Flood Plain Vegetation Changes on the Grant-Kohrs Ranch National Historic Site Between 1993 and 2000

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by

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Executive Summary

We evaluated the report "Vegetation Mapping and Analysis of the Grant-Kohrs National Historic Site" by Thompson et al. (1995) and determined vegetation and riparian health changes between 1993 and 2000 on riparian sites on the Grant-Kohrs Ranch National Historic Site. We found the methodology and procedures of Thompson et al. (1995) to be accepted procedures for a mapping of riparian plant communities and determination of riparian health for management studies. We then repeated their measurements to determine if their measurements were accurate and to determine changes between 1993 and 2000. We located 13 riparian polygons where fences excluded livestock grazing and other known disturbances (i.e., such as fire) had not occurred and thus allowed for direct comparisons between study periods. We found few differences in species composition and no difference in structural diversity or plant communities between 1993 and 2000. We believe the relatively few changes in species composition, and no changes in area of plant communities between 1993 and 2000, suggests that plant community recovery is being delayed by non-livestock grazing factors. Polygon health measurements did show improvement between 1993 and 2000. The improvement in polygon health was associated with decreased shrub utilization, decreased standing decadent and dead woody material, shrub regeneration, increased deep binding rootmass, and increased streambank stability. However, the very dry conditions of 2000, and the resulting low stream flows, produced seasonal improvement (i.e., streambanks appeared more stable), but may not be representative of bank erosion dynamics during a more normal or average stream-flow period. We hypothesize that the factor or factors delaying recovery are related to site changes, but the riparian health evaluation methods used by Thompson et al. (1995) and repeated for this study are too coarse for assigning levels of site specific causative factors.

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1) Introduction

In1995, the Riparian Wetland Research Association released a report entitled, *Vegetation mapping and analysis of the Grant-Kohrs Ranch National Historic Site* (Thompson et al. 1995). This report documented the riparian condition on the ranch during the 1993 field season, while also mapping vegetation communities and habitat types found on the ranch. Several of the riparian community types documented by Thompson et al. (1995) are categorized as human-induced disturbance types and are plant communities commonly associated with livestock disturbance in Montana (Hansen et al. 1995). The report infers that livestock grazing on the ranch is a major factor in propagating disclimax vegetation communities, lack of streambank stability, lack of tree/willow regeneration, and poorly functioning riparian attributes on the Grant-Kohrs Ranch National Historic Site (GKR). Thompson et al. (1995) does refer to the presence of mining-related deposits and the presence of “slickens”, but makes no reference to potential impacts of mining related deposits on plant community or stream health. Given that 2 to 3 million of tons of mine tailings were introduced into the Clark Fork River and Deer Lodge Valley (Arco, 1998), the visual presence of "slickens" and streambank mine tailing deposits on the GKR, and past reports documenting concerns of mining deposits and their influence on vegetation (Kapustka et al. (1995), Rader et al. (1996), Rice and Ray, 1984) it is reasonable to consider mine tailings as a potential causative factor in plant community composition and health.

a) Setting

All fieldwork occurred on the Grant-Kohrs National Historic Ranch during July/September 2000. The polygons delineated by Thompson et al. (1995) and found within the fenced riparian area were specifically selected for re-measurement to validate the methodology of that study and to measure any changes in plant community or riparian health after 7 years of livestock exclusion. Appendix 1 lists the polygons and their areas (acres) and Appendix 2 is a map of the study area. The identification number of each polygon is the same as that of the 1993 survey.

Growing season conditions between 1993 and 2000 were very different. The total precipitation from January to September of 1993 was 12.6 inches as compared to 5.7 inches for the same time period in 2000. The 30-year average precipitation for this nine-month period in the Deer Lodge Valley is 9.30 inches (Western Regional Climate Center web page). Thus, the 1993 field season experienced above normal precipitation events during the months of June, July and August; whereas, the year 2000 had much below normal precipitation.

b) Objectives

Our objectives were to critically review the methodology of the report entitled, *Vegetation mapping and analysis of the Grant-Kohrs Ranch National Historic Site* (Thompson et al. 1995) and to repeat the vegetation and site measurements for riparian sites along the Clark Fork River that had been excluded from livestock grazing. By repeating Thompson's et al. (1995) study we would determine if their measurements seemed accurate and to determine changes in site and vegetation variables between 1993 and 2000 on riparian areas where livestock grazing was excluded.

2) Materials and Methods

Our field methods are predominantly those outlined in *Vegetation Mapping and Analysis of the Grant-Kohrs Ranch National Historic Site* (Thompson et al., 1995). Modification of field methods included the use of an updated version of Montana Riparian/Wetland Research Program (RWRP) (previously Montana Wetland and Riparian Association or MWRA) form for the polygon health evaluation (RWRP, 2000). Because the current RWRP polygon health evaluation form differs slightly from the form used by Thompson et al. (1995), we modified the polygon health measurement to use only the same measured variables between 1993 and 2000. Vegetation health measurements were identical between study years. Soil/hydrology measurements included for calculation of the soil/hydrology health score for comparison between years were: (1) amount of fine material present to hold water and act as a rooting medium, (2) human caused bare ground, (3) active lateral cutting, and (4) streambank root mass protection.

The field inventory methods rely heavily on ocular estimates by an observer to place vegetation and site attributes in the "proper class". We took precautions to reduce observer bias in ocular estimates by field training and selecting a field technician with experience in the techniques used by RWRP and by only having one person taking measurements. The field technician, Mr. Thad Jones, was a former employee of MWRA, was trained by MWRA, and had worked for the MWRA for one summer. During 2000 he also trained with the field staff of Mr. Peter Rice for three weeks at the Grant-Kohrs Ranch to ensure accurate plant species identification and consistent plant cover estimations. Re-measurements of riparian polygons occurred in July and August 2000.

