APPENDIX A

FOLSOM DAM SAFETY AND FLOOD DAMAGE REDUCTION PROJECT

HABITAT EVALUATION PROCEDURES

FEBRUARY 2007

INTRODUCTION

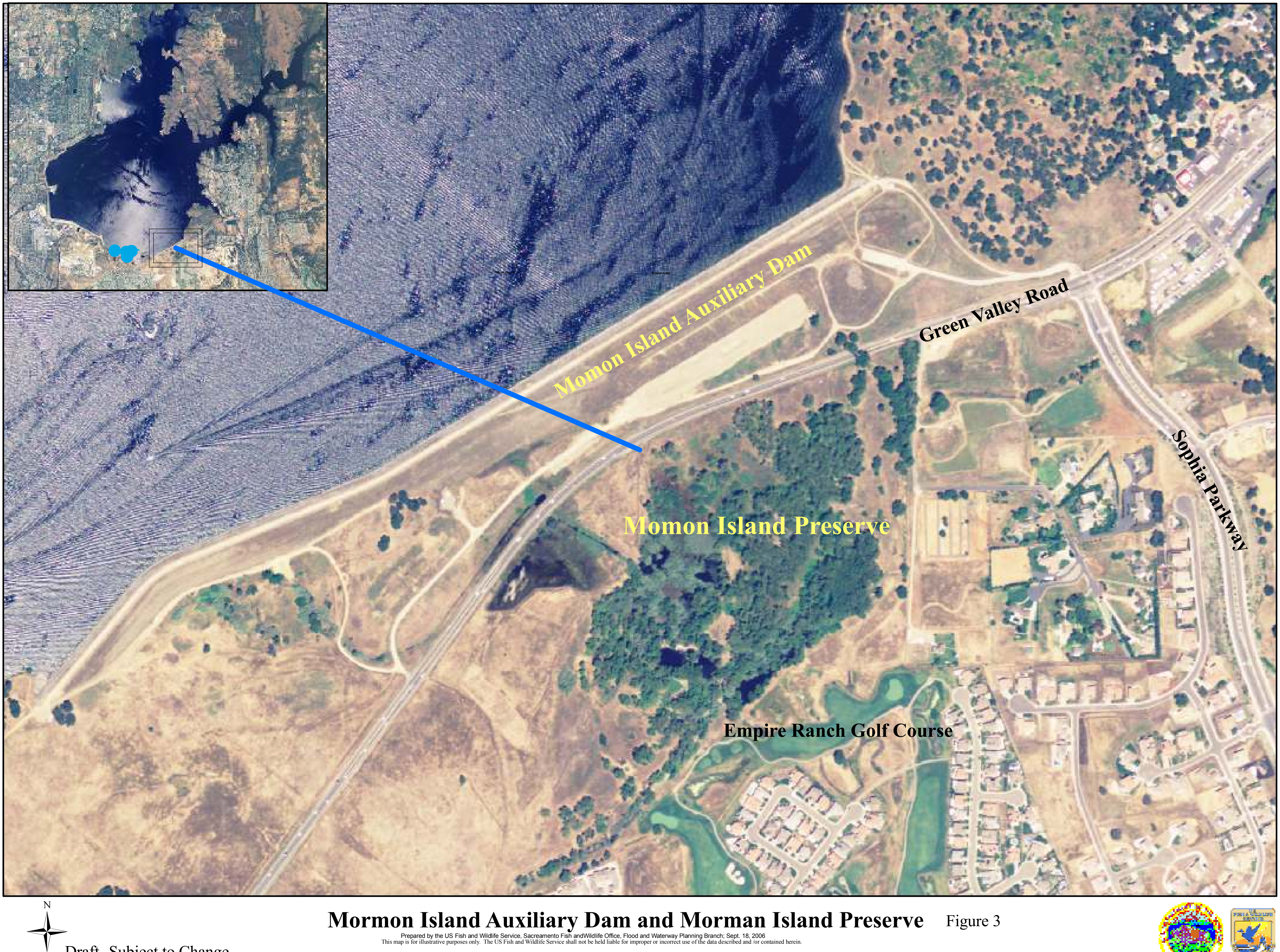
The U.S. Army Corps of Engineers (Corps) and the U.S. Bureau of Reclamation (Reclamation) seek to significantly reduce the risk of flooding along the main stem of the American River in the Sacramento area while meeting dam safety and public safety objectives. The project is authorized by the Corps' American River Watershed Investigation, Folsom Dam Modification project under section 101 (a) (6) of the Water Resources Development Act (WRDA) of 1999 and the Bureau's Dam Safety Program (static, earthquake, etc) (Reclamation 2006). Modifications to the existing authorities were made in the Energy and Water Appropriations Act of 2006, which directed the Secretary of the Army and the Secretary of the Interior to collaborate on authorized activities to maximize flood damage reduction improvements and address dam safety needs at Folsom Dam and Reservoir as one Joint Federal Project.

This application of Habitat Evaluation Procedures (HEP) is intended to provide a quantification of the impacts on fish and wildlife resources associated with Folsom Dam Safety and Flood Damage Reduction (Folsom DS/FDR). Any dam raise or spillway construction measure would be a major modification and would allow Folsom Dam to pass the probable maximum flood (PMF) volume without failure and meet Reclamation's Dam Safety Program.

PROJECT AREA

The project area is in the American River watershed, and would affect lands around Folsom Reservoir, and along the North and South Forks of the American River, which are impounded by Folsom Dam (Figure 1 and Figure 2). The project could also directly affect the Mormon Island Preserve located just downstream of Mormon Island Auxiliary Dam (MIAD) and the lower American River--the river's reach downstream of Folsom Dam (Figure 3).

The American River is the second largest tributary to the Sacramento River. The three forks (north, middle, and south) of the river originate in the Sierra Nevada Mountains at an elevation of about 10,400 feet (mean sea level), and generally flow in a southwesterly direction. The Middle Fork joins the North Fork near the City of Auburn, just upstream of Folsom Reservoir; the North Fork then joins the South Fork just upstream of Folsom Dam. All three forks of the American River above Folsom Reservoir are nationally popular areas for whitewater sports, and the reach of the South Fork from Coloma to the reservoir is the State's most popular whitewater rafting run.



Draft- Subject to Change

Mormon Island Auxiliary Dam and Morman Island Preserve Figure 3

Prepared by the US Fish and Wildlife Service, Sacreamento Fish andWildlife Office, Flood and Waterway Planning Branch; Sept. 18, 2006
This map is for illustrative purposes only. The US Fish and Wildlife Service shall not be held liable for improper or incorrect use of the data described and /or contained herein.

Folsom Dam, located near the city of Folsom, is a multi-purpose dam built by the Corps in 1955, and operated by Reclamation. It is the largest of about 20 dams in the American River watershed and, except for Nimbus Dam, is the furthest downstream. Five reservoirs in the upper American River watershed (Loon Lake, Ice House, Union Valley, French Meadows, and Hell Hole) represent 90% of the existing storage capacity upstream of Folsom Reservoir.

The main dam is a 345-foot high concrete gravity dam across the American River channel. Associated with Folsom Dam is a series of auxiliary dams and dikes which span topographic lows; these structures are needed to contain the reservoir. Mormon Island Dam is the largest of these structures, and is located on the southeast end of the reservoir. Folsom Reservoir blocks about 20 miles of the North Fork and 10 miles of the South Fork, and has a total storage capacity of 974,000 acre-feet, which fills the reservoir to an elevation of 466 feet above mean sea level (msl).

Reclamation operates Folsom Dam as an integrated component of the Central Valley Project. The dam's primary purposes have been to: provide flood control; provide instream flows; manage Sacramento-San Joaquin Delta water quality; produce hydropower; provide recreation; and more recently, protection and restoration of the region’s fish and wildlife resources.

PROJECT DESCRIPTION

The Folsom DS/FDR project includes measures to remedy dam safety issues associated with seismic, static, and hydrologic concerns, and to provide increased flood damage protection. These measures include several different options to remedy the various issues at the Folsom facilities. The Folsom Facilities to be addressed by one or more of the engineering options include the main concrete dam, the right and left wing dams, Mormon Island Auxiliary Dam (MIAD), and eight dikes (1 through 8). The concrete dam and earthen wing dams serve to impound water associated with the main stem of the American River. MIAD serves to dam water within an historic river channel, while the earthen dikes serve to contain water at low spots in the topography during periods when the reservoir is full or nearly full.

The improvements would be designed so that they could be constructed and operated without affecting ongoing water conservation and hydropower operations. The plan would maintain the current Folsom Dam design flood control release of 115,000 cubic feet per second (cfs) and an emergency release of 160,000 cfs. Four scales of enlargement alternatives were developed using maximum flood control pool elevations of 468, 486.5, 489.5 and 499.5 feet msl.

Several constraints were imposed on plan formulation for Folsom DS/FDR project, these are:

- dam raise measures are solely for flood control as stipulated in section 566 of WRDA 1999;

- dam raise measures are to avoid disruptions to the normal operation of Folsom Dam for water supply, hydropower, and flood control;
- no loss of flood protection from existing flood damage reduction projects is permitted;
- minimize disturbance of habitat for threatened and endangered species.

The no action alternative serves as the base against which the proposed flood protection and Dam Safety alternatives will be evaluated to determine effectiveness and to identify effects that would result from them. Several actions that are currently authorized are expected to be completed prior to implementation of any Folsom DS/FDR project. Therefore, the effects and benefits associated with these actions are part of the no-action condition. See the accompanying Fish and Wildlife Coordination Act report for a complete description of the no action condition. A complete project description can be seen in the March 2007 Folsom DS/FDR FEIR/EIR.

Alternative 1 – No Dam Raise/Minimal Embankment Raise, Fuseplug Spillway

Under Alternative 1, there would be no raise to the concrete structure with minimal modifications to the existing spillway. A large auxiliary spillway would be constructed adjacent to the left wing dam to address hydrologic and flood control concerns. Some of the earthen structures would be raised to address hydrologic concerns, but not to increase the flood storage capacity of the reservoir since this alternative is a Dam Safety only alternative.

Alternative 2 – 4-foot Dam and Embankment Raise

Alternative 2 incorporates a 4-foot dam raise with a fuseplug auxiliary spillway and gate-controlled tunnel spillway for better hydrologic control of large flood events. Under this alternative, there could be a 4-foot raise to the concrete structure with some modifications to the existing spillway gates. An auxiliary spillway with a chute or a tunnel would be constructed to address hydrologic and flood control concerns. All of the earthen structures could be raised to address hydrologic concerns and to provide additional flood storage capacity.

Alternative 3; Preferred Alternative- Joint Auxiliary Spillway, 3.5-foot Parapet Wall Raise

Under the Preferred Alternative a smaller six-submerged tainter gate (six gate) auxiliary spillway would be constructed to address both Dam Safety and Flood Damage Reduction objectives including hydrologic and flood control concerns. Construction of the six gate auxiliary spillway would increase project discharge capacity. The 3.5-foot raise, in conjunction with modification and/or replacement of the three emergency spillway gates and the six-gate auxiliary spillway, would only serve as additional freeboard for the Folsom facilities. Once construction is completed the raise would not exceed the existing take line for a 200-year design event and there would be an anticipated lower maximum water surface elevation. The 3.5-foot raise, modification and/or replacement of the three emergency spillway gates and the six-gate auxiliary spillway, have been identified by the Corps as their Selected Plan within the Corps' Post Authorization Change report. The remaining elements of Alternative 3 are Dam Safety Modification as revised above.

A tentative schedule showing the sequencing of construction for the preferred alternative is shown in Table 1.

Table 1
Folsom DS/FDR Project Phase Sequencing

Activity ID	Folsom Facility	Construction Period
1	Auxiliary Spillway Excavation Phase 1	September 2007 to March 2009
2	Right and Left Wing Dam Static Modifications	February 2008 to March 2009
3	Mormon Island Jet Grouting	July 2008 to December 2009
4	Auxiliary Spillway Excavation Phase 2	September 2010 to January 2014
5	Dike 5 Static Modifications	September 2009 to May 2010
6	Mormon Island Seismic Overlay	June 2015 to April 2017
7	Dike 4 and 6 Static Modifications	September 2017 to April 2018
8a	Pier Tendon Installation at Main Dam	January 2014 to March 2015
8b	Spillway Pier Wraps & Braces	August 2016 to April 2018
8c	Spillway Gate Repairs	January 2018 to August 2020
9	Auxiliary Spillway Approach Channel Excavation and Gate Structure Construction	September 2011 to December 2014
10	Raise of all Folsom Facilities	September 2018 to September 2019

Alternative 4 – 7-foot Dam and Embankment Raise

Alternative 4 contains many of the same elements as Alternative 3 with the exception of a 7-foot raise that could result in increased reservoir flood storage during large flood events. Under this alternative all Folsom Facilities and earthen structures would be raised 7 feet. A smaller four-submerged tainter gate (four gate) auxiliary spillway would be constructed to address hydrologic and flood control concerns.

Alternative 5 – 17-foot Dam and Embankment Raise

Alternative 5 was specifically developed as an alternative that would address both Dam Safety and Flood Damage Reduction requirements without the construction of an auxiliary spillway. Under this alternative all Folsom Facilities could be raised 17 feet which would increase reservoir storage capacity to control large flood events.

METHODOLOGY

HEP is a methodology developed by the Fish and Wildlife Service (Service) and other State and Federal resource and water development agencies which can be used to document the quality and quantity of available habitat for selected fish and wildlife species. HEP provides information for two general types of habitat comparisons: (1) the relative value of different areas at the same point in time; and (2) the relative value of the same areas at future points in time. By combining the two types of comparisons, the impacts of proposed or anticipated land-use and water-use changes on habitat can be quantified. In a similar manner, any mitigation needs (in terms of acreage) for the project can also be quantified, provided a mitigation plan has been developed for specific alternative mitigation sites.

A HEP application is based on the assumption that the value of a habitat for selected species or the value of a community can be described in a model which produces a Habitat Suitability Index (HSI). This HSI value (from 0.0 to 1.0) is multiplied by the area of available habitat to obtain Habitat Units (HUs). The HUs and Average Annual Habitat Units (AAHUs) over the life of the project are then used in the comparisons described above.

The reliability of a HEP application and the significance of HUs are directly dependent on the ability of the user to assign a well-defined and accurate HSI to the selected evaluation elements or communities. Also, a user must be able to identify and measure the area of each distinct habitat being utilized by fish and wildlife species within the project area. Both the HSIs and the habitat acreage must also be reasonably estimable at various future points in time. The HEP team, comprised of Corps, Reclamation and Service staff, determined that these HEP criteria could be met, or at least reasonably approximated, for the Folsom DS/FRD project. Thus HEP was considered an appropriate analytical tool to analyze impacts of the proposed project alternatives[1]. Further the HEP team determined that HSI values for habitats impacted by the Folsom DS/FRD project would be taken from the American River Watershed Investigation, Folsom Bridge (Bridge) project, the American River Watershed Investigation Long-Term Evaluation (Long-Term) and the American River Watershed Investigation Folsom Dam Modification (MODS) project. HSI values for oak/grey pine woodland and seasonal wetland habitats were used from the data collected in Reach 1 and riparian woodland habitat HSI values were used from data collected in Reach 3 in 2005, from the Bridge project. Chaparral HSI values were taken from Long-Term data, collected in 2000 for the inundation impacts and the direct impacts for chaparral HSI values were taken from MODS data, collected in 2004, for the staging, borrow and construction use areas.

GENERAL HEP ASSUMPTIONS

Some general assumptions are necessary to use HEP and Habitat Suitability Index (HSI) Models in the impact assessment:

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[1] For further information on HEP see ESM 100-104 which is available from the Service's Sacramento Fish and Wildlife Office.

Use of HEP:

1. HEP is the preferred method to evaluate the impacts of the proposed project on fish and/or wildlife resources.
2. HEP is a suitable methodology for quantifying project-induced impacts to fish and wildlife habitats.
3. Quality and quantity of fish and wildlife habitat can generally be numerically described using the indices derived from the HSI models and associated habitat units.
4. The HEP assessment is applicable to the habitat types being evaluated.

Use of HSI Models

5. HSI models are hypotheses based on available data.
6. HSI models are conceptual models and may not measure all ecological factors that affect the quality of a given cover-type for the evaluation species (e.g. vulnerability to predation). In some cases, assumptions may need to be made by the HEP Team and incorporated into the analysis to account for loss of those factors not reflected by the model.

The additional HEP field work for the project was completed by staff from the Service's Sacramento Fish and Wildlife Office, the Corps (Sacramento District) and Reclamation and occurred during May 2006 and included vegetation mapping around the Folsom Reservoir. Six cover-types would be permanently impacted by the project including oak woodland, oak savannah, blue oak/grey pine woodland, riparian woodland, seasonal wetland, annual grassland and other[2]. These cover-types were mapped by the HEP Team on aerial photographs in the field then digitized into ArcGIS. Using the project footprint supplied by Reclamation and the Corps acreages were quantified using GIS. The cover-types and acreage affected by the proposed work is summarized in Table 2 and Table 3.

2. "Other" encompasses those areas which do not fall within the other cover-types such as gravel and paved roads, parking areas, buildings, bare ground, riprap, etc.

Table 2. Summary of Cover-Types, Acres Impacted, and Compensation Recommended for the Alternatives Compared to the Preferred Alternative for the Construction of the Folsom DS/FRD Project, California.

Folsom DS/FRD Project					
Alternative	3 (Preferred)	1	2	4	5
Cover-Type	Impacted Acres: Compensation Needed	Difference from the Preferred Alternative Impacted Acres	Difference from the Preferred Alternative Impacted Acres	Difference from the Preferred Alternative Impacted Acres	Difference from the Preferred Alternative Impacted Acres
Oak/grey pine woodland	52.4 : 64.5	0.39	0.39	0.70	-1.07
Riparian woodland	42.7 : 48.0	-0.28	-0.62	-0.15	-1.66
Chaparral	0.7 : 0.8	0	0	0	-0.21
Seasonal wetland	1.2 : 4.7	0	0	0	0
Total	**97.0 : 117.9**				

Table 3. Preliminary Summary of Cover-Types, Impacted Acres and Compensation Recommended for the Inundation and Construction at Dikes 1-3 of the Folsom Reservoir for the Folsom Dam Raise Alternatives 3.5, 4.0, 7.0, or 17 feet as part of the Folsom DS/FDR Project, California.

Folsom Dam Raise Alternatives				
	3.5-ft Raise (Preferred)	**4-ft Raise**	**7-ft Raise**	**17-ft Raise**
Cover Type	Impacted Acres: Compensation Needed	Impacted Acres: Compensation Needed	Impacted Acres: Compensation Needed	Impacted Acres: Compensation Needed
Oak/Grey Pine woodland	781.5 : 939.4	820.2 : 985.8	935.1 : 1,123.8	1,331.8 : 1,600.1
Riparian woodland*	45.47 : 0.02	48.68 : 0.02	56.5 : 0.02	48.68 : 0.02
Chaparral	32.2 : 34.1	34.3 : 36.3	40.8 : 43.2	34.3 : 36.3
Seasonal wetland*	0.58 : 0.0	0.58 : 0.0	0.58 : 0.0	0.58 : 0.0
Total	**859.8 : 973.5**	**903.8 : 995.12**	**1,033 : 1,167**	**1,415.4 : 1,636.4**

*No permanent impacts to riparian woodland and seasonal wetland are expected from the short inundation that would occur from a raise component of the Folsom DS/FDR project. Acres shown are from the construction at Dikes 1-3.

Eleven HSI models were used in this HEP application to quantify project impacts. A summary of the models applied for each cover-type is also included in Table 4. The western gray squirrel and plain titmouse models were selected to evaluate the oak woodland, and oak/grey pine woodland cover-types. These species were chosen because they utilize this cover-type for

Table 4. HEP Cover-types, proposed HSI models, and model variables for the Folsom DS/FDR Project, California.

COVER-TYPE	PROPOSED I	HSI MODEL VARIABLES
(1) Oak woodland	Western gray squirrel	V1 - Canopy closure of mast-producing species>5m tall V2 - Density of leaf litter layer V3 - Tree canopy cover V4 - Den site availability per acre
	Plain titmouse	V1 - Tree diameter V2 - Trees per acre V3 - % composition of tree species that are oaks
(2) Riparian woodland	Yellow warbler	V1 - % deciduous shrub crown cover V2 – Average height of deciduous shrub canopy V3 - % deciduous shrub canopy comprised of hydrophytic shrubs
	Northern oriole	V1 - Average height of deciduous tree shrub V2 – % deciduous tree crown cover V3 – Stand width
	Western fence lizard	V1 - % ground cover V2 – Average size of ground cover objects V3 – Structural diversity/interspersion V4 - % canopy cover
(3) Seasonal wetlands	Great egret (feeding)	V1 - Percentage of area with water 10-23 cm deep V2 - Percentage of submerged or emergent vegetation cover in zone 10-23 cm deep
	California vole	V1 - Height of herbaceous vegetation V2 - Percent cover of herbaceous vegetation V3 - Soil type V4 - Presence of logs and other types of cover
	Red-winged blackbird	V1 - Predominance of narrow or broadleaf monocots V2 - Water presence throughout the year V3 - Presence or absence of carp V4 - Presence or absence of damselflies or dragonflies V5 - Mix of herbaceous vegetation V6 - Suitability of foraging substrate
(4) Chaparral	Bobcat	V1 - % shrub cover V2 - % herbaceous cover V3 – degree of patchiness V4 – rock outcroppings
	Wrentit	V1 - % shrub cover V2 - % shrub cover $\leq$5 feet
	California thrasher	V1 – Presence of low shrub openings V2 – Shrub/seedling cover
(5) Annual grassland	No HEP proposed; disturbed areas will be reseeded after construction is complete.	

nesting and foraging. The western fence lizard, yellow warbler, and northern oriole models were chosen to evaluate the project impacts to the riparian woodland cover-type. These species were selected because the bird species utilize the riparian tree canopy provided by the cover-type for nesting and foraging. For analysis purposes these two cover types were treated as one because the same models were chosen by the HEP Team. The western fence lizard utilizes the ground component of the cover-type including rocks boulders, and downed wood for shelter and foraging.

The red-winged blackbird, great egret (feeding) and California vole models were selected for evaluating impacts to the seasonal wetland cover-type because these species forage, nest, or inhabit this cover-type.

The bobcat, wrentit and California thrasher models were selected for evaluating impacts to the chaparral cover-type because these species forage, nest, or inhabit this cover-type.

The annual grassland and “other” cover-types were not included in the HEP analysis because they do not currently provide significant habitat for wildlife species or the conditions (habitat values) after the completion of work are expected to be similar to pre-project conditions.

The cover-type designations and HSI models were also selected in part to be consistent with previous impact analyses completed for the American River Watershed Investigation Folsom Dam Modification project which is occurring concurrently with the Folsom Bridge project. More information on the HEP for those projects can be found in the Service’s Fish and Wildlife Coordination Act Report for those projects.

RESULTS AND DISCUSSION

This HEP analyzed the potential impacts of the proposed Folsom DS/FDR project. Impact areas were divided into five components to facilitate possible design changes and subsequent impact analyses as the planning process proceeds toward selection of a construction alternative. The components are: (1) the construction footprint of the spillway alternatives; (2) impacts associated with Safety of Dams construction at dikes 4 thru 8, both wing dams, and MIAD; (3) impacts from borrow and stockpile; (4) impacts associated with the Flood Damage Reduction construction as dikes 1 thru 3; and (5) the potential impacts to vegetation in the new reservoir inundation zone.

The HEP does not address potential impacts to aquatic resources at Folsom Reservoir during construction, nor are potential lower American River fishery impacts addressed for the construction period or subsequent reservoir operation.

Construction Impacts

The impacts and mitigation recommended for the Preferred Alternative for the Folsom DS/FDR project is summarized in Table 5. A specific compensation site was not analyzed in this HEP application. Instead a typical site was developed, and assumptions were made that the site would be an annual grassland area without existing woody vegetation for a baseline condition. For the riparian and seasonal wetland cover-types, a critical assumption was made that any site selected for compensation would require the appropriate hydrology to support these cover-types.

Folsom Reservoir Inundation

Between 811.74 and 1,323.35 acres could be affected by enlarging Folsom Dam, depending on which dam raise alternative is selected. Some of these lands are already developed or otherwise disturbed habitat which provides little or no value for wildlife species, and some support vegetation that is tolerant of flooding. Table 5 summarizes the acreages of each habitat which provides value for wildlife and is expected to receive inundation over the life of the project. Inundation effects around Folsom Reservoir would occur in large part by the frequency, timing, and duration of flooding. Studies to date indicate that predicting the effects of inundation on vegetation is not straightforward. The raising of Folsom Dam would have potential for at least two significant impacts on vegetation: (1) changes in vegetation composition caused by inundation affecting survival and reproduction of vegetation within the zone between current and proposed maximum reservoir levels; and (2) effects of inundation on soil erosion and slippage, especially on steep slopes as are found along the upper reservoir and the forks of the American River.

The vegetation types exposed to flooding are not, in general, highly tolerant of flooding. With the exception of riparian and riverine habitats, natural flooding does not occur in the areas which would be flooded by raising Folsom Dam. Studies of the effects of inundation on blue oaks (1975 *in* USFWS 1980; MWA-JSA 1994) have found that blue oaks can survive some flooding, but may be sensitive to periods of inundation of as little as 7 days. It is not clear from these studies, however, at what time of year flooding occurred, and the ability of vegetation to tolerate inundation depends on the time of year. For example, deciduous trees, such as oaks, tend to be much more sensitive to flooding during their period of active growth (i.e., in the spring), while winter-dormant plants appear to be more tolerant of flooding (USFWS 1980). Folsom Reservoir can reasonably be expected to fill during a major spring flood event, when oaks are actively growing. The absence of blue oaks within the current inundation zone of Folsom Reservoir and other foothill impoundments indicate that blue oaks cannot tolerate the flooding regime existing there. Further, evergreen species, including grey pines and live oaks, occur commonly around the reservoir, and tend to be more sensitive to inundation than deciduous trees such as blue oaks (MWA-JSA 1994).

The other factor which could affect vegetation is erosion of the saturated soil in the new inundation area during a flood event from the water being drawn down or wind driven wave wash during a major storm event. Slopes in the Folsom Reservoir area are generally between 5 and 25% (USACE 2001). Slopes in the Mooney Ridge area in the northwestern corner of the

Table 5. **Alternative 3, Preferred**- Summary of Cover-Types, Acres Impacted, Net Change in Average Annual Habitat Units With- and Without-Project, and Compensation Recommended for the Direct Impacts and Inundation Impacts of Construction and Raise of the Folsom DS/FDR Project, California.

Folsom Dam Auxiliary Spillway and Dike Construction						
	Cover-Type	**Acres Impacted**	**AAHUs W/O Project**	**AAHUs W/ Project**	**Net Change in AAHUs**	**Compensation Needed**
Construction, Haul Rds, Borrow & Stockpile	Oak - grey pine woodland	35.29	0.07	16.23	-16.16	42.37
	Riparian woodland	39.08	0.13	30.09	-19.96	43.88
	Seasonal wetland	0.89	0.00	0.18	-0.18	3.56
	Chaparral	0.26	0.04	0.15	-0.10	0.27
Dikes 4-8, Wing Dams & MIAD	Oak - grey pine woodland	16.04	7.38	0.04	-7.34	20.75
	Riparian woodland	1.93	1.49	0.01	-1.48	2.19
	Seasonal wetland	0.28	0.06	0.00	-0.06	1.12
	Chaparral	0.26	0.15	0.04	-0.10	0.28
Spillway (Six-Gate)	Oak - grey pine woodland	1.07	0.49	0.00	-0.49	1.38
	Riparian woodland	1.66	1.28	0.01	-1.27	1.88
	Seasonal wetland	0	0	0	0	0
	Chaparral	0.21	0.12	0.03	-0.08	0.22
Raise- 0 feet (Inundation)	Oak - grey pine woodland	773.08	355.62	1.57	-354.04	928.23
	Riparian woodland	45.45	35.00	35.00	0.00	0
	Seasonal wetland	0.58	0.12	0.12	0.00	0
	Chaparral	32.22	23.20	5.24	-17.96	34.08
[3]Dikes 1-3 Raise	Oak - grey pine woodland	8.46	3.89	0.02	-3.87	11.16
	Riparian woodland	0.02	0.02	0.54	-0.02	0.02
	Seasonal wetland	0	0	0	0	0
	Chaparral	0	0	0	0	0

[3] Construction at Dike 1-3 is dependent on the implementation of the raise component of the Folsom DS/FDR project. Impact acres for this component are preliminary in this document.

reservoir and the shoreline just west of the South Fork of the American River exceed 30% (USACE 2001). It is likely that during a major flood event some, or all, of the soil on steep slopes would experience some erosion. The extent of erosion and its effect on vegetation would be difficult to predict.

Assuming a worst case scenario that over the life of the project all of the existing vegetation (except riparian and seasonal wetlands) in the inundation zone would be lost, a mitigation need was developed for each cover-type using the HEP results. Statistically, there is a relatively small chance of complete inundation coupled with total loss of vegetation. However, it is reasonable to expect some impacts, especially at the lower zones due to the potential for more frequent inundation, over the life of the project.

Given the uncertainties on effects of inundation on vegetation and soil erosion, the HEP Team decided to recommend that a monitoring and adaptive management program be developed to monitor vegetation around the reservoir over the life of the project. Baseline conditions would be managed and updated at intervals (10 years). After major flood events (those which encroach above the existing maximum flood pool elevation), vegetation would be surveyed and damages attributable to inundation would be mitigated as deemed appropriate using the best management practices at the time (replanting on site would be the first priority).

FOLSOM BRIDGE PROJECT

REACH 1 EAST NATOMA STREET TO PARKING LOT NEAR SOUTH END OF DAM

PA 1 - Future Without Project (Impact Area)

OAK WOODLAND

WESTERN GRAY SQUIRREL

TY 0 - Baseline (measured)
V1 - % canopy closure of trees and shrubs that produce hard mast (65%)
V2 - Density of leaf litter layer (M)
V3 - % tree cover (61%)
V4 - Den site availability (53)

HSI Food $= (V1 \times V2)^{1/2}$ HSI Cover/Reproduction $= (V3 \times V4)^{1/2}$

HSI = 0.46 (lowest of values)

TY 1
V1 - no change from TY 0
V2 - no change from TY 0
V3 - no change from TY 0
V4 - no change from TY 0

HSI = 0.46

TY 60
V1 - no change from TY 1
V2 - no change from TY 1
V3 - no change from TY 1
V4 - no change from TY 1

HSI = 0.46

PLAIN TITMOUSE

TY 0 - Baseline (measured)
V1 - dbh
V2 - Number trees/acre
V3 - % trees that are oaks

$$HSI = \frac{V1 + V2 + V3}{3}$$

HSI = 0 .65

TY 1
V1 - no change from TY 0
V2 - no change from TY 0
V3 - no change from TY 0

HSI = 0.65

TY 60 V1 - no change from TY 0
V2 - no change from TY 0
V3 - no change from TY 0

HSI = 0.65

PA 2 - Future With Project (Impact Area)

Assume: 1. All vegetation removed from temporary and permanent impact zones in year 1
2. temporary easement areas will not be replanted with woody vegetation

WESTERN GRAY SQUIRREL

TY 0 - Baseline (measured) HSI = 0.46

TY 1 -		
	V1 - no trees	SI = 0
	V2 - low leaf litter	SI = 0.2
	V3 - no trees	SI = 0
	V4 - no den sites	SI = 0

HSI Food $= (V1 \times V2)^{1/2} = (0 \times 0.2)^{1/2} = 0$

HSI Cover/Reproduction $= (V3 \times V4)^{1/2} = (0 \times 0)^{1/2} = 0$

HSI = 0

TY 60- V1 - no change from TY 1
V2 - no change from TY 1
V3 - no change from TY 1
V4 - no change from TY 1

HSI = 0

TY 100 no change from TY60

PLAIN TITMOUSE

TY 0 - Baseline (measured) HSI = 0.65

TY 1 -		
	V1 - no trees	SI = 0.2
	V2 - no trees	SI = 0
	V3 - no trees	SI = 0

$$HSI = \frac{V1 + V2 + V3}{3} = \frac{0.2}{3} = 0.06$$

TY 60 - V1 - no change from TY 1
V2 - no change from TY 1
V3 - no change from TY 1

HSI = .06

TY 100 – no change from TY60

MP 1 - Management Area - Future Without Project (Compensation Site)

Assume: 1. Annual grassland area selected for conversion to oak woodland.

WESTERN GRAY SQUIRREL

TY 0 - Baseline (estimated)

V1 - % canopy closure of trees and shrubs that produce hard mast (no trees)	SI = 0
V2 - Density of leaf litter (low)	SI = 0.2
V3 - Den site availability (no trees)	SI = 0

HSI Food = $(V1 \times V2)^{½}$
= $(0 \times 0.2)^{½}$
= 0

HSI Cover/Reproduction = $(V3 \times V4)^{½}$
= $(0 \times 0)^{½}$
= 0

HSI = 0

TY 1 -
V1 - no change from TY 0
V2 - no change from TY 0
V3 - no change from TY 0
V4 - no change from TY 0

HSI = 0

TY 15 - no change from TY 1 HSI = 0
TY 60 - no change from TY 15
TY 100- no change from TY TY60

PLAIN TITMOUSE

TY 0 - Baseline (estimated)

V1 - dbh (0)	SI = 0.2
V2 - Number trees/acre (0)	SI = 0
V3 - % trees that are oaks (0)	SI = 0

$$HSI = \frac{V1 + V2 + V3}{3} = \frac{0.2 + 0 + 0}{3} = .06$$

TY 1 -
V1 - no change from TY 0
V2 - no change from TY 0
V3 - no change from TY 0

HSI = .06

TY 15 - no change from TY 1 HSI = .06
TY 60 - no change from TY 15 HSI = .06
TY 100- no change from TY 60

MP 2 - Management Area - Future With Project (Compensation Site)

Assume:
1. Acquire lands (currently annual grasslands)
2. Annual grassland area prepared for planting in TY 1 , provide access and maintenance roads
3. Plant 100% blue and live oak trees (4"x4"x14" tree pots) at a density of 400 trees/acre and cover crop
4. Moderate management intensity (assume 1.5 inches dbh after 10 yrs; 90 percent survival).
5. Watering, weed, pest control for minimum of 3 years and remedial actions as necessary to ensure plant establishment.
6. Assume maximum growth rate of 12"/year
7. Develop O&M manual
8. TY 51 values equal values measured for impact zone

WESTERN GRAY SQUIRREL

TY 0 - Baseline (estimated) HSI = 0

TY 1 -	V1 - tree species planted /no mast	SI = 0
	V2 - low	SI = 0.2
	V3 - 0 (no trees)	SI = 0
	V4 - 0 (no trees)	SI = 0

HSI = 0

TY 15 -	V1 - oak trees reach 16ft. high 8%	SI = 0.15
	V2 - low	SI = 0.2
	V3 - 8%	SI = 0.15
	V4 - 0	SI = 0

HSI Food = $(V1 \times V2)^{1/2}$ = $(0.15 \times 0.2)^{1/2}$ = .17

HSI Cover/Reproduction = $(V3 \times V4)^{1/2}$ = $(0.15 \times 0)^{1/2}$ = 0

HSI = 0

TY60	V1 - 40%	SI = 0.8
	V2 - medium	SI = 0.8
	V3 - 53%	SI = 1.0
	V4 - 24/ac	SI = 1.0

HSI Food = $(V1 \times V2)^{1/2}$ = $(0.8 \times 0.2)^{1/2}$ = 0.40

HSI Cover/Reproduction = $(V3 \times V4)^{1/2}$ = $(1.0 \times 1.0)^{1/2}$ = 1.0

HSI = 0.40

TY 100	V1 - 60%	SI = 1.0
	V2 - high	SI = 1.0
	V3 - 53%	SI = 1.0
	V4 - 24/ac	SI = 1.0

HSI Food = $(V1 \times V2)^{1/2}$ = $(1.0 \times 1.0)^{1/2}$ = 1.0

HSI Cover/Reproduction = $(V3 \times V4)^{1/2}$ = $(1.0 \times 1.0)^{1/2}$ = 1.0

HSI = 1.0

PLAIN TITMOUSE

TY 0 - Baseline (estimated)

HSI = .06

TY 1 -	V1 - tree species planted (oak) (0 dbh)	SI = 0.2
	V2 - 400 (100% ≤ 16 ft tall; no trees)	SI = 0
	V3 - 100% (no trees)	SI = 0

$$HSI = \frac{V1 + V2 + V3}{3} = \frac{0.2 + 0 + 0}{3} = 0\ .06$$

TY 15 -	V1 - oak trees reach 16 ft. high (dbh = 1.75)	SI = 0.2
	V2 - ≥ 100 tree/ac	SI = 1.0
	V3 - 100%	SI = 1.0

$$HSI = \frac{0.2 + 1.0 + 1.0}{3} = 0.73$$

TY 60 -	V1 - 13 dbh	SI = 0.6
	V2 - ≥ 100 tree/ac	SI = 1.0
	V3 - 100%	SI = 1.0

$$HSI = \frac{0.6 + 1.0 + 1.0}{3} = 0\ .86$$

TY 100- no change from TY60

PA 1 - Future Without Project (Impact Area)

SEASONAL WETLAND

GREAT EGRET

TY 0 – Baseline (measured)

V1 - % area with water 4-9 inches deep
V2 - % of substrate in zone 4-9 inches deep with sub- and emergent vegetation

$$HSI = \frac{V1 + V2}{2} = 0.23$$

TY 1 – no change from baseline HSI = 0.23
TY 60 – no change from baseline HSI = 0.23
TY 100- no change from baseline

RED-WINGED BLACKBIRD

TY 0 – Baseline (measured)

V6 quality of foraging areas within 620 feet of suitable nest areas

Condition C wetland $HSI = (0.1 \times V6)^{1/2} = 0.2$

TY 1 – no change from baseline HSI = 0.2
TY 60 – no change from baseline HSI = 0.2
TY 100 – no change from baseline

CALIFORNIA VOLE

TY 0 – Baseline (measured)

V1 – Height herbaceous vegetation
V2 - % herbaceous cover
V3 – Soil type

$$HSI = \frac{V1 + V2 + V3}{3} = 0.76$$

TY 1 – no change from baseline HSI = 0.76
TY 60 – no change from baseline HSI = 0.76
TY 100- no change from baseline

PA 2 - Future With Project (Impact Area)

Assume: 1. All vegetation removed from temporary and permanent impact zones in year 1
2. temporary easement areas will not be replanted with woody vegetation
3. existing drainages culverted under roads

GREAT EGRET

TY 0 – Baseline (measured)

V1 - % area with water 4-9 inches deep
V2 - % of substrate in zone 4-9 inches deep with sub- and emergent vegetation

$$HSI = \frac{V1 + V2}{2} = 0.23$$

TY 1 – V1 – 0 SI = 0
V2 - 0 SI = 0.1

$$HSI = \frac{0 + 0.1}{2} = 0.05$$

TY 60 – no change from TY 1 HSI = 0.05
TY 100 no change from TY60

RED-WINGED BLACKBIRD

TY 0 – Baseline (measured)

V6 quality of foraging areas within 620 feet of suitable nest areas

Condition C wetland $HSI = (0.1 \times V6)^{1/2} = 0.2$

TY 1 – no change from baseline HSI = 0
TY 60 – no change from baseline TY 1 HSI = 0
TY 100 – no change from baseline

CALIFORNIA VOLE

TY 0 – Baseline (measured)

V1 – Height herbaceous vegetation
V2 - % herbaceous cover
V3 – Soil type

$$HSI = \frac{V1 + V2 + V3}{3} = 0.76$$

TY 1 – V1 – 0 SI = 0
V2 – 0 SI = 0
V3 – not silty or loamy ; not friable SI = 0.2

$$HSI = \frac{0 + 0 + 0.2}{3} = 0.06$$

TY 60 – no change from TY 1 HSI = 0.06
TY 100 – no change from TY60

MP 1 - Future Without Project (Compensation Area)

Assumption: 1. Annual grassland area will be converted to wetlands

GREAT EGRET

TY 0 - Baseline (measured)
V1 - % of area with water 4-9 inches deep (0) SI = 0
V2 - % of area 4-9 deep with emergent/submergent vegetation (0) SI = .1

$$HSI = \frac{V1 + V2}{2} = \frac{0 + 0.1}{2} = .05$$

TY 1 no change from TY 0
TY 4 no change from TY 1
TY 60 no change from TY 4
TY 100 no change from TY 60

CALIFORNIA VOLE

TY 0 - Baseline (estimated)
V1 - Height of herbaceous vegetation ($\geq$ 6in.) SI = 1.0
V2 - % cover of herbaceous vegetation (80%) SI = 6.7
V3 - soil type (mod. friable) SI = 0.5

TY 1 - V1 - no change from TY 0
V2 - no change from TY 0
V3 - no change from TY 0

$$HSI = \frac{V1 + V2 + V3}{3} = \frac{1.0 + 0.7 + 0.5}{3} = .73$$

TY 4 - V1 - no change from TY 1
TY 60 - V1 - no change from TY 4
TY 100- no change from TY 60

RED-WINGED BLACKBIRD

TY 0 - Baseline (estimated) - upland area unsuitable for species HSI = 0

TY 1 - no change from TY 0
TY 4 - no change from TY 1
TY 60 - no change from TY 4
TY 100 – no change from TY 60

<u>MP 2 - Future With Project (Compensation Site)</u>

Assumption:
1. Acquire annual grassland area
2. Portion of wetland area will have permanent water
3. Wetland will be designed to provide equal mix of open water and emergent vegetation
4. Carp will not be stocked
5. Site baseline is a Condition C wetland.
6. Site is minimum of 1-acre in size and access and maintenance roads are provided.
7. 40% of area designed for summer conditions of water 4-9 in deep
8. Plant appropriate wetland plant species, provide pest control and maintenance as needed for minimum of 3 years or until wetland is established.
9. Cover crop planted on all disturbed non-wetland areas.

