United States Department of the Interior

FISH AND WILDLIFE SERVICE
San Francisco Bay-Delta Fish and Wildlife Office
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In Reply Refer to:
2022-0043398

Ms. Alicia Kirchner
Chief, Planning Division
Sacramento District
U. S. Army Corps of Engineers
1325 J Street
Sacramento, California 95814

Subject: Supplemental Fish and Wildlife Coordination Act Report for the Lower San Joaquin River Feasibility Study - Segment TS_30_L Habitat Evaluation Procedures

Dear Ms. Kirchner:

Per our Scope of Work for FY 2022, please find enclosed the subject report.

If you have any questions, please contact Steven Schoenberg of my staff at (916) 930-5672, or by email at Steven_Schoenberg@fws.gov.

Sincerely,

DANIEL WELSH
Digitally signed by DANIEL WELSH
Date: 2022.11.30 08:16:10 -08'00'

Daniel Welsh
Deputy Field Supervisor

Enclosure

cc:
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SUPPLEMENTAL FISH AND WILDLIFE COORDINATION ACT REPORT FOR THE LOWER SAN JOAQUIN RIVER FEASIBILITY STUDY:

SEGMENT TS_30_L HABITAT EVALUATION PROCEDURES

PREPARED BY:

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INTRODUCTION

This report is a supplement to the Fish and Wildlife Service's (Service) Fish and Wildlife Coordination Act (FWCA) detailed report (hereafter, "2016 FWCA") on the U.S. Army Corps of Engineers (Corps) Lower San Joaquin River Feasibility Study (LSJRFS) (FWS 2016). The purpose of this supplemental report is to present the results of a habitat evaluation of one reach segment within that study known as TS_30_L. We also provide preliminary recommendations for the siting of mitigation for the impacts of construction of that reach.

BACKGROUND AND COORDINATION HISTORY

The preferred alternative for the proposed project (alternative 7a) involves some 24 miles of levee improvements, of which TS_30_L is part, and two tidal gates in an overall effort to protect greater Stockton from flood events. The 2016 FWCA did not include a formal habitat evaluation of any of the project elements because of limited information, and funding and schedule constraints within the Corps' "SMART" planning guidance (Corps 2015a). Therefore, we were limited to a Corps-provided desktop analysis using aerial images and their estimates of impact, and our own observations during several hours of site visits to the project element locations. The 2015 draft Integrated Feasibility Report/Final Environmental Impact Statement/Report (FS/FEIS/R) stated that a full mitigation plan, including field surveys and habitat evaluations as appropriate, would be done during the Pre-construction Engineering and Design (PED) phase (Corps 2015b).

The Corps issued a final FS/FEIS/R for the project in 2018 (Corps 2018). There are significant differences from the project as described in the final environmental document (Corps 2018). The 2018 FS/FEIS/R states that mitigation bank credits would be obtained to offset impacts of the project; however, such credits are not currently nor foreseeably available. In response to our 2016 FWCA, the Corps also committed in its 2018 FS/FEIS/R to evaluate other on and near impact site opportunities for mitigation, including some we had identified (FWS 2016). The project elements that would incorporate mitigation for impacts included one setback levee, within Fourteenmile Slough, which would incorporate mitigation in the forms of some riparian and Shaded Riverine Aquatic (SRA, a type of riparian cover adjacent to water) cover types, and was also intended to accept elderberry transplants (host plant for the federally listed Valley Elderberry Longhorn Beetle, or VELB) from other parts of the project. However, constructing other reaches like TS_30_L in advance of the Fourteenmile Slough element creates the additional need to develop mitigation elsewhere.

The Feasibility Study entered the PED phase around October 2019 and the Service was funded in late 2020 to resume FWCA coordination activities. The Corps had selected the segment TS_30_L as the first construction element, a 5,900 foot long stretch of levee bordered at the south by March Lane and to the north by the Fourteenmile Slough levee near White Slough. In environmental documents and our 2016 FWCA report, this segment is one of several in the Delta Front work element, which includes Shima Tract, Fivemile, Tenmile, and Fourteenmile Slough, with "TS" referring to the Tenmile Slough levee. The work at TS_30_L originally involved the installation of cutoff walls, slope reshaping, and application of west facing rock protection.

Project refinements to TS_30_L have since been identified which would likely increase impact beyond the estimates in the environmental documents, including a 20-foot westward levee prism shift which is needed to allow room for a patrol road to inspect the land (east) side of the levee. This would extend water side work (rock revetment, patrol road, levee reconstruction), in most sections, all the way to the irrigation ditch (the westward extent of the natural habitat). Additionally, at the time of the 2018 FS/FEIS/R, there was consideration of applying for a variance which would permit some vegetation on the lower slopes of levees. During PED, however, the Corps determined it would not seek a vegetation variance, but might consider a design deviation based on risk assessment which could permit some vegetation growth. Whether or not a design deviation is approved, nearly all vegetation within the impact footprint area would be removed initially due to earthwork.

