. There was no fencing and heavy disturbance of the banks and dam was evident. Abundant seasonal aquatic vegetation including pondweed (*Potamogeton* spp. L.) and arrowhead (*Sagittaria* L.) was observed.

Watershed 0-16

(Legal description: SE 1/4, SE 1/4, S10, R10E, T17S)

This watershed is located approximately ten miles northwest of Emporia (five miles east of Americus). Draining 13.6 hectares, this area has severe, active gullying (will be described in detail in the RESULTS AND DISCUSSION part of this paper) associated with an approximately three-tenths hectare pond.

Soil types present include four percent 1-3 % sloped Labette, 22 % of 3-6 % sloped Labette, and 18 % and 55 % of 4-7 % sloped Martin and eroded Martin respectively. Soils around the pond periphery were predominantly Labette 3-6 % sloped.

This watershed was sampled in March 1983. Vegetation present included switchgrass (Panicum virtgatum L.), Indian grass and big and little bluestem (A. scorparius Michaux). Side-oats grama was abundant in the overgrazed areas. Prairie cordgrass (Spartina pectinata Link) thrived in the gully deltas close to the inflow. Baptisia spp. L., indigo, and Achillea millifolium L., yarrow, were present though in small numbers. The go-back area while seeded to brome grass, did not appear to be a good stand (plant vigor, frequency and soil stability was apparently less than its potential). It appears that this area may be the origin of the gully system due to bareground caused by discing before planting.

The eight year old pond was approximately three-tenths of a hectare and built for flood retention and livestock water supply. It was partially fenced (the dam and some of the spillway). One main inflow area was present. Seasonal aquatic vegetation appeared to be sparse.

Watersheds F-7 and E-8

(Legal description: NE 1/8, S20 and 21, R13E, T19S).

This watershed is located approximately 12 miles east of Emporia on Highway 131. It drained 16 and four-tenths hectares including eight hectares across the road. The area across the road was another watershed (E-8) which was evaluated. The landowner built a dam approximately nine years before F-7. E-8 was partially cultivated and damage to the dam from washout was noticeable. It should be recognized that cropland runoff from across the road may have accelerated the sedimentation of the F-7 pond. A picture was taken from the dam of the F-7 watershed. In addition, the drainage included a soft shouldered highway and ditches which had to be considered in the sampling evaluation. Rock and gravel appeared to have increased soil stability on the shoulders.

The soil types present included 95 % of Elmont, 4-7 % and 5 % of Kenoma, 1-3 % slope. The E-8 drainage soil type profile was similar except for a limited amount of eroded Kenoma with 1-3 % slope. Soil around the pond periphery was Elmont, 4-7 % slope. Watershed F-7's prime land use was grazing and has been grazed or burned for about ten years. The rangeland across the road was early intensively grazed.

The immediate drainage of the F-7 pond was grazed until about 1979, since then it has been ungrazed and unmanaged in any way (some trees were cut for fire wood). The highway and ditches did contribute to the drainage and therefore should be mentioned. Some rilling and gullying was evident (from the back of the E-8 dam) and bareground was observed. Vegetation in the immediate drainage has apparently changed from December 1982 when sampled to the present. Vigorous big bluestem, Indian grass and switchgrass (five to six feet tall) appeared abundant. Woody species including Maclura pomifera Nuttall (Osage orange), Juniperus virginiana L. (red cedar), and Symphoricarpos orbiculatus Moench (buckbrush) were uncommon. Weedy forbs including Veronica baldwinii Torrey (western iron weed) were less common than desirable species (see APDI evaluation in Appendix B). Since "abandonment", a later stage of succession has taken place. Abundance of the "big four" has decreased. Carex spp. L. (sedge), side-oats grama and Sporobolus asper (Michaux) Kunth (rough dropseed), and dominating the grass communities. Small rills and channels were being created under the litter due to lack of basal and root development. Buckbrush was dominant; leaving little ground cover.

Watershed E-8, apparently managed regularly, was remaining stable except for some increase in ironweed and ragweed. The dominate species were Indian grass and switchgrass. In addition, little bluestem was abundant. Side-oats grama and other intermediates appeared to be establishing themselves better than in the past.

The pond on F-7 was built in 1963 for flood retention and a stock water supply. It is approximately four-tenths of a hectare. An old water control structure (in front not through the dam) was present. The spillway seemed to be eroding along with the dam berm (front). Apparently age and sedimentation have increased the abundance of pondweed and other submergents. These involved at least 30 % of the surface area.

In the delta area, trees appeared well established and thrive on the ponds perimeter.

A vegetation problem of this magnitude is usually associated with sedimentation and increasing pond age. Traces of fencing were evident. The absence of trampling appeared to keep the shorelines even.

Since there were no records available, it was difficult to evaluate watershed F-7. Descriptions of F-7 included E-8 when possible (mainly in physical and soil characteristics).

...oma-Ladysmith IV Association

These deep, nearly level, gently sloping well-drained soils have a silty clay subsoil. They are associated with broad ridgtops on upland and gently sloping side slopes. Most of this association is in rangeland. The major concern of management is maintaining the range in good condition. Necessary management techniques include proper stocking, uniform distribution of grazing and moisture conservation by keeping adequate ground cover (Neill 1981).

Watershed N-2

(Legal description: SE 1/4 of NE 1/4 and NE 1/4 of SE 1/4, RS21, R11E, T20S.)

This watershed is approximately 16 and a half hectares in size. Located about eight miles south and one mile west of Emporia, its range site classification is loamy upland.

The soil types present are: 75 % of Kenoma, 1-3 % slope, 19 % of Elmont, 4-7 % slope and 6 % of Elmont, 1-4 % slope. Soils around the pond periphery are predominantly Elmont, 4-7 % slope.

Sampling was finished November of 1982. The vegetation composition was dominated by little bluestem and Indian grass. Rough dropseed, big bluestem, side-oats and Bouteloua hirsuta Lagasca y Segura (hairy grama) and carex sedge were also frequent. Artemesia ludvocaiana N. (sagebrush) and Bromus inermis Leysser (smooth brome grass) dominated the least desirable species. Smooth brome was considered undesirable because it seeded naturally (i.e. invaded) from a nearby source. (If a good stand is established, it might be considered an intermediate.) In addition, this area displayed a variety of forbs including Achillea millifolium L. (yarrow), Asclepias spp. L. (milkweed) and Gutierezia dracunculoides Decandolla, Blake (broomweed). This area was grazed probably from early April to late time by a cow herd. A pen and feeding area are located far from the pond site.

The pond site was an interesting feature of this watershed. The cement dam was constructed in 1929 and created approximately one-half hectare of surface water. A flow tube for watering cattle was present below the dam. Trees were kept off the dam but were abundant around the pond periphery. Salix spp. L. (willow), Populus spp. L. (cottonwood), Robina spp. L. (black locust) and Morus spp. L. (mulberry) comprised the riparian vegetation. The pond site was completely fenced. Inside the fence (which was approximately 15 feet away from the banks) Indian grass and switchgrass are abundant. The age of the pond may be estimated by the decrease in surface area due to siltation. Aerial photographs (Results and Discussion) and thorough observation of the delta area vegetation and composition patterns seemed to suggest the design of pond was at least one-tenth of a hectare more in surface area than the original pond site. Observed seasonal aquatic vegetation appeared to be abundant and included pondweed and algae.

Tully-Florence (V) Association

Deep, gently sloping and strongly sloping, well drained soils that have a dominantly silty clay or cherty clay subsoil; on uplands.

Watershed A-4

(Legal description: NE 1/4...NE 1/4, S21, R10E, T15S.)

This watershed is located approximately five miles west of Allen and two miles south of highway 56. Draining approximately six and four-tenths hectares it includes only two soil types.

Soil types present include: 72 % Clime-Sogn, 5-20 % slope and

28 % of Zaar, 2-5 % slope. The pond periphery is predominantly 2-5 % slope Zaar. Zaar soil is well suited for range although overgrazing reduces grass vitor (Neill 1981).

Steers and cows with calves grazed April to June and appear to be managed properly. Sampling was accomplished March 1983. Vegetation was composed of little bluestem, Indian grass, switchgrass and sideoats grama. Invasion of woody or broadleaf plants seemed insignificant. Gullys were present, but there were signs of healing and stabilization.

The pond was less than one-tenth of a hectare and had two inflow areas. One appeared to be intermittently spring fed. Although fencing was absent, there was a gravelled area for cattle access to water. The dam was constructed for flood retention and water supply for livestock. Seasonal aquatic vegetation included pondweed, algae.

Watershed P-15

(Legal description: SE 1/4, S7, R10E, T17S)

Located approximately 17 miles northwest of Emporia. Ross Reservation (owned by Emporia State University) is a part of this watershed. The watershed itself drained approximately 37 hectares and was managed by several owners making monitoring difficult. It had several land uses including haying, grazing and wildlife management.

Soil types include 43 % of Clime-Sogn, 5-20 % slope; 18 % eroded Clime, 3-7 % slope; 18 % of eroded Kenoma, 1-3 % slope; 18 % of Labette, 1-3 % slope and 3 % of Ladysmith, 0-2 % slope. Soil type around the pond periphery was predominantly Clime-Sogn.

Most of this association is range. The main concerns of management are proper stocking, conserving moisture, and maintaining the range in good condition. It has good potential for range use and fair for rangeland wildlife habitat (Neill 1981).

Sampling was completed in March 1983. Results showed a diverse composition including good stands of Indian grass, big and little bluestem and switchgrass. A hayed brome grass field was present in addition to Prunus spp. L. (wild plum), buckbrush and Rosa spp. L. (wild rose). At least 15 other less common species of forbs and weeds including Baptisia austrailis spp. and Aster spp. L., Asclepias spp., and Cirsium spp. Miller (thistle) were observed.

The pond (Gladfelter Pond) was approximately one hectare in size. The dam was 26 years old at the time of sampling. Dam construction was for flood control. There were three major inflows into this pond. aeqenus augustifolia L. (Russian olive) and Salix nigra Marshall (black willow) dominated the pond periphery. Switchgrass and other grasses were planted for dam and spillway protection. Observed seasonal aquatic vegetation included pondweed. Cattle were excluded from the pond but deer tracks indicated that it was being used by some wildlife.

Watershed D-9

(Legal description: NW 1/4 of NE 1/4, S7, R10E, T17S)

This watershed is located approximately four miles west of ericus. Its eight and five-tenths hectares of drainage are on a mey upland range site. The pond was approximately one-tenth of a hectare.

Soil types present include: 55 % of Clime-Sogn, 5-20 % slope; 31 of Labette-Dwight complex, 0-2 % slope; and 14 % of eroded Clime, 7 % slope. Soils around the pond periphery were predominantly Clime-gn with 5-20 % slopes.

The land was grazed in the spring by cows with calves (occasional teer grazing). Some areas have apparently been disturbed due to ngregating and overgrazing.

Sampling was finished in January of 1983. Results showed sideoats rama, little bluestem and Indian grass to be the main species. though the composition was basically good, distribution problems peared to decrease soil stability and increase invasion of desirables. Gutierizia dactyloides, Veronica baldwinii, Urtica spp. (nettle) and Buchloe dactyloides (N.) Englemann (buffalo grass) were mon in isolated yet disturbed areas.

The pond site was between two ridges of Clime-Sogn and Labette-ight complexes. The pond was approximately one-half of a hectare. was built for flood retention and livestock water supply. The two inage ways emerged from Clime-Sogn and had eroded down to the estone shelf. The dam was unseeded and unfenced with an undeveloped illway. Shoreline vegetation was lacking, apparently due to the latively short life (nine years) and steep banks.

METHODS AND MATERIALS

Range/watershed condition and sedimentation rates of 17 study areas in Lyon County were evaluated from January to May 1983. These sites were pasture or native prairie watersheds ranging from 39.6 to 3.9 hectares in size. Several had multiple land uses and soil types. Each area was described in detail in the Description of Study Areas section of this paper. Several sites were selected through prior knowledge of them. Aided by the local district conservationist others were located.

Two aspects of watershed management were examined: 1) range condition/ground cover and 2) sedimentation. The objective was to attempt to establish a stastistical relationship between range condition and sedimentation.

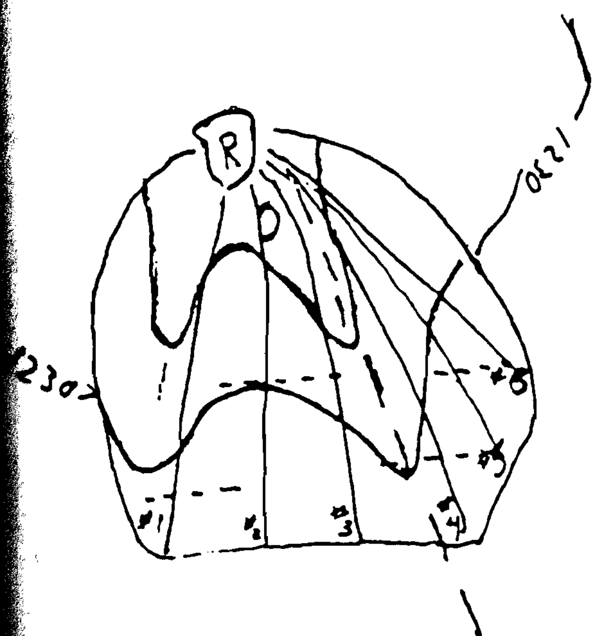
Range Condition Sampling

Range condition/ground cover was evaluated by means of a modified step-loop method. This was developed originally by Kenneth Parker for the U. S. Forest Service (Parker 1951). When compared to other sampling methods, Parker explains, "the loop method is sensitive to differences and changes within and between range condition classes" (Wilk 1984).

Sampling transects for production are usually taken along the contour. The modified method consists of sampling transects from the highest to the lowest elevation (Figure 5). This practice is more sensitive to gully and rill erosion than the clipped-plots.

A topography map was used to delineate each watershed. Transects were first located on the map and then in the field (Figure 6). Landmarks such as telephone poles and trees were used to help

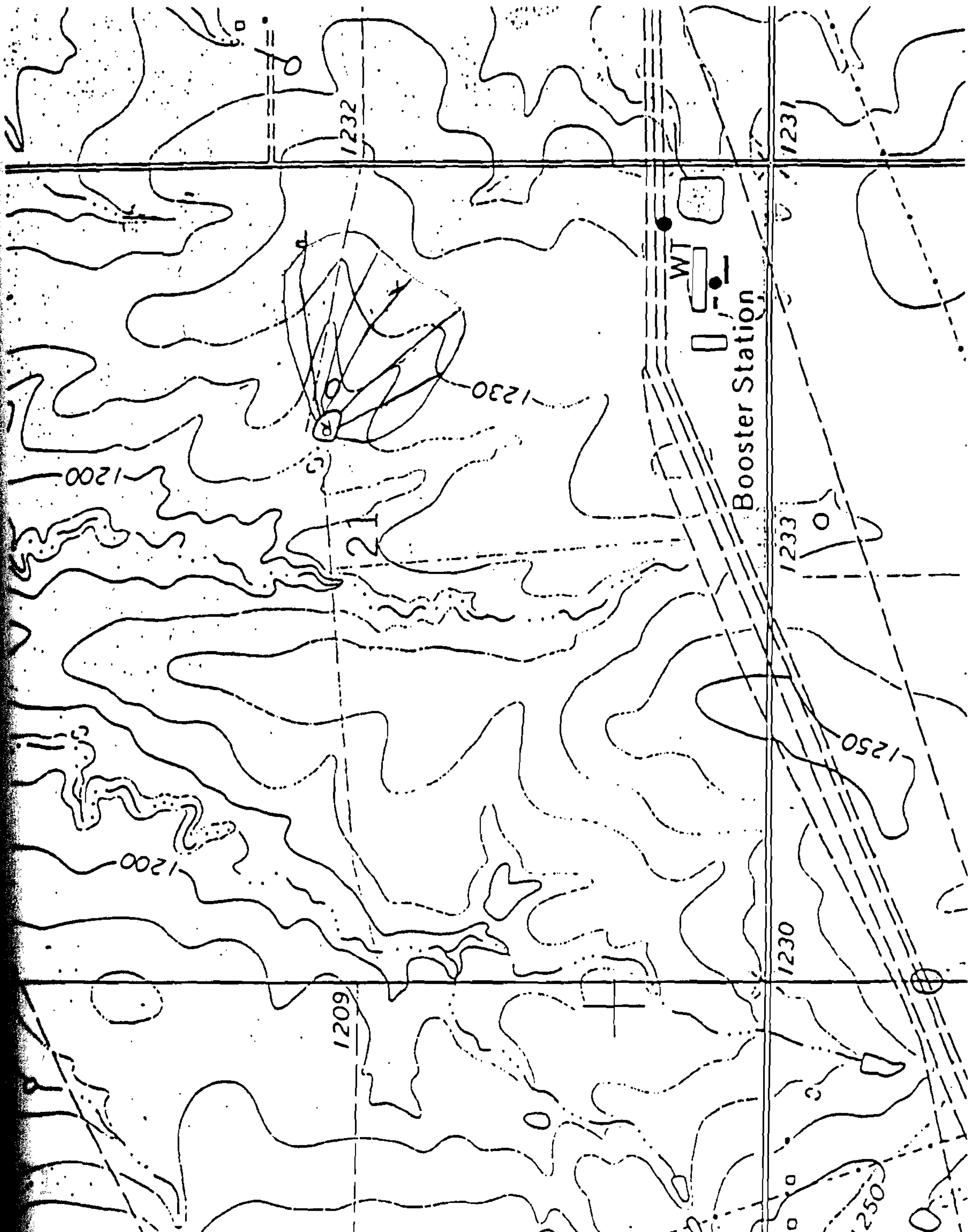
Figure 5. Transect establishment for watershed and range condition sampling. (Note: difference between sampling for range and watershed condition evaluation.) (Scale: 1 KM approximately = 235 mm.)



----- Range Condition Transects

——— Watershed Condition Transects

Figure 6. A topographical view of watershed and reservoir with transects drawn. P, R, T represent the perimeter (drainage), reservoir and transects in the watershed 112. (Scale: 1 Km approximately = 235 mm.)


Booster Station
WT
1232
1231
1230
1233
1200
1200
1230
1250
1209
1250
21

establish field transects.)

The Step-Loop Method

Samples were taken using a rod approximately one meter long (waist high) with a three-quarters inch loop attached to the end. At every other step, the loop was placed at the toe and a "hit" (plant species, litter or bareground) recorded (Figure 7). Only hits on the plant base were recorded as a species hit. If the loop landed in the middle of a clump-type vegetation (e.g. little bluestem), a plant species was also recorded. If, however, the loop landed on a leaf of grass and no other ground cover was evident a bareground hit was recorded. Occasionally there was an atypical situation. For example, a highway ran through watershed F-7. The shoulders were dirt and loose gravel with a "bare-ground" appearance (Figure 8a). However, the accompanying ditches appeared to be adequately covered. One parking area for fuel unloading was also graveled and appeared to have adequate cover (Figure 8b). These areas were noted and the shoulder areas estimated.

In the original step-loop method, 100 samples were taken in each transect. However, when sampling the entire watershed, the number of samples depended on the length of slope and size of drainage. For example, on a watershed covering 40 hectares, there may be 300 samples in a transect at the longest distance between high and low point (i.e., pond perimeter to drainage perimeter). If the drainage consists of several different slope lengths, there may be 50 to 200 per transect.

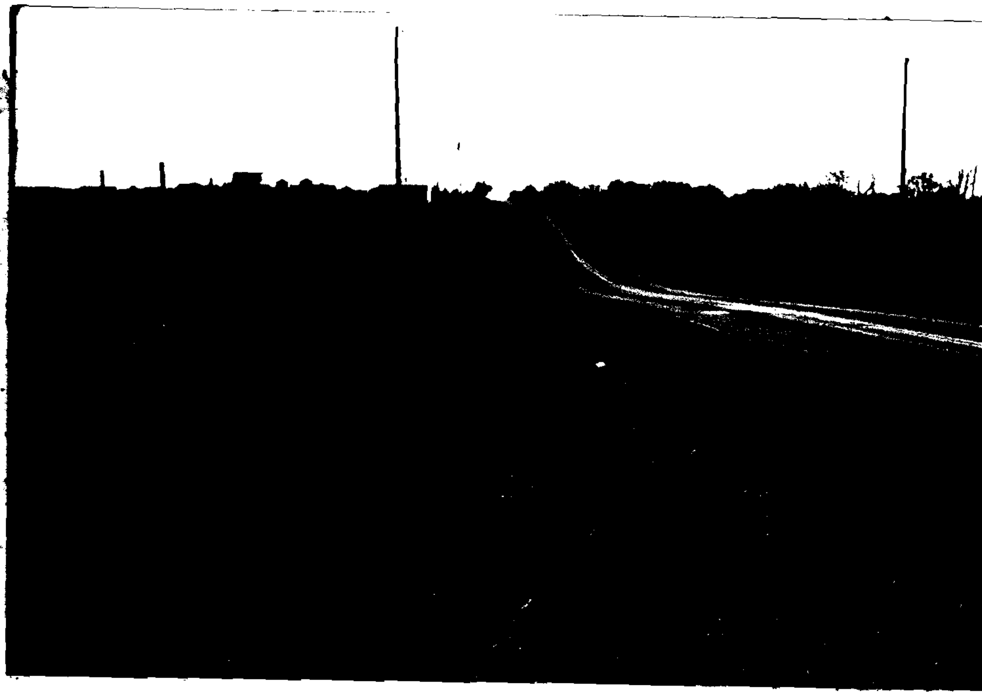
The Field Data Sheet

In order to quantify and organize recorded data and observations, a "field data" sheet was developed. An accurate and organized account of sampling for each study site could be obtained in this manner.

Figure 7. Photograph of sampling rod and technique.

Figure 8a. Photograph of F-7 showing highway shoulders and ditches (Anderson 1975) included highways and roads in sedimentation study on wildlands.

Figure 8b. Photograph of watershed F-7 showing parking area. (Soil and sand from this parking may eventually be deposited in the pond.)



Sampling results were recorded on the "field data" (Range Condition Evaluation Criteria) sheet similar to Figure 9. The sheet includes names of tallgrass prairie species taken from a list compiled by other researchers (Wilk 1984). Three categories of plants (mainly native grasses) were recognized: "Desirables" (increasers), "Intermediates" (decreasers), and "Least desirables" (invaders).

The second part consisted of "litter hits" and "bareground hits." Bareground was easily recognized. Litter was not so easily distinguishable. Any organic or inorganic matter which was observed to be a soil erosion deterrent was considered a litter hit. (Although rock should have been separate, its frequency seemed to insignificant.) If soil movement was evident directly below the object (closer to the pond), it was recorded as "bareground."

The last part consisted of "# of hits" and "% of hits" followed by "field notes." Field notes included soil movement observations, their sources and locations, and unidentified plants which may or may not have been significant to the sampling.

The Scorecard System

One way to quantify, qualify and evaluate range samples is by using a "scorecard" rating system. This "scorecard" system was based upon those of Parker (1951) and Wilk (1984). These utilized forage density, composition, and litter hits to evaluate range condition, production and potential soil loss.

Data were recorded on a scorecard which provides a standard percentage for excellent, good, fair, poor and very poor range condition (Parker 1951). A combination of the original scorecard and the "tallgrass prairie scorecard" (Wilk 1984) was used to evaluate

Figure 9. Range condition evaluation criteria sheet (field data sheet).

Range Condition Evaluation Criteria (adapted from Parker 1951)

Name of Watershed:

Date:

Observer:

Ansc to 25 % - DES

Bocu to 10 % - DES

Ansc 25 % - INT

Bocu 10 % - INT

DESIRABLES:	Ange	Ansc	Sonu	Pavi
Spas	Sppe	Fes*	Brin*	
INTERMEDIATES:	Bocu	Bohi	Bogr	CAR
agsm	Buda	ELY	Spcr	
LEAST DESIRABLES:	Arol	ARI	BRI	CHL
Veba	Xadr	SYM	Getr	ART
AMB	MUH	Paca	Leco	

BAREGROUND:

LITTER COVER:

OF HITS

% OF HITS

Field note: Soil stability, large areas of bareground slope, etc.

* Species are not native but if planted may be considered desirable if numbers remain relatively low.

range condition on the study areas.

The "tallgrass watershed scorecard" differs from the other scorecards in its ability to put a greater emphasis on soil stability. Several scorecards were used to develop the tallgrass watershed scorecard. The range condition scorecard evaluates the composition and density for the forage production potential only. "Litter" and "bare-ground" hits and the plant hits were designed to evaluate general soil stability.

The watershed condition scorecard developed in this study uses the above in addition to other characteristics important to watershed evaluation. These scorecards will be described completely below.

<u>The Range Condition Scorecard</u>

The original scorecard utilized a "borderline" approach. For example, some plants are considered desirable until the forage density increases enough to significantly be in competition with more desirable grasses (i.e., big bluestem; Indian grass). In this situation, Parker used a percentage index. Little bluestem is considered desirable if its density percentage is 25 % or lower. Once above 25 %, it is considered "intermediate." Sideoats grama is similar except its desirable percentage is 10 % or less. Its intermediate percentage is > 10. These values may differ from range site to range site. Therefore, if different range sites are present, percentage values may vary within watersheds. On completion of sampling the entire watershed by transects, percentages were estimated and the values rated accordingly (excellent, good, fair, poor and very poor).

As a result of regional and vegetation standards (i.e., the tallgrass vs. the shortgrass prairies), other differences were encountered. Fescue (Festuca spp. L.) and smooth brome are least desirables in a native tallgrass prairie. However, for watershed purposes, these plants may be desirable or intermediate. Still, under some conditions, any grass is probably considered desirable.

Ground cover was also evaluated using the "step-loop" method. This measurement illustrated general soil movement and erosion tendencies. After data was recorded and tallied, percentages of cover (litter + forage hits) were compared to bareground percentages. Gullies and denuded areas were noted and observations used in the soil stability rating.

The Tallgrass Watershed Condition Scorecard

In addition to utilizing a range condition scorecard, a "watershed" condition scorecard was developed (Figure 10). This scorecard incorporates several factors important for watershed evaluation. These are: 1) values for range condition/ground cover (RC/GC); 2) a management/conservation practices factor (MCPF); 3) a relative erosion potential factor (REPF) and 4) a total watershed plant erosion deterrence index (TWPEDI). These are added together in index form. The index was developed by establishing the theoretically worst condition (lowest value) and best condition (highest value), then applying them to a numbered system to find a rating. Excellent, good, fair, poor and very poor and their respective + or - ratings were then developed. The important factors are discussed in detail. The RC/GC has been previously explained.

The Management and Conservation Practices Factor (MCPF)

The MCPF deals with the treatment of the watershed and is directed toward a positive goal of maximum production consistent with minimum

Figure 10. An example of the watershed scorecard, in its entirety, including its factors and variety scales. (This scorecard is to watersheds with total number of samples 1468-2969.)

CATEGORY III T#3S 1468–2969

STUDY AREA	R/C	GCI	MCPF	Rating	REPF**	SER	TWPEDI*	WCRV	RATING	R/C, GCI, TPEDI
Best	9	9	A+5 B+1 C(DO) F(GO) I(K–12) M(N+1) 12	(12)	EFCSL –5	+5	09 (1904.1)	44	Excellent	9 Excellent 8 Good + 7 Good 6 Fair + 5 Fair 4 Poor + 2 Poor – 1 Very Poor
K–17	7	7	A 0 B 0 C(D–1) F(G–1) I(K+2) M(N+1) 1	(1)	EFCS1 +7.7	–8	5 (1055.9)	14 (4)	Poor	
N–2	9	9	A 5 B+4 C(DO) F(GO) I(K+2) M(N+1) 12	(12)	EFCSL 0	0	7 (1312.2)	37 (2)	Excellent	WCRV RATING 44–35 Excellent Good + 34–26 Good Fair + 25–27 Fair 16– 8 Poor 7– 0 Very Poor

* – Deterrence
** – Difference between EFCSL and MTSL

AREA	R/C	GCI	MCPF	RATING	REPF**	SER	TWPEDI*	WCRV	RATING	R/C, GCI, TPEDI
Q-13	9	9	A-5 B 0 C(D-1) F(G-1) I(K+2) M(N+1) 7	(7)	EFCSL +4.8	- 5	5 (828.9)	25 (3)	Fair	9 Excellent 8 Good + 7 Good 6 Fair + 5 Fair 4 Poor + 3 Poor 2 Poor - 1 Very Poor
P-15	9	9	A 0 B 4 C(D-3) F(G-1) I(K+2) M(N 1) 3	(3)	EFCSL +4.3	- 4	7 (1164.8)	24 (1)	Fair	

WCRV	RATING
44-35	Excellent
	Good +
34-26	Good
	Fair +
25-17	Fair
16- 8	Poor
7- 0	Very Poor

* - Deterrence
** - Difference between EFCSL and MTSL

ecological harm. Therefore, this factor emphasizes the long-term effects and consequences (Figure 11). It is the sum of several values. Well managed watersheds have a positive, larger value. Poorly managed watersheds have smaller or even negative values.

In this study, pond fencing and cattle accessibility are major concerns. In range management, distribution problems are associated with salting, feeding and resting area locations and therefore would be the main concern. For this reason distribution and use around ponds are treated separately.

Thorough observation typically gave a general idea of the distribution problems. In addition, the location of the problem was considered. Even if the congregating areas were away from the pond they might be in line with the drainage and therefore be responsible for inflow sedimentation problems. Due to distribution of livestock use, most watersheds had a pattern of "all or none" demonstrating few "in-betweens" as far as the rating system was concerned. A value of "+5" was given to study areas that had congregating areas (i.e., salting, feeding and resting) away from the pond and appropriate range fencing (for grazing systems.).

Cattle use (trailing and grazing) can directly affect the pond. Erosion from the pond periphery, including the dam can fill the pond with sediment as well as widen it (thus decreasing mean depth). Accordingly, a value of +4 is given when the entire pond was fenced. If only the dam is fenced, a +2 is given.

The second part of this factor is the condition of the overall soil stability including trailing/gullying and overgraze/distribution problem areas (notice distribution is involved twice, once as a cause and once as an effect). This demonstrates the importance of use and

Figure 11. Management and Conservation Practices Factor derivation. (Category "A" may be described and rated differently according to land use and special situations.)

Derivations of Management and Conservation Practices Factor

A. Congregating areas (salting, feeding, etc.) away from pond; appropriate range fencing up to +5.

B. Pond fenced — +4 (if only dam is fenced subtract 2)

C. Trailing and gullying -- (a) numerous, shallow and slight (D -1); (b) few, deep and severe E -3)

F. Overgrazed -- (a) restricted areas (G -1); (b) overall (H -3)

I. Land use -- (a) hayed (J +3); (b) grazed (K +2); (c) seeded go-back or abandoned (L +1)

M. Burning -- (a) proper burns (right time of year) (N +1); (b) lack of burns (O 0); (c) improper burns (wrong time of year; including wildfire) (P -1) distribution in terms of soil stability. These were generally rated on severity of disturbance and area disturbed.

Trailing/gullying were divided into two types according to stages: numerous, shallow or slight which is given a -1 and deep and severe; a -3. The "-1" represents the typical "cattle trailing" involving a slight management problem or highly erosive site. This may or may not be a problem at present; nevertheless, they have potential to be severe.

Deep and severe gullying receives a "-3" due to its overall detrimental effects. A severe gully decreases mean available water capacity and increases soil and nutrient losses. This includes those gullies which show pedestalling and uncontrolled soil loss (lack healing signs). This phenomena indicates a change of management system is in order and may require complete rest (no cattle) or earthwork.

The next part of the MCPF is the distribution of use. A -1 is given if the watershed showed distribution problems. In erosion potential, restricted areas including feeding, salting and resting areas probably indicate such a problem. A -3 is assigned to the entire overgrazed condition. This is to say overstocking is apparent and total mismanagement is evident. Expansive rilling and sheet erosion may be more probable under these conditions.

The next area of interest of the MCPF is the land use. Simply, if the watershed is hayed it receives a +3 due to uniform distribution and utilization. If grazed, it receives a +2 because grazing is desirable and usually necessary for a productive pasture with proper management. Seeded go-back or abandoned land receives a +1 because some ground cover and plant communities are better than none (cropland or development).