GREAT EGRET

TY 0 - Baseline (estimated)

V1 - % of area with water 4-9 inches deep (0)	SI = 0
V2 - % of area with water 4-9 deep with emergent/submergent vegetation	SI = 0.1

$$HSI = \frac{V1 + V2}{2} = \frac{0 + 0.1}{2} = .05$$

TY 1 -

V1 - 40%	SI = 0.4
V2 - 5%	SI = 0.2

$$HSI = \frac{0.4 + 0.2}{2} = \frac{0.6}{2} = .30$$

TY 4 -

V1 - 40%	SI = 0.4
V2 - 40% - 60%	SI = 1.0

$$HSI = \frac{0.4 + 1.0}{2} = .70$$

TY 60 - no change from TY 4 HSI = .70
TY 100 no change from TY 60

CALIFORNIA VOLE

TY 0 - Baseline (estimated)

V1 - Height of herbaceous vegetation ($\geq$ 6 in.)	SI = 1.0
V2 - % cover of herbaceous vegetation (80%)	SI = 0.7
V3 - soil type (mod friable)	SI = 0.5

$$HSI = \frac{V1 + V2 + V3}{3} = \frac{1.0 + 0.7 + 0.5}{3} = .73$$

TY 1 - V1 - ≥ 6 in SI = 1.0
V2 - 90% SI = 0.85
V3 - no change fro baseline SI = 0.5

$$HSI = \frac{1.0 + 0.85 + 0.5}{3} = .78$$

TY 4 - V1 - no change from TY 1 SI = 1.0
V2 - 100% SI = 0
V3 - no change from TY 1 SI = 0.5

$$HSI = \frac{1.0 + 0.85 + 0.5}{3} = .78$$

TY 60- no change from TY 4
TY 100 –no change from TY 60

RED-WINGED BLACKBIRD

TY 0 - Baseline (estimated) - upland area unsuitable for species

HSI = 0

TY 1 - V1 - Emergent vegetation is old/new growth monocot (other) SI = 0.1
V2 - Water present throughout year (yes) SI = 1.0
V3 - Carp presence (absent) SI = 1.0
V4 - larvae of dragonflies/damselflies presence (yes) SI = 1.0
V5 - vegetation density (sparse first year) SI = 0.1

$$HSI = (V1 + V2 + V3 + V4 + V5)^{1/2} = (0.1 \times 1.0 \times 1.0 \times 1.0 \times 0.1)^{1/2} = 0.1$$

TY 4 - V1 - old/new growth monocots SI = 1.0
V2 - no change SI = 1.0
V3 - no change SI = 1.0
V4 - no change SI = 1.0
V5 - 50% SI = 1.0

$$HSI = (1.0 \times 1.0 \times 1.0 \times 1.0 \times 1.0)^{1/2} = 1.0$$

TY 60 - no change from TY 4 HSI = 1.0
TY 100- no change from TY 60

AMERICAN RIVER WATERSHED INVESTIGATION
FOLSOM BRIDGE PROJECT

REACH 3 - FOLSOM PRISON ACCESS ROAD TO SOUTH END OF BRIDGE

RIPARIAN

YELLOW WARBLER

TY 0 – Baseline (measured)

V1 - % deciduous shrub crown cover
V2 - average height of deciduous shrub canopy
V3 - % deciduous shrub canopy comprised of hydrophytic shrubs

$HSI = (V1 \times V2 \times V3)^{1/3}$

TY 1 – no change from baseline HSI = 0.22
TY 60 – no change from baseline HSI = 0.22
TY 100 – no change from baseline

NORTHERN ORIOLE

TY 0 – Baseline (measured)

V1 - average height of deciduous tree canopy
V2 - % deciduous tree crown cover
V3 – stand width

$HSI = (V1 \times V2 \times V3)^{1/3}$

TY 1 – no change from baseline HSI = 0.77
TY 58 – no change from baseline HSI = 0.77
TY 100 – no change from baseline

WESTERN FENCE LIZARD

TY 0 – Baseline (measured)

V1 - % ground cover
V2 - average size of ground cover objects
V3 - structural diversity/interspersion
V4 - % canopy cover

$CI = (2V1 \times V2 \times V3)^{1/3}$
$TI = (V1 \times V4)^{1/2}$

$HSI = (CI \times TI)^{1/2} = 0.63$ (average of transects)

TY 1 – no change from baseline HSI = 0.63

TY 60 – no change from baseline HSI = 0.63
TY 100 – no change from basline

PA 2 - Future With Project (Impact Area)

Assume: 1. All vegetation removed from temporary and permanent impact zones in year 1.
2. Temporary easement areas will not be replanted with woody vegetation.

YELLOW WARBLER

TY 0 – Baseline (measured)

V1 - % deciduous shrub crown cover
V2 - average height of deciduous shrub canopy
V3 - % deciduous shrub canopy comprised of hydrophytic shrubs

$HSI = (V1 \times V2 \times V3)^{1/3}$

TY 1 –	V1 – no shrubs	SI = 0
	V2 – no shrubs	SI = 0
	V3 - no shrubs	SI = 0

$HSI = (V1 \times V2 \times V3)^{1/3} = 0$

TY 60 –	V1 – no shrubs	SI = 0
	V2 – no shrubs	SI = 0
	V3 - no shrubs	SI = 0

$HSI = (V1 \times V2 \times V3)^{1/3} = 0$

TY 100- no change from TY 60

NORTHERN ORIOLE

TY 0 – Baseline (measured)

V1 - average height of deciduous tree canopy
V2 - % deciduous tree crown cover
V3 – stand width

$HSI = (V1 \times V2 \times V3)^{1/3}$

TY 1 -	V1 – no trees	SI = 0
	V2 – no trees	SI = 0
	V3 – no trees	SI = 0

$HSI = (V1 \times V2 \times V3)^{1/3} = 0$

TY 60 – V1 – no trees SI = 0
V2 – no trees SI = 0
V3 – no trees SI = 0

HSI = $(V1 \times V2 \times V3)^{1/3} = 0$

TY100 - no change from TY 60

WESTERN FENCE LIZARD

TY 0 – Baseline (measured)

V1 - % ground cover
V2 - average size of ground cover objects
V3 - structural diversity/interspersion
V4 - % canopy cover

CI = $(2V1 \times V2 \times V3)^{1/3}$

TI = $(V1 \times V4)^{1/2}$

HSI = $(CI \times TI)^{1/2}$ = 0.63 (average of transects)

TY 1 – V1 – no ground cover SI = 0
V2 – no cover objects SI = 0
V3 – A SI = 0.1
V4 – no canopy cover SI = 1.0

CI = $(2V1 \times V2 \times V3)^{1/3} = 0$

TI = $(V1 \times V4)^{1/2} = 0$

HSI = $(CI \times TI)^{1/2} = 0$

TY 60 – no change from TY 1
TY100 - no change from TY 60

<u>MP 1 – Management Area – Future Without the Project (Compensation Site)</u>

Assume: 1. Existing riparian river bank upstream of Rossmoor Bar can be enhanced by planting riparian species (south side of river).

YELLOW WARBLER

TY 0 – Baseline (measured)

V1 - % deciduous shrub crown cover (0) SI = 0
V2 - average height of deciduous shrub canopy (5 ft) SI = 0.82
V3 - % deciduous shrub canopy comprised of hydrophytic shrubs (0) SI = 0

HSI = $(V1 \times V2 \times V3)^{1/3} = 0$

TY 1 – no change from baseline HSI = 0
TY 15 – no change from baseline HSI = 0
TY 30 – no change from baseline HSI = 0
TY 60 – no change from baseline HSI = 0
TY100 - no change from TY 60

NORTHERN ORIOLE

TY 0 – Baseline (measured)

V1 - average height of deciduous tree canopy (27 ft)	SI = 0.77
V2 - % deciduous tree crown cover (0)	SI = 0
V3 – stand width (1)	SI = 0.2

HSI = $(V1 \times V2 \times V3)^{1/3}$ = 0

TY 1 – no change from baseline HSI = 0
TY 15 – no change from baseline HSI = 0
TY 30 – no change from baseline HSI = 0
TY 60 – no change from baseline HSI = 0
TY100 - no change from TY 60

WESTERN FENCE LIZARD

TY 0 – Baseline (measured)

V1 - % ground cover (0)	SI = 0
V2 - average size of ground cover objects (< 1 ft)	SI = 0.2
V3 - structural diversity/interspersion (A)	SI = 0.1
V4 - % canopy cover (0)	SI = 1.0

CI = $(2V1 \times V2 \times V3)^{1/3}$ = 0

TI = $(V1 \times V4)^{1/2}$ = 0

HSI = $(CI \times TI)^{1/2}$ = 0

TY 1 – no change from baseline HSI = 0
TY 15 – no change from baseline HSI = 0
TY 30 – no change from baseline HSI = 0
TY 60 – no change from baseline HSI = 0
TY100 - no change from TY 60

MP 2 – Management Area – Future With Project (Compensation Site)

Assume:
1. Acquire lands.
2. Watering, weed and pest management for a minimum of 3 years and remedial actions as necessary to ensure plant establishment.
3. Willow species and cottonwoods (80% of woody plantings will be planted near the mean summer water surface elevation and less water tolerant plants (oaks, etc) will be planted higher on the bank.
4. The site will extend no more than 25 feet up the bank from mean summer water surface elevation
5. Assume average growth rate of 24 inches/year for willows and cottonwood trees..

YELLOW WARBLER

TY 0 – Baseline (measured)

	V1 - % deciduous shrub crown cover (0)	SI = 0
	V2 - average height of deciduous shrub canopy (5 ft)	SI = 0.82
	V3 - % deciduous shrub canopy comprised of hydrophytic shrubs (0)	SI = 0

HSI = $(V1 \times V2 \times V3)^{1/3}$ = 0

TY 1 –	V1 - % deciduous shrub crown cover (5%)	SI = 0.15
	V2 - average height of deciduous shrub canopy (1 ft)	SI = 0.17
	V3 - % deciduous shrub canopy comprised of hydrophytic shrubs (80%)	SI = 0.80

HSI = $(0.15 \times 0.17 \times 0.80)^{1/2}$ = 0.14

TY 15 –	V1 - % deciduous shrub crown cover (75%)	SI = 1.0
	V2 - average height of deciduous shrub canopy (5ft)	SI = 0.82
	V3 - % deciduous shrub canopy comprised of hydrophytic shrubs (80%)	SI = 0.80

HSI = $(1.0 \times 0.82 \times 0.80)^{1/2}$ = 0.81

TY 30 –	V1 - % deciduous shrub crown cover (75%)	SI = 1.0
	V2 - average height of deciduous shrub canopy (5ft)	SI = 0.82
	V3 - % deciduous shrub canopy comprised of hydrophytic shrubs (80%)	SI = 0.80

HSI = $(1.0 \times 0.82 \times 0.80)^{1/2}$ = 0.81

TY 60 – no change from TY 30
TY100 - no change from TY 60

NORTHERN ORIOLE

TY 0 – Baseline (measured)

	V1 - average height of deciduous tree canopy (27 ft)	SI = 0.77
	V2 - % deciduous tree crown cover (0)	SI = 0
	V3 – stand width (1)	SI = 0.2

HSI = $(V1 \times V2 \times V3)^{1/3} = 0$

TY 1 – V1 - average height of deciduous tree canopy (27 ft) SI = 0.77
V2 - % deciduous tree crown cover (0) SI = 0
V3 – stand width (< 300 ft) SI = 0.5

HSI = $(V1 \times V2 \times V3)^{1/3} = 0$

TY 15 – V1 - average height of deciduous tree canopy (16 ft) SI = 0.77
V2 - % deciduous tree crown cover (25%) SI = 1.0
V3 – stand width (< 300 ft) SI = 0.5

HSI = $(0.77 \times 1.0 \times 0.5)^{1/3} = 0.54$

TY 30 – V1 - average height of deciduous tree canopy (40 ft) SI = 1.0
V2 - % deciduous tree crown cover (50%) SI = 1.0
V3 – stand width (< 300 ft) SI = 0.5

HSI = $(1.0 \times 1.0 \times 0.5)^{1/3} = 0.79$

TY 60 - V1 - average height of deciduous tree canopy (>40 ft) SI = 1.0
V2 - % deciduous tree crown cover (75%) SI = 0.9
V3 – stand width (< 300 ft) SI = 0.5

HSI = $(1.0 \times 0.9 \times 0.5)^{1/3} = 0.77$

TY 100- no change from TY 60

WESTERN FENCE LIZARD

TY 0 – Baseline (measured)

V1 - % ground cover (0) SI = 0
V2 - average size of ground cover objects (< 1 ft) SI = 0.2
V3 - structural diversity/interspersion (A) SI = 0.1
V4 - % canopy cover (0) SI = 1.0

CI = $(2V1 \times V2 \times V3)^{1/3} = 0$

TI = $(V1 \times V4)^{1/2} = 0$

HSI = $(CI \times TI)^{1/2} = 0$

TY 1 – V1 - % ground cover (0) SI = 0
V2 - average size of ground cover objects (< 1 ft) SI = 0.2
V3 - structural diversity/interspersion (A) SI = 0.1
V4 - % canopy cover (0) SI = 1.0

CI = $(2V1 \times V2 \times V3)^{1/3} = 0$

TI = $(V1 \times V4)^{1/2} = 0$

HSI = $(CI \times TI)^{1/2} =0$

TY 15 –	V1 - % ground cover (5%)	SI = 0
	V2 - average size of ground cover objects (≤ 1 ft)	SI = 0.2
	V3 - structural diversity/interspersion (A)	SI = 0.1
	V4 - % canopy cover (40%)	SI = 1.0

$CI = (2V1 \times V2 \times V3)^{1/3} = 0$

$TI = (V1 \times V4)^{1/2} = 0$

$HSI = (CI \times TI)^{1/2} = 0$

TY 30 –	V1 - % ground cover (25%)	SI = 1.0
	V2 - average size of ground cover objects (2 ft)	SI = 0.8
	V3 - structural diversity/interspersion (C)	SI = 1.0
	V4 - % canopy cover (75%)	SI = 0.33

$CI = (2V1 \times V2 \times V3)^{1/3} = 1.16\ (1.0)$

$TI = (V1 \times V4)^{1/2} = 0.57$

$HSI = (CI \times TI)^{1/2} = 0.75$

TY 60 –	V1 - % ground cover (50%)	SI = 1.0
	V2 - average size of ground cover objects (2 ft)	SI = 0.8
	V3 - structural diversity/interspersion (C)	SI = 1.0
	V4 - % canopy cover (75%)	SI = 0.33

$CI = (2V1 \times V2 \times V3)^{1/3} = 1.16\ (1.0)$

$TI = (V1 \times V4)^{1/2} = 0.57$

$HSI = (CI \times TI)^{1/2} = 0.75$

TY100 - no change from TY 60

PA 1 - Future Without Project (Impact Area)

CHAPARRAL

BOBCAT

TY 0 – Baseline (measured)

V1 - % shrub cover
V2 - % herbaceous cover
V3 - degree of patchiness
V4 – rock outcroppings

$$HSI = \frac{V1 + V2 + V3 + 2V4}{5} = 0.56$$

TY 1 V1 – no change from TY 0
V2 - no change from TY 0
V3 - no change from TY 0
V4 – no change from TY 0

HIS = 0.56

TY 60 V1 – no change from TY 1
V2 - no change from TY 1
V3 - no change from TY 1
V4 – no change from TY 1

HSI = 0.56
TY100 - no change from TY 60

WRENTIT

TY 0 – Baseline (measured)

V1 - % shrub cover
V2 - % shrub cover ≤ 5 feet(19%)
HSI = $(V1 \times V2)^{1/2} = 0.34$

TY 1 V1 – no change from TY 0
V2 - no change from TY 0
HSI = $(V1 \times V2)^{1/2} = 0.34$

TY 60 V1 – no change from TY 1
V2 - no change from TY 1

HSI = $(V1 \times V2)^{1/2}$ = 0.34

TY100 - no change from TY 60

CALIFORNIA THRASHER

TY 0 – Baseline (measured)

V1 – Presence of low shrub openings SI=1.0
V2 - Shrub/seedling cover SI=1.0

HSI = $(V1 \times V2^2)^{1/3}$ = 1.0

TY 1 - V1 – no change from TY 0
V2 - no change from TY 0

TY 60- V1 – no change from TY 1
V2 - no change from TY 1
TY100 - no change from TY 60

PA 2 - Future With Project (Impact Area)

Assume: 1. All vegetation removed from temporary and permanent impact zones in year 1
2. Temporary easement areas will not be replanted with woody vegetation

BOBCAT

TY 0 – Baseline (measured)

V1 - % shrub cover
V2 - % herbaceous cover
V3 - degree of patchiness
V4 – rock outcroppings

HSI = $\frac{V1 + V2 + V3 + 2V4}{5}$ = 0.56

TY 1 V1 – no shrub cover SI = 0.2
V2 - no herbaceous cover SI = 0.2
V3 – patchiness (1) SI = 0.2
V4 – no rock outcroppings SI = 0.1

HSI = $\frac{0.2 + 0.2 + 0.2 + 0.2}{5}$ = 0.16

TY 60 V1 – no change from TY 1
V2 - no change from TY 1
V3 - no change from TY 1

V4 – no change from TY 1

HSI = 0.16

TY100 - no change from TY 60

WRENTIT

TY 0 - V1 - % shrub cover

V2 - % shrub cover ≤ 5 feet

HSI = $(V1 \times V2)^{1/2}$ = 0.34

TY 1 V1 – no shrub cover SI = 0

V2 - no shrubs SI = 0

HSI = $(0 \times 0)^{1/2}$ = 0

TY 60 V1 – no change from TY 1

V2 - no change from TY 1

HSI = 0

TY100 - no change from TY 60

CALIFORNIA THRASHER

TY 0 – Baseline (measured)

V1 – Presence of low shrub openings

V2 - Shrub/seedling cover

HSI = $(V1 \times V2^2)^{1/3}$ = 0.34

TY 1 - V1 – no shrubs SI = 0

V2 - no shrubs/seedlings SI = 0

HSI = $(0 \times 0^2)^{1/3}$ = 0

TY 60- V1 – no change from TY 1

V2 - no change from TY 1

TY100 - no change from TY 60

<u>PA 3 - Future Without Project (Inundation Area)</u>

<u>CHAPARRAL</u>

BOBCAT

TY 0 – Baseline (measured)

V1 - % shrub cover SI=1.0
V2 - % herbaceous cover SI=0.98
V3 - degree of patchiness SI= 0.6
V4 – rock outcroppings SI=1.0

$$HSI = \frac{V1 + V2 + V3 + 2V4}{5} = 0.72$$

TY 1 V1 – no change from TY 0
V2 - no change from TY 0
V3 - no change from TY 0
V4 – no change from TY 0

HIS = 0.72

TY 60 V1 – no change from TY 1
V2 - no change from TY 1
V3 - no change from TY 1
V4 – no change from TY 1

HSI = 0.72

TY100 - no change from TY 60

WRENTIT

TY 0 – Baseline (measured)

V1 - % shrub cover SI=0.40
V2 - % shrub cover ≤ 5 feet(19%) SI=0.09

$HSI = (V1 \times V2)^{1/2} = 0.19$

TY 1 V1 – no change from TY 0
V2 - no change from TY 0

$HSI = (V1 \times V2)^{1/2} = 0.19$

TY 60 V1 – no change from TY 1
V2 - no change from TY 1

$HSI = (V1 \times V2)^{1/2} = 0.19$

TY100 - no change from TY 60

CALIFORNIA THRASHER

TY 0 – Baseline (measured)

V1 – Presence of low shrub openings	SI=1.0
V2 - Shrub/seedling cover	SI=1.0

HSI = $(V1 \times V2^2)^{1/3}$ = 1.0

TY 1 - V1 – no change from TY 0
V2 - no change from TY 0

TY 60- V1 – no change from TY 1
V2 - no change from TY 1

TY100 - no change from TY 60

PA 4 - Future With Project (Inundation Area)

Assume: 1. All vegetation removed from temporary and permanent impact zones in year 1
2. Temporary easement areas will not be replanted with woody vegetation

BOBCAT

TY 0 – Baseline (measured)

V1 - % shrub cover	SI=1.0
V2 - % herbaceous cover	SI=0.98
V3 - degree of patchiness	SI=0.6
V4 – rock outcroppings	SI=1.0

$$HSI = \frac{V1 + V2 + V3 + 2V4}{5} = 0.72$$

TY 1

V1 – no shrub cover	SI = 0.2
V2 - no herbaceous cover	SI = 0.2
V3 – patchiness (1)	SI = 0.2
V4 – no rock outcroppings	SI = 0.1

$$HSI = \frac{0.2 + 0.2 + 0.2 + 0.2}{5} = 0.16$$

TY 60 V1 – no change from TY 1
V2 - no change from TY 1
V3 - no change from TY 1
V4 – no change from TY 1

HSI = 0.16

TY100 - no change from TY 60

WRENTIT

TY 0 - V1 - % shrub cover
V2 - % shrub cover ≤ 5 feet

HSI = $(V1 \times V2)^{1/2}$ = 0.34

TY 1 V1 – no shrub cover SI = 0
V2 - no shrubs SI = 0

HSI = $(0 \times 0)^{1/2}$ = 0

TY 60 V1 – no change from TY 1
V2 - no change from TY 1

HSI = 0
TY 100 - no change from TY 60

CALIFORNIA THRASHER

TY 0 – Baseline (measured)

V1 – Presence of low shrub openings
V2 - Shrub/seedling cover

HSI = $(V1 \times V2^2)^{1/3}$ = 1.0

TY 1 - V1 – no shrubs SI = 0
V2 - no shrubs/seedlings SI = 0

HSI = $(0 \times 0^2)^{1/3}$ = 0

TY 60- V1 – no change from TY 1
V2 - no change from TY 1

TY 100 - no change from TY 60

MP 1 - Management Area - Future Without Project (Compensation Site)

Assume: 1. Annual grassland area selected for conversion to oak woodland.

BOBCAT

TY 0 – Baseline (estimated)

V1 - % shrub cover (no shrubs) SI = 0.2
V2 - % herbaceous cover (100%) SI = 0.8
V3 - degree of patchiness (1) SI = 0.2
V4 – rock outcroppings (no) SI = 0.1

$$HSI = \frac{V1 + V2 + V3 + 2V4}{5} = \frac{0.8 + 0.8 + 0.2 = 0.2}{5} = 0.28$$

TY 1 V1 – no change from TY 0
V2 - no change from TY 0
V3 - no change from TY 0
V4 – no change from TY 0

HSI = 0.28

TY 15 V1 – no change from TY 1
V2 - no change from TY 1
V3 - no change from TY 1
V4 – no change from TY 1

HSI = 0.28

TY 30 V1 – no change from TY 15
V2 - no change from TY 15
V3 - no change from TY 15
V4 – no change from TY 15

HSI = 0.28

TY 100 V1 – no change from TY 30
V2 - no change from TY 30
V3 - no change from TY 30
V4 – no change from TY 30

HSI = 0.28

WRENTIT

TY 0 – Baseline (estimated)

V1 - no shrub cover SI = 0
V2 – no shrubs SI = 0

$HSI = (V1 \times V2)^{1/2} = (0 \times 0)^{1/2} = 0$

TY 1 V1 – no change from TY 0
V2 - no change from TY 0

HSI = 0

TY 15 V1 – no change from TY 1
V2 - no change from TY 1

HSI = 0

TY 30 V1 – no change from TY 15
V2 - no change from TY 15

HSI = 0

TY 100 V1 – no change from TY 30
V2 - no change from TY 30

HSI = 0

CALIFORNIA THRASHER

TY 0 – Baseline (estimated)

V1 – no shrubs	SI = 0
V2 – no shrubs/seedlings	SI = 0

HSI = $(V1 \times V2^2)^{1/3} = (0 \times 0^2)^{1/3} = 0$

TY 1 - V1 – no change from TY 0
V2 - no change from TY 0

HSI = 0

TY 15 - V1 – no change from TY 1
V2 - no change from TY 1

HSI = 0

TY 30 - V1 – no change from TY 15
V2 - no change from TY 15

HSI = 0

TY 100- V1 – no change from TY 30
V2 - no change from TY 30

HSI = 0

<u>MP 2 - Management Area - Future With Project (Compensation Site)</u>

Assume:
1. Acquire lands (currently annual grasslands)
2. Annual grassland area prepared for planting in TY 1 , provide access and maintenance roads
3. Plant chaparral species at a density of 400 trees/acre and cover crop
4. Watering, weed, pest control for minimum of 3 years and remedial actions as necessary to ensure plant establishment.
5. Develop O&M manual

BOBCAT

TY 0 – Baseline (estimated)

V1 - % shrub cover (no shrubs)	SI = 0.2
V2 - % herbaceous cover (100%)	SI = 0.8
V3 - degree of patchiness (1)	SI = 0.2
V4 – rock outcroppings (no)	SI = 0.1

$$HSI = \frac{V1 + V2 + V3 + 2V4}{5} = \frac{0.8 + 0.8 + 0.2 = 0.2}{5} = 0.28$$

TY 1	V1 – area cleared and planted (1%)	SI = 0.2
	V2 – 100%	SI = 0.8
	V3 - no change from TY 0	SI = 0.2
	V4 – no change from TY 0	SI = 0.1

HSI = 0.28

TY 15	V1 – 30%	SI = 1.0
	V2 – 100%	SI = 0.8
	V3 – 2	SI = 0.6
	V4 – no change from TY 1	SI = 0.1

$$HSI = \frac{1.0 + 0.8 + 0.6 + 0.2}{5} = 0.52$$

TY 30	V1 – 50%	SI = 1.0
	V2 – 100%	SI = 0.8
	V3 – 2	SI = 0.6
	V4 – no change from TY 1	SI = 0.1

$$HSI = \frac{1.0 + 0.8 + 0.6 + 0.2}{5} = 0.52$$

TY 100	V1 – 50%	SI = 1.0
	V2 – 100%	SI = 0.8
	V3 – 2	SI = 0.6
	V4 – no change from TY 1	SI = 0.1

HSI = $\underline{1.0 + 0.8 + 0.6 + 0.2}$ = 0.52

5

WRENTIT

TY 0 – Baseline (estimated)

	V1 - no shrub cover	SI = 0
	V2 – no shrubs	SI = 0

HSI = $(V1 \times V2)^{1/2} = (0 \times 0)^{1/2} = 0$

TY 1	V1 – area cleared and planted (1%)	SI = 0
	V2 – area cleared and planted (100%)	SI = 1.0

HSI = $(V1 \times V2)^{1/2} = (0 \times 1.0)^{1/2} = 0$

TY 15	V1 – 30%	SI = 0.15
	V2 – 80%	SI = 0.8

HSI = $(0.15 \times 0.8)^{1/2} = 0.49$

TY 30	V1 – 50 %	SI = 0.33
	V2 – 80 %	SI = 0.8

HSI = $(0.33 \times 0.8)^{1/2} = 0.64$

TY 100	V1 – 50 %	SI = 0.33
	V2 – 80 %	SI = 0.8

HSI = 0.64

CALIFORNIA THRASHER

TY 0 – Baseline (estimated)

	V1 – no shrubs	SI = 0
	V2 – no shrubs/seedlings	SI = 0

HSI = $(V1 \times V2^2)^{1/3} = (0 \times 0^2)^{1/3} = 0$

TY 1 -	V1 –no	SI= 0
	V2 - 1%	SI= 0

HSI = 0

TY 15 -	V1 – yes	SI = 1.0
	V2 - 30%	SI = 0.35

HSI = $(1.0 \times 0.35^2)^{1/3} = 0.50$

TY 30 - V1 – yes SI = 1.0
V2 - 50% SI = 1.0

HSI = HSI = $(1.0 \times 1.0.^{2})^{1/3}$ = 1.0

TY 100- V1 – no change from TY 30
V2 - no change from TY 30

HSI = 1.0

APPENDIX A-2

HSI MODELS

NORTHERN ORIOLE
HABITAT SUITABILITY INDEX MODEL

HABITAT SUITABILITY INDEX MODEL

NORTHERN ORIOLE (*Icterus spurius*)

BREEDING HABITAT, CENTRAL VALLEY

CALIFORNIA

U.S. Fish and Wildlife Service
Ecological Services
Sacramento, California

January 1988

COVER TYPE	LIFE REQUISITE	HABITAT VARIABLES
Valley Woodland (W)	Reproduction/Cover	Average height of deciduous tree canopy (V_1)
Riparian (R)		Percent deciduous tree Crown cover (V_2)
		Stand width (V_3)

FOOD

The diet of the northern oriole is comprised mainly of insects. Fruits, berries, and nectar are also utilized (Bent 1958; Martin et al. 1961). For purposes of this model, it is assumed that if suitable habitat is available for nesting and cover, food resources are not limiting.

Minimum habitat area

Minimum habitat area is defined as the minimum amount of contiguous habitat that is required before an area will be occupied by a species. Based on reported pair densities (Walcheck 1970; Gaines 1974; Pleasant 1979), it is assumed that at least 0.25 acres of suitable habitat must be available for the northern oriole to occupy an area. If less than this amount is present, the HSI is assumed to be zero.

VARIABLE	HABITAT TYPE	SUGGESTED TECHNIQUE
V_1 Average height of deciduous tree canopy	R, W	Range finder and clinometer on belt transect
V_2 Percent deciduous tree crown cover	R, W	Line intercept
V_3 Stand width	R, W	Visual observation, aerial interpretation

HSI Determination

LIFE REQUISITE COVER TYPE EQUATION

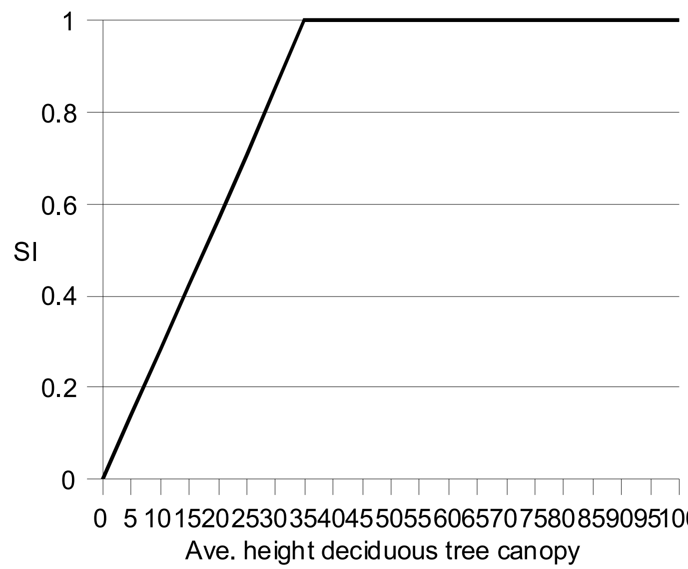
Reproduction R, W $(V_1 \times V_2 \times V_3)^{1/3}$

The HSI value for the northern oriole is equal to the reproduction/cover value.

Model Applicability

The model applies to breeding habitat of the northern oriole in the Central Valley of California up to 500 feet in elevation.

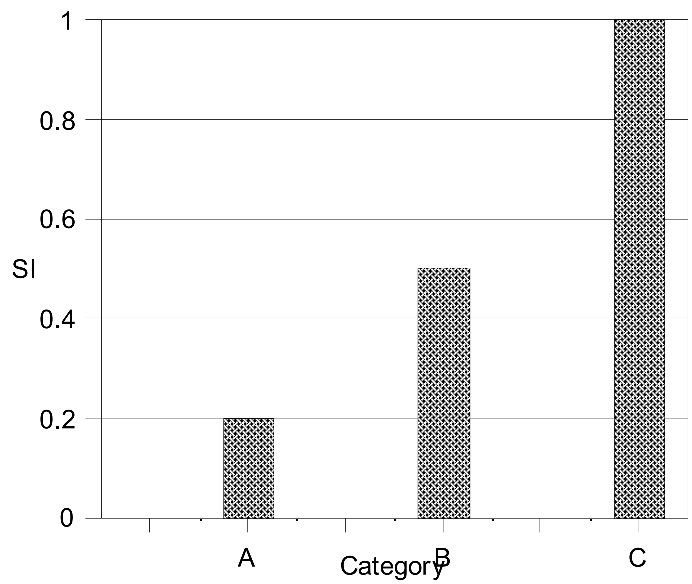
1. Average height of deciduous tree canopy.



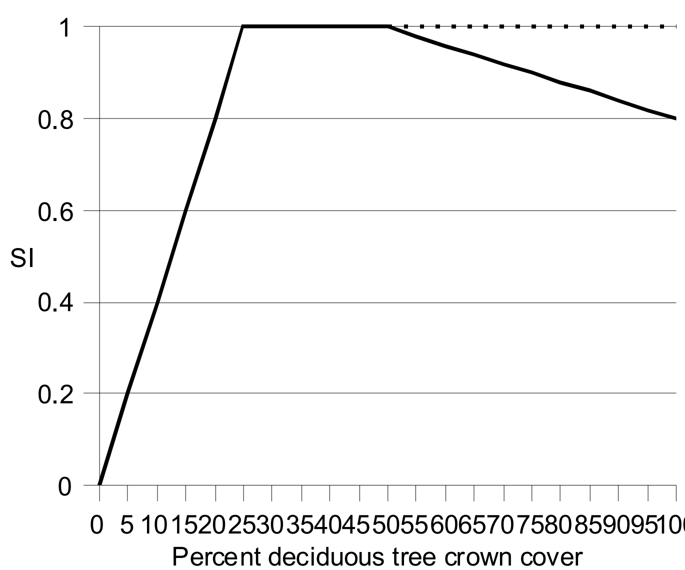
Assumption: Orioles nest almost exclusively in large, preferably deciduous, trees (derived from nesting data of Schaefer (1976A)). Tree height of 35 feet or greater is optimum the dominant canopy strata equals those trees comprising 50% of total canopy closure.

2. Percent deciduous tree crown cover.

Assumption: Orioles prefer open stands of deciduous trees for nesting (Grinnel and Miller 1944). Crown cover of 25-50% is assumed to be optimum.



3. Stand width
Assumption: Orioles prefer large blocks of riparian or oak woodland for nesting (USFWS 1981).



A - Woodland a narrow band comprising the width of one tree.
B - Woodland a strip less than 300 feet wide at its widest point.

C - Woodland greater than 300 feet wide at widest point.

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WESTERN FENCE LIZARD

HABITAT SUITABILITY INDEX MODEL

HABITAT SUITABILITY INDEX MODEL

WESTERN FENCE LIZARD (*Sceloporus occidentalis*)

by
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Division of Ecological Services
Sacramento, California

INTRODUCTION

The western fence lizard (*Sceloporus occidentalis*) ranges from British Columbia southward through Washington, Oregon and throughout California and the Great Basin to northwestern Baja California (Smith, 1948; Stebbins, 1985). It occupies a wide variety of habitats, excluding extreme desert conditions, from sea level to over 9500 feet in the Sierra Nevada. In California, four subspecies are present (Jennings, 1987). Preferring wooded, rocky areas, it frequents talus and rocky outcrops of hillsides, canyons and along streams. Western fence lizards are attracted to old buildings, woodpiles, fences, telephone poles, woodrat nests and banks with rodent burrows. It requires cover and, except for dispersing females (Jennings, personal communication) is seldom encountered in open fields or extremely barren areas (Stebbins, 1954). It is frequently a colonizer of disturbed habitats (Lillywhite, et. al., 1977).

The western fence lizard can be semi-arboreal (Cunningham, 1955; Davis and Verbeek, 1972). Trees apparently do not constitute a life requisite as was shown by *Sceloporus occidentalis* populations in chaparral (Lillywhite, Friedman and Ford 1972) and at high elevations (Grinnell and Storer, 1924). Trees may simply act as another type of available cover. This indicates the microhabitat plasticity of this species (Rose, 1978).

MODEL APPLICABILITY

This model was designed for use in plant communities found in the Central Valley of California and surrounding foothills up to an elevation of approximately 1500 feet and applies to the subspecies *S. o. occidentalis* and *S.o. biseriatus*. The model is based on both empirical data provided by expert review and information obtained from current literature.

Cover Type	Life Requisite	Habitat Variable
Riparian (R) Oak savannah (O) Oak woodland (W) Scrub (S) Annual Grassland (G)	Cover/Reproduction	Percent ground cover (V_1) Average size of ground cover objects (V_2) Structural diversity/ Interspersion (V_3)
	Thermoregulation	Percent ground cover (V_1) Percent canopy cover (V_4)

Habitat Variable	Cover Type	Suggested Techniques

V_1 - Percent ground cover	R.O.W.S,G	Line intercept, measurement of random points using a 3 feet diameter loop.
V_2 - Average size of ground cover objects	R.O.W.S,G	Line intercept
V_3 - Structural diversity/ interspersion	R.O.W.S,G	Ocular estimate
V_4 - Percent canopy cover	R.O.W.S,G	Spherical densiometer, line intercept, point intercept on aerial photos.