A more detailed site visit to the TS_30_L impact area was conducted in March 2021. Among the more notable observations was the apparent high wildlife use by songbirds and raptors, elderberry bushes, and mixture of habitat elements (trees, snags, shrubs, herbaceous areas, native trees, exotics). Persistence of the habitat appeared to be a consequence of both proximity to an irrigation drainage ditch, and apparent low maintenance at least on the lower levee slope. Several potential areas for mitigation were discussed and/or looked at briefly in early 2021 as well.

We provided a site visit report in March 2021 with our findings and, after further review of the project history, we also provided a May 2021 guidance memo with our preliminary recommendations for mitigation and imminent construction as it pertains to TS_30_L. In brief, we concluded no path forward to 2021 construction because of unresolved matters of project impacts without mitigation agreed and in place prior to project impacts, unevaluated changes to the project, elderberry impacts which required reconsultation, and the need to evaluate on/near site mitigation options. Our primary recommendation, if the Corps intended to proceed with TS_30_L construction in the near term, was to plan a mitigation area in a corridor adjacent to the affected habitat.

Beginning late August 2021, the Service participated in a number of calls with the Corps related to the sequencing of the project, various mitigation locations and ratios, and technical assistance under the Endangered Species Act (ESA) regarding federally listed species. The Corps planned to proceed with the project beginning with vegetation removal in early 2022 in advance of other construction. To quantify the baseline habitat value of the impacted areas before these anticipated impacts, the Corps communicated to the Service the need to conduct a habitat evaluation of the impact area of TS_30_L. That habitat evaluation, based on field work conducted in December 2021, is the focus of this supplemental report. At the time of the writing of this report, vegetation has not been impacted because the project has not yet begun. On July 26, 2022, the Service attended a site visit to view additional potential mitigation sites. To better assist the Corps' mitigation planning, this report also includes an initial evaluation and prioritization of these mitigation sites based on our observations and best professional opinion.

HABITAT EVALUATION PROCEDURES

Habitat Evaluation Procedures, or "HEP", is an accounting methodology developed by the Service and other agencies to quantify habitat value of a particular area of habitat to selected wildlife species or communities associated with that habitat (FWS 1980a, 1980b, 1981). It is based on models which calculate an index value between 0.0 and 1.0, the Habitat Suitability Index (HSI), that is used to weight habitat area. HSI models consist of a set of habitat variables which are measured or estimated (usually denoted V1, V2... etc.) that are considered important life requisites to the particular wildlife species or community. These variables, or Vs, are converted to Suitability Indices (SIs) using graphical relationships or best-fit word descriptions provided in the model that assign an index value to a measured or assumed variable quantity. The SIs are then combined using equations to obtain the HSI. A series of HSIs are estimated for several points in time in the future (called Target Years, or TYs), over the life of the project; these sets of HSIs for the target years are commonly referred to as "futures". For these futures, the HSI is multiplied by the habitat area to obtain habitat units, which are summed and averaged over the life of the project (Average Annualized Habitat Units, or AAHUs). This routine can be applied to both an impacted project site and a proposed mitigation site. AAHUs are used as the metric to compare habitat values of the future without the project to the future with the project.

APPLICATION AND LIMITATIONS

HEP is a tool that can be useful in assessing the need and adequacy of mitigation for impacts of an action but it has limits and assumptions. AAHUs for a mitigation site can be compared to that of an impact site to estimate the area of mitigation necessary to provide at least the same habitat value. HEP does not normally include and therefore does not evaluate habitat values within a landscape context: corridor values that permit the movement of wildlife across a landscape, the distribution and rarity of habitat across a region, actual use by wildlife, or the interaction between habitats, agriculture or urban components. It is often a coarse evaluation, subject to error in the measurements themselves and variation in the way wildlife resources use habitat in different regions of the Country. HEP is also not used for listed species. Instead, mitigation for effects on listed species is determined separately during ESA consultation, often using guidance documents and similar treatment as in other consultations for the individual species. Listed species guidance can vary, and may involve the use of standardized mitigation ratios and other factors.