The last factor is still controversial and not well studied. rning has been regarded as necessary by some and detrimental by hers. In this study, proper burning is regarded as a positive nagement tool. Therefore, watersheds with proper burns (controlled) ceive a +1. Lack of burning is assigned a "0" because uncontrolled rning can destroy everything. However, succession is a slow process. ody invaders may not affect soil stability until they begin to domi-te the plant community. Improper burns, whether deliberate, cidental or natural, may be deterimental to the watershed in both roduction and soil loss. Therefore, improperly burned watersheds receive a -1.

he Relative Erosion Potential Factor (RPEF)

This factor attempts to take into account the important variables of physical characteristics and vegetation type (natural and man-influenced). Through research of the diversity of study sites and their locations, it was recognized that different areas had different potential. This potential when identified might make management more efficient and in turn less harmful to the resource than the current methods of maximum, short-termed production (with little or no emphasis on conservation). In runoff and erosion, slope is probably the major variable of concern. In addition to slope, rainfall is a most important factor, however, it is regarded as a constant not a variable. The lack of gauging stations in the immediate areas of the study sites made it impossible to use a variable rainfall factor for each water-shed. Therefore, the SCS rainfall factor of 225 (used in the "WSLE Ly17") is the constant rainfall factor in this study.

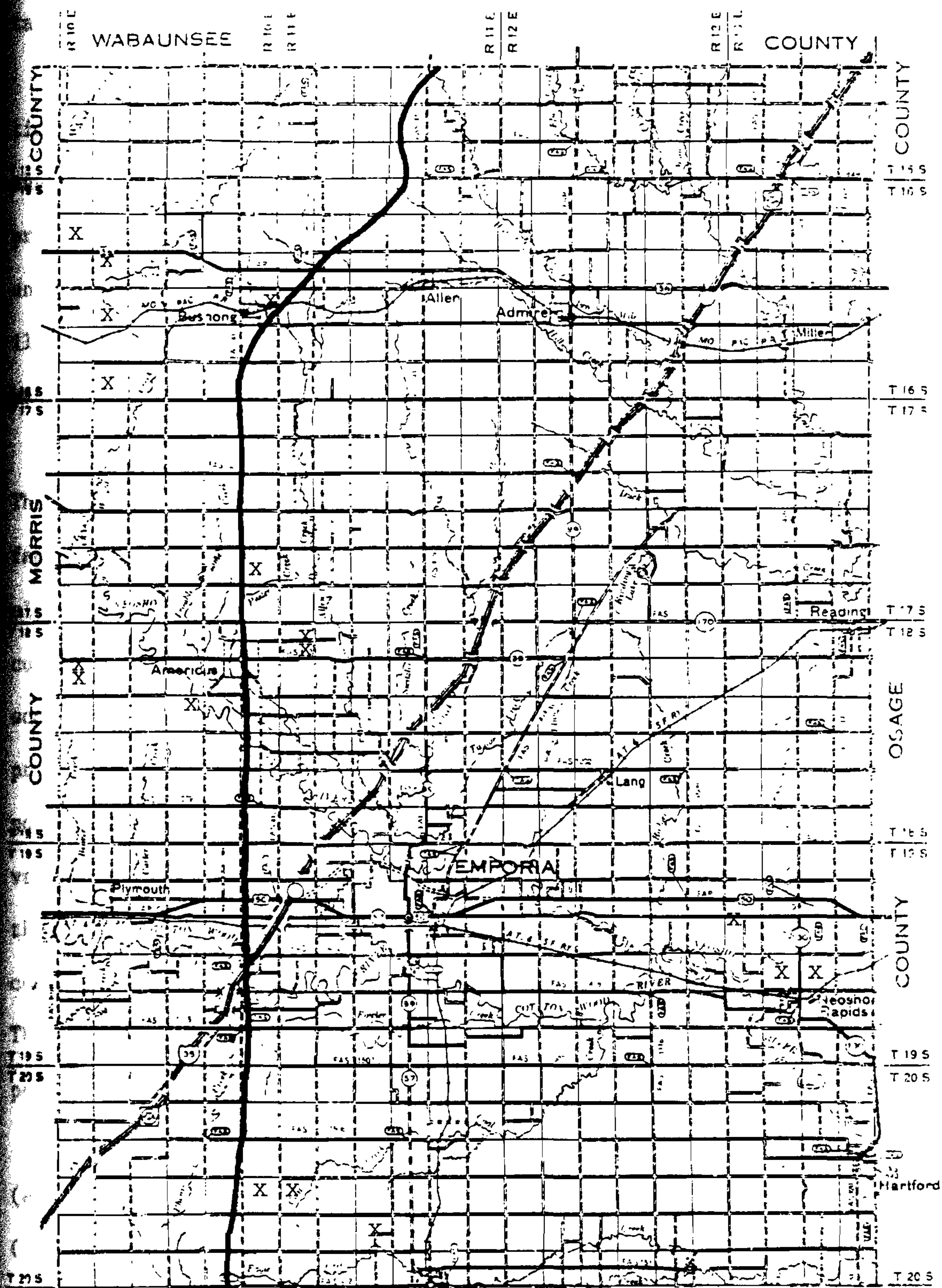
Background of the range sites is necessary to refer to certain reas. Two areas in Lyon County are recognized by the SCS as separate "resource areas": the "Flint Hills" and "Cherokee Hills." They differ by described rainfall, growing seasons, and wind velocity (Appendix A).

A map showing the division line illustrates the two "land resource" areas (Figure 12). This line is not particularly accurate but is accepted by the SCS as official. The study areas in this study are marked with an "X" and are as closely identified as possible. "Utilizing the USLE (Universal Soil Loss Equation) in the Relative Erosion Potential Factor."

Initially, a rating system for different slope and soil types was established. Problems arose with this approach demonstrating the complexity of estimating slope through soil type inventory. Physical characteristics such as available water capacity and runoff also created problems due to percentage and land use. After several trials it was realized that a different approach in terms of sedimentation and erosion had to be used. This part of the study attempted to measure the relationship between watershed condition and erosion/sedimentation.

"The USLE (Wischmeier and Smith 1965, 1978) is widely used to estimate sheet and rill erosion. Although the USLE was originally developed for cropland east of the Rockies, its use has been extended to rangeland, construction sites, forest lands, and surface mines in all parts of the United States and in several foreign countries" (Foster 1981). The USLE lacks a true measure of gully erosion and uses a "cover" factor which is probably the most significant variable affected by land use. Because of shortcomings of the USLE, application to rangeland (grazed land) has been slow. In the southwest, for

Figure 12. Map of Flint Hills and Cherokee Hills "Land Resource Area" boundaries in Lyon County. (X approximately identifies location of study areas) (SCS, Emporia Field Office, personal contact). (Scale: 1 KM approx. = 17 mm).



WABAUNSEE
COUNTY
MORRIS
COUNTY
OSAGE
COUNTY
R 10 E
R 11 E
R 12 E
T 15 S
T 16 S
T 17 S
T 18 S
T 19 S
T 20 S
Allen
Admire
Bushong
Miller
Americus
Reading
Lang
EMPORIA
Plymouth
Neosho Rapids
Hartford

ample, where research of this nature (watershed erosion and sedimen-tion) is being conducted, questions are still arising.

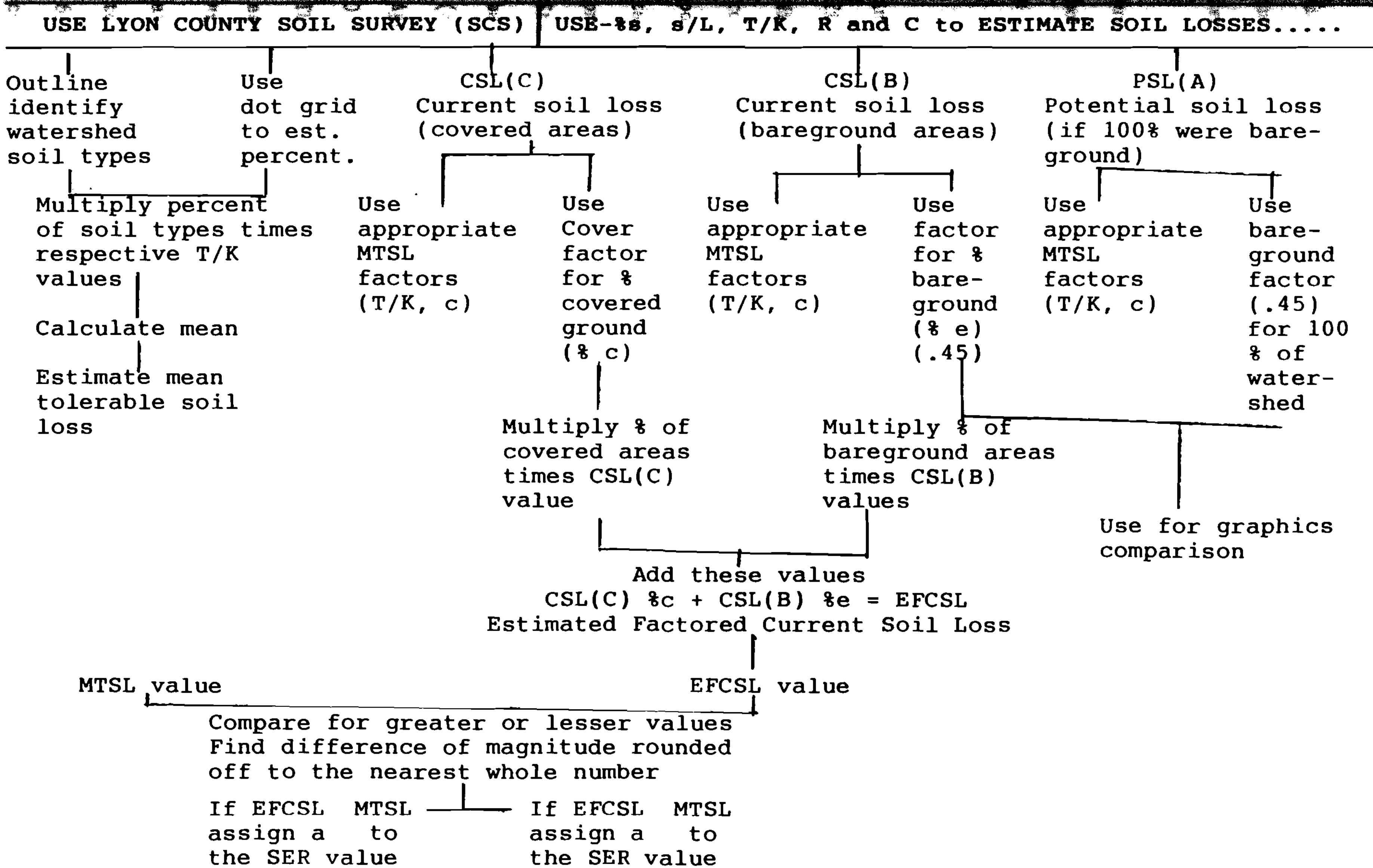
If the researchers in the southwest are bewildered by these ques-ons, how are the researchers of the "tallgrass prairie" suppose to swer them? First, it has to be demonstrated that there is indeed a roblem. Secondly, the magnitude of the problem has to be determined d shown it is worth the effort. One result of this study was to llustrate the need for increased research, including modifications and nipulations of variable factors.

The "C" or cover factor in the USLE was modified in this study. is will be explained in detail later. The relative erosion potential ctor of each watershed is determined by natural variables including lope, soil erodibility and rainfall. The REPF may be effected by over and land use. A key idea in the development of the watershed corecard was the recognition of the REPF in forage production and soil rotection. This approach to watershed management investigates the ossibility of identifying, understanding and manipulating the riables. The USLE attempts to do this by theoretically manipulating hose variables. It appears then, that this modified USLE (WSLE Ly17) ould be used to determine erosion potential in a given watershed. his erosion potential factor makes comparisons between watersheds ossible.

Terms of the WSLE Ly17, are similar to the USLE. Slope, T/K (erodibility), rainfall, "C" (cover factor) (Figure 13) and TSL (tolerable soil loss) are included in both equations. A brief explana-tion of these terms relative to this study is given below.

The length of slope factor refers to the area from where the slope egins to where the slope ends and varies from watershed to watershed.

Figure 13. Flow chart showing the development of factors used in the WSLE Ly17, based on the USLE (Wischmeier and Smith 1965). Where as: %s is slope percent, s/L is length of slope, T/K is total erodibility, R is rainfall and C is the cover factor. (The USDA-SCS slide rule calculator was used to find soil loss. The "P" factor in the original USLE has a value of 1 in most cases.)


USE LYON COUNTY SOIL SURVEY (SCS)
USE-%s, s/L, T/K, R and C to ESTIMATE SOIL LOSSES.....
Outline identify watershed soil types
Use dot grid to est. percent.
Multiply percent of soil types times respective T/K values
Calculate mean
Estimate mean tolerable soil loss
CSL(C) Current soil loss (covered areas)
Use appropriate MTSL factors (T/K, c)
Use Cover factor for % covered ground (% c)
Multiply % of covered areas times CSL(C) value
CSL(B) Current soil loss (bareground areas)
Use appropriate MTSL factors (T/K, c)
Use factor for % bare-ground (% e) (.45)
Multiply % of bareground areas times CSL(B) values
PSL(A) Potential soil loss (if 100% were bare-ground)
Use appropriate MTSL factors (T/K, c)
Use bare-ground factor (.45) for 100 % of water-shed
Use for graphics comparison
Add these values
CSL(C) %c + CSL(B) %e = EFCSL
Estimated Factored Current Soil Loss
MTSL value
EFCSL value
Compare for greater or lesser values
Find difference of magnitude rounded off to the nearest whole number
If EFCSL MTSL assign a to the SER value
If EFCSL MTSL assign a to the SER value

In this study, SCS (district conservationist; Emporia Field Office), interpretation and observations from contour maps were used to estimate length and percent of slope.

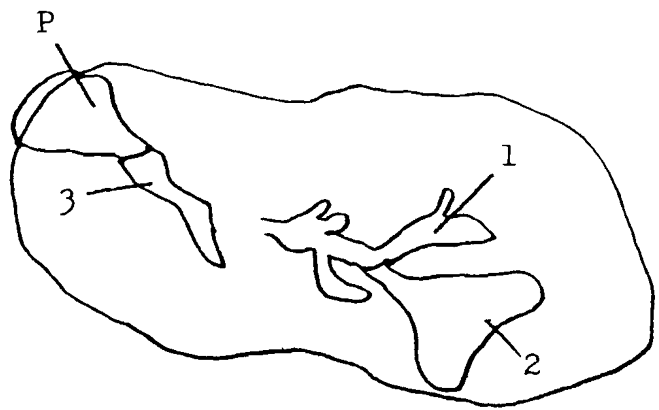
The T/K factor is a value established by the SCS. This shows erodibility of different soils found in Lyon County. It applies to both wind and water erosion. Where more than one soil type occurred in a watershed the mean value was used.

The rainfall factor is 225 and is constant.

The cover factor is probably the most complex of all the factors in the USLE. This was modified several times during the study. The first trial used the established "C" value for the entire watershed. With the diversity of soil types and T/K values associated it was soon realized this method was inappropriate for estimating the erosion potential; a new approach was then taken. As part of the sedimentation/erosion, research aerial photographs of the study areas were projected from a tripod-mounted projector (courtesy Agriculture Stabilization Conservation Service) on to a sheet of paper. Areas of bare ground were located and their size determined with a planimeter (Figure 14). These were ground truthed. (Additional sketches are in Appendix D). These areas were bare and therefore could be evaluated as 0 % canopy and 0 % ground cover with the established value being 0.45. This "0.45" value was multiplied by the percentage of eroded acres established in the sedimentation part of this research creating the "bare ground" (B) factor. The remaining percentage of acreage was set at 0-5 % canopy and variable ground cover percentages were correlated to their respective "C" values (Table 2E SECT. IC, TG Notice KS-93, 6/21/82) (Table 2). Current soil loss for eroded areas % e) and covered areas (% c) were determined separately. Assuming all bare

Figure 14. Sketch of watershed and planimeter readings with outlined eroded areas. (Scale: 1 KM approximately = 162 mm)

Watershed 0-16



Drainage- 13.6 ha.
Pond- 0.32 ha.

Erosion area #1	0.57 ha.
Erosion area #2	1.13 ha.
Erosion area #3	0.73 ha.
% of Eroded Watershed	18%

(1 km. 162mm.)

Table 2. Values of "C" which were used with GCI values to estimate CSL values. (Personal contact USDA, SCS - Emporia).

Vegetal Canopy			Cover That Contacts the Surface					
Type and Height of Raised Canopy 2/	Canopy Cover 3/	Type 4/	Percent Ground Cover					
	%		0	20	40	60	80	95-100
Column No.:	2	3	4	5	6	7	8	9
No appreciable canopy		G	.45	.20	.10	.042	.013	.003
		W	.45	.24	.15	.090	.043	.011
Canopy of tall weeds or short brush (0.5 m fall ht.)	25	G	.36	.17	.09	.038	.012	.003
		W	.36	.20	.13	.082	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.075	.039	.011
	75	G	.17	.10	.06	.031	.011	.003
		W	.17	.12	.09	.067	.038	.011
Appreciable brush or bushes (2 m fall ht.)	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.085	.042	.011
	50	G	.34	.16	.085	.038	.012	.003
		W	.34	.19	.13	.081	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.077	.041	.011

Table 2. (Continued)

Vegetal Canopy			Cover That Contacts the Surface					
Type and Height of Raised Canopy 2/	Canopy Cover 3/ %	Type 4/	Percent Ground Cover					
			0	20	40	60	80	95-100
Column No.:	2	3	4	5	6	7	8	9
Trees but no appreciable low brush (4 m fall ht.)	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.087	.042	.011
		G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.085	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.083	.041	.011

1/ All values shown assume: (1) random distribution of mulch or vegetation, and (2) mulch of appreciable depth where it exists.
2/ Average fall height of waterdrops from canopy to soil surface: m = meters.
3/ Portion of total-area surface that would be hidden from view by canopy in a vertical projection, (a bird's-eye view).
4/ G: Cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 inches deep.

W: Cover at surface is mostly broadleaf herbaceous plants (as weeds) with little lateral-root network near the surface, and/or undecayed residue.

ground had the same soil loss, the CSL(B), (using the 0.45 factor from Table 2), was multiplied by the percentage of eroded areas. This product was added to the CSL(C) (using the cover factor from data obtained from the range condition survey) which was multiplied by the remaining percentage (covered) of the watershed. This was the estimated and factored current soil loss (EFCSL) for a given watershed (Figure 15). The equations and derivations for the USLE and WSLE Ly17 are seen in Table 3.

The difference between the EFCSL and MTSL is calculated. If the value is negative, a positive rating is given to the actual value and if the difference is positive, a negative rating is given to the value. Numbers were rounded to the nearest integer and a 0 rating given when appropriate. This gives the watershed having the highest differences of EFCSL and MTSL a lower rating. For watershed L-3, the EFCSL was greater than the MTSL (Table 4). Watershed L-3's value was +10.6 (rounded off to +11). Therefore, a low REPF rating of "-11" was assigned (Appendix C). This rating was then added to the other values (MCPF, etc.) to calculate the Watershed Condition Rating Value (WCRV) of the watershed condition scorecard.

Total Watershed Plant Erosion Plant Deterrence Index (TWPEDI)

Through this theory, a rating system based on individual plants' erosion deterrence characteristics, the "relative plant erosion deterrence rating system" or "RPEDRS" was developed. The RPEDRS assigns a value to be used in the "total watershed plant erosion deterrence index" (TWPEDI). Several steps are included in the development of the factor used in the TWPEDI. The first step was the actual range condition and ground cover sampling. (When doing a range

Figure 15. Flow chart of derivations of (Current Soil Loss) (C) and bare ground (CSL [B]) factors used in the WSLE Ly17 (Watershed Soil Loss Equation for 17 Lyon County watersheds).

DERIVATIONS OF FACTORS

USE LYON COUNTY SOIL SURVEY (SCS)			USE SCS RAINFALL MAP	USE COVER FACTOR SHEET SCS T-2
%/s	s/L	T/K	R	C
Identify soil types and their respective slope percentages.	Observed and measured on map with the aid of dist. conser.	Identify soil types and resp. soil erodibility. Find mean when more than one soil type is present	Constant 225	Identify cover factor
Find means when more than one soil type is present.				

%/s, s/L, T/K → Use slide rule calculator with these factors. (Calculator was developed for use with USLE by M. E. Springer, D. K. Springer, C. B. Breinig and F. R. Parris for the USDA - SCS.)

C → Identify cover factor:

- Covered CSL(C) → % GCI survey results (perrennials only) from step-loop data
- Bareground CSL(B) → Use theoretical % cover (.45) for bareground

Estimate % of watershed for each

Sketch and measure watershed

Identify and outline

- Observed covered areas
- Pond
- Observed bareground areas

Measure with planimeter and record in hectares; convert to % of watershed

Subtract pond and covered area from 100% watershed to get CSL (C) and CSL(B) factors.

Table 3. The USLE and WSLE Ly17 and their derivations.

Universal Soil Loss Equation (Wischmeier and Smith 1965). (Identify and set % of Slope on slide-rule calculator.) The USLE = R x K x SL x P x C = soil loss...where as:

Rainfall factor (constant 225)

K = Erodibility (in WSLE Ly17 T/K is used)

SL = Slope Length

P = Conservation Practices factor (most croplands use a 1 for uniformity)

C = Cover factor

Watershed Soil Loss Equation for 17 Lyon County watersheds (Identify and set % of Slope on slide-rule calculator.) (WSLE Ly17) = } (CSL(C) % C) + (CSL(B) % e)} = EFCSL...where as:

CSL(C) = Current soil loss using the cover factor of covered areas used in the WSLE Ly17. (Found by using the USLE and slide-rule calculator.)

CSL(B) = Current soil loss using the 0 % cover factor for bare ground (0.45) used in the WSLE Ly17. (Found by using the USLE and slide-rule calculator.)

% C = Percentage of ground cover survey (step-loop)

% e = Percentage of bare ground from eroded watershed survey

EFCSL = Estimated/factored current soil loss

TAble 4. Definitions, values and an example using the Watershed Soil Loss Equation (Ly17).

WS# L-3	%	S %	SL	T/K	R	c	=	TSL
(Eroded)	37.9	4	500	10	225	0.45	=	4.9
(Covered)	62.1	4	500	9.6	225	.029	=	3.7

Where values are as follows:

% eroded CSL(B) = 35 T/A

% covered CSL(C) = 2.1 T/A

The equation is as follows:

EFCSL = ¼ (CSL(B) % e) + CSL(C) % c) ¶ and compareto mTSL

L-3 100 % WS (WSLE Ly17) for rangeland

¼ (CSL(B) % e) + (CSL(C) % c) ¶ = EFCSL ¼ (35 x 37.9 %) +

(2.1 x 62.1 %_ ¶ = 13.03 t/a + 1.30 t/a = 14.3 T/A

EFCSL 14.3 > mTSL 3.7 T/A

condition and ground cover evaluation the "c" factor may already be included with other data.) Then the areas were evaluated. This included using the plants as an individual erosion deterrent. Since each species has not been tested individually, logical and scientific assumptions of a general trend was established. Although some plants (i.e., little bluestem), are better erosion deterrents in groups than in single form, tests in Nebraska did not emphasize numbers (Weaver and Kramer 1934). They appeared to emphasize anatomical structure such as root system development (rhizomes present), overall growth structure (columnar or spreading) and canopy (ground cover potential). Results from tests (Table 5) showed that with tops, big bluestem and prairie cordgrass had six to seven times the potential as did bluegrass and western wheatgrass in erosion deterrability. In erosion time in minutes, with an artificial water source <u>in situ</u>, big bluestem and prairie cordgrass held the soil for 780 minutes or more. In contrast, western wheatgrass held soil for 191 minutes and bluegrass for only 80 minutes (Weaver and Kramer 1934). (Testing times without tops attempted to simulate grazed plants. There appeared to be a significant difference between those with and without tops, therefore, the mean was used.)

In a study, "comparing dominant prairie grasses as interplanting ground covers on eroded soil", Aikman and Dermot (1943) concluded from data that Indian grass and big bluestem were important species on dry upland and wet lowland sites. Little bluestem was important on the dry upland. Their study evaluated soil protection of interplanting strips on cropland. In addition, Aikman and Dermot stated that based upon basal area the value of a pure big bluestem stand is less than little bluestem. However, in a native mixture, big bluestem is an excellent

Table 5. Minutes time taken to erode 1 by .05 meters of soil by artificial water source.

SPECIES	With tops	Without tops	Mean
Big bluestem	780	280	530
Prairie cordgrass	780+	120	450
Western wheatgrass	191	146	119
Bluegrass	80	240	160

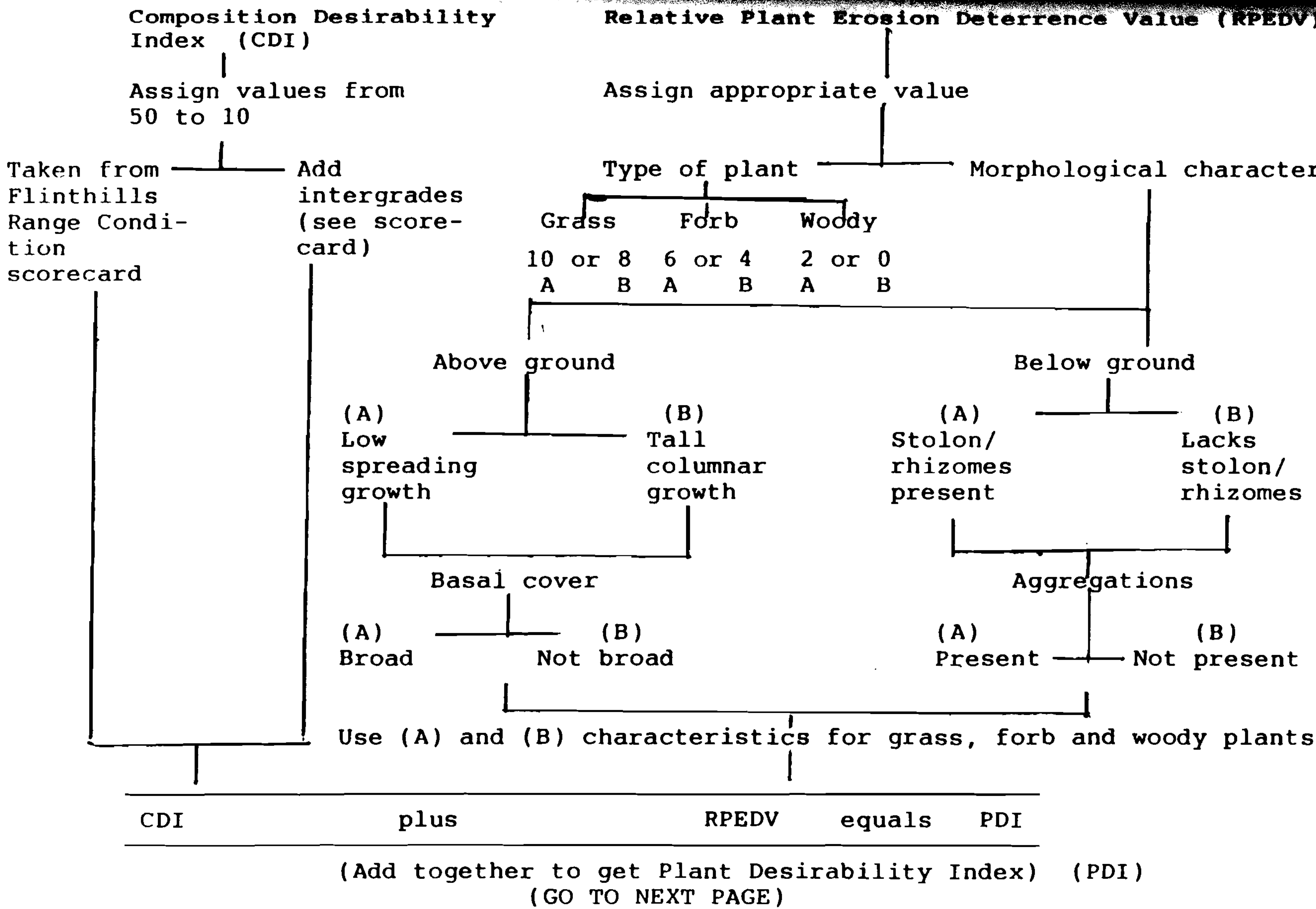
Taken from "Relative Efficiency of Roots and Tops of Plants in Protecting the Soil from Erosion" (Weaver and Kramer 1934).

soil protector.

The rating system was based on the above results and then applied to the plants sampled. A flow chart (Figure 16) illustrates the criteria and ratings. The relative plant erosion deterrence value (RPEDV) was given to each different growth types. Grasses exhibit either good root development and broad basal coverage (prairie cord-grass, big bluestem, etc.) or poor root development; lacking broad basal coverage or being an annual (three awn). However, grasses are more efficient soil holders than forbs and woody species. Good root system grasses are rated at 10 because they are the best. Poor soil holding grasses (three awn) are given an 8 rating.

Forbs are probably the most difficult to rate in comparison to each other. Two general forms present in the study areas are the low, spreading growth of a Amorpha canescens Pursh (lead plant) and the columnar growth of the Helianthus maximillianii Schrader (maximillian sunflower). The first growth form is given a 6 compared to the other form which is rated as a 4. These ratings are based on a general theory that forbs with low, spreading growth forms are more efficient at retaining soil. However, exceptions are possible (maximillian sun-flower). The emphasis here is on the diversity of the genus (Helianthus) itself. The maximillian sunflower grows in columnar form and appears to offer little canopy. Despite this the maximillian sunflower has a well developed root system for holding the soil base. (This is where the numbers and closeness of plants might make a difference.) This rating system attempts to rate in terms of direct topsoil disturbance and wash (from runoff). Though some plants may exhibit some of the characteristics desirable to prevent soil loss (Figure 16) species that exhibit all or most are assigned the highest

Figure 16. Flow chart illustrating criteria and rating system.


Composition Desirability Index (CDI)
Assign values from 50 to 10
Taken from Flinthills Range Condition scorecard
Add intergrades (see scorecard)
Relative Plant Erosion Deterrence Value (RPEDV)
Assign appropriate value
Type of plant
Morphological character
Grass
Forb
Woody
10 or 8
6 or 4
2 or 0
A B A B A B
Above ground
Below ground
(A) Low spreading growth
(B) Tall columnar growth
(A) Stolon/ rhizomes present
(B) Lacks stolon/ rhizomes
Basal cover
Aggregations
(A) Broad
(B) Not broad
(A) Present
(B) Not present
Use (A) and (B) characteristics for grass, forb and woody plants
CDI plus RPEDV equals PDI
(Add together to get Plant Desirability Index) (PDI)
(GO TO NEXT PAGE)

Multiply PDI times the Total Number of Samples (T#S) from survey. (T#S is actually the summation of the number of plants relative to their PDI value)

↓

The result is the Multiple Plant Desirability Index (MPDI)

↓

Summation of MPDI

↓

The result is the Accumulative Plant Desirability Index (APDI)

↓

Divide the APDI by the watershed size (WSS) or DS)

↓

The result is the TWPEDI which is used in the watershed scorecard for Lyon County rating.

Woody species are also categorized by their growth form and ability to prevent soil loss. For example, a locust or Osage orange tree offering little or no canopy or runoff/wash deterrability is assigned a "0", because of average distance from ground to leaves and its root system. "Buckbrush" or "wild rose" is assigned a 2 rating due to their "ground covering" growth compared to trees. Low growth forms of brushy vegetation are also found in aggregates whereas trees may lack this pattern.

In order to relate the "RPEDV" to range condition, a composition desirability index (CDI) in production and nutrition was established for each plant species (Table 6.) Part of this was developed from the "Flint Hills Range Condition Scorecard" list and intergrades were developed for those plants which were questionable (Appendix A). This index is as follows: Desirable plants receive a 50, intergrades (those rated in between intermediate and desirable i.e., percentages of little bluestem) receive a 40, intermediate rated plants receive a 30, a 20 was given to the lower intermediate and a 10 was assigned to a least desirable plant.

