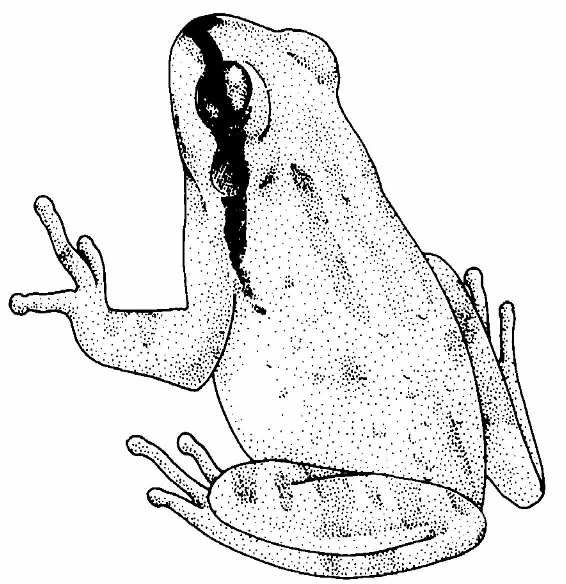
California Wildlife Habitat Relationships Program
California Department of Fish and Game

HABITAT SUITABILITY MODELS FOR USE WITH ARC/INFO: PACIFIC TREEFROG



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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.

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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.

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.

PACIFIC TREEFROG (*Hyla regilla*)

HABITAT USE INFORMATION

General

The Pacific treefrog (*Hyla regilla*) occurs along the Pacific coast south from British Columbia into portions of Baja California and east to Idaho and Nevada. The species is widespread in California and is absent only from the driest desert habitats. The Pacific treefrog occurs from sea level to at least 3,384 m (11,000 ft) in the Sierra Nevada (Stebbins 1985). Pacific treefrogs are nocturnal except during the breeding season when they call during the day.

Food

Pacific treefrogs take a variety of larval and adult invertebrates including slugs, spiders, isopods, centipeds, earthworms, and insects. More adult insects than larvae are consumed indicating that the frogs feed primarily on flying prey (Needham 1924; Brattstrom and Warren 1955; Johnson and Bury 1965).

Pacific treefrogs often sit on floating vegetation and feed on insects that land there. They may also climb bushes or sticks to heights up to 0.7 m (2 ft) above the water to feed (Brattstrom and Warren 1955).

Tadpoles are generally nondiscriminatory suspension feeders that ingest bacteria, diatoms, blue-green algae, green algae, protozoa, microscopic arthropods, their own fecal pellets, and a wide variety of organic and inorganic debris (Jensen 1967; Hendricks 1973; Wagner 1986). Wagner (1986) found tadpoles feeding on pine pollen when it was available in the Sierra Nevada.

Water

Pacific treefrogs are associated with permanent and temporary water of all kinds in all California habitats, except the driest desert habitats. Tadpoles require standing water for periods long enough to complete their aquatic development (Stebbins 1985).

Cover

During the breeding season, individuals take daytime cover under clumps of vegetation and surface objects near water. During the remainder of the year, they leave their breeding sites and seek cover in moist niches in buildings, wells, rotting logs and burrows. Some individuals may also hibernate (Zeiner et al. 1988).

During the day in the breeding season, Pacific treefrogs utilize bodies of water that are in the correct temperature range. Brattstrom and Warren (1955) found individuals avoiding water warmer than 20EC (68EF), and they preferred water above 10EC (50EF). During the nonbreeding season, Pacific treefrogs are nocturnal secluding themselves in cool retreats during the day (Cunningham and Mullally 1956).

In a study of old-growth and logged redwood forest, Bury (1983) recorded the presence of Pacific treefrogs on one logged study site, and no individuals were found on old-growth sites.

Pacific treefrogs exhibit polymorphic body color, and the two main morphs are brown or green. Morey (1990) demonstrated that individuals select resting substrate that matches their skin color.

Reproduction

Breeding and egg-laying may occur in any body of water, but temporary pools with plenty of submerged and emergent vegetation appear to be favored. Egg clusters are usually deposited on stems anchored to the bottom in quiet shallow water (Zeiner et al. 1988). Reproduction occurs over a period of a few weeks anytime between January and July depending on availability of water and water and air temperature (Stebbins 1985). Egg-laying does not take place until the water temperature reaches 12EC (54EF) but ceases if temperatures exceed 15EC (59EF) (Brattstrom and Warren 1955). Females remain at breeding sites for a few nights during the breeding season, while males stay there from 2 weeks to over 2 months. Females deposit eggs in numerous small clusters averaging around 25 eggs (range 9-70) per cluster. Multiple egg clutches have been observed in southern California (Perrill and Daniel 1983), and individual females may lay up to 700 eggs. Eggs hatch in 1-5 weeks. Tadpoles generally complete their aquatic development in 1 month but may require up to 3 months at higher elevations where water temperatures are colder. Males may attain sexual maturity in less than 1 year at some localities (Jameson 1957).