MODEL SELECTION

The process of model selection for this HEP study involved preliminary assessment of the habitat during a site visit, a review of available models, and communication with a HEP team that included Service and Corps staff. Models were selected that we considered to best represent the values of the affected habitat and mitigation, and the majority of the habitat components. A site visit was first conducted on March 9, 2021. Vegetation had just started to leaf out, however, the general habitat characteristics could be observed. There was a mix of woody vegetation dominated by dense shrub species, particularly willows, blackberry, and buttonbush, together with some larger and taller willows, other taller trees such as oaks and some non-natives (walnuts, pecan) and patches of rose and elderberry. Snags (larger dead limbs or entire dead trees) were evident throughout the site. The woody vegetation was interspersed with tall herbaceous plants, especially thistle. Wetland patches were also seen in association with what appeared to be an agricultural drainage ditch at or slightly beyond the toe of slope, which was maintained on the west side and had water (or evidence of recent water). At this time, and in subsequent visits to the site, a variety of avian wildlife were noted such as hummingbirds, sparrows, mockingbirds, raptors, quail, and others. The habitat mix varied over the length of TS_30_L, with areas dominated by shrubs, trees, or herbaceous plants, depending on exact location.

On the basis of these initial observations, we reviewed available models and selected a suite of five HEP models that would complement one another and best represent the values provided by the existing habitat. These included published models, modifications to published models, and in-house unpublished models locally developed and applied to evaluations of other Corps projects. A HEP "package", consisting of the models, summary of methods, and basic rationale, was provided to the Corps prior to field sampling. The Corps noted prior to field sampling, per their current guidance, that unpublished and modified models would need to undergo a certification process, which involves review by the Corps' Engineering Research and Development Center (ERDC) and communication with Service staff. However, given the field conditions (late fall), the Service and Corps mutually agreed to proceed and complete field sampling, in advance of completion of the certification process. The Service responded to all ERDC requests for documentation and justification of models used to the extent these were available. The Corps notified the Service that certification was forthcoming, and to proceed at least for use in this specific application (HEP evaluation of TS_30_L) (August 4, 2022, email from David Fluetsch, Sacramento District). The selected models and rationales are as follows:

Yellow Warbler (Schroeder 1982): The preferred habitat of this species is a deciduous riparian assemblage of hydrophytic species such as willows and cottonwoods. It is a summer resident in similar habitat in the Central Valley of California. This model emphasizes the lower and middle canopy and the habitat preference of this species for hydrophytic shrubs. The Service developed and validated this model for use throughout this species' range; however, the original model is derived from early work in the eastern United States which acknowledged forest use as occasional only. That original model had three variables, all associated with shrubs and/or lower canopy (percent deciduous crown cover, average shrub height, and percent hydrophytic shrubs). We used a modification of this published model that we had also applied to other local Corps Federal projects since 1998. This modification added a fourth variable for tall trees, consistent with forage beats by this species in the West ranging up to 40 feet above the ground, presence of trees in portions of the project area, and expected effect of the project on this combination of tall trees with a shrub understory. During the Corps' certification process, we researched and responded to Corps questions to justify this modification, noting that partial use of the higher canopy by this species had been well documented in the West.

Riparian Songbird Guild (Roberts et al. 1986): This is an unpublished model originally developed for application to forested or scrub-shrub wetlands in Humboldt Bay, and was the original model used to evaluate riparian forest habitat in the 1999 and 2009 HEPs of the Corps' Napa Creek project (FWS 2009). It is intended to apply to a relatively broad range of bird species (mostly in the order Passeriformes, but also associated species in the order Piciformes) that use plants, snags or associated insects for food, or use the plants and snags for nesting. Variables include shrub and tree cover, tree height, canopy layering category, snags, and overall woody cover. The variables focus on somewhat shorter canopy elements. This model has the smallest snag dimension (4 inches) of the three models with snag variables used for TS_30_L. This was deemed appropriate because of the presence of woodpeckers and birds at TS_30_L, and the small snags present that would be impacted by the project.

Riparian Forest Cover Type (DeHaven 2001): This unpublished model was developed by the Service's Sacramento Fish and Wildlife Office originally for Corps bank protection actions along the lower Sacramento River, and was later modified for use in the Corps' Llagas Creek project. It is a generalist model, intended to quantify values to a range of bird and mammals that could utilize this habitat. It combines vegetation parameters such as height, closure, stand width, understory, and species number, and has discounting factors for non-native dominance and distance from water. This model is sensitive to structural diversity of habitats and narrowing of corridors by project actions. It was considered appropriate for TS_30_L in light of the combination and variation in tree and shrub cover, and stand width, at this location.

Downy Woodpecker (Schroeder 1983): The species' habitat covered by this published model associates primarily with older soft wood riparian species like willow and cottonwood in lowland stream bottoms. Older trees are not common in TS_30_L, but are present and considered a significant component which would be affected by the project. The variables are snags (6 inch minimum; required for value) and basal area at breast height, the latter of which can only be coarsely estimated in thick young stands such as TS_30_L. Nevertheless, this model was included in this HEP analysis because it reflected the values, albeit limited, of this older vegetation component, the presence of snags at TS_30_L, and the observation of cavity dwellers such as woodpeckers and owls at this site.

