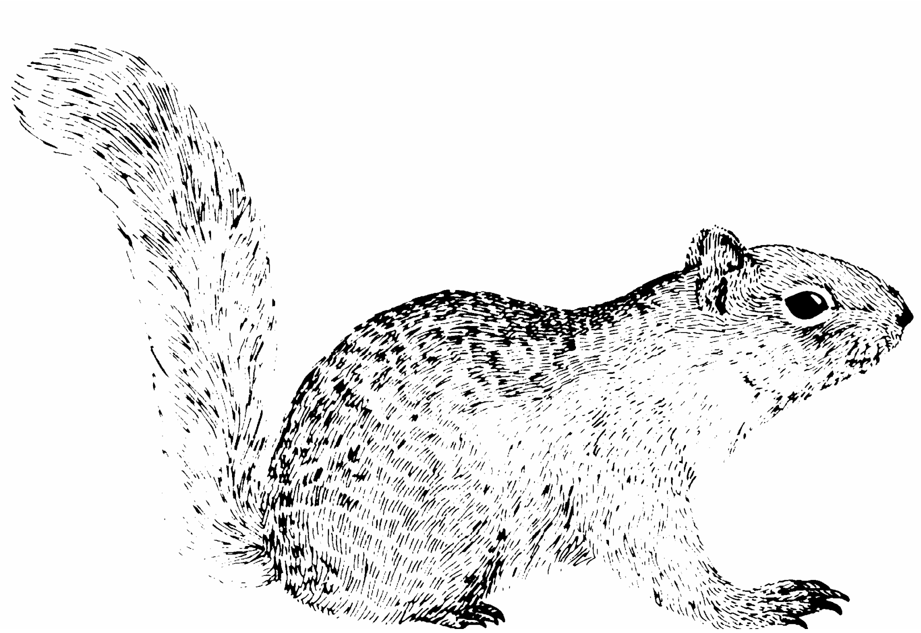
California Wildlife Habitat Relationships Program
California Department of Fish and Game

HABITAT SUITABILITY MODELS FOR USE WITH ARC/INFO: CALIFORNIA GROUND SQUIRREL



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HABITAT SUITABILITY MODELS FOR USE WITH ARC/INFO: CALIFORNIA GROUND SQUIRREL

by

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PREFACE

This document is part of the California Wildlife Habitat Relationships (CWHR) System operated and maintained by the California Department of Fish and Game (CDFG) in cooperation with the California Interagency Wildlife Task Group (CIWTG). This information will be useful for environmental assessments and wildlife habitat management.

The structure and style of this series is basically consistent with the "Habitat Suitability Index Models" or "Bluebook" series produced by the USDI, Fish and Wildlife Service (FWS) since 1981. Moreover, models previously published by the FWS form the basis of the current models for all species for which a "Bluebook" is available. As is the case for the "Bluebook" series, this CWHR series is not copyrighted because it is intended that the information should be as freely available as possible. In fact, it is expected that these products will evolve rapidly over the next decade.

This document consists of two major sections. The Habitat Use Information functions as an up-to-date review of our current understanding regarding the basic habitat requirements of the species. This section typically builds on prior publications, including the FWS "Bluebook" series. However, the Habitat Suitability Index (HSI) Model section is quite different from previously published models. All models in this CWHR series are designed as macros (AML computer programs) for use with ARC/INFO geographic information system (GIS) software running on a UNIX platform. As such, they represent a step up in model realism in that spatial issues can be dealt with explicitly. They are "Level II" models in contrast to the "Level I" (matrix) models initially available in the CWHR System. For example, issues such as habitat fragmentation and distance to habitat elements may be dealt with in spatially explicit "Level II" models. Unfortunately, a major constraint remains the unavailability of mapped habitat information most useful in defining a given species' habitat. For example, there are no readily available maps of snag density. Consequently, the models in this series are compromises between the need for more accurate models and the cost of mapping essential habitat characteristics. It is hoped that such constraints will diminish in time.

While "Level II" models incorporate spatial issues, they build on "Level I", nonspatial models maintained in the CWHR System. As the matrix models are field tested, and occasionally modified, these changes will be expressed in the spatial models as well. In other words, the continually evolving "Level I" models are an integral component of the GIS-based, spatial models. To use these "Level II" models one must have (1) UNIX-based ARC/INFO with GRID module, (2) digitized coverages of CWHR habitat types for the area under study and habitat element maps as required for a given species, (3) the AML presented in this document, and (4) a copy of the CWHR database. Digital copies of AMLs are available from the CWHR Coordinator at the CDFG.