Using the RPEDV values and the CDI, another index is established; the "plant desirability index" (PDI) (Table 7). This index is the sum of the RPEDV and CDI which not only theorizes the desirability from a nutritional and production standpoint, it also demonstrates the presence of soil stability according to species composition and individual soil deterrent potential. (Appendix B contains PDI values for most watersheds studied.)

On the grounds that study area and sample sizes differed (some drastically), an "accumulative plant desirability index" (APDI) was

Table 6. Derivation of the Composition Desirability Index (PDI). (Taken from "Flinthills Range Condition Scorecard) (partially from Wilk 1984).

Category	Rating	Explanation or example
Desirable	50	Big four (see field data)
*Intergrade	40	Percentage rated plants
Intermediate	30	Nonpercentage rated plants
*Intergrade	20	Percentage rated plants
Least desire	10	Poor nutrition, grazing response and competition with desirables

* Those plants which are rated according to percentages including sideoats gramma, little bluestem and wild rose.

Table 7. Plant desirability indexes for some "tallgrass prairie species".

SPECIES	CDI	+	RPEDV	=	PDI
(Grasses)					
*Big bluestem	50		10		60
Little bluestem	40		8		48
*Prairie cordgrass	50		10		60
*Western wheatgrass	30		10		40
*Bluegrass	10		10		20
Johnson grass	10		10		20
(Forbs)					
*Lead plant	40		6		46
Maximillian sunflower	40		4		44
*Ironweed	10		4		14
Broomweed	10		6		16
(Woody)					
Red cedar	10		2		12
Honey locust	10		0		10

1) CDI - Composition Desirability Index

2) RPEDV - Relative Plant Erosion Deterrence Value

3) Plant Desirability Index

* Samples tested for soil protection capabilities (Weaver and Kramer 1934)

deemed necessary. The APDI was the sum of "multiple plant desirability" indexes. From field data sheets species sampled were categorized by their PDI and their numbers recorded (from step-loop survey). There may be one or several plants in each PDI; due to inconsistencies in composition PDI values may vary or be missing among watershed.

The product of the number of plants and their respective PDI accounted for all of the species sampled. In addition, the accumulated total of all of the plants for a given watershed was noted. For example, all plants that had a PDI of 60 were counted and the number of plants sampled (from step-loop survey) in the watershed was multipled times the PDI value of 60. In one watershed, three plants were given a 60 PDI rating. If the total number of plants was 364, the "multiple plant desirability index" (MPDI) would be the product or 21,840. Each specie or species frequency and its respective PDI was multiplied as above. The products (MPDIs) are added and their sums recorded as the accumulative plant desirability index" (APDI) value.

Because the entire watershed was being studied, a total erosion deterrence value had to be determined for individual watersheds. The "total watershed plant erosion deterrence index" (TWPEDI) attempts to quantify the erosion deterrent potential through the plant survey, evaluations and rating systems. Utilizing all the fore-mentioned data and calculations, the TWPEDI was calculated. Calculations relative to each watershed were obtained by dividing the APDI by the watershed size (WSS). (The equation, its derivation and definition of terms are in Table 8.) The TWPEDI value was added to the scorecard.

Summarizing the Watershed Scorecard

The watershed scorcard utilizes a management/conservation practices factor (MCPF) rating; adding or subtracting according to factors evaluated. Such factors include fencing, congregating areas and their locations, burning management and erosion areas, in addition to other related factors. This rating appears to demonstrate a need for limited management changes or total mismanagement. This rating is added into the scorecard's WCRV.

The relative erosion potential factor (REPF) of each watershed is also a part of the scorecard. This factor uses the Universal Soil Loss Equation (USLE) and a "modified" version of it, the Watershed Soil Loss Equation... (WSLE Ly17) to estimate and factor current soil loss (EFCSL) over the entire watershed. Percentages of soil types and their slopes were evaluated from SCS soil survey information. Then the amount of eroded land was estimated by projecting an aerial photograph of a given watershed, down on sketch paper. The areas which were obviously eroded were outlined (some areas were observed in the field and also sketched). The outlined areas were planimetered, measurements converted and percentages calculated. An evaluation of plants sampled in each area was accomplished (from field data and APDI sheets -- Appendix B). Counting perennials only, excluding litter and bare ground hits, a percentage of ground cover was extrapolated from the SCS "cover factor sheet." A "c" factor for "bare ground" (0.45) and a variable c factor for remaining grund cover was estimated separately (Figure 15). Percentages of soil types and their respective slopes' percentages were multiplied then the mean percentage calculated. This value represented the slope percent. The slope length was estimated by studying maps and field observations. Soil erodibility (T/K) values for eroded (% e) and covered (% c) areas were estimated separately. This was done by finding the mean of all the T/K for the soil types found in the respective situations (% e and % c) separately. The rainfall factor was a constant 225 in this study. Separately, a MTSL (mean tolerable soil loss) value was calculated by multiplying the soil type TSL (SCS) by their respective percentages present in the watershed. This was done for both % e and % c.

The WSLE Ly17 was then used to calculate the estimated factored current soil loss (EFCSL). The CSL for % e (from aerial photographs) and % c were calculated using the SCS - USLE slide-rule calculator. These were termed the CSL(B) and CSL(C). Products of the CSL(B) % e and CSL(C) % c were added resulting in the EFCSL. This value, expressed in tons per acre, was compared to the MTSL of the entire watershed. If the EFCSL was greater than the MTSL value, the REPF received a low rating. In contrast, if the EFCSL was less than the MTSL value, a high rating was given to the REPF.

The scorecard also uses a "total watershed plant erosion deterrence index", developed by assigning an even numbered 10-0 rating to each plant relative plant erosion deterrence value (RPEDV). Based partly on the tallgrass prairie scorecard, each plant receives a multiple of 10 value from 50 to 10. Plants are rated from desirable (50) to least desirable (10) or its "composition desirability index" (CDI). The CDI was then multiplied by the RPEDV to calculate the "plant desirability index" (PCI). (The process of combining the production-oriented index (CDI) with the erosion deterrence value (RPEDV), allows a thorough investigation into the association of production and conservation.) The PDI was multiplied by the "respective number sampled" for each PDI. This product is the "multiple plant desirability index" (MPDI). The sum of the MPDI values are termed the accumulative plant desirability index (APDI) and accounts for the entire watershed (according to transects sampled). The APDI was multiplied by the "total number sampled" and the products divided by the watershed size. The quotient is the TWPEDI.

(The range condition and ground cover index was also rated for each watershed using the same scale as the TWPEDI.)

Upon completion of all the factor and index calculations, their values were added and the sum put into the WCRV rating scale (Figure 10).

<u>The Categorized Method</u>

As a result of the variability of watershed size and total number of samples taken, a categorized approach was deemed necessary. (This method involved using different total number of samples (T#S) categories.)

Statistical analyses were calculated for the relationship between several factors of the watershed condition scorecard and other variables. Sediment yield (SY1) and watershed condition rating using the total number of samples (T#S) rating; (I, II, III) categories. (Sediment yield was not used in the watershed scorecard rating or WCRV.) Categories I, II, III represent the T#S 295-715, 744-1146, 1468-2969 respectively. Table 9 shows the rating scale for the TWPEDI values respective to their T#S categories.

<u>Sediment Deposition Survey</u>

Sampling began August 21 and extended through September 21, 1983. In most study areas, water in the deposition area had receded. Accessible areas were sampled by means of a simple, probe apparatus. Its design originated from that of the hydraulic core sampler used by SCS soil scientists. This approach appears not to have been tried before in Lyon County.

Table 9. Rating scale for TWPEDI for 17 Lyon County watersheds (by category).

	I	II	III
EXCEL.	900.8 - 1126 +	1699.6 - 2124.5 +	1523.3 - 1904.1+
GOOD +	889.6 - 900.7	1678.4 - 1699.5	1504.3 - 1523.2
GOOD	664.3 - 889.5	1253.4 - 1678.3	1123.4 - 1504.2
FAIR +	653.2 - 664.2	1232.3 - 1253.3	1104.5 - 1123.3
FAIR	427.9 - 653.1	807.3 - 1232.2	723.6 - 1104.4
POOR +	416.7 - 427.8	786.1 - 807.2	704.4 - 723.5
POOR	191.4 - 416.6	361.2 - 786.0	323.7 - 704.5
V.P.	180.3 - 191.3*	340.0 - 361.1*	304.6 - 323.6*
SELL IT	0 - 180.2	0 - 339.9	0 - 304.7

I is for T#S from 295 to 715

II is for T#S from 744 to 1146

III is for T#S from 1468 to 2968

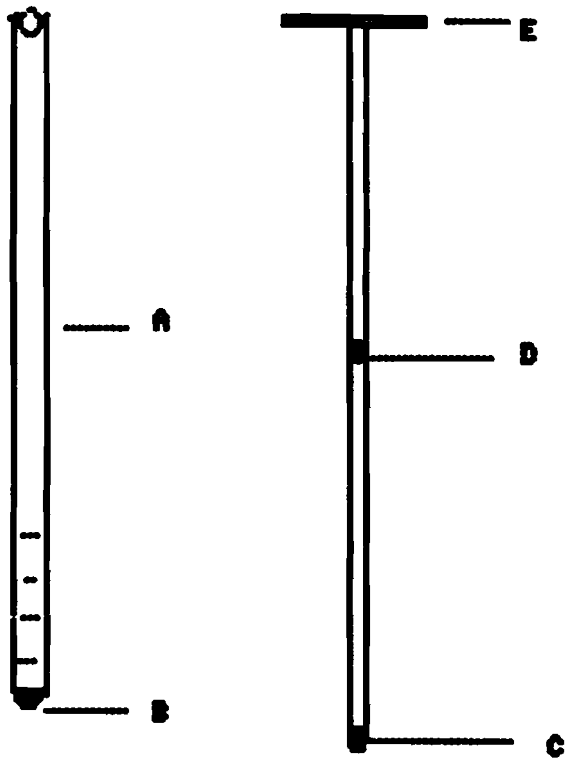
* worst possible for that category

Apparently, probing is acceptable if used in addition to other sediment sampling methods. A sedimentation study, on the Black Creek watershed in Indiana, used both a fathometer and probe (EPA 1977). Most sediment sampling methods found in the literature, utilized a sediment trap. This method is more accurate than the "probe" method used in this study. However, the sediment trap had some disadvantages. The trap method involved "construction"; meaning some time consumption and costs were inevitable. Another problem is the seasonal restrictions. During the grazing season, protection was necessary if the pond lacked fencing. Cattle grazing can hamper sampling or damage the trap. The probe method may be favored despite of its poor accuracy. Perhaps, in a practical sense, the probe method's advantages may overshadow its lack of accuracy. One advantage is its apparent suitability to the climate in Lyon County. Ordinarily, the rainfall pattern appears to be one of wet springs and hot, dry summers. Pond levels probably fluctuate the most in these times due to the variation in the rates of runoff and evaporation. Sampling times may be limited for this reason. The probe method, being faster than the sediment trap, may therefore be more useful. Another advantage is the flexibility of the probe. It might be used to sample the pond periphery, possibly giving a better idea of the sedimentation source. More information about the advantages and uses are discussed in the Results and Discussion part of this paper.

Probe Design and Sampling Procedure

The probe design (Figure 17) consisted of a six foot acrylic plastic tube approximately 2 inches in diameter. Notches were cut to create a "sediment piercing" effect in the end of the tube. A wooden

Figure 17. Two part sampling probe design. The letters A, B, D and E represent the acrylic tube, sediment piercing end, leather gromet and screw, "push-rod" assembly and handle respectively.


E
A
D
B
C

rod with a handle and a round piece of leather bolted to the end completed the "drive-rod" assembly. The wet leather expanded, creating a vaccuum.

The tube was pushed down into the sediment deposition area (inflow area/s) basin. This was roughly the bottom of the sample area. The rod was then inserted and pressed through the tube until the pressure was felt on the top end of the rod. When a sufficient amount of internal pressure was built up enough to move the rod upward, the rod was pulled back through the tube until the bottom sediment layer was dislodged. The suction created held the sediment until the probe was removed and held over a container. The rod was pushed through the tube, forcing the sediment into the container.

A total of ten subsamples were taken in each study area deposition site. Several study areas had more than one deposition site. In this situation, each site was sampled and the mean recorded.

Each sediment sample was marked for identification, partially dried outdoors and finally dried in a microwave oven. When completely dried, the sediment "bars" were ground in an electric grinder with a 2-1/2 inch auger bit and #6 grind plate (the #6 refers to the amount and number of grooves in the plate which designates the degree of grinding, i.e., fine or coarse). These weights were divided by the area and again by the pond age to give an estimated sediment yield. A correlation of ground cover and range condition with sediment yield for the study areas was attempted.

Since several soil types were present in the watersheds, they would likely effect the sediment composition. The Black Creek sediment study used a particle size test to aid in source identification (EPA 1977). It was thought that the establishment of a particle size test, (i.e., percentage of sand, silt and clay) might give some insight of the origin of the sediment. Therefore, if the origin of deposition was determined and the soil profile was known, a rough estimate of soil loss might be possible. The "Bouycous" test was utilized for particle size analysis (Foth et al 1980).

The Bouycous Test

Because it was difficult to identify soil type of the sediment, a particle size analysis was used. The Bouycous test used a hydrometer, in a cylinder of solution, to measure specific gravity of particles. Two hydrometer readings were taken. Sand is the largest of the particles, therefore it is the first to settle. On the basis that sand settles first, the second reading was the clay and silt reading. The weight of sand was then calculated (Foth et al 1980).

In order to classify the soil, a texture triangle (Foth et al 1980) was used and the results of the "Bouycous test" converted to percentages of sand, silt and clay. The study areas were grouped by their soil classes in an attempt to compare sample areas. (Appendix A contains all of the study area information including soil type and physical characteristics.)

Sediment Yield from the Entire Watershed (SY1)

The total grams sampled were divided by the size of the entire watershed and then by the age of the site. This would give grams per hectare per year or g/ha/y. Sediment yield from the entire watershed was termed SY1. Table 10 shows all of the above factors. In situations where more than one deposition site (sample areas) was present, the mean of the sites were used. Several statistical analysis were used including T-test, analysis of variance, boundary line analysis and

Table 10. Summary of sediment yield and range sampling data.

WS#	1 R/C % = Rat.	2 GCI % = Rat.	3 PA Yrs.	4 DS Hect.	5 Sed. Sam Grams	6 SA. #	7 SY1 G/Ha/Y
1	83-E	72-G	37-1=36	14.3	576.45	1	1.12
2	85-E	87-E	57-1=56	16.5	751.60	1	1.82
3	52-F	64-G*	8-1=7	15.1	780.90	1	7.40
4	72-E	92-E	37-1=36	6.4	854.45	1	3.70
5	46-G	84-G	28-1=27	10.9	m(605.35)	2	2.06
6	56-G	90-E*	13-1=12	11.3	m(609.18)	2	4.40
7	40-G	90-E	28-1=27	16.4	540.00	1	1.21
8	35-G	94-E*	37-1=36	8.1	412.40	1	1.41
9	53-G	93-E	10-1=9	8.5	m(319.30)	2	4.17
10	20-F	93-E	18-1=17	18.4	551.90	1	1.76
11	51-G	94-E	8-1=7	6.3	224.80	1	5.00
12	37-G	84-G	25-1=24	10.6	743.50	1	2.97
13	87-E	85-E	13-1=12	39.6	m(623.13)	2	1.31
14	14-P	95-E	12-1=11	5.4	479.50	1	8.07
15	86-E	88-E	27-1=26	36.9	m(565.35)	3	0.59
16	61-G	87-E	9-1=8	13.6	911.41	1	8.38
17	64-G	87-E	37-1=36	14.1	856.25	1	1.68

1) R/C - Range condition, E-Excellent, G-Good, F-Fair, P-Poor.
2) GCI - Ground cover index (see range condition).
3) PA - Pond age (subtracting one from the original) accounts for differences in sampling times).
4) DS - Drainage size in hectares.
5) Total sediment sampled in survey (in cases where more than one deposition area means were used).
6) SA - Number of deposition areas sampled.
7) SY1 - Sediment yield from the entire watershed.

correlation with multiple regression. These analyses involved factors of the watershed scorecard which will be discussed later.

Sediment Yield from Eroded Watershed (SY2)

As research progressed, it became evident that sediment yield from the entire watershed and the eroded portions were probably different. The sediment yield from eroded watersheds was termed the "SY2O" value. This sediment yield value was calculated by multiplying watershed size (WSS) by the percentage of eroded watershed (% e) which equalled hectares eroded (HaE). The total grams sampled (TGS) was divided by hectares eroded then divided by the age of the pond site (PA). The equation was as follows: WSS X % e = HaE ... TGX/HaE/PA = SY2. Table 11 shows all (except for watershed size) of the above values for each watershed.

Within sampled watershed data, as the percentage of eroded area increased, the amount of sediment yield (g/ha/y) decreased and as the percentage of eroded area decreased, the sediment yield increased because a larger number was used in the operation. The larger the dividend value used in the formula, the smaller the quotient. For example, the SY1 and SY2 values for C-14 were 8.07 and 1,090 g/ha/y respectively (Table 12). The eroded area was 0.7 % of the entire watershed. However, watershed J-1 had 34.3 % eroded watershed. Its SY1 and SY2 values were 1.12 and 3.27 g/ha/y respectively.

Testing the WSLE Ly17 (EFCSL values)

The WSLE Ly17 and its EFCSL values were compared to the sedi-ment yield (SY) values using the Modified Universal Soil Loss Equation (MUSLE) on Oklahoma and Texas watersheds (Smith et al 1984). Modifications including adjusting the conservation practices (P) factor rrelation with multiple regression. These analyses involved factors f the watershed scorecard which will be discussed later.

edIment Yield from Eroded Watershed (SY2)

As research progressed, it became evident that sediment yield from the entire watershed and the eroded portions were probably different. The sediment yield from eroded watersheds was termed the "SY20" value. This sediment yield value was calculated by multiplying watershed size (WSS) by the percentage of eroded watershed (% e) which equalled hectares eroded (HaE). The total grams sampled (TGS) was divided by hectares eroded then divided by the age of the pond site (PA). The equation was as follows: WSS X % e = HaE ... TGX/HaE/PA = SY2. Table 11 shows all (except for watershed size) of the above values for each watershed.

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Table 11. Sediment yield for eroded areas of watersheds (SY2 = ...1) DS X % EW = HaE...2) TGS/HaE/PA.)

#	1 AE %	2 HaE	3 PA Yrs.	4 EW %	5 Sed. Sam. TGS	6 SA. #	7 SY2 G/Ha/Y
1	11.0	4.9	37-1=36	34.3	576.45	1	3.27
2	1.1	.2	57-1=56	.9	751.45	1	67.10
3	14.0	5.8	8-1=7	37.9	780.90	1	19.23
4	1.3	.5	37-1=36	8.8	854.45	1	47.46
5	2.6	1.1	28-1=27	10.1	m(605.35)	2	20.38
6	3.5	1.4	13-1=12	12.4	m(609.18)	2	36.26
7	9.9	4.1	28-1=27	25.0	540.00	1	4.87
8	14.6	6.0	37-1=36	74.0	412.20	1	1.90
9	1.2	.5	10-1=9	6.0	m(319.30	2	70.95
10	3.9	1.6	18-1=17	9.0	551.90	1	20.29
11	.3	.09	8-1=7	1.5	224.80	1	356.98
12	3.1	1.3	25-1=24	12.5	743.50	1	23.83
13	9.9	4.1	13-1=12	10.4	m(623.13)	2	12.67
14	.1	.04	12-1=11	.7	479.50	1	1,090.00
15	13.0	5.4	27-1=26	14.6	m(565.35)	3	4.03
16	6.0	2.5	9-1=8	18.4	911.41	1	45.57
17	9.1	3.8	37-1=36	36.2	856.25	1	6.26

1) AE - Area eroded in acres*
2) HaE - Area eroded in hectares*
3) PA - Pond age (subtracting one from the original age accounts for differences in sampling times)
4) EW - Eroded watershed*
5) Total sediment sampled in survey (in cases where more than one deposition area means were used (TGS)
6) SA - Number of deposition areas sampled
7) SY2 - Sediment yield in grams per hectare per year from eroded areas only.

(Note: * indicates aerial photographs were used in estimations...see Methods and Materials)

Table 12. Factors which were important in the analysis of this watershed study.

WS#	1 R/C percent	2 GCI percent	3 MCPF (- or +)	4 SER (- or +)	5 T..I (	6 WV +/-	7 % EW)	8 PA yrs.	9 DS ha.	10 SY1 (gr/ha/yr)	11 SY2 (gr/ha/yr)
1	83	72	1	- 8	5	14	34.3	36	14.3	1.12	3.27
2	85	87	12	0	7	37	.9	56	16.5	1.82	67.10
3	52	64	- 5	-11	5	1	37.9	7	15.1	7.40	19.23
4	72	92	7	- 1	9	33	8.8	36	6.4	3.70	47.46
5	46	84	2	- 3	5	18	10.1	27	10.9	2.06	20.38
6	56	90	1	- 4	5	18	12.4	12	11.3	4.40	36.26
7	40	90	2	0	7	25	25.0	27	16.4	1.21	4.87
8	35	94	4	-18	5	7	74.0	36	8.1	1.41	1.90
9	53	93	2	- 3	9	24	6.0	9	8.5	4.17	70.95
10	20	93	5	- 1	3	21	9.0	17	18.4	1.76	20.29
11	51	94	7	+ 1	9	33	1.5	7	6.3	5.00	356.98
12	37	84	1	- 7	7	15	12.5	24	10.4	2.97	23.83
13	87	85	7	- 5	5	25	10.4	12	39.6	1.31	12.67
14	14	95	8	+ 1	9	30	.7	11	5.4	8.07	10.90
15	86	88	3	- 4	7	24	14.6	26	36.9	0.59	4.03
16	61	87	2	- 3	5	20	18.4	8	13.6	8.38	45.57
17	64	77	1	- 8	5	14	36.2	36	14.1	1.68	6.26

1) R/C - Range condition taken from step-loop survey
2) GCI - Ground cover index taken from step-loop survey
3) MCPF - is the management and conservation practices application on the watersheds.
4) SER - is the value of the soil erodibility rating (or the opposite of the EFCSL).
5) TWPEDI - is the total watershed plant erosion deterrence index.
6) WV - is the watershed condition rating value from the watershed scorecard.
7) % EW - are percentages of watershed eroded (from aerial photo).
8) PA - are pond ages (1 yr. was subtracted which accounts for all complete sediment periods).
9) DS - is the drainage size of the watersheds.
10) SY1 - is the sediment yield of the total watershed (grams/hectare/year).
11) SY2 - Represents the sediment yield of the eroded areas only. (Table 11).

of the MUSLE by substituting an adjusted MCPF and dividing EFCSL by pond age (PA) values were accomplished to allow comparisons within the sampled watershed data. It was hoped that these modifications might also make comparisons of other studies possible.

RESULTS AND DISCUSSION

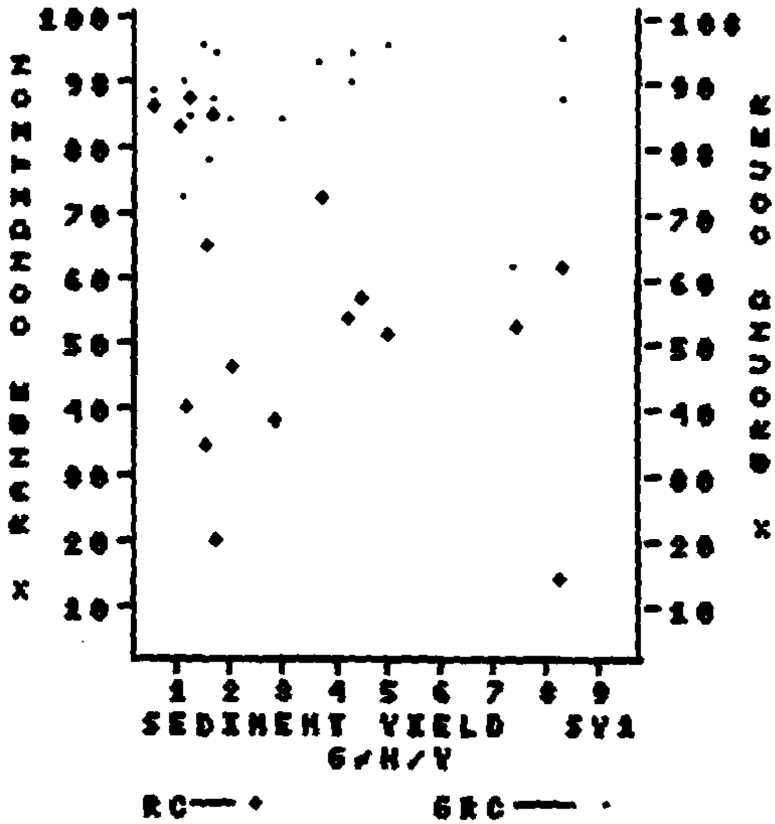
The General Hypothesis and Results

This study focused on the long-term effects of watershed management upon watershed productivity and ecology. It began with a hypothesis that a relationship between sediment yield and range condition/ground cover could be measured. Preliminary results illustrated that collected data was not sufficient to support the hypothesis of a measurable relationship between sediment yield and range condition/ground cover evaluations.

Rhoades et al (1975) measured sediment yield from different watersheds including rangeland and cropland. Although no sampling method was mentioned it is assumed that the widely accepted "SCS clip-plot" method was used (excluding cropland). The study demonstrated features of sediment yield from watersheds including differences between sediment yield from watersheds including differences between sediment yield from "good to excellent" and "fair to poor" conditioned rangeland. Some specific sediment yield measurements were taken on an eroded (rilled and gullied) watershed. A guaging station was placed at the overfall to accurately measure sediment from the gully.

In my study, the calculated correlation between sediment yield and range condition/ground cover was negative and nonsignificant (r value for RC and GCI were -0.333 and -0.021 respectively with 14 df r = 0.497). Assuming the sediment yield values were accurate, there was no significant correlation between sediment yield and range condition/ground cover. A scatter diagram (Figure 18) illustrates the little regression in the relationship of range condition (RC) and ground cover (GCI) vs. sediment yield (SY1) values for all 17 study areas. However, in a study in Utah, the effect of watershed condition on rainstorm

Figure 18. A scatter diagram of range condition (RC) and ground cover vs. sediment yield (SY1)... ($r = -0.33$ which was not significant; $p < 0.05$).


SEDIMENT YIELD SY1
G/H/Y
RC
GRC

runoff and erosion in terms of ground cover was investigated. Good ground cover resulted in runoff of 2 % of the rainfall and .05 tons per acre. As ground cover decreased runoff percentage of rainfall and soil loss increased as can be seen in Figure 19 (Branson et al 1981). It is difficult to compare my results due to regional differences. (Note that in my study all GCI values were greater than 60 % which was rated good in Branson's study.)

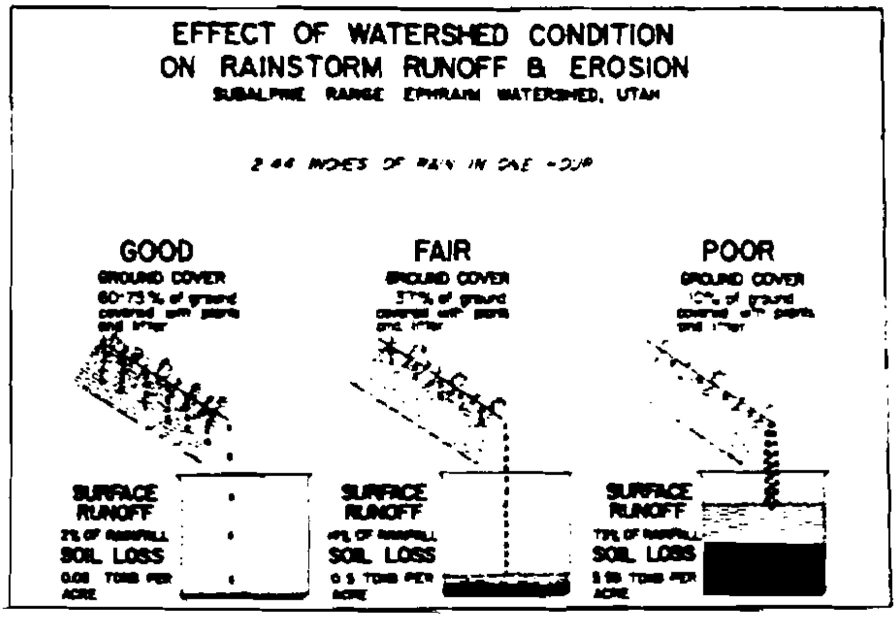
Range Condition and Ground Cover Sampling Results

Range condition and ground cover results are probably the least complex of all the criteria of the watershed scorecard. Both were sampled similarly (step-loop). However, they indicate quite different characteristics of evaluation.

Range condition evaluation emphasizes forage and ecological niche, i.e., climatic conditions, response to grazing pressure (i.e., increasers/decreasers) and climax. In addition, the physical characteristics including height, weight (vigor), nutritional value and overall interactions within the plant communities (response to chemical or hormonal inhibitors) are recognized. All of these components are important when evaluating the "condition" of grazing lands in production.

When considering long term production (stability), ecological characters must also be observed and evaluated. This evaluation is termed "ground cover index." It aids in identification and rating overall soil stability. Soil stability effects numerous physical and chemical perameters including available water capacity, infiltration, absorption and fertility as well as a base for root and plant growth. Chemical characters provide a nutrient base, a location for reactions

Figure 19. Effects of various densities of ground cover in controlling overland flow and soil erosion (from Bailey and Copeland 1961; Branson et al 1981).


EFFECT OF WATERSHED CONDITION
ON RAINSTORM RUNOFF & EROSION
SUBALPINE RANGE EPHRAIM WATERSHED, UTAH
GOOD
GROUND COVER
FAIR
GROUND COVER
POOR
GROUND COVER
SURFACE RUNOFF
SOIL LOSS
SURFACE RUNOFF
SOIL LOSS
SURFACE RUNOFF
SOIL LOSS

and interactions (carbon fixation...adsorption...aeration) among other beneficial purposes. Therefore, a general ecological observation may be made by examining soil stability.

It may be illogical or impractical to assume soil stability is the necessary evaluation needed. However, it may be logical and practical to use soil stability as an indicator of overall watershed/range trend.

Ground cover is an indication of stability. Excessive trampling effects soil stability. Reynolds and Packer (1962) describe an "unconfounded study using a 'mechanical' hoof on the end of a weighted bar to trample wheatgrass and cheatgrass. With ground cover up to 40 %, trampling reduced ground cover and increased size of bare soil openings. With ground cover of 90 to 95 %, none of the trampling treatments reduced ground cover less than 70 % (an acceptable level for this site), nor increased bare soil openings beyond maximum acceptable distances for the site (more than 4 inches on wheatgrass sites or more than 2 inches on cheatgrass sites). With 80 to 85 % ground cover, trampling disturbance of 40 % or more reduced ground cover and increased bare spaces beyond acceptable levels for the site. At 70 to 75 % ground cover, all but the 10 % trampling disturbance altered ground cover and bare opening conditions beyond acceptable levels for the site." Although Reynolds and Packer's study was unconfounded, it appears to illustrate the significance of ground cover in grazed systems where trampling is inevitable.

<u>Sediment Yield Sampling - The Entire Watershed</u>

The probe method used in this study exhibited both positive and negative qualities. It was relatively simple and inexpensive to build. The probe was easy to maintain and clean. It was quick and easily used. However, it lacked accuracy.

Sediment yields are usually measured in tons per square mile per year (Holland 1971) or kilograms per hectare per year (Smith et al 1984). Due to the sampling method used in this study, results of the sediment sampling were recorded in grams per hectare per year (g/h/y). Total grams sampled (TGS) ranged from 225 to 912 grams. Sediment yields ranged from 0.59 to 8.38 with a mean of 3.36 g/h/y (Figure 20).

Several factors were responsible for the probe method's inefficiency. First of all, it appears that sampling was insufficient (ten on each area). Ponds ranged from seven to 56 years old. Watersheds G-12 and L-3 had been renovated several times. Apparently, sediment yield should have been much higher from lack of conservation methods (i.e., pond fencing). Watershed N-2 was 56 years old and had two inflow areas. It was obvious from aerial photographs of 1984 (Figure 21) and field observations, sedimentation had already filled in approximately one-eighth of the original pond in one of those areas. Wetland vegetation (rushes and sedges) were well established in this area making sampling impossible.