Hairy Woodpecker (Souza 1987): The habitat represented by this published model is also older, larger, trees in a variety of forest types and densities. Measurements include mean tree diameter at breast height (used in two suitability indices), canopy cover, and snag count. It has an even larger snag dimension criterion (10 inches) than other models in this HEP study. It was included for the HEP at TS_30_L as an alternative to the Downy Woodpecker model. This model emphasizes larger trees and snags, but without an absolute requirement for snags to yield value in a plot. Larger trees and snags were present, but infrequent and patchy, at this location.

STUDY ACTIVITIES

The HEP evaluation for TS_30_L involved the following sequence of activities:

a) *Field Sampling*: Sampling was conducted on December 2, 3, 7, and 8, 2021. The Service author of this report was present on all days (Steven Schoenberg, Senior Biologist), and was assisted by one or two Corps staff each day (Savannah Fahning, Jessica Agajan, Steve McLemore, Miranda Doutch, or Dave Fluetsch). Conditions were considered fair due to some leaf drop and shedding of terminal branches, but acceptable for the purposes of the study. The suboptimal field conditions mean that there is some potential underestimate of features such as woody vegetation height and cover that could result in an underestimate of baseline value, but not to a major degree. The measurement requirements for the selected models included both transect and plot based parameters.

The plot size and extent of effort for each parameter was tailored by the Service staff's best judgement to complete the sampling in a reasonable time, given the size of the site, the need to assess 20 variables in the five models, limited remaining season due to ongoing leaf and branch shedding, and short days at the time of the field work. The TS_30_L site is also typified by the presence of a dense, often thorned, lower shrub layer, and patchy dense woody stems. The limited time available to meet these study needs and difficulty moving within a site with these characteristics necessitated a coarse, visual estimation of some variables. Detailed measurement protocols for each variable are provided in Appendix A, TAB: Models.

Taking these factors into consideration, a plot length of 300 feet was selected, which could be sampled within study time constraints while still capturing the variation in habitat suitability over the length of the site. Two perpendicular transects were set up in each plot. Transect position within a plot was decided by selecting two single digits from a random number table (1-9), which were each multiplied by a tenth of the total plot length to determine the locations of the perpendicular transects. After a plot and its transects were set up, a waypoint location of the beginning (south end) of each plot was recorded on a GPS device. When all sampling was completed, the spatial data for the plot boundaries were downloaded from the GPS device using the software Garmin Basecamp, and converted to a shapefile (Appendix D, Plate 1). Three photographs were taken on each plot, one facing north from the beginning of each plot, and west across each of the two perpendicular transects. Measurements were recorded on paper data sheets, one per plot (Appendix C). All raw data were entered into a multitab Excel spreadsheet file, designed to convert the data into SIs and HSIs for each model (Appendix A). In a few rare instances of missing data, all noted in Appendix C, either reference photos and/or similar data from other models were used to develop a best estimate of values for those variables.

b) *Data Reduction*: Measurements from the two transects for each plot were averaged to obtain plot specific values for the transect-based measurements and, with the values for the other full plot measurements, were used to obtain a single plot-specific variable for each SI and then, using the model equations, plot specific HSIs for each model. These plot-specific HSIs were averaged to determine a reach-wide HSI for each model. This manner of calculation, with plot-specific HSIs used to obtain a reach-wide average, is typical in HEP studies. Some test calculations were done by assigning a single, reach-wide average SI for snag density and basal area to each of the plots, to see if variation between plots in these particular variables might bias the reach-wide HSI. However, these test calculations showed that the reach-wide average HSI would be the same with either calculation routine (Appendix A, TAB: HSIdatacalcs, lines: 224-225, 282), so this alternative routine was not used, and is not discussed further in this report.

c) *Futures*: Initial, solely HEP-based, estimates of mitigation needs were made by developing mitigation site futures and calculating and comparing changes in habitat value (AAHUs) for the Corps-determined 13.88 acre impact footprint and a hypothetical 10 acre (ac) restoration site (Appendix A, TAB: futures). The ratio of losses at the impact site to gains at the restoration site, adjusted by area, is the theoretical mitigation ratio. As noted in the general assumptions described below, for the purposes of this exercise, we assume that restoration at the mitigation site, including planting, is complete by the time of first project impact.

