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Cumulative Effects Analysis Process for the Yellowstone Ecosystem

Forest Service



Forest Service
National Park Service
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CUMULATIVE EFFECTS ANALYSIS PROCESS
for
THE YELLOWSTONE ECOSYSTEM

I INTRODUCTION

The Endangered Species Act necessitates that the cumulative effects of land uses and management activities be evaluated as part of the biological assessment process. Cumulative effects can be defined as "The combined effect upon a species or its habitat caused by the activity or program at hand, as well as other reasonably foreseeable events which are likely to have similar effects upon that species or its habitat. Cumulative effects can result from individually minor but collectively significant events taking place over a period of time."

Considering the myriad of demands placed on public and private lands within the Yellowstone Ecosystem, cumulative effects analysis has become an integral part of biological evaluations being prepared in occupied grizzly bear habitat. In addition to this use, the cumulative effects process can and should be used as an effective tool in management of grizzly bear habitat prior to the usual reactionary need most often associated with biological evaluations. Used in this manner, we will be better able to achieve our goal to "secure and maintain a viable, self-sustaining (recovered) population of wild free-ranging grizzly bears and the ecosystem upon which it depends."

In January of 1984, the Yellowstone Ecosystem Management Subcommittee of the Interagency Grizzly Bear Committee identified the need to develop a cumulative effects assessment process for use throughout the ecosystem. The objective developed by the subcommittee was, "Develop methodology to quantitatively and qualitatively assess the cumulative effects of human activity on grizzly bear habitat and bear use of that habitat in the Yellowstone Ecosystem." A task force representing each National Forest of the ecosystem, Yellowstone National Park, the Interagency Grizzly Bear Study Team, U.S. Fish and Wildlife Service and the Montana Fish, Wildlife and Parks Department was assembled to develop the process.

II APPROACH

Early in the cumulative effects process it became apparent that computer implementation would be necessary. The process therefore was modeled for computer implementation and is now referred to as the Cumulative Effects Model (CEM).

Design

The Cumulative Effects Model (CEM) is designed to: 1. Quantify individual and collective effects of land uses and activities in space and through time, and 2. Provide managers an analytic tool for evaluating alternative decisions relative to grizzly bear recovery goals and objectives.

The CEM is composed of three submodels: 1. Habitat, 2. Displacement, and 3. Mortality (see Figure 1). The habitat and displacement submodels determine the habitat effectiveness value of an area while the mortality submodel determines the mortality risks. The submodels integrate basic variables which are significant and subject to management.

The Habitat Submodel incorporates four variables: 1. Food and thermal cover, 2. Habitat diversity, 3. Seasonal equity, and 4. Denning suitability. These basic variables combined indicate the year-round habitat quality of an area (see Chapter III for details).

The Displacement Submodel includes four variables of human activity: 1. Type of Activity, i.e. motorized, non-motorized or explosive; 2. Nature of Activity, i.e. linear, point or dispersed; 3. Length of Activity, i.e. diurnal or 24 hour; 4. Disturbance Intensity, i.e. high or low. Displacement is characterized by a coefficient of habitat effectiveness and by an associated zone of influence (see Chapter IV for details). The displacement submodel is directly linked to the habitat submodel via the food/cover variable.

The Mortality Submodel incorporates five basic variables regarding human activity: 1. Habitat Quality, 2. Nature of Activity (Point, Linear, Dispersed), 3. Intensity of Use, 4. Availability of Attractants and 5. Presence of Firearms. The relative risk of mortality can be compared between activities (see Chapter V for details). The mortality submodel is indirectly linked to the habitat submodel via habitat quality and to the displacement submodel via the nature and intensity of human activity.

By integrating the submodels, the CEM provides two basic outputs: 1. Habitat effectiveness value, and 2. Mortality risk index.

Development

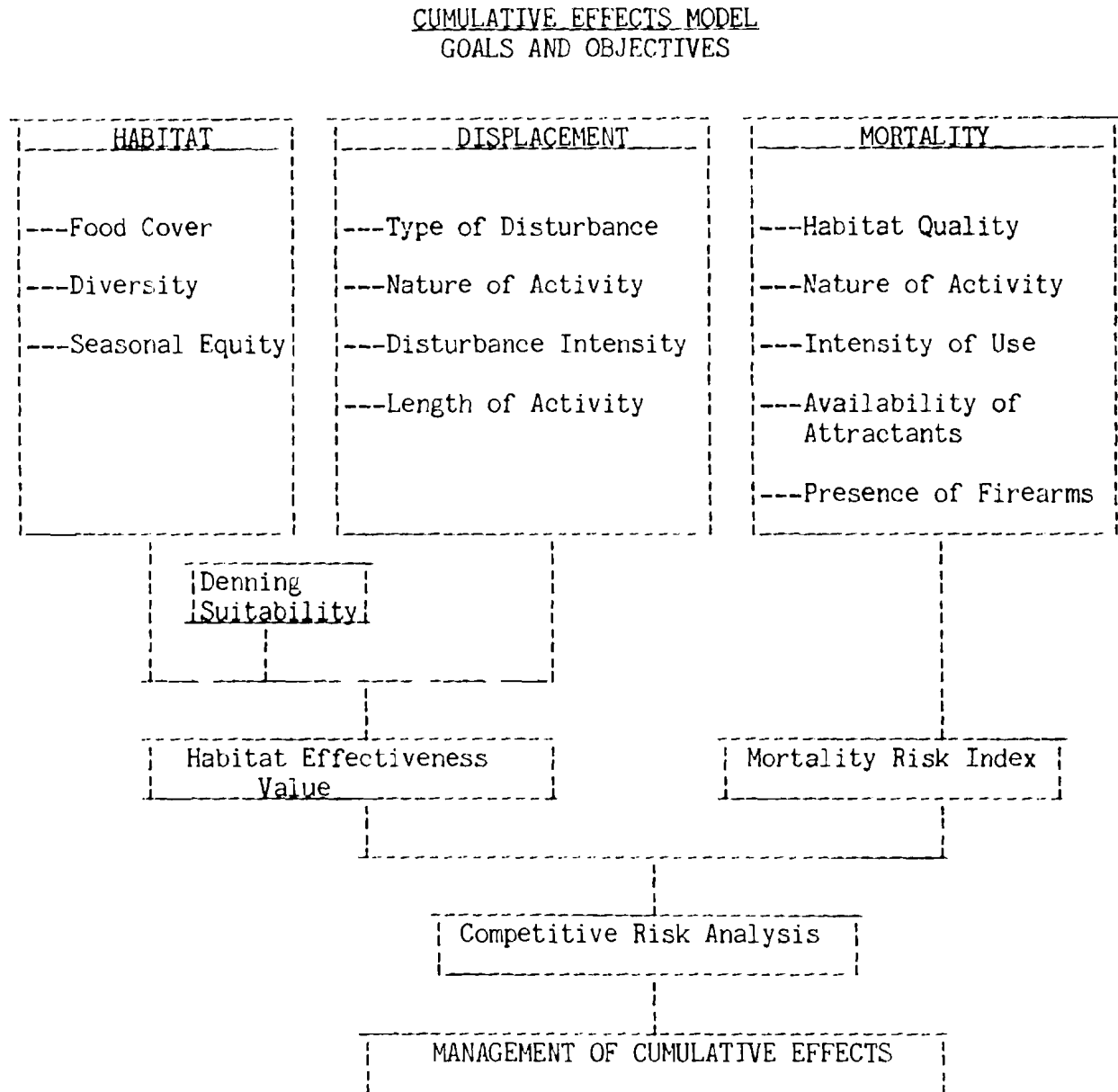
Development of the CEM entails two basic steps: 1. Deriving and mapping the habitat components, and 2. Categorizing and mapping the land uses and activities.

A series of digitized base maps displaying habitat/cover types for forested habitat components, non-forested habitat components, ungulate seasonal ranges and trout spawning streams to a five acre resolution are generated. Both existing and potential habitat values for unique cells (polygons on the final composite map) are generated by season and stored in a computer file.

A series of digitized overlay maps showing location and nature/type of existing land uses are also generated. Coefficients for displacement and mortality associated with different land uses are generated. The independent and combined effects upon habitat effectiveness value and mortality risk index are generated by month and stored in a computer file.

Once thresholds appropriate for grizzly bear recovery are established for the two outputs, managers can manipulate the numerous variables and analyze the competitive risks of various land uses via computer simulations.

Figure 1.



Delineation of Grizzly Bear Management Units

To deal with an ecosystem as large as Yellowstone, it was necessary to break the area into smaller more manageable units to:

1. Be able to assess existing and proposed activities without having the impacts washed out by too large an area.
2. Closely match individual grizzly bear use patterns and habitat ecology.
3. Prioritize areas where land use management needs would require a cumulative effects analysis.

Bear management units were delineated using primarily, grizzly bear radio relocation data and secondarily, topographic features. The entire area within currently designated occupied grizzly bear habitat was broken into bear management units.

Initially, areas were delineated which had a substantial number of radio locations during 0, 1, 2, or 3 "active" seasons. Active seasons were considered to be Spring (March through May), Summer (June through August), and Fall (September through November). Areas of extensive and contiguous substantial three-season use as well as areas without substantial use during any season were identified.

All areas with extensive and contiguous three-season use serve as a core for a bear management unit. Prominent topographic features between adjacent three-season use core areas serve as unit boundaries. Where a "non-use" or one to two-season use area adjoins a three-season use core area, a prominent topographic feature closest in proximity to the three-season use area serves as a boundary.