Secondly, the correct pattern of sampling was hard to achieve. Each deposition area had its own shape. Sampling patterns in some areas were not practical in others. Sampling was supposed to be done in the bottom basin, rock and other debris sometimes made it difficult to sample (Figure 22). In addition, sample size may have been inadequate (10 on each area).

Pond levels were also a problem. Watersheds had different topographic characteristics and management patterns. C-14 was spring fed, B-11 was not grazed and had much more vegetation in the sampling area than any of the others. Some ponds had higher storage capacities and

Figure 20. Bar chart showing results of sediment studies for entire watersheds (SY1).

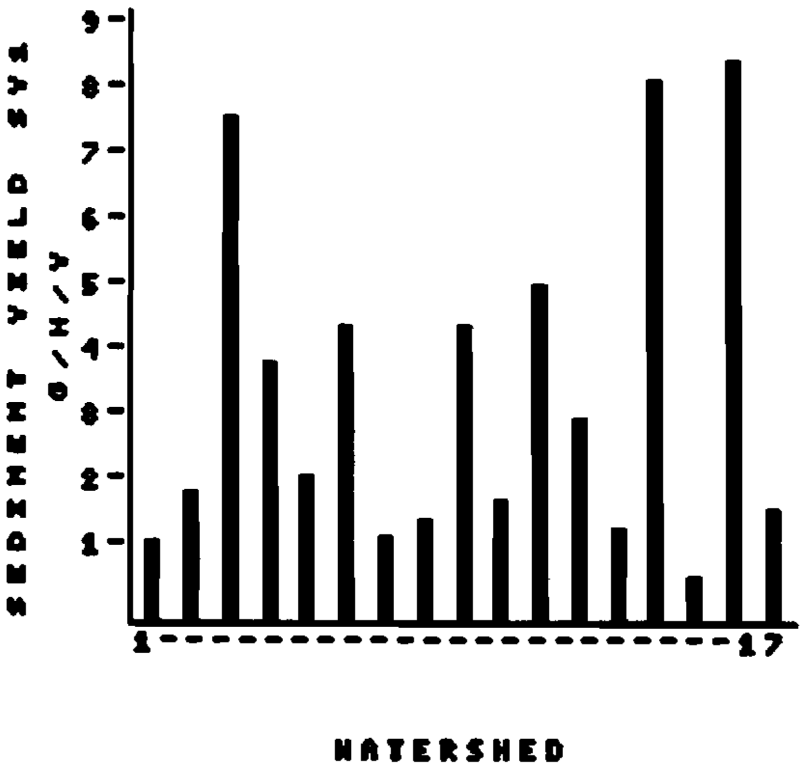

SEDIMENT YIELD SYS
G/M/Y
9
8
7
6
5
4
3
2
1
1
17
WATERSHED

Figure 21. Aerial photograph of watershed N-2 (center right).

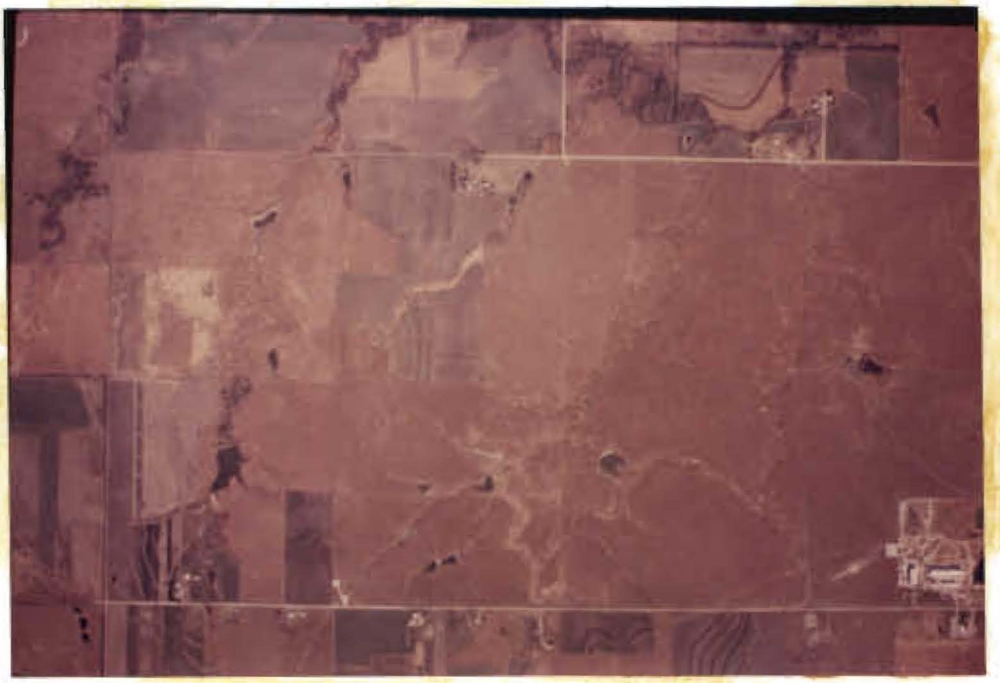


Figure 22. Ground view of filled in area on watershed N-2.

multiple deposition areas. Five out of 17 watersheds had multiple sampling areas. One of those (P-15) had three sampling areas (Figure 23). In addition, Q-13 had a sediment pond in one of the draws which may have reduced sedminention of the main body of the lake.

The Black Creek Report demonstrated the effectiveness of a sediment pond in trapping sediment (EPA 1977).

Evaluation of the Sediment Probe

From the results, it is evident that the probe, as a "sediment yield" sampling device, had no validity in this research (unless a reasonable sampling pattern is achieved). It appears it could be used for sediment sampling for particle size or other non-quantitative analysis. It needs to be tested in controlled areas. Comparable watersheds and situations would apparently make a difference. A compariosn between reservoir traps and the probe might help solve some of the problems encountered.

With all the negative aspects of the probe's design and scientific use, it's nonscientific use must be recognized. The landowner could use the probe to monitor bank silt (away from the inflow area). If incremented, the probe might also be placed in the pond each spring before the rains and to be read after the water had receded in dry periods. This would be a rough estimate, however it could demonstrate the sedimentation rate each month or year if monitored closely. Most landowners could operate the probe easily and educate themselves on their watersheds simultaneously.

The unexpected results of the sediment yield study led to the watershed scorecard. It was evident that range condition and ground cover were not the only factors related to the sedimentation of a pond.

Figure 23. Aerial view of watershed P-15 (lower right).

The unacceptable results demonstrated a need to attempt to identify factors. Partial reasoning why a particular pond's sediment yield was higher than the others appeared to be in the factors identified in the scorecard.

It was difficult to analyze all the factors related. An attempt was made to correlate sediment yield (SY1) with each scorecard factor. This proved to be insufficient. The r values were low (referred to earlier in Results and Discussion). This and other statistical analyses will be discussed later.

Sediment Yield Sampling - Eroded Watershed

Although the sampling method was unacceptable, another treatment was analyzed. It involved analyzing sediment yield data using the % EW (from aerial photographs described in Methods and Materials) value or "SY2". This was assuming that the majority of sediment was from the percentage of eroded watershed areas (Figure 24). The results are found in Table 14. SY2 values ranged from 1.90 to 1,089.77 and the mean was 107.695 g/h/y.

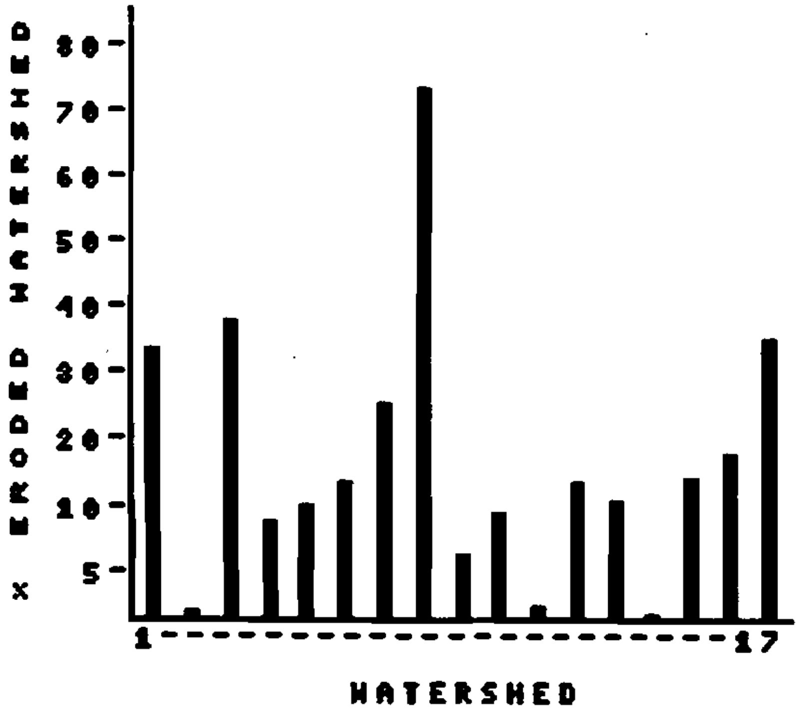
A T-test tested the significance of difference between means using SY1 and SY2 values. There was no 1.90 to 1,089.77 and the mean was 107.695 g/h/y.

A T-test tested the significance of difference between means using SY1 and SY2 values. There was no significant difference ($p < 0.05$).

An F-test analyzed the variance. There was a significant difference ($p > 0.05$).

The SY2 was calculated by multiplying % EW value times the total watershed size (WS) equalling the hectares eroded (HE). The total grams sampled (TGS) was divided by the HE value. The quotient was

Figure 24. Bar chart showing results of percent of eroded watershed (% EW).


% ERODED WATERSHED
80
70
60
50
40
30
20
10
5
1
17
WATERSHED

divided by the pond age (PA).

It was evident that as the HE (or % EW) increased, SY2 decreased from SY1 values. Predictably, as the HE or % EW decreased SY2 increased from SY1 values (Figure 25). The standard deviation for SY1 and SY2 were 2.538 and 266.348 respectively. The difference between standard deviation for the two values for 17 watersheds was approximately 264. The difference between SY1 and SY2 (SY1-SY2) values ranged from 0.49 (E-8) to over 1,000 (C-14) g/h/y. The WCRV scores for these watersheds were poor and good respectively. This may indicate a relationship between WCRV ratings and (SY1-SY2) values. Those were the extremes. The mean of the differences was 105 with most being between two and 50 g/h/y. Further research might use a scoring factor for (SY1-SY2) values in the watershed scorecard results.

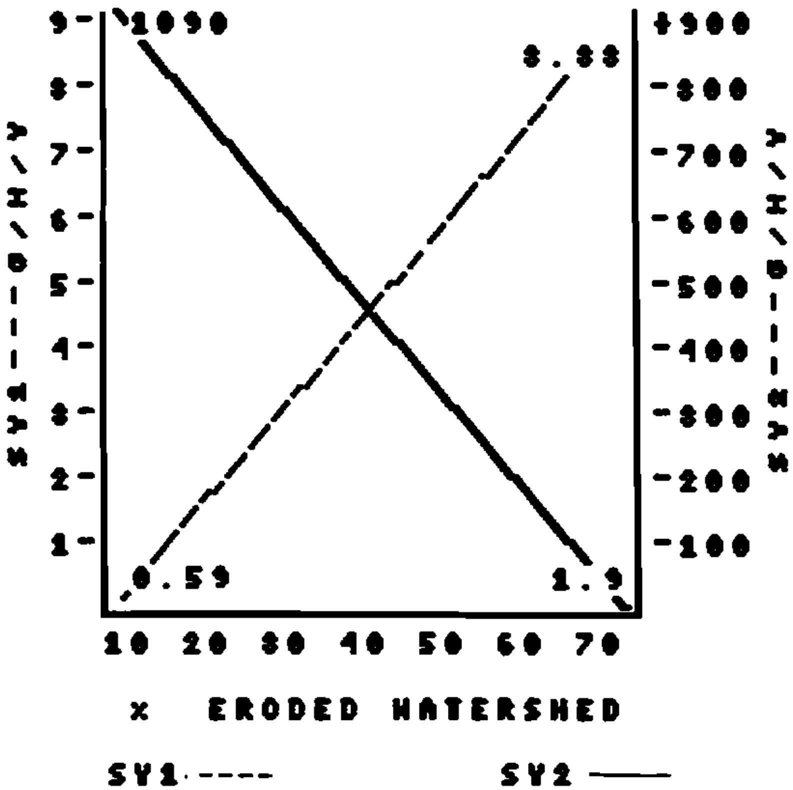
Watershed Condition Scorecard and Results

The scorecard used six factors related to watershed condition (similar to the Pacific Southwest Inter-Agency Committee PSIAC method) (Branson et al 1981). Included were previously mentioned range condition, ground cover index values, management and conservation practices, relative erosion potential (from physical and soil characteristics), and the total plant erosion deterrence index using individual and plant groups. Each will be treated separately. (The scorecards can be seen in Appendix C.)

The Management and Conservation Practices Factor

Several indicators of conservation or lack of conservation and management practices were rated for each watershed. These included congregating areas and proper fencing (evidence of cattle distribution management), pond use and fencing, trailing and gullying, overgrazed

Figure 25. Graph illustrating the inverse relationship between "gross" sediment yield (SY1) and eroded area sediment yield (SY2) vs. percent of eroded watershed.


9
8
7
6
5
4
3
2
1
1090
8.88
0.59
1.9
900
800
700
600
500
400
300
200
100
10 20 30 40 50 60 70
% ERODED WATERSHED
SY1 ----
SY2 ——

areas (evidence of lack of grazing distribution management), land use and burning. Each will be discussed separately.

Congregating Areas and Range Fencing

Congregating areas including salting, feeding or resting areas may be erosive sites. Cattle habitually travel to water from these congregating areas creating trails, gullys and effecting soil properties. A study by Knoll and Hopkins (1959) analyzed the effects of trampling and grazing on certain soil properties. Some of their results showed consistant trampling compacts the soil which decreases infiltration and increases runoff. Reynolds and Packer (1962) adds "...soil compation reduces water-storage capacity, lowers aeration, inhibits root penetration, and restricts activities of soil animals." The location of these areas are important in terms of soil stability and sedimentation. These erosive sites may be around the pond (if not fenced) or they may be away from the pond.

Those sites around the pond are most likely to be the major sediment yielding due to the proximity to the pond. Sites away from the pond may or may not be in a covered "draw". Sites in a sparsely covered draw could possibly contribute more sediment than the sites not in the draw. Theoretically, it is possible that more sediment can be "filtered" out by certain grasses in the draw. Bennett (1935) Weaver and Kramer (1934) and Schlechtl (1980) have studied the relation of grass cover to erosion control. It is probable that grasses used for erosion control do act as a filter.

The Photograph in Figure 26 shows a congregating area away from the pond and out of the draw on watershed N-2. The lack of erosive sites from these areas and covered draws give this ara a rating of + 5. In

Figure 26. Photograph showing the congregating area away from the pond and out of the draw on watershed N-2. (Notice trees on other side of slope. This designates the pond's perimeter. Runoff from congregating area goes away from pond.)

contrast, other photographs show congregating areas away from the pond/ in the draw (received + 4) and near the pond (Figure 27). Some study areas had congregating areas near the pond (excluding banks or dams), outside the drainage and therefore could not be rated down (Figure 28). Here is a question to be addressed. If the congregating/grazing areas are eroded and outside the drainage should it be considered in the rating? Since grazing distribution was not limited to the actual drainage, it will not effect the pond directly. In addition, grazing on the back of the dam could increase washout potential. In this study, it the congregating areas were outside the drainage, no consideration was given. Other situations were treated accordingly.

In addition, fencing was considered in this rating. In most cases, fencing created small grazable areas. Resting and rotational grazing are perhaps indicators of appropriate fencing development. However, most watersheds were grazed early intensively or deferred (several landowners returned their questionnaires explaining their management techniques and patterns). Most study areas received no score for "congregating areas...appropriate fencing" due to management practices.

Pond and Dam Fencing

Pond fencing was another practice which was rated. Ponds that were completely fenced received a + 4; if only the dam was fenced a - 2 was added. Two of the 17 study areas had adequate fencing of the pond and dam. One, O-16, only had the dam fenced (Figure 29). The best pond fencing was on the N-2 pond site. A photograph (Figure 30) illustrates the total exclusion of the pond and dam from cattle use. There was a tube through the dam leading to a watering trough. This area appeared to have little ground cover or soil stability.

Figure 27. Photograph illustrating congregating areas away from the pond; in the draw (I-6)

Figure 28. Photographs showing congregating area outside the drainage and therefore is not used in the rating on watershed C-14.

Figure 29. Photograph shows fenced dam on watershed 0-16.

Figure 30. Photograph of watershed N-2 illustrating total exclusion of cattle from pond and dam.


Pond fencing was possibly the most important practice in this sedimentation study. Several problems were associated with uncontrolled pond access. As cattle were allowed to trample and graze the pond perimeter (banks), the soil-holding vegetation was depleted. Photographs of two areas of the same pond illustrate the difference in disturbed and undisturbed pond shorelines (Figure 31 and 32). Pond waves and rainfall can erode the banks quickly resulting in decrease of overall productivity. Bank erosion may effect the pond in many ways including physical and limnological characters. Satterlund (1972) states: "Turbid water often reaches higher temperatures and has a lower dissolved oxygen content than clear water. The lower dissolved oxygen level derives from both the higher temperature and the biochemical oxygen demand of the organic fraction of the sediment."

Physically, as banks and dams eroded, the soil went directly into the pond and resulted in premature aging (filling in). Simultaneously, the pond surface area increased. With high evaporation rates, premature sedimentation and increasing surface area the pond's volume decreased. An increase in rainfall and runoff is needed to fill the pond and replace nutrients to the shoreline. Water level fluctuations increase productivity by flooding new areas. In addition, decaying vegetation can temporarily clear the water.

These characteristics were important in the ecological system. Without sampling, however, they may not be evident. Close (general) observations may reveal an overwhelming increase in aquatic vegetation from the decrease in depth if turbidity does not increase (Figures 33 and 34). Submergent and emergent vegetation may be desirable in larger bodies of water. However, in a small body of water, these may become a

Figure 31. Photograph showing pond usage on watershed L-3. (Notice uneven bank.)

Figure 32. Photograph of same pond as above where cattle were excluded. (Notice even banks.)

Figure 33. Photograph showing bank erosion on dam berm contributing to vegetation problem.

Figure 34. Photograph showing deposition area on watershed I-6. (Notice pond weed is beginning to establish itself.)

nuisance if not controlled. A decrease of vegetation can occur if turbidity increases. Every trophic level from predators (man, mammals, birds) down to the primary producers are effected in some way by turbidity and sedimentation. It appears that research of the relationships between turbidity and sediment was lacking in Lyon County ponds. However, Satterlund (1972) recognizes that "control of erosion and sedimentation will contribute to the solution of water quality problems in wildland management."

Most of the ponds were developed for cattle water supply and not recreational use. A decrease of the pond longevity can lower cattle production and health. In Lyon County, no study has been made of the effects of pond water quality on cattle production.

However, studies reveal that turbidity can increase surface temperature through insolation. Harmful bacterial growth, lower productivity and less palatibility is linked to pond water quality and cattle health. Absorbed ions on sediment may also contribute to excess nutrient salts and are often the means by which biocides are carried into the water (Satterlund 1972).

Cattle need a minimum of 30-40 liters of water per head per day, especially in the hot, windy summers (Stoddart et al 1975). In a controlled study, temperatures were raised to 21, 27 and 32 degrees centigrade. Milk cows consumed 6, 17 and 50 % more water respectively than when the temperature was 16 degrees centigrade (Stoddart et al 1975). Milk production partially depends on quantity and quality of water intake. Gains and milk production lessen as water consumption decreases. This will effect the health of the herd which is financially unbeneficial to the rancher. Another financial problem is pond maintenance. Dam repairs, dredging, and pond building have increased in cost in the last ten years. Cost sharing is only available on approved pond developments which improve grazing management. In the past this was not a requirement. All the problems just mentioned (and some not discussed) can be linked to uncontrolled pond use by herbivores. In addition, it can be beneficial to cattle dependent on it for growth and health. The ecological systems (pond/watershed) will benefit because well developed and managed ponds effect distribution and grazing patterns.

Trailing and Gullying

Trailing and gullying effect the watershed including the pond in several ways. Trailing caused by trampling compacts soil resulting in increased runoff. Results of trampling studies discussed earlier, showed the decrease of growth in eroded trails. In addition, on this certain study area, "cattle stopped using the trail when it had eroded to a depth of eight t 14 inches" (Knoll and Hopkins 1959). At this point they create another trail.

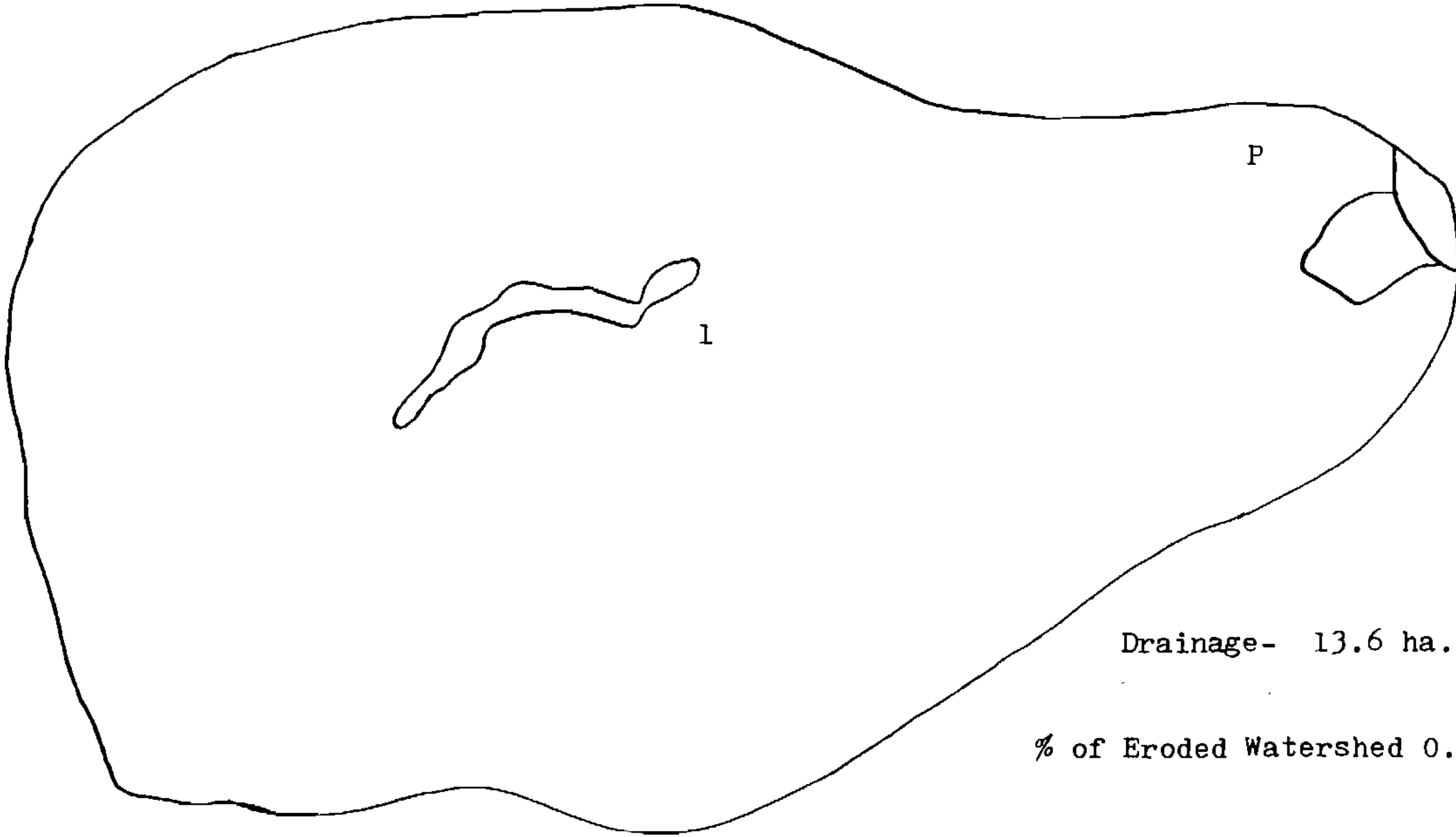
Trailing and gullying was given a rating of -1 if they were numerous, shallow or slight and -3 if they were deep and severe. In six study areas 0 was given. Trailing appeared to be insignificant or healing (Figure 35). Trails are perhaps the consequence of distribution or other management problems. They are also associated with several environmental factors including slope, soil type and climate among others.

Severe gullies can increase at a tremendous rate. Sketches from aerial photographs (Figure 36 and 37) show gullying on WS# 0-16. Sketches number one and two were drawn from photographs taken in 1973 and 1978 respectively. The first sketch shows a gully approximately one-tenth of a hectare in 1973. Five years later, the gully had

Figure 35. Photograph showing healing gully (notice vegetation is beginning to cover bare ground.)

Figure 36. Sketch from aerial photograph of watershed 0-16 taken in 1973 (outlined eroded areas). (Scale: 1Km approximately = 648 mm.)

Watershed 0-16 (1973)

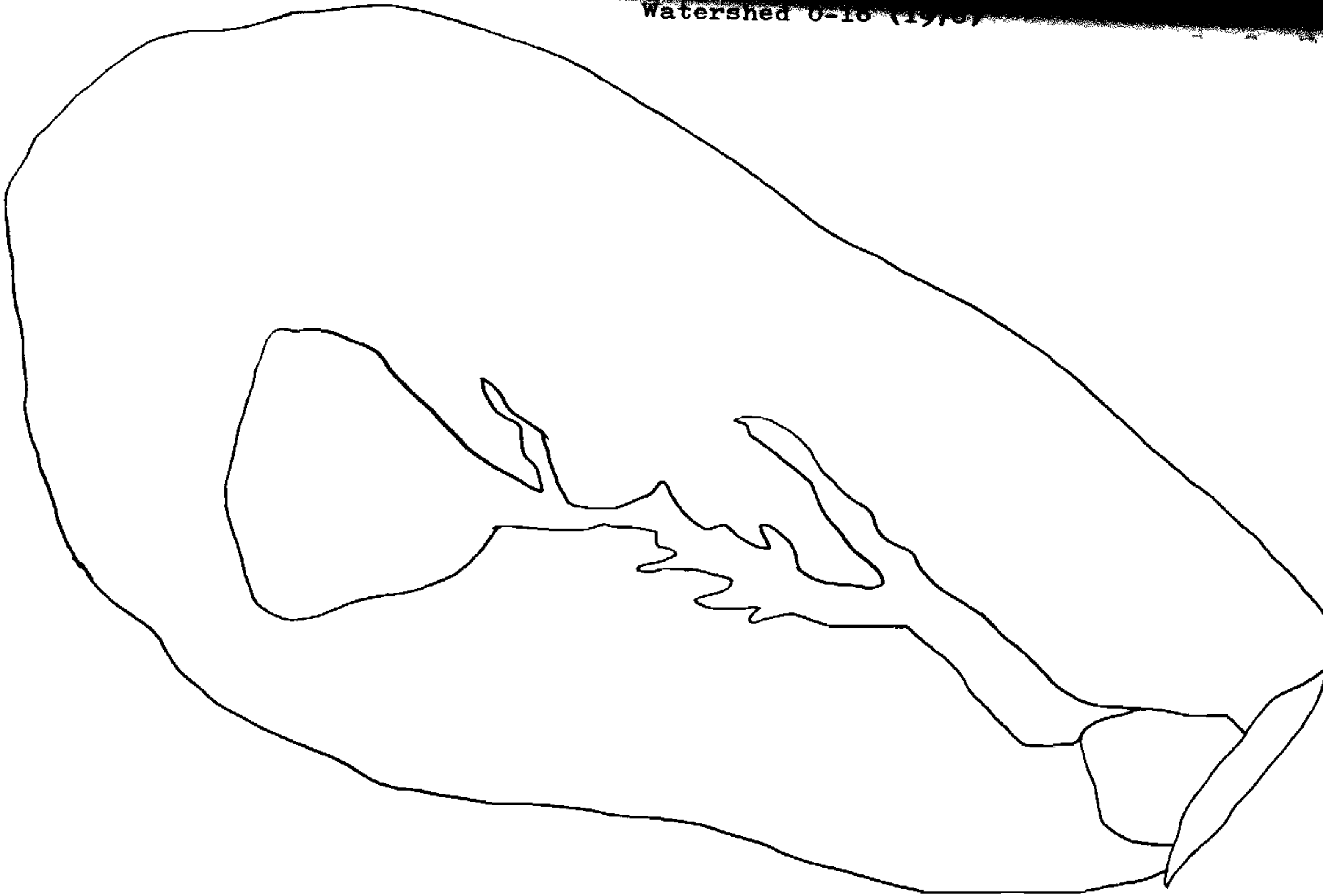


Drainage- 13.6 ha.

% of Eroded Watershed 0.38%

Figure 37. Sketch from aerial photograph of watershed 0-16 taken in 1978. (Notice difference of eroded areas between 36 and 37.) (Scale: 1 Km approximately = 648 mm.)

Watershed O-18 (1978)



Drainage- 13.6 ha.

% of Eroded Watershed- 16.1%

increased to two and two-tenths hectares (an increase of 14 %). Therefore, severe gullies were rated the lowest due to their instability and detrimental effects on the systems involved. They contribute the majority of sediment in most cases. In addition, cattle may graze the newest vegetation around the gullies (possibly due to the available nutrients and palatibility). Erosion is accelerated where this occurs. Extremely severe gullies (difficult to cross) may split the grazing areas decreasing distribution of grazing. Equipment damage and rancher inconvenience are possible. Occasionally, equipment may create gullies. Watershed G-12 exhibits gullying caused by vehicle tracks (Figure 38).

Slight gullying or trailing can usually be controlled by resting, rotational grazing or distribution changes. Severe gullies may entail construction equipment and other expensive methods of repair. Watershed N-2 had a gully created by a washout of the emergency spillway. The partly rocked gully (outside of the drainage) appears to be less active after this application (Figure 39). Schlechtl (1980) discusses methods of gully control, used worldwide, ranging from simple tree and brush arrangements to complicated stablizing processes. Gill (1979) explains about gully control in a watershed development manual especially for soil and water conservation. In some cases, total rest and reseeding could prove sufficient. Trails and gullies can reduce the overall productivity of the watershed, decreasing stable, long term cattle production potential.

Overgrazing

This section pertained to observable overgrazing problems including overall and restricted areas. Entire watersheds which were overgrazed received a -3, watersheds with restricted overgrazed areas

Figure 38. Photograph showing vehicle trails on watershed G-12. (Notice overall ground cover appears to be adequate where not driven on.)

Figure 39. Photograph showing rock to stabilize gully on watershed N-2.

received a -1 and watersheds showing little sign of overgrazing received a 0. Approximately 53 % were rated 0, 41 % were rated -1 and one watershed received a -3.

Occasionally there may be overlap with the other ratings (congregating areas, etc.). However, there were differences between restricted areas and overall overgrazing. Restricted areas may include congregating areas which (i.e., hilltops and shaded areas) can also be overgrazed. Congregating areas were not necessarily used for grazing (salting). The effects of overgrazing are still being documented. Depletion of nutrients, loss of plant root base (through erosion) compaction, unsuccessful natural seeding, and decreases in infiltration and available water capacity may be related to overgrazing. These changes are accompanied by changes of plant communities (succession or regression) and the lowering of forage productivity consequentially decreasing cattle production (Figures 40 and 41) of F-7 pictures this situation which will be discussed with the brief watershed description later in this paper. Similar to trailing and gullying restricted overgrazed areas can be managed by exclusion or a change of distribution.