Two future comparisons were done. In the first, we varied habitat development. Two future scenarios were developed to describe the range of potential mitigation ratios and areas: a "best case" scenario with the fastest development and higher optimum ranges reflective of high management and success; and a "worst case" scenario, which has a more moderate rate of habitat development and maxima. This "worst case" scenario is not unsuccessful, but takes into consideration the possibility of less than fully optimal habitat for certain model parameters. Such limits on habitat potential may reflect constraints created by variability in weather and water availability, unforeseen disturbances like fire and disease, site-specific limitations such as power line easements, natural variation in parameters, and/or reduced long term management.

In the second comparison, we varied mitigation start. We compared mitigation that was started 10 years prior to impact, with mitigation concurrent with impact, for the worst case scenario only (see RESULTS, below).

d) *Mitigation Site Qualitative Evaluation*: Based on site visit observations, and our best professional opinion, we analyzed six identified locations in terms of other habitat value characteristics not reflected in the selected HEP models (distance from impact, corridor value, utility easements, buffer value, adjacent land use, floodplain/connectivity to delta waters, benefits to special-status species, unit size, etc.). Together with the futures estimate of mitigation site habitat value from the HEP, this qualitative evaluation was used to prioritize the sites and propose a recommended mitigation ratio for each location.

c) *Documentation*: Documentation of study activities is provided within the Appendices of this report (Excel spreadsheet, data forms, models, plates) and/or, as appropriate, is maintained in electronic files at the Service's field office (Excel spreadsheet; shapefile of plot boundaries; reference photographs; email communications).

ASSUMPTIONS

The following assumptions apply to the analysis and findings in this report:

-The impact site at TS_30_L, about 13.88 ac, can be adequately assessed as a single cover-type consisting of a mosaic of patches of scrub, herbaceous, scrub and tree cover in varied proportions, wetland, and ditch cover.

-All vegetation will be initially removed within this 13.88 ac project footprint.

-For the purposes of assessing without-project habitat value, we assume that the baseline measurements in this HEP are representative of the future, which is explicit in the calculations as shown by a constant HSI for the life of the project, without the project.

-The life of project is 50 years, equivalent to the period of economic analysis, and the period of analysis is 51 years, equal to the life of project plus construction, assumed to be one year.

-There is an inherent, unknown, level of error due to simplification of the measurement techniques for many of the variables, such as rough visual estimates of cover proportions (see Appendix A for details). Nevertheless, the measurements are assumed to be of adequate accuracy to represent existing habitat values of the site and hence, determine the losses and mitigation need associated with project implementation.

-There is also an inherent, unknown, level of error due to simplification of the calculation procedure, which uses the average HSI across plots and the overall impact area (13.88 ac), to calculate habitat value. Again, although higher precision is possible with a stratified sample across patch subtypes, and much greater effort, the simplified procedure is assumed adequate to represent existing habitat values and losses with project implementation.

-For the purpose of the simplified analysis of futures, below, we assume that mitigation site construction is completed at Target Year 1, the time of impact. Impact in this situation is the clearing of vegetation in TS_30_L, which would occur in the winter preceding construction-related earth-moving later that same year. In habitat restoration, earthwork is done before planting. Accordingly, the results discussed below for concurrent mitigation would apply only to a situation where restoration is complete (i.e., including planting), by the time of first impact.

RESULTS

Results are expressed in habitat value changes, in AAHUs, calculated for the five models at the impact site and a theoretical 10 ac site under best and worse case future scenarios (Table 1).

Table 1: Habitat Values for TS_30_L HEP study. Impact is loss of December 2021 baseline. Mitigation is for a conceptual 10 ac site started concurrent with construction, under best and worst case future habitat scenarios. See text and Appendix A for details.

	Habitat Value change, AAHUs			area to offset AAHU loss, ac		“mitigation ratio”	
future habitat scenario:		best	worst	best	worst	best	worse
	Impact	mitigation	mitigation				
Model:	TS_30_L	10ac	10ac				
Yell. Warbler	-8.8	8.8	5.9	9.9	14.9	0.72	1.08
Rip. Songbird	-8.8	5.7	3.0	15.5	29.3	1.12	2.11
Rip. Forest CT	-10.0	8.9	5.4	11.3	18.8	0.81	1.35
Downy Wood.	-3.2	2.1	1.4	14.8	22.2	1.07	1.60
Hairy Wood.	-0.9	4.1	0.9	2.1	9.2	0.15	0.88

Comparison of the losses at the impact site to the gains at the theoretical mitigation site is used to determine the mitigation need in terms of acres and the mitigation ratio. In such an analysis, it is customary for the Service to apply to its recommendation the result from the model that shows the greatest ratio. This practice ensures that in-kind values for other models with lower ratios would be at least fully compensated. For TS_30_L under the stated assumptions, and assuming a reasonable worst-case future scenario for mitigation, full compensation for loss of habitat values for all models would be achieved by a ratio (impact site: mitigation site) of about 2.11:1. This would require a riparian mitigation area of 29.3 ac to offset the habitat value impacts to the 13.88 ac at TS_30_L. As we explain below (Analysis), this result is not a precise prescription for our mitigation recommendation due to factors beyond the scope of the models.