Variable 1. Percent ground cover

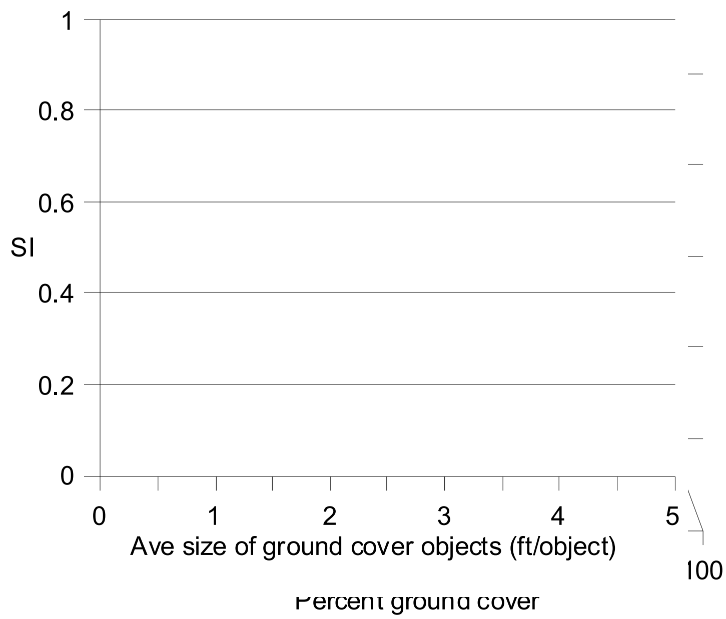
Assumes:

Only those objects less than 8 feet above the ground surface are considered. This includes rocks, logs, branches, tree trunks, fences, wood piles and live vegetation. Western fence lizards exhibit no well-defined habitat preference, but favor areas with logs, trees or other objects upon which they can climb, sun and display (Fitch, 1940). Brush piles and cavities under rocks and logs provide refuge (Marcellini and Mackey, 1979). An amount of ground cover beyond a particular density results in less than optimal conditions as it conceals predators and interferes with movement and the ability to defend a territory (Davis and Ford, 1983). Davis and Verbeek (1972) found that western fence lizards avoided dense grasslands. However, dispersing juveniles will cross dense grasslands and colonize any suitable isolated habitat found (Jennings, personal communication).

In California, western fence lizards centered their territorial activities about logs, fence posts, stumps and exposed boulders from which males display (Carpenter, 1980) and to observe mates or rival males (Fitch, 1940).

Eggs are placed in damp, friable, well-aerated soil from mid-May to mid-July in pits dug by the female and covered with loose soil (Stebbins, 1954) or under rocks and logs (Jennings, personal communication). In non-riparian conditions, nest sites are probably limited to areas within the shade of large cover objects.

Ground cover ranging from 25 to 70 percent is considered optimum for western fence lizards as it provides sufficient cover for maximum use of an area while not being so abundant as to interfere with movement. Western fence lizards undergo hibernation from November to February (Smith, 1946) and require cover for winter survival (Jennings, personal communication).



Variable 2. Average size of ground cover objects.

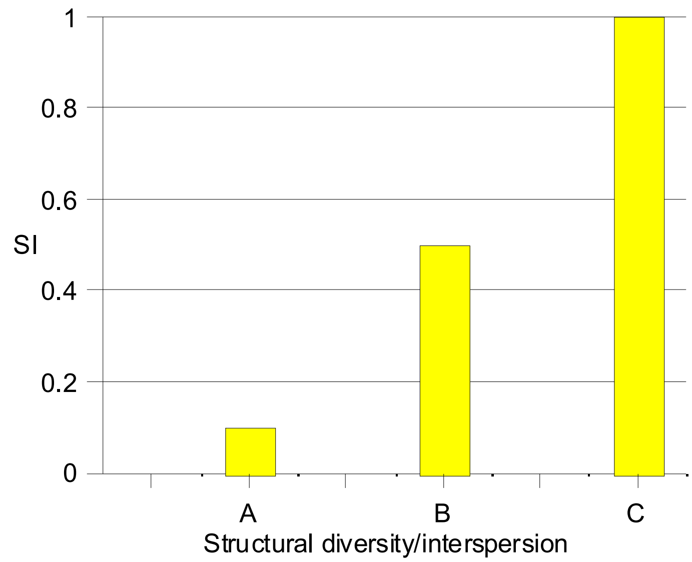
Assumes:

Ground cover objects include tree trunks but no other living material. The objects must be sufficiently large to provide escape cover. Western fence lizards have the habit of running to the opposite side of their perch (rock, log, etc.) when approached (Nussbaum et al., 1983). The objects must also be large enough to provide cover for hibernation, nest building, shade for summer thermoregulation, and to offer vantage points for territorial defense and mating display.

An average ground cover object size of 3.0 feet and larger is considered optimum as it is sufficiently large to provide for escape cover, thermoregulation and reproductive needs.

The average size of ground cover objects greater than 4 inches is diameter are measured in the field using the line intercept method and is determined by the formula:

$$\text{Average size of ground cover objects} = \frac{\text{Total feet of line intercepted}}{\text{Total number of ground cover objects intercepted}}$$



Variable 3. Structural diversity/interspersion

Assumes:

This variable is related to the habitat heterogeneity. The western fence lizard areas have a mixture and sufficient quantity of cover types (rocks, logs, living vegetation, rodent burrows, cracks and crevices) in a semi-open environment with lots of habitat edge allowing for sufficient exposure to the sun (Ruth, personal communication), escape cover and a production base for food organisms (Jennings, personal communication). These areas usually have a significant vertical component in the form of large boulders, trees, fence rows, old buildings or log piles (Nussbaum et al, 1983). Davis and Ford (1983) found optimal habitat was provided by large fallen oaks in various stages of decay or by large, standing oaks from which limbs and branches had fallen to the ground creating massive tangles. Western fence lizards commonly show low distributions in climax communities due to the homogeneity of the habitat(Ruth, personal communication).

A - Low habitat diversity. Ground cover limited to 1 or 2 types (i.e., grassland and bare soil). Site mostly homogeneous with little edge. Cover component mostly one dimensional without a significant vertical element (average less than 1 foot above ground). An exception may be rock talus which can be good (Ruth, communication).

B - Moderate habitat diversity. Two or more major ground cover types occur (i.e., large rocks, logs and woodpiles). A moderate amount of edge and interspersion is present between vegetation types and/or ground cover types. A significant vertical element to the cover component (average 1 -4 feet above ground) is present.

C - High habitat diversity. Three or more major ground cover types are present (i.e., large rocks, logs and woodpiles). Heterogeneity is high with logs of edge between evenly dispersed vegetation and cover types. Overall, habitat has a significant vertical component (average greater than 4 feet above ground). May include rock talus.

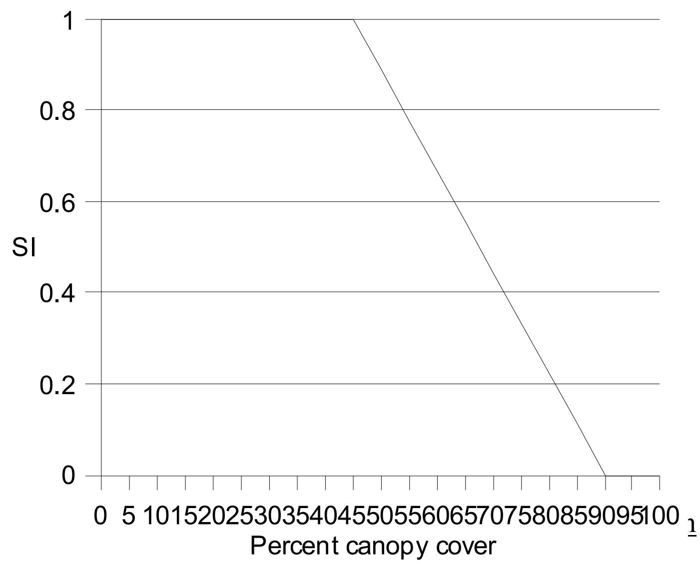
Variable 4. Percent canopy cover

Assumes:

The canopy is defined as standing live vegetation greater than 6 feet above ground. This variable relates directly to the ability of the habitat to provide sufficient exposure so that western fence lizards can thermoregulate.

The ability of a western fence lizard to thermoregulate in an area is a major determinant of its habitat occupancy. The ability of this species to absorb sunlight and warm quickly enables it to inhabit areas from sea level to over 9000 feet in elevation (Tanner and Hopkin, 1972). Western fence lizards typically move from areas of sunlight to shade to maintain their desired body temperature. Davis and Verbeek (1972) found this species shifted from rocks to trees and vice versa according to ambient temperature. Western fence lizards avoid dense, shaded woods (Stebbins, 1959).

A canopy cover ranging from 0 - 45 percent is considered optimum as it provides sufficient sunlight on the ground or ground cover surface for thermoregulation by western fence lizards. An area with a canopy cover greater than 90 percent is considered uninhabitable for western fence lizards due to a lack of sunlight on the ground surface for thermoregulation.



CALCULATIONS

<u>Life Requisite</u>

Cover//Reproduction $_3)^{1/3}$

Thermoregulation R.O.W.S,G $TI = (V_1 \times V_4)^{½}$

<u>HSI Determination</u> $HSI = (CI \times TI)^{½}$

Assumes percent ground cover is the major determining factor due to its importance in reproduction, predator avoidance and thermoregulation.

An HSI value of 1.0 is considered optimum. An HSI value greater than 1.0 achieved through the use of this formula is to be considered 1.0.

ASSUMPTIONS

Feeding

It is assumed that where all necessary habitat components are present, food availability is not a factor limiting the use of an area by western fence lizards. Low availability of insects may be a limiting factor on winter recruitment of juveniles into the adult population (Jennings, personal communication). In arid areas, food can be limiting to adults in late summer (Ruth, personal communication).

The western fence lizard is an opportunistic insectivore which feeds on a variety of insects and other arthropods including leaf hoppers, aphids, beetles, wasps, termites, ants and spiders (Fitch, 1940; Johnson, 1965; Rose, 1976; Stebbins, 1954).

Rose (1976) found the three primary groups in the fence lizard diet to be ants (*Formicidae*), beetles (*Coleoptera*) and termites (*Isoptera*). Johnson (1965) found flies (*Diptera*), beetles and ants to be important prey while Clark (1973) found grasshoppers (*Acrididae*) the most common prey item. Otvos (1977) found moths or butterflies (*Lepidoptera*) the most common prey item in stomachs analyzed. Western fence lizards commonly bask or loaf in the shade and eat whatever arthropod comes close enough to attract their attention (Tanner and Hopkin, 1972). It can therefore be assumed that food availability is not a limiting factor under normal lizard population levels and habitat conditions.

Reproduction

It is assumed that, if ground cover of rocks, logs, trees, woodpiles, etc. of sufficient size and quantity are available for non-reproductive activities, then areas with moist, friable soil necessary for lizard nesting purposes would be present beneath the cover and should not be a limiting factor. Females may travel several hundred feed to find appropriate nesting conditions (Ruth, personal communication).

Water requirements

Considering the wide distribution of this species in all but the most extreme desert regions, it is unlikely that water availability would be a limiting factor to the western fence lizard though densities are often highest where water (seeps, ponds, etc.)are nearby (Ruth, personal communication). This assumes that sufficient ground cover exists for thermoregulation and nesting. This species receives the bulk of its moisture through metabolic water from its prey (Ruth, personal communication). These lizards may lower metabolic rates to compensate for higher body temperatures and water stress during warm seasons (Tsuji, 1985).

ACKNOWLEDGMENTS

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HABITAT SUITABILITY INDEX MODELS: YELLOW WARBLER

by

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PREFACE

This document is part of the Habitat Suitability Index (HSI) Model Series (FWS/OBS-82/10), which provides habitat information useful for impact assessment and habitat management. Several types of habitat information are provided. The Habitat Use Information Section is largely constrained to those data that can be used to derive quantitative relationships between key environmental variables and habitat suitability. The habitat use information provides the foundation for HSI models that follow. In addition, this same information may be useful in the development of other models more appropriate to specific assessment or evaluation needs.

The HSI Model Section documents a habitat model and information pertinent to its application. The model synthesizes the habitat use information into a framework appropriate for field application and is scaled to produce an index value between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). The application information includes descriptions of the geographic ranges and seasonal application of the model, its current verification status, and a listing of model variables with recommended measurement techniques for each variable.

In essence, the model presented herein is a hypothesis of species-habitat relationships and not a statement of proven cause and effect relationships. Results of model performance tests, when available, are referenced. However, models that have demonstrated reliability in specific situations may prove unreliable in others. For this reason, feedback is encouraged from users of this model concerning improvements and other suggestions that may increase the utility and effectiveness of this habitat-based approach to fish and wildlife planning. Please send suggestions to:

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YELLOW WARBLER (*Dendroica petechia*)

HABITAT USE INFORMATION

<u>General</u>

The yellow warbler (*Dendroica petechia*) is a breeding bird throughout the entire United States, with the exception of parts of the Southeast (Robbins et al. 1966). Preferred habitats are wet areas with abundant shrubs or small trees (Bent 1953). Yellow warblers inhabit hedgerows, thickets, marshes, swamp edges (Starling 1978), aspen (*Populus* spp.) groves, and willow (*Salix* spp.) swamps (Salt 1957), as well as residential areas (Morse 1966).

Food

More than 90% of the food of yellow warblers is insects (Bent 1953), taken in proportion to their availability (Busby and Sealy 1979). Foraging in Maine occurred primarily on small limbs in deciduous foliage (Morse 1973).

Water

Dietary water requirements were not mentioned in the literature. Yellow warblers prefer wet habitats (Bent 1953; Morse 1966; Stauffer and Best 1980).

Cover

Cover needs of the yellow warbler are assumed to be the same as reproduction habitat needs are discussed in the following section.

Reproduction

Preferred foraging and nesting habitats in the Northeast are wet areas, partially covered by willows and alders (*Alnus* spp.), ranging in height from 1.5 to 4 m (5 to 13.3 ft) (Morse 1966). It is unusual to find yellow warblers in extensive forests (Hebard 1961) with closed canopies (Morse 1966). Yellow warblers in small islands of mixed coniferous-deciduous growth in Maine utilized deciduous foliage far more frequently than would be expected by chance alone (Morse 1973). Coniferous areas were mostly avoided and areas of low deciduous growth preferred.

Nests are generally placed 0.9 to 2.4 m (3 to 8 ft) above the ground, and nest heights rarely exceed 9.1 to 12.2 m (30 to 40 ft) (Bent 1953). Plants used for nesting include willows, alders, and other hydrophytic shrubs and trees (Bent 1953), including box-elders (*Acer negundo*) and cottonwoods (*Populus* spp.) (Schrantz 1943). In Iowa, dense thickets were frequently occupied by yellow warblers while open thickets with widely spaced shrubs rarely contained nests (Kendeigh 1941).

Males frequently sing from exposed song perches (Kendeigh 1941; Ficken and Ficken 1965), although yellow warblers will nest in areas without elevated perches (Morse 1966).

A number of Breeding Bird Census reports (Van Velzen 1981) were summarized to determine nesting habitat needs of the yellow warbler, and a clear pattern of habitat preferences emerged. Yellow warblers nested in less than 5% of census areas comprised of extensive upland forested cover types (deciduous or coniferous) across the entire country. Approximately two-thirds of all census areas with deciduous shrub-dominated cover types were utilized, while shrub wetlands types received 100% use. Wetlands dominated by shrubs had the highest average breeding densities of all cover types [2.04 males per ha (2.5 acre)]. Approximately two-thirds of the census areas comprised of forested draws and riparian forests of the western United States were used, but average densities were low [0.5 males per ha (2.5 acre)].

Interspersion

Yellow warblers in Iowa have been reported to prefer edge habitats (Kendeigh 1941); Stauffer and Best 1980). Territory size has been reported as 0.16 ha (0.4 acre) (Kendeigh 1941) and 0.15 ha (0.37 acre) (Kammeraad 1964).

Special Considerations

The yellow warbler has been on the Audubon Society's Blue List of declining birds for 9 of the last 10 years (Tate 1981).

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This model has been developed for application within the breeding range of the yellow warbler.

Season. This model was developed to evaluate the breeding season habitat needs of the yellow warbler.

Cover types. This model was developed to evaluate habitat in the dominant cover types used by the yellow warbler. Deciduous Shrubland (DS) and Deciduous Scrub/Shrub Wetland (DSW) (terminology follows that of U.S. Fish and Wildlife Service 1981). Yellow warblers only occasionally utilize forested habitats and reported populated densities in forests are low. The habitat requirements in forested habitats are not well documented in the literature. For these reasons, this model does not consider forested cover types.

Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous that is required before an area will be occupied by a species. Information on the minimum habitat area for the yellow warbler was not located in the literature. Based on reported territory sizes, it is assumed that at least 0.15 ha (0.37 acre) of suitable habitat must be available for the yellow warbler to occupy an area. If less than this amount is present, the HSI is assumed to be 0.0.

Verification level. Previous drafts of the yellow warbler habitat model were reviewed by Douglass H. Morse and specific comments were incorporated into the current model (Morse, pers. comm.).

Model Description

Overview. This model considers the quality of the reproduction (nesting) habitat needs of the yellow warbler to determine overall habitat suitability. Food, cover, and water requirements are assumed to be met by nesting needs.

The relationship between habitat variables, life requisites, cover types, and the HSI for the yellow warbler is illustrated in Figure 1.

The following sections provide a written documentation of the logic and assumptions used to interpret the habitat information for the yellow warbler and to explain and justify and variable and equations that are used in the HSI model. Specifically, these sections cover the following: (1) identification of variables that will be used in the model; (2) definition and justification of the suitability levels of each variable; and (3) description of the assumed relationship between variables.

Reproduction component. Optimal nesting habitat for the yellow warbler is provided in wet areas with dense, moderately tall stands of hydrophytic deciduous shrubs. Upland shrub habitats on dry sites will provide only marginal suitability.

It is assumed that optimal habitats contain 100% hydrophytic deciduous shrubs and that habitats with no hydrophytic shrubs will provide marginal suitability. Shrub densities between 60 and 80% crown cover are assumed to be optimal. As shrub densities approach zero cover, suitability also approaches zero.

Figure 1. Relationship between habitat variables, life requisites, cover types, and the HSI for the yellow warbler.

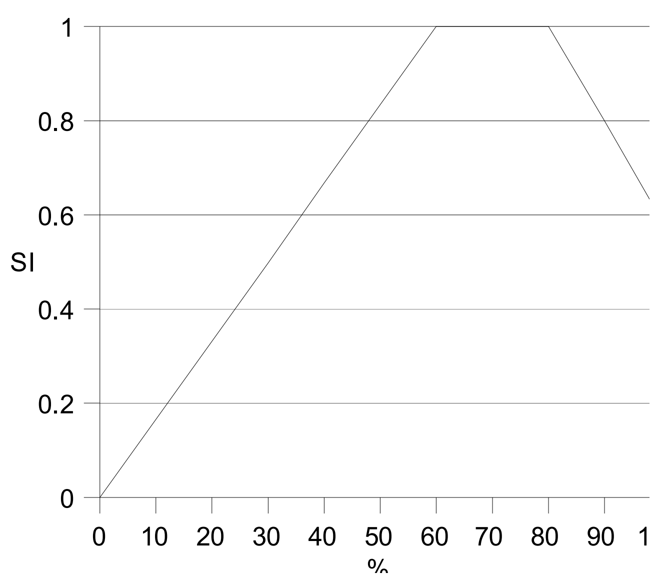
Habitat variable	Life requisite	Cover types	
Percent deciduous shrub crown cover Average height of deciduous shrub canopy Percent of shrub canopy comprised of hydrophytic shrubs	Reproduction	Deciduous Shrubland Deciduous Scrub/ Shrub Wetland	HSI

Totally closed shrub canopies are assumed to be of only moderate suitability, due to the probable restrictions on movement of the warblers in those conditions. Shrub heights of 2 m (6.6 ft) or greater are assumed to be optimal, and suitability will decrease as heights decrease to zero.

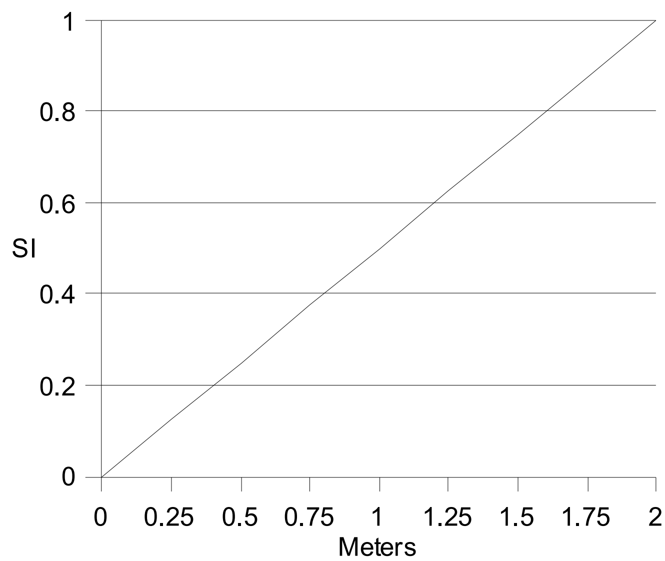
Each of these habitat variables exert a major influence in determining overall habitat quality for the yellow warbler. A habitat must contain optimal levels of all variables to have maximum suitability. Low values of any one variable may be partially offset by higher values of the remaining variables. Habitats with low values for two or more variables will provide low overall suitability levels.

Model Relationships

Suitability Index (SI) graphs for habitat variables. This section contains suitability index graphs that illustrate the habitat relationships described in the previous section.

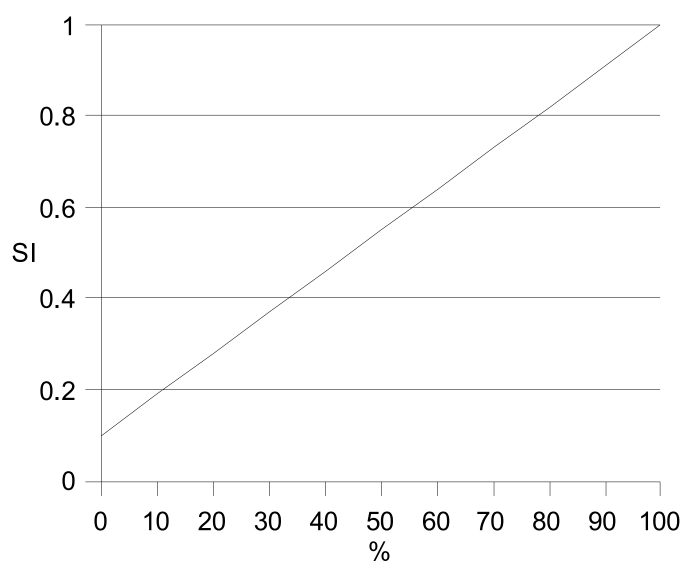


Cover-type Variable
DS,DSW V_1
Percent deciduous shrub crown cover.



DS,DSW V_2
Average height of deciduous shrub canopy.

DS, DSW V_3
Percent of deciduous shrub canopy comprised of hydrophytic shrubs.



Equations. In order to obtain life requisite values for the yellow warbler, the SI values for appropriate variables must be combined with the use of equations. A discussion and explanation of the assumed relationship between variables was included under Model Description, and the specific equation in this model was chosen to mimic these perceived biological relationships as closely as possible. The suggested equation for obtaining a reproduction value is presented below.

Life requisite	Cover type	Equation
Reproduction	DS,DSW	$(V_1 \times V_2 \times V_3)^{1/2}$

HSI determination. The HSI value for the yellow warbler is equal to the reproduction value.

Application of the Model

Definitions of variables and suggested field measurement techniques (Hays et al. 1981) are provided in Figure 2.

Figure 2. Definitions of variables and suggested measurement techniques.

Variable (definition)	Cover types	Suggested techniques
V_1 Percent deciduous shrub crown cover (the percent of the ground that is shaded by a vertical projection of the canopies of woody deciduous vegetation which are less than 5 m (16.5 ft) in height).	DS,DSW	Line intercept
V_2 Average height of deciduous shrub canopy (the average height from the ground surface to the top of those shrubs which comprise the uppermost	DW,DSW	Graduated rod

shrub canopy).

V_3 Percent of deciduous shrub canopy comprised of hydrophytic shrubs (the relative percent of the amount of hydrophytic shrubs compared to all shrubs, based on canopy cover).	DW.DSW	Line Intercept

SOURCES OF OTHER MODELS

No other habitat models for the yellow warbler were located.

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HABITAT SUITABILITY INDEX MODELS: RED-WINGED BLACKBIRD

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PREFACE

This document is part of the Habitat Suitability Index (HSI) Model Series [Biological Report 82(10)] which provides habitat information useful for impact assessment and habitat management. Several types of habitat information are data that can be used to derive quantification relationships between key environmental variables and habitat suitability. This information provides the foundation for the HSI model and may be useful in the development of other models more appropriate to specific assessment or evaluation needs.

The HSI Model Section documents the habitat and includes information pertinent to its application. The model synthesizes the habitat use information into a framework appropriate for field application and is scaled to produce an index value between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). The HSI Model Section includes information about the geographic range and seasonal application of the model, its current verification status, and a list of the model variables with recommended measurement techniques for each variable.

The model is a formalized synthesis of biological and habitat information published in the scientific literature and may include unpublished information reflecting the opinions of identified experts. Habitat information about wildlife species frequently is represented by scattered data sets collected during different seasons and years and from different sites throughout the range of a species. The model presents this broad data base in a formal, logical, and simplified manner. The assumptions necessary for organizing and synthesizing the species-habitat information into the model are discussed. The model should be regarded as a hypothesis of species-habitat relationships and not as a statement of proven cause and effect relationships. The model may have merit in planning wildlife habitat research studies about species, as well as in providing an estimate of the relative quality of habitat for that species.

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I gratefully acknowledge Dr. Gordon H. Orians, Department of Zoology, University of Washington, Seattle, for his review of this red-winged blackbird model . The cover of this document was illustrated by Jennifer Shoemaker. Word processing was provided by Carolyn Gulzow, Dora Ibarra, and Elizabeth Graf.

RED-WINGED BLACKBIRD (*Agelaius phoeniceus L.*)

HABITAT USE INFORMATION

General

The red-winged blackbird *(Agelaius phoeniceus L*) nests in fresh-water and brackish herbaceous wetlands, bushes and small trees along watercourses, and certain upland cover types from (American Ornithologists' Union 1983:723):

> ... east-central, south-coastal and southern Alaska..., southern Yukon west-central and southern Mackenzie, northwestern and central Saskatchewan, central Manitoba, central Ontario, southern Quebec..., New Brunswick, Prince Edward Island, Nova Scotia and southwestern Newfoundland south to northern Baja California, through Mexico... and along both coasts of Central America to Nicaragua and northern Costa Rica .... and to southern Texas, the Gulf coast and southern Florida. [This blackbird winters] from southern British Columbia, Idaho, Colorado, Kansas, Iowa, the southern Great Lakes region, southern Ontario and New England... south throughout the remainder of the breeding range, with the southwestern and most of Middle American populations being sedentary.

The red-winged blackbird traditionally was considered to be a wetland nesting bird. It has adapted, within the last century, to habitat changes brought about by man; it now commonly nests in hayfields, along roadsides and ditches, and in other upland sites (Dolbeer 1980).

Food

Red-winged blackbirds vary their diet throughout the year, presumably in response to the nutritive demands of reproduction. The percent of waste grain and seeds in the diet of male blackbirds in one study in Ontario, Canada, was at least 80 to 87% in March and April, 46% in May, only 10% in July, and 85% in late July to October (McNicol et al. 1982). Insects amounted to 51 to 84% of the diet during May and July. The diet of female red-winged blackbirds varied between 67 and 79% insect parts in May and July but was only 15% insectivorous in late July-October, after fledging had occurred.

Water

References describing the dependency of the red-winged blackbird on surface water for drinking and bathing were not found in the literature. Nesting occurs in herbaceous wetlands and upland habitat near surface water and in suitable vegetation distant from free water. Red-winged blackbirds seem to prefer habitats near wetlands for foraging. Communal roosting, which occurs after fledging is completed, is either in herbaceous wetlands or dense communities of young trees with thick canopies growing on moist sites (Micacchion and Townsend 1983).

Cover

The red-winged blackbird nests in a variety of habitats. Blackbirds in southern Michigan prefer old and new hay fields, pastures, old fields, and wetlands with robust vegetation capable of supporting nests and dense cover that provides protection for nests (Albers 1978). They avoid cut or fallow fields, woodlots, agricultural croplands, open water, and tilled soil.

Areas with tall, dense, herbaceous vegetation seem to provide preferred nest sites. Blackbirds that nest early in the breeding season select tall, dense, old-growth herbaceous vegetation while blackbirds that nest late in the breeding season select tall, dense, new-growth herbaceous vegetation (Albers 1978). Upland nest sites of red-winged blackbirds in Ontario were in plant communities commonly dominated by goldenrod (*Solidago* spp.), alfalfa (*Medicago sativa*), fleabane (*Erigeron* spp.), clover (*Trifolium* spp.), various thistles (*Cirsium* spp.), and similar herbaceous weeds (Joyner 1978). Blackbirds in fresh water sites selected old- and new-growth of broad-leaved monocots, like cattails (*Typha* spp.) and broad-leaved sedges (*Carex* spp.), and commonly rejected old- and new-growth of narrow-leaved monocots and forbs (Albers 1978). Woody species, such as hightide bush (*Iva* frutescens) and groundselbush (*Baccharis halimifolia*), and robust herbaceous plants, like cattails, supported the most nests in tidal herbaceous wetlands (Meanley and Webb 1963).

The density of preferred plant cover is not adequately described either in the literature or in this model. The height of preferred plant cover is inferred, below, from descriptions of nest sites.

Red-winged blackbirds frequently use scattered trees and fence posts near their breeding territories as observation posts. Blackbirds use both herbaceous wetlands and trees for communal roosts after fledging is completed. Roost trees characteristically are young, occur at high densities, provide thick canopies, and are adapted to moist sites (Micacchion and Townsend 1983).

<u>Reproduction</u>
Red-winged blackbirds are migratory in the northern portion of their range. Males migrate to or congregate at future nesting habitats in late winter, and females arrive at the territories in early spring (Case and Hewitt 1963). In areas with resident populations, individuals of both sexes may remain near breeding territories throughout the year, even though the areas are not actively defended or used in winter except, perhaps, as roosting sites (Orians pers. comm.). Males are polygynous, and up to six females commonly nest within a male's territory (Holm 1973). Harem size was larger in herbaceous wetlands with open stands of cattails than in herbaceous wetlands dominated by bulrushes (*Scirpus* spp.) or by closed stands of cattails (Holm 1973). Harem size has sometimes been observed to exceed 10 to 12 females and, in one instance, numbered 32 females (Orians pers. comm.).

Males do not participate in nest building, incubation, or feeding of the incubating female (Orians pers. comm.). Males may help feed nestlings and are likely to help feed fledglings. The timing of breeding varies throughout the range of the red-winged blackbird. Nesting frequently begins in March or April and is completed by mid-July in the more temperate habitats. Most young in North America are fledged by late July.

Herbaceous wetlands dominated by cattails generally seem to be the most productive habitats for red-wing blackbirds in terms of nests/ha or number of young fledged/ha (Robertson 1972). Favorable herbaceous wetland sites produce more suitable food per unit area and have higher nest densities, highly synchronous nesting, higher nest survival rates. and lower nest predation rates than do upland nest sites.

Nests of red-winged blackbirds are placed on the edges of cattail clumps that border areas of open water (Wiens 1965). Herbaceous wetlands that are dominated by cattails and have open, permanent water have the optimum number of available nest sites. Early nests are placed in the old growth vegetation remaining from past growing seasons, while late nests may be built on new growth. Nest success in one herbaceous wetland habitat seemed related to: (1) increased depth of permanent water (up to 50 cm or more), which apparently reduced mammalian predation on nests; (2) nest placement close to water (greater nest success was observed for nests 20 cm above water than nests 100 cm above water), (3) nest placement in herbaceous wetland vegetation interspersed with open water, rather than in herbaceous wetland vegetation where no open water was present; and (4) nest placement in marsh grass and loosestrife (*Decadon verticillatus*), rather than in sweet gale *(Myrica gale*) and sedges (Weatherhead and Robertson 1977). Other studies have indicated that nests placed at 1.2 m heights were more successful than nests placed at 0.6 m heights in tidal herbaceous wetlands on Chesapeake Bay (Meanley and Webb 1963) and that nest success was higher when permanent water levels were greater than 25 cm (Robertson 1972).

Nests of red-winged blackbirds in upland sites typically are wound between and attached to stalks of herbaceous vegetation (Bent 1958). Early nests are entwined with old growth stems and late nests with the sturdiest stems of the new growth. Activities, such as intensive livestock grazing, mowing, and burning of old growth stubble, make herbaceous uplands unavailable for early nest placement. Mowing hayfields during the nesting season disrupts nesting success on upland sites (Albers 1978). Red-winged blackbirds seem to prefer areas with the densest, tallest herbaceous vegetation for nest placement. Vegetation that restricted visibility was more important than the number of plant stems and leaves per unit area. Trees greater than 5.0 m in height were in most territories (Albers 1978). The mean height of nest placement was 15 cm in monotypic stands of reed canarygrass (*Phalaris arundinacea*) 58 cm high (Joyner 1978). Nest sites often are close to open water (Joyner 1978), although no specific descriptions of acceptable distances of upland nest sites from open water were found in the literature.

Interspersion

The red-winged blackbird seems to be closely associated with the presence of standing water (Bent 1958) and certain types of dense herbaceous vegetation for nest placement. Herbaceous wetlands or sloughs I with extensive cattails, bulrushes, sedges, reeds (*Phragmites* spp.), or tules (*Scirpus* spp.), historically have provided important nesting habitat for the blackbird (Bent 1958). However, blackbirds also nest in dense herbaceous cover in hayfields, along roadsides and ditches, and in other upland sites (Dolbeer 1980). Red-winged blackbirds forage for insects in understory, midstory, and overstory canopies (Snelling 1968) during the nesting season.

The blackbird is primarily a seed eater, except during fledging. The species sometimes forms large communal flocks in wetland herbaceous habitats or in trees and brushlands and these birds may forage on agricultural crops or understory seed sources (Mott et al. 1972; Johnson and Caslick 1982). After the autumn migration from the northern portion of their range, red-winged blackbirds frequently roost in herbaceous wetland habitats, trees, or shrubs and feed on seeds within understory vegetation.

Special Consideration

Red-winged blackbirds shift from a dispersed insectivorous feeding behavior during the nesting season to a communal granivorous feeding habit after fledging has occurred. They frequently move into agricultural areas at this time. Costs related to their consumption of grain can become high and may exceed the benefits of insect control related to their foraging habits during fledging (Bendell et al. 1981). Damage to ripening corn (*Zea mays*) occurs during August and September (Somers et al. 1981; Stehn and de Becker 1982), when blackbirds often congregate at night in herbaceous wetlands or in roosts in young deciduous trees in great concentrations (perhaps up to 1 million birds) (Stehn and de Becker 1982). The distance from these autumn roosts to corn fields and the proximity of corn fields to traditional flightlines strongly influences the amount of damage inflicted on individual corn fields. Bird damage to crops in Ohio diminished consistently as distances from communal roosts increased from 3.2 to 8 km, and the level of damage remained constant and low at distances of 8 to 19.2 km (Dolbeer 1980).

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geoqraphic area. This model will produce an HSI for nesting habitats of the red-winged blackbird. The breeding range and the year-round range of the blackbird occur throughout the contiguous 48 States.

Season. The model will produce an HSI for nesting habitat throughout the nesting seasons, which generally occurs from March to late July.

Cover types. This model was developed to evaluate habitat in herbaceous wetlands (HW) and upland herbaceous cover types, such as pasture and hayland (P/H), forbland (F), and grassland (G) (terminology follows that of U.S. Fish and Wildlife Service 1981).
Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous habitat that is required before a species will live and reproduce in an area. Specific information on minimum areas required for red-winged blackbirds was not found in the literature. It is assumed, however, that a wetland area must contain at least 0.10 ha in emergent herbaceous vegetation, like cattails, to be considered nesting habitat for the blackbird. Several studies have described the minimum territory for male red-winged blackbirds as 0.02 ha (Weatherhead and Robertson 1977; Orians 1980). A 0.10 ha area of emergent herbaceous vegetation might, therefore, potentially provide territories for up to five male blackbirds. Territories in upland habitats are much larger than those in wetland habitats. It is assumed that a block of upland and habitat must be at least 1.0 ha in area to provide adequate breeding habitat for red-winged blackbirds.

Verification level. This model was developed from descriptive information about nesting cover and species-habitat relationships identified in the literature. The HSI derived from the use of this model describes the potential of an area for providing nesting habitat for the red-winged blackbird. The model is designed to rank the suitability of nesting habitat as would a biologist with expert knowledge about the reproductive requirements of the blackbird. The model should not be expected to rank habitats in the same way as population data because many nonhabitat-related criteria can significantly impact populations of wildlife species.

Model Description

Overview. The red-winged blackbird uses a variety of habitat layers throughout the year. Tall, dense, herbaceous vegetation seems to satisfy nesting, foraging, and cover requirements. The red-winged blackbird readily uses midstory and overstory layers of habitat at times but does not seem to be dependent on the presence of these layers.

The red-winged blackbird typically nests in tall (over 0.5 m), dense (undefined) herbaceous vegetation, although it occasionally nests in shrubs and trees. This nest site requirement is best met in herbaceous wetland habitats where nest sites are available in sturdy cattails over open, permanent water. Nesting requirements also can be met by suitable herbaceous vegetation in upland sites. Tall, sturdy, herbaceous stems or midstory or overstory components are used as display perches or observation posts. Red-winged blackbirds nesting in herbaceous wetland habitats may feed on insects associated with shrub, tree canopy, or herbaceous vegetation within the wetland or on insects associated with midstory and overstory canopies or in the grass understory outside the wetland boundary (Snelling 1968). Birds nesting in upland sites typically forage for insects in understory vegetation near the nest site.

This model attempts to evaluate the ability of a habitat to meet the food and reproductive needs of the red-winged blackbird during the nesting season. The logic used in this species-habitat model is described in Figure 1. The following sections document this logic and the assumptions used to translate habitat information for the red-winged blackbird into the variables selected for the HSI model. These sections also describe the assumptions inherent in the model, identify the variables used in the model, define and justify the suitability level of each variable, and describe the assumed relationships between variables.

FIGURE 1

Food and reproductive components (herbaceous wetland cover types). There are three conditions (A, B, and C) included in Figure 1. Condition A wetlands, with a minimum of 0.10 ha in emergent herbaceous vegetation, can be very productive nesting habitats for red-winged blackbirds if water is present throughout the year, water chemistry is favorable for photosynthesis, and abundant, persistent, emergent vegetation suitable for nest placement is present. The qua1ity of such a wetland as nesting habitat for red-winged blackbirds can be estimated with the following five habitat variables.