Unlike many HSI models produced for the FWS, this series produces maps of habitat suitability with four classes of habitat quality: (1) None; (2) Low; (3) Medium; and (4) High. These maps must be considered hypotheses in need of testing rather than proven cause and effect relationships, and proper use of the CWHR System requires that field testing be done. The maps are only an initial "best guess" which professional wildlife biologists can use to optimize their field sampling. Reliance on the maps without field testing is risky even if the habitat information is accurate.

The CDFG and CIWTG strongly encourage feedback from users of this model and other CWHR components concerning improvements and other suggestions that may increase the utility and effectiveness of this habitat-based approach to wildlife management planning.

ACKNOWLEDGMENTS

The primary credit for this document must go to the field biologists and naturalists that have published the body of literature on the ecology and natural history of this species. They are listed in the References section. Ecological information of this sort is generally very expensive and time-consuming to obtain. Yet this basic ecological understanding is exactly what is needed most if the goal of accurately predicting changes in distribution and abundance of a particular species is ever to be achieved. The CWHR System is designed to facilitate the use of existing information by practicing wildlife biologists. We hope it will also stimulate funding for basic ecological research. Funding for producing this model was provided by the California Department of Forestry and Fire Protection and the University of California Agricultural Experiment Station.

We thank Barry Garrison, Karyn Sernka, and Sandie Martinez of the California Department of Fish and Game for their assistance in typing, editing, and producing this report.

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CALIFORNIA GROUND SQUIRREL (*Spermophilus beecheyi*)

HABITAT USE INFORMATION

General

The California ground squirrel (*Spermophilus beecheyi*) occurs from southern Washington south through Oregon and California to northern Baja California (Burt and Grossenheider 1964; Tomich 1982). In California, it is a common permanent resident throughout the state excluding parts of the Great Basin and Mojave and Colorado Desert regions. It is common and widespread throughout almost all vegetated habitats in the earlier successional stages. These ground squirrels commonly use openings and disturbed areas, particularly along roadsides, croplands, and grazed meadows. They occur from sea level to about 3,333 m (11,000 ft) elevation (Grinnell and Dixon 1918; Zeiner et al. 1990).

California ground squirrels are active during the day. They may become torpid for periods of time when food is scarce and temperatures are extreme, especially during fall and winter at high elevations and late summer in hot, lowland areas. The timing of inactivity varies greatly with individuals, populations, weather, and habitat (Linsdale 1946; Fitch 1948; Davis and Swade 1983; Dobson and Davis 1986; Zeiner et al. 1990).

Food

California ground squirrels are omnivorous. They eat seeds, nuts, acorns, fruits, bulbs, fungi, and stems and leaves of grasses, forbs, shrubs and trees. They also eat some insects, bird eggs, and carrion. They forage on the ground, and in low shrubs and trees. They also dig up plants. They store food for inactive periods (Grinnell and Dixon 1918; Fitch 1948; Sandberg 1975; Tomich 1982; Zeiner et al. 1990).

Water

Water requirements are probably satisfied by food (Binz 1984; Linsdale 1946).

Cover

Cover is provided by burrows excavated in friable soils, often near rocky areas or under trees or logs. The burrow system may be elaborate, with 6-20 entrances. The tunnel lengths average

11 m (35 ft), and range from 1-42 m (3-138 ft). Three types of burrows are dug. Male burrows are simple, and these burrows are usually dug at the outskirts of the colony. The long, complex nest burrows are occupied by females with young. Long, multibranched colonial burrows are used by both sexes and the young after leaving the nest burrow (Grinnell and Dixon 1918; Linsdale 1946). Owings and Borchert (1975) found that California ground squirrels preferred to place their burrows under tree cover, away from ground cover and on sloping ground.