As a consequence, some management units contain extensive areas of known substantial three-season bear use (Madison, Washburn, Lamar/Slough, Crandall/Sunlight, Firehole/Hayden, Pelican/Clear, and Two Ocean/Lake, B.M.U.'s). Other units are characterized by virtually no bear use (Boulder, Teton, Plateau, and Henry's Lake B.M.U.'s). These minimal use units all occur around the periphery of occupied grizzly habitat. Other units (Gallatin, Hellroaring/Bear, Shoshone, Thorofare, Bechler/Grassy L.) have substantial bear use during only one to two seasons or have only a limited area of three-season use.

Subunit Delineation

Each management unit may contain up to four subunits. Subunits therefore provide further landscape resolution as well as finer attunement to grizzly bear habitat use patterns. Subunits are delineated primarily on the basis of seasonal component representation and interspersion. An optimal subunit corresponds to a contiguous but more-or-less interspersed area of Spring range accompanied, in fairly close proximity, by significant areas of Summer and Fall range. This complex is typically encompassed by a major drainage and portions of intervening ridges. On the other hand, some subunits are distinguished, as are some units, by a uniform lack of high value seasonal components or by the presence of high value feeding opportunity during only one or two seasons. In the latter case, the one or two higher value seasonal components are too far distant from other seasonal components for a significant number of bears to efficiently integrate them in yearly ranges.

A subunit corresponds to the optimal scale for incorporating information on grizzly bear habitat utilization. Insufficient information is contained at the individual polygon or component level pertaining to all important factors such as equity of seasonal feeding opportunities and landscape patterns of food availability. On the other hand, at the unit level, too much extraneous information is contained which obscures the most energetically efficient area, given general habitat conditions, at which a grizzly bear can apparently operate. Subunits will be delineated once habitat mapping of the unit is complete.

III HABITAT SUBMODEL

Description

The habitat submodel provides a relative numeric evaluation of grizzly bear habitat. The evaluation is expressed as "habitat value." Habitat value can reflect both potential and existing conditions, i.e., a range of foraging environments, both simulated and extant. Habitat value derivation incorporates the factors of food, cover, habitat diversity, and equity of seasonal feeding opportunity.

Value attributable to denning habitat is not incorporated in the submodel. Denning habitat is not considered to be limiting in the greater Yellowstone area (Judd et al., in press). However, habitat value thresholds will be defined after mapping completion which would identify management subunits requiring management of high quality denning habitat--those sites meeting all of the following criteria:

1. Cover type: SF, LP3, WB2, WB3, or WB
2. Habitat type: *Abies lasiocarpa*/*Vaccinium scoparium*-*V. scoparium* phase, *Abies lasiocarpa*/*Vaccinium scoparium*-*Pinus albicaulis* phase, *Abies lasiocarpa*/*Vaccinium globulare*-*V. scoparium* phase, or *Pinus albicaulis*/*Vaccinium scoparium* habitat type
3. Elevation: greater than 8100' (2450 m)
4. Aspect: northerly (between 292 and 360° and 0 and 68°)
5. Slope: 30 to 60°
6. Topography: mid to upper one-third slope
7. Soils: sandy loam

The habitat submodel culminates in calculation of habitat value (UHV_i) for each bear management unit. This value (UHV_i) is an average of subunit habitat values ($SUHV_{pi}$) weighted by relative area. Subunits are therefore the primary management level at which grizzly bear habitat values are calculated. Subunit habitat values are relative and, consequently, meaningful only in comparison to other units or subunits.

Habitat value of an area the size of a subunit (25,000 to 100,000 acres) 10,000 - 40,000 ha) depends not only on average food and cover values but also on diversity attributable to edge density and the consistency or equity of feeding opportunity across seasons during which bears are actively foraging. Landscape diversity or edge density and seasonal feeding opportunity equity are treated as attributes of a management subunit in this model and only indirectly as attributes of a management unit. Subunit values ($SUHV_{pi}$) are therefore a direct function of mean habitat value (MHV_{pi}), which incorporates the effect of edge density, and seasonal subunit value equity (E_{pi}).

Increased continuity of feeding opportunity across seasons is considered to increase the habitat value of a subunit. Evenness or continuity of feeding opportunity would logically result in greater fidelity of bears to an area (subunit). This greater fidelity is a probable consequence of increased habituation and increased efficiency of habitat exploitation. Therefore, as disparity of subunit seasonal values (SHV_{pik}) increases, mean subunit habitat value (MHV_{pi}) decreases.

An index, E_{pi} , of seasonal feeding opportunity equity is utilized in submodel calculations. E_{pi} is an adjusted coefficient of variation for seasonal subunit habitat value (SHV_{pik}). Decreased E_{pi} corresponds to increased disparity in seasonal values. MHV_{pi} is therefore reduced as a direct function of E_{pi} 's fractional value which is, in turn, constrained to a minimum value of .667.

Mean subunit habitat value (MHV_{pi}) is, as its name implies, the mean of seasonal subunit values (SHV_{pik}) calculated for Spring, Summer, and Fall. SHV_{pik} is, in turn, an area weighted mean of individual component habitat values (HV_{jku}). Subunit habitat value (SHV_{pik}) primarily reflects foraging opportunity, although value attributable to thermal and security cover is also integrated. Greater seasonal habitat value therefore primarily reflects greater quality and diversity of available foods over a broader area.

Individual component habitat values (HV_{jku}) are derived from base unit area component habitat values (UHV'_{jku}). Base unit area component value integrates value of characteristic available foods, diversity of feeding opportunity, and feedsite density or preference for each habitat component by season (Spring, Summer, or Fall) (Mattson, 1985). Two factors are applied to base unit area values (UHV'_{jku}) to derive individual component values (HV_{jku}): (1) adjustment to value (Cvr_{tk}) based on a specific distance threshold from forest-nonforest edge into both forest and non-forest stands (Table 1, Appendix); and (2) adjustment to value (Ung_{tk} or Trt_{tk}) based on inclusion in protein-rich areas (Table 2, Appendix).

Grizzly bear are known to especially prefer forest-nonforest ecotones in the greater Yellowstone area (Graham 1978, Blanchard 1983, Brannon 1984, Schleyer et al. 1984). Base unit area component values are therefore adjusted according to distance from this ecotone, with coefficients defined by frequency distribution of recorded feedsites. Yellowstone grizzly bear are also known to prefer food items, i.e., ungulates and cutthroat trout, distinguished by concentrated protein (Cole 1972, Schleyer 1983, Knight et al. 1984). An additional factor is therefore applied to base unit area values which accounts for value added by extensive concentrations of protein-rich foods and which varies according to the type of protein-rich food and, for ungulates, the season and type of range.

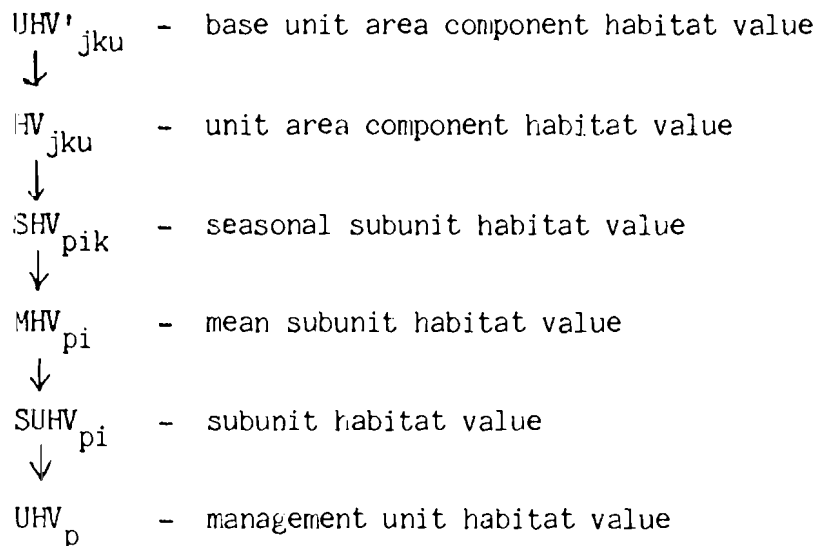
Base unit area habitat values (UHV'_{jku}) range from a maximum of 1.291 to a minimum of 0.000. Base unit area values also vary for each component according to presence of ungulate concentrations and season. A benchmark base value of 1.000 is accorded the habitat type unadjusted for cover type, with greatest seasonal value; for this study, the nonforest *Scirpus* spp.-*Carex* spp. geothermally influenced habitat type. This habitat type is subsumed in the more generic low elevation marsh/fen nonforest component.

Base unit area component values are given in Tables 3-6 (Base Values) found in the Appendix. These values are arranged in a matrix of habitat types and cover types, by season and by the presence of a protein-rich resource. In this submodel, habitat components correspond to intersections of habitat type and cover type in the matrix or to any appropriate aggregation of such fine scale components. Comparison of table values is meaningful only when stratified by presence (UNG) or absence (W/O UNG) of protein-rich food concentrations. Comparison between the two strata or categories is legitimate only after multiplying the UNG value by an appropriate factor (Ung_{tk} or Trt_{tk}) adjusting for the type of protein-rich food present and the type of ungulate range.