We also conducted a futures analysis to compare mitigation scenarios (worst case only) where the mitigation was assumed initiated 10 years before impact (Table 2). This was intended to illustrate the mitigation value in excess of that needed for TS_30_L, which could be used to offset a future impact (APPENDIX A, TAB: futureexcess). For purposes of this exercise, we assume that the impact is the same as TS_30_L, although another reach would likely have a different baseline and area. Over a 51 year period of analysis of that scenario, an earlier mitigation start lowered the mitigation ratio. The greatest difference is for the Hairy Woodpecker model (ratio of 0.49 compared to 0.88, above) which is attributed to the longer period of snag presence. The minimum effect, for the Riparian Songbird Guild model, is slight (ratio of 2.05 compared to 2.11, above). Taken together, the results indicate that the recommended mitigation ratio with advance mitigation (or remaining excess used for future impacts) remains about 2:1.

Table 2: Habitat Values for TS_30_L HEP study. Impact is loss of December 2021 baseline. Mitigation is for a conceptual 10 ac site started either concurrent with construction or 10 years before construction (“10 yr”, below), under worst case futures scenario. See text and Appendix A for details.

	Habitat Value change, AAHUs			area to offset AAHU loss, ac		“mitigation ratio”	
start scenario:		concurrent	10 yr	concurrent	10 yr	concurrent	10 yr
site:	Impact	Mitigation	Mitigation				
Model:	TS_30_L	10ac	10ac				
Yell. Warbler	-8.8	5.9	6.7	14.9	13.1	1.08	0.94
Rip. Songbird	-8.8	3.0	3.1	29.3	28.4	2.11	2.05
Rip. Forest CT	-10.0	5.4	5.7	18.8	17.7	1.35	1.28
Downy Wood.	-3.2	1.4	1.5	22.2	20.8	1.60	1.50
Hairy Wood.	-0.9	0.9	1.3	9.2	6.8	0.88	0.49

ANALYSIS

Here, we consider differences between the impact site and alternative mitigation locations (Appendix D, Plates 2-3). This analysis involves other factors not inherent in HEP which, together with the HEP results, are used to develop recommendation for siting priority and site-specific mitigation ratios for impacts at TS_30_L. Unless noted otherwise, the sites are privately owned. These mitigation locations are:

- Adjacent Corridor: This would be immediately west of TS_30_L, about 80-100 feet wide and roughly the length of TS_30_L. This would make it about 25 ac, corresponding to the parcel in which it is located. There is a force sewer main and associated easement running the full north-south length of the parcel and another shorter easement where high power lines cross. As with TS_30_L, adjacent land use is residential to the east and rice agriculture within this site and to the west.
- Manteca: This site is located 18 miles south of TS_30_L, about a half mile southwest of the intersection of South McKinley Street and Pink Muhly Lane. About 150 ac, it is currently in agriculture (gourd such as squash or pumpkin). It is surrounded by levees, and part of the site is close to Walthall Slough, a perennial waterway which has some natural oak woodland, riparian, and wetland vegetation.
- Van Buskirk Park: This site is about 5 miles south of TS_30_L along the right (north) bank of French Camp Slough. It is a recently decommissioned golf course with redevelopment pending, on land deeded to the City of Stockton for the purpose of community recreation. Currently, the site has been cleared of most woody vegetation, although some scrub has regrown in former water features. The mitigation concept is to include a component of habitat restoration of some of the 152 ac in redevelopment of the site in a way that would be consistent with that purpose. Improvement of the levee at this site is another component of the LSJRFS, although it could be set back or modified to provide tidal influence and additional benefit.
- Kumar Property: This site is a horseshoe-shaped area of 50 ac, currently with young olive trees, that surrounds another 40-50 ac mitigation site managed by the Center for Natural Lands Management known as the Pace Preserve. This mitigation site has a mosaic of trees, shrubs, and wetlands. High-power lines run through the site. It is several miles west of TS_30_L. The idea at this site would be to remove the olive trees and perform habitat restoration. Vegetation may be limited under the power lines.
- Solari Property: This 50 ac site is fallowed, former farmland with a few shrubs. It is also a few miles west of TS_30_L. It appears bordered by hay fields. It is perhaps 100 yards or so from the San Joaquin River, which is leveed. There are no visible power lines or other known utilities.
- Pump Station: This 113 ac site is a mile or so north of TS_30_L at the corner of 14 Mile and White Sloughs. An actual pump station takes up a small portion of the site, and another portion of the site was used at one time as sewage ponds. Several high-voltage lines and associated towers run through the site. Most of the site is fallow herbaceous weeds, and some scrub. The concept for this site would be to restore riparian (with shorter habitat types or wetland under power lines). It may be possible to modify the levee alignment to allow tidal exchange.