Entire overgrazing refers to situations where most of the grazable watershed in either undesirable plants or denuded with little or no plant cover. A picture of watershed L-3 (the only one rated -3) illustrates an area with grazed go-back (Figure 42). Entire overgrazing management may involve a decrease in stocking, reseeding or other costly developments of changes. The overgrazing situations may be difficult due to the areas involved. Some restricted areas had been entirely overgrazed close to the pond. Others had areas away from the pond. These situations should be analyzed more closely according to circumstances involved. For example, I-6 had a severely overgrazed

Figure 40. Photograph of transect on watershed F-7 in winter of 1983.

Figure 41. Photograph of transect on watershed F-7 in Fall of 1986.

Figure 42. Photograph showing grazed go-bck on watershed L-3. (Note: this photograph was taken in 1986, four years after preliminary rating was given.)

area planted in brome grass. This area appeared to be grazed too early. By June or July annuals, including ragweed and foxtail, dominated this area. Limestone and chert was evident through the vegetation. Cracks and soil washes were also common in this area (Figure 43). It was in the watershed next to the pond, therefore soil was lost directly into the pond. Several photographs illustrate the above problems (Figures 44 and 45). However, this overgrazed area was only about 20 % of the total drainage. The remainder was good to fair condition with good soil stability. Original sampling, done in the fall, showed a good range condition and excellent ground cover.

Land Use

Three land use classifications were used: hayed, grazed and seeded go-back or abandoned. They received +3, +2 and +1 respectively.

Hayed land received the highest score for several reasons. Haying uniformly utilizes the grasses, meaning little or no over use. Haying is controlled use. When done at the right time of the year and every other year, haying can be a positive management tool. In addition good quality prairie hay can be obtained.

Grazed land received +2 due to the attention needed to maintain stability. For example, a rancher has to manage herbivores by grazing systems, fencing and distributional tools. A grazed area can stay in good condition or can deteriorate within a few years if management and climatic conditions are undesirable. An important part of management is recognizing undesirable climatic or ecological conditions and compensating for them (rest, decrease stock, etc.).

Figure 43. Photograph illustrates dominance of ragweed and other annuals. (Notice cracking as evidence of soil shrinkage.)

Figure 44. Photograph illustrating limestone and chert fragments showing through vegetation.

Figure 45. Photograph showing brome pasture next to pond. Soil stability appears to be fair.

However, it is possible for grazed lands to be ecologically sound and still be productive. Managed grazing is beneficial. Cattle help in seeding. They also increase fertility by organic waste excretions. Properly managed grazing deters regression to a lower serial stage, thus keeping the desirable plants vigorous and abundant.

Seeded go-back or abandoned land is only given a +1 for obvious reasons. Go-back land is cropland seeded to grassland. A good stand of grass is often difficult to obtain because of erosion and nutrient depletion. Go-back lands in this study appeared to have poor grass stands. Most were seeded to brome, apparently of low grazing quality.

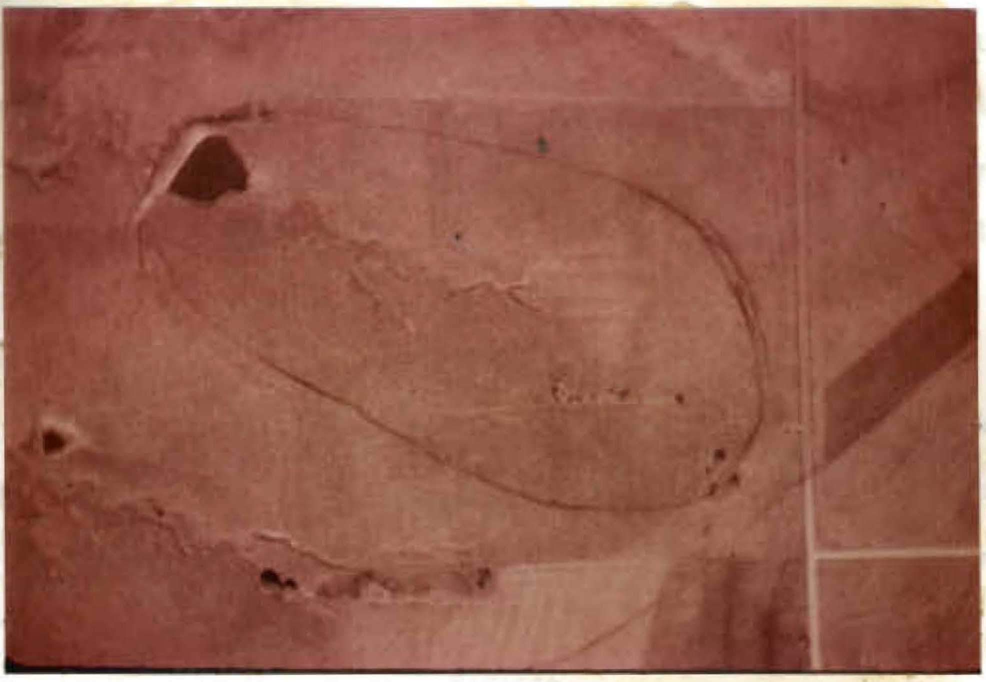
Watershed L-3 had go-back exhibiting frequent clumping accompanied by erosion around the plants. Erosion (gravel) pavement was also observed and areas were considered to have fair to poor ground cover. In addition, these areas were estimated to be the major origin of sedimentation by sheet or gully erosion. Watersheds O-16, M-10 and L-3 displayed these traits. On L-3, 36 % (5.4 ha) of a 15.1 hectare watershed consisted of go-back and had a major sediment problem. The pond in this watershed has had to be dredged three times in seven years prior to the time of sampling. Watershed O-16 contained an active, branching, severe gully (approximately 8 ft. D X 5 ft, W X 300 ft. L) (Figure 46). It possibly originated from the go-back on highly sloped areas. This is illustrated by aerial photographs from 1973 and 1984 (Figures 47 and 48).

Abandoned lands were also rated a +1. It's probable that they would be more stable than go-back areas. However, unless burned, successional vegetation would dominate decreasing the stability. One example of this is watershed F-7. For over 20 years it was grazed

Figure 46. Photograph illustrating gullying on O-16.

Figure 47. Aerial photograph of watershed 0-16 (taken in 1978 from aerial photograph; SCS, personal contact.) (Scale: 1 km approximately 80 mm.)

Figure 48. Aerial photograph of 0-16 taken in 1984 from slide (lower left hand corner). (ASCS, personal contact) (Scale: 1 km approximately 360 mm.)



properly. At the time of the survey the "big four" plants dominated and were vigorous. Big bluestem and Indian grass were commonly five to six feet tall. It has been abandoned for ten years (seven prior to the survey) and succession was observable. Osage orange, western juniper and buckbrush are much more abundant. Sedges and wild annuals were replacing the desirable grasses. Desirable grasses appear to be less than four feet tall. Still, soil stability is apparently slowly decreasing though stability is evident.

Several watersheds had multiple land use. These watersheds were rated according to the following: 1) over 60 % is the land use that will be rated, 2) over 35 % go-back or abandoned +1. Most areas were grazed and treated as such when rated.

Burning

This sometimes controversial practice is still being analyzed. In some areas, management after burning is the issue. H. L. Schantz (1934) states: "Burning, followed by close overgrazing, will rapidly destroy grass cover. Burning is therefore being discouraged by the best practices. Good management will insure protection of soils by a dense grass cover." More recently, Launchbaugh and Owensby (1978) recommend frequent controlled burning at the right time of year. Their guidelines include frequency, time of year, climatic conditions and general observations on the burning practice.

Proper burning is recognized as a positive management tool and areas using it are given a +1 (Figure 49). Proper burning is beneficial in several ways. Woody invasion can be controlled relatively safely and inexpensively through proper burning. Heat can increase chemical reactions and ecological interactions in the soil.

Figure 49. Photograph showing burning in background.

These include nitrogen fixation and storage transfer. In addition litter and rank grass can be removed allowing for fresh, new growth. Ferris and Hulbert (1980) stated that their results should be interpreted with caution. Results of some species may have been influenced by prior treatments. Prescribed burning is recognized by all of the government agencies at the state and federal levels.

Areas not burned received a 0. Succession is generally a slow process and is better than uncontrolled fire. Areas with improper burns rate a -1 due to the detrimental effects of this occurrence. Fire (accidental or intentional) at the wrong time of the year can leave the soil exposed to precipitation. The result can be heavy runoff and erosion. Too frequent fire can decrease understory and destroy valuable plants. This may again result in soil instability. These effects do not include the lack of all of the benefits that accompany proper burning.

Approximately 13 (76 %) used proper burning (according to questionnaires). The remaining watershed (4) lacked burning. There were no improper burn scores given.

The Relative Erosion Potential Results

The next part deals with natural variables; the "relative erosion potential factor" (REPF) and its rating. An equation, similar to the USLE, was developed for the watersheds studied. This equation is the "Watershed Soil Loss Equation for 17 Lyon County watersheds" (WSLE Ly17). It is similar to the USLE, however, it is not strictly for cropland and utilizes several cover factors. These include current soil loss for covered ground {CSL(C)}, bare ground {CSL(B)} and their cover factors and the potential soil loss {PSL(A)} for each area; it emphasized the entire drainage. In addition, a tolerable soil loss (TSL), a mean tolerable soil loss (MTSL), and an estimated factored current soil loss (EFCSL) for each study area are included. Each will be discussed separately.

Several factors had to be used in the (WSLE Ly17). These included percent of slope (% s), slope length (s/L), total erodibility (T/K), cover factor (c) and rainfall (R). The % s ranged from 3 to 7.5 with a mean of 4.6. The s/L ranged from 250 to 500 with a mean of 361.8 (the majority were around 300). T/K soil erodibility values (taken from SCS) ranged from 8.51 to 13.92 with a mean of 10.7. A constant 225 was used for the rainfall factor. A comparison of how these variables effect the EFCSL will be discussed later.

The CSL(C), C, csl and c Factors

CSL(C) (current soil loss) values ranged from 2,228 to 9,675 with the mean being 5,850 kilograms/hectare (kg/h). CSL(C) was using the cover factor "C" (ranging from 0.009 to 0.092; with a mean of 0.039) for survey results from 2,228 to 4,725 with the mean being 2,925 kg/h. Approximately 65 % of the watersheds had a csl value $< 3{,}000$ kg/h. The "c" factor for csl is for the survey results using the perennials and litter and ranged from 0.007 to 0.041 with a mean of 0.016. The values (CSL and csl) were compared using a T-test. They were found to be significantly different ($p > 0.05$) (Table 13). (This determined that the "(CSL)" using the "C" factor would be used in the EFCSL.)

In as much as current soil loss (CSL) values depend on USLE factors, several comparisons of slope percent, slope length, etc.

Table 13. Results of T and F-tests for several factors and values ($p < 0.05$).

Factors	T-test	F-test
SY1 -- SY2	NS	S
CSL(C) — PSL(A)	NS	NS
CSL — csl	NS	NS
MTSL — TSL	NS	NS
EFCSL — MTSL	S	NS
AASY — MASY	S	Not tested
PMSY — PASY	S	Not tested

AASY - Annual adjusted sediment yield
CSL(B) - Current soil loss for bare ground areas
CSL - Current soil loss using only perennials in cover factor
csl - Current soil loss using perennials and annuals in cover factor
EFCSL - Estimated factored current soil loss
MTSL - Mean tolerable soil loss
MASY - The AASY using the mean age of ponds
PASY - Predicted adjusted sediment yield using an adjusted P management practices) and K (erodibility) factor of the original MUSLE
PMSY - Predicted sediment yield using the original MUSLE factors of P and K
PSL(A) - Potential Soil Loss
SY1 - Sediment yield for entire watershed
SY2 - Sediment yield for eroded watershed
TSL - Tolerable soil loss

should be made. The higher sloped watersheds including A-4, H-5 and G-12 appeared to have no distinct pattern. A-4, with a 7 % slope, 450 foot s/L and T/K value of 12.70, had a CSL value <1 ton per acre. H-5 also had a 7 % slope but its s/L was 250 feet and T/K value was 10.76. Its CSL value was 3,825 kg/h. G-12 had the third highest CSL value at 8,775 kg/h (highest was 9,675 kg/h). It had a 7.5 % slope, 275 foot s/L, and 10.57 T/K value.

There was still some question about the effect of slope length (s/L) and slope steepness (% s) on rangeland soil erosion. McCool (1982) cited research reported by Meyer and others done in 1975, which "indicated that slope steepness has much less effect on soil loss from short interill areas than would be calculated from the relationships developed from longer plots (cropland) and reported by Smith and Whitt in 1947 and Wischmeier and Smith in 1957, 1965, and 1978."

McCool (1982) cited additional research by Meyer and others who reported: "Considerable erosion occurred even when the soil surface was level, but the increase in erosion with slope steepness over a broad range of steepness was relatively small. Erosion only doubled for a steepness change from 2 to 20 %." Relationships reported by Wischmeier and Smith on nonrangeland indicated a nearly 20-fold increase (McCool 1982).

Information from the preceeding paragraphs indicates that s/L may be the deciding factor for the difference between H-5 and A-4 having a

sizes differed by approximately 4.5 hectares.

It appears that the cover factor (taken from GC %) was the deciding factor of 0.013 (80 % GC) and G-12 had a cover of 0.037 (66 %

Figure 50. Aerial photograph of watersheds H-5 and G-12 (upper left). (Scale: 1 Km approximately = 80 mm.)

GC); a difference 0.024 or 14 % GC. The differences in the % s, s/L and T/K is 0.5 %, 25 feet and 0.19 respectively. There was only a half hectare difference in drainage size. Yet the difference between CSL(C)s was 49,350 kg/h. Another interesting point is that these watersheds almost border each other (Figure 50).

In references to lesser sloped areas, three watersheds exhibited slopes of 3 % including F-7, N-2 and C-14. Watersheds C-14 and F-7 both had 300 foot s/L with 12.90 and 8.81 T/K values respectively.

In addition to the above factors, a mean tolerable soil loss (MTSL) value was used. The TSL was the amount of soil loss a soil type can tolerate before the productivity is significantly effected. The MTSL was the mean TSL of those soil types found in the watershed (Appendix A).

In Table 14, when MTSL values were compared (< or >) with CSL values, 23 % of the watersheds' CSL values exceeded the MTSL values. The MTSL was important because it gave an estimate of how much soil could be lost before productivity was reduced. This may also help estimate the potential of the area. In addition, the difference between the CSL and MTSL could give an idea of the magnitude of the problem. For example, watershed N-2 had the highest MTSL value: 11,025 kg/h. Its CSL value was less than the MTSL value 5,625 kgb/h; making a difference of 5,400 kg/h. It appears this watershed is in good condition. "Theoretically" N-2 could lose another 4,500 kg/h before it would show a decrease in productivity.

Watershed I-6 had a MTSL value of 6,975 and CSL value of 7,875 kg/h. The CSL value exceeded the MTSL value by 900 kg/h. I-6 is already losing 900 kg/h too much. The worse watershed was K-17 which

Table 14. Current soil loss estimate using the "Calculator for Planning Conservation Systems" (1) and the USLE (USDA-SCS, Personal contact) (Multiply t/a X 2250 = KG/H...Branson et al 1981).

	2	3	4	5	6	7	8	9	10	11	12	13
WS#	% s	s/L (ft.)	T/K	R *	GC (percent)	gc (percent)	"C"	"c"	CA	MTSL (tons / acre)	CSL (tons / acre)	csl (tons / acre)
1	4.5	275	13.92	*	54	71	.056	.032	4	3.9 >	3.6	2.0
2	3.0	500	10.87	*	59	80	.040	.013	<1	4.9 >	2.5	< 1
3	4.0	500	9.60	*	73	81	.029	.011	<1	3.7 >	2.1	< 1
4	7.0	450	12.70	*	85	89	.009	.007	<1	3.6 >	< 1	< 1
5	7.0	250	10.76	*	80	90	.013	.006	<1	4.4 >	1.7	< 1
6	4.5	400	9.32	*	58	76	.051	.025	5	3.1 <	3.5	1.8
7	3.0	300	12.90	*	69	82	.030	.010	5	4.9 >	1.3	< 1
8	3.5	300	10.56	*	63	85	.038	.009	2	4.2 >	1.9	< 1
9	6.0	250	9.89	*	57	80	.061	.013	8	3.0 <	4.1	< 1
10	4.0	500	12.84	*	62	68	.039	.030	0	3.3 >	1.9	1.6
11	3.5	300	9.56	*	65	71	.036	.032	0	3.7 >	2.3	2.1
12	7.5	275	10.57	*	66	84	.037	.012	0	3.5 <	3.9	1.3
13	6.0	450	10.65	*	62	86	.039	.008	<1	3.3 <	3.9	< 1
14	3.0	300	8.81	*	65	88	.036	.007	6	3.6 >	1.8	< 1
15	4.5	500	9.87	*	63	84	.038	.012	4	3.2 >	2.9	< 1
16	4.0	350	8.51	*	78	88	.018	.007	3	3.2 >	1.5	< 1
17	4.0	250	10.59	*	43	58	.092	.041	9	3.6 <	4.3	2.0

1) This slide-rule calculator was developed for use with the USLE by researchers M. E. Springer, University of Tennessee, D. K. Springer, C. B. Breining and F. R. Parris, Soil Conservation Service: USDA for field use.

2) "% s" represents the percentage of slope (USLE).

3) "s/L" represents the length of slope from highest contour to lowest contour (pond) in watersheds (taken from topography map; courtesy Lyon County SCS).

4) "T/K" represents a value estimated by multiplying each erodibility factor (T/K) by the percentage of water shed (using a dot-grid and the Lyon County Soil Survey, SCS).

5) "R" represents the rainfall constant 225.

6) "GC" represents the ground cover percentage when only perennial plant hits from the range condition survey are counted.

7) "gc" represents the ground cover percentage when litter and perennials from range condition survey results are counted.

8) "C" represents the cover factor value when only the perennial plant hits from the range condition survey are counted (taken from Table e Section I-C TB Notice KS-93, 6/21/82, SCS.

9) "c" represents the cover factor value when litter and perennials are counted...(see above)

10) "CA" represents the percentage of canopy (a plant desirability index rating with 12 or 16 is not appreciable) canopy.

11) "MTSL" represents the "mean tolerable soil loss" (used same method to estimate as T/K value; see #4 above).

12) "CSL" represents the current soil loss using the "C" and "GC" values in its estimation.

13) "csl" represents the current soil loss using the "c" and "gc" values in its estimation.

NOTE: The csl values are all less than the CSL and MTSL. An analysis using the c, gc and csl value may under-estimate the soil loss problem. The CSL in watersheds 6, 9, 12, 13 and 17 exceed the MTSL implying that the watersheds are evidently losing more soil at the current rate than is tolerable for good stability.

had a CSL value of 9,675 kg/h and MTSL of 8,100 kg/h. This appeared to indicate a major soil loss problem. The soil loss exceeded tolerable levels by 1,575 kg/h. F-7 was probably in the best condition. Its CSL was 2,925 kg/h lower than its MTSL 11,025 kg/h. This area has 8,100 kg/h to lose before reduction of productivity. F-7 values demonstrated the importance of a good soil condition. Its CSL value was low, however its MTSL was high. The combination of these two factors made F-7 one of the best watersheds in terms of soil stability. The MTSL values were used in several applications and their results will be summarized later.

The CSL(B) and PSL(A) Values

In as much as the CSL values are only for those areas which have ground cover, other factors were added to the WSLE Ly17. Areas which were bare ground also had to be evaluated. CSL(B) uses the cover factor "0.45"; 0 % ground cover (bare ground). This value ranged from 33,740 kg/h to 123,750 kg/h with a mean of 72,000 kg/h. This value was the estimate for "eroded CSL(B) {excluding MTSL, PSL(A) and CSL(C)} The table includes % EW which was used in the SY2 (sediment yield) calculations prior to the "scorecard results." It was used to estimate the estimated factored current soil loss (EFCSL). Estimating the CSL(B) value was a little less involved since the cover and the rainfall factors were constant. Analysis of the table revealed several interesting watersheds. E-8 had the highest % EW at 74 %, with percent slope, slope length, and T/K values of 3.5 %, 300 foot, and 10.56 respectively. Its CSL(B) value was 60,750 kg/h. The highest of CSL(B) values, 123,750 kg/h was exhibited by watershed G-12. Its slope

Table 15. Current soil loss estimate using the "Calculator for Planning Conservation Systems" (1) and the USLE This attempts to compare two treatments of CSL and PSL (potential soil loss).

WS#	2 % s	3 s/L (ft.)	4 T/K	5 R *	6 "C"	7 EWS %	8 MTSL	9 PSL(A)		10 CSL(B) (Tons per acre)	11 CLS(C)
1	4.5	275	13.92	*	0.45	34.3	3.9	22.5	<	27.0	3.6
2	3.0	500	10.87	*	0.45	0.9	4.9	32.5	>	29.0	2.5
3	4.0	500	9.60	*	0.45	37.9	3.7	37.5	>	35.0	2.1
4	7.0	450	12.70	*	0.45	8.8	3.6	45.0	<	50.0	< 1
5	7.0	250	10.76	*	0.45	10.1	4.4	55.0	>	41.0	1.7
6	4.5	400	9.32	*	0.45	25.0	3.1	31.0	>	30.0	3.5
7	3.0	300	12.90	*	0.45	12.4	4.9	19.0	>	16.0	1.3
8	3.5	300	10.56	*	0.45	74.0	4.2	24.0	<	27.0	1.9
9	6.0	250	9.89	*	0.45	6.0	3.0	37.5	>	30.0	4.1
10	4.0	500	12.84	*	0.45	9.0	3.3	22.0	<	31.0	1.9
11	3.5	300	9.56	*	0.45	1.5	3.7	31.0	>	26.0	2.3
12	7.5	275	10.57	*	0.45	12.5	3.5	46.0	<	55.0	3.9
13	6.0	450	10.65	*	0.45	10.4	3.3	44.0	<	45.0	3.9
14	3.0	300	8.81	*	0.45	0.7	3.6	22.0	>	15.0	1.8
15	4.5	500	9.87	*	0.45	14.6	3.2	32.0	<	35.0	2.9
16	4.0	350	8.51	*	0.45	18.4	3.2	30.0	>	28.0	1.5
17	4.0	250	10.59	*	0.45	36.2	3.6	21.5	<	24.0	4.3

1) This slide-rule calculator was developed for use with the USLE by researchers M.E. Springer, University of Tennessee, D.K. Springer, C.B. Breinig and F.R. Parris, Soil Conservation Service: USDA for field use.

2) "% s" represents the percentage of slope for eroded areas only (USLE)

3) "s/L" represents the length of slope from highest contour to lowest contour (pond) in watersheds for eroded areas only (taken from topography map; courtesy Lyon County SCS).

4) "T/K" represents a value estimated by multiplying each erodibility factor (T/K) by the percentage of watershed using eroded areas only (using a dot-grid and the Lyon County Soil Survey SCS).

5) "R" represents the rainfall constant 225.

6) "C" represents the cover factor value using...0.45 (taken from Table e Section I-C TG Notice KS-93, 6/21/82, SCS) representing the 100 % bare ground value corresponding to eroded watershed.

7) EWS represents the "eroded watershed" estimated by outlining from aerial photographs and field observations.

8) MTSL represents the "mean tolerable soil loss" for only the eroded soil types mapped. (Used same method of estimate as T/K value; see #4 above.)

9) PSL(A) represents the potential soil loss for the total watershed using the bare ground cover factor value.

10) CSL(B) represents the current soil loss using only the eroded areas mapped using bare ground factor cover value.

11) CSL(C) represents the current soil loss using the original cover factor.

percent, slope length, and T/K values were 7.5 %, 275 feet and 10.57 respectively. Twelve and one-half percent was eroded watershed. The combination of moderately high T/K (E-8...10.56) and high % s appears to be one reason why the CSL(B) of G-12 was higher than E-8's. This may be inaccurate because cropland was present in E-8.

Watershed C-14, the most stable of the 17 areas, had a CSL(B) of 33,750 kg/h. Its % s, s/L and T/K were 3.0 %, 300 feet, and 8.81 respectively. It also had one of the lower CSL(C) values (4,050 kg/h). An apparently comparable area (except for size), F-7, had % s and s/L equal to C-14 with an approximate difference of 8,775 kg/h. Still its CSL(B) and CSL(C) were not tested for significance. Graphics in Figure 51 illustrate unconfounded relationships between CSL(C), CSL(B), EFCSL and MTSL.

The PSL(A) value uses the same 0.45 factor, however it estimates for the entire watershed (if 100 % were bare ground). This value ranged from 42,750 to 123,750 kg/h with a mean of 69,750 kg/h. PSL(A) values represent the potential amount of soil which could be lost if watersheds were 100 % bare ground.

T-test results illustrated no significant difference between the CSL(B) and PSL(A) ($p < 0.05$). It must be recognized that CSL(B) may not include all of the soil types used in PSL(A), therefore some differences were present. In addition, it is impossible to believe that these areas will ever be 100 % bare ground (unless broken). The PSL(A) was used merely as a reference point and to show the "potential soil loss" possible. Those watersheds with CSL(B) value exceeding the PSL(A) value appear to be the least stable. Graphics illustrate relationships between CSL(C), CSL(B) and PSL(A) (Figure 52).

Figure 51. Graphics illustrating the relationship between CSL(C), PSL(A), EFCSL and MTSL. (Graphic design taken from Gebhart 1982)

```
   3.6
1. 0---'-------------27
        (11.6)       £
MTSL--[3.6]
   2.5
2. 0---r--------------29
       (4.5)          £
MTSL------[4.5]
   2.1
3. 0--?---------------------35
           (14.3)           £
MTSL---[3.7]
 <1
4. 0-----------------------------50
        (5.3)                    £
MTSL----[4.3]
   1.7
5. 0-'------------------------41
        (5.8)                 £
MTSL---[3.9]

   3.5
6. 0---/----------------------30
         (6.7)                 £
MTSL---[3.1]
   1.3
7. 0-'-T------16
     (4.9)    £
MTSL----[5.0]
   1.9
8. 0-'------------------27
              (21.0)    £
MTSL---[3.1]
    4.1
9. 0----'-r-----------------30
        (5.7)                £
MTSL---[3.0]
    1.9
10. 0--'-----------------------31
        (4.5)                   £
MTSL---[3.1]
    2.3
11. 0--[---------------26
      (2.7)            £
MTSL----[3.8]

    3.9
12. 0--'---T-----------------------55
        (10.3)                     £
MTSL---[3.8]
    3.9
13. 0--?------------------------45
        (8.0)                   £
MTSL--[3.4]
   1.8
14. 0-?-------15
     (1.9)    £
MTSL--[3.3]
    2.9
15. 0--?--------------------35
        (7.6)               £
MTSL--[3.3]
   1.5
16. 0'---------------20
      (6.4)          £
MTSL--[3.4]
    4.3
17. 0---L----T-----24
        (11.4)     £
MTSL---[3.7]
```

Figure 52. Graphics illustrating the relationship between CSL(C), CSL(B), EFCSL and MTSL. (Graphic design taken from Gebhart 1982)

```
   3.6
1. 0---------------------22.5
MTSL--[3.6] (11.6)       £
   2.5
2. 0---------------------32.5??
MTSL--(2.4)--[4.5]       £
   2.1
3. 0---------------------37.5
MTSL---[3.7] (14.3)      £
   (1
4. 0---------------------45
MTSL----[4.3] (5.3)      £
   1.7
5. 0---------------------55
MTSL---[3.9] (5.8)       £

   3.5
6. 0---------------------31
MTSL---[3.1] (6.7)       £
   1.3
7. 0---------19
MTSL----[5.0] (4.9)  £
   1.9
8. 0---------------------24
MTSL---[3.1]  (26.1)     £
   4.1
9. 0---------------------37.5
MTSL---[3.8] (5.9)       £
   1.9
10. 0--------------------22
MTSL---[3.1] (4.5)       £
   2.3
11. 0----------------31
MTSL----[3.8] (2.7)  £

    3.9
12. 0--------------------------46
MTSL---[3.8] (10.3)            £
    3.9
13. 0------------------------44
MTSL--[3.4] (8.2)            £
    1.8
14. 0---------22
MTSL--[3.3] (1.9)  £
    2.9
15. 0--------------------32
MTSL--[3.3] (9.5)        £
    1.5
16. 0-----------------30
MTSL--[3.4] (7.6)     £
    4.3
17. 0-----------------21.5
MTSL---[3.7] (11.4)   £
```

The EFCSL Values

The CSL(B) and CSL(C) factors only estimated the values of soil loss. To find the "estimated factored current soil loss" for the entire watershed, a combination of the factors and the amount of area they represented was formulated. This was the EFCSL value for the entire watershed.

EFCSL values were developed to represent soil stability. The values were the sum of the two soil loss factors previously mentioned (CSL(B) and CSL(C)) multiplied times their respective covered or eroded percentages. The EFCSL values ranged from 4,275 to 47,250 kg/h with a mean of 17,550 kg/h. Results are found in Table 16 (notice no watersheds' EFCSL exceed CSL(B) values and most are far from them).

Watersheds E-8 and L-3 had the highest EFCSL values, with 47,250 and 32,175 kg/h respectively. E-8's high value was probably due to the high (% e) percent eroded (74 %) combined with the 60,750 CSL(B) value. Its remaining covered ground (26 %) had only 4,275 kg/h CSL(C) value. Another watershed G-12, had the highest CSL(B), 123,750 kg/h with 12.5 % eroded. Its percentage of covered ground, 87.5, had a CSL(C) value of 8,775 kg/h. Watershed C-14 had the lowest CSL(B), % e and EFCSL of the 17 watersheds. In addition, C-14 had the highest % c. The CSL(B) value was 33,750 and the % e was .7 %.

Through observation and evaluations (i.e., range condition), watershed A-4 was expected to have an EFCSL less than the MTSL value. It had 8.8 % e with a 112,500 kg/h CSL(B) value. Its % c was 91.2 % with a CSL(C) value of 2,228 kg/h. Although the % c was high and CSL(C) was low, the EFCSL value (11,925 kg/h) was greater than any MTSL values of the 17 watersheds. The CSL(B) value was the second highest

Table 16. The EFCSL (estimated factored current soil loss) equation and its value for 17 study areas in Lyon County. Also shown is the relationship (</>=) between the MTSL and the EFCSL. (Multiply T/A X 2250 = Kg/h...Branson et al 1981).

WS#	EFCSL[1] (CSL(B) X % e) + (CSL(C) X %c)=EFCSL	(</=/>)[2]	MTSL[3] (Tons / Acre)	TSL (Tons / Acre)
1	(27t/a X 34.3 %)+(3.6t/a X 65.7 %)=11.6	>>>	3.6	3.3
2	(29t/a X 8.6 %)+(2.5t/a X 82.4 %)= 4.5	===	4.5	4.0
3	(35t/a X 37.9 %)+(2.1t/a X 62.1 %)=14.3	>>>	3.7	3.7
4	(50t/a X 8.8 %)+(.99t/a X 91.2 %)= 5.3	>>>	4.3	5.0
5	(41t/a X 10.1 %)+(1.7t/a X 89.9 %)= 5.8	>>>	3.9	3.5
6	(30t/a X 12.4 %)+(3.5t/a X 87.6 %)= 6.7	>>>	3.1	3.0
7	(16t/a X 25.0 %)+(1.3t/a X 75.0 %)= 4.9	<<<	5.0	5.0
8	(27t/a X 74.0 %)+(1.9t/a X 26.0 %)=21.0	>>>	3.1	4.0
9	(30t/a X 6.0 %)+(4.1t/a X 94.4 %)= 5.7	>>>	3.0	3.0
10	(31t/a X 9.0 %)+(1.9t/a X 91.0 %)= 4.5	>>>	3.1	3.0
11	(26t/a X 1.5 %)+(2.3t/a X 98.5 %)= 2.7	<<<	3.8	4.0
12	(55t/a X 12.5 %)+(3.9t/a X 87.5 %)=10.3	>>>	3.8	3.3
13	(45t/a X 10.4 %)+(3.9t/a X 89.6 %)= 8.0	>>>	3.4	4.0
14	(15t/a X 0.7 %)+(1.8t/a X 99.3 %)= 1.9	<<<	3.3	3.0
15	(35t/a X 14.6 %)+(2.9t/a X 85.4 %)= 7.6	>>>	3.3	3.3
16	(28t/a X 18.4 %)+(1.5t/a X 81.6 %)= 6.4	>>>	3.1	3.0
17	(24t/a X 36.2 %)+(4.3t/a X 63.8 %)=11.4	>>>	3.7	3.7

1) EFSCL — This is the abbreviation for the "estimated factored current soil loss" which adds the product of the CSL for eroded areas only (using the 0.45 value) times the percent of area eroded to the CSL of the covered areas using the cover value (from ground cover %) times the remaining percentage to get an estimated soil loss which includes the bare ground and covered areas. (WSLE Ly17).