Polygons delineated on a Grant-Kohrs Ranch NHS map by Thompson et al. (1995) that included riparian communities along the Clark Fork River were selected for re-measurement. We further limited site comparisons to those areas that were fenced in 1994 to exclude cattle grazing. This resulted in 17 polygons with a total area of 122 acres (Appendix 1). Polygon numbers are the same as Thompson et al. (1995). Three polygons, numbers 36, 38, and 40, were found to significantly differ in area between 1993 and 2000 because of the fence placement to exclude livestock grazing (part of polygon in both grazed and ungrazed areas). One polygon, number 34, burned in 1998. We completed inventories of these polygons (all plot data attached), but did not use these polygons for comparisons between years. We believe the addition of polygons 34, 36, 38 and 40 for comparative statistics would not be appropriate for our study objective of comparing the sites between 1993 and 2000 with the only known difference being the exclusion of livestock grazing.

For comparison of individual species between 1993 and 2000, we report coverage on a species composition basis and total coverage basis. Species composition was determined by dividing the coverage of each species by total plant coverage of the polygon to place species on a proportion basis (Bonham, 1989). Naming of plant species follows Thompson et al. (1995).

A set of photo comparisons are presented as Appendix 6. We did not have the exact locations of photo points or exposure information so the comparisons are provided only as qualitative comparison.

a) Sampling Design

Our sampling design was a repeat of Thompson et al. (1995). In doing the repeat measurements we used the same polygons and repeated their methodology for field measurements.

b) Data Analyses

Class data were initially transformed to midpoints for analyses. Where data were approximately normally distributed, we used a paired t-test to test for significant differences in variables between 1993 and 2000. Where data did not meet the assumptions of normality or homogeneity of variances, we transformed the data using standard transformation procedures (Sokal and Rolf, 1995) in order to meet assumptions for valid t-tests. Markowski and Markowski (1990) state that when two sample sizes are equal (the case for this study) that the t-test is insensitive to the heterogeneity of variances. Our null hypothesis for each tested variable was that there was no difference in the variable between 1993 and 2000. Differences were considered significant when $p \leq 0.10$. For those variables where conditions of normality were not met, we used a non-parametric test, Wilcoxon signed ranks test, to determine if there were significant difference in the data. Our null hypothesis for each tested variable was that the two samples (from different years) were from the same population, but we report only the means in tables. All statistical analyses were performed using SPSS (SPSS, 2000).

3) Results and Discussion

Our results are presented in the approximate order of the presentation of Thompson et. al. (1995). However, we begin with an evaluation of Thompson et al. (1995) methodology.

a) Methodology Evaluation

We found the methodology of Thompson et al. (1995) to be very similar to currently accepted methods of riparian inventory. The current RWRP methodology includes a channel assessment procedure and a slightly modified method for the polygon health evaluation. The current methodology for polygon health evaluation uses the same vegetation items for scoring, but differ in scoring of "hydrology/streambank" category.

b) Vertical Heterogeneity

Vertical heterogeneity is a measure of coverage of life-forms by height classes. Thompson et al. (1995) states that data on vertical heterogeneity " provides insight into the vertical and horizontal distribution of the polygon vegetation. We found that the mean canopy cover of shrubs in height layer's 2 and 3 and for total shrubs were greater in 1993 compared to 2000, but canopy cover of shrubs in layer 1 was greater in 2000 (Table 1). Mean total canopy cover of forbs and grasses in height layer 2 were greater in 1993. The increased coverage of shrubs in layer 1 may be associated with a decrease in shrub utilization and increased shrub recruitment in 2000 as compared to 1993 (Table 3). Kovalchik and Elmore (1992) found that willow seedlings are very sensitive to grazing and trampling damage that may have occurred previous to livestock grazing exclusion. However, the reduction in coverage of shrubs in height layer 2 is not consistent with other studies (Green and Kauffman, 1995; Clary and Medin, 1990) that found relative dramatic increases in shrub coverage following grazing exclusion. In Oregon, it was found that the mean height and density of woody species increased dramatically after 10 years without livestock grazing (Green and Kauffman, 1995). In Nevada, Clary and Medin (1990) found that after 5 to 10 years of grazing deferment shrubs were rebounding. Therefore, after seven years of deferred grazing on the GKR we would expect find increases in shrub cover, especially below browsing height (layer 1 and 2), if livestock browsing was the predominant cause of the decreased shrub growth. Unknown to us is how wildlife browsing and trespass livestock grazing may be influencing shrub recovery and it is likely that the dry conditions of 2000 impacted shrub growth. The decrease in grasses in height layer 2 and reduced coverage of shrubs in layer 3 may be associated with the dry conditions of 2000. The reduced coverage of total forbs could also be associated with the much dryer conditions of 2000 compared to 1993; however, Popolizio et al. 1994 report significantly lower coverage of the forbs *Trifolium repens* and *Taraxacum officinale* in protected versus grazed riparian area in Colorado.

Table 1. Mean coverage (%) of vertical heterogeneity of life-form on Grant-Kohrs Ranch National Historic site in 1993 and 2000.								
Height Layer	Trees 1993 / 2000		Shrubs 1993 / 2000		Graminoids 1993 / 2000		Forbs 1993 / 2000	
3 (over 6 ft.)	1.2	2.5	38.5	29.4*[1]	0	0	0	0
2 (>1.5 to 6 ft.)	0	0	23.3	13.1*	45.4	33.8*	17.3	13.1
1 (up to 1.5 ft.)	0	0.08	2.6	7.2*	36.1	41.5	20.0	16.9
Total	1.2	2.6	64.3	49.7*	81.5	75.4	37.3	30.0*

*[1] Means in the same life-form and height layer followed by * are statistically different ($p \leq 0.10$) between years using an unpaired t-test.

c) Structural Diversity and Structural Components

Structural diversity indicates the degree of vegetative vertical (height) and horizontal (canopy cover) presence in a polygon (Thompson et al. 1995). There are 11 possible structural diversity categories and trees and shrubs are major components of structural diversity because of their persistent, woody nature (Thompson et al. 1995). In 2000, the structural diversity classes of the 13 polygons were the same as in 1993 (Table 2). Thompson et al. (1995) states that structural diversity of a stand will usually change with succession or if management changes. Certainly grazing management changed with the exclusion of grazing between the 1993 and 2000, but shrub or tree growth has not resulted in a change in structural diversity. As stated previously the lack of change in shrub and tree growth, especially shrubs, is surprising because shrub response is often dramatic following livestock grazing exclusion.