Variable 1 (V1) refers to the type of emergent herbaceous vegetation available in the wetland.

V1 = 1.0 if emergent herbaceous vegetation is predominantly old or new growth of broad-leaved monocots, like cattails.

V1 = 0.1 if emergent herbaceous vegetation is predominantly narrow-leaved monocots or other herbaceous materials.

Variable 2 (V2) considers the water regime of the wetlands. The suitability index of V2 is 1.0 if the wetland is permanently flooded or intermittently exposed with water usually present throughout the year. This is a desirable condition because permanent water is necessary to support persistent populations of invertebrates that overwinter in various larval instars, maximizing the production of aquatic insects that emerge throughout the next spring and early summer. These insects seem to be the favored food source for blackbirds nesting in herbaceous wetlands (Orians 1980). The presence of permanent water within the wetland may reduce mammalian predation on nests of red-winged blackbirds (Robertson 1972).

V2 = 1.0 if water usually is present in the wetland throughout the year.

V2 = 0.1 if the wetland usually is dry during some portion of the year.

Variable 3 (V3) pertains to the abundance of carp (*Cyprinus carpio*) within the wetlands. Carp disturb submergent vegetation within the wetlands, which may destroy habitat for emergent aquatic insects (like Odonates) and reduce wetland food sources for blackbirds.

V3 = 1.0 if carp are absent from the wetland.

V3 = 0.1 if carp are present within the wetland.

Variable 4 (V4) in the model measures the abundance of larvae of emergent aquatic insects. The adult form of these species provides a potentially important food source for red-winged blackbirds nesting in wetland habitats. The biomass of these benthic invertebrates is variable within a herbaceous wetland at any one time, as well as between sampling periods (Hynes 1972). This biomass should not be regarded as a direct measure of productivity because production, in terms of both numbers and weight, is many times larger than that present at any one sample periods, and the assessment of numbers or biomass per unit of area presents formidable, perhaps insurmountable, difficulties (Hynes 1972). The presence or absence of suitable benthic invertebrates can be determined by sampling with a sieve net (Needham and Needham 1970) along the edge of clumps of emergent vegetation. Sampling is more likely to be accurate than inferences about the presence of benthic invertebrates based on measures of water chemistry that may inadequately consider pollutants that impact aquatic food chains. Inferences about the presence of benthic invertebrates based on the appearance of aquatic vegetation also are less accurate than sampling (Orians pers. comm.). Therefore, sampling to determine the presence or absence of important benthic invertebrates is the preferred assessment technique.

V4 = 1.0 if larvae of damselflies and dragonflies (Order Odonata) are present in the wetland.

V4 = 0.1 if larvae of damselflies and dragonflies are not present in the wetland.

Dense stands of emergent vegetation in wetlands prevent sunlight from penetrating to the water surface, which reduces aquatic productivity. A mat of vegetation can form a wetland "floor", which reduces the availability of arthropods to red-winged blackbirds and may result in increased nest predation. Open water, interspersed throughout the emergent herbaceous vegetation, supports submergent vegetation within the wetland boundary that can be used by aquatic insects as food and cover. The openings also provide an interface between emergent vegetation and open water, which increases the vegetation surface area available to emerging insects and foraging red-winged blackbirds and may increase the presence of potential nest sites. Blackbirds frequently nest on the edge of cattail clumps that border open water (Wiens 1965). They are highly territorial, and the number of territories in a wetland is assumed to be dependent on the quantity of edge between emergent vegetation and open water that is available for nest sites. An exact measure of the amount of edge within a wetland can be difficult and unreliable because of the highly dynamic nature of the herbaceous vegetation, resulting from water level fluctuations, life cycles of the vegetation, and activities of animals like muskrats (*Ondatra zibethica*). Measures of the patchiness of emergent herbaceous vegetation and open water within a wetland is represented by variable 5 (V5) in the model.

Blackbirds prefer patchy stands of cattails interspersed with areas of open water over dense homogeneous stands of cattails (Robertson 1972). Variable 5 is assumed to have a suitability index of 1.0 when the quantity of open water and emergent vegetation is about even (about 40% to 60%). Robertson (1972) found a nesting density of about 96 nests/ha in herbaceous wetland habitat when patchy vegetation was about 41% of the total wetland area. Wetlands with large areas of emergent vegetation and small areas of open water receive relatively low SIs because of the small quantity of suitable nest sites. Case and Hewitt (1963) described the Inlet Valley Marsh in New York as a small, closed herbaceous wetland with upland trees and shrubs immediately adjacent for nesting and foraging sites. The red-winged blackbird nesting density in this herbaceous wetland was about 33/ha. Variable 5 is assigned an SI of 0.3 when a wetland is completely covered with emergent herbaceous vegetation, as described above.

Conditions where there are small areas of emergent vegetation and large areas of open water also receive a low SI because of the reduced availability of niche spaces. Moulton (1980) found red-winged blackbirds nesting in emergent vegetation along ditch banks that surrounded large areas of open water in rice (*Oryza sativa*) paddies in northern Minnesota. Nest densities averaged about 2.5 nests/ha of total wetland habitat, presumably because both nests and emergent vegetation were restricted to long, narrow strips of edge. The territorial behavior of red-winged blackbirds may have restricted the nest density along the ditch banks. An SI of 0.1 is assigned to V5 for wetland habitats with a limited amount of emergent herbaceous cover. The SI's for wetlands with different amounts of emergent herbaceous vegetation are listed below. User's can interpolate between listed values as needed.

V5 = 1.0 if the wetland area contains about an equal mix of emergent herbaceous vegetation and open water.

V5 = 0.3 if the wetland area is covered by a dense stand of emergent herbaceous vegetation.

V5 = 0.1 if the wetland area contains a few patches of emergent herbaceous vegetation and extensive areas of open water.

Condition B wetlands are wetlands that are likely to be dry sometime during the year or that do not have an aquatic insect resource. These wetlands may still provide some habitat for nesting red-winged blackbirds. Blackbirds will tend to use the available emergent vegetation as nest sites and rely on vegetation surrounding the wetland as a foraging substrate. The distance that red-winged blackbirds will fly from wetlands to forage on insects in upland habitats is not known. In this model, only foraging sites within 200 m of wetlands that contain nest sites are assumed to be useful to blackbirds. The quality of a wetland without permanent water or an aquatic insect resource is assumed to be no better than the quality of available foraging sites outside the wetland (V6). Wetlands that only have upland habitats with understory vegetation (such as old fields, pastures, or hay fields) available as foraging substrates are given an SI of 0.1. Wetlands near uplands that have a deciduous midstory or tree canopy as a foraging substrate are assumed to have an SI of 0. 4. Red-winged blackbirds nesting in one herbaceous wetland will forage on insects in other, close-by, herbaceous wetlands (Holm 1973). Condition B wetlands situated within 200 m of a condition A herbaceous wetland that has an emergent aquatic insect fauna (Odonates) and undefended foraging areas are given an SI of 0.9.

V6 = 0.1 if the only suitable foraging substrate is an understory layer.

V6 = 0.4 if the suitable foraging substrates include a midstory and/or an overstory layer.

V6 = 0.9 if the suitable foraging area is a condition A wetland.

<u>Food and reproductive components (upland cover types)</u>. Upland habitats (Fig. 1; condition C) frequently are less productive than are wetland habitats. The number of young red-winged blackbirds fledged per territory may be as large in upland sites as in some wetland habitats (Dolbeer 1976). The number of young fledged/ha in upland sites, however, frequently is less than 10% of the number fledged/ha in good

quality wetland habitat. For example, Robertson (1972) reported 133 young fledged/ha in one wetland study area, while only 5 young fledged/ha in nearby upland sites. The nesting density in the wetland habitat, with patches of emergent, herbaceous vegetation interspersed with patches of open water, was about 10 times higher than in upland habitats. Robertson found about 100 red-winged blackbird nests/ha in suitable wetland habitat, 2 to 13 nests/ha in hay fields, and 0.1 nests/ha in a Christmas tree plantation.

Robertson's (1972) data on the numbers of nests/ha and young fledged/ha suggest that, if the best wetland habitats have an HSI of 1.0, the best upland sites may have an HSI of about 0.1. Graber and Graber (1963) determined that summer populations of red-winged blackbirds (number/40 ha) in Illinois from 1958 to 1959 were 301 birds in herbaceous wetlands (whether condition A or B is unknown), 342 birds in edge shrubs, 204 birds in sweet clover, 158 birds along drainage ditches, 134 birds in mixed hay, 89 birds in red clover (*Trifolium pratense*), 65 birds in oat (*Avena sativa*) fields, 64 birds in ungrazed grasslands, 58 birds in alfalfa, 30 birds in wheat (*Triticum aestivum*), 27 birds in fallow fields, 24 birds in pastureland, 23 birds in shrub-grown areas, 5 birds in corn fields, and 3 birds in soybeans (Glycine max). The observed nest densities would not exceed the values measured by Robertson (1972) for upland habitats even if all of the birds in each of these different habitat types were nesting females.

The type of upland cover available as nest sites for the red-winged blackbird is represented by V7 in the model. Red-winged blackbirds nest in a wide variety of upland sites. For example, blackbirds nested in hay fields and old fields, but not in tilled and fallow fields, in southern Michigan (Albers 1978). Important characteristics of upland nest sites include the presence of dense, tall, herbaceous vegetation, the availability of fence posts and other structures that serve as display perches for males and as observation posts for both males and females, and a proximity to open water (Joyner 1978). Specific information on the preferred proximity of nest sites in upland habitats to open water were not found in the literature.

Variable 7 (V7) describes the availability of dense, sturdy herbaceous vegetation in forbland, grassland, and pasture/hayland upland sites. Variable 7 has a habitat suitability index of 0.1 if the herbaceous vegetation is dense and tall, like sweet clover (Melilotus spp.), mixed hay, alfalfa, and coarse weeds, which provide suitable nest sites and protective cover. Variable 7 has a suitability index of 0.0 if the habitat site has some other surface cover, such as cut or fallow fields, agricultural fields, woodlots, or tilled soils.

V7 = 0.1 if upland habitat provides dense, tall, herbaceous vegetation.
V7 = 0.0 if upland habitat has some other surface cover.

Early nests of red-winged blackbirds in upland sites are more productive than are late nests (Dolbeer 1976). Early nests are placed in robust, dense, old herbaceous growth. Activities that are destructive to this vegetation, such as mowing, heavy grazing pressure, or burning, reduce habitat suitability for red-winged blackbirds. The occurrence of disturbances that might impact nesting success in upland cover types is included as V8 in the model.

V8 = 0.1 if disturbances, such as mowing, heavy grazing, or burning, do not occur to the potential habitat site in most years.

V8 = 0.0 disturbances occur to the potential habitat site in most years.

<u>HSI determination</u>. Three types of habitat conditions (A, B, and C) are described in Figure 1. Condition A represents a wetland that contains the preferred vegetative structure for nest placement, permanent water that supports a population of emergent aquatic insects that are available as food, the absence of

carp, and the interspersion of open water within emergent herbaceous vegetation. The equation combining the SIs for VI to VS to estimate an HSI for condition A wetlands is:

$$HSI = (V1 \times V2 \times V3 \times V4 \times V5)$$

Condition B habitats (Fig. 1) are wetlands where the emergent herbaceous vegetation does not have the preferred structure, there is no permanent water, carp are present, or benthic invertebrates are absent. Condition B habitats have a basic SI of 0.1, determined by the 0.1 SI for the unsuitable conditions of V1, V2, V3, or V4. The basic SI of 0.1 can be increased if suitable foraging substrate is available outside the boundary of the wetland. Food sources are considered more limiting if only an understory layer is available than if deciduous midstory and/or overstory layers also are available as foraging surfaces. A condition B habitat may be of highest value to red-winged blackbirds if the birds can readily feed on emergent aquatic insects in a nearby condition A herbaceous wetland habitat. The equation for estimating the HSI for condition B habitats is:

$$HSI = (0.1 \times V6)^{1/2}$$

Condition C habitats are upland sites, like grass, forb, and pasture/hayland cover types. Their HSI'S, which will be either 0.1 or 0, are described by the following equation:

$$HSI = (V7 \times V8)^{1/2}$$

The measure of habitat quality represented by the HSI actually reflects an estimate of the quantity of niche space available to the blackbird. Habitats with higher HSIs are assumed to contain more niche space than habitats with lower HSI'S. More niche space in a habitat frequently means that more individuals will occur in that habitat.

Application of the Model

Summary of model variables. This model can be applied by interpreting a recent, good quality, aerial photograph of the assessment area and making selected field measurements. The habitat to be evaluated is outlined on the aerial photograph. Each wetland within the assessment area is identified and a 200 m zone drawn around its perimeter. The wetlands within the assessment area are evaluated, on a per ha basis, with field observations and measurements that determine: (1) the type of emergent vegetation present; (2) the probable permanency of the water; (3) the presence or absence of carp; (4) the presence or absence of larval stages of emergent aquatic insects; (5) the mix of open water and emergent herbaceous vegetation; and (6) the nature of vegetative cover within 200 m surrounding the wetland (Fig. 2). The proportion of open water and emergent herbaceous vegetation within the wetland is estimated from a map made after boating or wading through the wetland. The presence of benthic invertebrates is determined from field sampling. Upland habitats within the assessment area are evaluated by ground truthing to determine cover types and land-use practices. Habitat conditions, like the presence of dense, tall herbaceous cover and the probability that disturbances such as grazing, burning, mowing, and tilling will occur during the March to July nesting season, are noted.

Definitions of variables and suggested field measurement techniques are provided in Figure 3.

Model assumptions. I have assumed that it is possible to synthesize results from many studies conducted in different seasons of the year different locations in North America into a model years, and a wide variety of nest sites throughout North America into a model describing the relative quality of breeding habitat for the red-winged blackbird. My basic assumptions about habitat criteria important to red-winged blackbirds are based on descriptive and correlative relationships expressed in the literature. My descriptors of habitat quality will obviously be in error if authors made incorrect judgements or measurements or if I have emphasized the wrong data sets or misinterpreted the meaning of published data.

I have assumed that the quality of some wetland habitats exceeds the quality of best upland habitats. This assumption was based largely on quality of the blackbirds fledged per hectare of wetland and upland habitats. I compiled and analyzed characteristics of wetland habitats that seemed to distinguish habitats where varying numbers of red-winged blackbirds were fledged. I assumed that I could meaningfully bound the size of study areas to be evaluated as nesting habitat as $\geq$ 0.1 ha for wetland sites and ∃ 1.0 ha for suitable upland sites. I arbitrarily selected distances (200 m) that blackbirds might fly from their nests in wetlands to forage on insects and seeds in surrounding vegetative cover. I assumed that the presence of dense, tall, herbaceous cover reasonably close to water, coupled with a strong probability that the dense cover would remain relatively undisturbed during the breeding season, would adequately indicate the value of upland habitats as nest sites for the red-winged blackbird.

The values for Variables 1 through 8 are estimates. The ecological information available does not seem sufficient to suggest: (1) other pertinent variables; (2) more appropriate values for the present variables; or (3) more definitive interrelationships between the variables. Finally, I have assumed that the multiplicative relationship described in the model is appropriate summary statement to provide a Habitat Suitability Index that reflects the relative importance of different habitats as nest sites for the red-winged blackbird.

Figure 3. Definitions of variables and suggested measurement techniques.

Variable (definition)		Cover type	Suggested technique
VI	Type of emergent	HW	Identify the dominant species of emergent herbaceous vegetation in the wetland. Determine if the dominant species is a broad-leaved monocot.
V2	Water regime	HW	Determine whether or not water will be retained in the wetland throughout the year in most years; use, if possible, indicators like muskrat houses and fish. Evaluate records describing permanence and level of water in wetland. Determine the classification type of wetland if the wetland has been classified.
V3	Abundance of carp within the wetland.	HW	Determine presence of carp by seining, using local data about presence of carp within wetland or observations to see if water is clear or generally murky, as it is when carp are feeding.

V4	Abundance of larval	HW	Collect insect larvae by dragging astages of emergent aquatic sieve net along water bottom near edge insects(Order Odonata) of clumps of emergent herbaceous within the wetland. vegetation. Sampling is done for some fixed time period. A second sampling procedure involves kicking up the substratum at the edge of clumps of emergent herbaceous vegetation in front of the mouth of a net in some standardized manner (Hynes 1972:240). The collected invertebrates are sorted and identified by comparison with illustrations in an appropriate manual (like Needham and Needham 1970) to determine the presence of damselfly and dragonfly larvae (Order Odonata).
V5	Percent emergent	HW	Determine the mix of open water and herbaceous canopy emergent herbaceous vegetation within the wetland study area. Estimate the mix from a map prepared after wading, walking, or boating through the wetland or from a map made from a recent, high quality, aerial photograph
V6	Types of foraging sites	HW	Use map measurer (Hays et al. 1981) available outside the wetland. to determine if another wetland with an emergent aquatic insect population occurs within 200 m of nest sites within the wetland being evaluated. Map vegetation within 200 m of the wetland and determine, using a dot grid (Hays et al. 1981) or a planimeter, if deciduous midstory and overstory layers comprise at least 10% cover when projected to the ground surface. If midstory and/or overstory do not provide at least 10% cover, and a condition. A wetland does not occur within 200 m of the wetland being evaluated assume only the understory layer is available as a foraging substrate.
V7	Presence of dense, sturdy	F,G,P/H	Interpret the aerial photograph or a herbaceous vegetation Vegetation on-site map prepared from the aerial photograph to determine areas of upland herbaceous vegetation. Ground truth to determine types of herbaceous vegetation occurring in the upland within the assessment

			area and determine if tall, dense, herbaceous cover covers at least 10% of the surface area.
V8	Occurrence of disturbances	F,G,P/H	Ground truth to predict past and future like grazing, mowing, burning, land-use practices (types of and tilling on potential uplanddisturbances that may impact nesting nest sites. success).

SOURCES OF OTHER MODELS

Weatherhead and Robertson (1977) identified and quantified some parameters that affected the nesting success of red-winged blackbirds in wetland habitats in Ontario, Canada. They determined that nesting success, as judged by numbers of young fledged per female, was positively correlated with territory quality scores based on nest placement. Nesting success seemed to be related to four parameters: (1) water depth within the wetland; (2) height of nest above the herbaceous wetland floor; (3) relative openness of nesting cover within the wetland; and (4) the identity of the support vegetation holding the nest. Two of these variables are represented in the present model of habitat suitability for the red-winged blackbird: (1) presence or absence of permanent water; and (2) the relative openness of vegetation within flooded herbaceous wetlands. No other models for use in predicting the quality of nesting habitat for red-winged blackbirds were found in the literature.

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HABITAT SUITABILITY INDEX MODELS: GREAT EGRET

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PREFACE

The habitat suitability index (HSI) model for the great egret presented in this report is intended for use in the habitat evaluation procedures (HEP) developed by the U.S. Fish and Wildlife Service (1980) for impact assessment and habitat management. The model was developed from a review and synthesis of existing information and is scaled to produce an index of habitat suitability between 0 (unsuitable habitat) and 1.0 (optimally suitable habitat). Assumptions used to develop the HSI model and guidelines for model applications, including methods for measuring model variables, are described.

This model is a hypothesis of species-habitat relations, not a statement of proven cause and effect. The model has not been field tested, but it has been applied to three hypothetical data sets that are presented and discussed. The U.S. Fish and Wildlife Service encourages model users to convey comments and suggestions that may help increase the utility and effectiveness of this habitat-based approach to fish and wildlife management. Please send any comments or suggestions you may have on the great egret HSI model to the following address.

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Earlier versions of the habitat suitability index model and narrative for the great egret were reviewed by Dr. R. Douglas Slack and Jochen H. Wiese. The model's structure and functional relationships were thoroughly evaluated by personnel of the U.S. Fish and Wildlife Service's (FWS) National Coastal Ecosystems Team. Model and narrative reviews were also provided by FWS Regional personnel.

GREAT EGRET (*Casmerodius albus*)

INTRODUCTION

The great egret, also called common egret or American egret, is a large white heron in the order Ciconiiformes, family Ardeidae. Great egrets stand 37-41 inches tall and have a wing spread to 55 inches (Terres 1980). The species is associated with streams, ponds, lakes, mud flats, swamps, and freshwater and salt marshes. The birds feed in shallow water on fishes, amphibians, reptiles, crustaceans and insects (Terres 1980).

Distribution

The great egret is a common breeding species in all coastal areas south from southern Oregon on the Pacific coast and from Maine on the Atlantic coast; in riverine, palustrine and estuarine habitats along the coast of the Gulf of Mexico; and in the Eastern-Central United States (Palmer 1962; Erwin and Korschgen 1979; American Ornithologists' Union 1983). The great egret undergoes an extensive postbreeding dispersal that extends the range of the species to most of the United States exclusive of the arid Southwest (Byrd1978). Young birds hatched in Gulf coast colonies tend to move northward for a short period (Byrd 1978; Ogden 1978). However, with the onset of colder weather most great egrets and other herons migrate south and many winter along the gulf coast in Texas, Louisiana, and Florida (Lowery 1974; Oberholser and Kincaid 1974; Byrd 1978). Analysis of banding data indicates that many birds winter in Cuba, the Bahamas, the Greater and Lesser Antilles, Mexico, and Central America (Coffey 1948). Lowery (1974) suggested that during severe winters, a higher proportion of the population winters farther south.

Life History Overview

Great egrets nest in mixed-species colonies that number from a few pairs to thousands of individuals. A colony may include other species of herons, spoonbills, ibises, cormorants, anhingas, and pelicans. Colony and nest-site selections begin as early as December along the gulf coast, but most great egrets do not initiate nesting activities until mid-February or early March (Bent 1926; Oberholser and Kincaid 1974; Chaney et al. 1978; Morrison and Shanley 1978). Eggs have been recorded from March through early August, and young have been observed in nests from mid-May through late August (Oberholser and Kincaid 1974; Chaney et al. 1978). Clutch size varies from one to six eggs per nest, but three to four eggs is most common (Bent 1926). Incubation period in a Texas colony ranged from 23 to 27 days (Morrison and Shanley 1978). The first flights of young have been noted about 42 days after hatching (Terres 1980).

SPECIFIC HABITAT REQUIREMENTS

Food and Foraging Habitat

Fish constitute up to 83% of the great egret's diet (Hoffman 1978). Most fish taken by great egrets are minnow-sized 3.9 inches, but fish up to 14 inches can be captured and swallowed (Willard 1977; Schlorff 1978). Other major food items include insects, crustaceans, frogs, and snakes, while small mammals, small birds, salamanders, turtles, snails, and plant seeds are occasionally taken (Baynard 1912; Bent 1926; Hunsaker 1959; Palmer 1962; Genelly 1964; Kushlan 1978b).

Little specific information exists on the food habits of various age classes of great egrets. An adult great egret weighing 32.3 ounces (oz) (Palmer 1962) may require approximately 3.9 oz of food per day (estimated by using the wading bird weight-daily food requirement model proposed by Kushlan 1978b). Daily food requirements are undoubtedly higher during the nesting season when adults are feeding young (Kushlan 1978b).

Great egrets usually forage in open, calm, shallow water areas near the margins of wetlands. They show no preference for fresh-, brackish, or saltwater habitat. Custer and Osborn (1978a,b) found that feeding habitat selection in coastal areas of North Carolina varied daily with the tidal cycle. During low tide, great egrets fed in estuarine seagrass beds. During high tide, freshwater ponds and the margins of *Spartina* marshes were used. Inland, great egrets feed near the banks of rivers or lakes, in drainage ditches, marshlands, rain pools (Bent 1926; Dusi et al. 1971; Kushlan 1976b), and occasionally in grassy areas (Weise and Crawford 1974). Feeding sites are generally not turbid and are fairly open with no vegetative canopy and few emergent shoots (Thompson 1979b).

Great egrets forage singly, in single-species groups, and in mixed-species associations (Kushlan 1978b). Great egrets generally fly alone to feeding sites (Custer and Osborn 1978a,b) and may use the same feeding site repeatedly. The density and abundance of fish at a given location in estuarine habitats may vary with season, time of day, tidal stage, turbidity, and other factors. If feeding success is low, great egrets may move to other areas (Cypert 1958; Schlorff 1978) and join other conspecifics in good feeding habitats (Custer and Osborn 1978a,b). Most instances of group feeding have been observed during specific environmental conditions, such as lowered water levels, that tend to concentrate prey (Kushlan 1976a,b; Schlorff 1978).

Meyerriecks (1960, 1962) and Kushian (1976a, 1978a, b) provided detailed information on hunting techniques employed by great egrets. The "stand-and-wait" and "slow-wade" methods are used most frequently. Because of their long legs, great egrets can forage in somewhat deeper water than most other herons. In New Jersey, foraging depths ranged from 0 (standing on the bank while fishing) to 11 inches, but depths ranging from 4 to 9 inches were most commonly used (Willard 1977). In North Carolina, great egrets fed in water with a mean depth of 25.1 cm (9.8 inches) in *Spartina* habitat and of 6.8 inches in non-*Spartina* habitat (Custer and Osborn 1978b). Mean water depth was 7.9 inches for foraging great egrets in California (Hom 1983). In addition to wading, great egrets can feed by alighting on the surface of deep waters to catch prey, a method rarely employed (Reese 1973; Rodgers 1974, 1975).

Although recent declines of great egret populations in the central coastal region of Texas occurred simultaneously with declines in coastal marine and estuarine fish populations (Chapman 1980), no causal relationship has been proven. At present there are no known management practices that provide suitable food alternatives for piscivorous species, such as the great egret, during periods of fish population decline. Known fish nursery and feeding areas need protection from destruction or habitat alteration to ensure adequate prey populations for fish-eating birds.

Water

The physiologic water requirement of great egrets is probably met during feeding activities in aquatic habitats (Dusi et al . 1971). Water depth affects the quantity, variety, and distribution of food and cover; great egret food and cover needs are generally met between the shoreline and water 1.6 feet deep (Willard 1977).

Interspersion

Suitable habitat for the great egret must include (1) extensive shallow, open water habitat from 4 to 9 inches deep (Willard 1977); (2) food species present in sufficient quantity (Custer and Osborn 1977); and (3) adequate nesting or roosting habitat close to feeding habitat. Most great egrets at a colony in North Carolina flew less than 2.5 miles from nesting colonies (and presumably, from roosting sites) to feeding areas (Custer and Osborn 1978a), but flight distances of up to 22.4 miles have been recorded in the floodplain of the Upper Mississippi River (Thompson 1979b).

Several heronries may be close together. Great egrets from one colony may fly over or near an adjacent colony, but rarely feed in the same areas as conspecifics from the adjacent colony (Thompson 1979b).

HABITAT SUITABILITY INDEX (HSI) MODELS

Model Applicability

Geographic area. The habitat suitability index (HSI) models in this report were developed for application in coastal wetland habitats in Texas and Louisiana. Because there are few differences in habitat requirements along the Atlantic coast, the remainder of the gulf coast, and inland sites in the Southeastern United States, the HSI models may also be used to evaluate potential habitat in those areas.

Season. This model will produce an HSI values based upon habitat requirements of great egrets during the breeding season (February to August). Because there is no apparent seasonal difference in feeding habitat preference and because winter nocturnal roosts are similar to nesting sites, the HSI models may also be used to evaluate winter habitat for the great egret.

Cover types. Great egrets nest on upland islands and in the following cover types of Cowardin et al. (1979): Estuarine Intertidal Scrub-Shrub wetland (E2SS), Estuarine Intertidal Forested wetland (E2FO), Palustrine Scrub-Shrub wetland (PSS) (including deciduous and evergreen subclasses), and Palustrine Forested wetland (PFO) (including deciduous and evergreen subclasses). Great egrets may also feed in these wooded wetlands, but preferred feeding areas may be any one of a wide variety of wetland cover types.

Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous suitable habitat required before an area can be occupied by a particular species. Specific information on minimum areas required by great egrets was not found in the literature. If local information is available to define the minimum habitat area, and less than this amount of area is available, the HSI for the species will be zero.

Verification level. The output of these HSI models is an index between 0 and 1.0 that is believed to reflect habitat potential for great egrets. Two biologists reviewed and evaluated the great egret HSI model throughout its development: Dr. R. Douglas -Slack, Texas A&M University, College Station, and Jochen H. Wiese, Environmental Science and Engineering Company, Gainesville, Florida. Their recommendations were incorporated into the model-building effort. The authors, however, are responsible for the final version of the models. The models have not been field-tested.

Model Descriptions

Feedinq HSI model. Great egret feeding habitat suitability is related to prey availability. Habitat suitability is optimal when two conditions are met: (1) the populations of minnow-sized fish are high; and (2) shallow open water (necessary for successful prey capture), aquatic vegetation (necessary for prey survival and reproduction), and deeper water are present in a ratio that maximizes prey density and minimizes hunting interference. Use of this model assumes that deep or permanent water environments are not limiting in coastal habitats and that fish populations are distributed uniformly. Because great egrets hunt a variety of species in many different habitat types, a general approach to modeling feeding habitat suitability is presented. Suitability of all wetland cover types for feeding is determined by integrating two factors: (1) the abundance of prey and (2) the accessibility of prey.

The abundance of prey is determined by the ability of the habitat to support the major prey species, especially minnow-sized fish. It is assumed that the abundance of major prey species is related to the primary and secondary productivity of the aquatic habitat; however, few field studies have documented this relationship. The model assumes that prey abundance is not limiting in coastal habitats. Therefore, the accessibility of prey is used as the indicator of feeding habitat suitability.

The accessibility of prey is determined by water depth and percentage cover of aquatic vegetation. A wetland with 100% of its area covered by water 4-9 inches deep is assumed to be optimal for feeding by great egrets (V_1). Although an absence of submerged or emergent vegetation would render fish species most vulnerable to capture, it is unlikely that many prey species would use such an area because it totally lacks cover. The model assumes, therefore, that optimal conditions for both the occurrence and susceptibility to capture of prey species exist when 40%-60% of the wetland substrate is covered by submerged or emergent vegetation (V_2). When such vegetation is lacking, the habitat has a low value for feeding great egrets because small fish may use unvegetated water that is too shallow for their larger aquatic predators.

	Habitat variable	Component
V_1	Percentage of area with water 10-23 cm deep.	

Food HSI (Feeding)

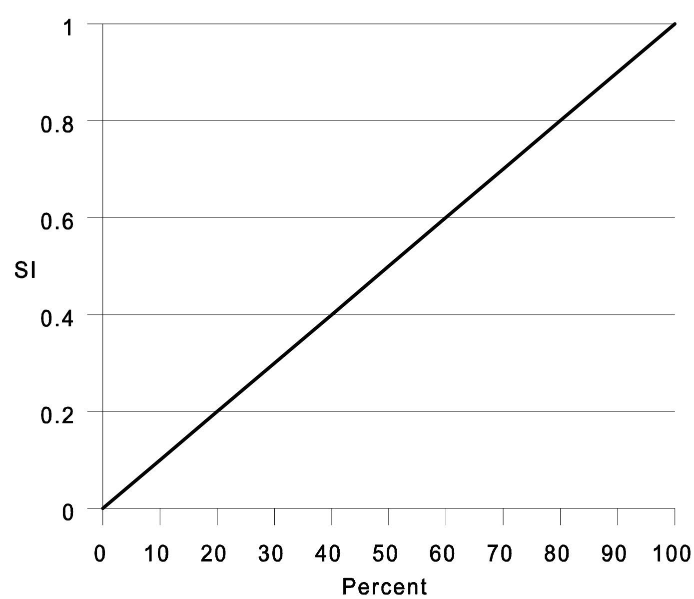
V_2 Percentage of submerged or emergent vegetation cover in zone 10-23 cm deep.

Suitability Index (SI) Graphs for Model Variables

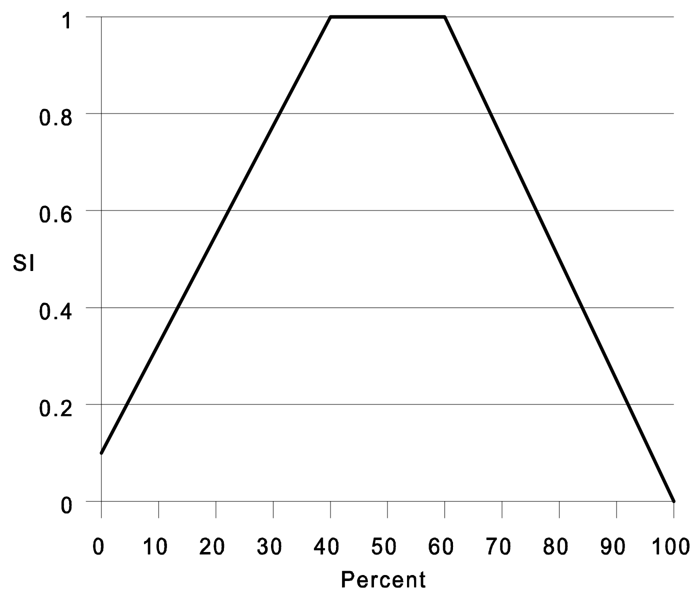
This section provides graphic representation of the relationship between habitat variables and habitat suitability for the great egret in wetland (see Table 2 for abbreviations) and upland (U) cover types. The SI values are read directly from the graph (1.0 = optimal suitability, 0.0 = no suitability) for each variable.

The SI graphs are based on the assumption that the suitability of a particular variable can be represented by a two-dimensional linear response surface. Although there may be interdependencies and correlations between many habitat variables, the model assumes that each variable operates independently over the range of other variables under consideration.

V_1 Percentage of study area with water 4-9 inches deep. In tidal areas, use depth at mean low tide. In nontidal areas, use average summer conditions.



V_2 Percentage of substrate in zone 4-9 inches deep covered by submerged or emergent vegetation.



Feeding HSI.

$$HSI = \frac{V_1 + V_2}{2}$$

Data representing three hypothetical study areas for great egret were used to calculate sample HSI values The HSI values obtained are believed to reflect the potential of the areas to support feeding or nesting great egrets.

Field Use of Models
The level of detail needed for application of these models will depend on time, money, and accuracy constraints. Detailed field sampling of all variables will provide the most reliable and replicable HSI values. Any or all variables can be estimated to reduce the amount of time or money required to apply the models. Increased use of the subjective estimates decreases reliability and replicability, and these estimates should be accompanied by appropriate documentation to insure that decision makers understand both the method of HSI determination and quality of data used in the model. Techniques for measuring habitat variables included in the great egret HSI models are suggested in Table 5.

A project area may contain both potential feeding and nesting habitat. To decrease the cost and time necessary to evaluate the area, assume that food is not limiting and apply only the nesting HSI model. This recommendation is based upon the following assumptions: (1) in most coastal areas of Texas and Louisiana, aquatic habitats suitable for feeding are abundant and are, therefore, less of a limiting factor to great egrets than are suitable nesting sites; and (2) nesting value is easier and more accurately estimated by using subjective methods than is food value. The variables used to measure food use of past colony sites, and (2) the enhancement of a site by the presence of other herons. These two factors are usually, but not always, interrelated. Great egrets tend to use the same colony site in successive years until the site is degraded, and the site may include great blue herons. When applying the HSI model , the user should be aware that an area known to be used by great egrets (or great blue herons) is more likely to be used in future years than an area with an equal HSI value not known to have a history as a colony site.

Table 5. Suggested measurement techniques for habitat variables used in the great egret HSI models.

Variable	Suggested technique
V_1	The percentage of the area with water 4-9 inches deep can be determined by line transect sampling of water depth.
V_2	The percentage of substrate in the 4-9 inches water depth zone covered by submerged or emergent vegetation can be determined from available cover maps, aerial photographs, or by line transect sampling.

HABITAT SUITABILITY INDEX MODEL

CALIFORNIA VOLE (*Microtus californicus*)

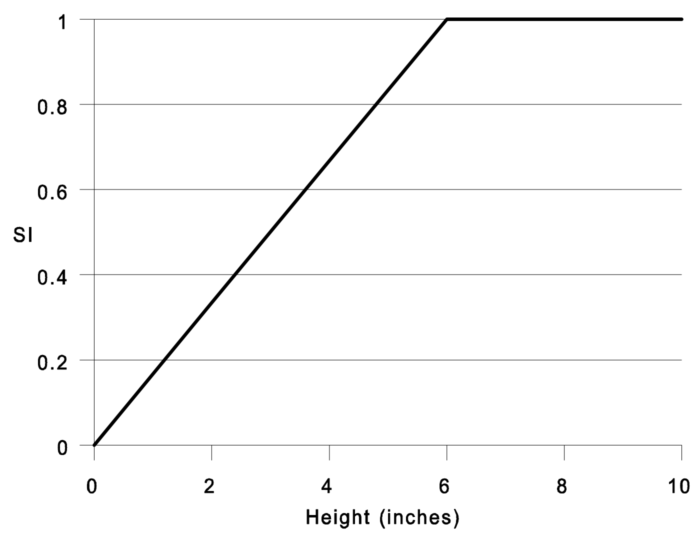
U.S. Fish and Wildlife Service
Division of Ecological Services
Sacramento, California

Cover-Type	Life Requisite	Habitat Variable
Annual Grassland Seasonal Wetland	Food/Cover Reproduction	Height of herbaceous vegetation (V1) Percent cover of herbaceous vegetation (V2) Soil Type (V3)
Riparian Woodland Oak Woodland	Reproduction Food/Cover	Height of herbaceous vegetation (V1) Percent cover herbaceous vegetation (V2) Soil Type (V3) Presence of logs and other types of cover (V4)

Variable	Cover-Type	Sampling Technique
V1 - Height of herbaceous	Annual Grassland Oak Woodland Riparian Woodland Seasonal Wetland	Average vegetation height in 1 m^2 quadrat
V2 - Percent cover of herbaceous vegetation	Annual Grassland Seasonal Wetland Oak Woodland Riparian Woodland	1 m^2 quadrat
V3 - Soil Type	Annual Grassland Seasonal Wetland Oak Woodland Riparian Woodland	Site inspection County Soil Survey
V4 - Presence of logs and other types of cover	Annual Grassland Seasonal Wetland Oak Woodland Riparian Woodland	Visual inspections Sample point

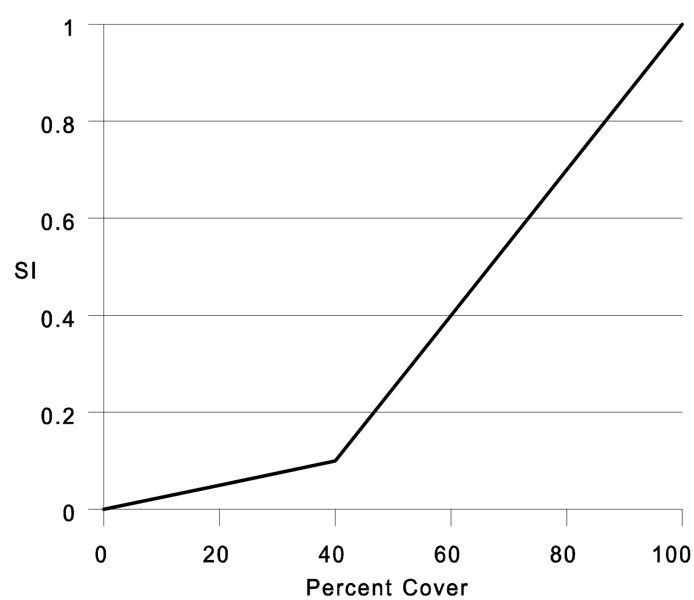
Variable 1: Height of herbaceous vegetation.