2) The relationship of the EFCSL to the MTSL may demonstrate the severity of the problem. A watershed whose EFCSL is = to the MTSL should be looked at closer to see if management changes are needed. If the EFCSL exceeds the MTSL, a change of management is (critical) needed. Although the numbers may not be totally accurate the difference between the values is also important. The watershed whose EFCSL exceeds the MTSL by 5 or more needs treatment as soon as possible. If the difference is less than 5, the manager will be made aware of the fact that stability is decreasing and future plans should include a thorough evaluation.

3) MTSL -- is an average of the entire watershed's tolerable soil loss (using 0.45 and cover values).

of the areas. It appears that watersheds with a very high CSL(B) value will probably lose more soil than can be tolerated by the area. Watershed size and land use probably effect EFCSL values. However, as was mentioned earlier, slope percent and length may have been the most important factor affecting soil loss rates. Due to variability significant comparisons between watersheds were impossible.

TSL and MTSL Values

The mean tolerable soil loss (MTSL) value appeared to be a way to refer to each watersheds' potential. MTSL values ranged from 6,750 kg/h to 11,250 kg/h with a mean of 8,100 kg/h. (The TSL values were the same.) Results from a T-test showed no significant difference between these two values ($p < 0.05$). However, MTSL values were used for EFCSL and SER analysis.

Table 16 showed relationships between EFCSL and MTSL including less than, equal to or greater than. This relationship between EFCSL and MTSL values indicated a reference for each watershed. Approximately 6 % of the watersheds had EFCSL values less than MTSL values. Ninety-three percent of the watersheds had EFCSL values greater than MTSL values. One watershed had equal EFCSL and MTSL values. Watersheds whose EFCSL was greater than their MTSL indicated management problems and soil instability leading to a decrease in production. Watershed whose EFCSL value equalled the MTSL indicates areas which can either lose less or more soil depending on management practices and climatic phenomona.

Watersheds F-7, B-11, and C-14 had EFCSL values less than MTSL values. Watershed C-14 was analyzed earlier. Watershed F-7 needs to be recognized due to its "borderline" condition. Its EFCSL (11,025 kg/hg) is one-tenth less than its MTSL value (11,250). This indicates it still is in good condition but it is gradually getting less stable. This was a part of the study where an erosion model might be useful for a short-termed estimation. For example, how much cover factor change would have to occur before the EFCSL exceeded the MTSL? Theoretically, substituting different % c values could lead to improved management plans.

Watershed B-11 had the second lowest CSL(B), highest % c, and lowest EFCSL values. However, the MTSL was the fourth highest, making this watershed appear to be stable.

Watershed N-2 had the most questionable results. Its respective EFCSL and MTSL values were equal. This indicates that an increased rainfall or storm frequency pattern combined with a management problem could destabilize the area; it should be carefully monitored.

The remaining watersheds had EFCSL values greater than their respective MTSL values. T-test results indicated a significant difference between the EFCSL and MTSL values ($p > 0.05$). This illustrates the need for management changes on the majority of watersheds.

Even though watersheds now had a "less than or greater than" relationship established, it appeared this could not be used for the scorecard. The soil erodibility rating (SER) was developed to add to the scorecard and will be explained later. One way to do this is to use a "how much less or more" approach. This was termed the "difference of values" (DOV). It was the magnitudinal difference between the EFCSL and MTSL values. (For simplicity no conversions from t/a to Kg/h were made.) Table 17 shows EFCSL, MTSL, DOV, and SER values for the 17 watersheds studied. The DOV was negative or positive. It

Table 17. Results of soil erodibility survey for 17 watersheds on Lyon County grasslands.

	1		2	3	4	5	6
Watershed Number	EFCSL (Tons/Acre)		MTSL	DOV (Positive/Negative)	ROWN	SER	Land Use r,v,w,x,y,z
1	11.6	>	3.6	+ 8.0	+ 8	- 8	w
2	4.5	=	4.5	0	0	0	w
3	14.3	>	3.7	+10.6	+10	-10	z,w
4	5.3	>	4.3	+ 1.0	+ 1	- 1	w
5	5.8	>	3.9	+ 1.9	+ 2	- 2	w
6	6.7	>	3.1	+ 3.6	+ 4	- 4	z,w
7	4.9	<	5.0	- .10	0	0	w,r
8	21.0	>	3.1	+18.0	+18	-18	w,y
9	5.7	>	3.0	+ 2.7	+ 3	- 3	w
10	4.5	>	3.1	+ 1.4	+ 1	- 1	x,w
11	2.7	<	3.8	- 1.1	- 1	+ 1	v
12	10.3	>	3.8	+ 6.5	+ 7	- 7	w
13	8.0	>	3.4	+ 4.6	+ 5	- 5	w
14	1.9	<	3.3	- 1.4	- 1	+ 1	w,x
15	7.6	>	3.3	+ 4.3	+ 4	- 4	w,x,v,z
16	6.4	>	3.1	+ 3.3	+ 3	- 3	w,z
17	11.4	>	3.7	+ 7.7	+ 8	- 8	w,x,z

1) EFCSL - Estimated factored current soil loss (WSLE Ly17)

2) MTSL - Mean tolerable soil loss averaged from SCS data and soil survey.

3) DOV - Difference of MTSL and EFCSL values; demonstrating relationship and severity of problem.

4) ROWN - DOV rounded off to the nearest whole number.

5) The soil erodibility rating is used in the watershed condition scorecard estimation.

6) The land use is important in overall stability.

The key is as follows: r = rested; v = non-grazed; w = grazed; x = hyaed; y = cropland (presently); z = go-back. In the case of multiple land use the larger size of area land use is listed first...(above).

NOTE: If the difference of values, "COV", is negative, the SER will be positive (showing that the smallest DOV is the best in terms of overall ratings). If the DOV is positive, the SER will be negative (showing the large DOV is the worst in terms of overall rating). (Multiply T/A X 2250 = Kg/h.)

ranged from -1.4 to +18.0. This number reflected whether the watershed had a soil loss problem and how much of a problem it had. Watersheds having negative DOV values were deemed more stable than watersheds having positive values because EFCSL values were subtracted from MTSL values. Apparently, unstable watersheds would have EFCSL values greater than MTSL values, giving a positive number. EFCSL values less than MTSL values, giving a negative number, indicated a more stable watershed. The number was rounded to the nearest whole number. This number was assigned the inverse of the integer and termed the "soil erodibility rating" (SER).

SER Values

The SER (soil erodibility rating) ranged from +1 to -18 with a mean of -4.4. The SER was the factor used in the watershed condition scorecard. Its value was the exact opposite of the EFCSL value or the "inverse value." For example, "if the EFCSL value was -1, the SER value was +1." This attempted to quantitatively recognize the magnitude of soil loss problem. (Due to the development of the SER value, t/a was not converted to kg/h.)

The SER reflected the condition. Negative values were undesirable because it subtracted form the WCRV (score) showing a "low condition or unstable watershed." Positive values were desirable because they added to the scorecard score showing a "higher condition or stable watershed."

Watersheds N-2 and F-7 received 0 SER values because it appeared that natural or unnatural changes of the WSLE Ly17 could decrease or increase soil loss. However, it is probable that N-2 will stay more stable than F-7 due to recent abandoning of F-7.

No watershed received more than a +1 SER value. However, as was reported earlier, the two most stable watersheds were C-14 and B-11. Both had +1 SER values and characteristically comparable. Most SER values were bedtween -10 and +1 which shows some difference from the EFCSL. This is due to a combination of EFCSL and MTSL values. The mean values for EFCSL and SER were 7.8 and -4.4 respectively, however, there was only 0.2 difference between their standard deviations.

One aspect of the relationship between the EFCSL and SER is the effect of the magnitude of the MTSL value. For example, J-1 had an EFCSL value of 11.6 t/a with the MTSL value being (approximately the mean) 3.6 t/a, the SER was -9 t/a. Watershed K-17 had EFCSL and MTSL values of 11.4 and 3.7 t/a respectively, its SER value was also -8 t/a.

Watershed D-9 had EFCSL and MTSL values of 5.7 and 3.0 t/a respectively, its SER value was -3 t/a.

The TWPEDI Values and Their Factors

The TWPEDI (total watershed plant erosion deterrence index) results showed excellent, good, fair, and poor ratings of 24, 47, 24 and 5 % respectively. The TWPEDI consisted of a plant desirability index (PDI) which is made up of the sum of a composition desirability index (CDI) and the relative plant erosion deterrence value (RPEDV) of each watershed. The PDI was multiplied by the number of samples relative to each PDI (R#S) to get the multiple plant desirability index (MPDI). The sum of the MPDI is termed the "accumulative plant desirability index" (APDI). These will be briefly reviewed separately then combined.

The plant desirability index (PDI) consisted of the CDI X RPEDV and included bare ground and litter using the step-loop survey data.

The PDI stayed constant (meaning the basic components were similar) throughout the sampled areas. The PDI ranged from -35 (bare ground) to 60 ("big four" plant species). A mean for each study area ranged from 23.1 to 40.3. However, most were between 23 and 28 (Table 18). The mean appeared to reflect diversity when bare ground was excluded.

Sample numbers for each RPEDV (R#S) ranged from 696 to 1. Total number of samples (T#S), i.e., the sum of R#S, ranged from 2,969 to 295 and the mean was 1,035.8.

The MPDI (PDI X R#S) ranged from -385 to 41,006. The negative number represents bare ground and ranged from -385 to -12,915 with a mean of -3,878.2.

The APDI (accumulative plant desirability index) was the sum of the MPDI. It ranged from 11,003 to 106,693 with a mean of 35,954. (With 2,000 samples, i.e. 100 % big bluestem and no bare ground, the best would be 120,000.)

The APDI value was divided by the watershed size. These values were put into a ratings scale. The good, poor, etc, ratings were given a numberical value from the scale found on the watershed scorecard (Appendix C). This value was added to the score in the WCRV and is the TWPEDI rating value.

TWPEDI ratings had low correlations showing no significance in any of the other watershed or sediment yield values (Table 19). The TWPEDI was developed to evaluate the soil holding potential of the plants and their communities. Depending on the type of study, there are two aspects of this concept. Results from a study already cited showed the soil protection of individual big bluestem, prairie cordgrass and blue-grass plants to be relatively good soil holders (Weaver and Kramer

Table 18. Factors and values for estimating the Total Watershed Plant Erosion Deterrence Index (TWPEDI) of 17 watersheds in Lyon County.

WS#	1 PDI	2 mPDI	3 R#S	4 T#S	5 MPDI		6 APDI
1	-35 to 60	23.6	264 to 2	715	- 6,405	-15,840	20,534
2	-35 to 60	25.8	364 to 1	1,471	- 5,635	-21,840	53,802
3	-35 to 60	25.6	438 to 3	912	- 2,550	-26,280	41,772
4	-35 to 60	40.3	136 to 2	418	- 2,550	- 8,160	16,598
5	-35 to 60	31.0	250 to 2	744	- 2,415	-21,000	32,727
6	-35 to 60	25.4	201 to 3	755	- 2,100	-12,060	28,077
7	-35 to 60	26.2	217 to 1	797	- 385	-11,220	33,050
8	-35 to 60	27.5	64 to 4	295	- 595	- 3,720	11,003
9	-35 to 60	26.0	256 to 1	1,108	- 2,905	-10,324	39,813
10	-35 to 60	28.6	171 to 2	450	- 1,120	- 8,208	15,442
11	-35 to 60	30.2	99 to 4	297	- 525	- 5,940	12,189
12	-35 to 60	30.2	164 to 2	514	- 2,695	- 9,840	18,734
13	-35 to 60	24.9	696 to 2	2,511	-12,915	-33,600	81,061
14	-35 to 60	27.5	154 to 1	323	- 525	- 7,392	12,705
15	-35 to 60	25.2	707 to 2	2,969	-12,145	-41,006	106,693
16	-35 to 60	23.1	504 to 5	1,146	- 2,660	-30,240	50,495
17	-35 to 60	24.4	364 to 1	1,468	- 7,805	-21,840	36,531

1) PDI represents the Plant Desirability Index which is the sum of the Composition Desirability Index (CDI) and the Relative Plant Erosion Deterrence Value (RPEDV). (Bare ground and Litter were given - 35 and 35 respectively.)

2) mPDI represents the mean Plant Desirability Index.

3) R#S represents the number of samples relative to each PDI.

4) T#S represents the total number of samples taken on each watershed.

5) MPDI represents the Multiple Desirability Index which is the product of PDI times the Relative Number of Samples (R#S).

6) APDI represents the Accumulative Plant Desirability Index which is the sum of MPDI values.

Table 19. Results from multiple regression correlation matrix using the MULREG BIOM-PC package ((C) F. James Rohlf 1984). See key below.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
F	RC	GI	MF	SR	TI	WV	EW	PA	DS	S1	S2	EL	ML	CF	TS
	(%)						%	YR	HA	(K/H/Y)		(KG/HA)			
1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
3	NS	NS	NS	NS	NS	&	NS	NS	NS	NS	NS	NS	NS	NS	NS
4	NS	NS	NS	NS	NS	&	+b	NS	NS	NS	NS	NS	NS	NS	NS
5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
6	NS	NS	–a	–a	NS	NS	+a	NS	NS	NS	+a	NS	NS	NS	NS
7	NS	NS	NS	&	NS	&	NS	NS	NS	NS	–b	NS	NS	NS	NS
8	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
9	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	+B
10	NS	NS	NS	NS	NS	NS	NS	NS	+A	NS	NS	NS	NS	NS	NS
11	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
12	NS	NS	NS	NS	NS	&	&	NS	NS	NS	NS	NS	NS	NS	NS
13	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
14	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
15	NS	NS	NS	NS	NS	NS	NS	NS	+B	NS	NS	NS	NS	NS	NS

& - designates reciprocal correlations (RC–GI or GI–RC)
– = $p < 0.05$
+ = $p > 0.05$
TEST A15 SY1 - no significant correlations
TEST A5 SY1 - designated by large no correlations
TEST B11 SY2 - designated by small letters
TEST B5 SY2 - no significant correlations

1) F - Factors being analyzed
2) RC - Range condition
3) GI - Ground Cover Index
4) MR - Management conservation and practices factor
5) SR - Soil erodibility rating
6) TI - Total watershed plant erosion deterrence index
7) WV - Watershed scorecard value
8) EW - Eroded watershed
9) PA - Pond age
10) DS - Drainage size
11) S1 - Sediment yield for entire watershed
12) S2 - Sediment yield for eroded watershed
13) EL - Estimated factored current soil Loss
14) CF - Cover factor
15) ML - Mean tolerable soil loss
16) TL - Total Number of Samples

1934). In a study of grazing effects on sdeimentation, McCalla et al (1984) reported "sediment production was consistently less from the midgrass than from the shortgrass community."

RPEDV ratings were developed from physical and life history characteristics of the plants. TWPEDI ratings were developed to evaluate the soil holding potential of plant communities for each watershed. Although the TWPEDI is only a part of the WCRV scorecard results, it may be the most important. The plant communities basically respond to their environment and management. The SER value evaluated watersheds in reference to soil stability. Occasionally there may be correlation between soil erodibility and plant communities. In this study there was a low positive correlation ($r = .461$), however, there was no significant difference ($p < 0.05$). (Further analysis will be discussed later.)

Although correlations were low, some analysis of several watersheds may aid in understanding the TWPEDI factor.

Due to variability of watershed sizes, watersheds may be uncomparable to each other. However, a manipulation of numbers could help further analyze a watershed and its possibilities.

The Categorized Approach

Due to sample number variability, three categories were established. Categories I, II and III had 295-715, 744-1146 and 1468-2969 samples taken. These categories represented the total number of samples (T#S) taken. T#S highly correlated with the drainage (watershed) size (DS). (This program will be analyzed later.) The correlation coefficient for DS and T#S was .855. This was significant

$(p > 0.01$; d.f. = 14).

Approximately 47 % of the watersheds were in Category I with Category II consisting of 35 %. The remaining watersheds were in Category III. Watersheds from each of the categories will be reviewed. It is recognized that ratings, models and computations presented in the following paragraphs are theoretical. However, a good manager should be able to roughly predict the general effects on plant communities and condition due to certain changes in management.

Category I Watersheds

Watershed J-1, in Category I, was weakly dominated by the big four and other desirable species (Appendix B). Undesirables were relatively low (4 %) and litter was approximately 17 % of the total survey. Perhaps the deciding factor was bare ground. Bare ground comprised 26 % of the survey and was rated -35. The combination of undesirables and bare ground comprised over 30 % of the TWPEDI. J-1 was rated fair. It appears that bare ground and undesirables must be reduced to raise its rating to good. When analyzed in this manner, computer models and programs would be helpful in future management plans. For example, if several years of deferred grazing decreased bare ground and increased litter by 50 %, the APDI would increase from 20,534 to 26,810. This would be approximately a 24 % increase raising the rating from fair to good.

Watershed M-10 was an atypical situation. Approximately 30 % was hayed prairie, 15 % was mowed lawn, and 55 % was horse grazed. Apparently, land uses of this watershed effected its plant community structure. M-10's bare ground was a relatively low percentage (7 %), litter was 6 % and desirables (including the big four) comprised 14 %

of the watershed's species.

The dominant factor was the intermediate and least desirables which consisted of 44 % and 29 % respectively. Of the least desirables, the three-awn and annual grasses alone comprised 65 % of the least desirables and 19 % of the entire watershed.

If resting and burning resulted in 75 % (62 plants) of those least desirables (three-awn...PDI = 18) improving to intermediates (blue grama, sedge, and Scribner's panicum...PDI = 38) and 50 % bare ground to litter, the APDI would increase from 15,442 to 16,714. This would raise the rating from poor to poor plus. If 25 % of the intermediates (little bluestem) improved to desirables (big four), the APDI would increase from 16,447 to 17,470. This would increase the rating to fair.

It appears improving intermediates to desirables in addition to improvement of bare ground percentage to litter is necessary to raise the rating to good in M-10. Bare ground percentage may not be as significant as the lack of desirable rated plants (PDI = 58 or 60).

These numbers may appear high. However, depending on the stability and fertility of the soil, a few years of resting and controlled burning (isolated fall burning in the first year of rest will decrease three-awn and annuals significantly) will improve the overall condition. In addition to decreasing these undesirable grasses, bare ground may also decrease and increase litter percentage. This would surely raise the AODI even more.

Category II Watersheds

Category II consisted of nothing less than fair rated watersheds.

Out of seven watersheds, four were rated fair, one excellent and one good.

Watershed O-16 had a TWPEDI rating of fair but it had a severe gully, probably caused by go-back land. The go-back land was reflected in the least desirable plant community (19 %) of the watershed. Planted brome grass, used in go-back planting, comprised 73 % of the least desirables.

In this watershed, it appeared that the rating could be increased to excellent if 75 % of the brome (PDI=30) plants were intermediate to desirable (side-oats gramma). The APDI value would be 52,111 (the original APDI value would be 52,111 (the original APDI value was 50,495). When the APDI was put into the TWPEDI equation the rating was excellent.

In watershed O-16, the effect of "borderline" rating of side-oats grama (< 10 % desirable...) complicates the problem. If 75 % of brome was changed to gramma side oats gramma's rating would have gone from desirable to intermediate, therefore decreasing the PDI from 58 to 48. This could be confusing and a computer program would be helpful. In addition, with management changes, it is possible that bare ground (6 %) would decrease thus increasing litter.

Category III Watersheds

Category III contained watersheds with T#S from 1,468 to 2,969. One watershed was rated fair and the other two rated good. P-15 was rated good. This was the second largest of the watersheds studied (36.9 hectares). It consisted of several land uses including hayed, grazed and non-grazed. Approximately 30 % of P-15 is a state owned research facility. The hayed area was chiefly brome grass (dominated the least desirable). The non-grazed areas included food plots and wildlife-oriented species. This is probably the reason for the percentage (18 %) of least desirables. Due to desired wildlife use, wild rose and wild plum thickets were abundant. These plants may provide canopy but also inhibit grass growth; increasing bank erosion in the drainage. A photograph of this bank erosion shows exposed shrub roots and little grass to the rear but shows thick stands of Indian and switchgrasses to the front (Figure 53).

Due to multi-landowned (four) drainage, watershed size is a very important factor in this situation. It is logical to assume that it is difficult to monitor a large watershed having several owners.

Percentages of the plant categories (desirable, etc.) appeared to be close. The dominating plants were the "lower rated" desirables (PDI=58); comprising of 24 % of the species sampled. Twenty-one percent of the hits were litter, 12 % bare ground and 20 % of the hits were higher rated desirables (big four). An interesting point is the percentage of non-plant hits. The combination of litter and bareground hits comprised 33 % of the total samples.

If management practices improved 50 % of litter hits to intermediates, the APDI would be increased from 106,693 to 107,447, however, the rating would still be good. If native grasses (big four mix) instead of brome would have been planted, brome hits might have been reduced to 38 (10 %) of the original. Desirables (native grasses) would have increased to 972. This would increase the APDI value from 107,447 to approximately 114,470. Even this event would not have raised the rating. It appears that other values (bare ground, etc.)

Figure 53. Photograph on watershed P-15 showing unstable soil under brush.

might have to be changed in order to raise the TWPEDI rating for P-15.

The SCS Clip-plot and USFS Step-loop Methods: A Comparison of Results

A survey of range condition was performed by the Soil Conservation Service. The Soil Conservation Service Resources Inventory, 1982---March 1985 contains the results of the inventory for Lyon County (personal contact). Table 20 shows results of range condition survey using SCS clip-plot (R/P {CP}) and Forest Service step-loop (R/P {SL}) methods. Conservationists used the clip-plot method (R/P {CP}) which uses dry weight and frequency for range condition classes. According to the inventory 43,000, 144,000, 83,000 and 19,000 acres were rated excellent, good, fair and poor respectively. Estimated percentages were 15 %, 50 %, 29 % and 7 % for excellent, good, fair and poor respectively.

In comparison, the step-loop method of the U. S. Forest Service was used in this study. Estimated percentages of the 17 watersheds surveyed (R/P {SL}), showed 29 %, 53 %, 12 %, and 6 % were rated excellent, good, fair and poor condition respectively. Comparing the two survey results shows that 1 % separated poor condition ratings. The main differences were in the fair and excellent ratings. One reason for the differences in the fair and excellent rating percentages is probably due to the relatively small acreage sampled (using the step-loop) in this survey.

In addition to the range condition survey, the table shows the WCRV results compared with the other surveys. Apparently the rating percentages of the WCRV move to the next rating of the range condition. For example, the WCRV is 6 %, 18 %, 47 % and 29 % for excellent, good,

Table 20. A comparison of SLS watershed condition scorecard (this study) and the SCS condition survey (taken from SCS Resources Inventory, 1982--March 1985. (SCS, Emporia Office, personal contact).

Acres	Condition	R/P (CP)* %	R/P (SL)$ %	WCRV %
43,000	EXCELLENT	15	29	6
144,000	GOOD	50	13	18
83,000	FAIR	29	12	47
19,000	POOR	7	6	29

* - Range condition survey "clip-plot" method SCS
$ - Range condition survey "step-loop" method USFS

Divide Acres by 2.47 = Hectares

fair and poor. The percentage for excellent R/P (CP) is 15 % and the WCRV is 6 %. For good rating, the R/P (CP) is 50 % and the WCRV is 18 %. The percentages for fair R/P (CP) and WCRV are 29 % and 47 % respectively. The poor percentage for R/P (CP) is excellent for WCRV. This apparently shows the effect of the other factors in the watershed condition scorecard.

The Watershed Condition Rating Value (WCRV)

When all of the fore-mentioned factor values (range condition, ground cover, management and conservation, relative erosion potential (SER and TWPEDI)) were added together, the score was rated by scale from excellent to poor. Appendix C shows all of these factor values and scores for each watershed. As was discussed in the section under TWPEDI, categories were deemed necessary to report accurate results. Table 21 shows the WCRV ratings for each category (notice one very poor is put in with poor percentages). The watershed scorecard rating can be changed by manipulating the values. This is done by improving management and conservation, thus stabilizing or increasing long term production. For comparison, Table 22 shows TWPEDI ratings for each category.

The most important factor was the management and conservation practices factor. This was the factor that all of the other factors evolve from. Range condition and ground cover were effected by grazing, fencing and other management techniques. The TWPEDI was directly associated with the range condition since it uses the plant composition as part of the survey. The soil erodibility rating reflected both natural and management characteristics. Apparently, the

Table 21. WCRV ratings for each watershed studied.

Watershed Number	TOTAL NUMBER OF SAMPLES 295 - 715	744 - 1146	1468 - 2969
J- 1	POOR		
N- 2			EXCELLENT
L- 3	VERY POOR		
A- 4		GOOD	
H- 5		FAIR	
I- 6		FAIR	
F- 7		FAIR	
E- 8	POOR		
D- 9		FAIR	
M-10	FAIR		
B-11	GOOD		
G-12	POOR		
Q-13			FAIR
C-14	GOOD		
P-15			FAIR
O-16		FAIR	
K-17			POOR

Table 22. TWPEDI ratings for each watershed studied.

Watershed Number	TOTAL NUMBER OF SAMPLES 295 - 715	744 - 1146	1468 - 2969
J- 1	FAIR		
N- 2			GOOD
L- 3	FAIR		
A- 4		EXCELLENT	
H- 5		FAIR	
I- 6		FAIR	
F- 7		GOOD	
E- 8	FAIR		
D- 9		EXCELLENT	
M-10	POOR		
B-11	EXCELLENT		
G-12	GOOD		
Q-13			FAIR
C-14	EXCELLENT		
P-15			GOOD
O-16		FAIR	
K-17			FAIR

best way to improve the watershed production and ecology is through management and conservation practices.

Statistical Analysis

In addition to the T- and F-tests, several other trials and testing methods were attempted. These included correlations using all 17 areas (inclusive method) and "categorized" (categorized method) by the "total number of samples" (I, II, III).

The Categorized Method

This method involved correlations using the total number of samples (T#S) categories.

As a result of the data obtained, the variability of watershed size and total number of samples taken, a categorized approach was deemed necessary.

A correlation coefficient was calculated for the relationship between sediment yield from the entire watershed (SY1) and watershed condition rating (sediment yield was not used in the watershed score-card rating or WCRV) using the total number of samples (T#S) rating; (I, II, III) categories. Categories I, II, III represent the T#S 295-715, 744-1,146, 1,468-2,969 respectively.

When graphed, SY1 was the dependent variable. Watershed condition (WCRV) was the independent variable. It lacked sediment yield data in its development.

Category I contained seven watersheds whose T#S values ranged from 295 to 715. The calculated r2 value using an exponential curve equation was 0.583 (Y = 8.936) which was between -1 and 1. This demonstrates a positive correlation between (SY1) and (WCRV) for those watersheds in Category I. The critical value for r is 0.811 (d.f = 4, $p < 0.05$). A boundary line curve analysis (Webb 1972) was fitted to the coordinates satisfactorily using an exponential curve method. However, the scatter diagram shows a non-rectilinear relationship (Figure 54).

Category II contained six watersheds whose T#S value is from 744 to 1146. The calculated r2 value using a logarithmic equation was 0.002 (Y = 4.02) which is between -1 and +1. There was a very low positive correlation between SY1 and WCRV for those watersheds in Category II. The critical r = 0.878 (d.f. = 3, $p < 0.05$) showing no significance. A scatter diagram shows a non-rectilinear relationship. The boundary line curve did not fit the data satisfactorily and actually consisted of what appears to be a straight line (Figure 55).

Category III contains four watersheds whose T#S from 1468 to 2969. The calculated r2 = 0.016 (Y = 1.513) using an exponential equation curve and r2 = 0.233 (Y = 3.064) using a logarithmic equation. Both r2 values were between -1 and +1. This demonstrates a positive correlation between SY1 and WCRV in Category III. The critical r 0.969 (d.f. = 1, $p < 0.05$). There was no significant correlation. The boundary line curve for the exponential equation, i.e. r2 = 0.016 consisted of a much straighter line than using the logarithmic equation (Figure 56).

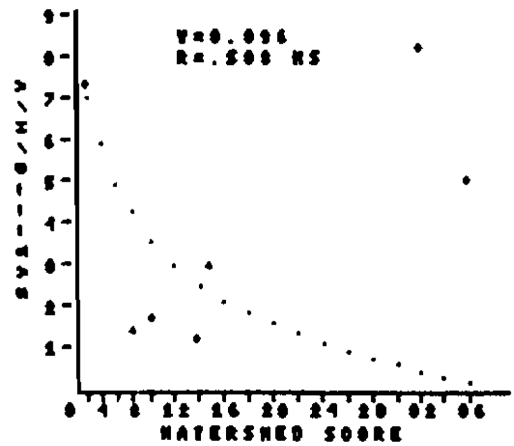
<u>The Inclusive Method-(using all 17 study-areas)</u>

The inclusive method used all 17 watersheds in the analysis. A correlation coefficient r was calculated for the relationship between sediment yield (SY1) and several component values of the watershed condition scorecard. Included were range consition (R/C) percent,

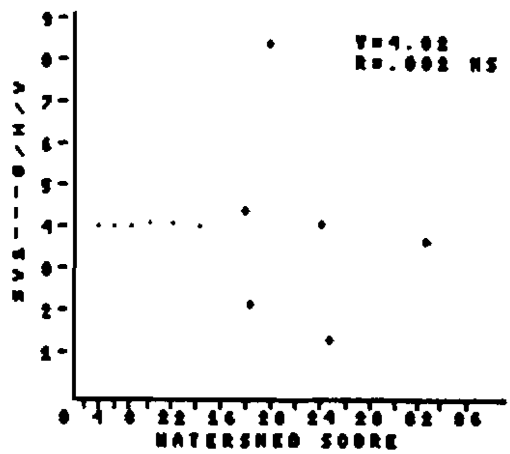
Figure 54. Boundary line analysis (using exponential curve method, gross sediment yield (SY1) vs. watershed scorecard (WCRV) for Category I (total number of samples = 295 to 715).

Figure 55. Boundary line analysis (using loga-rythmic curve method), gross sediment yield (SY1) vs. watershed scorecard (WCRV) for Category II (total number of samples = 744 to 1146).

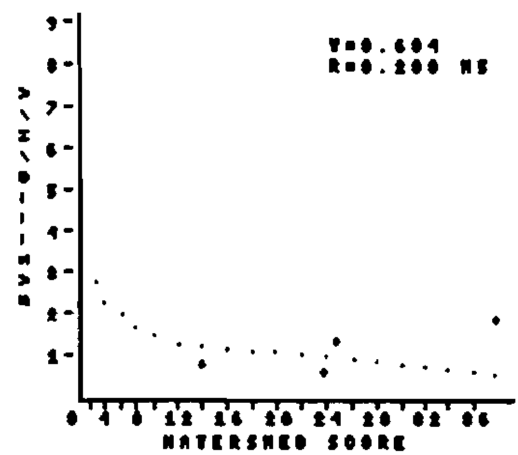
Figure 56. Boundary line analysis (using loga-rythmic curve method, gross sediment yield (SY1) vs. watershed scorecard (WCRV) for Category III (total number of samples = 1468 to 2969).



FOR
TOTAL NUMBERS OF SAMPLES
295-715



FOR
TOTAL NUMBERS OF SAMPLES
744-1146



FOR
TOTAL NUMBERS OF SAMPLES
1460-2969

ground cover index (GCI) percent, soil erodibility rating (SER), the total watershed plant erosion deterrence index (TWPEDI) and watershed condition rating value (WCRV) respectively. All critical r values = 0.497 (d.f. = 14, $p < 0.05$).

There was no significance between correlation coefficients SY1 vs. R/C, GCI, SER, TWPEDI or WCRV values.