Three vegetation structural components that were different between 1993 and 2000 were mean canopy cover of shrub regeneration, shrub utilization, and standing dead wood (Table 3). Shrub regeneration was greater and shrub utilization was lower in 2000 as compared to 1993. With the exclusion of livestock grazing we would expect increased shrub regeneration, decreased shrub utilization, and decreased standing dead wood as vigor of shrubs improved (Ehrhart and Hansen, 1997). Use of shrubs by wild ungulates was evident and averaged almost 5% in 2000.

Table 2. Frequency distribution of structural diversity categories			
Category	Category Definition	Frequency 1993	/ 2000
3	Only medium herbaceous layer present.	1	1
6	Tall shrubs and herbaceous understory present.	2	2
7	Tall shrubs, medium trees/ shrubs and herbaceous understory present.	10	10

Table 3. Mean cover class of shrub utilization (%) and shrub regeneration (%) and standing dead wood (%) in 1993 and 2000.		
Structural Components	1993	2000
Shrub Utilization	17.5*	4.9
Shrub Regeneration	9.4*	17.1
Standing Dead Wood	10.7*	2.4

d) Vegetative Type Classification

The areas (acreage) of the different vegetative types found in the riparian polygons were not statistically different between 1993 and 2000 (Table 4). The lack of change in vegetation types is consistent with results showing no change in structural diversity. The time necessary for observing changes in community types following different types of management changes has not been quantified by ecologists.

Table 4. Number of polygons and area (acres) of habitat types, community types, dominance types in 1993 and 2000.				
Vegetative Type Name[1]	Number of Types 1993	/ 2000	Area Occupied (acres) 1993	/ 2000
Salix geyeriana Community Type	13	12	71.6	60.9
Betula occidentalis Community Type	9	7	21.0	21.8
Salix exigua Community Type	6	2	4.1	1.1
Populus trichocarpa/*Cornus stolonifera* Community Type	3	3	2.3	1.0
Agrostis stolonifera Community Type	2	2	4.1	6.7
Salix geyeriana/*Carex rostrata* Habitat type	0	2	0	3.0
Poa pratensis Community Type	1	0	1.4	0
Juncus balticus Community Type	1	2	2.1	3.9
Deschampsia cespitosa Habitat Type	1	2	0.3	3.1
Agropyron repens Community Type	1	0	0.5	0
Populus trichocarpa/Symphoricarpus occidentalis Community Type	0	1	0	2.6
Centaurea maculosa Dominance Type	1	0	0.1	0
Totals[2]	39	31	107.5	104.0

[1] Type descriptions and names are from Hansen et al. 1995.
[2] The difference in total acres is associated with minor differences in polygon boundaries. Appendix 1 lists acreage of each polygon and Appendix 2 is a map of polygons.

e) Tree Regeneration and Age Group Distribution

Nine riparian polygons had trees present in 1993 compared to only four polygons in 2000. However, the difference between years is one of a taxonomic difference in species listed and is not considered ecologically significant. Thompson et al. (1995) identified *Salix amygdaloides* (a tree-like willow) in four polygons; whereas, we identified the same willow as *Salix lasiandra* (a tall shrub). Our identification of this species as *Salix lasiandra* was confirmed by Janet Hardin (field bontanist for Peter Rice). Therefore, comparisons of tree regeneration and age group distribution were compared between the study periods for only *Populus trichocarpa*.

There was no difference in tree canopy cover composition between 1993 or 2000 which averaged 0.6% and 1.8 %, respectively. *Populus trichocarpa* was characterized by mature and decadent trees (category 7- 11) with no seedlings (regeneration category 1) in all three polygons in 1993 and two out of the four polygons in 2000 (Table 5). The *Populus trichocarpa* in polygon 70, a mature tree, must have been overlooked in 1993. Judging from the location and proximity of *Populus trichocarpa* seedlings to mature trees it is likely that seedlings are from vegetative reproduction (suckers) from mature trees. No seedlings were seen in traditional niches such as on recent gravel bar deposits or on the banks of the river. The lack of change is consistent with findings on tree vertical heterogeneity, structural diversity, and vegetation type changes. Thompson et al. (1995) comments on the lack regeneration of trees and the predominance of older age groups (mature, decadent and dead). However, because of the small coverage of trees, and low number of polygons with trees, we believe comparisons between 1993 and 2000 are not biologically revealing.

Table 5. Tree age group distribution and age group categories between 1993 and 2000.

Polygon	Age Distribution Category		Regeneration Category	
	1993	2000	1993	2000
57	7	4	1	2
70	0	7	1	1
72	11	8	1	2
75	7	7	1	1

f) Dominant and Co-Dominant Plant Species

Dominant and co-dominant plant species by life form were generally the same species in 1993 and 2000 (Table 6). Dominant shrubs in the study in 1993 and 2000 were *Salix exigua*, *Salix boothii*, *Salix bebbiana*, *Betula occidentalis*, and *Symphoricarpus occidentalis*. Of the shrubs, we found significant differences in mean cover composition (%) between 1993 and 2000 for only *Cornus stolonifera*, *Salix exigua*, *Rosa woodsii*, and total shrubs (Table 7). Actual cover values are reported in Appendix 4. Cover composition of *Cornus stolonifera* and *Rosa woodsii* changed by less than 1%. Cover composition of *Salix exigua* decreased by 2.3% between 1993 and 2000. Total shrubs were also found to decrease. As stated previously, the lack of an increase in shrub coverage is contrary to other studies showing improved shrub coverage following grazing exclusion.