In summary, calculated subunit (or unit) habitat value varies according to area representation and base unit area value of habitat components, presence of ungulate concentrations and cutthroat trout spawning streams, interspersions of forest and nonforest components, equity of feeding opportunity through the bears' active seasons, and habitat type diversity. Highest values correspond with subunits having concentrations of ungulates, trout spawning streams, high habitat diversity, equity of seasonal feeding opportunity, habitat components with uniformly high base unit area values, high density of forest-nonforest edge, and forest cover at optimal successional stages.

Successive incorporation of habitat values culminating in grizzly bear management unit habitat values is displayed in Figure 2.

Figure 2



Assumptions

1. Area habitat quality, aside from human interference, is substantially a function of cover and food availability.
2. When human presence is not a factor, food availability considerably outweighs cover and denning habitat in contribution to area habitat value or quality.

3. Feedsite, scat, and radio relocation data collected by the IGBST are representative of the grizzly bear population in the greater Yellowstone area.
4. Habitat type, with cover type superimposed, is an accurate predictor of food and cover value for grizzly bear within an area 10,000 to 40,000 ha in size.
5. Subunit habitat value is accurately predicated by habitat diversity, equity of feeding opportunity through the bears' active seasons, habitat type (or component) representation, and presence of protein rich animal food sources.

Variables

A_{pij} = total area representation of habitat component j in subunit i of unit p.

SUA_{pi} = total area of subunit i in unit p.

UA_p = total area of unit p.

P_{pih} = proportionate area representation of habitat type (or habitat type aggregate) h in subunit i of unit p.

UHV'_{jku} = base unit area value of component j during season k in protein-rich strata u.

Trt_{tk} = adjustment factor for inclusion in influence zone of cutthroat spawning stream type t during season k.

Ung_{tk} = adjustment factor for presence of ungulate concentrations on range type t during season k.

Cvr_{tk} = adjustment factor for distance zone x from forest-nonforest edge into cover type t during season k.

HV_{jku} = $UHV'_{jku} * Cvr_{tk} * (Trt_{tk} \text{ or } Ung_{tk})$

SHV_{pik} = $(\sum_{j=1} A_{pij} * HV_{jku}) / SUA_{pi}$

MHV_{pi} = $(\sum_{k=1} SHV_{pik}) / 3$

E_{pi} = $1 - ((\sqrt{\sum (SHV_{pik} - MHV_{pi})^2} / MHV_{pi}) / 4.242)$

$SUHV_{pi}$ = $MHV_{pi} * E_{pi}$

UHV_p = $(\sum_{i=1} SUA_{pi} * SUHV_{pi}) / UA_p$

IV DISPLACEMENT SUBMODEL

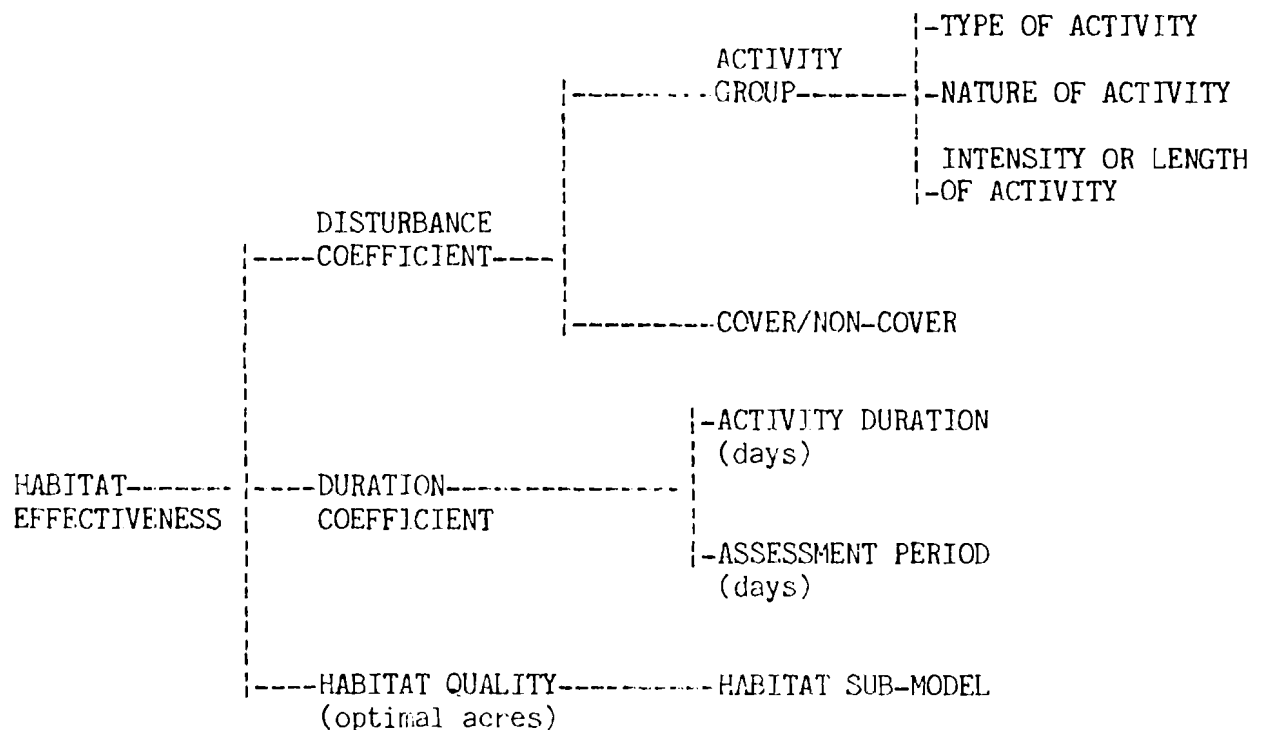
Description

The Displacement Submodel's objective is to quantify the effects of disturbance associated with human uses or activities on the grizzly bear's ability to use a specific habitat. The interaction of habitat quality and disturbance determines the habitat effectiveness (actual carrying capacity). The following steps were used to develop this submodel:

1. Stratify all activities and human uses occurring in the Yellowstone Ecosystem into groups reflecting similar effects.
2. Assign disturbance coefficients and zones of influence for each activity group.
3. Identify how the effects of disturbance for a specific area or project are aggregated in space and time.
4. Identify the procedures to operate the submodel.

Figure 3 shows the main components and relationships of this submodel.

Figure 3 Displacement Submodel Diagram



Activity Stratification

Activities and human uses which occur in the Yellowstone Grizzly Bear Ecosystem were stratified into groups having similar disturbance potentials. Usually activity lists reflect the type of user or function responsible for the activity; e.g., timber harvest, campground, oil and gas drilling, or thinning operation. This type of activity list would be enormous. Grouping activities by the degree and type of disturbance not only reduces the number of categories to deal with, but simplifies the analysis without giving up model resolution.

Thirteen activity groups, stratified by the following criteria, were identified:

1. Type of Activity; i.e., motorized, non-motorized, or explosive;
2. Nature of the Activity; i.e., linear, point, or dispersed;
3. Length of Activity; i.e., diurnal or 24 hour;
4. Disturbance Intensity; i.e., high or low;

The type of activity is determined by the dominant disturbance element associated with the activity. If the activity is primarily mechanized and produces loud equipment noises it is motorized. If the activity is primarily human activities without loud equipment it is non-motorized. Any time above ground explosives are used the activity type is explosive. Figure 4 shows the flow diagram for structuring the activity groups

Figure 4 Activity Group Diagram

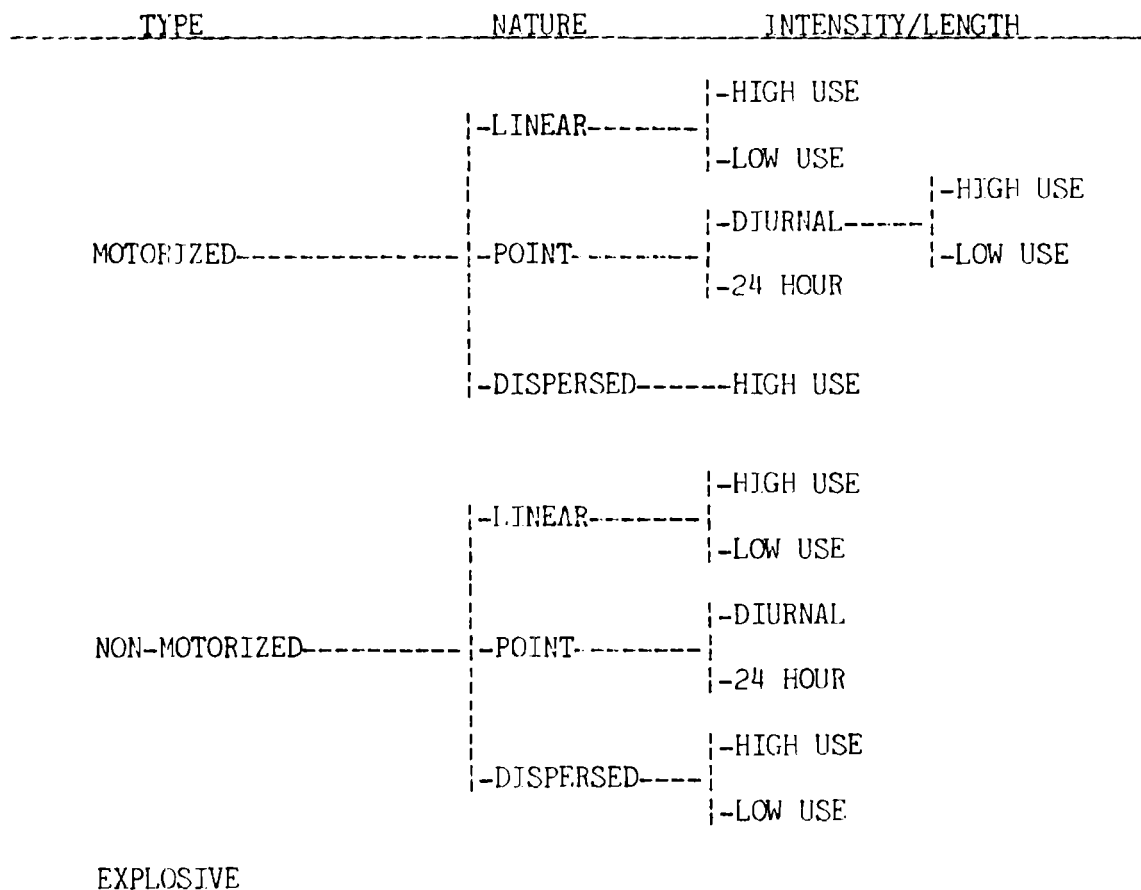


Table 8 identifies the activity groups including definitions and specific examples of activities.