Interspersion and Composition

Areas of nonbreeding activity extended up to 910 m (3,000 ft) away from breeding sites (Brattstrom and Warren 1955), and adult migrations to and from breeding localities occur at night usually during or just after rains. Home range studies have revealed that movements are generally small with most individuals moving less than 10 m (33 ft) during an entire breeding season (Jameson 1957; Schaub and Larsen 1978). However, Schaub and Larsen (1978) recorded several individuals moving approximately 200 m (660 ft) in less than 4 days. Except for migration to and from breeding sites, movements usually do not exceed a few meters except on rainy nights when longer distances may be traveled. Jameson (1957) relocated 83 frogs 300 m (985 ft) from their home pond, and 67% of the relocated individuals returned to the same pond within 9 days. In a similar study, 414 frogs were moved to a pond 1,000 m (3,281 ft) from the home pond. Five frogs were recaptured at the home pond within 28 days, and no frogs were recaptured at the relocation pond. Jameson (1956) reported that juvenile Pacific treefrogs disperse less than 183 m (600 ft). Whitney (1980) reported that males were territorial during the breeding season, defending circles around themselves with radii of about 50 cm (20 in). Territories are maintained by vocalizations and physical combat.

Brattstrom and Warren (1955) suggested that no competition occurs between the Pacific treefrog and other sympatric species of frogs and toads, with the possible exception of the California treefrog (*Hyla cadaverina*). Pacific treefrogs and their tadpoles are preyed upon by introduced fishes, bullfrogs (*Rana catesbeiana*), garter snakes (*Thamnophis* spp.), a variety of birds, nocturnal mammals, and predator insect larvae (Zeiner et al. 1988; Bradford 1989).

Special Considerations

Dramatic, worldwide population declines have been recently reported for amphibians, and several factors, both natural and anthropogenic, may be partly responsible for these declines. Uncertainty exists regarding the possible long-term consequences of acidification, pesticides, or airborne toxins on the viability of worldwide frog populations (Philips 1990; Bradford et al. 1992).

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 Pacific treefrogs throughout California.

Season .

This model is designed as a year-round model for the Pacific treefrog.

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 occupied by Pacific treefrogs. 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 Pacific treefrogs was not found in the literature. Our model assumed two home ranges as the minimum area required to support a Pacific treefrog 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 System 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 2 ha (5 ac). Many Pacific treefrog 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 its 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 (cover and feeding suitabilities are identical for this species). The geometric mean would have resulted in a base map with no suitable habitat since Pacific treefrogs reproduce only in lacustrine and riverine habitats.

Distance to water .

Pacific treefrogs require free water. All cells further than 30 m (98 ft) 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 became available, this model could be modified to make use of it.

In conclusion, field surveys could document 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 (98 ft) from water, it receives a suitability value of zero. All other grid cells retain their original values. The home range size of the Pacific treefrog (0.1 ha [0.02 ac]) is smaller than the size of our habitat patches (2.02 ha [5.0 ac]) so additional spatial analysis is unnecessary.

Problems with the Approach

Habitat map accuracy .

The 2.02 ha (5.0 ac) resolution of the CWHR habitat map is probably too large 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 water location, it is vital that the hydrologic coverages be accurate. The stream coverages we used were accurate at a scale of 1:250,000, and we found this scale to have unacceptable accuracy. We edited these files, however, to include all water courses identified on 1:24,000 USGS quadrangles. This may still be insufficient since some small permanent streams, ponds, and springs are not included on these maps.

SOURCES OF OTHER MODELS

No other habitat models for Pacific treefrog were found.

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APPENDIX 1: Pacific Treefrog Macro

```
/*        PACIFIC TREEFROG

/* myfmodel.aml - This macro creates an HSI coverage for the
/*             Pacific Treefrog
/*             in Sierras.

/* 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

/* Note:  the user of this macro must have a thorough understanding
/*      of ARC/INFO GRID before attempting to interpret this macro.
/*      (See the ARC/INFO GRID Command References manual, ESRI,
/*      Redlands, CA).

/*      The user must also have access to the documentation which
/*      accompanies this macro:  Habitat Suitability Models for Use
/*      with ARC/INFO:  Pacific Treefrog.

/* Revision: 1/15/94

/*

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

/* 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 Pacific treefrogs (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
  &goto Meters
&else
  &goto Feet

&label Meters

&setvar StreamDist = 30
&setvar AcreCalc   = 4047
&goto Begin

&label Feet

&setvar StreamDist = 98
&setvar AcreCalc   = 43560

&label Begin

/*   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


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

&return
```