California ground squirrels live in areas with herbaceous ground cover such as grasslands and woodland habitats or openings in brush and forest habitats. Friable soils are required, and rocks, scattered trees, logs, and other ground cover enhance the habitat. They often inhabit agricultural lands, particularly grazing lands. Open terrain offering clear sightlines is preferable, though surface rocks, logs, and fences may be used as lookouts. California ground squirrels are rarely found in areas where there is a dense understory or tall grass (Grinnell and Dixon 1918; Evans and Holdenreid 1943; Zeiner et al. 1990)

Reproduction

California ground squirrels build a cup-shaped nest of dried vegetation in the burrow. The females are polyestrous. The timing of the breeding season varies greatly throughout California. Mating occurs from January through July, with peak activity in March through June. Following a gestation period of about 30 days, an average of 6-7 young are born (range 3-15). Females usually produce one litter per year (Grinnell and Miller 1918; Linsdale 1946; Zeiner et al. 1990). Some females may produce two litters per year (Simpson and Lamunyon 1980). The young are weaned at about 55 days and are full-grown in 7-8 months. Chapman and Lind (1973) found a direct relationship between the number of freeze-free days and the litter size produced.

Interspersion and Composition

The home range is usually less than a 137 m (450 ft) radius around the burrow. In California, home ranges of males averaged 0.1 ha (0.4 ac), while female home ranges averaged 0.2 ha (0.6 ac) (Evans and Holdenreid 1943). Individual home ranges often overlap considerably. Swihart et al. (1988) reported a home range size of 0.17 ha (0.4 ac).

California ground squirrels may live singly, or in small, dispersed colonies of one or more families (Maser et al. 1981). Evans and Holdenreid (1943) thought that they may hold small territories during the breeding season. Fitch (1948) suggested that they do not hold territories. Dobson (1983) found territorial behavior between males and to a lesser extent between males and females during the breeding season.

Male and female California ground squirrels may disperse in search of breeding sites but natal dispersal is usually male biased (Dobson 1981; Dobson 1982; Holekamp 1984). Evans and Holdenreid (1943) found that both male and female California ground squirrels disperse during the breeding season. Dobson (1979) found that 100% of surviving juvenile males dispersed from their natal area while 5% of surviving females dispersed.

In Madera County, California, Fitch (1948) recorded the distance between trap sites for 1,043 movements as follows: 90% were under 275 m (900 ft); 9% were between 275 and 596 m (900 and 1,950 ft); and 1% exceeded 596 m (1,950 ft). Stroud (1982) found that few California ground squirrels moved between two colonies that were 150 m (500 ft) apart. Evans and Holdenried (1943) found that the maximum distance moved was 1,097 m (3,600 ft), and approximately 70% of the animals studied moved less than 137 m (450 ft).

Special Considerations

California ground squirrels are considered the most destructive of all ground squirrel species in California (Grinnell and Miller 1918). They can cause significant damage to fruit, nut, vegetable, forage and grain crops. They are a serious competitor with livestock for forage (Marsh 1985). Grinnell and Dixon (1918) calculated that 200 ground squirrels consumed the same amount of forage as a 454-kg (1,000-lb) steer. Their burrows cause erosion and damage irrigation ditches and dams (Tomich 1982). They may also inhibit tree regeneration by eating seeds and seedlings (West 1992). California ground squirrels are also a major source of bubonic plague (*Yersinia pestis*) and have been a dominant source of this disease in humans (Nelson 1980; Tomich 1982). California ground squirrels, however, are an important prey species to a wide variety of carnivorous birds, mammals, and reptiles.

Their populations may be controlled using toxic baits, shooting, trapping, and burrow fumigation or flooding (Ginnell and Dixon 1918; Tomich 1982; Salmon and Schmidt 1982; Marsh 1985; Protopapas and Crabb 1986). Physical destruction of burrows is not an effective way to control ground squirrels (Stroud 1984; Salmon et al. 1987).

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area.

The California Wildlife Habitat-Relationships (CWHR) System (Airola 1988; Mayer and Laudenslayer; 1988, Zeiner et al. 1990) contains habitat ratings for each habitat type predicted to be occupied by California ground squirrels in California.

Season.

This model is designed to predict the suitability of habitat for California ground squirrels throughout the year. The model works best, however, at predicting habitat suitability for breeding habitat.

Cover types.

This model can be used anywhere in California for which an ARC/INFO map of CWHR habitat types exists. The CWHR System contains suitability ratings for reproduction, cover, and feeding for all habitats California ground squirrels are predicted to occupy. These ratings can be used in conjunction with the ARC/INFO habitat map to model wildlife habitat suitability.

Minimum habitat area.

Minimum habitat area is defined as the minimum amount of contiguous habitat required before a species will occupy an area. Specific information on minimum areas required for California ground squirrels was not found in the literature. This model assumes two home ranges is the minimum area required to support a California ground squirrel population during the breeding season.