Table 8 Activity Groups

MOTORIZED LINEAR - Motorized activities restricted to roads, trails, or linear corridor of travel such as aircraft flight corridors or seismic lines.

HIGH USE - vehicle traffic exceeding one vehicle per daylight hour. Would include recurring low elevation <1500 feet (<500 meters) above the ground aircraft use, or seismic exploration without above ground explosives.

LOW USE - e.g., vehicle traffic less than one vehicle per daylight hour. Generally associated with primitive roads or jeep trails.

MOTORIZED POINT - Motorized activities restricted to a specific point or area; e.g., drilling operation, timber harvest activities, boat dock or ramp, generator site, or resort complex.

DIURNAL - Activities which produce loud equipment noises and occur only during the daylight hours.

HIGH INTENSITY - e.g., major timber harvest activities, or day use only recreation complex.

LOW INTENSITY - e.g., fire wood cutting.

24 HOUR - Activities which produce loud equipment noises on a 24 hour operating period; e.g., oil and gas drilling operation, mill/minesite, or resort complex.

MOTORIZED DISPERSED - concentrated off road vehicle activities which are not restricted to roads or trails, but rather occur over broad areas. Use would be >1 person/habitat component/day. Can include either over land (e.g., motorcycle) or over snow (e.g., snowmobile) activities.

NON-MOTORIZED LINEAR - Non-vehicle use associated with roads or trails. Would include roads closed to motor vehicle traffic.

HIGH USE - greater than three parties/day.

LOW USE - less than three parties/day.

NON-MOTORIZED POINT - Human activities restricted to a specific point or area.

DIURNAL - e.g., picnic ground or trail head.

24 HOUR - e.g., campground, or summer home.

NON-MOTORIZED DISPERSED - Human activities not restricted to a linear corridor or a specific point.

HIGH USE - greater than one person/habitat component/day; e.g., concentrated hunting use area.

LOW USE - less than one person/habitat component/day; e.g., area without easy access, or without recreation attractions.

EXPLOSIVES - Activities in which very loud explosions are associated with the activity; e.g., seismic exploration or road construction.

Disturbance Coefficients/Zones of Influence

Disturbance coefficients and zones of influence for each activity group were identified using the team's subjective ratings. Available research data which the core team reviewed was collected primarily in other grizzly bear ecosystems and not felt to be representative of grizzly behavior in the Yellowstone ecosystem. The zone of influence identifies the distance in which grizzlies would be affected by the activity, and the coefficient identifies the degree of disturbance (on a scale of 0.0 to 1.0) within the zone of influence. When selecting the zone of influence, ridgeline and line of sight distances are used when less than the mileage estimate. Disturbance can influence bear use in two ways: (1) actual displacement, and (2) change in use patterns reducing the time available for a bear to use an area; e.g., 24 hour to nocturnal use periods. Both of these factors were considered in coefficient development. Cover was felt to be important in determining both the zone of influence and the degree of disturbance. Cover is defined as that vegetation capable of hiding 90 percent of a standing adult bear from view of a human at a distance equal to or less than 200 feet (61 meters). Separate values were developed for cover and non-cover situations. Another consideration in coefficient development was bear behavior, specifically bear habituation to recurring (predictable) non-threatening activities. Attractions associated with various activities which might override the bear's flight response was not considered in this submodel. Attractions associated with a given activity are a key element in the mortality submodel.

It was not automatically assumed that all bears would be displaced from an activity's zone of influence. Instead it was estimated how grizzly bears would respond to a given activity in relation to a 24 hour period; i.e., what percent of the bears would still use the zone of influence for what percent of the 24 hour period. A disturbance coefficient of 0.0 means that none of the zone of influence would be available (total displacement for the life of the activity) to the bear. A disturbance coefficient of 1.0 means that habitat effectiveness is not affected by the activity. A coefficient of 0.5 means that either one half of the bears are displaced, all the bears can use the area for only half the day, or any combination thereof. The result is the same, the ability to support bears is reduced by 50 percent. Table 9 shows the displacement coefficients and zones of influence for the thirteen activity groups.

Based on the assumption that bears are sensitive to multiple simultaneous sources of disturbance, disturbance within overlapping zones of influence is cumulative. It is also assumed because of lack of better data that the cumulative relationship between overlapping disturbance coefficients is additive. Therefore within overlapping zones of influence, for activities occurring at the same time, the sum of the disturbance coefficients is used in the habitat effectiveness calculation ($DC > 1.0 = 1.0$); e.g., cover habitat within the zone of influence of a high use road ($DC = 0.7$) and a non-motorized diurnal point activity ($DC = 0.8$) the cumulative DC equals 0.5 [$(1.0 - 0.7) + (1.0 - 0.8) = 0.5$]. In the habitat effectiveness calculation the coefficient cannot be greater than 1.0, but it can when considering activity scheduling and coordination.

Table 9 Displacement Coefficients(DC)/Zones of Influence(ZI)

ACTIVITY GROUP	COVER	DC	NON-COVER	DC
	ZI		ZI	
Motorized Linear High Use	ridge line, 0.5 mile	0.7	ridge line, 2.0 miles	0.6
Motorized Linear Low Use	ridge line, 0.5 mile	0.9	ridge line, 2.0 miles	0.3
Motorized Point Diurnal High Intensity	ridge line, 1.0 mile	0.5	ridge line, 2.0 miles	0.4
Motorized Point Diurnal Low Intensity	ridge line, 1.0 mile	0.7	ridge line, 2.0 miles	0.5
Motorized Point 24 Hour	ridge line, 1.0 mile	0.2	ridge line, 2.0 miles	0.1
Motorized Dispersed	N.A.	0.5	N.A.	0.4
Non-Motorized Linear High Use	0.1 mile	0.8	line-of-sight, 0.5 mile	0.7
Non-Motorized Linear Low Use	none	1.0	line-of-sight, 0.5 mile	0.9
Non-Motorized Point Diurnal	0.3 mile	0.8	line-of-sight, 0.5 mile	0.5
Non-Motorized Point 24 Hour	0.3 mile	0.5	line-of-sight, 0.5 mile	0.3
Non-Motorized Dispersed High Use	N.A.	0.8	N.A.	0.7
Non-Motorized Dispersed Low Use	N.A.	1.0	N.A.	0.9
Explosives	ridge line, 1.0 mile	0.5	ridge line, 2.0 miles	0.3

Habitat Effectiveness

Habitat quality determines the ability of a specific habitat to support a bear (Habitat Submodel). Disturbance determines the ability of a bear to use a specific habitat (Disturbance Submodel). Habitat effectiveness is the product of these two submodels, and identifies the habitat's actual carrying capacity.

Habitat effectiveness is determined with an analysis of overlapping disturbance zones-of-influence and habitat polygons, and equals the disturbance coefficient times the optimal acres within the affected portion of the polygon. An example: 640 acres of grizzly spring range, 50 percent receiving high use non-motorized dispersed use in good cover would reduce the habitat effectiveness (HE) of this 640 acre spring range by 20 percent ($ZI = 0.5 \times 640 = 320$; $DC = 0.6$, $1.0 - 0.6 = 0.4$, $0.4 \times 320 = 128$, $128/640 = 0.2$). This assumes that all 640 acres are of equal habitat quality. If habitat quality is not constant then the out come of this analysis can be quite different; e.g., 640 acres of grizzly spring range, 50 percent low quality habitat (0.2) and 50 percent high quality habitat (0.8), non-motorized dispersed high use occurring in the high quality portion with good cover would reduce the habitat effectiveness of this 640 acres by 32 percent; ($ZI = 0.5$, $0.5 \times 640 = 320$; $OPT.A = 320 \times 0.8 = 256$; $DC = 0.6$, $0.6 \times 256 = 153.6$; $OPT.A = 320 \times 0.2 = 64$; $153.6 + 64 / 256 + 64 = 0.68$, $1.0 - 0.68 = 0.32$); if the dispersed use occurred in the lower quality portion the over all habitat effectiveness would be reduced by only 8 percent ($ZI = 0.5$, $0.5 \times 640 = 320$; $OPT.A = 320 \times 0.2 = 64$; $DC = 0.6$, $0.6 \times 64 = 38.4$; $OPT.A = 320 \times 0.8 = 256$; $38.4 + 256 / 64 + 256 = 0.92$, $1.0 - 0.92 = 0.08$). Habitat quality must be considered in the quantitative analysis of habitat effectiveness. This is a mathematically simple but often logistically demanding procedure. The technique is to simply identify for every homogeneous vegetative unit (polygon) within a zone-of-influence of a given activity (1) the polygon's optimal acres (number of 1.0 quality acres; e.g., 40 acres of 0.5 quality rating equals 20 optimal acres), (2) percent of the unit effected by the zone of influence, and (3) the disturbance coefficient involved. The product of (1)x(2)x(3) above divided by the total optimal acres equals the percent loss in habitat effectiveness at a given point in time.