Other relationships, were graphed using the boundary line analysis and logarithmic equation with data from the inclusive method. This was done by utilizing WCRV as dependent variable and % EW as the independent variable where Y = 35.29 and r2 = 0.076. The r2 value displayed a low correlation which was not significant ($p < 0.05$).

Using a Computer-Based Multiple Regression-Correlation Analysis

Through trial analysis including T- and F-tests, it was deemed necessary to use a more involved analysis. To fulfill this need, a software program for multiple regression and correlation (MULREG- (C) F. James Rohlf 1984) was used. This program was able to do multiple variable analysis (Tables 23a-b).

A series of treatments were utilized in order to remove nonsignificant factors; lessening error tendencies. The program performed an analysis of variance (ANOVA) for 15 variables. In addition, a single variable was correlated with all the others. The variables and abbreviations used were as follows: range condition (RC), ground cover index (GCI), management...factor (MCPF), soil erodibility rating (SER), total plant...index (T..I), watershed...value (WV) (these are all variables in the watershed scorecard). In addition, there were several variables which were used in the development of those fore-mentioned

Figure 57. Boundary line analysis (using loga-rythmic curve method, for the relationship between percentage of eroded watershed (%EW) and watershed scorecard values (WCRV).

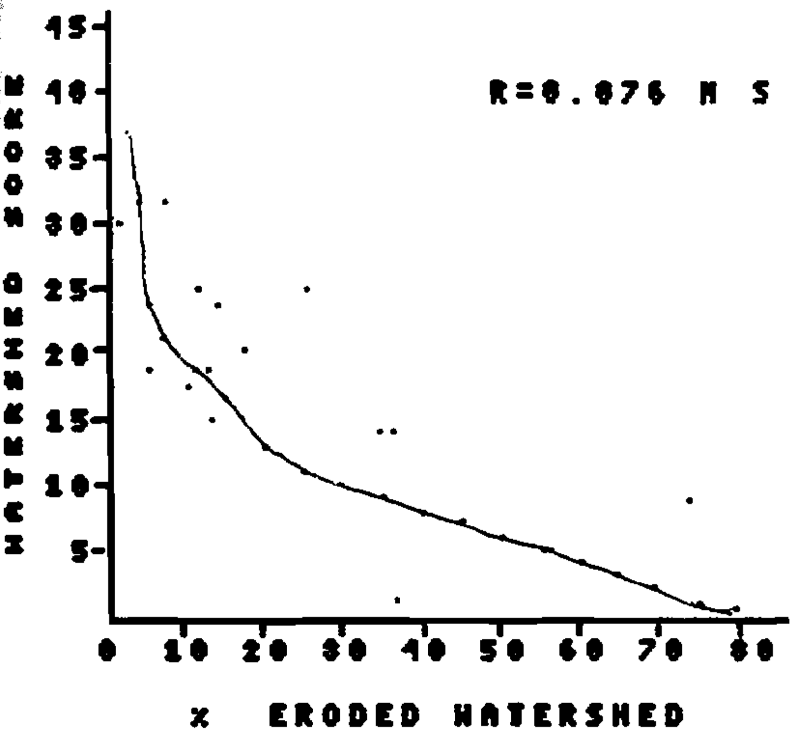

R=0.876 N S
45
40
35
30
25
20
15
10
5
0
10
20
30
40
50
60
70
80
% ERODED WATERSHED

Table 23a. Data from correlation matrix MULREG BIOM-PC package (CF James Rohlf 1984). Dependent variable = WY..SY1.

	RC	GCI	MCPF	SER	TWPEDI
RC	1.000	REP	REP	REP	REP
GCI	-0.352	1.000	REP	REP	REP
MCPF	0.116	0.635	1.000	REP	REP
SER	-0.019	0.440	0.510	1.000	REP
T.I	-0.003	0.424	0.386	0.462	1.000
WV	0.189	0.634	0.840	0.843	0.624
% EW	-0.069	-0.340	-0.464	-0.899	-0.448
PA	0.354	-0.075	0.347	-0.148	-0.040
DS	0.549	-0.184	0.043	-0.022	-0.335
SY1	-0.333	-0.207	-0.152	0.178	0.259
SY2	-0.466	0.346	0.387	0.392	0.510
ECSL	0.053	-0.455	-0.490	-0.992	-0.450
CF	0.126	-0.204	-0.150	-0.242	-0.133
MTSL	0.167	-0.123	0.192	0.321	0.285
T#S	0.730	-0.055	0.170	0.899	-0.031

(See List of Abbreviations)

Note: REP - designates reciprocal correlations (RC to GCI or GCI to RC).

All were nonsignificant $p < 0.05$.

Table 23b. Data from correlation matrix MULREG BIOM-PC package (CF James Rohlf 1984). Dependent variable = SY1

	WV	% EW	PA	DA	SY1
RC	REP	REP	REP	REP	REP
GCI	REP	REP	REP	REP	REP
MCPF	REP	REP	REP	REP	REP
SER	REP	REP	REP	REP	REP
T.I	REP	REP	REP	REP	REP
WV	1.000	REP	REP	REP	REP
% EW	-0.761	1.000	REP	REP	REP
PA	0.149	0.236	1.000	REP	REP
DS	0.549	-0.184	0.043	1.000	REP
SY1	-0.024	-0.209	-0.628	0.178	1.000
SY2	0.373	-0.353	-0.299	-0.340	0.545
EXAL	-0.819	0.924	0.223	0.031	-0.221
CF	-0.200	0.203	0.118	0.062	-0.274
MTSL	0.340	-0.127	0.518	-0.081	-0.263
T#S	0.244	-0.181	0.150	0.860	-0.401

Note: REP - designates reciprocal correlations (RC to GCI or GCI to RC).

All were nonsignificant $p < 0.05$.

values. These include percent of eroded watershed (% ES), pond age (PA), drainage size (DS), estimated...soil loss (ECSL), cover factor (CF), mean tolerable soil loss (MTSL) and total number of samples (T#S). The remainder of variables, sediment yield (SY1) and sediment yield using percentage eroded watershed (SY2), were not related to the scorecard and were individual measures.

Analysis of Residuals

The analysis or residuals (AOR) quantified the error between the observed and expected for designated variable, SY1, SY2 and PD, with the other variables for each treatment. The 95 % confidence level was indicated by numerical values from -1.97 to 1.97 (on printout). A brief summary of residual analysis for each treatment will follow.

Results of the Multiple Regression-Correlation Analysis

This analysis involved three major tests A, B and C. Test A used the sediment yield using the percent of eroded watershed (SY2). Test C used two added variables; peak discharge (PD) and runoff volume (R3).

Test A: Dependent Variable...Sediment Yield (SY1)

The first test (A) involved all 15 variables. An ANOVA showed that only one variable, drainage size, was significantly correlated (d.f. = 1, 2; $p < 0.05$).

The dependent variable SY1 was correlated with all variables and a correlation matrix was developed. The multiple correlation coefficient was 0.99 and the multiple correlation coefficient squared was 0.98 ($p < 0.05$).

AOR values for Treatment A15SY1 ranged from 1.4. to -1.41. One hundred percent were within the 95 % confidence interval (Table 24).

From the matrix previously mentioned, all variable correlations less than 0.34 and 0.40 were removed to lessen errors in analysis. This matrix correlated each variable with other variables and itself. Several treatments were analyzed.

Treatment 1A5SY1 used those variables whose correlations were greater than 0.34. These included PA, DS, SY1, SY2 and T#S.

Test B: Dependent Variable...Sediment Yield (SY2)

The second test (B), involving all 15 variables, used the percent of eroded watershed sediment yield (SY2). An ANOVA showed no significant difference (d.f. = 1/12; $p < 0.05$).

The correlation coefficients of dependent variable SY2 were calculated. A correlation matrix was developed. Only the multiple correlation coefficient was significantly different ($p > 0.05$).

AOR values for Treatment B15SY2 ranged from -1.40 to 1.41. One hundred percent were within the 95 % confidenced limits.

Treatment B11SY2 utilized all variables whose correlation coefficients were values greater than 0.34. In all there were 11: RC, GCI, MCPF, SER, T..I, WV, % EW, DS, SY1, SY2, ECSL. Calculated r values ranged from 1.00 (the variable and itself) to -0.99. The highest correlations were found between the SER and ECSL (-0.99), % EW and ECSL (0.92), WV and SER (0.84) and WV and MCPF (0.84) (Table 23a-b).

The ANOVA using SY2, showed no significant difference (d.f. = 1/6 $p < 0.05$). The multiple correlation coefficient value using SY 2 was 0.98 with $p > 0.05$. The multiple correlation coefficient squared value was 0.86 ($p > 0.05$).

Table 24. Results from multiple regression correlation matrix MULREG BIOM-PC package (CF James Rohlf 1984).

TEST	NOVA	MCC	MCCsq	AOR
A15 SY1*	DS	+	-	17—100 %
A5 SY1*	PA	+	-	14-- 82 %
B15 SY2*	0	+	NS	17—100 %
B11 SY2*	% EW	+	+	17—100 %
B5 SY2*	0	+	-	16— 98 %
C13 PD*	DS	+	+	17—100 %

*- Designates the dependent variable in that test.

\- $p < 0.05$

\+ $p > 0.05$

AOR values for Treatment B11SY2 ranged from -1.97 to 1.92 with. One hundred percent were within the 95 % confidence limit.

Treatment B5SY2 used only the variable correlation values greater than 0.40. This stipulation decreased the variable number from 11 to five. From the correlation matrix, correlation values ranged from 1.00 to -0.003 and overall the number of negative values were approximately equal to the number of positive values. The highest correlation value was 0.56 (SY1 and SY2) (d.f. = 11; $p > 0.05$).

ANOVA of the five variables demonstrated no significant difference (d.f. = 11; $p < 0.05$). The multiple correlation coefficient using the SY2 was 0.76 (d.f. = 11; $p < 0.01$). Therefore, there was a significant correlation. The multiple correlation coefficient squared value was 0.58 ($p < 0.05$).

AOR values for Treatment B5SY2 ranged from -1.29 to 3.23. Ninety-four percent were within the 95 % confidence interval.

Test C: Dependent Variable...Peak Discharge (PD)

Test C added two more variables to the 11 mentioned above, peak discharge (PD) and runoff volume (R3). These are not directly used in the watershed scorecard. However, physical characteristics were used in their computations.

The correlation matrix demonstrated a range of correlation values from -0.05 to 1.00. The highest was 0.96 (PD and DS) ($p > 0.05$) (PD and DS) and 0.56 (RC and PD) ($p < 0.05$).

The ANOVA showed only one (DS) significantly different. The multiple correlation coefficient using the PD variable was 0.98 ($p > 0.05$). The squared multiple correlation coefficient value was

0.96 (p > 0.05).

AOR values for Treatment C13PD ranged from -1.64 to 1.70. One hundred percent were within the 95 % confidence interval.

An Introduction to the MUSLE and Comparison of the WSLE Ly17

The MUSLE (Modified Universal Soil Loss Equation) substitutes the runoff energy factor for the rainfall factor in the USLE to predict sediment yield (Williams 1975).

The MUSLE was utilized on watersheds in Texas and Oklahoma. The results of predicted and measured sediment yields per event were compared. Only one (cropland) was significantly different (p > 0.05). "Mean sediment yield per event ranged from essentially none to 812 kg/ha on watershed Y10" (Smith et al 1984).

A modification was made in the K factor of the MUSLE. According to the slide rule calculator used to EFCSL values (using the WSLE LYL7), A "T/K" factor was substituted for the K factor. Smith's watershed's studies K factor ranged from 0.28 to 0.37. The "T/K" factor used in my study ranged from 8.57 to 13.92. Although the difference was obvious, it was decided the T/K value best represented that factor which was necessary in this study.

EFCSL results were first compared to the original PMSY (sediment yield using the MUSLE). It was obvious that there was a significant difference between these two (Table 25).

In addition to the modification previously mentioned, adjustments in the P factor were also used (Williams 1975). An adjusted management P factor (AMPF) correlating with the MCPF of the watershed scorecard was substituted into the MUSLE (PASY). PASY results were compared to

Table 25. The MUSLE (modified universal soil loss equation and its value for 17 study areas in Lyon County. Due to the high variability in the values, a paired test of significance between columns 3 and 4 and 6 and 7.

WS#	1 EFCSL	2 MTSL	3 PMSY	4 PASY	5 PA Yr.	6 AASY	7 MASY
	(Kilograms per Hectare)					Kgr./Ha./Yr.	
1	26,100	8,100	226,875	226,875	36	6,302	9,864
2	10,125	10,125	227,401	27,740	56	495	1,206
3	32,175	8,325	172,968	259,453	7	37,065	11,281
4	11,925	9,765	27,001	16,201	36	450	704
5	13,050	8,775	34,737	31,263	27	1,158	1,359
6	15,075	6,975	225,393	225,393	12	18,783	9,780
7	11,025	11,250	149,946	134,952	27	4,998	5,867
8	52,500	6,975	83,633	100,359	36	2,788	4,363
9	12,825	6,750	271,722	133,391	9	14,821	5,780
10	10,125	6,975	295,254	346,431	17	20,378	15,062
11	6,075	8,550	12,523	92,512	7	1,789	544
12	23,175	8,550	99,023	111,401	24	4,642	4,844
13	18,000	7,650	725,145	248,621	12	20,718	10,810
14	4,275	7,425	41,307	32,128	11	2,921	1,397
15	17,100	7,425	581,267	313,884	26	12,072	13,647
16	14,400	6,975	74,358	66,224	8	8,365	2,910
17	25,650	8,325	298,983	82,347	36	2,287	3,580

1) EFCSL - This is the abbreviation for the "estimated factored current soil loss: which adds the product of the CSL for eroded areas only (using the 0.45 value) times the percent of area eroded to the CSL of the covered areas using the cover value (from ground cover %) times the remaining percentage to get an estimated soil loss which includes the bare ground and covered areas.
2) MTSL - is an average of the entire watershed's tolerable soil loss (using 0.45 and cover values).
3) PMSY - this value was calculated using the original MUSLE...11.8i (QPq) (exp. 0.56) KCPSL, (Williams 1975; Smith et al 1984) to predict sediment yield in a given period of time.
4) PASY - this value was calculated using an adjusted "P" factor derived from the MCPF and scale (Table 26) inserted into the MUSLE.
5) PA - Pond age
6) AASY - this value (predicted adjusted annual sediment yield) was calculated by dividing the PASY value by the pond age.
7) MASY - this value was calculated by dividing PASY values by the mean pond age of the 17 watersheds (23).

the EFCSL results. It was again obvious that these two estimates were significantly different (without a t-test).

PMSY results were compared to PASY results to test the adjusted P factor. The original P factor was 1.0 for unity of conservation (terracing, etc. was given different values) on cropland. It was apparent from the MSY results that an adjustment related to conservation and management practices characteristic to each watershed was necessary.

Comparing Watersheds N-2 and E-8 with the Adjusted MUSLE

For example, watershed N-2 had the highest WCRV (37), a SER value of 0 (MTSL equalled EFCSL values) and a .9 % EW. Its PMSY value was 277,400.74 kg/ha/yr using the MUSLE. In comparison, E-8 had a low WCRV (4), a SER value of -18 and the highest % EW (74). Its PMSY value was 83,632.63 kg/ha/yr. In as much as the physical watershed characteristics were comparable, this was illogical. Other cases were similar. It was evident that the adjustment had to be associated with the MCPF of the scorecard. The AMPF and MCPF values were correlated in a scale from 0.1 to 1.5 (Table 26). The MCPF for N-2 was 12, its AMPF was 0.1. E-8's MCPF was 4 with an AMPF of 0.8. The significance of the adjustment factor was the difference from 1.0 to 0.1 and 0.5 respectively. When the AMPF was substituted into the MUSLE, the PASY for N-2 and E-8 was 27,720.07 and 100,359.16 kg/ha/yr respectively. N-2's PASY decreased by 252,000 kg/ha/yr. However, E-8's PASY increased

Table 26. Scale for MCPF and P factor in MUSLE.

MCPF	P
- 5	1.5
- 4	1.4
- 3	1.3
- 2	1.2
- 1	1.1
1	1.0
2	.9
3	.9
4	.8
5	.8
6	.7
7	.6
8	.5
9	.4
10	.3
11	.2
12	.1

1) MCPF - Management and conservation practices factor of the WSLE Ly17.

2) P - Practices factor of the MUSLE (Williams 1975; Smith et al 1984)

by 16,000 kg/ha/yr. A test of significance showed no significant difference ($p < 0.05$).

It must be pointed out that the EFCSL is an estimate of average current soil loss per area and sediment yield is the annual measurement of sediment measured at (a) given location(s). The original USLE was an estimate of average current soil loss. Theoretically it may be difficult to compare non-annual estimates to annual measurement.

A General Comparison of PASY with Smith's Study Results

Smith's literature lacked several items making an accurate comparison almost impossible. In addition, this study lacked gauging stations (rainfall and sediment measurement) which would have been beneficial in a more precise comparative analysis. Due to the lack of precise measurements, my research used a sediment yield per hectare per year. Smith's study used a kg/ha/event measurement. If a hypothetical situation is used, ASY results appear to be somewhat comparable to Smith's results. For example, some watersheds were monitored for three to four years, however in that time, the number of events ranged from 4 to 50. As was previously mentioned Smith's SY results ranged from virtually none to 812 kg/ha/event. My ASY results ranged from 346,431 to 16,200 kg/ha/yr. If the highest SY in Smith's study (812) and its corresponding event number (23) were multiplied, the SY would be 18,676 kg/ha. The sediment yield for four years would be 3,248 kg/ha/yr. If pond ages (ranging from 7 to 56 years) were used in the ASY, values would range from 450 to 20,718 kg/ha/yr. The PASY and the AASY were obviously significantly different.

This demonstrated that the pond age could be the deciding factor in the AASY. Several technical aspects, climate and watershed characteristics (i.e. soil type and runoff) differed. However, some general similarities are evident. In addition, the results of Smith's sediment yield study may not be compared with the results of this estimated soil loss study because of the lack of specific data.

Comparing the AASY and MASY values

In as much as PA had a high variability, the PASY was divided by the mean PA of approximately 23 years. The result was the predicted adjusted sediment yield (using the mean PA (MASY). (These results were shown in Table 25.) A paired test of the 17 watersheds showed a significant difference between mean AASY and MASY values ($p > 0.05$). Eight watersheds showed a decrease in MASY values with the remaining showing increases. The largest and smallest decreases between AASY and MASY values were observed in watersheds L-3 and B-11 respectively. The largest and smallest increase between values were observed in watersheds J-1 and H-5 respectively.

Conclusion

The results of this study indicated that much more research on watershed dynamics are needed in this region. Aspects of watershed management including data for measured, observed and calculated variables are necessary to understand and manage watersheds for all land uses. In addition, results of the scorecard indicated that all of the factors within are related to the MCPF. The MCPF factor significantly correlated with the WCRV.

The comparisons between the values using WSLE Ly17 and MUSLE demonstrated some validity in the total watershed condition approach. Even though there was a significant difference between the EFCSL and AASY values, EFCSL is a soil loss estimation and AASY is the predicted annual sediment yield. Perhaps these two values are incomparable due to this difference.

The multivariate factor approach to watershed evaluation and sedimentation has some validity. A study correlating watershed factors to sedimentation used an equation which included slope, age, gross erosion, non-incised channel density, and a watershed shape factors (Stall and Bartelli 1959).

It is recognized that this research was developed for landowner use and may be inconclusive. However, it may also be useful for professional managers in this region.

SUMMARY

Sediment Measurement by-Probing

Several tallgrass watershed characteristics and aspects of watershed management were analyzed in 17 watersheds in Lyon County. Measurements included sediment yield by the probe method and range condition and ground cover using the step-loop method.

The probe was tested as an alternative to other methods (reservoir trap, etc.). The probe was inefficient in measuring sediment yield. Yields ranged from 0.59 to 8.38 g/h/y. Sediment yields are usually measured in kilograms per hectare per year or tons per square mile per year. Several circumstances were responsible including number of sediment samples per sampling area differences in sampling areas (shape and condition). It did appear to be useful as a sediment sampler for composition (particle size testing).

The Watershed Scorecard

A system for evaluating watershed condition was developed from observations and calculations of established watershed data; similar to those found in the USLE. In addition, range condition and ground cover measurements, using an accepted method, were also utilized. The MCPF was derived from observations of management, conservation practices and land uses. An equation (WSLE Ly17) utilizing the estimated soil loss (USLE) for percent covered and bare ground areas resulted in the EFCSL. A soil stability rating was derived from the relationship ber percent covered and bare ground areas resulted in the EFCSL. A soil stability rating was derived from the relationship between the EFCSL and MTSL for each watershed resulted in the SER values. Calculations utilizing range condition and composition resulted in a plant erosion deterrence rating for individual species for each watershed (TWPEDI). The RC, GCI, MCPF, SER and TWPEDI ratings were added together to obtain a watershed condition value for each watershed. SY1 values were used to estimate the SY 2 values which helped locate nonpoint sediment source areas.

Statistical Analysis

Numerous measurements and calculations were correlated using the "Boundary analysis" and the MULREG computer program. Results showed some correlation between variables; however, the number of watersheds analyzed appeared to be insufficient. The total number of variables (15) was two less than the number of watersheds studies (17). Apparently these circumstances made the correlations less significant. More study areas need to be analyzed. T-tests and F analysis ($p = 0.05$) were used to test significance of means and variances.

Testing the WSLE Ly17

In as much as no accurate sediment measurement was obtained, data from the WSLE Ly17 equation (EFCSL) were used in the MUSLE (PMSY) to compare soil loss and predicted sediment yields. A non-tested significant difference was obvious. In order to better analyze these results, several manipulations including adjusted T/K and P factors inserted into the MUSLE resulting in the PASY values. PASY values were divided by PA values to obtain the annual sediment yield values (AASY). In as much as PA varied from 7 to 56 years, the AASY was divided by the mean PA (23). The results (MASY) was compared to the AASY. A T-test showed a significant difference ($p > 0.05$).

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APPENDIX A

APPENDIX A

Kansas Range Site Description

"LRA 76 - Bluestem Hills (Flint Hills) - An area of deeply dissected limestone and shale uplands 1,000 to 1,600 feet above MSL."

Climate

The mean annual precipitation is 30 to 36 inches from west to east across the LRA. Annual precipitation will vary from 20 to 50 inches of which 65 to 70 % can be expected during the grow season (with April through August the heaviest months). The wind velocity is quite high throughout the year, averaging 9 to 12 miles per hours. It is usually highest in March and April." (An excerpt from Soil Conservation Service Technical Guide, SCS-AS411, personal contact).

Kansas Range Site Description

"LRA 112 - Cherokee Prairies - Gently sloping dissected plains that are underlain by sandstones, limestones, and shale. This loess mantles the northern part. Elevation is 700 to 1,200 feet above MSL.

Climate

The mean annual precipitation varies from 35 to 42 inches from west to east but has varied from 22 to 55 inches. Generally, 65 to 70 % of the annual precipitation occurs during the growing season with May, June and September the heaviest months. The wind velocity is moderately high throughout the year, averaging 7 to 11 miles per hour. It is usually highest in March and April." (An excert from Soil Conservation Service Technical Guide, SCS-AS411, personal contact.)

TABLE 1. PHYSICAL CHARACTERISTICS OF SOIL PROFILES FOUND ON STUDY SITES (continued)

	INCHES DEPTH	RATING	RATING	RATING	IN/IN	T O P S O I L	IN/HR	
KENOMA								
Ka	$10^{35}/60^{4}/0$	medium	moderate	medium	0.22-0.24	high	0.2-0.6	very slow
Kb*	$6^{53}/45^{4}/0$	low	mod.low	medium	0.22-0.24	high	0.2-0.6	very slow
Kc	$10^{35}/48^{4}/0$	medium	moderate	medium	0.22-0.24	high	0.2-0.6	very slow
Kd*	$6^{53}/40^{4}/0$	low	mod.low	medium	0.22-0.24	high	0.2-0.6	very slow
LABETTE								
La	$8^{5}/25^{54}/38$	medium	moderate	medium	0.21-0.24	medium	0.2-0.6	slow
Lb	$8^{5}/20^{54}/38$	medium	moderate	medium	0.21-0.24	medium	0.2-0.6	slow
Lc*	$4^{5}/20^{54}/30$	low	mod.low	medium	0.21-0.24	medium	0.2-0.6	slow
LABETTE	$8^{53}/25^{54}/38$	θ	θ	slow	0.21-0.24	medium	0.2-0.6	slow
Ld complex								
DWIGHT	$4^{3}/45^{4}/49$	θ	θ	slow	0.21-0.24	medium	0.6-2.0	slow
MARTIN								
Ma	$13^{54}/60^{4}/0$	high	moderate	medium	0.21-0.23	high	0.2-0.6	slow
Mb	$12^{54}/60^{4}/0$	high	moderate	medium	0.21-0.23	high	0.2-0.6	slow
Mc*	$5^{45}/60^{4}/0$	medium	mod.low	rapid	0.21-0.23	high	0.2-0.6	slow
TULLY								
Ta	$10^{5}/60^{54}/0$	medium	moderate	medium	0.18-0.23	high	0.2-2.0	slow
Tb*	5/45/0	low	mod.low	medium	0.18-0.23	high	0.2-2.0	slow
TULLY	$10^{5}/60^{54}/0$	θ	θ	rapid	0.18-0.23	high	0.2-2.0	slow
Tc complex								
CLIME	$8^{4}/11^{4}/34$	θ	θ	rapid	0.12-0.20	low	0.06-0.6	slow

TABLE 1. PHYSICAL CHARACTERISTICS OF SOIL PROFILES FOUND ON STUDY SITES

SOIL TYPE	SOIL** TOP/SUB BDRK/SHALE	NATURAL FERTILITY	ORGANIC MATTER	SURFACE RUNOFF	AVAILABLE WATER CAPACITY	R FACTOR	PERMEABILITY (SURFACE LAYER)	R FACTOR
	INCHES DEPTH	RATING	RATING	RATING	IN/IN T O P S O I L		IN/HR	
CLIME								
Cb	$8^{4}/15^{4}/34$	medium	moderate	medium	0.12-0.20	low	.06-0.6	slow
Cc*	$5^{4}/7^{4}/28$	low	mod.low	medium	0.12-0.20	low	.06-0.6	slow
SOGN	$9^{5}/-/9$	θ	θ	rapid	0.17-0.22	very low	0.6-2.0	slow
Cd complex								
CLIME	$4^{4}/11^{4}/34$	θ	θ	rapid	0.12-0.20	low	.06-0.6	slow
ELMONT								
Ea	$12^{3}/36^{5}/48$	medium	moderate	medium	0.19-0.24	high	0.6-2.0	mod.slow
Eb	$12^{3}/36^{5}/48$	medium	moderate	medium	0.19-0.24	high	0.6-2.0	mod.slow
Ec*	$6^{53}/35^{5}/41$	low	mod.low	medium	0.19-0.24	medium	0.6-2.0	mod.slow
ERAM								
Ed	$9^{35}/25^{4}/34$	medium	moderate	medium	0.16-0.24	medium	0.2-2.0	slow
Ee*	$6^{543}/19^{4}/24$	low	mod.low	medium	0.15-0.19	low	0.2-0.6	slow
BATES	$7^{3}/20^{4}/27$	θ	θ	rapid	0.16-0.24	low	0.2-2.0	moderate
Ef complex								
ERAM	$7^{3}/24^{2}/31$	θ	θ	rapid	0.20-0.22	low	0.6-2.0	slow
FLORENCE	$13^{3}/33^{51}/46$	θ	θ	rapid	0.08-0.15	low	0.6-2.0	moderate
Fa complex								
LABETTE	$8^{5}/25^{54}/38$	θ	θ	rapid	0.21-0.24	medium	0.2-0.6	slow

* - Eroded soil
** - 1) Clay; 2) Clay Loam; 3) Silty Loam; 4) Silty Clay; 5) Silty Clay Loam (particle size)
θ - Data not available

TABLE 1. PHYSICAL CHARACTERISTICS OF SOIL PROFILES FOUND ON STUDY SITES (continued)

	INCHES				T O P S O I L			
	DEPTH	RATING	RATING	RATING	IN/IN		IN/HR	
<u>LADYSMITH</u>								
Le	8/29/31	medium	moderate	slow	0.21-0.23	high	0.2-2.0	very slow
<u>BATES</u>								
Ba	9/25/34	medium	moderate	medium	0.20-0.22	low	0.6-2.0	moderate
<u>ZAAR</u>								
Za	14/60/0	high	moderate	medium	0.12-0.18	high	< 0.06	slow

* - Eroded soil
** - 1) Clay; (2) Clay Loam; 3) Silty Loam; 4) Silty Clay; 5) Silty Clay Loam (particle size)
θ - Data not available
(information taken from Lyon County Soil Survey - USDA Conservation Service - 1981)

STUDY AREA ROSTER

WATERSHED		SOIL TYPE(S)	TYPE-PERCENTAGE OF SLOPE	LAND USE	HECTARES
#5	J1	Fa, Cd, Ta, Tb, Ed, Tc	Tully-Clime Complex (7-15); Eram (3-6) Clime-Sogn (5-20); Tully (2-7)	Grazed	13.1
#4	N2	Ka, Eb, Ea	Kenoma (1-3); Elmont (1-7)	Grazed*	16.6
#5	L3	Kb, Ka, Fa, Cd, Kd	Kenoma (1-7); Florence-Labette (2-12) Clime-Sogn (5-20); Kenoma (3-6)	Go Back Grazed	14.9
#5	A4	Za, Cd	Zaar (2-5); Clime-Sogn (5-20)	Grazed	4.7
#5	H5	Fa, Tc	Tully-Clime Complex (7-15) Florence-Labette Complex (2-12)	Grazed	10.9
#3	I6	Ma, Mb, Cd, La, Le (Slope eroded)	Labette (1-3); Labette (2-6) Clime-Sogn (5-20; Martin (4-7)	Go Back Grazed	12.8
#3	F7	Ka, Eb, Le	Kenoma (1-3); Elmont (4-7) Ladysmith (0-2)	Grazed*	9.4
#3	E8	Db, Ka, Eb, Le (Slope eroded)	Kenoma (1-3); Elmont (4-7) Ladysmith (0-2)	Grazed	8.1
#4	D9	Cd, Cb, Ld (Slopes eroded)	Clime (3-7); Labette-Dwight Complex (0-2) Clime-Sogn (5-20)	Grazed	7.7

STUDY AREA ROSTER

WATERSHED		SOIL TYPE(S)	TYPE-PERCENTAGE OF SLOPE	LAND USE	HECTARES
#3	M10	Le, Ef, Ed, Cd, Le (Slopes eroded)	Eram (6-15); Eram & Bates (6-15) Clime-Sogn Complex (5-20); Ladysmith (0-2)	Grazed	16.4
#3	B11	Ma, Ea, Ed, Ka, Mc (Slopes eroded)	Elmont (1-6); Martin (1-7) Kenoma (1-3)	Non-grazed	5.0
#5	G12	Ld, Fa, Tc	Tully-Clime Complex (7-15) Labette-Dwight Complex (7-15) Florence-Labette Complex (2-12)	Grazed	10.4
#1	Q13	Cd, Cc, Mb, Mc (Slopes eroded)	Clime-Sogn (5-20); Martin (1-7)	Grazed	44.8
#3	C14	Ed, La	Eram (3-6); Labette (1-3)	Grazed Hayed	5.3
#5	P15	Ka, Kb, Cc, Cd, Cb, Lc, Ld, La, Le (Slopes eroded)	Kenoma (1-3); Klime (3-7) Clime-Sogn (5-20); Ladysmith (0-2) Labette (1-6); Labette-Dwight Complex (0-2)	Grazed Rested Hayed	37.1
#3	O16	Mc, La, Mb, Lb (Slopes eroded)	Martin (4-7); Labette (3-6)	Go Back Grazed	17.0
#3	K17	Mb, Mc, Lb (Slopes Eroded)	Martin (4-7): Kenoma (1-3)	Hayed Grazed	14.0

(Some information taken from Lyon County Soil Survey - USDA Soil Conservation Service--1981)

Use with soil survey legend, page 97.
* Rested for last seven years.

