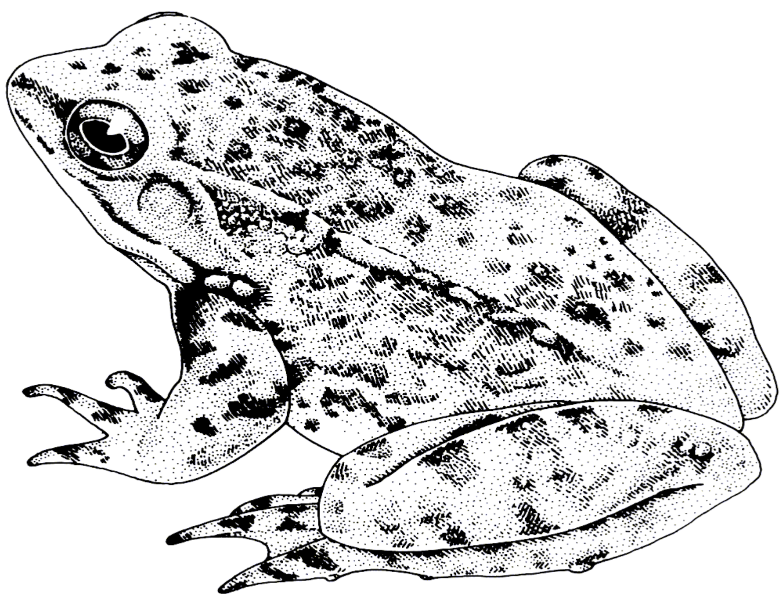
California Wildlife Habitat Relationships Program
California Department of Fish and Game

HABITAT SUITABILITY MODELS FOR USE WITH ARC/INFO: MOUNTAIN YELLOW-LEGGED FROG



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by

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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.

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MOUNTAIN YELLOW-LEGGED FROG (*Rana muscosa*)

HABITAT USE INFORMATION

General

The mountain yellow-legged frog (*Rana muscosa*) occurs primarily at elevations above 1,800 m (5,940 ft) in the Sierra Nevada from Plumas County to southern Tulare County (Zeiner et al. 1988). In the north, a population in Butte County is separated from the main Sierra group by the Feather River Canyon. In southern California, isolated populations exist on Mount Palomar and in the San Gabriel, San Bernardino, and San Jacinto mountains. Mountain yellow-legged frogs are found from 1,380 m (4,500 ft) to over 3690 m (12,000 ft) in the Sierra Nevada and from 370 m (1,200 ft) to 2,310 m (7,500 ft) in southern California (Zeiner et al. 1988). This species is associated with streams, lakes, and ponds in most montane habitats.

Food

Mountain yellow-legged frogs feed primarily on aquatic and terrestrial invertebrates, but they tend to prefer terrestrial insects (Stebbins 1951). Adults have been observed eating tadpoles of the Yosemite toad (*Bufo canorus*) (Mullally 1959), and cannibalism in captivity has been reported (Heller 1960). Tadpoles graze on algae and diatoms along rocky bottoms in shallow water of streams, lakes, and ponds.

Water

Mountain yellow-legged frogs are associated with streams, lakes, and ponds in montane habitats and are seldom found more than two or three jumps from water (Mullally and Cunningham 1956; Stebbins 1985). They prefer lakes or streams with slow to moderate water flow (Mullally and Cunningham 1956; Heller 1960). Tadpoles may require up to three over-wintering periods to complete their aquatic development (Cory 1962).

Cover

In the Sierra Nevada, mountain yellow-legged frogs are associated with streams, lakes, and ponds in montane riparian, lodgepole pine (*Pinus contorta* var. *murrayana*), subalpine conifer, and wet meadow habitat types. In southern California, populations are restricted to streams in ponderosa pine (*P. ponderosa*), montane hardwood-conifer, and montane riparian habitats (Zeiner et al. 1988). Streams or lakes with sloping banks and a depth of several centimeters at the water's edge are preferred to those with water that is more than 0.6 m (2 ft) deep at the shore (Mullally and Cunningham 1956). The terrestrial component of their environment is composed of rocks, logs, and vegetation occurring on the bank or protruding from the water. Lakes or streams with gently sloping banks that are covered by conglomerates of rocks 15-61 cm (6-24 in) in diameter are preferred over aquatic habitats with banks covered by sand or large boulders (Mullally and Cunningham 1956). In the San Bernardino Mountains, Mullally (1959) found these frogs exclusively in streams where they exhibited a preference for large, clear pools up to 1 m (3 ft) deep. Mountain yellow-legged frogs usually crouch on rocks or clumps of grass within a few jumps of water. When disturbed, they dive into water, take refuge under rocks, or rest exposed on the bottom. Less commonly, frogs bury themselves in bottom sediments, and during dry conditions they may use rodent burrows (Stebbins 1985).