Activity Duration

When an activity occurs and how long it lasts is just as important as its disturbance potential in determining the effects of disturbance on grizzly habitat effectiveness. Activity duration is another input coefficient into the submodel. This coefficient is simply the proportion (0.0 - 1.0) of the activity's duration in relation to the assessment period. The assessment period's length can vary with the detail of the analysis. For most applications a monthly assessment period, aggregated by season (spring, summer, fall, denning) seems appropriate. In special circumstances daily assessment periods could be used. The shorter the assessment period the more refined your analysis of activity duration, increasing your capability to identify activity bottlenecks and opportunities for activity schedule coordination; e.g., with a monthly assessment period you cannot evaluate when in the month the activity occurs, only the overall proportion of the month involved. If a specific portion of a month is important then you must use a shorter assessment period. Habitat effectiveness would have to be calculated for each assessment period, thus increasing the need for the logistically demanding mapping procedures. An example using a monthly assessment period, aggregated by season would work like this: an activity with a 90 day operating period (May 15 to July 15); spring defined here as May - June and summer as July, August, and September.

The duration coefficient for June would be 1.0, while for May and July it would be 0.5. For spring the coefficient would be 0.75 and for summer it would be 0.17. These coefficients are multiplied against the product of the disturbance coefficient and optimal acres (habitat quality) to determine the habitat effectiveness for the entire assessment period.

Inter-Relationships With Other Submodels

The effects of disturbance is one of three main components of the cumulative effects model. The Disturbance Submodel is linked directly with the Habitat Submodel, the product is habitat effectiveness. Habitat quality from the Habitat Submodel is an acre input into the habitat effectiveness equation; i.e., habitat quality expressed in optimal acres x disturbance coefficient x percent of polygon involved with the zone-of-influence x activity duration coefficient. This link with habitat quality creates a feedback loop between the two submodels. The Mortality Submodel is only indirectly linked with the Disturbance Submodel. The identification of bear displacement from one area to another could influence the high quality/ low quality levels (bear numbers) significantly changing the mortality risks identified in the Mortality Submodel. This relationship must be kept in mind when interpreting the model outputs.

Disturbance Submodel Operation Procedures/Non-Computer Operation

Assuming that habitat mapping, analysis unit delineation, and seasonal habitat elements have been completed follow these steps to implement the Disturbance Submodel. (1) Identify and map all existing activities and human uses within a selected bear analysis unit. Complete a separate map for each assessment period based on identified activity durations, and selected assessment period stratification. (2) For each map above identify zones-of-influence and disturbance coefficients (from Table 9). (3) Overlay habitat polygon maps and activity zones-of-influence maps and identify for each polygon involved the percent of polygon overlapping a given zone-of-influence, the appropriate disturbance coefficient(DC) for each zone-of-influence, and the appropriate duration coefficient for each zone-of-influence. Be sure to sum the disturbance coefficients for any overlapping zones-of-influence. (4) Compute the existing habitat effectiveness for each assessment period. Be sure habitat quality reflects appropriate seasonal rating. (5) Do the same for any proposed activities or human uses on a projected yearly basis for at least a 5 year planning period. A cartographic computer program has been designed to do all this for you. Training will be available on how to use the cartographic model to complete analysis of cumulative effects on an interactive basis at the terminal.

V MORTALITY SUBMODEL

Description

As man-caused mortality of grizzly bears within the Yellowstone Ecosystem continues to be one of the most significant deterrents to population recovery, it is necessary that the risk of grizzly bear mortality due to man's activity be evaluated in the cumulative effects process. The mortality submodel provides a relative numeric evaluation of this risk. The mortality submodel culminates in the calculation of a mortality risk indice for each bear management unit and or subunit.

Five basic variables are incorporated into the mortality submodel:

1. Habitat Quality
2. Nature of Activity (Point, Linear, Dispersed)
3. Intensity of Use
4. Availability of attractants
5. Presence of firearms.

These five basic variables combine to form distinct activity groups for which mortality risk indices were developed.

The following is a description of each of the variables that comprise the activity groups:

1. Habitat Quality

Deciding whether an activity occurs in low or high quality habitat is primarily based on stratification criteria established in the "Yellowstone Guidelines" (1979). As all lands within occupied grizzly bear habitat are stratified, activities occurring in Situation 1 habitat are categorized as high quality while activities occurring in Situation 2 areas are categorized as low quality. Activities occurring in management Situation 3 areas and private lands fall into the quality habitat immediately adjacent to it. While it is recognized that habitat quality can vary within a stratified area, stratification by management situation is currently the most consistent measure of habitat quality. As habitat mapping and habitat values are calculated according to the habitat submodel, habitat quality can be further refined.

2. Nature of Activity

In looking at the potential sources of illegal man-caused mortality, it was found that they could be categorized into the three groupings established in the displacement submodel. The following is a description of each group along with those uses which are typically represented in each grouping:

Point Source - This group includes those activities by which man could be providing grizzly bears with a food attractant. The following are examples of situations which would be classified as point sources of mortality: 1. Backcountry camps with food, livestock feed, game meat, etc., 2. Private homes, 3. Road killed animals, 4. Developed campgrounds, 5. Bear baiting stations, 6. Domestic sheep allotments.

Linear Source - This group includes roads, trails, and stream corridors where grizzly mortality could occur. Linear sources are divided into 10 mile segments. (Ex. 20 mile road equals 2 sources, 8 mile trail equals 1 source).

Dispersed Source - This group would include those activities not associated with point and linear sources. Examples would be hunting off the trail or road, berry picking, hiking off trail, cross country skiing, etc. Dispersed sources are measured in units of people/habitat component/day. Mortalities associated with dispersed sources would be associated with random grizzly bear/human encounters.

3. Intensity of Use

As each activity is categorized, intensity of use on both linear and dispersed sources should be determined. The following are guidelines for assigning intensity of use levels:

Low Use: Roads < 1 vehicle/daylight hour
 Trails/Roads closed to vehicle < 3 parties/day
 Dispersed < 1 person/habitat component/day

High Use: Roads > 1 vehicle/daylight hour
 Trails/Roads closed to vehicles > 3 parties/day
 Dispersed > 1 person/habitat component/day

4. Availability of Attractants

Availability of attractants at point sources of activity has been a significant factor in grizzly bear mortality throughout the ecosystem. Whether attractants are available to bears or not is defined as follows:

Attractants Available: Food attractants are available to grizzly bears. If food storage requirements are in effect, but not enforced, the attractants at the point source are considered available.

Attractants Unavailable: Food attractants are unavailable to grizzly bear. Food storage requirements are enforced to a level that point sources are considered unavailable.

5. Presence of Firearms

While grizzly bears are protected within the Yellowstone Ecosystem, numerous mortalities due to firearms have been recorded. The Yellowstone area is unique in that a large portion of the area, Yellowstone and Grand Teton National Parks, have regulations prohibiting the carrying of firearms, while the remainder of the area has no such regulations. Risk of bear mortality is therefore higher on those lands allowing firearms. Activities are categorized as follows:

Firearms Present: No restriction on the public carrying firearms. Generally includes all lands other than those within the National Parks.

Firearms Absent: Firearms cannot be carried by the public. Generally includes all lands within the National Parks.

Mortality risk indices for each activity group were developed by categorizing each man-caused grizzly mortality occurring in the ecosystem through the period 1973-1983. Mortality data was obtained from Kenneth J. Greer, Montana Department of Fish, Wildlife and Parks. Specific data on individual mortalities not available from K. Greer was obtained from individuals who have investigated the mortalities.

Mortalities were then adjusted upwards for all categories with known losses due to firearms. This increase was based on the fact that all mortalities associated with firearms are not reported. Knight and Eberhardt (1985) reported that during the 1959-1970 period, calculations suggest that roughly half of the actual mortalities may have been recorded. Activity groups with known firearm losses were increased by a factor of 2.0 to reflect non-reported mortalities. The mortality risk indice is simply the adjusted losses for each activity group divided by the total number of adjusted losses.

Due to a relatively small sample size, several categories have indices of .00. Managers must be aware that cumulative activities in these apparent low risk categories may increase mortality risk and treat them appropriately.

Table 10 depicts the mortality risk indices for activity groups.