Equations used in this research

WSLE Ly17 - (CSL(C) % c) + (CSL(B) % e) = EFCSL

1) USLE - RxCxKxPxSL = estimated mean annual soil loss

2) MUSLE - 11.8 (QqP) KxCxPxSL: where Q = runoff volume in m ; qP = peak runoff rate in m /sec.; K = soil erodibility factor; C = crop management factor; P = erosion control-practice factor, and SL = slope length.

AASY - 11.8 (QqP) T/KxCxPxSL: where Q = runoff volume in m ; qP = peak runoff rate in m /sec.; T/K = soil tolerability/ erodibility factor; C = cover factor; P = scaled management/conser-vation practices factor from the watershed scorecard, and SL = slope length.

SY1 - Total grams/hectares/ (pond age - 1)

SY2 - WSS x % e = HE... TGS/HE/(PA-1)

1) (Wischmeier and Smith 1965)

2) (Williams 1975)

Species list and (abbreviations) of the tallgrass watershed scorecard.

DESIRABLES

1. Ange- Andropogon gerardii- Big bluestem- Vitman
2. ** Ansc- Andropogon scoparius- Little bluestem- Michaux
3. Pavi- Panicum virgatum- Switch grass- Linnaeus
4. Sonu- Sorghastrum nutans- Indian grass (Linnaeus) Nash
5. Spas- Sporobolus asper- Rough dropseed (Michaux) Kunth
6. * Tripsacum dactyloides- Eastern gama grass- (Linnaeus) L.
7. * Helianthus maximilianii- Maximillian sunlower- Schrader
8. Sppe- Spartina pectinata- Prairie cordgrass- Link
9. ELY- Elymus spp.- Wild ryes- Linnaeus
10. Amca- Amorpha canescens- Lead plant- Pursh
11. * Desmanthus illionensis- Ill. bund. flr.- (Michaux) MacMillian
12. * Petalostemon spp.- Prairie clovers- (M.) - Fernald
13. ** ROS- Rosa spp.- Linnaeus
14. * Baptisia austrailis- Blue false indigo- LInnaeus

INTERMEDIATES

15. *** Popr- Poa pratensis- Kentucky blue grass- Linnaeus
16. ** Bocu- Bouteloua curtipendula- Side-oats gramma- (M.) Torrey
17. Bogr- B. gracillis- Blue grama- Humbolt, Bonpland and Kunth
18. * B. hirsuta- Hairy grama- Lagasca y Segura
19. Buda- Buchloe dactyloides- Buffalo grass- (Nuttall) Engelmann
20. Diol- Dichanthelium oliganthes var. scribnerianum- (Nash) Gould
21. * Agropyron smithii- Western wheatgrass- Rhydberg
22. * Eragrostis spectabilis- Purple love grass- (Pursh) Steudell
23. AGR- Agrostis- Bentgrass- Linnaeus
24. CAR- Carex spp.- Sedge- Linnaeus
25. Acmi- Achillea millifolium- Yarrow- Linnaeus
26. ERI- Erigeron spp.- Fleabane- Linnaeus
27. Sila- Silphium lacinatum- Compass plant- Linnaeus

UNDESIRABLES

28. ARI- Aristida spp.- Three awn grasses- Linnaeus
29. BRO- Bromus spp.- Brome grasses- Linnaeus
30. *** Brin- Bromus inermis- Smooth brome- Leysser
31. Chloris verticillata- windmill grass- Nuttall
32. Digitaria spp.- Crabgrass- Heister ex. Fabricus
33. Paca- Panicum capillare- Common witchgrass- Linnaeus
34. Spcr- Sporobolus cryptanderous- Sand dropseed- Torrey
35. AMB- Ambrosia spp.- ragweeds- Linnaeus
36. Euma- Euphorbia marginata- Snow-on-the-mountain- Pursh
37. Veba- Veronica baldwinii- Western Iron weed- Torrey
38. VER- Verbena spp.- Vervains- Ventenat
39. Guda- Gutierezia dracunculoides- Anual broomweed- Decandolla, Blake
40. * Juniperous virginiana- Red cedar- Linnaeus
41. Syor- Symphoricarpos orbiculatus- Buckbrush- Moench
42. Arlu- Artimesia ludvociana- Sagebrush- Nuttall

43. RHU- Rhus spp.- Sumac- Linnaeus
44. Codr- Cornus drummondii- Rough-leaved dogwood- Meyer
45. PRU- Prunus spp.- Plum- Linnaeus
46. Mapo- Maclura pomifera- Osage orange- (Raffinesque) Schneider
47. Gltr- Gledistia triacanthos- Honey locust- Linnaeus
48. SET- Setaria spp.- Foxtail- Beauvois
49. ECH- Echinochloa spp.- Barnyard grass- Linnaeus
50. * Helianthus spp.- Sunflower- Linnaeus
51. AST- Aster spp.- Wild aster- Linnaeus
52. MUH- Muhlenbergia spp.- Muhly- Schreber
53. *** FES- Festuca spp.- Fescues- Linnaeus
54. Leco- Leptaloma cognatum- Fall witchgrass- (Schultes) Chase
55. CIR- Cirsium spp.- Thistles- P. Miller
56. OPU- Opuntia spp.- Prickly pear- P. Miller
57. ASC- Asclepias spp.- Milkweeds- Linnaeus
58. SOL- Solidago spp.- Goldenrods- Linnaeus
69. POL- Polygnum spp.- Smartweeds- Linnaeus
60. RUM- Rumex spp.- Docks- Linnaeus

Note:

* Represents those species which were absent on sampled watersheds yet were on the Tallgrass Prairie Species List (Wilk, 1984).

** Represents those species which are rated according to their percentages species sampled. Example Ansc to 25%- Desirable; Ansc > 25%- Intermediate

*** Represents those species which may be rated according to land use. Example: smooth brome would be considered desirable in a brome pasture yet undesirable in a tallgrass prairie

Citations from McGregor, Barkley, Brooks and Schofield, 1986

Table 1. The method of analysis used to determine physical and soil characteristics for each watershed.

	(D9)				T#S 744-1146		
1 # of Sq.	2 S/T	% / s	3 %	4 Hect.	5 < / s (km)	6 (R) (m)	7 (P.D.) (m/s)
1.5	*Cb	*3-7	14	1.1	0.22	6,117	31.63
6.0	Cd	5-20	55	4.3			
3.5	Ld	0.2	31	2.8			
11.0	3	0-20	100	8.1			

1) A dot grid was used to estimate percentages of soil types in watersheds. (Used Lyon County Soil Survey...SCS).

2) "</s" - designates the length of slope from highest contour to pond in watershed which represents drainage length (taken from topography map, courtesy Lyon County SCS)

3) "(R)" - stands for the value of "runoff volume" of a 10 yr. frequency. (Lyon County SCS)

4) "(P.D.)" - represents the value of "peak discharge" of a 10 yr. frequency. (Lyon County SCS)

This watershed has 3 soil types. The other watersheds are composed of 2 to 6 soil types, increasing the complexity of the analysis.

Table 2. The method of analysis used to determine physical and soil characteristics for each watershed.

	(G-12)				T#S	295-715	
1	2		3	4	5	6	7
# of Sq.	S/T	% / s	%	Hect.	< / s (km)	(R) (m)	(P.D.) (cm/s)
1.5	Ld	0-2	6.7	0.70	0.08	29,792	2.55
6.0	Fa	2-12	43.3	4.5			
3.5	Tc	7-15	50.0	5.2			
11.0	3	0-20	100	10.4			

1) A dot grid was used to estimate percentages of soil types in watersheds. (Used Lyon County Soil Survey...SCS.)

2) "</s" - designates the length of slope from highest contour to pond in watershed which represents drainage length (taken from topography map. Courtesy Lyon County SCS.)

3) "(R)" - stands for the value of "runoff volume" of a 10 yr. frequency. (Lyon County SCS)

4) "(P.D.)" - represents the value of "peak discharge" of a 10 yr. frequency. (Lyon County SCS)

This watershed has 3 soil types. The other watersheds are composed of 2 to 6 soil types, increasing the complexity of the analysis.

Table 3. The method of analysis used to determine physical and soil characteristics for each watershed.

	(C-14)			T#S	295-715		
1	2		3	4	5	6	7
# of Sq.	S/T	% / s	%	Hect.	< / s (km)	(R) (m)	(P.D.) (cm/s)
10	Ka	1-3	59	3.2	0.09	4,293	1.25
1	Ed	3-6	6	.73			
6	Tc	7-15	35	1.8			
17.0	3	1-6	100	5.6			

1) A dot grid was used to estimate percentages of soil types in watersheds. (Used Lyon County Soil Survey...SCS)

2) "</s" - designates the length of slope from highest contour to pond in watershed which represents drainage length (taken from topography map, courtesy of Lyon County SCS)

3) "(R)" - stands for the value of "runoff volume" of a 10 yr. frequency. (Lyon County SCS)

4) "(P.D.)" - represents the value of "peak discharge" of a 10 yr. frequency. (Lyon County SCS)

This watershed has 3 soil types. The other watersheds are composed of 2 to 6 soil types, increasing the complexity of the analysis.

Table 4. The method of analysis used to determine physical and soil characteristics for each watershed.

	(A-4)			T#S	1468-2969		
1 # of Sq.	2 S/T	% / s	3 %	4 Hect.	5 < / s (km)	6 (R) (m)	7 (P.D.) (m /s)
	Ka	1-3	75	12.6	0.15	12,820	2.87
	Eb	4-7	19	3.2			
	Ea	1-4	6	.8			
——	3	1-7	100	16.6			

1) A dot grid was used to estimate percentages of soil types in watersheds. (Used Lyon County Soil Survey...SCS)

2) "</s" - designates the length of slope from highest contour to pond in watershed which represents drainage length (taken from topography may, courtesy of Lyon County SCS)

3) "(R)" - stands for the value of "runoff volume" of a 10 yr. frequency. (Lyon County SCS)

4) "(P.D.)" - represents the value of "peak discharge" of a 10 yr. frequency. (Lyon County SCS)

This watershed has 3 soil types. The other watersheds are composes of 2 to 6 soil types, increasing the complexity of the analysis.

Table 5. The method of analysis used to determine physical and soil characteristics for each watershed.

	(H-5)			T#S	744-1146		
1	2		3	4	5	6	7
# of Sq.	S/T	% / s	%	Hect.	< / s (km)	(R) m)	(P.D.) (m /s)
9	Tc	7-15	56	6.1	.08	8,628	2.43
	Eb	4-7	19	3.2			
	2	2-15	100	10.8			

1) A dot grid was used to estimate percentages of soil types in watersheds. (Used Lyon County Soil Survey...SCS)

2) "</s" - designates the length of slope from highest cntour to pond in watershed which represents drainage length. (taken from topography may, courtesy Lyon County SCS)

3) "(R)" - stands for the value of "runoff volume" of a 10 yr. frequency. (Lyon County SCS)

4) "(P.D.)" - represents the value of "peak discharge" of a 10 yr. frequency. (Lyon County SCS)

This watershed has 3 soil types. The other wateshеds are composed of 2 to 6 soil types, increasing the complexity of the analysis.

Table 6. The method of analysis used to determine physical and soil characteristics for each watershed.

	(0–16)			T#S	744–1146		
1 # of Sq.	2 S/T	% / s	3 %	4 Hect.	5 < / s (km)	6 (R) (m)	7 (P.D.) (m /s)
	La	1–3	4	0.70	0.11	13,522	2.87
	Lb	3–6	22	3.8			
	Mb	4–7	18	3.1			
	Mc	4–7*	55	9.5			
	2	1–7	100	17.1			

1) A dot grid was used to estimate percentages of soil types in watersheds. (Used Lyon County Soil Survey...SCS)

2) "</s" - designates the length of slope from highest contour to pond in watershed which represents drainage length. (taken from topography map, courtesy Lyon County SCS)

3) "(R)" - stands for the value of "runoff volume" of a 10 yr. frequency. (Lyon County SCS)

4) "(P.D.)" - represents the value of "peak discharge" of a 10 yr. frequency. (Lyon County SCS)

* represents soil types which have lost enough topsoil to be mapped as eroded.

This watershed has 3 soil types. The other watersheds are composed of 2 to 6 soil types, increasing the complexity of the analysis.

APPENDIX B

Table 1. Application of plant desirability index values to calculate accumulative plant desirability index.

I-6

SPECIES	PDI[1]	X	FREQUENCY[2]	=	MPDI[3]
Ange, Sonu, Pavi	60.0		201		12,060
Bocu, Spas, Ansc	58.0		132		7,946
Pasc, CAR*	38.0		14		532
Litter	35.0		133		4,655
BRO	30.0		92		2,760
Paca	20.0		37		740
ARI, MUH, SET	18.0		57		1,026
ART	16.0		26		416
Veba	14.0		3		42
Bare ground	-35.0		60		-2,100
	25.4 (M)		755		28,077 (A)

Note: 1) PDI - Plant Desirability Index
2) FREQUENCY - In transect samples
3) MPDI - Multiple Plant Desirability Index
* - Designates wetland species
(A) - Accumulative Plant Desirability Index
(M) - Mean

Table 2. Application of plant desirability index values to calculate accumulative plant desirability index.

	0–16				
SPECIES	PDI[1]	X	FREQUENCY[2]	=	MPDI[3]
Ange, Sonu, Pavi, Sppe	60.0		504		30,240
Ansc, Spas, Bocu	58.0		212		12,296
Spcr, CAR*	38.0		20		760
Litter	35.0		121		4,235
BRO, FES	30.0		157		4,710
Chve, Paca, Leco	30.0		8		160
ARI, MUH	18.0		19		342
Gudr, AST	16.0		16		256
Veba	14.0		5		60
Opu	12.0		8		96
Bare ground	-35.0		76		-2,660
	23.1 (M)		1146		50,495 (A)

Note: 1) PDI - Plant Desirability Index
2) FREQUENCY - In transect samples
3) MPDI - Multiple Plant Desirability Index
* - Designates wetland species
(A) - Accumulative Plant Desirability Index
(M) - Mean

Table 3. Application of plant desirability index values to calculate accumulative plant desirability index.

E-8

SPECIES	PDI[1]	X	FREQUENCY[2]	=	MPDI[3]
Ange, Sonu, Pavi	60.0		62		3,720
Bocu, Spas	58.0		7		406
Ansc	48.0		64		3,072
Pasc, PAN, Spcr, CAR*	38.0		44		1,672
Litter	35.0		64		2,240
BRO	30.0		10		30
Paca	20.0		4		80
ARI, MUH	18.0		12		216
Gudr, ART	16.0		4		64
POL	14.0		7		98
Bare ground	-35.0		17		-595
	27.5		295		11,003 (A)

Note: 1) PDI - Plant Desirability Index
2) FREQUENCY - In transect samples
3) MPDI - Multiple Plant Desirability Index
* - Designates wetland species
(A) - Accumulative Plant Desirability Index
(M) - Mean

Table 4. Application of plant desirability index values to calculate accumulative plant desirability index.

N-2			
SPECIES	PDI[1] X	FREQUENCY[2] =	MPDI[3]
Ange, Sonu, Pavi	60.0	364	21,840
Ansc, Spas, Bocu	58.0	296	17,168
Buda	40.0	1	40
Pasc, Bogr, Agsm, CAR*	38.0	166	6,308
Litter	35.0	305	10,635
BRO	30.0	43	1,290
ARI, MUH, SET, AGR, ECh	18.0	24	432
ART, Gudr, AST, AMB, RUM	16.0	97	1,552
Veba, EUP, SOL	14.0	8	112
Getr	10.0	1	10
Bare ground	-35.0	161	-5,635
	25.8	1471 (T#S)	53,802 (A)

Note: 1) PDI - Plant Desirability Index
2) FREQUENCY - In transect samples
3) MPDI - Multiple Plant Desirability Index
* - Designates wetland species
(A) - Accumulative Plant Desirability Index
(M) - Mean

Table 5. Application of plant desirability index values to calculate accumulative plant desirability index.

A-4

SPECIES	PDI[1] X	FREQUENCY[2] =	MPDI[3]
Ange, Sonu, Pavi	60.0	438	26,280
Ansc, Spas	58.0	109	6,322
Bocu	48.0	160	7,680
Pasc, ELY, Bogr, CAR*	38.0	35	1,330
Litter	35.0	38	1,330
BRO	30.0	33	990
ARI	18.0	3	54
Gudr	16.0	11	176
Veba	14.0	8	112
SYM	12.0	4	48
Bare ground	-35.0	73	-2,550
	25.6 (M)	912 (T#S)	41,772 (A)

Note: 1) PDI - Plant Desirability Index
2) FREQUENCY - In transect samples
3) MPDI - Multiple Plant Desirability Index
* - Designates wetland species
(A) - Accumulative Plant Desirability Index
(M) - Mean

Table 6. Application of plant desirability index values to calculate accumulative plant desirability index.

P-15					
SPECIES	1 PDI	X	2 FREQUENCY	=	3 MPDI
Ange, Sonu, Pavi	60.0		632		37,920
Ansc, Spas, Bocu	58.0		707		41,006
Buda	40.0		8		320
Bogr, ELYm, CAR*	38.0		83		3,154
Litter	35.0		636		22,260
BRO, FES	30.0		378		11,340
Paca, Leco	20.0		26		520
ARI, MUH	18.0		70		1,260
ART, Gudr	16.0		16		256
Veba, SOL	14.0		7		98
Syca, Rosa, PRU, Codr, RHU	12.0		57		684
Getr	10.0		2		20
Bare ground	-35.0		347		-12,145
	25.2 (M)		2,969 (T#S)		106,693 (A)

Note: 1) PDI - Plant Desirability Index
2) FREQUENCY - In transect samples
3) MPDI - Multiple Plant Desirability Index
* - Designates wetland species
(A) - Accumulative Plant Desirability Index
(M) - Mean

Table 7. Application of plant desirability index values to calculate accumulative plant desirability index.

	D-9				
SPECIES	PDI[1]	X	FREQUENCY[2]	=	MPDI[3]
Ange, Sonu, Pavi	60.0		126		7,560
Ansc, Spas	58.0		178		10,324
Bocu	48.0		140		6,720
Buda	40.0		6		240
Pasc, Bogr, CAR*	38.0		63		2,394
Litter	35.0		256		8,960
BRO, FES	30.0		102		3,060
Chve	20.0		1		20
ARI, AND	18.0		82		1,476
ART, Gudr, AST	16.0		48		768
Veba, RHU, SOL	14.0		11		154
Syca	12.0		11		132
Getr	10.0		1		10
Bare ground	35.0		83		-2,905
	26.0 (M)		1108 (T#S)		39,813 (A)

Note: 1) PDI - Plant Desirability Index
2) FREQUENCY - In transect samples
3) MPDI - Multiple Plant Desirability Index
* - Designates wetland species
(A) - Accumulative Plant Desirability Index
(M) - Mean

Table 8. Application of plant desirability index values to calculate accumulative plant desirability index.

M-10

SPECIES	PDI[1]	X	FREQUENCY[2]	=	MPDI[3]
Ange, Sonu, Pavi	60.0		41		2,460
Bocu, Spas	58.0		24		1,392
Ansc	48.0		171		8,208
Pasc, Bogr, CAR*	38.0		25		950
Litter	35.0		28		980
BRO, FES	30.0		17		510
Paca	20.0		27		540
ARI, SET	18.0		83		1,494
AMB	14.0		2		28
Bare ground	-35.0		32		-1,120
	28.6 (M)		450 (T#S)		15,442 (A)

Note: 1) PDI - Plant Desirability Index
2) FREQUENCY - In transect samples
3) MPDI - Multiple Plant Desirability Index
* - Designates wetland species
(A) - Accumulative Plant Desirability Index
(M) - Mean

Table 9. Application of plant desirability index values to calculate accumulative plant desirability index.

F-7

SPECIES	PDI[1] X	FREQUENCY[2] =	MPDI[3]
Ange, Sonu, Pavi	60.0	187	11,220
Bocu, Spas	58.0	34	1,972
Ansc	48.0	217	10,416
Pasc, Bogr, Spcr, CAR*	38.0	62	2,356
Litter	35.0	105	3,675
BRO, FES	30.0	47	1,410
Paca, Chve	20.0	28	560
ARI, MUH	18.0	72	1,296
ART, Gudr, AST, AMB	16.0	30	480
Veba	14.0	1	14
Syca	12.0	3	36
Bare ground	-35.0	11	-385
	26.2 (M)	797 (T#S)	33,050 (A)

Note: 1) PDI - Plant Desirability Index
2) FREQUENCY - In transect samples
3) MPDI - Multiple Plant Desirability Index
* - Designates wetland species
(A) - Accumulative Plant Desirability Index
(M) - Mean

APPENDIX C

I. WATERSHED SCORECARD T#S 295-715 (continued)

STUDY AREA	R/C	GCI	MCPF	RATING	REPF**	SER	TWPEDI*	WCRV	RATING	R/C, GCI, TPEDI
C-14	3	9	A+5 B 0 C(D-0) F(G-1) I(K+3) M(N+1) 8	(8)	EFCSL -1.4	+1	9 (969.5)	30 (7)	Good	9 Excellent 8 Good + 7 Good 6 Fair + 5 Fair 4 Poor + 3 Poor 2 Poor - 1 Very Poor
L-3	5	7	A 0 B 0 C(D-3) F(G-3) I(K+1) M(NO) -5	(-5)	EFCSL 10.6	-11	5 (452.3)	1 (6)	Very Poor	
M-10	5	9	A+5 B 0 C(D-0) F(G-1) I(K+1) M(NO) 5	(5)	EFCSL +1.4	-1	3 (382.2)	21 (3)	Fair	WCRV RATING 44-35 Excellent Good + 34-26 Good Fair + 25-17 Fair 16- 8 Poor 7- 0 Very Poor

* - Deterrence
** - Difference between EFCSL and MTSL

I. WATERSHED SCORECARD T#S 295-715 (continued)

STUDY AREA	R/C	GCI	MCPF	RATING	REPF**	SER	TWPEDI*	WCRV	RATING	R/C, GCI, TPEDI
G-12	7	7	A 0 B 0 C(D-1) F(G-1) I(K+2) M(N+1) 1	(1)	EFCSL +6.5	-7	7 (729)	15 (4)	Poor	9 Excellent 8 Good + 7 Good 6 Fair + 5 Fair 4 Poor + 3 Poor 2 Poor - 1 Very Poor
J-1	9	7	A 0 B 0 C(D-1) F(G-0) I(K+1) M(N+1) 1	(1)	EFCSL +8	-8	5 (633.8)	14 (1)	Poor	
Worst	1	1	A 0 B 0 C(D-3) F(G-3) I(K+1) M(N-1) -6	(-6)	EFCSL -25	-25	1 (187.8)	-28		WCRV RATING 44-35 Excellent Good + 34-26 Good Fair + 25-17 Fair 16- 8 Poor 7- 0 Very Poor

* - Deterrence
** - Difference between EFCSL and MTSL

II. WATERSHED SCORECARD T#S 744-1146

STUDY AREA	R/C	GCI	MCPF	RATING	REPF**	SER	TWPEDI*	WCRV	RATING	R/C, GCI, TPEDI
Best	9	9	A+5 B+4 C(D0) F(G0) I(K+2) M(N1) 12	(12)	EFCSL -5	5	9 (2124.5)	44	Excellent	9 Excellent 8 Good + 7 Good 6 Fair + 5 Fair 4 Poor + 3 Poor 2 Poor - 1 Very Poor
H-5	7	7	A 0 B 0 C(D-1) F(G-0) I(K+2) M(N+1) 2	(2)	EFCSL +2.7	-3	5 (1221.2)	18 (2)	Fair	
I-6	7	9	A 0 B 0 C(D0) F(G-1) I(K+1) M(N+1) 1	(1)	EFCSL +3.6	-4	5 (888.5)	18 (5)	Fair	WCRV RATING 44-35 Excellent Good + 34-26 Good Fair + 25-17 Fair 16- 8 Poor 7- 0 Very Poor

* - Deterrence
** - Difference between EFCSL and MTSL

II. WATERSHED SCORECARD T#S 744-1146 (continued)

STUDY AREA	R/C	GCI	MCPF	RATING	REPF**	SER	TWPEDI*	WCRV	RATING	R/C, GCI, TPEDI
F-7	7	9	A 0 B 0 C(D0) F(G0) I(K-2) M(N0) 2	(2)	EFCSL -.1	0	7 (763.3)	25 (1)	Fair	9 Excellent 8 Good + 7 Good 6 Fair + 5 Fair 4 Poor + 3 Poor 2 Poor - 1 Very Poor
A-4	9	9	A+5 B 0 C(D-1) F(G0) I(K+2) M(+1) 7	(7)	EFCSL +1	-1	9 (3570)	33 (3)	Good	
D-9	7	9	A 0 B 0 C(D-1) F(G0) I(K+2) M(N+1) 2	(2)	EFCSL +2.7	-3	9 (2095.4)	24 (4)	Fair	WCRV RATING 44-35 Excellent Good + 34-26 Good Fair + 25-17 Fair 16- 8 Poor 7- - Very Poor

* - Deterrence
** - Difference between EFCSL and MTSL

II. WATERSHED SCORECARD T#S 744-1146 (continued)

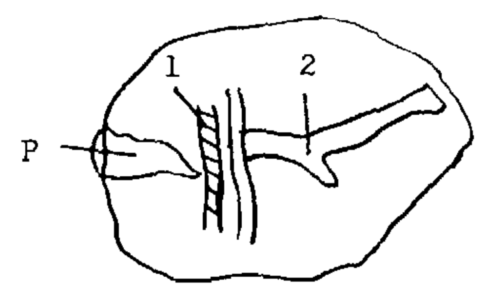
STUDY AREA	R/C	GCI	MCPF	RATING	REPF**	SER	TWPEDI*	WCRV	RATING	R/C, GCI, TPEDI
0-16	7	9	A 0 B 2 C(D-3) F(G0) I(K+2) M(N+1) 2	(2)	EFCSL +3.3	-3	5 (1202.3)	20 (6)	Fair	9 Excellent 8 Good + 7 Good 6 Fair + 5 Fair 4 Poor + 3 Poor 2 Poor - 1 Very Poor
Worst	1	1	A 0 B 0 C(D-3) F(G-3) I(K+1) M(N-1) -6	(-6)	EFCSL +6	-6	1 (354.1)	-9		

WCRV	RATING
44-35	Excellent
	Good +
34-26	Good
	Fair +
25-17	Fair
16- 8	Poor
7- 0	Very Poor

* - Deterrence
** - Difference between EFCSL and MTSL

APPENDIX D

Watershed F-7

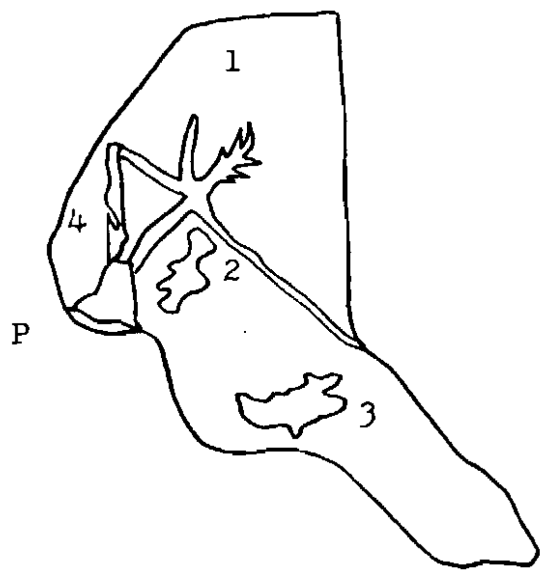


Drainage- 8.1 ha.
Pond- 0.51 ha.

Erosion area #1≈0.30 ha.
Erosion area #2≈3.7 ha.

% of Eroded Water. 25% (Scale: 1 km.≈162mm.)

Watershed I-6

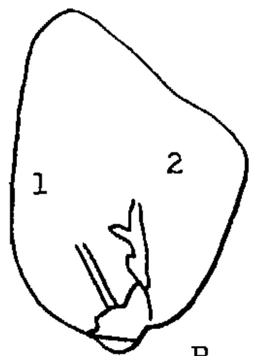


Drainage- 11.3 ha.
Pond- 0.30 ha.

Erosion area #1 1.2 ha.
Erosion area #2 0.17 ha.
Erosion area #3 0.30 ha.
Erosion area #4 0.13 ha.

% of Eroded Watershed 12.5% (Scale: 1 km. 162mm.)

Watershed A-4

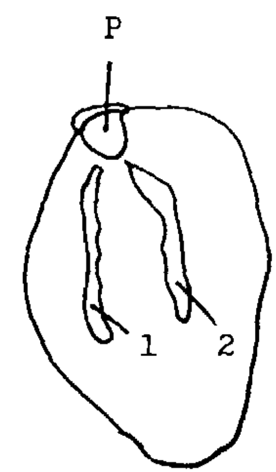


Drainage- 6.4 ha
Pond- 0.16 ha.

Erosion area #1 ≈ 0.16 ha.
Erosion area #2 ≈ 0.20 ha.

% of Eroded Watershed 8.8%   (1 km. ≈ 162mm.)

Watershed D-9

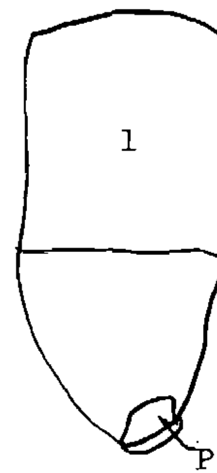


Drainage- 8.5 ha.
Pond- 0.13 ha.

Erosion area #1≳0.36 ha.
Erosion area #2≳0.13 ha.

% of Eroded Watershed 6% (Scale: 1 km.≈162mm.)

Watershed E-8



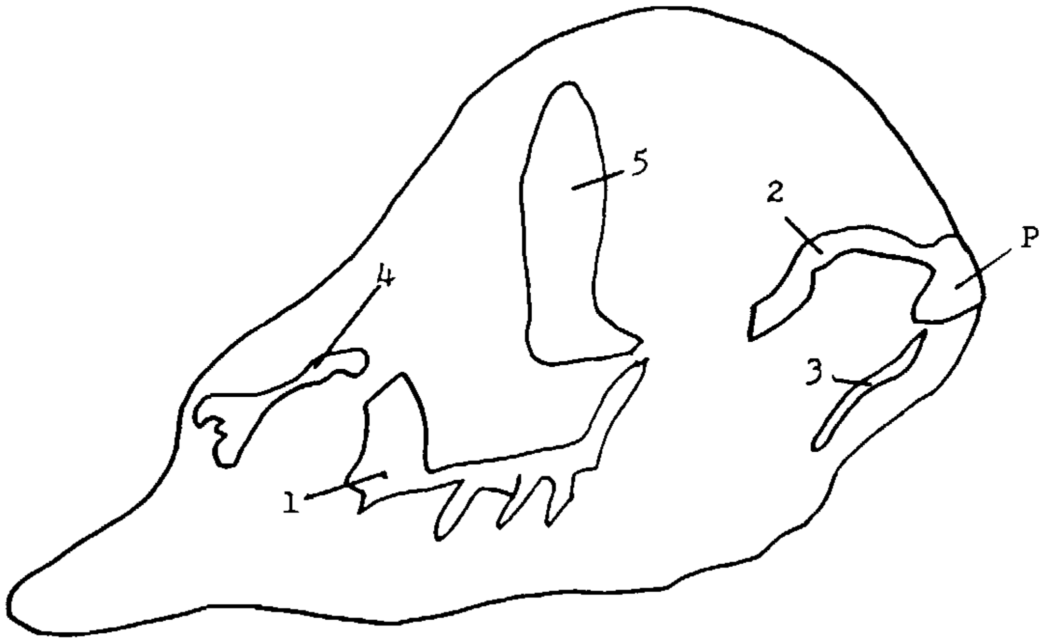
Drainage- 8.1 ha.
Pond- 0.24 ha.

Erosion area #1 ≈ 6.0 ha.

% of Eroded Watershed 74%

(Scale: 1 km.≈162mm.)

Watershed P-15



Drainage- 36.9 ha.
Pond- 0.60 ha.

Erosion area #1 ≈ 0.70 ha.
Erosion area #2 ≈ 0.73 ha.
Erosion area #3 ≈ 0.61 ha.
Erosion area #4 ≈ 0.32 ha.
Erosion area #5 ≈ 1.90 ha.