Verification level.

The spatial model presented here has not been verified in the field. The CWHR suitability values used are based on a combination of literature searches and expert opinion. We strongly encourage field testing of both the CWHR database and this spatial model.

Model Description

Overview.

This model uses CWHR habitat type is the main factor determining suitability of an area for this species.

A CWHR habitat type map must be constructed in ARC/INFO GRID format as a basis for the model. The GRID module of ARC/INFO was used because of it's superior functionality for spatial modeling. Only crude spatial modeling is possible in the vector portion of the ARC/INFO program, and much of the modeling done here would have been impossible without the abilities of the GRID module. In addition to more sophisticated modeling, the GRID module's execution speed is very rapid, allowing a complex model to run in less than 30 minutes.

The following sections document the logic and assumptions used to interpret habitat suitability.

Cover component.

A CWHR habitat map must be constructed. The mapped data (coverage) must be in ARC/INFO GRID format. A grid is a GIS coverage composed of a matrix of information. When the grid coverage is created, the size of the grid cell should be determined based on the resolution of the habitat data and the home range size of the species with the smallest home range in the study. You must be able to map the home range of the smallest species with reasonable accuracy. However, if the cell size becomes too small, data processing time can increase considerably. We recommend a grid cell size of 30 m (98 ft). Each grid cell can be assigned attributes. The initial map must have an attribute identifying the CWHR habitat type of each grid cell. A CWHR suitability value is assigned to each grid cell in the coverage based on its habitat type. Each CWHR habitat is rated as high, medium, low or of no value for each of three life requisites: reproduction; feeding; and cover. The geometric mean value of the three suitability values was used to determine the base value of each grid cell for this analysis.

Distance to water.

California ground squirrels do not require water.

Species' distribution.

The study area must be manually compared to the range maps in the CWHR Species Notes (Zeiner et al. 1990) to ensure that it is within the species' range. All grid cells outside the species' range have a suitability of zero.

Spatial analysis.

Ideally a spatial model of distribution should operate on coverages containing habitat element information of primary importance to a species. For example, in the case of woodpeckers, the size and density of snags as well as the vegetation type would be of great importance. For many small rodents, the amount and size of dead and down woody material would be important. Unfortunately, the large cost involved in collecting microhabitat (habitat element) information and keeping it current makes it likely that geographic information system (GIS) coverages showing such information will be unavailable for extensive areas into the foreseeable future.

The model described here makes use of readily available information such as CWHR habitat type, elevation, slope, aspect, roads, rivers, streams and lakes. The goal of the model is to eliminate areas that are unlikely to be utilized by the species and lessen the value of marginally suitable areas. It does not attempt to address all the microhabitat issues discussed above, nor does it account for other environmental factors such as

toxins, competitors or predators. If and when such information becomes available, this model could be modified to make use of it.

In conclusion, field surveys will likely discover that the species is not as widespread or abundant as predictions by this model suggest. The model predicts potentially available habitat. There are a variety of reasons why the habitat may not be utilized.

Definitions.

Home Range: the area regularly used for all life activities by an individual during the season(s) for which this model is applicable.

Dispersal Distance: the distance an individual will disperse to establish a new home range. In this model it is used to determine if Potential Colony Habitat will be utilized.

Day to Day Distance: the distance an individual is willing to travel on a daily or semi-daily basis to utilize a distant resource (Potential Day to Day Habitat). The distance used in the model is the home range radius. This is determined by calculating the radius of a circle with an area of one home range.

Core Habitat: a contiguous area of habitat of medium or high quality that has an area greater than two home ranges. This habitat is in continuous use by the species. The species is successful enough in this habitat to produce offspring that may disperse from this area to the Colony Habitat and Other Habitat.

Potential Colony Habitat: a contiguous area of habitat of medium or high quality that has an area between one and two home ranges. It is not necessarily used continuously by the species. The distance from a core area will affect how often Potential Colony Habitat is utilized.

Colony Habitat: Potential Colony Habitat that is within the dispersal distance of the species. These areas receive their full original value unless they are further than three home range radii from a core area. These distant areas receive a value of low since there is a low probability that they will be utilized regularly.

Potential Day to Day Habitat: an area of high or medium quality habitat less than one home range, or habitat of low quality of any size. This piece of habitat alone is too small or of inadequate quality to be Core Habitat.