Dominant graminoids were *Agrostis stolonifera*, *Bromus inermis*, *Juncus balticus*, *Agropyron repens*, *Poa pratensis*, and *Carex rostrata* (Table 6). *Agrostis stolonifera*, *Bromus inermis*, *Agropyron repens*, and *Poa pratensis* are exotic species and are considered invaders and would be expected to increase with livestock disturbance (Hansen et al. 1995; U.S. Department of Agriculture, 1982). The mean cover composition (%) of *Agrostis stolonifera* and *Poa pratensis* were lower in 2000 than in 1993, but *Bromus inermis* increased between 1993 and 2000 (Table 7). We believe the decreased cover composition of *Agrostis stolonifera* and *Poa pratensis* is consistent with ecological theory that disturbance invaders will decrease as disturbance factors (livestock grazing) are reduced (Hansen et al., 1995; Dyksterhuis 1949). The increase in *Bromus inermis* is inconsistent with this theory; however, it is logical to expect taller species such as *Bromus inermis* would replace shorter and less productive species such as *Agrostis stolonifera* and *Poa pratensis* with decreased livestock grazing (Dahl, 1995). Mean canopy cover composition of only two native graminoid species (*Juncus balticus* and *Deschampsia cespitosa*) were found to be significantly different between 1993 and 2000. Both these species showed increased coverage. *Deschampsia cespitosa* is considered a decreaser species, one that should decrease with grazing pressure (Hansen et al. 1995; U.S. Department of Agriculture, 1982), and increased between 1993 and 2000 as secondary succession theory would suggest. However, this species is known to be metal tolerant (Table 12) and associated with slicken areas (Rice and Ray 1984, Massey, 1998). *Juncus balticus* is considered an increaser (Hansen et al. 1995; U.S. Department of Agriculture, 1982) and should respond to decreased grazing pressure by a decrease in canopy cover. Therefore, we found inconsistent and relatively small changes in canopy cover composition between 1993 and 2000.

Table 6. Dominant and co-dominant riparian vegetation[1] (based on cover values) of life-forms[2].

Polygon Number	Shrubs		Graminoids		Forbs	
	1993	2000	1993	2000	1993	2000
39	Betocc Salboo	Betocc Salboo	Agrsto	Agrsto Agrrep	Cirarv	Cirarv
44	Salexi Salboo Salbeb	Salexi Salboo Salbeb	Agrsto Agrrep	Agrsto Broine	Eupesu Trihyb	Eupesu Cirarv
47	Betocc Salboo	Betocc Salboo	Agrsto Broine	Agrsto Broine Agrrep	Cirarv Trihyb	Cirarv Eupesu
48	Betocc	Betocc Salboo	Poapra Agrsto	Agrsto Broine Junbal	Trihyb Potans Lepper	Cirarv Eupesu
55	Salboo Salbeb Betocc	Salboo Salexi Salbeb	Agrsto Poapra	Agrsto Broine	Cirarv Trihyb Sisloe	Cirarv Eupesu
56	Betocc Salboo	Betocc Salboo	Agrsto Poapra Junbal	Agrsto Desces Junbal	Cirarv	Cirarv Eupesu
57	Salexi Betocc	Salboo Betocc Salbeb	Agrsto	Agrsto Broine	Cirarv Trihyb	Cirarv Glylep
69	Salexi Betocc	Salboo Betocc	Agrsto	Carros Junbal	Cenmac	Cirarv Glylep
70	Betocc	Betocc Salboo	Agrsto Poapra	Agrsto Broine	Cirarv	Cirarv
72	Betocc Salboo	Betocc	Agrsto	Agrsto Broine	Cirarv	Cirarv Eupesu Glylep
73	Salboo Betocc	Salboo Betocc Salbeb	Carros Junbal	Agrsto Junbal	Cirarv	Cirarv
74	Salboo Betocc	Salboo Betocc	Agrsto Broine Junbal	Agrsto Broine Junbal	Cirarv	Cirarv Glylep Eupesu
75	Salboo Symocc	Salboo Symocc Betocc	Agrsto Broine	Agrrep Broine	Cirarv Trihyb	Cirarv Eupesu

[1] Scientific and common names corresponding to six letter codes are listed in Appendix .
[2] Polygons that had trees present were 57,70, 72, and 75 and are discussed in the preceding section.

Table 7. Cover composition (%) of dominant, co-dominant or community type indicator species in 1993 and 2000 on the Grant-Kohrs Ranch National Historic Site.		
Life-form and Species	1993	2000
Trees		
Populus trichocarpa	0.6	1.78
Shrubs		
Alnus incana	0.25	0.11
Betula occidentalis	12.94	11.12
Cornus stolonifera	0.38**	0.09
Ribes spp.	1.08	0.37
Rosa woodsii	1.00*	0.37
Salix bebbiana	2.17	3.29
Salix boothii	9.45	9.44
Salix exigua	5.80**	3.51
Salix geyeriana	0.28	0.52
Salix lasiandra	0.12	0.09
Symphoricarpos occidentalis	2.25	1.94
Other Shrubs	0.07	0.19
Total Shrubs	35.79*	31.05
Graminoids		
Agrostis stolonifera	24.17*	16.72
Agropyron repens	3.58	4.89
Bromus inermis	4.71*	10.70
Carex spp.	1.03	1.53
Deschampsia cespitosa	0.53*	3.16
Juncus balticus	5.57	9.82
Poa pratensis	5.91*	1.39
Phleum pratense	0.53	0.30
Other grasses	0.57	1.69
Exotic grasses[2]	39.45	34.00
Total graminoids	46.60	50.20
Forbs		
Centaurea maculosa	0.77	0.80
Cirsium arvense	7.71	7.00
Equisetum spp.	0.11	0.31
Euphorbia esula	1.35*	4.41
Glycyrrhiza lepidota	0.15*	2.93
Potentilla anseriana	0.62	0.13
Solidago spp.	0.48	0.56

Trifolium repens	3.64*	0.08
Other forbs	1.66	2.93
Noxious Forbs[3]	9.15	12.90
Total Forbs	16.49	19.15

* Means of the same species are significantly ($p \leq 0.10$) different.
[1] In 1993 this species was identified as *Salix amygdaloides*.
[2] Exotic grasses is the sum of non-native grasses.
[3] Noxious Forbs is the sum of non-native aggressive forbs, *Centaurea maculosa*, *Cirsium arvense* and *Euphorbia esula*.