TABLE 10

				Known Losses (1973-1983)	Adjusted Losses (1973-1983)	Mortality Index
H I G H H A B I T A T Q U A L I T Y	P O I N T	Attractant Available	Firearms	14	28	.33
			No Firearms	15	15	.18
		Attractant Unavailable	Firearms	0	0	.00
			No Firearms	1	1	.01
	L I N E A R	High Use	Firearms	0	0	.00
			No Firearms	3	3	.04
		Low Use	Firearms	0	0	.00
			No Firearms	0	0	.00
	D I S P E R S E D	High Use	Firearms	1	2	.02
			No Firearms	0	0	.00
		Low Use	Firearms	6	12	.14
			No Firearms	0	0	.00
L O W H A B I T A T Q U A L I T Y	P O I N T	Attractant Available	Firearms	7	14	.17
			No Firearms	9	9	.11
		Attractant Unavailable	Firearms	0	0	.00
			No Firearms	0	0	.00
	L I N E A R	High Use	Firearms	0	0	.00
			No Firearms	0	0	.00
		Low Use	Firearms	0	0	.00
			No Firearms	0	0	.00
	D I S P E R S E D	High Use	Firearms	0	0	.00
			No Firearms	0	0	.00
		Low Use	Firearms	0	0	.00
			No Firearms	0	0	.00

As mortality factors may change over time due to improved management, enforcement, etc., mortality indices should be calculated annually using the last five years to reflect recent changes in mortality sources. This information will allow managers to evaluate and compare current management practices against the original data set. These mortality indices, however, would not be used in the calculation of the mortality risk index for a bear management unit or subunit.

Assumptions and Variables

1. Mortalities include all dead bears as well as bears removed from the ecosystem alive. (i.e. zoo's, other ecosystems, etc.)
2. Only man-caused grizzly mortalities are included in the development of mortality indices. No legally killed bears (hunting) or mortalities associated with research activities are included.
3. Distribution of mortalities does not differ throughout the period in a manner which would significantly alter the mortality indices.
4. Prior to 1983, bears removed at point sources were due to attractants being available unless specific evidence is available indicating the opposite.
5. All man-caused non-firearm related mortalities are reported.

Submodel Operation Procedure

1. List all existing activities from habitat effectiveness submodel for a grizzly bear management unit. Categorize as to whether the activity occurs within high or low quality habitat.
2. Categorize activities as to whether they are point linear or dispersed for each assessment period.
3. Assign to each activity within an assessment period intensity of use and availability of attractant values.
4. Determine whether or not firearms can be legally associated with the activity.
5. Select mortality index from Table 10 and assign to each existing activity.
6. Add mortality indices for each bear management unit and or subunit.

The value generated for each activity is not the probability of a grizzly bear being lost when a specific activity exists or is being proposed for a bear management unit. The cumulative mortality index for the bear management unit and/or subunit is a quantitative value of the mortality opportunities. The higher the value, the higher the risk of a grizzly bear mortality.

VI. THRESHOLD LEVELS

A final step in the development of a cumulative effects assessment entails establishing and validating threshold levels. These thresholds represent the minimum acceptable levels of habitat effectiveness and/or mortality risks required for species recovery. Thresholds could vary by season and by bear management unit.

Ideally, thresholds for habitat effectiveness should provide for the energetic/spatial needs of the grizzly bear population during "worst-case" situations (seasonally/annually). One possible approach would be to compare "worst-case" home range versus lifetime home range (seasonally/annually) of a representative set of adult female bears with multi-year histories of telemetry locations. Even approximate calculations of available energy for different seasons/years would greatly enhance our understanding and modeling of spatial needs of grizzly bears. By analyzing bears' spatial use in areas of comparable energetic value but with differing levels of human activity, it may be possible to assess the influence of human activity.

Establishing and validating threshold levels based on bears' response to varying environmental conditions and human activity will require habitat mapping of several bear management units and intensive analysis of the existing data. With declines occurring in both the grizzly bear population index and in key population parameters it would be highly desirable to establish interim threshold goals for both the habitat effectiveness value and the mortality index. The following goals are recommended for implementation throughout the ecosystem as interim guidance.

Habitat Effectiveness

Within each bear management unit and/or subunit, habitat effectiveness values at a minimum should be retained at the current level, with no decreases. However, when the current level is below 80% of potential habitat effectiveness, a minimum goal of reaching 80% is desired. Habitat effectiveness will be measured on a seasonal basis and not aggregated in order to safeguard against losses of seasonally significant habitat.

Mortality Index

It is readily accepted that man-caused grizzly bear mortality, particularly in the adult female segment, is the key issue in conserving the grizzly bear population in the Yellowstone ecosystem. With this in mind, it is recommended that the mortality index goal for each bear management unit and/or subunit be established at no increase above existing levels. Decreasing the existing index, particularly in the category of available attractants at point sources, should be an immediate priority.

VII MANAGEMENT OF CUMULATIVE EFFECTS

The cumulative effects model will enhance decision making for land and resource managers in several ways. First, it will provide the manager a quantified and graphic representation of the effective habitat values and mortality risks for the existing (as well as potential) situation. The manager then can use the computer to simulate the additive as well as the independent effects of different land uses (existing or proposed). In other words, the manager can ask a series of what if;;;?, questions and explore the relative consequences. The CEM should also enable the manager to discriminate which land use is contributing most to the simulated effects ("competitive risk analysis") and whether it influences habitat per se, habitat use, and/or survivorship of grizzly bears. This can be done in space and through time and at different planning levels.

Hence, through the CEM, the manager can optimize decisions by attaining grizzly bear recovery while minimizing social and economic costs.

APPENDIX

Table 1

Coefficients applied to components or portions of components contained within 150m of forest-nonforest edge.

<u>SEASON</u>	<u>Natural Edges</u>		<u>Man-made Edges</u>	
	<u>Nonforest</u>	<u>Forest</u>	<u>Nonforest</u>	<u>Forest</u>
Spring	17.5	21.2	8.8	10.6
Summer	12.5	15.4	6.2	7.7
Fall	6.0	8.3	3.0	4.2

Table 2

Coefficients applied to habitat component base unit area habitat values, by protein rich component type.

<u>PROTEIN RICH HABITAT COMPONENT TYPE</u>	<u>COEFFICIENT</u>	<u>SEASON APPLIED</u>
Moose winter range	1.00	Spring
Bison winter range	1.00	Spring
Geothermally influenced elk winter range	1.90 ^a	Spring
Higher elevation mountainous elk winter range	1.60 ^a	Spring
Lower elevation valley elk winter range	1.00	Spring
Summer-Fall high use ungulate range	1.50	Summer-Fall
Fish spawning stream (high value)	3.75 ^b	Summer
Fish spawning stream (low value)	1.90 ^c	Summer

a: Elk winter range coefficient supercedes moose and bison winter range coefficients (i.e. values are not additive or multiplicative).

b: Applied on a subunit basis, for subunits wt. > 1.5 miles of spawning stream receiving significant bear use; fish spawning stream coefficient supercedes Summer-Fall high use ungulate range coefficient.

c: Applied on a subunit basis, for units wt. between .5 and 1.5 miles of spawning stream receiving significant bear use; fish spawning stream coefficient supercedes Summer-Fall high use ungulate range coefficient.

Table 3 SPRING BASE UNIT AREA HABITAT VALUE

HABITAT OR COMMUNITY TYPE	SF0/LP0		SF1/LP1		SF2/LP2	
	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG
<i>Pinus contorta</i> /						
<i>Purshia tridentata</i>	.163	.013	.188	.025	.210	.020
<i>Carex geyeri</i>	.077	.001	.089	.002	.100	.001
<i>Calamagrostis rubescens</i>	.045	.022	.052	.040	.058	.033
<i>Vaccinium scoparium</i>	.196	.060	.227	.113	.253	.092
<i>Festuca idahoensis</i>	.047	.022	.054	.041	.060	.034
Moist meadow	.664	.245	.767	.459	.856	.376
Thermal	.677	.010	.782	.019	.872	.016
<i>Pseudotsuga menziesii</i> /						
<i>Symphoricarpos oreophilus</i>						
<i>Juniperus communis</i>		.113	.015	.159	.047	.144
<i>Arnica cordifolia</i>						
<i>Berberis repens</i>		.088	.012	.025	.037	.112
<i>Spiraea befulifolia</i>						
<i>Calamagrostis rubescens</i>	.016	.009	.055	.017	.088	.014
<i>Symphoricarpos albus</i>		.007	.039	.010	.122	.009
<i>Vaccinium globulare</i>						
<i>Picea engelmanni</i> /						
<i>Galium triflorum</i>	.010	.030	.034	.058	.054	.049
<i>Equisetum arvense</i>	.086	.182	.300	.350	.477	.294
<i>Abies lasiocarpa</i> /						
<i>Juniperus communis</i>						
<i>Arnica latifolia</i>						
<i>Ribes montigenum</i>						
<i>Vaccinium scoparium</i> -						
<i>Pinus albicaulis</i>						
<i>Vaccinium globulare</i> -						
<i>Vaccinium scoparium</i>	.012	.036	.041	.070	.065	.059
<i>Calamagrostis canadensis</i>	.039	.036	.137	.070	.218	.059
<i>Carex geyeri</i>	.009	.029	.033	.056	.052	.047
<i>Streptopus amplexifolius</i>						
<i>Symphoricarpos albus</i>						
<i>Spiraea betulifolia</i>						
<i>Calamagrostis rubescens</i>						
<i>Berberis repens</i>						
<i>Arnica cordifolia</i>	.016	.051	.057	.099	.090	.083
<i>Vaccinium scoparium</i> -						
<i>Calamagrostis rubescens</i>	.007	.022	.024	.042	.039	.035
<i>Vaccinium scoparium</i> -						
<i>Vaccinium scoparium</i>	.015	.006	.052	.012	.082	.010
<i>Vaccinium globulare</i> -						
<i>Vaccinium globulare</i>						
<i>Linnaea borealis</i>	.028	.026	.096	.050	.153	.042
<i>Thalictrum occidentale</i>	.048	.012	.166	.023	.264	.019
<i>Pinus albicaulis</i> /						
<i>Festuca idahoensis</i>						
<i>Juniperus communis</i>						
<i>Vaccinium scoparium</i>						
- <i>Abies lasiocarpa</i>						