Assumes: California voles require relatively tall herbaceous vegetation for both food (Gill 1977. Batzil 1986) and cover (Ingles 1965). Herbaceous vegetation ≥ 6 in tall is considered optimum.



Variable 2: Percent cover of herbaceous vegetation.

Assumes: Relatively dense herbaceous vegetation is needed for cover percent cover ≥ 100 percent is considered optimum (CDFG undated).



Variable 3: Soil type

Assumes: Friable soils such as silts and loams are optimum because voles can dig their burrows (Ingles 1965). Soils such as sands and clays are not optimum.

Suitability Index (SI)

SI = 1.0 if soil type is silty or loamy and friable.

SI = 0.5 if soil type is not silty or loamy and is moderately friable

SI = 0.2 if soil type is not silty or loamy and is not friable.

Variable 4: Presence of logs and other cover types within the sample area.

Assumes: California voles will use logs, brush piles, and rocks for cover in addition to their burrows (California Department of Fish and Game). These sources of cover are more important in woodland habitats than grassland and wetland habitats.

SI = 1.0 logs, brush piles, and rocks are abundant and well distributed throughout the sample site (e.g., $\geq$ 4 per sample site).

SI = 0.7 if logs, brush piles, and rocks are moderate abundant and distributed throughout the sample site (e.g., 2-4 per sample site).

SI = 0.4 logs, brush piles, and rocks are absent or sparsely distributed throughout the sample site ($\leq$ 1 per sample site).

SI = 0.1 if logs, brush piles, matted vegetation, and/or rocks are absent From sample area.

HSI Determination

For annual grasslands and seasonal wetlands.

$$HSI = \frac{V_1 + V_2 + V_3}{3}$$

For oak woodlands and riparian woodlands:

$$HSI = \frac{V_1 + V_2 + V_3 + V_4}{4}$$

All variables are assumed to contribute equally to the availability of a given habitat type for the California vole. Water is assumed not be a limiting factor and is represented by the herbaceous vegetation variables.

Model Applicability

This model is a hypothesis of the relationships between various attributes of grassland, wetland, and oak riparian woodland habitats and the suitability of these habitats to California voles. The model is designed for use in the Central Valley of California up to 2,500 feet in elevation. California voles are permanent year-round residents, and this model can be applied to these habitats at all times of the year.

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HABITAT SUITABILITY INDEX MODEL
Plain Titmouse (*Parus inornatus*)

by
Michael Long and Daniel Strait
U.S. Fish and Wildlife Service
Division of Ecological Services
Sacramento, California

June 1989

Habitat Use Information

General
The plain titmouse inhabits oak and piñon-juniper woodlands from Oregon south and west to Texas. It is a year-round resident, and maintains a territory throughout the year. The species is generally a secondary cavity nester, although it may occasionally excavate its own hole.

Food
As a group, titmice take a wide variety of foods, but they are considered insectivorous during the summer, and consumers of fruit, seeds, and some insects in the winter (Ferrins 1979). Root (1967 - cited by Verner 1979), found that a large proportion of their food consisted of plant material and arthropods living on the bark of trees. Wagner (1981) found the plain titmouse took a great variety of arthropod taxa.

The titmouse is primarily a bark forager, although it also forages on tree foliage and occasionally on the ground (Hertz et. al. 1976). Most foraging by this species is done between 0-30 feet (0-9 m) of the ground (Wagner 1981; Hertz et. al. 1976). Hertz et al. found that plain titmice showed a preference for foraging in blue oaks (*Quercus douglasii*) over coast live oaks (*Q. agrifolia*). Hertz et. al. (1976) attributed the avoidance of live oaks to their smooth bark which is poor habitat for arthropods. Block and Morrison (1986) also found the titmouse to use blue oaks more than valley oaks (*Q. lobata*), black oak (*Q. kelloggii*), and canyon live oak (*Q. chrysolepis*) for foraging at Tejon Ranch, California. The plain titmouse will forage extensively in live oaks however, especially when other oak species are not present (Dixon 1964).

Reproduction
The plain titmouse is a secondary cavity nester, nesting in natural cavities, old woodpecker holes, or nest boxes. It prefers natural cavities over excavated cavities (Wilson, pers. comm.). Bent (1946) reported nests from 3-32 feet (1-10 m) above the ground. Bent, citing Dawson (1923), reported the titmouse to occasionally excavate its own nest cavity in blue oaks. The plain titmouse prefers wooded areas with intermediate to high percentage canopy coverage dominated by blue, live and valley oaks (Verner and Boss 1980).

Cover
Cover is provided by the oak woodlands and riparian areas in which the plain titmouse lives. Roost sites are provided by natural cavities, old woodpecker holes, or by dense foliage which simulates a cavity (Dixon 1949).

Interspersion
Plain titmice maintain year-round territories. Three territories observed by Hertz et. al. (1976) averaged 2.0 acres (0.8 ha) in California oak woodland. Dixon (1949) found 12 territories ranged located primarily in live oak woodland. These territories ranged in size from 3.3-12.5 acres (1.3-5.1 ha) with an average size of 6.3 acres (2.6 ha). According to Dixon (1956) 2.5 acres (1.0 ha) would probably be close to an absolute minimum size for a territory.

Water Requirements
In a study by Williams and Koenig (1980), the plain titmouse was classified as an occasional drinker.

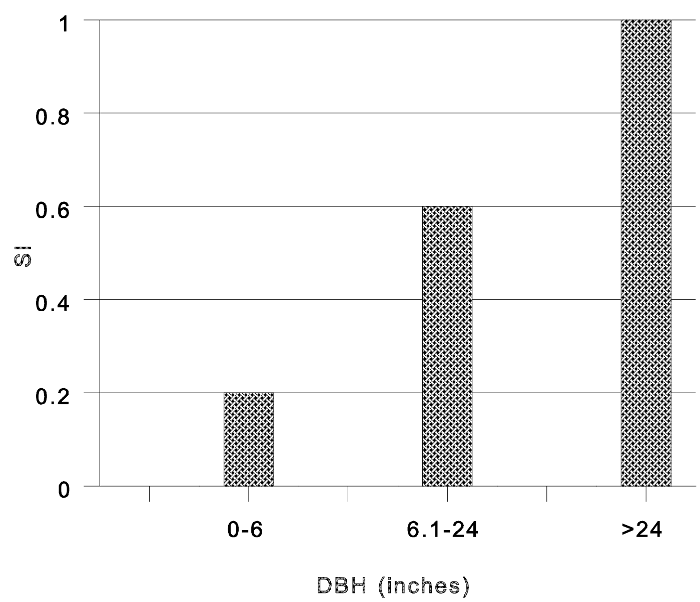
Model Applicability
This model was developed for use in evaluating habitat suitability of oak savannah, oak woodland, and riparian woodland in Merced, Fresno, Stanislaus, and San Benito Counties in California from 500 - 2,500 ft in elevation. The basic assumptions for using the model are that meeting the reproductive needs of the plain titmouse will take care of its cover and food needs throughout the year. This assumption seems warranted. Verner (1979) believes that proper management for oaks for breeding birds should also provide the habitat needs for species that use oaks at other times of the year. In addition, it is assumed that water is not a limiting factor. It is assumed that the model is valid for use in riparian areas as well as the oak woodlands despite the fact that the model was initially developed for oak woodlands.

Model Description

Little quantitative data were found on the habitat needs of the plain titmouse. The most useful information was the information on habitat factors related to breeding for the species presented by Ohmann and Mayer (1986). Using data from the California Wildlife Habitat Relationships data base and the Forest Inventory and Analysis Research Unit inventory, Ohmann and Mayer developed a habitat suitability index model for the plain titmouse from which Variable 1 was derived.

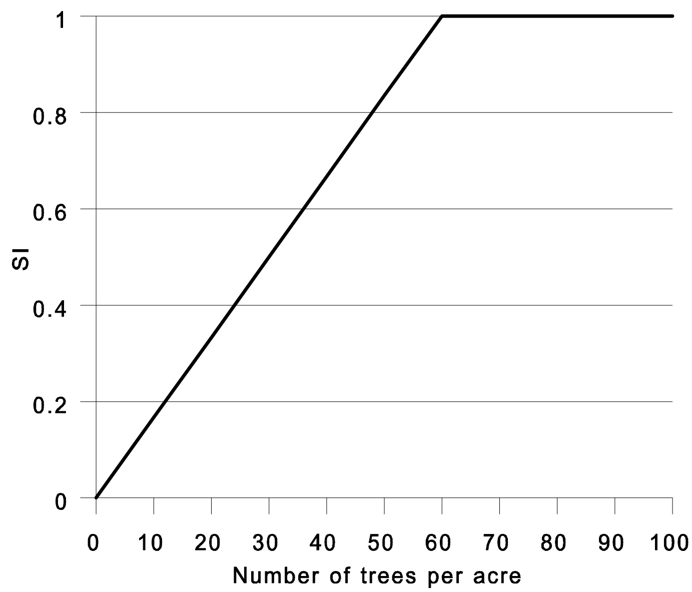
Variable 1. Tree diameter. (A tree is defined as a woody plant species 16 feet high or greater)

Ohmann and Mayer found tree size and percent canopy closure to be the major variables determining suitability of a habitat for the plain titmouse. Our model will assume that the diameter of a tree and the size of the canopy are correlated to the extent that they can be considered a single variable to be represented in this model by diameter at breast height (DBH). Presumably this variable best represents older trees with more cavities for nesting and greater bark surface which supports a greater prey base.



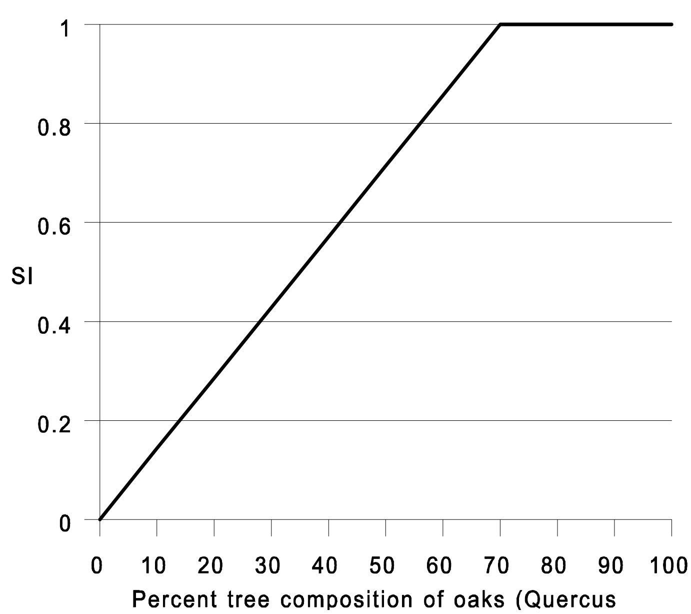
Variable 2. Trees per acre.

Plain titmouse abundance was found to increase as the number of trees increased (Wilson, pers. comm.). This may be particularly important in areas of low to moderate canopy cover. Studies at the Hopland, California field station found titmouse abundances to peak in areas with 60 trees/acre.



Both Variables 1 and 2 relate directly to the extent of a stand's canopy closure such that the importance placed on canopy closure by Ohmann and Mayer is incorporated into this model through the use of Variables 1 and 2.

Variable 3. Percent composition of tree species that are oaks (*Quercus*).
Verner and Boss (1980) stated that the plain titmouse prefers stands dominated by blue, live and valley oaks. We have been unable to find and studies documenting the presence of the plain titmouse in an area without a major proportion of oaks. For the sake of this model then, we will consider the presence of oaks to be a life requisite such that the optimum titmouse habitat is one dominated by oaks.



<u>HSI Determination</u>

In each sample area, tree diameter is measured along with the number of trees per acre and the percentage of those trees that are oaks. The Habitat Suitability Index for the sample site is then determined using the following formula:

$$HSI = \frac{V1 + V2 + V3}{3}$$

Suggestions for Applying the Model

1. The tree diameter classes for calculating Variable 1 (DBH) were not specified by Ohmann and Mayer. Therefore, all trees within the sample plot should be included in the DBH determination.

2. If no trees, 4-inch DBH or greater, are found in the sample plot, the HSI for the sample plot is 0.0. A 4-inch DBH tree is probably about the smallest tree that could have a cavity of sufficient size for the titmouse.

3. Ideally, all tree species in the study area should be fully leafed out when applying the model. Therefore, the best time for sampling is spring and summer.

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HABITAT SUITABILITY INDEX MODEL

BOBCAT (*Felis rufus*)

Pacific Gas and Electric Company

1986

Geographic Area: This HSI Model was developed for use on the west slope of the Sierra Nevada in Fresno County, California.

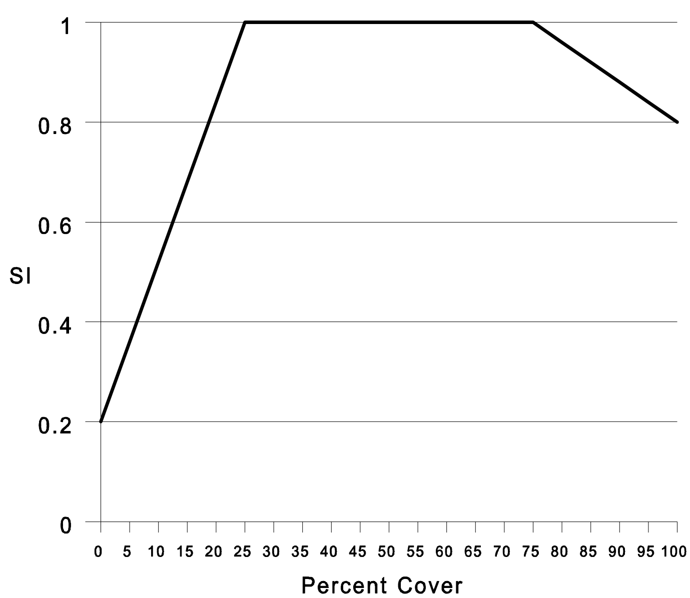
Season: This model was developed to evaluate year-round habitat suitability for the bobcat *(Felis rufus)*.

Cover Types: This model was designed to evaluate habitat suitability for the bobcat in the Chaparral cover type (terminology follows that of Verner and Boss 1980).

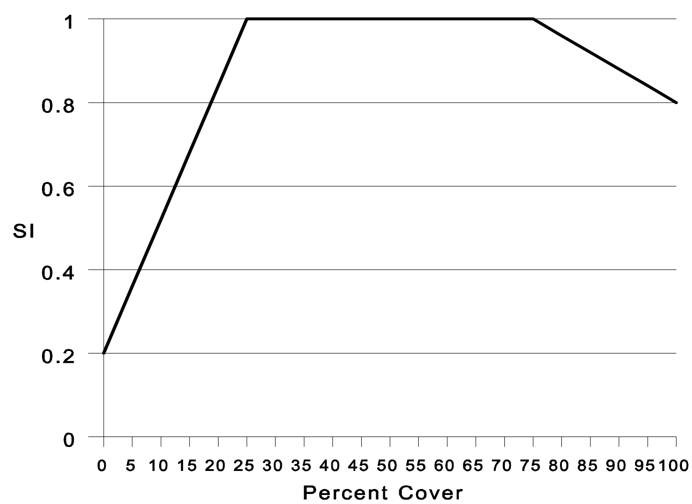
Guild:	Feeding	Breedinq
	Surface	Subsurface

Equation: $$HSI = \frac{(V_1 + V_2 + V_3 + V_4)}{5}$$

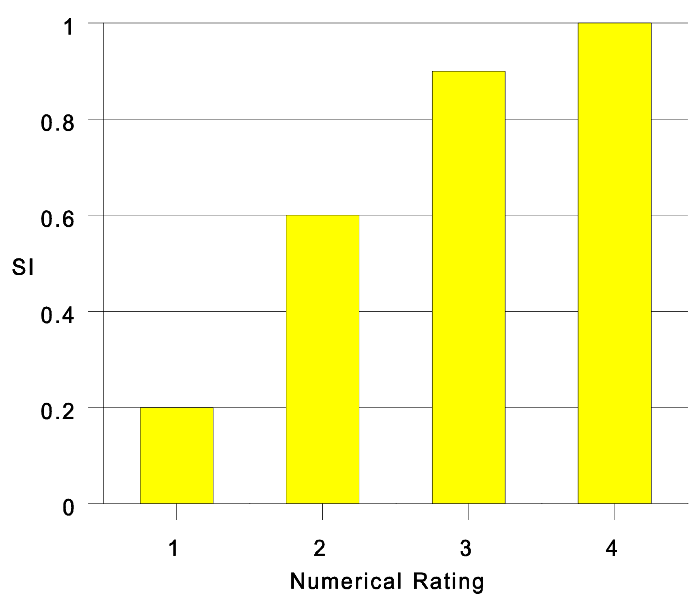
V1 - Percent Shrub Cover



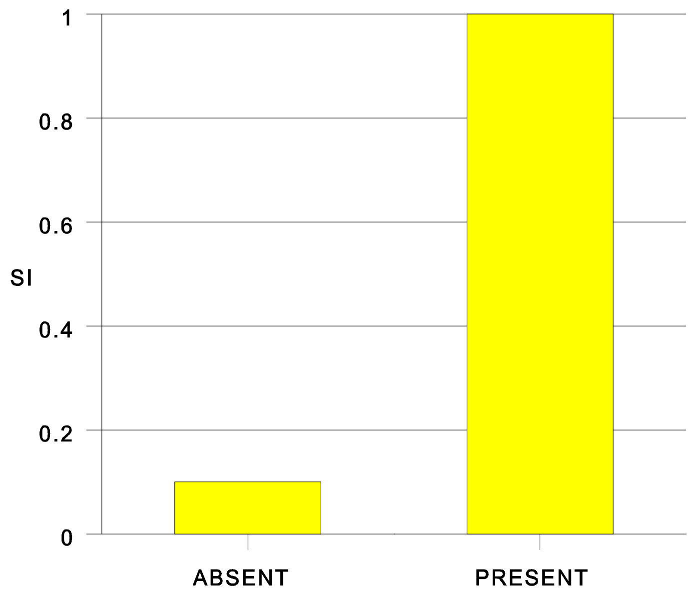
V2 - Herbaceous Cover



V3 - Degree of Patchiness



V4 - Rock Outcroppings



FISH AND WILDLIFE HABITAT CAPABILITY MODELS

AND

SPECIAL HABITAT CRITERIA

FOR THE NORTHEAST ZONE NATIONAL FORESTS

LASSEN NATIONAL FOREST
MENDOCINO NATIONAL FOREST
MODOC NATIONAL FOREST
PLUMAS NATIONAL FOREST

Karen Shimamoto and Daniel Airola (editors)

JANUARY 15, 1981

INTRODUCTION

by Hal Salwasser and Karen Shimamoto

Under National Forest Management Act (NFMA) planning regulations (36 CFR 219), fish and wildlife management indicator species are selected by each Forest for planning and management attention. These species will help guide land allocations and shape multiple-resource prescriptions in meeting legal requirements and local resource demand. To support this role each species must have a documented description of the habitat conditions needed to sustain it at different population levels. The minimum habitat conditions necessary for sustaining population viability are also required. The development of prescriptions to favor certain management indicator species also requires a description of habitat conditions associated with high population levels of each species. The descriptions of habitat conditions associated with different population levels are called <u>Habitat Capability Models (HCM)</u>.

NFMA regulations mandate that each Forest maintain habitat conditions to support wildlife and fish populations at or above the abundance and distribution needed for long-term population viability. However, neither managers nor scientists fully know what kinds, amounts, and distribution of habitats are necessary to maintain population viability. Therefore, existing knowledge of species ecology and habitat needs must serve to describe the habitat conditions needed. Models (standards and criteria) must be formulated to describe in quantitative and qualitative terms the habitat conditions by which to judge existing and projected habitat resources.

Most of the HCMs address the habitat conditions required by individual reproductive units within wildlife and fish populations. This is because land management projects usually affect small part of populations such as a breeding pair, a family unit, a small group of breeding pairs, or a small group of family units before whole population changes are noticed. Total population abundance and distribution on the Forest can be projected by aggregating and mapping those land areas that provide capable, available, and suitable habitat for reproductive units of populations.

The HCMs do not address some aspects of population viability. Minimum to optimum distances between reproductive units and population size are two important attributes of viability that must be addressed for relevant species outside the HCMs.

Special Habitat Criteria were first developed by biologists on the Stanislaus National Forest as an extension of the HCM concept (Hurley et al 1981). While HCMs describe habitat conditions for individual management indicator species, the information in the Special Habitat Criteria models describes conditions necessary to maintain or optimize populations of fish and wildlife species closely associated with special habitats (riparian, aspen, snags, etc.).

HABITAT CAPABILITY MODELS

The following format was used in the construction of each habitat capability model.

Model Applicability

Life Stage(s) - Identify the appropriate life stages covered by the model e.g. egg, larval, fry, juvenile, adult, all

Season(s) - Identify the appropriate season(s) e.g. fall, winter, spring, summer

Geographic Area - The model may apply to the species' entire range. However, if regional differences in habitat use and preference occur, separate models may be appropriate.

Intended Application - Most models will be formulated with Forest planning in mind. Some models, however, may be detailed enough to apply to project work. Provide a clear statement of the intended use.

Expected Reliability - The following hierarchy was used;

Level 1 - Model predicts existing carrying capacity density with acceptable variance, i.e. 10-20%

Level 2 - Model habitat capability ratings directly correlate with density estimates

Level 3 - Model habitat capability ratings directly correlate with ratings of the same sites by species authorities

iii

Level 4 – Model structure and outputs appear reasonable to species authorities

Level 5 – Model structure and outputs meet technical standards and appear reasonable to author(s), editor(s), and users.

Verification Status – The purpose of verification is to ensure that the model meets the expected reliability criteria and that it faithfully provides the intended outputs. Each step in verification depends on the expected reliability of the model. The following hierarchy was used:

1) Model is in draft.

2) Model reviewed by editor (the editor should check for conformance with model quality standards, sufficiency of documentation, and understandability).

3) Model reviewed by editor and users.

4) Model reviewed by species authority.

5) Model evaluated with sample data – apply the model with sample data sets which mimic various habitat conditions, e.g. high, medium, and low habitat capability. Evaluate model outputs as to how well they give a reasonable prediction of habitat conditions.

6) Model tested with field data - field data must be available to provide measurements of both habitat variables and indicators of habitat capability. The latter can range from ratings of habitat capability by species authorities to density estimates to actual densities. Statistical and sampling expertise is required to design and perform these tests.

Model variables were restricted to physical, chemical, or biological characteristics of habitats. Species population variables, such as birth rates and sex ratios, are not suitable due to high cost of measurement, difficulty of prediction, and dependency on other factors beyond habitat. The critical question answered was, "What environmental variable, when changed, will affect the capability of an area to support a management indicator species?"

Each of the identified habitat variables were combined with the others to produce a habitat capability model. Each variable has values with different implications for habitat capability. For example, the variable average tree canopy cover has a high habitat value for goshawks when it is between 40-60%. Each of the variables and its respective values were ranked according to habitat capability:

High: the values are related to the highest densities of the species; the values are preferred over other values;

Medium: the values are related to moderate densities of the species; the values are required for the long-term viability of the population or reproductive unit of the population;

low: the values are related to the lowest densities of the species; the values are denote marginal habitat capability for the species and would not be capable of supporting a viable population.

The variables were organized according to their importance in determining habitat capability and arrayed in rows under the headings high, medium, and low. An attempt was made to reduce redundant variables, retaining only those variables that are most practical to measure.

Documentation

As in model reliability and verification status, documentation for each model is in varying stages of completion. The levels of documentation are:

Level 1 - Literature references, written or personal communication, and the author's judgement are cited.

Level 2 - A narrative accompanies the model, summarizing why each variable was selected, how each variable is related to the species' habitat needs, and how habitat capability values were determined. This level also includes Level 1.

Level 3 - A narrative accompanies the model with documentation on the species ecology and habitat use. This information is related to the habitat variables in the model. It involves preparing a species note with the following information:

I. Distribution, Abundance, and Seasonality

II. Specific Habitat Requirements

A. Feeding
B. Cover
C. Water
D. Reproduction
E. Pattern

III. Species Life History

A. Activity Patterns
B. Seasonal Movements/Migration
C. Home Range/Territory
D. Reproduction
E. Niche

This level also includes Levels 1 and 2.

Level 4 - The habitat variables are aggregated to develop a mathematical formulation of the model (U.S. Fish and Wildlife Service 1980). Assumptions and limitations to be used when applying the model are provided and the necessary steps to correctly use the mathematical model is documented. The latter includes how to collect data on model variables, how to treat that data as model inputs, and how to interpret habitat capability based on the data. This level includes levels 1, 2, and 3.

Because many initial species models will be developed from scant data, modelers will rely on experiential evidence and intuition to establish the model variables and relationships. Such models will have level 1 or 2 documentation. As model application and verification improve, habitat relationships can be more accurately represented and the models made more quantitative. Models with level 3 or 4 documentation are examples of species where more information is known and the models have been "calibrated" with real data.

Vegetation Types and Successional Stages

The vegetation types and successional stages used in the habitat capability models are consistent with the California Wildlife Habitat Relationships Program for the Northeast Interior Zone (Laudenslayer in prep), the Western Sierra Zone (Verner and Boss 1980) and the North Coast-Cascades Zone (Marcot 1979). For convenience, the codes used for successional stages are defined in Table 1.

Rating Overall Habitat Capability

For any given area of land, habitat capability ratings (high, medium, low) will be different for each habitat variable. This makes rating the overall habitat capability difficult. Models for spotted owl and mule deer, have been developed to include a mathematical calculation of habitat capability where different ratings are quantitatively assessed and an overall capability index is mathematically calculated. The method for rating overall habitat capability for the other models, however, must be done using subjective biological judgement.

For such cases, the simplest approach is to assess the overall habitat capability rating in terms of a simple majority of variable ratings. For example, if three variables were rated as medium and one variable as high for bald eagle habitat, the overall rating could be considered medium.

In other situations, experience may justify identifying one or more variables as more important or possibly overriding other variables. Biologists should then weight these variables accordingly when determining overall habitat capability.

Table 1. Successional stage codes

Code	Definition
1	Barren/grass/forbs
2	Shrub/seedling/sapling; tree saplings <11" DBH
2a	<40% tree canopy closure
2b	40–70% tree canopy closure
2c	>70% tree canopy closure
3	Small sawtimber; 11–24" DBH
3a	<40% overstory canopy closure
3b	40–70% overstory canopy closure
3c	>70% overstory canopy closure
4	Medium to large sawtimber; >24" DBH
4a	<40% overstory canopy closure
4b	40–70% overstory canopy closure
4c	>70% overstory canopy closure
5	Two-storied stand; scattered overstory over a well-stocked understory (4a over 2c or 3c)

Literature Cited

Hurley, J. F., S. H. Robertson, S. R. Hrougher, and A. M. Palmer. 1981. Wildlife habitat capability models and habitat quality criteria for the Western Sierra Nevada. Stanislaus National Forest, 56p.

Laudenslayer, Jr, W. F. (in prep) California wildlife habitat relationships program: northeast interior zone, Vol. 1 – Species/habitat matrix. USDA Forest Service Region 5.

Marcot, B.G. (ed). 1979. California wildlife habitat relationships program: North Coast-Cascades Zone. USDA Forest Service, Six Rivers National Forest.

US Fish and Wildlife Service. 1980. Habitat Evaluation Process. 103 ESM.

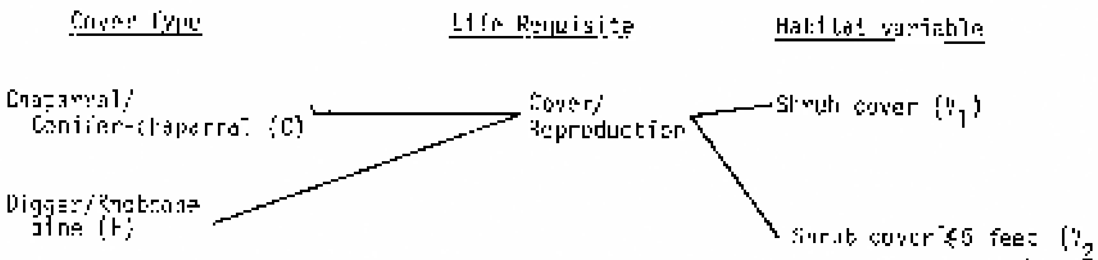
Verner, J. and A. A. Boss (Technical Coordinators). 1980. California wildlife and their habitats: western Sierra Nevada. USDA Forest Service. Gen. Tech. Rep., PSW-37, 439p.

DRAFT
HABITAT SUITABILITY INDEX MODEL
WRENTIT (*Chamaea fasciata*)

U.S. Fish and Wildlife Service
Division of Ecological Services
Sacramento, California

September 1984

VARIABLE		COVER TYPES	SUGGESTED TECHNIQUE
(V_1)	Shrub cover - % of ground shaded by a vertical projection of the shrub canopy	C,F	Line intercept
(V_2)	Shrub cover ≤5 feet	C,F	Belt transect, graduated rod


Cover Type
Life Requisite
Habitat variable
Chaparral/
Conifer-Chaparral (C)
Digger/Knobcone
pine (F)
Cover/
Reproduction
Shrub cover (V_1)
Shrub cover ≤5 feet (V_2)

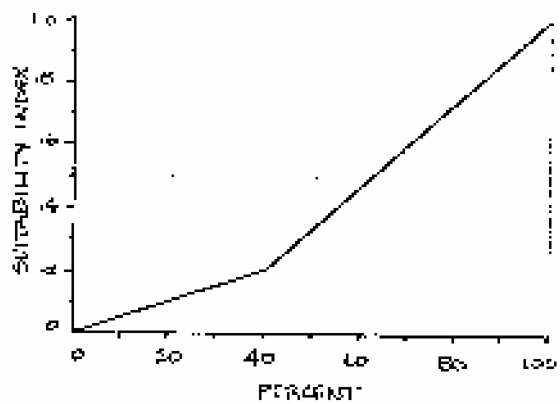
3

Variable 1. Shrub cover - % of ground shaded by a vertical projection of the shrub canopy

Assumes: 1) Dense stands of chaparral needed for optimum conditions.

2) Sample size should include an area of at least 2.0 acres

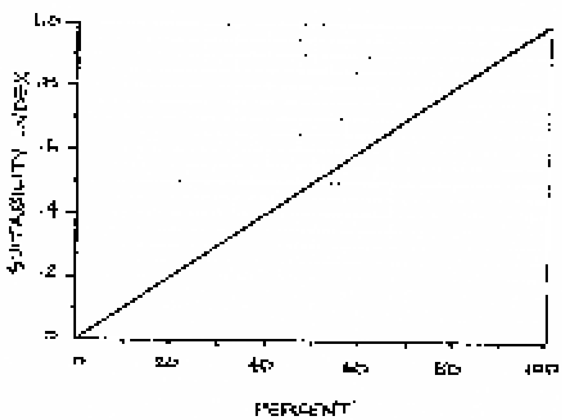
3) 40 percent canopy provides marginal quality and that 100 percent is optimum



Variable 2. Shrub cover <5 feet

Assumes: 1) Most nests are located within 1-4 feet from the ground.

2) Some additional height is needed for overhead protection.



4

Equation Used to Calculate Suitability Indices

Cover/Reproduction: $V_1 \times V_2$

HSI determination

Cover/reproduction was the only life requisite considered in this model, and the HSI for the wrentit is equal to the life requisite value for cover/reproduction.

5

General Assumptions

Overview

This model uses the reproductive habitat needs of the wrentit to determine overall habitat quality. It is assumed that cover needs are met by reproductive habitat needs and that neither food nor water will be more limiting than the wrentit's cover/reproductive needs. All of the life requirements of the wrentit can be provided in chaparral and other dense brush.

Cover/ reproduction component

Optimal nesting habitat for the wrentit is provided in moderately tall, dense stand of chaparral (Bent 1958, Small 1974). Dense stands of chaparral provides maximum protection for feeding and nesting. As such, it is assumed that optimal habitat contains 100 percent or greater of shrub crown canopy. Studies indicate that most of the nesting occurs between 1 and 4 feet off the ground and only occasionally have nests been found up to 7 feet from the ground (Bent 1969). Most of the wrentit's existence is spent beneath the crown foliage of brush not more than 5 feet from the ground (Bent 1969). Studies indicate that most of the life requisites of the wrentit are provided within an area ranging in size from 0.2 to 1.2 ha (0.5 to 3.0 acres) (Cogswell 1962, Bent 1958, Erickson 1938).

Literature Cited

Bent, A.C. 1948. Life histories of North American nuthatches, wrens, thrashers, and their allies. U.S. Natl. Mus. Bull. 195. 475 pp.

Cogswell, H.L. 1962. Territory size in three species of chaparral birds in relation to vegetation density and structure. PhD. Thesis, Univ. California, Berkeley. 567 pp.

Erickson, M.M. 1938. Territory, annual cycle, and numbers in a population of wrentits (*Chamaea fasciata*). Univ. California Publ. Zool. 42: 247-334

Harrison, H.H. 1979. A field guide to western birds nests. Houghton Mifflin Co. Boston.

Small, A. 1974. The Birds of California. Collier Macmillan Pub. Co., New York

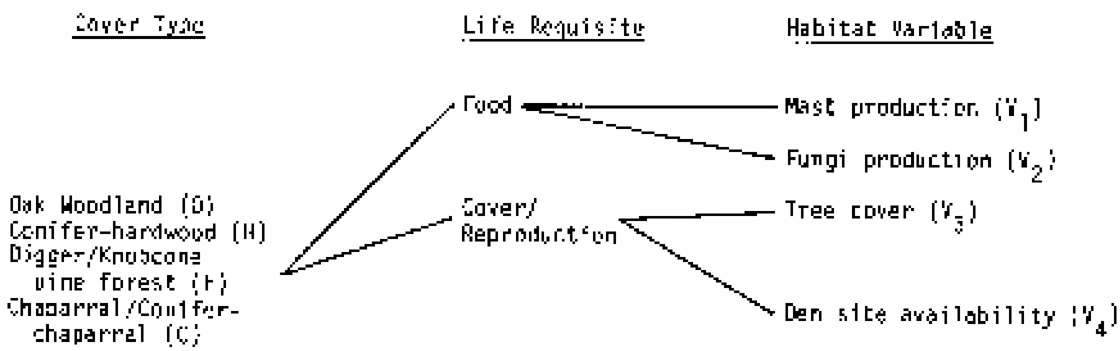
Williams, P.L., and W.D. Koenig. 1980. Water dependence of birds in a temperate oak woodland. Auk 97: 339-350.

DRAFT HABITAT SUITABILITY INDEX MODEL
WESTERN GRAY SQUIRREL (*Sciurus griseus*)

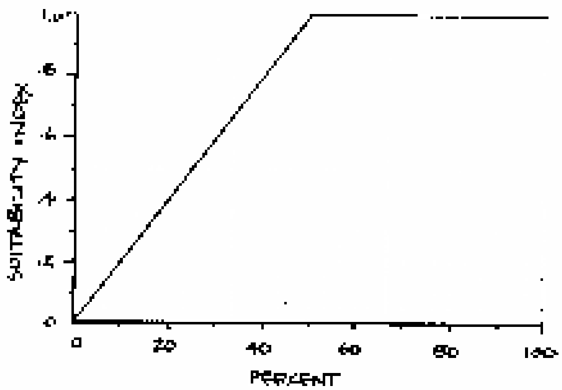
U.S. Fish and Wildlife Service
Division of Ecological Services
Sacramento, CA

September 1984

VARIABLE	COVER TYPES	SUGGESTED TECHNIQUE
(V_1) Mast production - % canopy closure of trees > 5 m (16.5 ft) tall and shrubs that produce hard mast	O,H,F,C	Line intercept
(V_2) Fungi production - estimate of density of leaf litter layer	O,H,F,C	Ocular estimate along line intercept
(V_3) Tree cover - % of ground surface shaded canopies of all woody vegetation > 5 m (16.5 ft) in height	O,H,F,C	Line intercept
(V_4) Den site availability - number of trees per acre with dbh ≥38.1 cm (15 in).	O,H,F,C	Belt transect, diameter tape



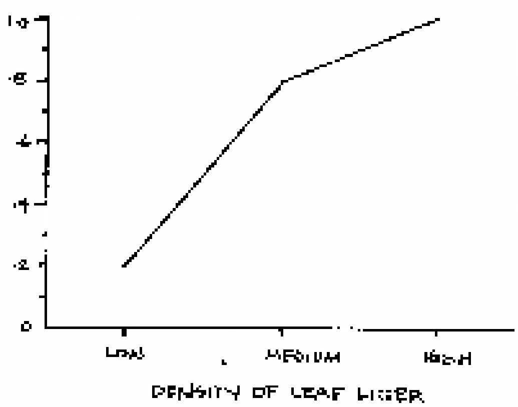
Variable 1. Hard mast production = % canopy closure of trees ≥ 5 m (16.5 ft) tall and shrubs that produce hard mast (e.g. oaks and conifers).



Assumes: 1) Optimum density of hard mast trees is between 40 - 100% canopy closure (derived from Shimamoto and Airola, 1981).

2) Trees ≤ 5 m (16.5 ft) tall will not produce significant mast (Allen, 1982).

Variable 2. Fungi production = an estimate of the density of the leaf litter layer.



Assumes: 1) Hypogeous fungi is a major component of the western gray squirrel diet (Stienecker, 1977).

2) Fungi is related to the amount of organic material (represented by leaf litter) in the uppermost soil layers (SCS, 1980).

Density of Leaf Litter (from SCS, 1980):

High - leaf litter is abundant with thick identifiable layers of leaves over mulch.

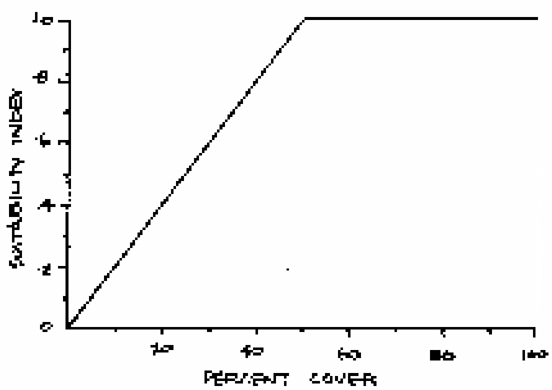
Medium - leaf litter is moderately abundant with low to moderate separation of leaf-mulch layers.

Low - leaf litter scarce with very thin leaf - mulch layer; little or no separation.

4

Squirrel

Variable 3. Tree cover - % of ground surface shaded by vertical projection of canopies of all woody vegetation ≥ 5 m (16 ft.) tall



Assumes: 1) Optimum conditions occur when tree cover ranges from 40 to 100% (derived from Shimamoto and Airola, 1981).