The dominant forbs, mostly exotic disturbance tolerant species, remained similar in 1993 and 2000 on a total basis; however, there was a significant decrease in mean cover (%) composition of *Trifolium repens* and an increase in mean cover composition (%) of *Euphorbia esula* (Table 7). *Glycyrrhiza lepidota* was the only native forb found to have a different mean canopy cover between 1993 and 2000 with an increase in coverage. Thompson et al. (1995) considered weed infestations as a major problem. Of the noxious weeds only *Euphorbia esula* showed an increase in canopy cover. *Euphorbia esula* is an exotic species that is extremely competitive, and was often found along the river bank. The decrease in *Trifolium repens* is consistent with other research showing that this species increases with livestock grazing and decreases with rest (Hansen et al. 1995; Popolizio et al. 1994). However, the much dryer conditions in 2000 compared to 1993 may also be a factor in decreased coverage of *Trifolium repens*.

g) Bare Ground

Mean cover of human caused bare ground and total bare ground were greater in 2000 compared to 1993 (Table 8). Human-caused bare ground includes slickens areas, cattle wallows and trails, recreation trails, etc. Slicken areas were estimated as a proportion of the human caused bare ground using cover class estimates and also showed an increase between 1993 and 2000. The much dryer conditions of 2000 compared to 1993 may have resulted in increased bare ground estimates.

Table 8. Mean cover (%) of natural bare ground[1], human caused bare ground, and total bare ground in 1993 and 2000 on Grant-Kohrs Ranch National Historic Site.		
Type of Bare Ground	**1993**	**2000**
Natural	0.7	3.4
Human Caused	1.1*	2.8
Slicken component of human caused[2]	0.8*	2.7
Total	1.6*	5.4

[1] Natural bare ground includes gravel and point bars, dried ponds etc. Natural bare ground includes gravel and point bars, dried ponds etc

[2] The mean cover (%) of slickens is an estimate of cover classes for only those 13 polygons used to compare 1993 and 2000 data. This data does not include all of the riparian areas of GKR.

* Means of same row are significantly different ($p \leq 0.10$) between years.

h) Stream Health Evaluation

We found an increase in deep binding root mass (%) and a decrease in percent of unstable banks on the Clark Fork River between 2000 and 1993 (Table 9). These results are in agreement with the geomorphic theory and empirical studies that suggest that following grazing elimination banks become more stable (Kauffman and Krueger, 1984; Magilligan and McDowell, 1997). However, with the much lower stream flows of 2000 as compared to 1993 it is likely that some of the observed improvement was associated with less river erosion forces.

Table 9. Mean riverbank with deep binding root mass (%) and unstable streambank (%) in 1993 and 2000.			
Percent Bank with Deep Binding Root Mass		Percent Bank Unstable	
1993	2000	1993	2000
41.6*	71.1	25.3*	16.0

* Means of the same category are significantly ($p \leq 0.10$) between years.

i) Polygon Health Evaluations

We found increases in polygon health between 1993 and 2000 (Table 11). The increase in the vegetative health score is related to increased shrub regeneration and a decrease in shrub utilization and decrease in the amount of decadent and down-woody material. The improved soil/hydrology score is related to increased deep binding rootmass and decreased later cutting. The increase in overall health resulted in the health category ratings improving with 4 of the 13 polygons in 1993 rated as “healthy” in 1993 compared to 8 in 2000 (Table 11). As stated previously it is difficult to ascertain how much of the improvement in decreased lateral cutting maybe associated with the low stream flow conditions in 2000 compared to 1993 and if the rate of improvement is what would be expected from grazing exclusion for this site.

Table 11. Comparison of polygon health in 1993 and 2000.

Vegetative Health 1993 / 2000		Hydrology Health 1993 / 2000		Overall Health 1993 / 2000		Health Category					
						Healthy 1993 /2000		At Risk 1993 / 2000		Unhealthy 1993 / 2000	
75.7*	79.5	88.5*	81.4	71.3*	80.5	4	8	7	4	2	1

Means of the same category are significantly different ($p \leq 0.10$) between years.

j) Photo Comparisons

A set of photo comparisons are presented as Appendix 6. We did not know the exact locations of photo points or exposure information so the comparisons are provided only as qualitative comparison. We believe the photo comparisons visually illustrate that for these areas vegetation conditions between 1993 and 2000 changed very little or possibly regressed.

4) Summary and Conclusions

We evaluated the report "Vegetation Mapping and Analysis of the Grant-Kohrs National Historic Site" by Thompson et al. (1995) and determined vegetation and riparian health changes between 1993 and 2000 on riparian sites on the Grant-Kohrs National Historic Site. The methodology of Thompson et al. (1995) used to evaluate riparian and wetland health is an adequate and appropriate tool for managers interested in capturing the broader influences and changes in riparian ecosystems. The methodology however is subjective and in this case applied to large polygons averaging 13 acres. Therefore, the methodology is not sensitive enough to accurately classify a percentage of change associated with a type of disturbance (i.e. grazing or heavy metals) where both may be having an outwardly similar influence. We found that many of the dominant species comprising the disturbance communities are tolerant of both elevated metal levels and increased grazing (Table 12). These similar responses make it difficult to categorize these communities as either associated with only livestock grazing or elevated levels of metals.