Table 3 - Continued

SPRING

	LP3	SF	LP	ASP
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	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG
Pico/Putr					.181	.028		
Cxge					.086	.002		
Caru					.050	.046		
Vasc					.218	.128		
Feid					.052	.047		
Mstmdw					.738	.522		
Thrml					.752	.022		
Psme/Syor							.056	.051
Juco	.022	.167					.071	.097
Arco								
Bere	.017	.131					.055	.076
Spbe								
Caru	.062	.018					.111	.004
Syal	.055	.010					.182	.006
Vagl								
Pien/Gatr	.038	.063	.047	.064			.068	.016
Eqar	.334	.379	.415	.385			.601	.094
Abla/Juco								
Arla								
Rimo								
Vasc-Pial								
Vagl-Vasc	.046	.076	.056	.077				
Caca	.153	.076	.190	.077				
Cxge	.036	.061	.045	.062	.040	.037		
Stam								
Syal								
Spbe								
Caru								
Bere								
Arco	.063	.107	.078	.109	.068	.066	.113	.026
Vasc-Caru	.027	.045	.034	.046	.030	.028	.049	.011
Vasc-Vasc	.057	.013	.071	.013	.062	.008	.103	.003
Vagl-Vagl								
Libo	.107	.055	.133	.055			.193	.013
Thoc	.185	.024	.230	.025			.335	.006
Pial/Feid								
Juco								
Vasc								
-Abla								

Table 3 - Continued

SPRING

	MFO/DF0		MF1/DF1		MF2/DF2		DF/DF3	
	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG
Pico/Putr								
Cxge								
Caru								
Vasc								
Feid								
Mstmdw								
Thrml								
Psme/Syor	.032	.030	.053	.048	.062	.056	.065	.059
Juco	.021	.069	.067	.069	.078	.076	.090	.083
Arco								
Bere	.016	.054	.052	.054	.061	.059	.070	.065
Spbe								
Caru	.015	.003	.106	.003	.118	.003	.129	.004
Syal	.053	.004	.170	.004	.200	.004	.230	.005
Vagl								
Pien/Gatr	.009	.011	.065	.011	.072	.012	.079	.013
Eqar	.081	.065	.577	.065	.639	.070	.701	.079
Abla/Juco								
Arla								
Rimo								
Vasc-Pial								
Vagl-Vasc								
Caca								
Cxge								
Stam								
Syal								
Spbe								
Caru								
Bere								
Arco	.015	.018	.109	.018	.121	.020	.132	.022
Vasc-Caru	.007	.008	.047	.008	.052	.008	.057	.009
Vasc-Vasc	.014	.002	.099	.002	.110	.002	.120	.003
Vagl-Vagl								
Libo	.026	.009	.185	.009	.205	.010	.225	.011
Thoc	.045	.004	.319	.004	.354	.004	.388	.005
Pial/Feid								
Juco								
Vasc								
-Abla								

Table 3 - Continued

SPRING

	WB0		WB1		WB2		WB/WB3	
	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG
Pico/Putr								
Cxge								
Caru								
Vasc								
Feid								
Mstrndw								
Thrml								
Psme/Syor								
Juco								
Arco								
Bere								
Spbe								
Caru								
Syal								
Vagl								
Pien/Gatr								
Eqar								
Abla/Juco								
Arla								
Rimo								
Vasc-Pial								
Vagl-Vasc							.037	.049
Caca							.124	.049
Cxge	.009	.009	.038	.032	.034	.036	.030	.039
Stam								
Syal								
Spbe								
Caru								
Bere								
Arco							.051	.0 ?
Vasc-Caru								
Vasc-Vasc								
Vagl-Vagl								
Libo								
Thoc							.150	.001
Pial/Feid	.105	.193	.259	.312	.265	.278	.270	.248
Juco								
Vasc								
-Abla								

Table 4 SUMMER BASE UNIT AREA HABITAT VALUE

HABITAT OR COMMUNITY TYPE	SF0/LP0		SF1/LP1		SF2/LP2		LP3	
	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG
Pico/Putr	.327	.134	.352	.144	.371	.153		
Cxge	.230	.180	.249	.193	.262	.204		
Caru	.110	.134	.119	.144	.125	.153		
Vasc	.142	.172	.154	.185	.162	.196		
Feid	.124	.149	.133	.160	.140	.169		
Mstmdw	.148	.025	.159	.026	.168	.028		
Thrml								
Psme/Syor								
Juco	.007	.012	.008	.012	.009	.009	.008	.011
Arco	.138		.167		.188		.154	
Bere	.042	.076	.052	.076	.058	.057	.048	.067
Spbe	.060	.106	.072	.106	.081	.079	.066	.093
Caru	.056	.075	.070	.075	.082	.052	.064	.063
Syal	.052	.018	.063	.018	.071	.013	.058	.016
Vagl	.060	.106	.072	.106	.081	.079	.066	.093
Pien/Gatr	.064	.120	.081	.120	.094	.083	.073	.101
Eqar	.198	.366	.250	.366	.291	.254	.227	.310
Abla/Juco	.064	.118	.081	.118	.094	.082	.073	.100
Arla	.064	.118	.081	.118	.094	.082	.073	.100
Rimo	.029	.023	.035	.023	.040	.010	.032	.017
Vasc-Pial	.237	.193	.286	.193	.326	.083	.263	.140
Vagl-Vasc	.185	.325	.234	.325	.272	.226	.212	.276
Caca	.166	.310	.210	.310	.244	.215	.190	.262
Cxge	.048	.086	.060	.086	.070	.060	.055	.073
Stam	.075	.141	.095	.141	.111	.098	.086	.120
Syal	.137	.066	.173	.066	.201	.046	.157	.056
Spbe	.024	.043	.030	.043	.035	.030	.027	.037
Caru	.069	.053	.088	.053	.102	.037	.080	.045
Bere	.081	.148	.102	.148	.119	.103	.093	.126
Arco	.065	.121	.082	.121	.096	.084	.075	.102
Vasc-Caru	.113	.210	.143	.210	.166	.146	.129	.178
Vasc-Vasc	.160	.245	.203	.245	.236	.170	.184	.207
Vagl-Vagl	.185	.344	.234	.344	.272	.239	.212	.292
Libo	.105	.194	.132	.194	.154	.135	.120	.165
Thoc	.091	.102	.115	.102	.134	.071	.104	.087
Pial/Feid								
Juco								
Vasc								
-Abla	.076	.062	.092	.062	.105	.027	.085	.045

Table 4 - Continued

SUMMER

	SF		LP		ASP		HEO/DEO	
	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG
Pico/Putr			.367	.109				
Cxge			.259	.146				
Caru			.124	.109				
Vasc			.160	.140				
Feid			.139	.121				
Mstmdw			.166	.020				
Thrml								
Psme/Syor					.101	.042	.072	.030
Juco					.008	.008	.005	.006
Arco					.152		.108	
Bere					.047	.050	.034	.036
Spbe					.066	.070	.047	.050
Caru					.063	.044	.046	.026
Syal					.057	.012	.041	.008
Vagl					.066	.070	.047	.050
Pien/Gatr	.097	.127			.072	.070	.053	.042
Eqar	.300	.389			.224	.216	.163	.127
Abla/Juco	.097	.125	.084	.056				
Arla	.097	.125	.084	.056				
Rimo	.035	.030						
Vasc-Pial	.286	.251						
Vagl-Vasc	.280	.346						
Caca	.251	.329						
Cxge	.072	.092	.062	.041				
Stam	.114	.150						
Syal	.207	.070			.155	.039	.112	.023
Spbe	.036	.046			.027	.026	.020	.015
Caru	.105	.057	.091	.025	.078	.031	.057	.018
Bere	.122	.158			.092	.088	.067	.052
Arco	.099	.128	.085	.057	.074	.071	.054	.042
Vasc-Caru	.171	.223	.148	.099	.128	.124	.093	.073
Vasc-Vasc	.243	.260	.210	.116	.182	.144	.132	.085
Vagl-Vagl	.280	.366			.209	.203	.152	.120
Libo	.159	.206			.118	.115	.086	.068
Thoc	.138	.109			.103	.060	.075	.036
Pial/Feid								
Juco								
Vasc								
-Abla	.092	.081						