Variable 4. Den site availability - number of trees per acre with dbh ≥ 38.1 cm (15 in)

Assumes: 1) Western gray squirrels most often utilize oak, cottonwoods, maples, conifers, and sycamores for den sites (Ingles, 1947).

2) Optimum den sites are provided by trees having an average dbh of 15 inches (Shimamoto and Airola, 1981).

5

Squirrel

Equations Used to Calculate Suitability Indices

a) Food:

Cover Type	Equation
O,H,F,C	$(V_1 \times V_2)^{1/2}$

b) Cover/Reproduction:

Cover Type	Equation
O,H,F,C	$(V_3 \times V_4)^{1/2}$

HSI Determination:

1) The minimum habitat area equals the mean minimum home range. If habitat area is less than one acre, the HSI value equals zero. (Ingles, 1947).

2) The HSI for the western gray squirrel will equal the lowest of the values for the food and cover/reproduction component.

Literature Cited

Allen, A.W. 1982. Habitat Suitability index models. Gray squirrel. FWS/OBS (WELUT) - 82/10.19. 11 pp.

Ingles, L.G. 1947. Ecology and life history of the California gray squirrel. Calif. Fish and Game 33(3):139-158.

Shimamoto, K. and D. Airola. 1981. Fish and wildlife habitat capability models and special habitat criteria for the northeast zone national forests. U.S. Forest Service publ. 250 pp.

Soil Conservation Service. 1980. Draft habitat suitability index model - western gray squirrel - Ecoregion 2610 - Central Valley. 15 pp.

Steinecker, W.E. 1977. Supplemental data on the food habits of the western gray squirrel. Calif. Fish and Game 56(1):36-48.

Appendix B

Federal Endangered and Threatened Species that Occur in or may be Affected by Projects in Placer, Sacramento, and El Dorado Counties

Document Number: 060915114416; Database Last Updated: September 15, 2006

Red-Legged Frog Critical Habitat - The Service has designated final critical habitat for the California red-legged frog. The designation became final on May 15, 2006.

County Lists

Listed Species
Invertebrates
Branchinecta conservatio
Conservancy fairy shrimp (E)

Branchinecta lynchi
Critical habitat, vernal pool fairy shrimp (X)
vernal pool fairy shrimp (T)

Desmocerus californicus dimorphus
Critical habitat, valley elderberry longhorn beetle (X)
valley elderberry longhorn beetle (T)

Elaphrus viridis
delta green ground beetle (T)

Lepidurus packardi
Critical habitat, vernal pool tadpole shrimp (X)
vernal pool tadpole shrimp (E)

Fish
Hypomesus transpacificus
Critical habitat, delta smelt (X)
delta smelt (T)

Oncorhynchus (=Salmo) *clarki henshawi*
Lahontan cutthroat trout (T)

Oncorhynchus mykiss
Central Valley steelhead (T) (NMFS)
Critical habitat, Central Valley steelhead (X) (NMFS)

Oncorhynchus tshawytscha
Central Valley spring-run Chinook salmon (T) (NMFS)
Critical Habitat, Central Valley spring-run Chinook (X) (NMFS)
Critical habitat, winter-run Chinook salmon (X) (NMFS)
winter-run Chinook salmon, Sacramento River (E) (NMFS)

Amphibians
Ambystoma californiense
California tiger salamander, central population (T)
Critical habitat, CA tiger salamander, central population (X)

Rana aurora draytonii
California red-legged frog (T)
Critical habitat, California red-legged frog (X)

Reptiles
Thamnophis gigas
giant garter snake (T)

Birds
Haliaeetus leucocephalus
bald eagle (T)

Plants
Calystegia stebbinsii
Stebbins's morning-glory (E)

Castilleja campestris ssp. succulenta
Critical habitat, succulent (=fleshy) owl's-clover (X)

Ceanothus roderickii
Pine Hill ceanothus (E)

Fremontodendron californicum ssp. decumbens
Pine Hill flannelbush (E)

Galium californicum ssp. sierrae
El Dorado bedstraw (E)

Oenothera deltoides ssp. howellii
Antioch Dunes evening-primrose (E)

Orcuttia tenuis
Critical habitat, slender Orcutt grass (X)
slender Orcutt grass (T)

Orcuttia viscida
Critical habitat, Sacramento Orcutt grass (X)
Sacramento Orcutt grass (E)

Senecio layneae
Layne's butterweed (=ragwort) (T)

Candidate Species
Fish
Oncorhynchus tshawytscha
Central Valley fall/late fall-run Chinook salmon (C) (NMFS)
Critical habitat, Central Valley fall/late fall-run Chinook (C) (NMFS)

Amphibians
Bufo canorus
Yosemite toad (C)

Rana muscosa
mountain yellow-legged frog (C)

Birds
Coccyzus americanus occidentalis
Western yellow-billed cuckoo (C)

Mammals
Martes pennanti
fisher (C)

Plants
Rorippa subumbellata
Tahoe yellow-cress (C)

Key:

- (E) Endangered - Listed as being in danger of extinction.
- (T) Threatened - Listed as likely to become endangered within the foreseeable future.
- (P) Proposed - Officially proposed in the Federal Register for listing as endangered or threatened.
- (NMFS) Species under the Jurisdiction of the National Oceanic & Atmospheric Administration Fisheries Service. Consult with them directly about these species.
- Critical Habitat - Area essential to the conservation of a species.
- (PX) Proposed Critical Habitat - The species is already listed. Critical habitat is being proposed for it.
- (C) Candidate - Candidate to become a proposed species.
- (V) Vacated by a court order. Not currently in effect. Being reviewed by the Service.
- (X) Critical Habitat designated for this species

Species of Concern - The Sacramento Fish & Wildlife Office no longer maintains a list of species of concern. However, various other agencies and organizations maintain lists of at-risk species. These lists provide essential information for land management planning and conservation efforts. See www.fws.gov/sacramento/es/spp_concern.htm for more information and links to these sensitive species lists.

Appendix C

Summary Table of Impacted Acres by Cover-Type

Impacted Acres by Cover-Type for the Various Components of the Folsom DS/FDR Project

Auxiliary Spillway

	6-gate Spillway	4-gate Spillway	Tunnel	Fuseplug
Chaparral	0.21	0.21	0.21	0.21
Oak/Grey Pine Woodland	1.07	1.77	1.46	1.46
Riparian Woodland	1.66	1.51	1.04	1.38

Flood Damage Reduction

	Dikes 1-3 Raise (COE)	Inundation 3.5-foot Raise	Inundation 4-foot Raise	Inundation 7-foot Raise	Inundation 17-foot Raise
Chaparral		**32.20**	34.30	40.80	34.30
Oak/Grey Pine Woodland	8.46	781.50	820.20	935.10	1331.80
Riparian Woodland	0.02	45.47	48.68	56.50	48.68
Seasonal Wetland	0.00	0.58	0.58	0.58	0.58

Dam Safety

	Contractor and Construction Sites	Haul Roads	Borrow and Stockpile	Dike Construction Zones (BOR)
Chaparral	0.47			0.26
Oak/Grey Pine Woodland	11.06	11.06	6.47	16.04
Riparian Woodland	2.44	2.44	27.00	1.93
Seasonal Wetland	0.89			0.28

Appendix D

Fish and Wildlife Coordination Act Report for the American River Watershed Investigation Folsom Dam Outlet Modification Project

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

IN REPLY REFER TO:
HC-COE

June 12, 2001

District Engineer
Corps of Engineers, Sacramento District
ATTN: Chief, Planning Division
1325 J Street
Sacramento, California 95814-2922

Subject: Transmittal of final Fish and Wildlife Coordination Act Report - American River Watershed Investigation, Folsom Dam Outlet Modification Project

Dear Colonel Walsh:

Please find enclosed our Fish and Wildlife Coordination Act (FWCA) report for the proposed Folsom Dam outlet modification project. We previously issued a revised draft FWCA report to evaluate additional elements to allow surcharge up to 474 feet above mean sea level, and an operation to restrict use of the enlarged outlets to 30,000 cubic feet per second (cfs) when inflows are less than 100,000 cfs. Consistent with our recommendation in the revised draft report, the Corps of Engineers has now adopted a modified rule restriction limiting outflows to 60% of inflows when inflows are greater than 25,000 cfs, with maximum releases made when inflows exceed 150,000 cfs. The enclosed report reflects this change, and other information in the recently-published draft Environmental Assessment.

We have informally coordinated with the California Department of Fish and Game and National Marine Fisheries Service (NMFS), and received concurrence from NMFS on the initial draft FWCA report. No other comments were received.

If you have any questions, please contact Dr. Steven Schoenberg of my staff at (916) 414-6564.

Sincerely,

Dale A. Pierce

Dale A. Pierce
Acting Field Supervisor

Enclosure

cc: AES, Portland, OR
COE, Sacramento District, CA (Attn: Patricia Roberson)
NMFS, Santa Rosa, CA (Attn: James Bybee)
NMFS, Sacramento, CA (Attn: Bruce Oppenheim)
CDFG, Director, Sacramento, CA
CDFG, Region II, Rancho Cordova, CA
SAFCA, Sacramento, CA
USBR, Sacramento, CA
USBR, Folsom, CA (Attn: Rod Hall)

UNITED STATES DEPARTMENT OF THE INTERIOR

FISH AND WILDLIFE SERVICE

FISH AND WILDLIFE COORDINATION ACT REPORT

FOR THE

AMERICAN RIVER WATERSHED INVESTIGATION FOLSOM DAM OUTLET MODIFICATION PROJECT, CALIFORNIA

prepared by

Dr. Steven A. Schoenberg
U.S. FISH AND WILDLIFE SERVICE
HABITAT CONSERVATION DIVISION
SACRAMENTO FISH AND WILDLIFE OFFICE
SACRAMENTO, CALIFORNIA

prepared for

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

May 2001

SUMMARY

Since construction of Folsom Dam, the lower American River has been subject to progressive grade and gravel loss, affecting the quality of riparian and riverine habitat. Enlargement of the existing outlets has been proposed by the Corps of Engineers (Corps) to increase the level of flood protection by enabling operators to balance outflows with inflows early in the storm hydrograph, and attain a maximum discharge of 115,000 cubic feet per second (cfs) through the enlarged outlets for the 10-year or larger event. This may have some adverse effect on chinook salmon and steelhead through loss of spawning gravels, destruction of redds and associated mortality of eggs or fry, and loss of stream edge riparian habitat. To minimize these impacts, the Corps has proposed to restrict the operation of the enlarged outlets for actual or forecast inflows below 150,000 cfs; in the 25,000-150,000 cfs inflow range, outflows would be limited to 60% of actual or forecast inflow. Relative to existing conditions, this "60% rule" increases the chance of outflows >50,000 cfs (from every 5 years to every 3.6 years), but does not alter the frequency of 115,000 cfs flows. An alternative rule restriction was also studied which would limit outflows to a fixed maximum of 30,000 cfs when inflows are less than 100,000 cfs. This "30,000 cfs rule" would increase the frequency of 115,000 cfs discharges (from every 10 years to every 6 years). In either case, the potential for higher outflows results from the infrequent combination of low creditable storage space in upstream reservoirs and moderate flood events. Other potential changes would involve a slight increase in ramping rates, and a slight reduction in cold water reserves during some spring operations.

The 30,000 cfs rule would likely reduce damage to gravels and redds, but would do so at the expense of possible benefits of variable intermediate range flows (30,000-100,000 cfs) -- seed distribution and support of riparian recruitment on high terraces, gravel replacement from bank deposits, replacement and transport of woody debris and detritus from the floodway to the river, and other functions. If one presumes that intermediate range benefits are related to the frequency distribution of peak outflows, the rule restriction setting outflow to 60% of inflow would overlap the historical operation, and presumably retain any such benefits. The 60% rule also does not alter the frequency of capacity (115,000 cfs) releases. For these reasons, the Fish and Wildlife Service concurs with adoption of the 60% rule.

Other proposed modifications associated with the project would allow surcharge to 474 feet above mean sea level (msl). In combination with the enlarged outlets, this would increase the period of inundation in the surcharge zone (470-474 feet msl) during rare large floods (181-200 year event), but eliminate this inundation during more frequent events (100-175 year event). Such exposure, with or without the project, may result in some loss of vegetation due to wave action or collapse of waterlogged soil. With surcharge, inundation would be less frequent, but of a longer duration. The cumulative inundation period in the surcharge zone would be about 23 hours per century with the project, compared to 9 hours per century without the project.

Based on the limited information available, any impacts associated with the proposed project are expected to be of a moderate and infrequent nature that could be adaptively managed. We recommend a sediment engineering model study be performed and analysis of recent grade and bank erosion surveys be completed to specifically evaluate the impacts that the enlarged outlets

could have on future river bank and gravel bed stability. We also recommend a long-term monitoring program for stream edge erosion, vegetation in the floodway and surcharge area, and spawning gravels be implemented and contingency mitigation actions be agreed to that would ensure no net loss in the quality or quantity of habitat over the life of the project. Such actions may include proactive measures such as biotechnical bank stabilization in areas at special risk and spawning gravel enhancement, as well as reactive measures such as modifying the operations of the outlets during impact-prone scenarios without compromising the flood control purpose of the project. Finally we recommend that, under certain spring conditions, use of the spillway in lieu of the enlarged outlets be evaluated as a measure to limit loss of coldwater reserves.

TABLE OF CONTENTS

SUMMARY i

INTRODUCTION 1

BACKGROUND 1

PROPOSED PROJECT 2

FISHERY RESOURCES 3
LOWER AMERICAN RIVER 3
FOLSOM RESERVOIR 5

VEGETATION 5
LOWER AMERICAN RIVER 5
FOLSOM RESERVOIR 6

WILDLIFE 6
LOWER AMERICAN RIVER 6
FOLSOM RESERVOIR 6

BASIS FOR IMPACT ANALYSIS 7

FUTURE WITHOUT THE PROJECT 18

FUTURE WITH THE PROJECT 18
LOWER AMERICAN RIVER 18
FISHERIES - IMPACTS 18
WILDLIFE - IMPACTS 23
ENDANGERED SPECIES - IMPACTS 23
FOLSOM RESERVOIR 25

DISCUSSION 26

CONCLUSION AND RECOMMENDATIONS 28

REFERENCES 30

Personal Communications 32

LIST OF TABLES

Table 1 Surcharge zone inundation under existing and project conditions 26

LIST OF FIGURES

Fig. 1. Plot of peak inflow versus outflow for Folsom Reservoir 8
Fig. 2. Plot of peak inflow and outflow for potential project operations 9
Fig. 3. Flood routing for the 5- and 10-year flood, 30,000 cfs restriction rule. 11
Fig. 4. Flood routing for the 5- and 10-year flood; 60% inflow restriction rule. 12
Fig. 5. Flood routing for 50-year flood 13
Fig. 6. Flood routing for 100-year flood 14

LIST OF APPENDICES

Appendix 1. NMFS letter of concurrence 33
Appendix 2. NMFS and USFWS Biological Opinions 34

INTRODUCTION

This is the Fish and Wildlife Service's (Service) Fish and Wildlife Coordination Act (FWCA) report for the Corps of Engineers' (Corps) proposed Folsom Dam Modification Project as part of the American River Watershed Investigation, California. Previously, we issued a revised draft FWCA report in January 2001 to evaluate two basic changes: (a) enlargement of the lower dam outlets so as to increase their maximum discharge from 32,000 to 115,000 cubic feet per second (cfs), and (b) various structures to allow surcharge up to 474 feet above mean sea level (msl). Operational changes assumed were: a) a rule restriction that would restrict outflows to a maximum of 30,000 cfs when actual or forecast inflow is less than 100,000 cfs, and b) the emergency spillway release diagram would be revised to sustain a 160,000 cfs release up to 474 feet, rather than the current 470 feet. We also considered additional information on the frequency of inundation of upland habitat due to surcharge, and a previous rule restriction involving a fixed 30,000 cfs release. The National Marine Fisheries Service (NMFS) concurred with the findings of our draft report (Appendix 1); no other comments were received.

Through additional study and coordination with the Service, the Corps has replaced the 30,000 cfs rule restriction with a modified rule restriction that would limit outflows in the 25,000-150,000 cfs range to 60% of the actual or forecast inflow. Very recently developed information includes a draft two-dimensional model on spawning bed movement, and an analysis of the effects of outlet operation on coldwater reserves (Ayres 2001, Corps 2001). This final report incorporates the modified rule restriction as the Corps' preferred plan and this additional recent information, and supersedes our previous report.

BACKGROUND

The lower American River flows about 23 miles from Nimbus Dam to the Sacramento River, primarily through properties developed for residential, light industrial, and urban use. Since completion of Folsom Dam in 1955, several recent storms have led the Corps to revise the probability of flooding due to levee failure along the American River from the original 250-year recurrence to a chance of about 1-in-70 years. In response, the Sacramento Area Flood Control Agency (SAFCA) and U.S. Bureau of Reclamation (USBR) negotiated an interim agreement in 1994 to reoperate Folsom Dam in a way which would limit the likelihood of levee failure and flooding to about 1-in-100 years. This agreement involves increasing the amount of flood control space from the original fixed 400,000 acre-feet (ac-ft) ("fixed 400 TAF") to a variable amount between 400,000 and 670,000 ac-ft based on the availability of flood control space in upstream reservoirs ("variable 400/670 TAF"). As part of this agreement, SAFCA must reimburse USBR for the forgone hydropower and water deliveries as a result of reduced storage.

With the revised flood threat conditions, the capacity of the dam outlets has limited the ability to balance flood control and water storage purposes. Originally, the fixed 400 TAF flood control space meant that inflows exceeding the outlet capacity (32,000 cfs) could be discharged through the spillway up to the safe channel capacity of 115,000 cfs. However, with the enlarged flood control space, these discharges can only be made from the outlets. If inflows exceed 32,000 cfs, the reservoir must be allowed to fill up to the spillway before a higher rate of discharge can occur. This reduces the time during which the maximum channel capacity can be used, leading to greater peak discharges and a reduced level of flood protection. Under certain situations, such as in 1997, the upstream reservoirs can fill and require that Folsom Lake be evacuated, but the remainder of the year may be drier so that storage that is carried over into the irrigation season is reduced.

A number of alternatives have been proposed and evaluated in the past, involving an array of structural and operational changes. In 1996, we evaluated options to construct a dry detention dam on the North Fork American River near Auburn, a Folsom stepped release plan which included various dam, levee, and floodway elements, and a Folsom modification plan, which involved structural changes of the dam and levees (USFWS 1996). In 1994, we evaluated other options, involving increased storage at either Folsom Reservoir or a new facility on Deer Creek (USFWS 1994a, b). In each case, the structural modifications were linked to operational changes at the existing facility at Folsom Dam.

In this report, we evaluate impacts of a revised Folsom Modification Plan under the existing 400/670 TAF interim operation agreement associated with: (a) structural modification of the existing outlets to allow higher discharges, (b) modification of the emergency spillway, dikes, and Mormon Island dam to allow surcharge up to 474 feet msl; and (c) two possible restriction rules. Other related actions, referred to as "common features", are being considered in a separate FWCA report.

PROPOSED PROJECT

The existing 8 outlets (two tiers at 205.5 and 275.5 feet msl) would be enlarged from the current 5 feet wide by 9 feet high to about 8-10 feet wide and 12-15 feet high. This construction is anticipated to last 5-6 years, and would be staged so that the existing release capacity would not be reduced during the construction period. The nature of the construction would involve precisely-controlled explosives and a seal on the upstream face of the dam so as to allow construction almost entirely in the dry. Staging would occur on barren or previously disturbed upland areas near the site. After completion, the total discharge capacity of the enlarged outlets together with the powerhouse outlets would be around 115,000 cfs at an elevation of 418 feet msl. Although operational criteria at lower inflows may vary, outflow must be 115,000 cfs when inflow is 150,000 cfs (10-year event) or more in order to achieve the desired level of flood protection.

For the purpose of this report, we considered two possible restriction rules for flows less than the 10-year event. In one case, outflow would not exceed 30,000 cfs until the projected or actual inflow equals 100,000 cfs, at which time outflow would be increased to 115,000 cfs ("30,000 cfs rule"). In the other case, outflow in excess of 25,000 cfs would be calculated as 60% of inflows until projected or actual inflows equals 150,000 cfs, at which time outflow would be increased to 115,000 cfs ("60% rule").

The surcharge space would be increased by 48,000 acre-feet by. (a) replacing three emergency spillway gates with Tainter gates, (b) raising the impervious core in Mormon Island dam, and Dikes 5 and 7, with slurry-wall construction, (c) raising penstock gate hoists and their hydraulic pumps, and (d) floodproofing Newcastle powerhouse. This would allow the emergency spillway release diagram to be modified, so that maximum releases of 160,000 cfs (i.e., the probable non-failure point of existing levees) could be maintained before the reservoir reaches 474 feet msl. If reservoir level is above 474 feet msl, dam outflow would be matched to inflow.

FISHERY RESOURCES

LOWER AMERICAN RIVER

There are four important recreational species in the affected study area. fall-run chinook salmon, rainbow trout (including steelhead), American shad, and striped bass. Chinook salmon are an anadromous species which enter the river in early summer, with peak abundance typically in mid-October. Although the escapement fluctuates between 10,000 and 90,000 adult fish, recent years have been particularly strong and consistent, with at least 50,000 adults returning to the river since 1995. A hatchery near the base of Nimbus Dam, which re-regulates flows from Folsom Dam, supplements the escapement by about 10,000 adults annually. The American River is one of the most important producers of fall-run chinook salmon in California, similar in magnitude to runs on the Feather River and to the hatchery on Battle Creek. On the lower American River, chinook salmon spawn almost exclusively in the upper 10 miles below Nimbus Dam, and mostly in the upper 5 miles, but recreational fishing effort spans the full river to the mouth at the peak of the run. Spawning activity peaks around mid-November in the American River. After hatching, the fry typically remain in the gravel for 6-8 weeks, emerging in mid-February through early March, and then rear in the river for several more months before migrating out to the ocean in late spring. Habitat concerns include sub-optimal flows and water temperature (in some years), a limited area of suitable spawning gravel, and various components of rearing habitat (in- and over-water object cover, run-riffle-pool composition).

Steelhead are the anadromous form of rainbow trout: adults generally enter and spawn in the American River in late winter (January through April), with the fry emerging from the gravel in 6-8 weeks, and the young remaining in the river for at least a year before moving out to the ocean. Steelhead spawning takes place on smaller gravels and is more widely distributed than is seen for chinook salmon, and may be observed anywhere from Cal Expo to Sailor Bar. As is the case throughout the Central Valley, steelhead have declined on the American River. The long rearing period renders this species particularly sensitive to high water temperatures in the summer and early fall, but they may also be affected by other habitat features such as limited availability of cover and spawning gravel. Despite the recent Federal listing of steelhead, some catch-and-release and limited sportfishing harvest (of hatchery-origin fish) is allowed on the American River. As with chinook salmon, the Nimbus Hatchery also produces steelhead trout for release into the Sacramento River. In the summer and fall of some low carryover storage years, coldwater reserves become depleted and temperatures in the American River exceed the tolerance of steelhead juveniles. As a result, the hatchery contribution in this river is larger for steelhead than for chinook salmon

An introduced species, striped bass are distributed somewhat lower in the American River than are the salmonids, generally from about the Sunrise Boulevard crossing downstream to the mouth. Little is known about its life history in the American River; it may be that there is a spring run that originates downstream from the Sacramento River and Sacramento-San Joaquin Delta, or these fish may seasonally enter the mouth of the river to forage after having spawned upstream in the mainstem Sacramento and Feather Rivers (Rich DeHaven, U S Fish and Wildlife Service, personal communication). In any case, water temperatures in the American River are often too cool for typical striped bass spawning at the time of these runs, and the American River is not known as a major spawning area for this species Recreational effort for striped bass is greatest during the spring, where some very large specimens are caught by both bait and fly fishermen, and where fishing effort can continue through early fall in some years. Striped bass are not generally seen in the winter months in the American River

American shad is another introduced species that supports a popular catch-and-release recreational fishery. These fish migrate from the Pacific Ocean into the American River in late spring to early summer, apparently timed by rising water temperature. At the peak of the runs, hundreds of fishermen can be seen from Nimbus Dam downstream to Paradise Beach, bank and driftboat fishing for the shad using small, colorful, weighted flies or darts.

A number of other non-game species also occur in the lower American River, such as the Sacramento pike minnow, Sacramento sucker, tule perch, and hardhead. The federally listed threatened Sacramento splittail, which spawns beginning mid-winter, has also been found in very low numbers in the most downstream areas of the American River, generally below the H Street bridge (6.5 miles from the mouth) During its spawning migration, the federally listed threatened delta smelt has been found on the Sacramento River as far upstream as Verona (near its confluence with the Feather River). Typically, delta smelt spawn farther downstream in more tidally-influenced areas, with an upstream limit around Clarksburg

The American River may be divided into geomorphically-distinct reaches that differ in gradient, tidal influence, depth, substrate and bar formation; differences which are major determinants in the type and quality of habitat to fish (Snider et al 1992). The initial 4 9 miles from the mouth to just below Paradise Beach Recreation Area is tidally-influenced, deep (due to previous dredging), and possesses a sand bottom with few gravel bars. The deep holes are used as holding water for adult salmon, and the flooded adjacent lands may be used by splittail, however, this area is not likely to be influenced by the flow differences caused by the proposed project because of the more important effect of tides and stage of the Sacramento River. The 6.7 mile portion from Paradise Beach to the Gristmill Recreation Area has a few more bars, is similar in gradient and substrate to the first reach, but is not tidally influenced As a consequence, flow fluctuations in the range of 4,500 to 22,000 cfs cause commensurate increases in the area of potential splittail habitat (SAFCA 1999). From Gristmill to Nimbus Dam, the river is high gradient with a gravel bed channel It is here, especially from Rossmoor Bar upstream, that the great majority of salmon spawning occurs in several important glide and bar complexes. Although it is known that flow increases in the low range (500-2,000 cfs) increase spawning habitat and success (via reduced superimposition, *see* Snider et al. 1996), the effect of flows in the range of those caused by the dam modifications has not been studied.

FOLSOM RESERVOIR

When full (i.e., around 1 million ac-ft), Folsom Lake encompasses about 10,000 surface acres of water and 75 miles of shoreline, extending about 15 miles up the north fork and 10.5 miles up the south fork of the American River. It supports a "two-stage" fishery: with warmwater species such as bass (largemouth, smallmouth, and spotted) and panfish (crappie, bluegill, sunfish) in the upper waters, and trout and landlocked salmon (kokanee and chinook) in the deeper waters. Various common catfish can also be caught near the bottom of shallower waters. Fish habitat is present within the inundation zone in the forms of young willow riparian which grows during extended periods of drought, as well as brush piles placed there by the California Department of Fish and Game (CDFG) and sportsmen groups. Both warmwater and coldwater fisheries tend to benefit from increased peak spring water storage as this results in better coldwater reserves for the salmonid fishes as well as increased spawning and rearing area for warmwater fish. A number of fishing derbies are held on Folsom Lake, however, overall boating is greatly affected by lake level. Boats docked at the marinas must be removed for the flood season when the lake level falls below about 412 feet msl (465,000 ac-ft storage) and ramps begin to go out of service when the lake level falls below 426 feet msl (579,000 ac-ft storage), although there is one ramp at 370 feet msl (213,000 ac-ft storage) that would presumably be available under all conditions.

VEGETATION

LOWER AMERICAN RIVER

The vegetation along the river consists of oak species and elderberry at higher elevations of the floodway, and cottonwoods and willows at lower elevations of both the floodway, as well as on gravel bars and islands within the river channel. Regeneration and persistence of the cottonwood-dominated community is limited, relying on inundation-dependent germination of seeds (~5,000-13,000 cfs is necessary to inundate most low terraces and up to 50,000 cfs is needed to cover high terraces). Portions of the floodway have been developed for recreation of various kinds (bike paths, picnic lawns and kiosks), and there are some areas that are bare -- gravel bars, gravel piles remaining from former hydraulic mining of gold, and actively eroding bank. Although the immediate edge of the river is mostly vegetated with riparian trees or scrub, the character is more variable along the floodway bench. Much of the bench vegetation is non-native annual grassland and spotty riparian or scrub. In general, the vegetation at the river margin can be classified as relatively mature, but unlikely to be self-sustaining because the riverbed has been downcut so much that hydric species like cottonwoods now rest on high banks well above their normal position near the low-water edge. Patches of wetland vegetation occur in backwaters and off river ponds throughout the river, though predominantly downstream of Watt Avenue.

FOLSOM RESERVOIR

The area around Folsom Reservoir itself possesses common plant communities like chaparral, non-native annual grassland, oak woodland and savanna, with more limited riparian forest and willow scrub around various feeder creeks and farther up the forks of the American River. There is very little vegetation at all within the fluctuation zone of the lake, except for some willows which temporarily established in the early 1990s by the end of a 6-year, region-wide, drought period.

The plant community of the 157-acre proposed surcharge area (i.e., lands within 470-474 feet msl) was surveyed by boat by a Corps consultant on August 10, 2000 (Jones and Stokes Associates, Sacramento). The area was dominated by oak woodland (105 acres), with lesser areas of grassland (20 acres), chaparral (14 acres), riparian scrub (13 acres) and oak savannah (5 acres).

WILDLIFE

LOWER AMERICAN RIVER

Some of the more common larger mammals are striped skunk, raccoon, and mule deer, however others including the mountain lion, coyote, and gray fox could be present in low numbers, or at least might migrate into the area in some seasons or years. Various small mammals such as California voles, pocket gophers, and bats are abundant. Raptor species and others such as the great blue heron, wood duck, owls, and woodpeckers either build nests or use cavities in the larger cottonwood trees. Various water birds also use the backwaters and marshy areas in certain locations along the lower river, while swallows forage on emerging aquatic insects above the river. Reptiles, particularly rattlesnake, gopher snake, western pond turtle, and western fence lizard can be commonly seen in the parkway. Some of the more common amphibians are western toad, Pacific tree frog, and bullfrog. The federally listed threatened valley elderberry longhorn beetle has been documented in the project area, which includes critical habitat for this species near Cal Expo. Also, one shrub in the surcharge zone has evidence of beetle occupation (exit holes).

FOLSOM RESERVOIR

The wildlife around Folsom Reservoir are similar to that just described for the lower American River, however, the importance of wildlife associations with chaparral, grassland, and oak woodland habitats increases and those of riparian habitats declines. The co-occurrence of oaks and elderberries provides a forage base and/or nesting habitat for a variety of species: quail, turkey, woodpeckers, scrub jay, as well as mammals such as gray squirrel and mule deer. An even wider array of insectivorous birds forage in the oak canopy. Other species are dependent on chaparral, such as wrentit and California thrasher. Grasslands are used by various small mammal and lizard species, many of which provide a prey base for red-tailed hawk, gray fox, and bobcat. Yet more species occur near the water in association with the limited willow habitat, including yellow warbler, belted kingfisher, Pacific treefrog, raccoon, and striped skunk.

BASIS FOR IMPACT ANALYSIS

A combination of flow predictions from engineering models and best professional opinion was used to evaluate the generalized effect of the proposed project on habitat. Using Corps guidance, the baseline condition is considered to be the current, 400/670 TAF variable flood space operation.

The Corps provided a simplified plot of peak inflow and peak outflow for the baseline (with existing outlets) and future (with enlarged outlet) conditions which had been updated to include the hydrology through 1998 (Fig. 1). In addition, a consultant to SAFCA (MBK engineers) provided a more detailed plot of both inflow and outflow against recurrence frequency to evaluate the effects of the proposed rule restrictions (Fig. 2). The MBK plot is considered more representative because it takes into account the difference between inflow and outflow due to ramping and other operational considerations. In general, since the 2-year event peak inflow is about the same order of magnitude as the existing outlet capacity, it is assumed that operations during events equal to or less than this size event would be the same with and without the project. Between events of 2- and about the 7-year event, the peak inflow increases beyond the capacity of the existing outlets, and at the 7-year event and larger, peak inflow is roughly equal to the capacity of the new outlets.

The range of event size of greatest interest is at an intermediate range of recurrence; above and below this range, there would not be significant differences between baseline and project conditions. The 10-year event (~150,000 cfs peak inflow) was selected to illustrate the maximum effect of the project, both because of the difference between it and the baseline condition, as well as because of the highest rate of recurrence involving capacity use of the enlarged outlets. The 5-year event was also modeled to predict whether the proposed rule restriction could reduce potential damage of moderately high flows during relatively frequent events.

The baseline condition was evaluated for two cases because of differences in space available for flood control in upstream reservoirs (French Meadows, Hell Hole, and Union Valley -- termed "creditable transfer space") at the onset of a storm event. When space is available upstream, Folsom Lake is maintained at a higher level, so that outflows during a 6-10- year event are higher. When the upstream reservoirs are more full, Folsom Lake is maintained at a lower level, which causes these outflows under to be lower. To confirm this, we reviewed a 75-year simulated record of upstream reservoir space which assumed current operations, and compared the peak 1-day rainflood inflow (plate 21 *in* Corps 1987) to the simulated space in the month in which the storm occurred (Robert Leaf, Surface Water Resources, Inc., personal communication). Considering just the 5-year and larger events, there was an even split in the number of events which occurred when the upstream reservoir space was available (8 events, 175,000-200,000 ac-ft) versus when space was limited (6 events, 36,000-133,000 ac-ft). Therefore, the two scenarios which were selected to bracket the range of baseline conditions were 200,000 ac-ft of upstream storage space, and 100,000 ac-ft of upstream storage space. Three with-project

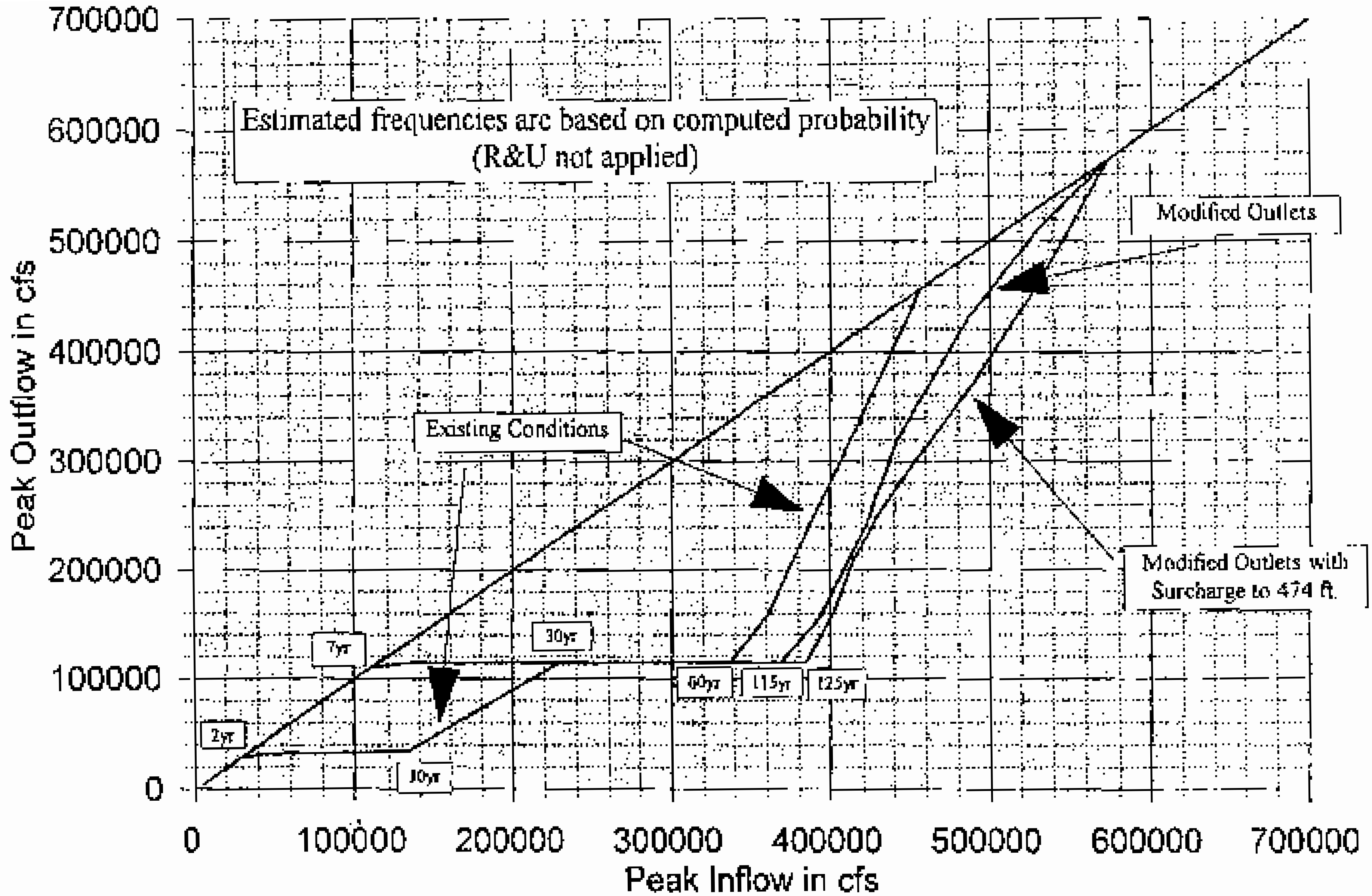


Fig. 1. Plot of peak inflow versus outflow for Folsom Reservoir (Corps, Tom Patten, May 2000).