There is little doubt that human disturbance, through livestock grazing or associated with sedimentation and stream changes associated with mining in the Upper Clark Fork River watershed, have impacted riparian communities and function. Since the majority of the disturbance-adapted plants that dominate the ranch's riparian areas are both grazing resistant and metal-tolerant it is difficult to assign a causative factor or a percentage of change associated with a causative factor. Therefore, we believe that Thompson et al. (1995) statements regarding that the plant communities and problems associated with polygon health are associated with livestock grazing are speculative. Likewise, when Thompson et al. (1995) lists the *Deschampsia cespitosa* habitat type as a non-disturbance type on the GKR, they probably incorrectly classified this type. There is strong evidence that the metal tolerant graminoid *Deschampsia cespitosa* is related to tailings deposits in the Upper Clark Fork River Valley (Rice and Ray 1984, Massey, 1998). Thus, when considering human disturbance associated with grazing or mine tailings in "metal tolerant" community types in the Upper Clark Fork River Valley it will be difficult to assign a percentage of change associated with a particular disturbance until we have more research on these communities.

We found no difference in the acreage of plant communities or frequency of structural diversity classes, and few differences in species composition between polygons compared between 1993 and 2000. We agree with Thompson et al. (1995) that the plant communities of Grant-Kohrs Ranch National Historic site are dominated by "disturbance type communities" as defined by Hansen et al. (1995). However, the lack of change in plant communities after seven years of grazing deferment suggest that factors other than livestock grazing are presently retarding the

Table 12. Grazing response, metal tolerance, and origin for some important species found on the Grant-Kohrs Ranch National Historic Site.

Species	Grazing Response[1]	Metal Tolerance	Origin
Graminoids			
Agrostis stolonifera	Exotic, Aggressive	Tolerant[2]	Introduced
Agropyron repens	Exotic, Aggressive	Unknown	Introduced
Bromus inermis	Exotic, Aggressive	Unknown	Introduced
Carex rostrata	Decreaser	Tolerant[9]	Native
Deschampsia cespitosa	Decreaser	Tolerant[3,11]	Native
Juncus balticus	Increaser	Tolerant[8,10]	Native
Poa pratensis	Exotic, Aggressive	Unknown	Introduced
Forbs			
*Centaurea maculosa**	Exotic, Aggressive	Tolerant[6,8,9]	Introduced
*Cirsium arvense**	Exotic, Aggressive	Tolerant[6,8,9]	Introduced
*Euphorbia esula**	Exotic, Aggressive	Tolerant[6,11]	Introduced
Glycyrrhiza lepidota	Increaser	Tolerant[10,11]	Introduced
Trifolium hybridum	Exotic	Unknown	Native
Shrubs/Trees			
Betula occidentalis	Decreaser	Tolerant[4,5,10]	Native
Rosa woodsii	Increaser	Tolerant[6,7,8,10]	Native
Salix boothii	Decreaser	Tolerant[4]	Native
Salix bebbiana	Decreaser	Tolerant[12]	Native
Salix exigua	Decreaser	Tolerant[4]	Native
Symphoricarpus occidentalis	Increaser	Tolerant[10]	Native
Populus trichocarpa	Decreaser	Unknown	Native

* Species on Montana Noxious Weed list.

1 Grazing response is how a plant species will generally respond to livestock grazing. Species that are rated as decreasers are expected to decrease with livestock grazing (and increase with grazing exclusion) and increasers are expected to increase with livestock grazing (and decrease with livestock exclusion). Exotic species are species of foreign origin and by definition are considered invader species. Invader species are not a natural component of the site and would by successional theory be expected to decrease with livestock exclusion (Dyksterhuis, 1949). We have termed some of these species as “Aggressive” to signify that they are known to occupy some sites for long-time periods, even with reduced grazing pressure.

2 Rauser and Winterhalder (1985), Wu, Bradshaw, and Thurman, (1975), and Wu and Antonovics (1975).

3 Cox and Hutchinson (1980), Hertstein and Jager (1986), Rauser and Winterhalder (1985), Von Frenckell-insam and Hutchinson (1993).

4 Massey, J. G. 1998.

5 Brown, M. T., and Wilkins, D. A. 1985.

6 Referenced by Dr. Tom Keck, Natural Resource Conservation Service, Deer Lodge Montana (personal communication; memo from S. Jennings to B. Rennick, June 5, 1998; Keck et al., Mapping Soil Impact Classes on Smelter Affected Lands).

7 Personal communication with Dr. Frank Munshower, Montana State University, Bozeman.

8 Field observations by Bob Rennick, CDM Federal Program, Corporation, Helena, Montana.

9 Reconnaissance conducted by the Reclamation Research Unit, ARTS Phase I Final Report, 1993.

10 Field observations by Janet Hardin, Botanist, The University of Montana, 2000.

11 Riparian and Wetland Research Program addendum to the Clark Fork River Riparian Zone Inventory. 1998.

12 Ray, G. J. 1985.

rate of change in vegetation communities back to potential natural plant communities. Polygon health measurements did increase (improve) between 1993 and 2000. The improved polygon health was associated with increased shrub regeneration, decreased shrub utilization, decreased decadent and down woody material, improved deep binding rootmass, and decreased lateral cutting. In general, the improvement was small, averaging less than one class. We believe it is not possible to predict how much change should be expected during seven years of grazing exclusion for this site. Magilligan and McDowell (1997) stress that stream recovery is dependent on length of time of protection and channel type with no lag time established. In general, the literature has supported that the removal of grazing pressure allows riparian vegetation to increase in height and percent cover, resulting in bank stabilization, provision of shade, and restoration of natural organic inputs to the channel (Marcuson, 1977; Platts et al., 1983; Kauffman et al. 1983; Kauffman and Krueger 1984a, 1984 b, Elmore and Beschta, 1987; Magilligan and McDowell, 1997). Clary and Medin (1990) report that dramatic vegetation successional changes can occur when the grazing stress is removed. Others report that herbaceous vegetation can greatly increase within several growing seasons (Platts and Nelson, 1984), and woody vegetation can rebound within 5 to 10 years (Rickard and Cushing 1982; Skovlin 1984) if habitat deterioration is not severe. Severe habitat deterioration however can require very long recovery times, perhaps decades (Knopf and Cannon, 1982) or more (Platts and Raleigh, 1984).