Day to Day Habitat: Potential Day to Day Habitat that is close enough to Core or Colony Habitat can be utilized by individuals moving out from those areas on a day to day basis. The grid cell must be within Day to Day Distance of Core or Colony Habitat.

Other Habitat: contiguous areas of low value habitat larger than two home ranges in size, including small areas of high and medium quality habitat that may be imbedded in them, are included as usable habitat by the species. Such areas may act as "sinks" because long-term reproduction may not match mortality.

The table below indicates the specific distances and areas assumed by this model.

Distance variables:	Meters	Feet
Dispersal Distance	152	500
Day to Day Distance/ Home Range radius	25	83

Area variables:	Hectares	M^2	Acres	Ft^2
Home Range	0.2	2,024	0.5	21,780
Core Habitat	≥ 0.4	≥ 4,048	≥ 1	≥ 43,560

Application of the Model

A copy of the ARC/INFO AML can be found in Appendix 1. The steps carried out by the macro are as follows:

1. **Determine Core Habitat**: this is done by first converting all medium quality habitat to high quality habitat and removing all low value habitat. Then contiguous areas of habitat are grouped into regions. The area of each of the regions is determined. Those large enough (≥ two home ranges) are maintained in the Core Habitat coverage. If no Core Habitat is identified then the model will indicate no suitable habitat in the study area.

2. **Identify Potential Colony Habitat**: using the coverage from Step 1, determine which regions are one to two home ranges in size. These are Potential Colonies.

3. **Identify Potential Day Use Habitat**: using the coverage derived in Step 1, determine which areas qualify as Potential Day to Day Habitat.

4. **Calculate the Cost Grid**: since it is presumed to be more difficult for animals to travel through unsuitable habitat than suitable habitat we use a cost grid to limit travel based on habitat suitability. The cost to travel is one for high or medium quality habitat. This means that to travel 1 m through this habitat costs 1 m of Dispersal Distance. The cost to travel through low quality habitat is two and unsuitable habitat costs four. This means that to travel 1 m through unsuitable habitat costs the species 4 m of Dispersal Distance.

5. **Calculate the Cost Distance Grid**: a cost distance grid containing the minimum cost to travel from each grid cell to the closest Core Habitat is then calculated using the Cost Grid (Step 4) and the Core Habitat (Step 1).

6. **Identify Colony Habitat**: based on the Cost Distance Grid (Step 5), only Potential Colony Habitat within the Dispersal Distance of the species to Core Habitat is retained. Colonies are close enough if **any** cell in the Colony is within the Dispersal Distance from Core Habitat. The suitability of any Colony located further than three home range radii from a Core Habitat is changed to low since it is unlikely it will be utilized regularly.

7. **Create the Core + Colony Grid**: combine the Core Habitat (Step 1) and the Colony Habitat (Step 6) and calculate the cost to travel from any cell to Core or Colony Habitat. This is used to determine which Potential Day to Day Habitat could be utilized.

8. **Identify Day to Day Habitat**: grid cells of Day to Day Habitat are only accessible to the species if they are within Day to Day Distance from the edge of the nearest Core or Colony Habitat. Add these areas to the Core + Colony Grid (Step 7).

9. **Add Other Habitat**: large areas (≥ two home ranges in size) of low value habitat, possibly with small areas of high and medium habitat imbedded in them may be utilized, although marginally. Add these areas back into the Core + Colony + Day to Day Grid (Step 8), if any exist, to create the grid showing areas that will potentially be utilized by the species. Each grid cell contains a one if it is utilized and a zero if it is not.

10. **Restore Values**: all areas that have been retained as having positive habitat value receive their original geometric mean value from the original geometric value grid (see *Cover component* section) with the exception of distant colonies. Distant colonies (colonies more than three home range radii distant) have their value reduced to low because of the low likelihood of utilization.

Problems with the Approach

Home Range Size.

The home range of a species may vary greatly depending on the habitat being evaluated. This model requires a single home range estimate be applied to all habitat types.

Cost.

The cost to travel across low suitability and unsuitable habitat is not known. It is likely that it is quite different for different species. This model incorporates a reasonable guess for the cost of movement. A small bird will cross unsuitable habitat much more easily than a small mammal. To some extent differences in vagility between species is accounted for by different estimates of dispersal distances.

Dispersal distance.