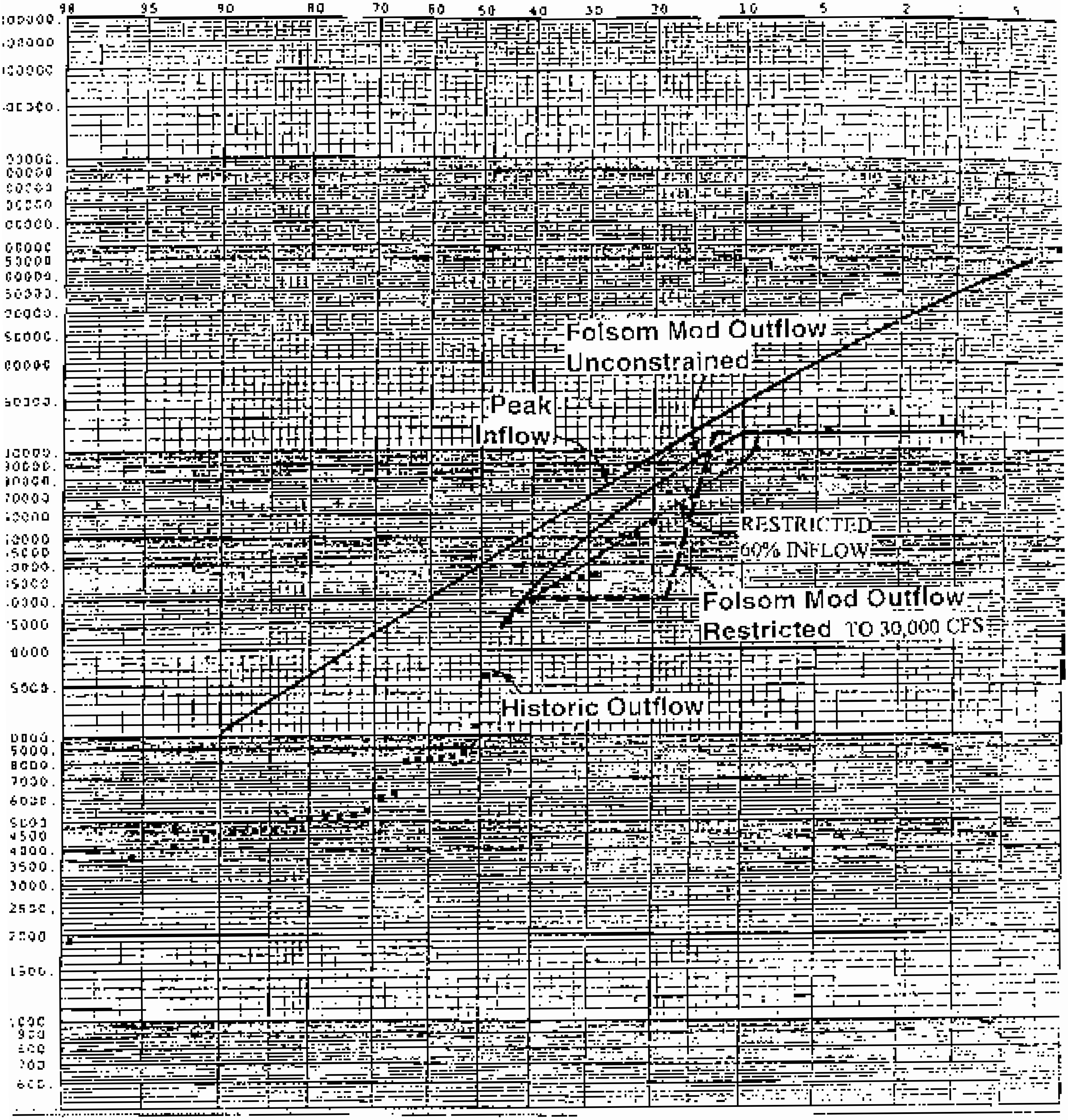


Fig 2 Plot of peak inflow and outflow for potential project operations (unconstrained, 30,000 cfs restriction, or 60% of inflow restriction) against exceedence frequency for Folsom Reservoir (MBK Engineers, Joe Countryman, September 2000)

conditions were also examined: no restriction, restricted to 30,000 cfs when inflows are less than 100,000 cfs, and restricted to 60% of inflow when inflows are less than 150,000 cfs (Figs. 3, 4)

The 50- and 100-year event scenarios were reviewed because they represent a somewhat different relationship between baseline and project conditions. Under existing conditions, peak inflows up to about 360,000 cfs can be controlled by the spillway (Tom Patten, Corps, Sacramento, personal communication). With the enlarged outlets, the maximum peak inflow which can be controlled by both the enlarged outlets and spillway increases to 410,000 cfs. Thus, for these larger, less frequent events within the flood protection level of the existing outlets (i.e., up to 65 years), peak river flows would be the same (115,000 cfs) with or without the project (Figs. 5, 6). But for events above the current flood protection level, the outlet modification would limit flows to 115,000 cfs, whereas under existing conditions, very high flows would occur (>160,000 cfs). The 100-year event, under present conditions, would result in levee damage or failure (Fig. 6)

In addition to the flood routings, the Corps provided a geomorphic analysis of the American River previously conducted for the purpose of evaluating a dry dam at Auburn. SAFCA provided the Environmental Impact Report (EIR) for a related project to develop a funding mechanism for flood control improvements, sections of the EIR for the Water Forum Proposal, and unrestricted access to other documents available through its consultants (Surface Water Resources, Inc. (SWRI), and Ayres Associates, both Sacramento). Data or analyses which could not be considered due to the schedule for submission of this report are the Ayres two-dimensional model of the lower portion of the river at 25,000 cfs, recent riverbed topography determined by the Corps and Department of Water Resources before and after the 1997 event, and yet-to-be-analyzed data on fish habitat and juvenile migration conducted by the Service and CDFG in 1997. We did review and consider reports up to 1997 on salmonid spawning activity and habitat provided by CDFG, Ayres' very recent draft report for two-dimensional modeling of the upper 12 miles of the river (Ayres 2001), and other information in the draft EA (Corps 2001)

To evaluate effects of surcharge storage around Folsom reservoir, MBK provided plots of reservoir storage for the 10-, 50-, and 100-year flood routings. The Corps provided information on vegetation in the surcharge zone, as well as a table of elevations within that zone which would be inundated at a given probability of recurrence. This allowed an assessment of the extent to which vegetation in the surcharge zone would be affected

Flood frequency: Under existing conditions, outflow matches inflow only up to 32,000 cfs, which is equivalent to a 2-year event. Additional inflows up to about the 7-year event are also released at 32,000 cfs. Above the 7-year event, the lake level reaches the spillway, with outflow increasing up to a maximum of 115,000 cfs at roughly the 20-year event, or about 5 times a century. When this level is reached, the dam can control flows at 115,000 cfs up to the 60-year event, the current estimated level of flood protection under existing conditions. Any flows above the 60-year event are uncontrolled under existing conditions

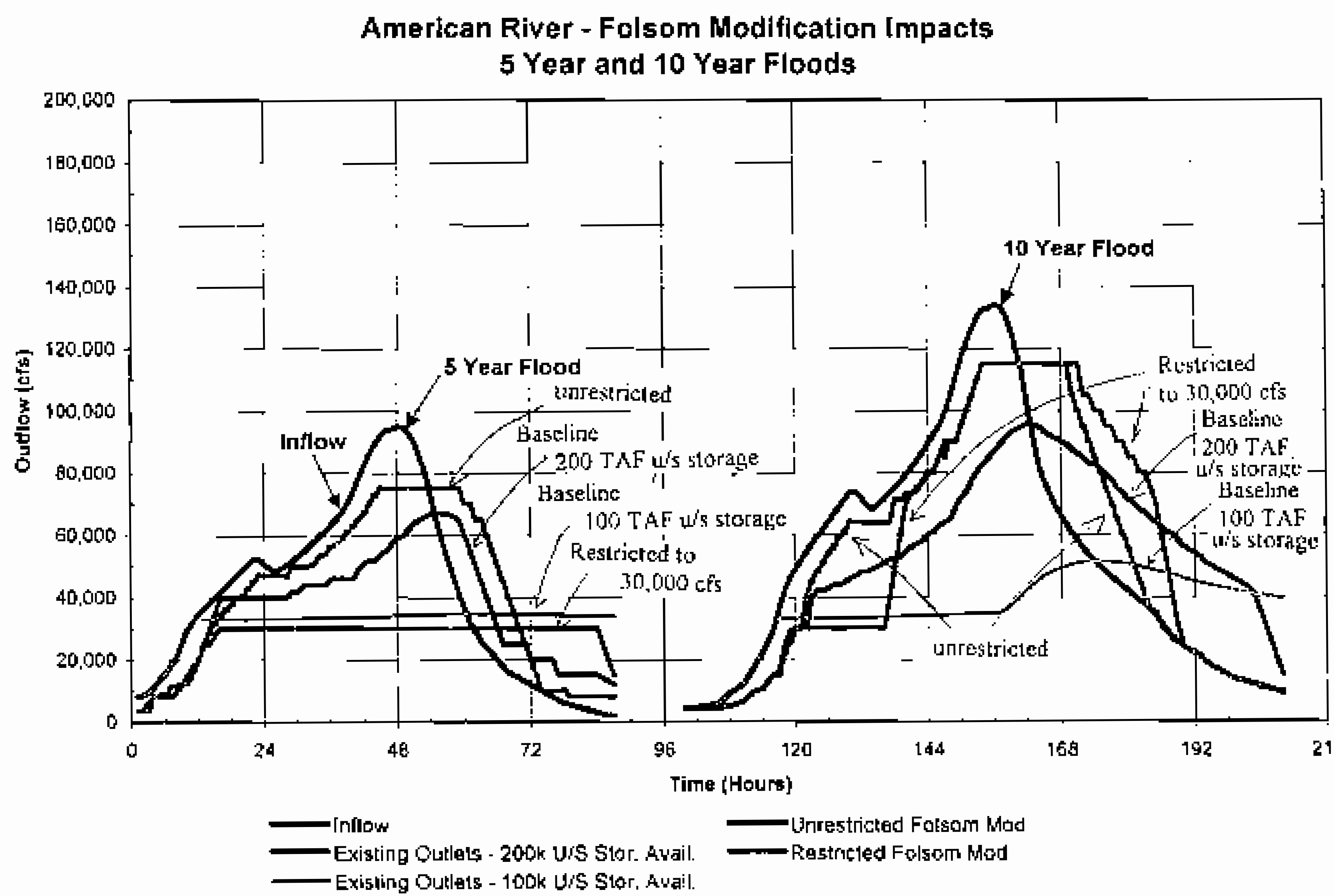


Fig. 3. Flood routing for the 5- and 10-year flood. Restricted operation assumes a release of 30,000 cfs unless actual or forecast inflows equal 100,000 cfs (MBK Engineers, Joe Countryman, September 2000).

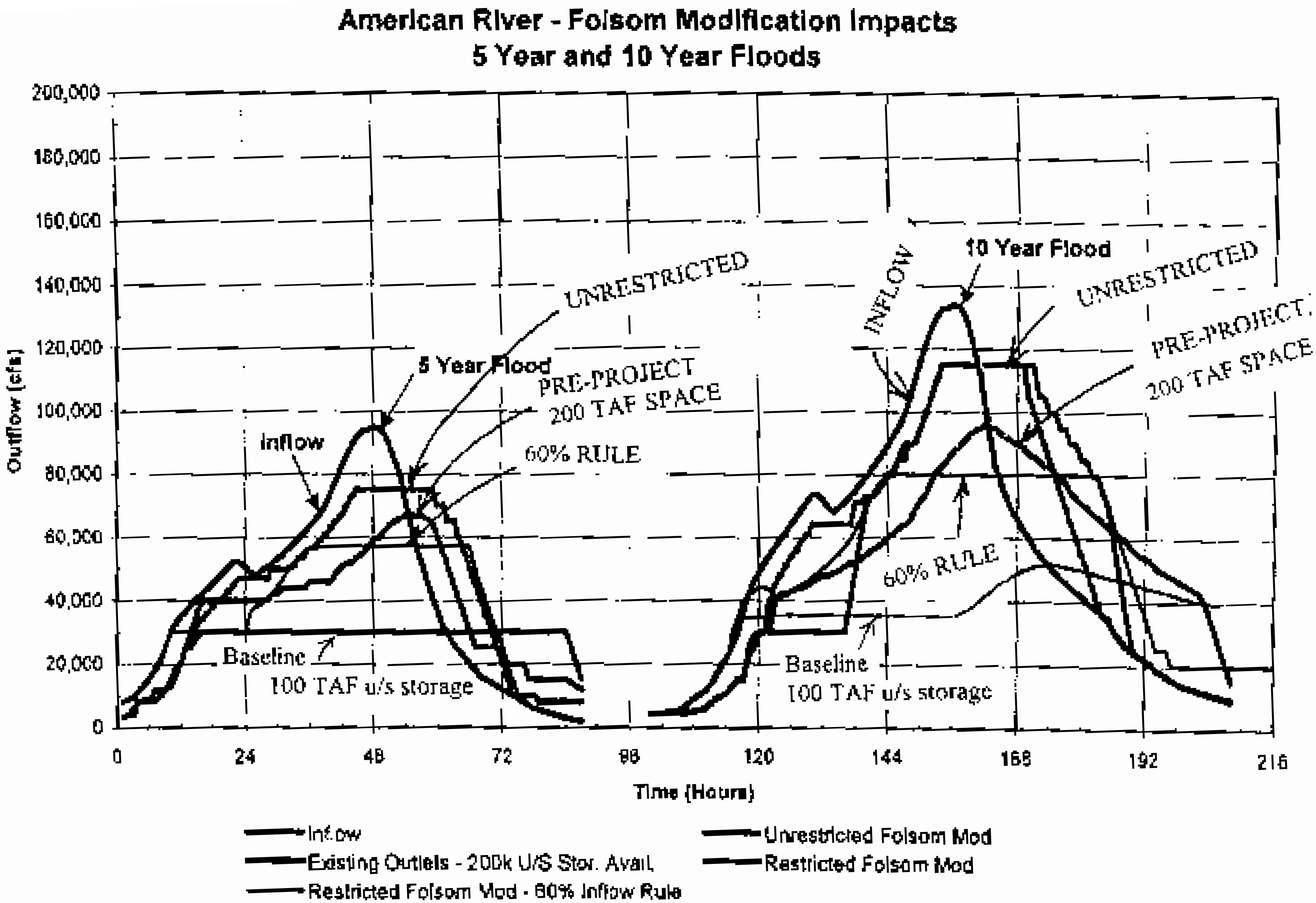


Fig. 4. Flood routing for the 5- and 10-year flood. Restricted operation assumes that outflow is 60% of inflow unless actual or forecast inflows equal 150,000 cfs (MBK Engineers, Joe Countryman, December 2000).

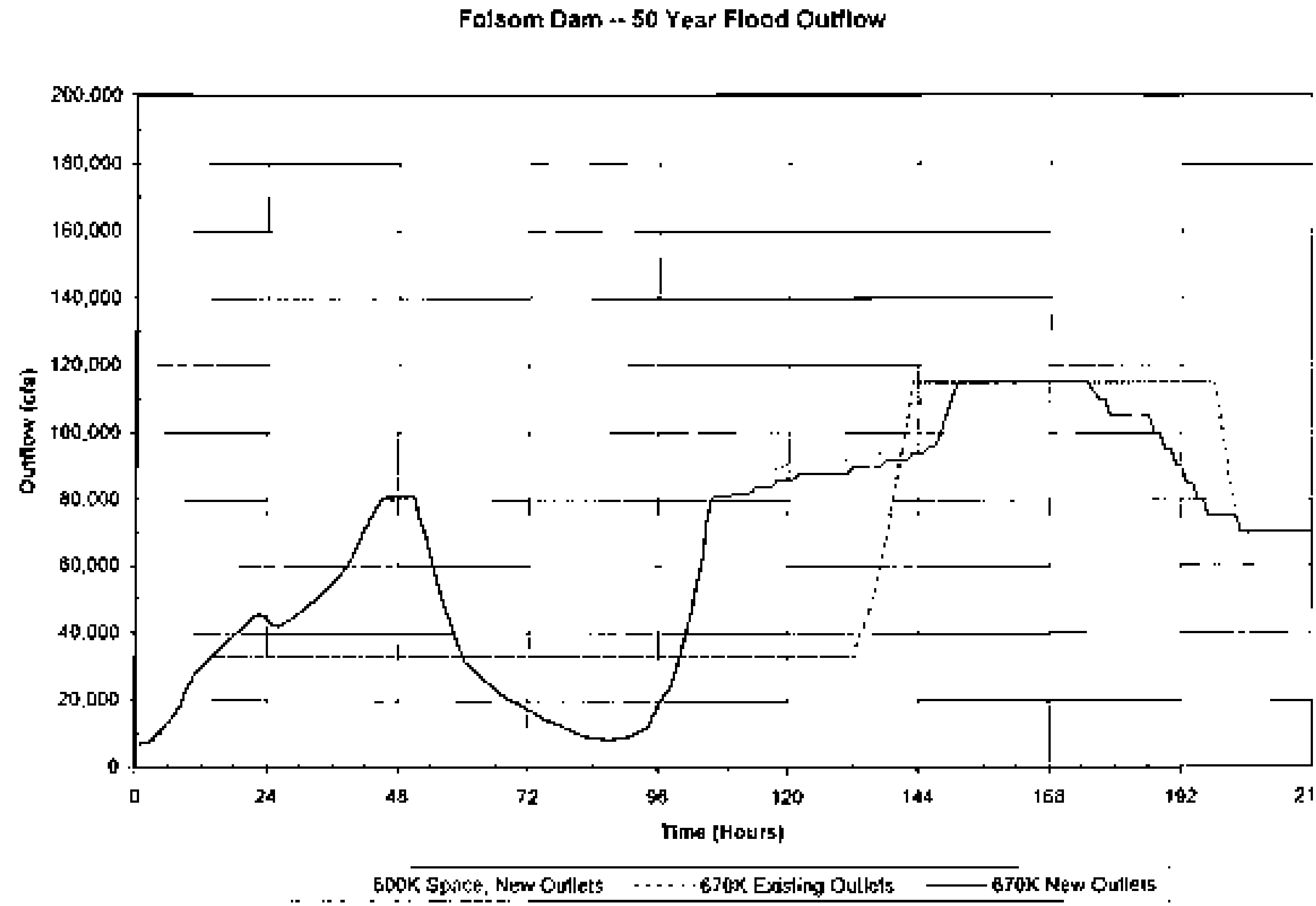


Fig. 5 Outflow predicted from 50-year flood routing under existing conditions, with the enlarged outlets, and with enlarged outlets plus 400/600 TAF reoperation

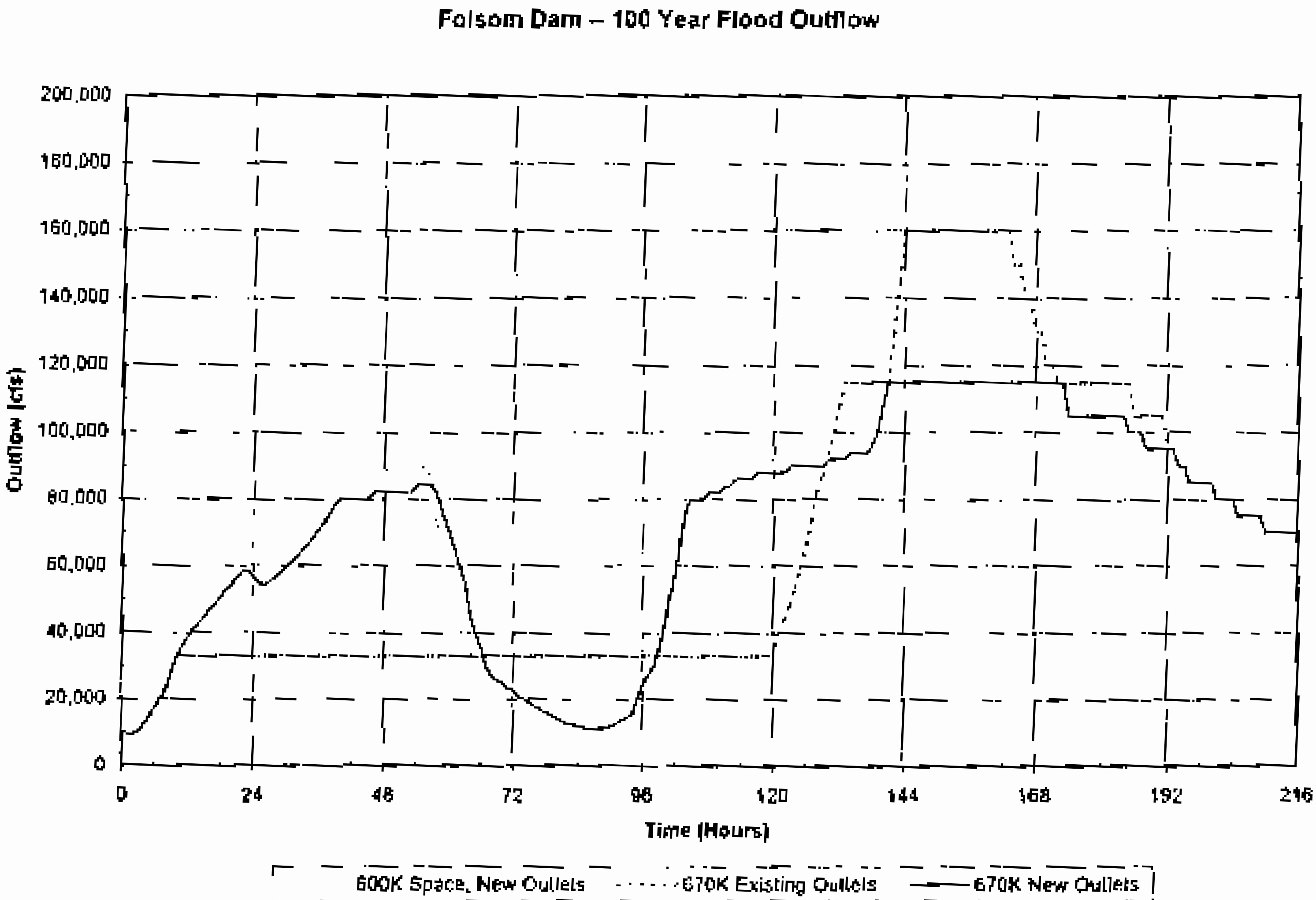


Fig 6 Outflow predicted from 100-year flood routing under existing conditions, with the enlarged outlets, and with enlarged outlets plus 400/600 TAF reoperation

A comparison of historical operations with peak inflow suggests more modest differences in outflow due to the proposed outlets than had been suggested previously, although this must be interpreted with a caution. With the new outlets and no rule restriction, outflows would have been 10,000 to 30,000 cfs higher than historical operations, and 30,000 to 70,000 cfs higher than projected without-project conditions, assuming a 400/670 TAF variable flood space (Fig. 2). If movement of gravels begins to occur at 50,000 cfs (discussed below, *see* "spawning gravels"), this additional release could result in a substantial increase in loss of spawning gravels during moderately frequent events.

The two rule restrictions would have somewhat different effects in mitigating the potential effect on spawning gravels. Under the 30,000 cfs rule, the enlarged outlets are used only when actual or predicted inflows are at least 100,000 cfs, limiting outflows to 30,000 cfs up to about the 6-year event. At most, the residual frequency of events in which the outlets could release more outflow than existing conditions (400/670 TAF) would roughly equal the difference between the 6-year event (~18% exceedence) and the 12-year event (~8% exceedence), or about 10% of the time. Moreover, during at least half of that 10%, upstream reservoir storage space would be at or near maximum, causing the baseline flows to be much higher and, therefore, resulting in nominal differences between the baseline and project conditions. So we conclude that, about 5% of the time -- or once every 20 years -- the project could have greater outflows than baseline conditions, generally outflows of 115,000 cfs. Such differences in these highest outflows may cause a significant, adverse impact on spawning gravel or Shaded Riverine Aquatic (SRA) cover.

Under the 60% rule, the enlarged outlets are used to the extent needed to release 60% of the actual or forecast inflow between 25,000 and 150,000 cfs. This restriction rule overlays the historical, fixed 400 TAF operation, which would therefore produce higher flows than the existing 400/670 TAF interim operation throughout this range, but lower flows than unconstrained operation without a restriction rule (Fig. 2). The frequency of events in which project-related outflows might increase is greater for the 60% rule than for the 30,000 cfs rule, roughly equal to the difference between the 2.5 year event (40% exceedence) and the 12-year event (~8% exceedence). Since upstream reservoir space is available at least half the time, we conclude that about 16% of the time, the 60% restriction rule could have greater outflows than baseline conditions. Although this is more frequent than just described for the 30,000 cfs rule, not all such flows are damaging, and flows are actually lower for the 60% rule than the 30,000 cfs rule for the upper portion of the exceedence range (8-15% exceedence). During these larger events, the 60% rule would yield an outflow up to 35,000 cfs below that of the 30,000 cfs rule. Moreover, if we exclude outflows less than 50,000 cfs (24% exceedence), the assumed threshold for riverbed movement, the increase in frequency of 50,000+ cfs flows due to the 60% rule is reduced from 16% to 8% (i.e., half of the 8-24% range). Although this is still more frequent than for the 30,000 cfs rule, we prefer the 60% rule because it would avoid those highest outflows with the most potential for damage to habitat, while preserving ecosystem functions (explained later) associated with the variable flows in the less damaging range of outflows. The 60% rule does not change the frequency of 115,000 cfs flows.

If one compares the 45-year record of dam operation (square symbols in Fig. 2) to what these flows would have been with the new outlets and the 30,000 cfs rule, two events would have had greater flows with the project compared to the historical operation. Both events had actual outflows in the range of 90,000-100,000 cfs -- already above the threshold flow that might cause gravel loss (*see below*, "spawning gravels"). Although the 60% rule overlaps historical operation, it is important to realize that a historical operation under a fixed 400 TAF flood space can sometimes produce higher flows than would a baseline condition of 400/670 TAF variable flood space (i.e., when upstream reservoir space is limited). Comparing only to the historical condition would obscure the potential impact. In fact, three events in the 1922-1996 record had peak inflows in this 100,000 cfs range when the simulated upstream storage would have been very low (1928, 1970, 1982). If one assumes a 400/670 TAF variable flood space, the differences between baseline conditions and the new outlets would have been much greater -- 50,000 cfs without the project versus 115,000 cfs with the 30,000 cfs rule, and 70,000-115,000 cfs with the 60% rule.

In considering the significance of the 8% increment anticipated with the proposed 60% rule, it must be realized that the likelihood of an outflow 50,000 cfs or more is already around 20% without the project. The new outlets, with the 60% restriction rule, would increase the long-term frequency of such outflows from about once every 5 years to about once every 3.6 years. Again assuming 50,000 cfs is the threshold for bed-moving or bank-eroding flow, this means such events would occur 28 times a century with the project -- 8 more than would have occurred under the baseline condition assuming continuation of the interim 400/670 TAF variable flood space operation. We consider this a worst-case condition for several reasons. First, these additional events would have a relatively short duration compared to the other events -- on the order of one day at the peak flow. Second, the actual frequency of such events may be lower than what we inferred from the calculated monthly transfer space spreadsheet. If these monthly values included the flood, it may be that the actual transfer space prior to the flood event was higher. This would reduce, but not eliminate, the likelihood that low transfer space would coincide with a 6- to 10-year event. At least one such event (1982) certainly would have had low transfer space in the month preceding the flood, and others are probable. Third, the project may impart some offsetting benefit during events between the 50- and 100-year events by limiting outflows to 115,000 cfs that would otherwise be as high as 160,000 cfs.

To address uncertainty in the threshold for bed-moving flows, the Corps contracted Ayres to develop a fine mesh, two-dimensional model to predict critical shear stress in the major spawning areas of the project area (Ayres 2001). If, at some sites, it is shown that the flow needed to cause bed movement is much higher than 50,000 cfs, the difference between the baseline and project conditions in terms of duration and area affected by bed-moving flows would be reduced. There may be localized areas that are more (or less) affected by flows caused by the outlets. Since dam construction, exposure to several large events may have redistributed the most susceptible spawning gravel to lower-energy areas where higher flows are needed to move them further.

The incremental increase in high flows over the long term could also elevate bank erosion and associated losses of riparian over baseline conditions. It is more difficult to assign a threshold flow value that causes damage, because such loss is affected by soil type, position of the vegetation on the bank, depth of the water, and duration of flow. Based on discussions with Ayres (Tom Smith, personal communication), we believe the threshold for damaging flows to be somewhere between the existing and proposed outlet capacities. As we discuss further below, most of this potential effect is likely to be avoided through the use of the restriction rule.

Outflow Pattern: The differences in flow duration were evaluated by comparing representative flood routings for the existing and project conditions (Figs. 3, 4). The flood routings are based on an inflow function representing an initial storm wave followed by a large one. With enlarged outlets, the expectation is that maintaining outflow equal to inflow early in the hydrograph will maximize the ability to control the major storm inflow peak later on. We compare the two baselines (100 and 200 TAF upstream space) with three project conditions: a) unrestricted, b) restricted to 30,000 cfs, and c) restricted to 60% of inflow.

For the 5-year event, the baseline condition with 200 TAF upstream space had a flood peak of around 70,000 cfs and a duration of about 3 days. The unrestricted project condition and 60% inflow restriction have a duration and peak flow very similar to this baseline condition. The 30,000 cfs restriction obviously results in a lower peak flow, which is one day longer than baseline. With 100 TAF upstream storage, the baseline and all project conditions are the same.

For the 10-year event, the baseline with 200 TAF storage achieves a peak flow of around 90,000 cfs with a fairly low ramping rate owing to use of the spillway. Both the unrestricted, and 30,000 cfs restriction had a peak outflow of 115,000 cfs for about a day, somewhat more than the baseline. The 60% restriction resulted in a slightly lower (and longer) peak outflow than the baseline (80,000 cfs). With 100 TAF upstream storage, the project conditions remain the same but the baseline flows drop to a maximum of 50,000 cfs due to greater available space in Folsom.

For the 50-year event (Fig. 5), flows would be 32,000 cfs with the existing outlets for the first 5 days, compared with up to 70,000 for a few hours with the enlarged outlets; spillway flows and duration would be roughly the same. The 100-year event (Fig. 6) shows nearly the same pattern as does the 50-year event, except for existing conditions, during which very high peak flows of 160,000 cfs would cause overtopping of the levees.

Flow velocity: Detailed information available on velocity has now been developed by Ayres Associates (Sacramento) for the entire lower American River, both as average channel velocity (JSA 1998), and as two-dimensional plots of velocity developed for the Corps at 115,000 cfs only (Ayres 2001). At 115,000 cfs, there are significant areas of the channel in excess of 6 feet per second (fps), velocities which could result in bank erosion. The Corps has also provided some average velocity data for five stations along the river over a range of flows. The velocity ranges corresponding to the flow range between the existing and proposed enlarged outlets (32,000-115,000 cfs) for these stations are: Goethe Park (8-11 fps), Sunrise Boulevard (6-10 fps), Watt (4-7 fps), Howe Avenue (3.5-4.5 fps), and Highway 160 (2-4 fps).

FUTURE WITHOUT THE PROJECT

We have emphasized the relative impacts during a 10-year event with low upstream storage, because the flood routings suggest that project and baseline conditions for other cases, except the 100-year flood, are similar. Under baseline conditions for the 10-year event, river flows would be largely limited to 32,000 cfs, with a brief peak of 50,000 cfs. This flow is probably less than what has occurred under the fixed 400 TAF flood space that was in operation from 1955-1994. The effects of such flows on riparian vegetation and bank stability are uncertain, but the pending model study by Ayres of velocities at 25,000 cfs may shed light on this question. The river bed would still be subject to at least 100,000 cfs of peak outflow about 10 times a century when there is either larger storm events and/or greater upstream storage available. These flows may result in some progressive loss of SRA cover or spawning gravels over the long term. Ayres (1997) calculated that 32,000 cfs would not be sufficient to mobilize bed materials, and found that bed profiles at selected locations did not change significantly in 1993 during an event of 16,200 cfs. On this basis, we expect that there would be nominal direct effects of continued existing outlet operations on spawning gravels during the 10-year event or less. In some areas, barren gravels may become slightly more colonized by vegetation under the baseline than with the enlarged outlets, due to reduced flows in the 50,000-115,000 cfs range. No change from existing conditions is expected for resources in Folsom Reservoir.

Infrequently, outflows up to 160,000 cfs would occur during the 100-year event, which could cause additional damage to levees, spawning areas, and riparian habitat.

FUTURE WITH THE PROJECT

The effects of construction itself would be negligible. We have inspected the dam and potential staging areas and determined the habitat values there to be nominal. Impacts would involve disturbance of wildlife due to noise from explosives and increased truck traffic, and temporary disruption of bare ground and sparsely vegetated upland areas. The remainder of this discussion concerns the impacts on reservoir and riverine resources that could result from operation of the enlarged outlets.

LOWER AMERICAN RIVER

FISHERIES - IMPACTS

Spawning Gravels: The effect of the project on spawning gravels can only be stated in a general way. With construction of the dam, sediment supply was cut off, the river bed has incised on the order of 8-10 feet or more, and cobbles suitable for salmonid spawning have been moved downstream. In addition, portions of the lower American River show the general armoring effect of dams, where sediment-free water winnows away the finer material at the surface, leaving larger pebble sizes at or just below the surface. These processes are believed to be continuing, and may be exacerbated at higher flows. The effect of the proposed dam modifications on spawning gravel may be adverse because it would add more of these higher flow events. However, the magnitude of such an impact would depend on how the increased flows and flow depths change the shear stress in the specific vicinity of the spawning beds, what area would be affected, and how often, relative to the baseline condition.

Evidence from both models and empirical observations suggest gravel movement does occur at the moderate to high flows that would be increased in frequency with the proposed outlet enlargement. During January 1997, for example, a 2-day peak flow of 105,000-109,000 cfs, similar to the maximum which could occur with unrestricted operation of the enlarged outlets, resulted in premature movement of salmonid fry as documented by recoveries from the CDFG fish trap at Watt Avenue (Robert Titus, CDFG, personal communication). Also, the Service conducted a study of spawning habitat at the five most important chinook salmon spawning areas before and after the January 1997 event (Mark Gard, Service, personal communication). Although these data have not been fully analyzed, significant gravel movement and/or grade changes were observed. These processes could have been accompanied by redd destruction, reduction in gravel quality or reduction in the overall area of suitable spawning gravels. Also, the Corps provided measured relationships of velocity to discharge at five locations, two of which were in the potential salmonid spawning reach. At Goethe Park, velocities would increase from 8 to 11 fps between 32,000 and 115,000 cfs. For the same flow range, velocities in the Sunrise Boulevard area, near another important spawning area, would increase from 6 to 10 fps. Such substantial increases could cause bed movement. Shear stress will also rise because of the additional 8-10 feet of water depth.

In studies conducted for the Corps for a previous proposal for a dry detention dam at Auburn, Ayres (1997) indicated that the critical shear stress, the force needed to begin to move the river bed material, is exceeded in significant portions of the lower American River beginning somewhere around 50,000 cfs, including larger materials in the vicinity of the major spawning beds in the upper portion of the study area. As flows increase above 50,000 cfs, the area in which critical shear stress is exceeded expands. Since this modeling was done for the 100-year flood only, the scenarios in Ayres' (1997) sediment budgets are not directly applicable to the proposed outlet enlargement. In addition, the model appeared to include only about 4 cross-sections per mile, and did not consider hydrology after 1992. Thus, any interpretation for the purposes of this project can only be qualitative. Nevertheless, the 100-year event scenario for the dry dam proposal is relevant because, like the enlarged outlets, it assumes flows are limited to 115,000 cfs. That modeling predicted a loss of about 3,800 tons of bed material between the Nimbus fish weir and San Juan Rapid during the 100-year event. Changes in bed elevation were predicted throughout most of the river, including in the vicinity of important chinook salmon spawning areas near Sunrise Boulevard (River Miles (RM) 19.8-20.6) and between RM 14.0-18.8. Because steelhead are more spread out, using a number of small-graveled riffles as far downstream as Cal Expo (~RM 5), impacts on this species' habitat may be widespread. We suspect that the model would predict less material to move during the relatively frequent but short duration flows of this magnitude with the enlarged outlets, but it is not possible to estimate the extent of impact on spawning gravels in this reach from available information.

Although there is insufficient information currently developed to determine the extent to which redds might be dislodged or spawning gravels scoured out, available information suggests this does occur at some level, and would be somewhat greater with the increased occurrence of high flows associated with the enlarged outlets, than under baseline conditions. On the other hand, under rare instances (50- to 100-year event), the project may impart some benefit by limiting flows to 115,000 cfs that would otherwise be as high as 160,000 cfs (Fig. 6). Notably, Ayres (1997, *see* their Fig. 4.31) suggest that the region of bed movement expands greatly between 100,000 cfs and 180,000 cfs. The maximum adverse effect of the outlet modification project is estimated to be an increase of not more than 50% above the future, long-term rate of bank and bed loss under baseline conditions. The more detailed, two-dimensional modeling of the key spawning reaches that is now underway should better specify the magnitude and extent of impacts associated with the enlarged outlet operations. Preliminary results of this most recent modeling indicate that the threshold for spawning gravel movement is near the vicinity of the 50,000 cfs predicted in the 1997 Ayres study (Ayres 2001).

Riparian Vegetation: It is more difficult to quantitatively assess the impact of high flows on riparian vegetation than it is for spawning gravel because the effect is believed to be influenced greatly by the duration, as well as the peak, of flood flows. Factors causing bank failure and loss of vegetation include the size and flexibility of vegetation, the slope of the bank, water velocity, depth of flow, and type of soil. Any losses of trees would constitute a reduction in the quality of both terrestrial habitat, as well as of over-water and in-water cover components of aquatic habitat. If these losses do occur, we anticipate there may be spot repair projects using riprap, that could further degrade habitat quality.

Under some situations, moderately high flows of long duration may cause more damage than higher peak flows of short duration, because movement of the root structures in vegetation can loosen the supporting soil with time and lead to massive bank failure. Since the flood routings suggest that duration of peak flows for the more significant, 10-year and larger events, is similar with or without the project (Figs. 3, 4), damage of this type is not expected.

Unfortunately, we are lacking a specific analysis of bank erosion for the proposed project. Previously, Ayres (1997) did such analyses for various options to a dry dam proposal. In that study, Ayres considered the duration and magnitude of a range of events at 30 critical locations on the lower American River, calculating long-term weighted average bank work as an index of erosion. Ayres concluded that alternatives which would cause an increase in duration of high-to-moderate in-bank flows would also increase the potential for lateral instability in the upper reaches of the lower American River. It is unclear whether the proposed outlet modifications and 60% rule would have such an effect. A similar analysis should be undertaken if not for this project, then for the anticipated permanent reoperation pursuant to revision of the Water Control Plan.

Fish stranding: When rivers rise and fall, there is a chance that fish, especially juveniles, can become stranded in isolated water bodies or on land. Normally, stranding would increase with the magnitude and frequency of water level fluctuations, with the descending limb of the hydrograph being the most important factor. With the new outlets, such water level fluctuation is evident in the project versus baseline comparison for a 10-year flood with low upstream storage. In that case, enlarged outlets would have a flow peak around 70,000 cfs compared to 32,000 cfs with the existing outlets. Since flows in either case would span the full width of the levee, even for lower reaches of the river which are important for Sacramento splittail spawning and rearing, stranding does not appear to constitute a significant impact of the project.

Spring operations: If a 10-year flood event were to occur at a time when the reservoir is becoming stratified, operation of the enlarged outlets could result in a reduction in cold water reserves. This is because both tiers of outlets are much lower (205.5 and 275.5 feet msl) than the spillway seat (417.2 feet msl). Discharging cooler water through the outlets rather than warmer water from the spillway could have some adverse effect on salmonid rearing in the remainder of the spring and summer. Had the project been in place in 1928, when the 1-day peak rainflood was 163,000 cfs on March 25 (followed by moderate unimpaired inflows in April and May), some loss of coldwater reserves and impact to salmonids could have occurred.

The impact related to springtime loss of coldwater reserves represents a more difficult case to mitigate; our initial review of unimpaired inflows suggest such an event is indeed rare, but possible (1-2 times per century). Factors such as the timing and temperature of inflow after a storm event, maximum storage, and extent of stratification could influence the magnitude of such an impact. In the draft EA, the Corps included an analysis by a consultant (SWRI, Sacramento) of potential effects of the outlets on coldwater reserves. SWRI opined that coldwater reserve reduction is not likely to occur because stratification would weaken during high inflows. While their analysis of an event on March 13, 1995, suggested that the reduction in reserves would be small, this was due more to the limited use of the spillway than lack of stratification, as the spillway release would have been 3°C warmer than the enlarged upper tier outlets. SWRI also notes that the difference in combined release temperature due to the project is further minimized by the 60% rule, because the restriction reduces the use of the enlarged outlets only, not releases through the power plant.