We provide 3 hypotheses for the relative minor changes observed between 1993 and 2000 on the Grant-Kohrs Historical Ranch. First, the time frame of the study may not be long enough to observe ecological changes. Second, the much dryer conditions in 2000 compared to 1993 may have resulted in drought impacts influencing measurements making comparisons problematic. Third, factors other than livestock grazing may be resulting in slow recovery of vegetation and stream conditions. From our study it is not possible to determine which factor or factors are most important in influencing the rate of change in the existing plant communities and riparian conditions presently occurring on the Grant-Kohrs National Historic Ranch.

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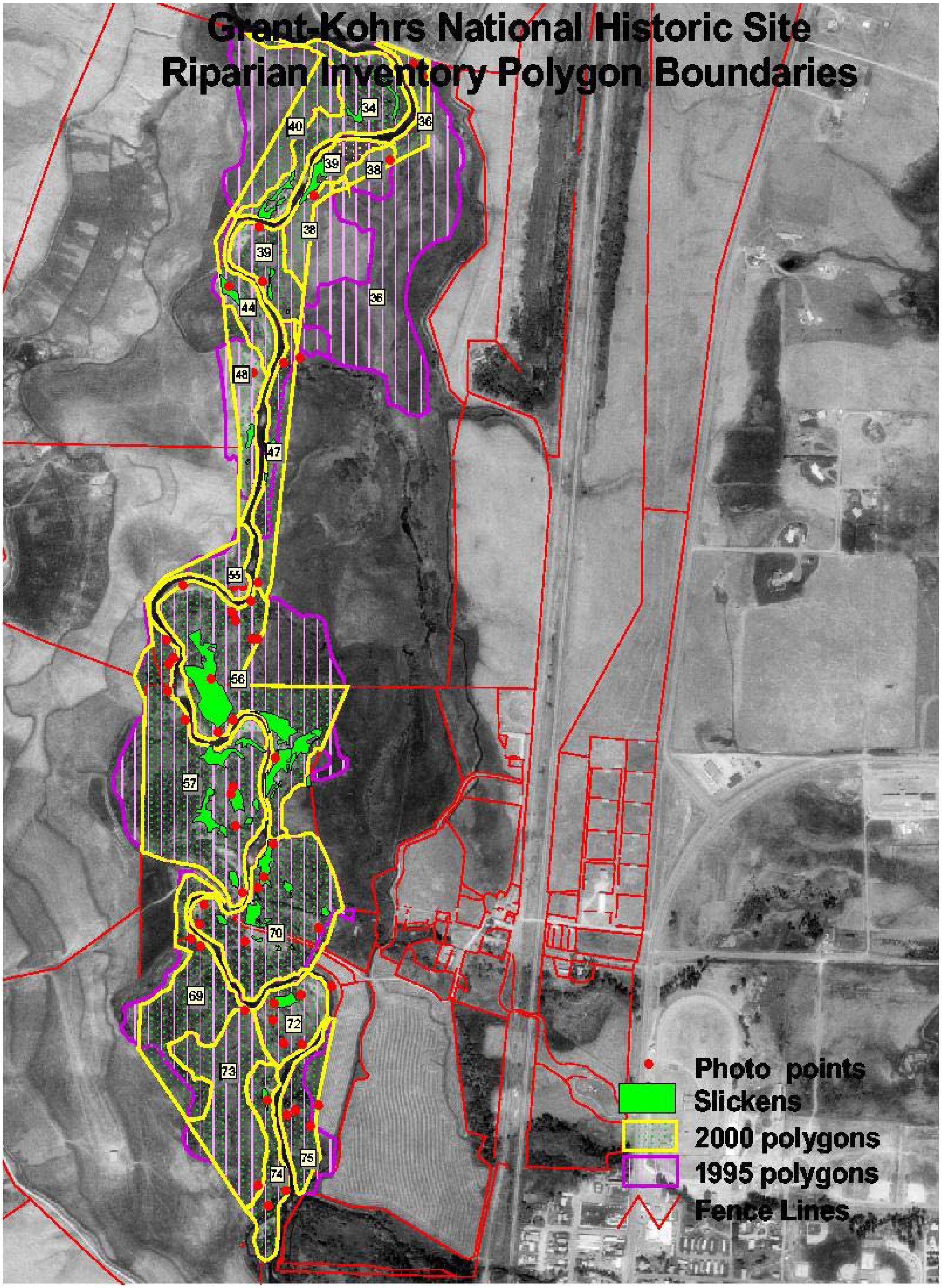
6) Appendices

Appendix 1. Area (acres) of polygons in 1993 and 2000 and a designation if compared between 1993 and 2000.			
Polygon Number	1993	2000	Attributes Compared
34	8.4	8.4	No, polygon burned in 1998.
36	23.3	2.4	No, large size discrepancy[1].
38	8.3	3.1	No, large size discrepancy.
40	11.7	4.2	No, large size discrepancy.
39	5.9	5.9	Yes
44	3.1	3.1	Yes
47	2.5	4.9	Yes
48	4.7	4.2	Yes
55	2.3	2.5	Yes
56	23.6	17.0	Yes
57	21.8	19.2	Yes
69	9.8	9.9	Yes
70	13.5	13.5	Yes
72	4.3	4.3	Yes
73	10.4	9.9	Yes
74	4.2	4.2	Yes
75	4.3	4.8	Yes

[1] Size differences were associated with fence placement and thus exclusion of grazing. These polygons were not completely within the fenced riparian, and therefore parts of the polygon were grazed by livestock, and were not compared.