Table 4 - Continued SUMMER

	MF1/DF1		MF2/DF2		DF/DF3		WBO	
	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG
Pico/Putr								
Cxge								
Caru								
Vasc								
Feid								
Mstmdw								
Thrml								
Psme/Syor	.072	.030	.089	.036	.106	.042		
Juco	.005	.006	.007	.006	.008	.007		
Arco	.108		.136		.162			
Bere	.034	.036	.042	.039	.050	.043		
Spbe	.047	.050	.059	.055	.070	.060		
Caru	.046	.026	.057	.031	.069	.035		
Syal	.041	.008	.051	.009	.061	.010		
Vagl	.047	.050	.059	.055	.070	.060		
Pien/Gatr	.053	.042	.066	.049	.079	.056		
Eqar	.163	.127	.204	.150	.244	.173		
Abla/Juco							.014	.089
Arla							.014	.089
Rimo							.010	.012
Vasc-Pial							.083	.098
Vagl-Vasc								
Caca								
Cxge							.010	.065
Stam								
Syal	.112	.023	.141	.027	.169	.031		
Spbe	.020	.015	.024	.018	.029	.020		
Caru	.057	.018	.071	.022	.086	.025		
Bere	.067	.052	.083	.061	.100	.070		
Arco	.054	.042	.067	.050	.081	.057		
Vasc-Caru	.093	.073	.116	.086	.139	.099		
Vasc-Vasc	.132	.085	.165	.100	.198	.116		
Vagl-Vagl	.152	.120	.190	.141	.228	.162		
Libo	.086	.068	.108	.080	.129	.092		
Thoc	.075	.036	.094	.042	.112	.048		
Pial/Feid							.010	.012
Juco							.064	.032
Vasc							.041	.048
-Abla							.027	.032

Table 4 - Continued

SUMMER

	WB1		WB2		WB/WB3	
	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG
Pico/Putr						
Cxge						
Caru						
Vaasc						
Feid						
Mstmdw						
Thrml						
Psme/Syor						
Juco						
Arco						
Bere						
Spbe						
Caru						
Syal						
Vagl						
Pien/Gatr						
Eqar						
Abla/Juco	.088	.138	.084	.138	.079	.137
Arla	.088	.138	.084	.138	.079	.137
Rimo	.038	.031	.036	.030	.035	.030
Vasc-Pial	.309	.256	.297	.254	.286	.251
Vagl-Vasc					.228	.377
Caca					.205	.359
Cxge	.066	.101	.062	.101	.059	.100
Stam					.093	.164
Syal						
Spbe						
Caru						
Bere						
Arco					.081 ?	.140?
Vasc-Caru						
Vasc-Vasc						
Vagl-Vagl						
Libo						
Thoc					.112	.110
Pial/Feid	.036	.032	.037	.033	.038	.033
Juco	.236	.212	.241	.214	.246	.216
Vasc	.152	.125	.147	.124	.141	.123
-Abla	.099	.083	.096	.082	.092	.081

Table 5 FALL BASE UNIT AREA HABITAT VALUE

	SF0/LP0		SF1/LP1		SF2/LP2		LP3	
	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG
Pico/Putr	.012	.012	.011	.011	.010	.010		
Cxge	.279	.299	.259	.279	.239	.258		
Caru								
Vasc	.148	.142	.137	.133	.127	.123		
Feid								
Mstmdw								
Thrml								
Psme/Syor								
Juco								
Arco								
Bere								
Spbe	.186	.127	.212	.129	.223	.147	.184	.181
Caru	.094	.115	.131	.116	.144	.134	.104	.168
Syal								
Vagl								
Pien/Gatr								
Eqar								
Abla/Juco	.242	.297	.338	.300	.372	.345	.268	.431
Arla	.231	.284	.324	.287	.356	.330	.256	.412
Rimo	.019	.104	.119	.110	.149	.152	.045	.242
Vasc-Pial	.050	.293	.317	.312	.397	.429	.119	.683
Vagl-Vasc	.524	.546	.734	.552	.807	.635	.581	.794
Caca	.452	.487	.633	.492	.696	.566	.501	.708
Cxge	.094	.115	.131	.116	.144	.134	.104	.168
Stam	.079	.098	.111	.099	.122	.114	.088	.142
Syal								
Spbe	.094	.115	.131	.116	.144	.134	.104	.168
Caru								
Bere								
Arco								
Vasc-Caru	.035	.043	.049	.044	.054	.050	.039	.062
Vasc-Vasc	.279	.334	.390	.338	.429	.388	.309	.485
Vagl-Vagl								
Libo	.298		.418		.459		.330	
Thoc	.110	.149	.155	.150	.170	.173	.122	.216
Pial/Feid								
Juco								
Vasc								
-Abla	.012	.068	.077	.072	.097	.099	.029	.158

Table 5 - Continued

FALL

	SF		LP		ASP		DFD	
	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG
Pico/Putr			.017	.016				
Cxge			.398	.410				
Caru								
Vasc			.211	.195				
Feid								
Mstmdw								
Thrml								
Psme/Syor								
Juco								
Arco								
Bere								
Spbe					.160	.116	.112	.066
Caru					.079	.103	.049	.040
Syal								
Vagl								
Pien/Gatr								
Eqar								
Abla/Juco	.405	.469	.424	.245				
Arla	.388	.449	.406	.234				
Rimo	.372	.345						
Vasc-Pial	.992	.976						
Vagl-Vasc	.880	.864						
Caca	.759	.770						
Cxge	.157	.182	.164	.095				
Stam	.133	.155						
Syal								
Spbe	.157	.182			.079	.103	.049	.040
Caru								
Bere								
Arco								
Vasc-Caru	.059	.068	.062	.036	.030	.038	.018	.015
Vasc-Vasc	.468	.528	.489	.275	.236	.299	.146	.116
Vagl-Vagl								
Libo	.500				.252		.156	
Thoc	.185	.235			.094	.133	.058	.052
Pial/Feid								
Juco								
Vasc								
-Abla	.242	.225						

Table 5 - Continued

FALL

	DF1		DF2		DF3/DF		WBO	
	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG
Pico/Putr								
Cxge								
Caru								
Vasc								
Feid								
Mstmdw								
Thrml								
Psme/Syor								
Juco								
Arco								
Arco								
Bere								
Spbe	.112	.066	.128	.100	.144	.134		
Caru	.049	.040	.056	.119	.063	.116		
Syal								
Vagl								
Pien/Gatr								
Eqar								
Abla/Juco							.201	.248
Arla							.192	.238
Rimo							.048	.055
Vasc-Pial							.129	.156
Vagl-Vasc								
Caca								
Cxge							.078	.096
Stam								
Syal								
Spbe	.049	.040	.056	.119	.063	.116		
Caru								
Bere								
Arco								
Vasc-Caru	.018	.015	.021	.044	.024	.044		
Vasc-Vasc	.146	.116	.167	.345	.189	.338		
Vagl-Vagl								
Libo	.156		.179		.194			
Thoc	.058	.052	.066	.154	.075	.150		
Pial/Feid							.056	.055
Juco							.048	.052
Vasc							.040	.050
-Abla							.031	.036

Table 5 - Continued

FALL

	WB1		WB2		WB/WB3	
	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG
Pico/Putr						
Cxge						
Caru						
Vasc						
Feid						
Mstmdw						
Thrm1						
Psme/Syor						
Juco						
Arco						
Bere						
Spbe						
Caru						
Syal						
Vagl						
Pien/Gatr						
Eqar						
Abla/Juco	.372	.455	.484	.497	.595	.535
Arla	.356	.436	.463	.475	.570	.512
Rimo	.149	.266	.257	.304	.372	.345
Vasc-Pial	.397	.752	.684	.859	.992	.976
Vagl-Vasc					1.291	.984
Caca					1.114	.877
Cxge	.144	.177	.187	.193	.230	.208
Stam					.195	.177
Syal						
Spbe						
Caru						
Bere						
Arco						
Vasc-Caru						
Vasc-Vasc						
Vagl-Vagl						
Libo						
Thoc					.272	.200?
Pial/Feid	.216	.259	.290	.300	.372	.345
Juco	.186	.249	.250	.285	.320	.324
Vasc	.123	.241	.212	.275	.307	.313
-Abla	.097	.173	.167	.198	.242	.225

Table 6 NON-FOREST BASE UNIT AREA HABITAT VALUE

NON-FOREST COMPONENTS	SPRING		SUMMER		FALL	
	UNG	W/O UNG	UNG	W/O UNG	UNG	W/O UNG
Dry Grassland	0	0	.108	.093	0	0
High Elev. Rocky Grassland	.087	.091	.122	.106	0	0
Low Elev. Moist Grassland	.474	.514	.300	.274	.480	.496
High Elev. Moist Grassland	0	0	.241	.258	.469	.478
Low Elev. Wet Grassland	.156	.078	.235	.207	.102	.094
High Elev. Wet Grassland	0	0	.144	.126	0	0
Low Elev. Marsh/Fen	.543	.358	0	0	.833	.500
High Elev. Marsh/Fen	0	0	.128	.111	.359	.127
Dry Forb Meadow	0	0	0	0	0	0
High Elev. Dry Forb Meadow	.408	.438	.149	.129	0	0
Moist Forb Meadow	.067	.070	.188	.165	0	0
Wet Forb Meadow	0	0	.171	.149	0	0
High Elev. Wet forb Meadow	0	0	0	0	0	0
Forb Dominated Seep	?	?	?	?	?	?
Wet Forest Openings	0	0	.320	.279	0	0
Dry-Moist Forest Opening						
Dry Sagebrush Shrubland	.278	.166	.257	.224	0	0
Rocky Mst. Sagebrush Shrubland	.377	.322	.290	.253	.278	.190
Mst.Sagebrush/Cinquefoil Shrub	.476	.477	.322	.282	.556	.381
Low Willow Shrubland	0	0	.164	.144	0	0
Low Elev. Tall shrub Comm.	.460	.290	.217	.188	.459	.460
High Elev. Tall Shrub Comm.	0	0	.149	.129	0	0
Tundra	0	0	0	0	0	0

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