PRELIMINARY MITIGATION RECOMMENDATIONS

The recommendations in this report are to be considered preliminary due to the limited information about the mitigation sites. These recommendations are based on the Service's best professional opinion on resource considerations only, such as habitat quality, fish and wildlife resource needs - including those of listed species, and landscape factors. Other factors such as real estate acquisition, cost, and implementation schedule are beyond our purview and are not discussed. As originally described in our FWCA report for the LSJRFS, repeated below, we use similarity in location and habitat type to prioritize mitigation options (Service 2016, p. 28):

> "In order of decreasing preference, the Service's preference for type and location of mitigation action for this project would be: (1) avoidance of impact, such as through changes in design or design approach; (2) minimization of impact, by similar means; (3) compensation on-site, as in the same location of the impact; (4) compensation near-site, and in-kind, as in very close proximity to the impact site on the same waterway, and of the same or similar habitat type, or, if an alternative habitat type, one which will benefit the affected fish and wildlife resources; (5) off-site compensation, also in-kind; and (6) off-site compensation, out-of-kind, meaning a moderately or completely different habitat type, but preferably, a cover type which is as or more desirable than that being affected. Existing conservation banks, due to their siting and other factors, would be considered of relatively low priority in this scheme."

Following this scheme as a guide, the Service's first preference of the location for mitigation of TS_30_L impacts is Adjacent Corridor. This is closest to the impact site and would replace several functions not achievable with other options. This is the only option which would provide, as well as enhance, a direct corridor for wildlife movement between habitat at Tenmile Slough/Bulkley Cove and Fourteenmile Slough. Habitat in Adjacent Corridor would replace the buffer between the Brookside residential community and adjacent rice agriculture currently provided by habitat in the TS_30_L footprint. Disturbance of a portion of the site, with relocation of the drainage ditch, is already necessary for the construction of TS_30_L, so the additional work for restoration would be modest. In the long term, lateral groundwater movement due to proximity to the drainage ditch would presumably support the restoration. During the design high water event, riparian vegetation here might provide an increment of wave attenuation that could enhance flood protection. The sewer main and easement location, depth, and associated vegetation restrictions, would need to be assessed for consistency with restoration. If tall unmowed (or infrequently mowed) herbaceous vegetation were allowed in this easement, this might replace the value of the herbaceous/woody mixture of the current habitat at TS_30_L.

In general, habitat quality increases with unit size and width, which are limited in Adjacent Corridor by the narrow width of the allowed woodland. However, we noted that the TS_30_L impact site is also narrow and experiences apparently high wildlife use. Raptors seen on tall snags during the March 2021 site visit may be foraging in plowed fields near the site at that time of year, or in the herbaceous grassland patches within the site. Site specific factors not explicit in the HEP models which may attract wildlife to this site include the patch combination of dense shrub, herbaceous, and tree cover, nearby semi-perennial water, semi-perennial water of the drainage ditch, associated wetlands, aspect (west facing), or other factors. The Service would recommend mitigation similar to the HEP-derived 2.11:1 ratio (mitigation area:impact area) for the Adjacent Corridor, due to its similarity in landscape functions, very close proximity to the impact site, and potential to integrate restoration work with project construction.

The Kumar, Solari, and Pump Station sites are similar in their next nearest proximity to the impact site, and have a mixture of advantages and disadvantages on first impression. Both the Kumar and Pump Station sites have significant powerline easements that would likely limit habitat restoration underneath them in those areas. The Solari property has no such easements, but it is a smaller unit size. The Pump Station has the potential for contaminants in minor areas which would require at least assessment and possibly cleanup. All are more or less isolated sites which do not act as a corridor, although all are in the general proximity of the San Joaquin River or White Slough, which are potential wildlife corridors. The Service would recommend a slightly higher mitigation ratio for these sites, on the order of 2.5:1. Because one or more of these sites have a higher near term certainty of implementation than the others, and their proximity to the impact site, they are considered second preference to Adjacent Corridor.