Appendix 2. Arcview map of Grant-Kohrs Ranch National Historic Site polygons measured in 1993 and 2000.



Appendix 3. Scientific names, six-letter abbreviations and common names of plant species presented in the paper.

Life-form and Species	Six-letter Abbreviation	Common Name
Trees		
Populus trichocarpa	Poptri	Black cottonwood
Shrubs		
Alnus incana	Alninc	Mountain alder
Betula occidentalis	Betocc	Water birch
Cornus stolonifera	Corsto	Red-osier dogwood
Ribes spp.	Ribspp	Gooseberries
Rosa woodsii	Roswoo	Wood's rose
Salix bebbiana	Salbeb	Bebb willow
Salix boothii	Salboo	Booth's willow
Salix exigua	Salexi	Sandbar willow
Salix geyeriana	Salgey	Geyer willow
Symphoricarpos occidentalis	Symocc	Western snowberry
Graminoids		
Agrostis stolonifera	Agrsto	Redtop
Agropyron repens	Agrrep	Quackgrass
Bromus inermis	Broine	Smooth brome
Carex rostrata	Carros	Beaked sedge
Carex spp.	Carspp	Sedges
Deschampsia cespitosa	Desces	Tufted hairgrass
Juncus balticus	Junbal	Baltic rush
Phleum pratense	Phlpra	Common timothy
Poa pratensis	Poapra	Kentucky bluegrass
Forbs		
Centaurea maculosa	Cenmac	Spotted knapweed
Cirsium arvense	Cirarv	Canada thistle
Equisetum spp.	Equspp	Horsetails
Euphorbia esula	Eupesu	Leafy spurge
Glycyrrhiza lepidota	Glylep	American licorice
Sisymbrium loosely	Sisloe	Smallweed tumblemustard
Solidago spp.	Solspp	Goldenrods
Trifolium hybridium	Trihyb	Alsike clover
Trifolium repens	Trirep	White clover

Appendix 4. Canopy cover (%) of dominant, co-dominant or community type indicator species in 1993 and 2000 on the Grant-Kohrs Ranch National Historic Site.		
Life-form and Species	1993	2000
Trees		
Populus trichocarpa	1.0	2.58
Shrubs		
Alnus incana	0.38	0.19
Betula occidentalis	20.19	18.69
Cornus stolonifera	0.58	0.15
Ribes spp.	1.65	0.62
Rosa woodsii	1.58*	0.62
Salix bebbiana	3.27**	5.38
Salix boothii	13.88	15.62
Salix exigua	8.69**	5.81
Salix geyeriana	0.46*	0.88
Salix lasiandra	0.19	0.15
Symphoricarpos occidentalis	3.31	3.23
Other Shrubs	0.11	0.35
Graminoids		
Agrostis stolonifera	39.42**	27.15
Agropyron repens	5.77	7.92
Bromus inermis	7.50*	17.77
Carex spp.	1.08	2.50
Deschampsia cespitosa	0.85*	5.15
Juncus balticus	7.88*	14.81
Phleum pratense	0.81	0.50
Poa pratensis	9.65*	2.31
Other grass	1.00	2.73
Forbs		
Centaurea maculosa	1.19	1.42
Cirsium arvense	11.96	11.15
Equisetum spp.	0.19	0.54
Euphorbia esula	2.12*	7.15
Glycyrrhiza lepidota	0.23*	4.88
Potentilla anseriana	0.96	0.19
Solidago spp.	0.77	0.88
Trifolium repens	5.96*	0.12
Other forbs	2.61	4.65
Total	154.92	163.23

* Means of the same species different ($p<0.05$) between years using an unpaired t-test. Means without * are not significantly ($p>0.10$) different.

Appendix 5. Disturbance-induced[1] community and dominance types on the Grant-Kohrs Ranch National Historic Site (from Thompson et al. 1995) and identified in 2000.		
Community Type (CT) or Dominance Type (DT)	Disturbance Induced	Mean Disturbance Induced[2]
Populus trichocarpa/Herbaceous (black cottonwood/ Herb.) CT	Yes	100%
Salix bebbiana (Bebb willow) CT	Yes	100%
Salix geyeriana (Geyer willow) CT	Yes	100%
Alnus incana (mountain alder) CT	Possibly	25%
Betula occidentalis (water birch) CT	Possibly	25%
Rosa woodsii (woods rose) CT	Yes	100%
Agrostis stolonifera (redtop) CT	Possibly	50%
Bromus inermis (smooth brome) CT	Possibly	50%
Juncus balticus (Baltic rush) CT	Possibly	67%
Poa pratensis (Kentucky bluegrass) CT	Yes	100%
Centaurea maculosa (spotted knapweed) CT	Yes	100%
Agropyron repens (quackgrass) DT	Yes	100%
Phleum pratense (common timothy) DT	Yes	100%

[1] Disturbance-Induced is from Thompson et al. (1995) and refers that the presence of the type on a site is due to human-induced disturbance.
[2] Mean % Disturbance Induced is from Thompson et al. (1995) and refers to the proportion of the community or dominance type associated with human-induced disturbance.

Appendix 6. Grant-Kohrs National Historic Ranch Photo Comparisons September 1993 and September 2000.

Photo 1: 1993 polygon 36

Photo 2: 2000 polygon 36

Photo 3: 1993 polygon 44

Photo 4: 2000 polygon 44

Photo 5: 1993 Polygon 56

Photo 6: 2000 Polygon 56

Photo 7: 1993 polygon 70

Photo 8: 2000 polygon 70

Photo 9: 1993 polygon

Photo 10: 2000 polygon 72

Photo 11: 1993 polygon 73

Photo 12: 2000 polygon 73

Photo 13: 1993 polygon 75

Photo14: 2000 polygon 75

Appendix 7. Photo comparison locations.