The distance animals are willing to disperse from their nest or den site is not well understood. We have used distances from studies of the species or similar species when possible, otherwise first approximations are used. More research is urgently needed on wildlife dispersal.

Day to day distance.

The distance animals are willing to travel on a day to day basis to use distant resources has not been quantified for most species. This issue is less of a concern than dispersal distance since the possible distances are much more limited, especially with small mammals, reptiles, and amphibians. Home range size is assumed to be correlated with this coefficient.

SOURCES OF OTHER MODELS

No other habitat models for California ground squirrels were found.

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APPENDIX 1: California Ground Squirrel Macro

```
/*        CALIFORNIA GROUND SQUIRREL
/* cgsmodel.aml - This macro creates an HSI coverage for the
/*           California Ground Squirrel.
/* Version:  Arc/Info 6.1 (Unix), GRID-based model.
/* Authors:  Irene Timossi and Reginald H. Barrett
/*        Department of Forestry & Resource Management
/*        University of California, Berkeley
/* Revision: 7/1/95
/* ------------------------------------------------------------------
/* convert .ID to uppercase for info manipulations
&setvar .ID [translate %.ID%]
/* Start Grid
grid
/*
&type (1)  Initializing Constants...
/*   Homerange: the size of the species' homerange in sq.m.
/*   High:  The value in the WHR grid which indicates high quality habitat.
/*   Medium:  The value in the WHR grid which indicates medium quality habitat.
/*   Low:  The value in the WHR grid which indicates low quality habitat.
/*   None:  The value in the WHR grid which indicates habitat of no value.
/*   MaxElev: The maximum elevation at which the species occurs.
/*   SpecCode: The WHR code for the species.
/*   AcreCalc:  The number needed to convert square units (feet or meters) to acres.
&setvar SpecCode = M072
&setvar .Measure [translate %.Measure%]
&if %.Measure% = METERS &then
  &do
    &setvar Homerange  = 2024
    &setvar AcreCalc   = 4047
  &end
&else
```

```
 &if %.Measure% = FEET &then
   &do
     &setvar Homerange  = 21780
     &setvar AcreCalc   = 43560
   &end
 &else
   &do
     &type Measurement type incorrect, check spelling.
     &type %.Measure%
     &type Only Meters and Feet are correct.
     &goto BADEND
   &end

&setvar High          = 3
&setvar Medium        = 2
&setvar Low           = 1
&setvar None          = 0



/*   The following global variables are declared in the menu:

/*  .WHRgrid (WHR grid name): the name of the grid containing all
/*   the WHR information.

/*  .Elevation (Elevation grid):  the name of the grid containing
/*   the elevation information.

/*  .Bound (Boundary grid name): the grid containing only the
/*   boundary of the coverage. All cells inside the boundary
/*   have a value of 1. All cells outside the boundary must
/*   have a value < 1.
```

```
/*  .ID (Identifier): a 1 to 4 character code used to identify
/*   the files produced by this program. You may prefer
/*   to use an abbreviation of the species' common name
/*   (e.g. use `fis1` for fisher).

/*  .SizeOfCell (Cell size): the size (width) of the cells
/*   used in the coverage grids. All grids used in the
/*   analysis must have the same cell size.

/*   .Measure:  the units the coverage is measured in (feet or meters).



&type (2)  Get geometric means

/*    Create a Geometric Means grid (%.ID%Geom) for the species by
/*    copying these values from the WHR grid.

%.ID%HSI = %.WHRgrid%.%SpecCode%_g



/*

&type (2)  Quiting from GRID and adding the acres field.....

/*     Quit from GRID (Q), then run additem to add an acre item to
/*     the HSI grid vat file (%ID%HSI.vat). Reindex on value when done.

Q
additem %.ID%HSI.vat %.ID%HSI.vat acres 10 10 i
indexitem %.ID%HSI.vat value

/*
```

```
&type (3)  Calculating acres.....

/*    Use INFO to calculate the acreage field: Multiply the number
/*    of cells by the cell size squared and divide by the number of
/*    square meters per acre (4047). Reindex on value when done.

&data arc info
arc
select %.ID%HSI.VAT
CALC ACRES = ( COUNT * %.SizeOfCell% * %.SizeOfCell% ) / %AcreCalc%
Q STOP

&END

indexitem %.ID%HSI.vat value

&label BADEND

&type -------------- All done! ----------------

&return
```