Reproduction

At high elevations, mountain yellow-legged frogs breed from May to August depending on local conditions. In southern California, reproduction takes place from March to May (Stebbins 1985). Usually 200 to 300 eggs are laid in shallow water and attached to sedges (*Carex* spp.), gravel or rocks (Stebbins 1985), but occasionally clusters of up to 500 eggs are found. Tadpoles generally over-winter and mature the next spring (Stebbins 1985). However, at high elevations two or three over-wintering periods may be necessary to complete metamorphosis (Cory 1962).

Interspersion and Composition

No studies have been published on home range size of the mountain yellow-legged frog. Typical home ranges for this species are probably less than 10 m (33 ft) in the longest dimension. Occasional movements of up to 50 m (165 ft) may be associated with habitat deterioration, where these animals may move to avoid desiccation (Zeiner et al. 1988). Males probably defend the area around themselves during the breeding season, and weak vocalizations given by males during this season may function in territorial defense (Zeiner et al. 1988).

Special Considerations

Recent, dramatic population declines have been reported for mountain yellow-legged frogs in montane environments (Phillips 1990; Bradford 1991). Several factors, both natural and anthropogenic, may in part be responsible for these declines. Extreme climatic conditions at high elevations can cause severe natural population fluctuations of this species (Bradford 1991). Over-wintering frogs may die when subjected to oxygen depleted waters in shallow lakes or streams (Bradford 1983). Localized population declines may also result from the predation of metamorphosing tadpoles by Brewer's blackbirds (*Euphagus cyanocephalus*) (Bradford 1991) and of tadpoles and adults by introduced salmonids (*Salmo* spp. and *Salvelinus* spp.) (Cory 1963; Zweifel 1968; Bradford 1989). Red-leg disease caused by the pathogen *Aeromonus hydrophila* may also cause mass extinction events (Bradford 1991). Acidification by atmospheric deposition of high elevation breeding waters may cause subleathal effects such as reduced embryo body size and premature hatching of mountain yellow-legged frog eggs (Bradford et al. 1992). The possible long-term effects of acidification or airborne toxins on the health of frog populations is unclear.

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. 1988) contains habitat ratings for each habitat type predicted to be occupied by mountain yellow-legged frogs throughout California.

Season.

This model is designed as a year-round model for the mountain yellow-legged frog.

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 predicted to be occupied by mountain yellow-legged frogs. These ratings can be used in conjunction with the ARC/INFO map to model wildlife habitat suitability.

Minimum habitat area.

Minimum habitat area is defined as the minimum amount of contiguous habitat that is required before a species will occupy an area. Specific information on minimum areas required for mountain yellow-legged frogs was not found in the literature. Our model assumed two home ranges as the minimum area required to support a mountain yellow-legged frog population.

Verification level.

The spatial model presented here has not been field tested. The CWHR suitability values used are based on a combination of published literature 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 as the initial factor determining suitability of an area for this species. In addition, proximity to permanent water is used to further constrain suitability. Further spatial modeling was not performed on this species. Our habitat maps had no patches smaller than two hectares (5 acres). Many mountain yellow-legged frog home ranges will fit in each habitat patch. If geographic data of a higher resolution were available, this model could be modified to include additional spatial analysis. If the cover value is greater than zero and the cell is close enough to water, it is included as suitable habitat.

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 for these models 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 cover value was used to determine the base value of the cell for this analysis (for this species cover and feeding suitabilities are identical). The geometric mean would have resulted in a base map with no suitable habitat since mountain yellow-legged frogs reproduce only in lacustrine and riverine habitats.

Distance to water.

Mountain yellow-legged frogs require free water. All cells further than 30 m from water received a suitability rating of zero.

Species' distribution.

The study area must be manually compared to the range maps in the CWHR Species Notes (Zeiner et al. 1988) 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 the predictions by this model suggest. The model predicts potentially available habitat. There are a variety of reasons why the habitat may not be utilized.