Although the impact appears minimal, slightly larger and later March events (such as occurred in 1928) might involve greater losses of cold water. Given the rarity of such an event, designing and installing a device to selectively discharge warmer water through the enlarged outlets does not seem practical. A more logical solution would be to develop a contingency plan to make some use of the spillway in lieu of the enlarged outlets in the event of late season flood releases. Such spillway use would be possible towards the end of March, and needed only for those years when creditable transfer space upstream is fully available. At that time, the reservoir could be filled somewhat above the spillway crest, to around 430-435 feet msl, allowing roughly 40,000-60,000 cfs to be released from all 8 gates combined (Chart A-4 *in* Corps 1987). Although this would only partially avoid the impact, other operations may be possible to limit use of the enlarged outlets and/or increase use of the spillway when the lake is undergoing stratification. For example, late season encroachment into the flood space could be employed to increase use of the spillway so as to avoid loss of coldwater reserves during outlet operations.

Flow spectrum: Although the 30,000 cfs rule restriction may reduce potential effects on spawning gravel area, it involves the elimination of intermediate flood flows of 30,000-115,000 cfs. Some areas where the bankfull stage is greater than 30,000 cfs might experience undercutting due to the long duration of constant flow. Less frequent inundation of high terraces could affect the recruitment of seed source and germination of certain riparian species such as cottonwood. Inputs of gravel from near-channel deposits, as well as detritus and wood from the floodway riparian area, would be reduced. Limiting flows to 30,000 cfs might cause bar gravels to become more stabilized by encroaching vegetation that would otherwise be scoured out. While excessive scouring is undesirable, some movement of bar material could be beneficial in replenishing spawning gravels.

Conversely, the 60% rule would enhance intermediate flows in the 30,000-115,000 cfs range. Presumably, these same ecosystem functions would be enhanced.

Cumulative impacts: The proposed enlarged outlets are a necessary prerequisite to any modification of the current 400/670 TAF variable storage space. After the outlets are constructed, it may be possible to promulgate a new flood control diagram with as little as 400/600 TAF variable storage space, and still maintain adequate flood protection. Although this reoperation is not part of the proposed project, it is a potential consequence of it. By reducing the variable storage space, up to 70,000 ac-ft of additional carryover would occur at the expense of mid-winter flows. This water would be detained generally during the first or second large storm of a particular water year, and could be anywhere from late December (such as occurred in 1996) to mid-February (as in 1998). This carryover could have benefits: improving the coldwater reserves, and reducing erosive flows over the spawning beds and along vegetated banks of the river. Several routings for the new outlets in combination with reduction of the variable flood space were also provided by MBK (Figs. 5, 6). The duration of peak flow with 400/600 TAF operation was slightly shorter for the 50-year event, but the same for the 10-year event (not shown) and 100-year event (Fig. 6); thus, no significant adverse impacts are expected due to flow.

Adverse cumulative impacts might include less splittail spawning habitat in the lower portion of the river, and less combined flows in downstream areas (both the Sacramento River and Delta). These impacts would occur generally at intermediate flows where upstream reservoirs are filled. Although SAFCA (2000) did evaluate the effect of long-term reoperation of the Corps' existing flood control requirements with this condition (i.e., fixed 400 TAF vs. variable 400/600 TAF), they did not provide information on Folsom storage, or isolate the effects of the enlarged outlets under the current operational agreement (fixed 400/670 TAF). Because the river flows for the 400/600 TAF and 400/670 TAF scenarios (both with enlarged outlets) are similar under most conditions, we expect that impacts on splittail would also be similar.

A more important cumulative effect to consider is that of the interim operation in combination with the enlarged outlets, for which the baseline would presumably be a fixed 400 TAF operation. As discussed earlier, a fixed 400 TAF flood space would have resulted in about the same frequency of flows above 50,000 cfs as was predicted for the 400/670 TAF flood space with the enlarged outlets and the restriction rule. What this means is that with rule-restricted operation of the enlarged outlets and some form of the variable flood control space (either 400/670 or 400/600 TAF), there is likely to be no significant change in high outflows that could cause habitat damage, compared to the past 45 years of historical operation

WILDLIFE - IMPACTS

Upland refugia: During flood control operations, higher peak flows could result in the temporary inundation of upland areas in the floodway where many mammals, birds, and other wildlife reside. The area of such impact would be slight, and confined to a narrow but very long band of levee or floodway face that would be submerged between the stage for discharge of the existing outlets (32,000 cfs), and the new outlets (115,000 cfs). We estimate there to be about 12 acres that would be inundated in this area, assuming an average stage height difference of 10 feet, and distance of 10 miles. Most active animals would have time to evade the rising water, and move into adjacent suburban or other upland areas. Some might become stranded and drowned on islands. Any hibernating animals would also be killed in inundated areas

Riparian habitat: As already discussed above (Fisheries-impacts), riparian habitat may be adversely impacted by the increased frequency of high flows. This would result in impacts to birds and other species that use woody vegetation, but these impacts would be confined mainly to habitat on the bank edge, not the benches of the floodway. Island habitat may also be slightly reduced if the incremental increase in higher flows were to cause erosion of these islands.

ENDANGERED SPECIES - IMPACTS

The Service has consultation responsibility for all federally listed species (except for anadromous salmonids, which are the responsibility of NMFS) that may be affected by the project. On May 7, 2001, our Endangered Species Division notified the Corps that the proposed action is not likely to adversely affect the listed delta smelt, Sacramento splittail, or valley elderberry longhorn beetle (Appendix 2). On March 15, 2001, NMFS determined that the project is not likely to adversely affect winter-run or fall/late-fall run chinook salmon or their critical/essential habitat. Below are brief discussions of the four federally listed threatened or endangered species under the Service's authority which are likely to occur in the project area

Valley Elderberry Longhorn Beetle (Desmocerus californicus dimorphus) (Threatened). All life stages of the valley elderberry longhorn beetle (VELB) are found exclusively on elderberry bushes (*Sambucus* spp.); larvae feed on the pith of the stems and roots, and adults consume the foliage. The larva chews an exit hole in the plant prior to pupation, and returns to the pith to pupate. The adults exit through this same hole, and then feed on foliage (perhaps flowers). Presence of the species is inferred from the occurrence of these exit holes. Adults are present and mate in the spring, with females laying single or a few eggs on live elderberry plants. Instars burrow into the stems after hatching and are not seen until pupation as adults the following spring. Elderberries most commonly occur in association with other species in riparian or savannah plant communities

While a only portion of the lower American River has been designated as critical habitat for VELB, elderberries are found throughout the river, and around Folsom Lake and Lake Natoma. Because these plants occur on the higher terrace of the riparian zone, they should not be subject to potential impacts of the project via mobilization of gravels or bank edge erosion. Some additional inundation of elderberry plants could occur with the project for the 52 elderberry shrubs identified within the surcharge storage space, of which one shrub shows evidence of VELB occupation (exit holes). In our May 7, 2001 letter, we concluded that such inundation is not likely to adversely affect the VELB.

Delta smelt (Hypomesus transpacificus) (Threatened): The delta smelt is a small, translucent estuarine fish which is endemic to San Francisco Bay, but which spawns in the Sacramento-San Joaquin Delta (Delta). Adults enter dead-end sloughs and channel edgewaters of the Delta to spawn between February and June, with the adhesive eggs attaching to hard substrates including rocks, tree roots, gravel, and submerged vegetation. Soon after hatching, its planktonic larvae move downstream to rear in the region of maximum turbidity (or entrapment zone), which can vary depending on outflow anywhere from the western portion of Suisun Bay to the confluence of the Sacramento and San Joaquin Rivers. Factors which are believed to be responsible for this species' decline are increased export (pumping), drainwater toxicity, and introduction of exotic species which compete with the smelt for food.

While the delta smelt historically occurred up to the confluence of the Sacramento and American Rivers, it is generally found downstream of Clarksburg. Even if it were to be found in the mouth of the American River, the proposed project operation would have a minimal effect on its habitat because of the predominant influence of tides and the Sacramento River on water levels in the first few miles of the American River. Although the effect of the outlets on delta outflow has not been specifically studied, SWRI (2000) did examine the combined effects of new outlets and 400/600 TAF variable space reoperation relative to a base condition of fixed 400 TAF space using the Department of Water Resource's PROSIM model. Those results indicate very slight changes in outflow for the combination of those actions, so it seems reasonable to assume that the outlets alone would have no more than a nominal impact.

Sacramento splittail (Pogonichthys macrolepidotus) (Threatened): The Sacramento splittail is another endemic California fish which is distributed from fresh to brackish waters, and whose abundance appears to be correlated with the area of flooded lands, much of which is formed during years of flood bypass operation. Spawning occurs in late April and May on inundated lands, and the larvae move to deeper areas in the summer as waters recede. This species' decline has coincided with increased pumping and reduced outflow to the Delta, loss of habitat, and consecutive years of drought. The potential impacts to this species in terms of stranding and loss of potential spawning and rearing habitat, which would also apply to other species in the lower American River, have already been discussed above (Fisheries - Impacts). As stated in our May 7, 2001 letter, we do not consider these impacts to adversely impact this species.

Central Valley Steelhead Trout (Oncorhyncus mykiss) (Threatened): The life history of the steelhead has already been reviewed above, as have several mechanisms (gravel movement at high flows, loss of bank vegetation and cover, diminution of coldwater reserves during spring operation) that could impact salmonid habitat due to the proposed project. Impacts on steelhead could be different because the species spawns later in the season, uses smaller gravels, and has a wider spawning distribution along the American River than does chinook salmon.

FOLSOM RESERVOIR

Fisheries: Operation of the enlarged outlets would occur outside the spawning season of warmwater fishes. MBK engineers provided representative plots of reservoir storage for 10-, 50-, and 100-year flood routings. The effect of the operation, under all event scenarios, would be to reduce the maximum storage level and amplitude of fluctuation in the reservoir. For example, under existing conditions, a 10-year event would result in a peak storage of about 540,000 ac-ft, and would take about 14 days to return to a stable level. The area would fluctuate between 5,800 to 8,300 acres. With the enlarged outlets, a 10-year event would peak at a lower storage, around 405,000 ac-ft (7,000 acres inundated), and would return to stability in about 6-7 days. This reduced fluctuation zone and duration of inundation might allow some additional recruitment and survival of willows within the inundation zone. Such vegetation is important cover for fishes, and would constitute a mild benefit. In terms of recreation, lake level change is widely thought to "turn off the bite", even at modest changes of 1-2 feet per day. Because lake level would reach stability sooner with the enlarged outlets, recreational fishing conditions should slightly improve.

Vegetation: Effects on wildlife could occur from any losses of habitat in the surcharge zone over the long term. Impacts of surcharge on habitat would be proximately caused by loss of soils through wave action during the inundation period, or through collapse of the shoreline soils, if there were slope failure of the heavier, waterlogged soils, as water levels dropped. Although short periods of inundation can be tolerated during most of the winter season, mortality can result if inundation occurs during the growing season, beginning around March.

With both the new outlets and the structures to allow surcharge, the probability of inundation decreases and the length of time increases (Table 1). For example, the probability of inundating up to elevation 473.8 msl under existing conditions is about 1 in 150 years, for a duration of 14 hours. With the proposed project, the chance of inundating that level is reduced to about 1 in 181, and the inundation period is extended to about 41 hours. At lower computed probabilities (1 in 125), lower portions of the surcharge zone (up to 472.5 msl) would be inundated for 18 hours under existing conditions only. A simple way of comparing the existing to the project conditions is to scale the inundation by its probability of occurrence. If the project life is 100 years, and the probability of inundation for 14 hours under existing conditions at 473.8 feet msl is 1 in 150, then the exposure per 100 years is 100/150 X 14, or about 9 hours. Similarly, the exposure per 100 years with the project would be 100/181 X 41, or about 23 hours. Thus, the cumulative inundation over the long term with the project is about twice that of existing conditions.

At this time, it is not possible to conclude with any degree of certainty whether such an increase in exposure would result in loss of the 157 acres of habitat within the surcharge zone. A high wind event and/or a large March runoff event could result in direct mortality or physical loss of this habitat. In our opinion, however, the chance of such a loss appears low given the short duration involved (14 additional hours) and very low frequency (less than once per century). The largest recorded March inflow of 163,000 cfs, in 1928, was much smaller than the 181-200 year event that would utilize the surcharge space. Given the uncertainty of the impact, but finite low probability of adverse impacts, a specific mitigation plan is not warranted. Nevertheless, a long-term monitoring/remedial action program of vegetation in the surcharge zone should be designed and implemented. At regular intervals (every 10 years), the surcharge area should be typed by habitat, including any eroded areas due to wavewash. If a 181-200 year event is recorded (i.e., peak inflows in excess of 400,000 cfs, *see* Fig. 1), habitat typing should be done the summer following the event to determine any loss of habitat and need for mitigation.

Table 1. Probability and duration of inundation in Folsom Reservoir under existing conditions and with construction of enlarged outlets and structures to allow surcharge to 474 feet msl (provided by Corps of Engineers, Sacramento District)

Expected Probability	Computed Probability	Existing Condition		New Outlets + Surcharge to 474	
		Elevation	Hrs Above 470	Elevation	Hrs. Above 470
84	100	471.3	17	457.0	
114	125	472.5	18	464.5	
128	150	473.8	14	465.7	
147	175	471.8	12	469.7	
151	181	471.8	12	474.0	41
164	200	473.3	11	474.1	35

Cumulative impacts: If the variable flood space were reduced to 400/600 TAF, the minimum area of the lake would increase from about 5,800 acres to about 6,600 acres. This would likely result in a moderate benefit to reservoir fishes.

DISCUSSION

Relative to baseline conditions of the existing outlets and interim operations, the flows associated with the proposed outlet enlargement may have a modest impact on important chinook salmon and steelhead resources or their habitat on the lower American River. We base this conclusion on the expected increase in frequency of discharges >50,000 cfs, discharges that recent study (Ayres 2001) has determined would result in forces that could erode the river bed and/or banks, causing losses of spawning gravels and bank edge vegetation. Similar occurrence of such flows occurred during the 1955-1994 operation of Folsom Reservoir under a fixed 400 TAF flood space, but are an inappropriate baseline for analysis. Presently, such flows are somewhat less likely due to interim reoperation at a variable 400/670 TAF flood space. Completion of the Ayres (2001) study will better specify the locations of spawning areas at risk, and the magnitude of impacts in the range of enlarged outlet operation. Nevertheless, a considerable amount of spawning gravel and riparian habitat has remained in the lower American River after repeated historical exposure to previous events >50,000 cfs, enough to support among the most important runs of fall-run chinook salmon and steelhead trout in the Central Valley. Due to the original dam construction, there has been an absence of gravel recruitment, and gradual grade changes that may be adversely affecting fish and wildlife resources. Therefore, care should be taken so that any additional structures or operations will minimize the rate of future loss of habitat.

In response to our previous report recommending that impacts be mitigated first by operations, the Corps has proposed a restriction rule to limit use of the outlets to 60% of the outflow for inflows in the 25,000 to 150,000 cfs range. Such a rule would limit impacts due to high flows to a confined range and frequency of events -- at most about half of those events occurring between the 24% and 8% probability of exceedence (i.e., when upstream reservoir space is limited). The 60% rule avoids the concern about the 30,000 cfs rule regarding the loss of flow spectrum between 30,000 and 100,000 cfs. Important riverine processes could be occurring in this flow range: replenishment of large woody debris, providing inputs of detritus from the floodway, germination of trees on high terraces, and preventing gravel bars from becoming fully encroached by scouring vegetation. The 60% rule should be implemented to approximate the historical and/or baseline condition, which should retain these processes at the baseline level of function.

In addition to the restriction rule, other factors in day-to-day operation may produce less frequent high outflows, or lower volumes of outflow than predicted by the flood routings. These include the degree of willingness of the Corps to allow encroachment into the flood space based on season, meteorology, or other basin conditions to meet conservation needs, the timing of high flows compared to the life history of the fishes, the actual duration of the inflow peaks, and the precision of the model we reviewed to evaluate upstream storage conditions. Typically, operators have tried to release less during moderate storm events to maximize water conservation. In two past years with modestly high peak inflows, these flows were captured instead of being released (1960 - 60,000 cfs; 1981 - 80,000 cfs). Although we cannot determine if such operations would be applicable with the enlarged outlets and revised hydrology, we would expect that the improved capability to make greater releases with the enlarged outlets to result in a similar effort to capture moderate inflow events. Otherwise, ramping requirements, water conservation needs, and storage conditions in the reservoir would all tend to also reduce the outflow peaks and in some cases, capture them.

Although we have not fully analyzed prospective changes to the flood diagram, such as to a 400/600 TAF variable flood control space, the information currently available suggests that such a revision would rarely affect operations during the flood control season. The changes would occur from the proposed outlet modification in the presence or absence of any modification to the flood control diagram. In a consultation letter of May 7, 2001, our Endangered Species Division expressed concern about future revision of the Water Control Manual (Corps 1987) as a result of the enlarged outlets, and potential effects of revised flows on splittail habitat. However, we noted that action would need to be considered in a future section 7 consultation, separate from the construction of the enlarged outlets and surcharge features.

CONCLUSION AND RECOMMENDATIONS

Because information is incomplete on how high outflows affect sediment movement and bank stability, it is not possible to formulate detailed mitigation recommendations. We recommend that the Corps complete or undertake studies to estimate, under various event scenarios, the effect of individual and repeated exposures of the river bed to these flows on potential salmon spawning areas and river banks. As a necessary prelude, the Corps should update hydrologic and topographic information, and evaluate various modeling approaches that would best predict these effects. Concurrently, data analyses should be completed by the Service and CDFG to evaluate the impact that 1997 flows had on chinook salmon and steelhead or habitat. The Corps and/or local sponsor should collate information on any bank damage or river bed changes in relation to outflows, particularly those which may have occurred recently. Although we are aware that the Corps has contracted for a study of the effects of the project on spawning gravels, no similar analysis has yet been undertaken as to the effects of project operation on river bank erosion. A separate analysis of bank erosion potential should be completed as soon as feasible, at least in advance of any proposed permanent reoperation involving revision of the Water Control Plan.

If as a result of these analyses, it is determined that the spawning areas or riparian habitat may be adversely affected by the enlarged outlets, the Corps should first consider alternative operational scenarios that would reduce or eliminate the risk of such impacts. Such actions may include additional operational rules, modification of the flood diagram to reduce the frequency or duration of high discharges, or possibly augmenting existing structures to permit these operations without detracting from flood protection (e.g., slight raising of Folsom Dam). If outlet operation could be further restricted when upstream reservoir space is low, this might eliminate the occasional high outflows we cite as potentially causing impacts on resources.

If such alternatives cannot completely eliminate impacts, a decision must be made as to whether the residual impact is of a sufficiently low magnitude that it can be fully mitigated. We believe this is the case for the proposed project, because the potential impacts are modest, and would manifest over the long term. Mitigation actions may consist of restocking spawning gravels or performing other channel modifications in which spawning areas would tolerate large flows, and stabilizing eroding banks with biotechnical repairs that emphasize natural materials (vegetation, wood) with an absolute minimum use of rock. Even in the event these impacts are considered insignificant (or there are predicted net benefits), we would still recommend a long-term monitoring program be implemented, and contingency actions be developed that would be done in case unanticipated impacts are observed. Biological monitoring elements in the lower river may include additional redd surveys after large discharge events, evaluation of juvenile rearing, and regular surveys of spawning gravel, bed topography, bank erosion, and riparian cover. The surcharge zone should also be surveyed for habitat distribution at regular intervals over the long term (e.g., every 10 years), and after each use of the surcharge zone (i.e., once every 150-200 years). Finally, a contingency plan to maximize use of the spillway should be developed for use in those instances in which flood releases might be needed when the reservoir is stratified.

Considering the array of possible operational rules that could be employed, and our initial evaluation of the worst case of identifiable impacts, we believe that the proposed outlets and surcharge structures are not likely to result in substantial changes in habitat quality or quantity in the immediate future. At worst, the project could result in some incremental reduction in habitat quality over the long term, but it does not appear to be of the sort that would be immediate, permanent, severe, or unmitigable. We also believe the flexibility in operation provided by the project structures could be used in ways which minimize impacts of the project and, possibly, provide benefits in some years. At the least, should it be shown that the existing condition of uncontrolled flows of up to 160,000 cfs during a 100-year event could cause habitat loss, the project would eliminate that particular risk. Lastly, if any unanticipated levels of impact are revealed at the conclusion of ongoing Corps studies, our recommendation to minimize them would involve adjustment of operations (including other restriction rules), rather than modifying the design of the outlets or discontinuing construction. The appropriate time to consider these adjustments, and completed studies on spawning gravel and bank erosion impacts, would be as part of a permanent reoperation, at the time that revision to the Water Control Plan associated with reoperation is submitted to the Service for additional FWCA coordination and ESA consultation activities. Accordingly, the Service does not object to construction of the proposed project at this time, even in the absence of complete information on the effects at high flows.

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APPENDIX 1   NMFS letter of concurrence

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

September 19, 2000

In Reply Refer to:
SWR-00-SA-0057:BFO

Dale Pierce, Acting Field Supervisor
Fish and Wildlife Service
Sacramento Office
2800 Cottage Way, Room W-2605
Sacramento, CA 95825-1846

Dear Mr. Pierce:

This letter transmits comments by National Marine Fisheries Service (NMFS) on the U.S. Fish and Wildlife Service (FWS) draft Fish and Wildlife Coordination Act (FWCA) report titled, "*American River Watershed Investigation Folsom Dam Outlet Modification Project, California*". The report evaluates the impacts to fish and wildlife of enlarging the outlet pipes on Folsom Dam from 5x9 feet to a maximum of 10x15 feet, which would increase total discharge capacity from 32,000 cfs to 115,000 cfs. The project is proposed by the Army Corps of Engineers (Corps) to increase the level of flood protection by enabling operators to balance outflows with inflows early in the storm hydrograph.

NMFS is responsible for the management, conservation and restoration of anadromous fish species listed as threatened or endangered under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.). In addition, recent amendments to the Magnuson-Stevens Fisheries Conservation Act require federal action agencies to consult with NMFS regarding potential adverse effects of their actions on Essential Fish Habitat (EFH), which has been designated for important anadromous and marine fish species.

The Pacific Fishery Management Council (PFMC) has recommended that EFH be adopted for the Pacific salmon fishery. The geographical extent of this EFH identification includes freshwater habitat currently or historically accessible to pacific salmon. Therefore, in addition to consultation under Section 7 of the ESA, an EFH consultation with NMFS will be required for this project.

NMFS has reviewed the FWCA report. The proposed Corps project may adversely affect federally threatened Central Valley steelhead (*Oncorhynchus mykiss*), and impact critical habitat, as well as adversely affect EFH for fall run chinook salmon (*O. tshawytscha*). As cited in the report the critical shear stress, the force needed to begin moving the bed material, is 50,000 cfs, in the vicinity of the major spawning beds. The increase in frequency of discharges > 50,000 would be about four times as frequent as under current existing conditions. Model runs conducted by Corps for the Auburn Dam proposal showed a loss of 3,800 tons of bed material between Nimbus fish weir and San Juan Rapid.

Direct impacts to steelhead spawning and habitat may occur, if under the worst-case scenario, water would be released during the first or second large storm of the season, December through mid-February.

We concur with the FWS recommendations that Corps conduct additional sediment engineering studies below Nimbus Dam to estimate the effect of these increased flows on salmon and steelhead spawning and their habitat. Operational alternatives should be evaluated first before enlarging the outlets. The Corps should also consider mitigation actions proposed by FWS such as restocking spawning gravels for both species in several areas below Nimbus as well as adding large woody debris to eroding banks in place of rip rap.

Due to the cost and length (5-6 years) of this major construction project NMFS recommends that the Corps initiate formal consultation with this agency and FWS pursuant to Section 7 of the ESA. The EFH consultation for this proposed action will be consolidated with the above referenced Section 7 consultation. The Corps may incorporate the EFH assessment into documents prepared for the formal consultation initiation package such as in the biological assessment.

Since the Bureau of Reclamation (Bureau) has already embarked on a Value Assessment (VA) of modifications to Folsom Dam for temperature control, perhaps the Bureau and the Corps can work together to find a solution that will increase flood protection and provide cooler temperatures during summer and fall

If you have any questions , please contact Bruce Oppenheim in our Sacramento Area Office, 650 Capitol Mall, Suite 6070, Sacramento, CA 95814. Bruce can be reached by telephone at (916) 498-8989 or by FAX at (916) 498-6697.

Sincerely,

for Rebecca Lent, Ph.D.
Regional Administrator

cc: NMFS-PRD, Long Beach, CA
U.S. Army Corps of Engineers, Sacramento District, CA (Attn: Patricia Roberson)

APPENDIX 2 NMFS and USFWS Biological Opinions

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

IN REPLY REFER TO
1-1-01-I-1706

May 7, 2001

Mr. Ken Hitch
Chief, Planning Division
Department of the Army
U.S. Army Engineer District, Sacramento
Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Subject: Review of the Proposed American River Watershed - Folsom Dam Modification Project, Sacramento, Placer, and El Dorado Counties, California

Dear Mr. Hitch:

This letter is in response to your June 19, 2000, request for formal consultation on the Proposed American River Watershed - Folsom Dam Modification Project, Sacramento, Placer, and El Dorado Counties, California (proposed action). Your letter was received by the Service on June 22, 2000, and was followed by letters containing additional information required for consultation dated January 26, 2001 (received February 5, 2001) and March 20, 2001 (received March 22, 2001). This response is in accordance with Section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*)(Act).

The U.S. Fish and Wildlife Service (Service) has reviewed the information contained in your June 19, 2000; January 26, 2001; and March 20, 2001 letters. Observations of the project site, including Folsom and Mormon Island Dams were made during an April 11, 2000, site visit involving representatives of the Service, the U.S. Army Corps of Engineers (Corps), National Marine Fisheries Service (NMFS), Bureau of Reclamation (Bureau), the Reclamation Board, and MBK Engineering. Additional observations of the staging areas associated with the proposed action were made during an January 18, 2001 site visit involving the Service, Corps, and Reclamation Board.

Based on the biological information contained in the June 2000 *Supplemental Biological Data Report, American River Project, Folsom Dam Modifications*; the February 2001 *Draft Environmental Assessment/Initial Study, American River Project, California, Folsom Dam Modifications*, the March 2001 *Draft Environmental Assessment/Initial Study, American River*

Watershed, California, Folsom Dam Modification Project; and observations made during the April 11, 2000, and January 18, 2001, site visits, the Service concurs with the Corps' determination that the proposed action is not likely to adversely affect the threatened valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), the threatened Sacramento splittail (*Pogonichthys macrolepidotus*), or the threatened delta smelt (*Hypomesus transpacificus*). A complete administrative record is on file at the Sacramento Fish and Wildlife Office (SFWO). The following narrative describes the proposed action and the specific measures that ensure the proposed action is not likely to adversely affect listed species.

Description of the Proposed Action

The Corps has proposed to use controlled interior blasting to enlarge the eight existing river outlets on Folsom Dam to allow them to conduct 115,000 cubic feet per second (cfs) at a reservoir elevation of 418 feet. Construction is scheduled to last 6 years, with no loss in the discharge capacity of the dam.

Surcharge storage, the reservoir storage located above the gross pool elevation [between 470 feet above mean sea level (amsl) and 474 feet amsl], will be used to increase the flood control capacity of the reservoir. Changes to the surcharge space will be accommodated via the replacement of the three emergency spillway gates with Tainter gates (as already exist on the five main spillways), relocation of the hydraulic power units for the penstock gate hoists, raising the impervious core (slurry wall) within Mormon Island Dam and Dikes 5 and 7, and by flood-proofing the Newcastle Power House.

Haul routes to and from the dam site are on existing, well-maintained access roads. Staging areas are situated within existing parking lots or equipment yards. Disposal will only occur at existing, permitted facilities.

Delta Smelt and Sacramento Splittail

Delta smelt occur in the portion of the lower American River that forms a backwater during elevated river stages in the lower Sacramento River. Delta smelt critical habitat includes areas of tidal influence, including the extreme lower reaches of the lower American River. Sacramento splittail spawn in the lower American River in greater numbers and throughout more of the reach than do the delta smelt. Given that the Sacramento splittail spawns more widely in the lower American river, and that spawning requires areas of shallow water with emergent and submergent vegetation which could be affected by the proposed action, this species is given the greater consideration in this effects analysis.

Dredging will occur on the upstream portion of Folsom Dam, within Folsom Lake, and will be timed so that impacts on downstream turbidity are within background levels. In the event that turbidity is increased downstream, it will most likely be entirely contained within Nimbus Reservoir. Dredge spoil will be dried in a containment area at the lake and disposed of off-site.

The proposed action will involve no direct effects on Sacramento splittail or delta smelt and will not destroy or adversely modify delta smelt critical habitat. Construction is to occur within and surrounding Folsom Dam. Delta smelt and Sacramento splittail do not occur in Folsom Lake or in Nimbus Reservoir, and will not be affected by the proposed action. Ground disturbing activities, such as within the staging areas and near Mormon Island Dam, will also occur outside of the range of these species.

The project has the potential to result in changes to the downstream habitat conditions for Sacramento splittail. Concerns over scour of gravels used by salmonids for spawning has resulted in the preparation of an operational Rule Restriction that applies to flows between the 2.5 to 10 year return interval. The Rule Restriction will limit Folsom outlet releases to less than historic levels for this critical range of flows. At above 150,000 cfs (larger than the 10 year flood), the restriction would be removed.

The restricted operation of Folsom Dam with the enlarged outlet works are likely to result in relatively lower peak flows with longer durations during the 5 and 10-year return interval inflow events. Given that the lower American River exists as a laterally confined fluvial system, the Service does not consider depth of flooding (as a function of flood magnitude) to be as limiting a factor to splittail reproduction as is duration of flooding. The change in flood duration is at the scale of hours, and perhaps may not exceed one day at events up to the 10 year return interval. In this regard, the proposed action is not likely to result in increases or decreases in splittail habitat at less than 10 year floods. The change is not appreciable because splittail generally require 4 to 5 weeks to move from a fertilized egg to a juvenile fish capable of evading predation.

The Rule Restriction would be removed at flows exceeding the 10 year event. In this situation, where discharges exceed 150,000 cfs, and with the enlarged outlet works, the lower American River will be able to reach the objective release more rapidly, which equates with a steeper ascending limb on the flood hydrograph. The descending limb of the flood hydrograph would not change appreciably, as the ramping down of flood releases is structured to avoid sloughing of downstream levees. Given that flood volume (inflow) remains the same as with the without-project condition, this scenario could potentially reduce the maximum magnitude of the downstream discharge but increase the duration of overbank flooding. However, as described above, the changed flood regime is not likely to be significantly different than with the without-project condition (baseline) and is therefore not likely to be measurably beneficial or detrimental to the splittail It should be noted that increases in splittail habitat could occur if and when the Bureau and Sacramento Area Flood Control Agency, via the Lower American River Task Force, implement large-scale floodplain restoration measures in the lower American River.

The Service is concerned that reoperation of the reservoir through the enlarged outlet works will adversely affect the Sacramento splittail via changed hydrology. Reoperation, however, will be addressed via the Corps' future modification of the Water Control Manual for Folsom Dam. Modification of the Water Control Manual is expected to appreciably change the magnitude and frequency of flood releases to the lower American River which, in turn, will influence the amount of spawning and rearing habitat available to the splittail. This interrelated action will be submitted for section 7 consultation under the Act once a combined Biological Assessment (BA), National

Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) document has been prepared. The concurrence with the determination that this proposed action is not likely to adversely affect the delta smelt and Sacramento splittail, and that it is not likely to destroy or adversely modify delta smelt critical habitat does not apply to future reoperation scenarios.

Valley Elderberry Longhorn Beetle

The proposed action involves the potential for adverse effects to elderberry shrubs (*Sambucus* spp.), and therefore, the valley elderberry longhorn beetle, in four general locations; the staging areas north of the dam; Mormon Island Dam, and Dikes 5 and 7; the Newcastle Powerhouse; and within the surcharge space of the reservoir. The Service's concurrence that the proposed action is not likely to adversely affect the valley elderberry longhorn beetle is conditioned upon the temporary nature of the impacts and the implementation of avoidance measures proposed by the Corps.

The elderberry shrubs located near the staging areas occur at varying distances from vehicle use and caching activities and in several cases, shrubs are located less than 100 feet from such activities. The Service expressed concerns regarding several of the shrubs found near the upper, graveled staging area during the January 18, 2001, site visit. At this time, the Corps agreed to construct *permanent* fencing (6 feet or higher, chain link, similar to that already present at the upper staging area) as far as is practicable beyond the dripline of the shrubs and to implement dust abatement measures (daily watering of the site, "road oil" is not suitable). The Service also requires that standard signs detailing the need to protect elderberry shrubs as habitat for the valley elderberry longhorn beetle be placed at the project site. The use of the staging areas is not expected to appreciably change the hydrology or vegetative community of the site, and off-site activities and off-road travel will not be permitted.

The Corps' surveys located no elderberry shrubs that would be affected by construction activities at Mormon Island Dam, Dike 5, Dike 7, and the Newcastle Powerhouse. It should also be noted that the slurry wall work at Mormon Island Dam will not affect the hydrology of the Bureau's wetland area located south of Folsom Reservoir, as it will only exclude seepage from water within the surcharge elevation.

There are 52 elderberry shrubs located within the surcharge storage space. The Corps' environmental documents state that the changes to the outlet works will result in a reduced frequency and duration of inundation for these shrubs. The Service's Fish and Wildlife Coordination Act Report (CAR) concludes that the frequency and duration of inundation may actually increase, albeit within the scale of hours over a large, modeled period (up to 150 years). Though periodic wetting can be beneficial to elderberry shrubs, prolonged immersion is not. Regardless, use of the surcharge space is a rare event as it occurs only during large runoff events when Folsom *and* upstream reservoirs are nearly full. As such, the proposed action is not likely to adversely affect these shrubs.

Conclusion

The proposed action involves avoidance and minimization measures adequate to avoid adverse effects on the delta smelt, the Sacramento splittail, and the valley elderberry longhorn beetle. The Service therefore concurs that implementation of the proposed action, as it has been described at this time, is not likely to adversely affect these species. The Service has also determined that the action, as proposed, is not likely to destroy or adversely modify delta smelt critical habitat.

This concludes the Service's review of the actions outlined in the request. As provided in 50 CFR §402.16, initiation or reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been maintained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, or in this case, any incidental take occurs; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this review; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, or in this case, any incidental take occurs, any and all operations causing such take must cease pending reinitiation and Service review.

If you have any questions regarding this response, please contact Jason Douglas or Christopher Nagano of my staff at (916) 414-6645.

Sincerely,

CJ Nagano

for Jan C. Knight
Chief, Endangered Species Division

cc:
U.S. Fish and Wildlife Service (Attn: Doug Weinrich), Sacramento, California
Corps of Engineers (Attn: Patricia Roberson), Sacramento, California
The Reclamation Board (Attn: Bonnie Ross), Sacramento, California
Bureau of Reclamation (Attn: Rod Hall), Folsom, California
National Marine Fisheries Service (Attn: Mike Aceituno), Sacramento, California

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

March 15, 2001

In Response Refer To:
SWR-00-SA-5716:BFO

Mr. Mark S. Capik
Acting Chief, Planning Division
Department of the Army
U.S. Army Engineer District
1325 J Street
Sacramento, CA 95814-2922

Dear Mr. Capik:

This is in response to your letter of February 2, 2001, requesting concurrence that the proposed Folsom Dam outlet enlargement project is not likely to adversely affect threatened Cental Valley steelhead (*Oncorhynchus mykiss*), Sacramento River winter-run chinook salmon (*O. tshawytscha*), Central Valley fall/late-fall run chinook salmon (*O. tshawytscha*), or their critical/essential habitat. The proposed U.S. Army Corps of Engineers (Corps) project consists of enlarging the eight existing river outlets and modifying the use of surcharge storage at Folsom Dam to increase flood plain protection to the lower American River and City of Sacramento. Flood protection from this project would increase from a probability of 1 chance in 100 to 1 chance in 130 years. The addition of the surcharge component would increase flood protection from 1 in 130 to 1 in 140 chance in any one year.

The National Marine Fisheries Service (NMFS) has reviewed the project description provided in the Draft Environmental Assessment/Initial Study - Folsom Dam Modifications dated February 2001; Surface Water Resources, Inc. (SWRI) Memo #887 dated January 25, 2001; Fish and Wildlife Coordination Act Report (FWCA) prepared by the Fish and Wildlife Service (FWS), revised January 2001; and the Supplemental Biological Data submitted to NMFS dated June 19, 2000.

By letter dated September 19, 2000 to FWS, the NMFS commented on the draft FWCA report expressing concerns that increased frequency of flows in the lower American River (LAR) may increase bedload movement (scouring) below Nimbus and have direct impacts to steelhead and salmon redds during the December through February spawning period. On December 12, 2000 the Corps hosted a meeting with FWS, NMFS, Sacramento Area Flood Control Agency (SAFCA), MBK Engineers and CH_2MHill consultants to discuss potential impacts of the Folsom Dam modifications. The Corps evaluated this potential effect and proposed adopting a "Rule Restriction" that would reduce Folsom Lake outflows to 60 percent of inflows unless forecasted inflows exceed 150,000 cfs.

The SWRI evaluated the potential temperature impacts of a "Rule Restriction" with and without the enlarged outlets and found no significant effect on cold water pool management capabilities (SWRI Memo #887). The operation of the enlarged outlets under the "Rule Restriction" would likely result in substantial cold-water pool conservation during most years. In addition, the Bureau of Reclamation's (Reclamation) standard operating procedure to use the spillways, would avoid the loss of cold water reserves from outlet operations during rare periods in the spring when Folsom Lake becomes stratified by the end of March.

Based on the best available information, NMFS concurs with your determination that the proposed project is not likely to adversely affect Central Valley steelhead, Sacramento River winter-run chinook salmon, and Central Valley fall/late fall-run chinook salmon, or their critical habitat. Our concurrence is contingent upon Reclamation operating Folsom Dam to the "Rule Restriction" as described above and in the draft Environmental Assessment dated February 2001.

This area has been identified as "esential fish habitat" (EFH) in Amendment 14 of the Pacific Salmon Fishery Management Plan, pursuant to the Magnuson-Stevens Fishery Conservation and Management ACT (MSA). Federal action agencies are mandated by MSA (section 305(b)(2)) to consult with NMFS on all actions that may adversely affect EFH and NMFS must provide EFH Conservation Recommendations (section 305(b)(4)(A)). Because the proposed action is not likely to adversely affect Central Valley fall/late-fall run chinook salmon in the area, and the habitat requirements of fall/late-fall run chinook salmon in the area are similar to the listed species, EFH Conservation Recommendations are not required at this time. However, if there is a substantial revision to the action, the Corps will need to initiate EFH consultation.

Should additional information reveal that the action may affect listed species in a way not previously considered or should the action be modified in a way that may cause additional effects to listed species, this concurrence determination may be reconsidered.

If you have any questions regarding these comments please contact Bruce Oppenheim in our Sacramento Area Office, 650 Capitol Mall, Suite 8-300, Sacramento, CA 95814. Bruce may be reached by telephone at (916) 930-3603 or by FAX at (916) 930-3629.

Sincerely,

for

Rebecca Lent, Ph.D.
Regional Administrator

cc: NMFS-PRD, Long Beach, CA