Application of the Model

A copy of the ARC/INFO macro (AML) can be found in Appendix 1.

To create the HSI Coverage, the first step is to eliminate areas too far from water. If the grid cell is more than 30 m from water it receives a suitability value of zero. All other grid cells retain their original values. Since the home range size of the mountain yellow-legged frog (100 m^2) is much smaller than the size of our habitat patches at 2.02 ha (20,235 m^2), no additional spatial analysis is necessary.

Problems with the Approach

Habitat map accuracy.

The resolution of the CWHR habitat map (2.02 ha) is probably too low to give an accurate assessment of how much area is available to this species.

Habitat elements.

Habitat elements are very important to most amphibian species. Without additional information about the distribution of essential elements, suitability maps will typically overestimate actual habitat.

Element map accuracy.

Since this model is based almost solely on permanent stream location, it is vital that the stream coverages be accurate. The stream coverages we were provided were accurate at 1 to 250,000. This accuracy is unacceptable. We edited these files to include all water courses identified on 1:24,000 USGS quadrangles. This may still be insufficient since some small permanent streams are not included on these maps.

SOURCES OF OTHER MODELS

No other habitat models for mountain yellow-legged frog were found.

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APPENDIX 1: Mountain Yellow-Legged Frog Macro

```
/*          MOUNTAIN YELLOW-LEGGED FROG

/* myfmodel.aml - This macro creates an HSI coverage for the
/*               Mountain Yellow-legged Frog.

/* Version:  Arc/Info 6.1 (Unix), GRID-based model.

/* Authors:  Irene Timossi, Sarah Miller, Wilde Legard,
/*          and Reginald H. Barrett
/*          Department of Forestry & Resource Management
/*          University of California, Berkeley

/* Revision: 2/10/95

/*

/* ------------------------------------------------------------------

/* convert .ID to uppercase for info manipulations

&setvar .ID [translate %.ID%]

/* Start Grid


grid

/*

&type (1)  Initializing Constants...

/*   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.

/*   StreamDist: The distance from perennial streams that is suitable
/*   for Mountain Yellow-legged frogs (StreamDist).

/*   SpecCode: The WHR code for the species

/*   AcreCalc:  The number need to convert square units (feet or meters) to acres.


&setvar SpecCode = A044

&if %.Measure% = Meters &then
  &do
    &setvar StreamDist = 30
    &setvar AcreCalc   = 4047
  &end
&else
  &if %.Measure% = Feet &then
    &do
      &setvar StreamDist = 98
```

```
      &setvar AcreCalc   = 43560
    &end
  &else
    &do
      &type Measurement type incorrect, check spelling.
      &type Only Meters and Feet are correct.
      &goto &BADEND
    &end

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

/*   WHR grid name (.WHRgrid): the name of the grid containing all
/*   the WHR information.
/*
/*   Boundary grid name (.Bound): 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.
/*
/*   Identifier (.ID): 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).
/*
/*   Euclidean distance to perennial streams grid (.Stream).
/*   Create this coverage (using GRID's eucdistance function and
/*   a permanent stream source-grid) before running this macro.
/*
/*  .Lake (Lake grid name): the grid containing the euclidean
/*   distance from the lakes.
/*
/*   .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)  Creating a Stream and Lake buffer grid...

/*    Create an HSI grid (%.ID%HSI) based on the HSI value of the
/*    WHR grid (%.WHRgrid%).

/*    All cells within StreamDist of a permanent stream receive their
/*    reproductive value (e.g. %.WHRgrid%.%SpecCode%_c).


docell
  if ((%.Stream% <= %StreamDist%) or (%.Lake% <= %StreamDist%))
     %.ID%HSI = %.WHRgrid%.%SpecCode%_c
   else
     if (%.Bound% == 1)
       %.ID%HSI = 0
     endif
   endif
end

/*  quit from grid and run the additem to add acres

Q
```

```
&type (3)  Add the acres field.....

/*  add acre item to grid coverage and index on value

additem %.ID%HSI.vat %.ID%HSI.vat acres 10 10 i

indexitem %.ID%HSI.vat value

&type (4)  Calculating acres.....

/*  Use info to fill in acreage field.  Multiply the number of
/*  cells by the cell size squared and divide by the number of
/*  square meters per acre (4047).

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

&END

/* index item since info changed vat

indexitem %.ID%HSI.vat value

&label BADEND

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

&return
```