Van Buskirk is more distant from the impact site, but has additional potential because it is close to a section of French Camp Slough near its confluence with the San Joaquin River, and also across the slough from the French Camp Mitigation Bank. This levee is heavily rocked and planned currently to be improved (raised, slurry wall) in place under the LSJRFS, but it could be set back or modified to provide a tidal connection. This would allow for water side vegetation (both wetlands and SRA cover) habitat at the land-water interface. Mitigation in the form of waterside vegetation and tidal connection would provide habitat values to the Delta and associated aquatic community. Although tidal habitats are not impacted by TS_30_L in particular, there are expected impacts to Delta tidal waters in other elements of the LSJRFS that do affect SRA cover and shallow water habitat generally. Actual habitat restoration area at Van Buskirk is likely to be partial due to other site uses, but still significant (~50-70 ac). If Van Buskirk were to be ready and available as mitigation for TS_30_L, the Service would recommend a lower mitigation ratio on the order of 2.0-2.5:1, with the lowest ratio associated with a setback design. However, due to distance from the impact site and lower certainty of near term implementation, it is considered third priority.

Manteca is the farthest from TS_30_L but it also is the largest in size of actual restorable habitat (150+ ac). It is far enough south that it is in the range of the listed riparian brush rabbit, which has been successfully propagated and introduced elsewhere on the west side of the San Joaquin River. Adequate water appears to be available through the existing agricultural infrastructure. This site, about a mile east of the San Joaquin River, would add to other habitat on Walthall Slough and the vicinity. Nevertheless, mitigating for impacts of TS_30_L, and likely other impacts within the LSJRFS so far away would have the adverse effect of consolidation (i.e., the formation of habitat voids by concentrating mitigation at one location, to offset impacts to widely distributed habitat). Here, mitigation would be at the south end of the LSJRFS, at the expense of impacted fragments and channel-associated riparian all to the north. Additionally, this particular site is also identified for habitat restoration under the Mossdale Tract Urban Flood Risk Reduction project (Mossdale UFRR) as an enhancement action. Although the Mossdale UFRR is in earlier planning and subject to change, the Service would need to further scrutinize the matter of changing the intent of enhancement to using it as mitigation for TS_30_L. Should Manteca ultimately be selected and ready for TS_30_L, the Service would recommend a higher mitigation ratio of at least 3:1. For these reasons, the Manteca site is considered fourth priority.

GENERAL RECOMMENDATIONS

1. Sequence: To ensure that the amount (area) of habitat is not reduced and, consistent with our general guidance, we recommend that mitigation be fully constructed and planted prior to the time of first impact. That is, if vegetation clearing and any associated elderberry transplantation for TS_30_L were done during the winter season to minimize impacts, the mitigation for those impacts should already be in place by the time of clearing.

2. Overall Mitigation Strategy: An overall strategy is recommended to incentivize early implementation and provide a mechanism for accounting impacts and mitigation. Because most sites are larger than needed for TS_30_L, any excess that is generated could potentially be used to offset impacts of future reaches of the LSJRFS. Mitigation ratios for future impacts will depend on the baseline habitat affected, the time that the excess mitigation has been in place, additional HEP study, and further coordination with the Corps expected as part of their development of an overall mitigation strategy.

3. Objectives: The Service will seek to achieve both (a) no net loss of in-kind habitat value, the resource category goal stated in Service (2016) as well as (b) no net loss of in-kind habitat area, for Resource Category 2 habitats. No net loss of area is justified when, as in this project area with its combined development for urban and agricultural uses, the habitat types are already rare and limited. This includes wetlands and riparian cover-types.

4. Mitigation Ratio: The recommended mitigation ratio will depend on the site, but should in no case be less than 2:1 on an area basis.

5. Listed Species compensation: To the extent possible, mitigation should include components of compensation for listed species, such as elderberry bushes for VELB, wetlands for giant garter snake, and habitats adjacent to tidal waters such as SRA cover and shallow water habitat for listed fishes.

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APPENDIX A: Excel Spreadsheet for HEP of TS_30_L

THIS IS THE "Models" TAB

This Excel Spreadsheet has seven TABS and calculates habitat value for the HEP sampling done at TS_30_L in December 2021 last edited 11/2/2022

This first TAB starts includes a description of the seven TABs in this excel spreadsheet, and describes the models used

Sampling dates: December 2, 3, 7, and 8, 2021

TABS	Models: describes the variables, curves, and methods used	
	HSIdatacalc: includes raw data from field datasheets, plot values for variables (V), associated suitability indicices (SI), and HSI	
		also includes rough calculation of sampled area (all habitat area), and average HSIs which are used in futures
	Tree Hts:	includes raw data from field datasheets, plot averages in meters and feet, SI calculations for V1(rfct) and V3(rsg) variables models
	Species: includes list of species seen in each plot, as noted on field datasheets	
	BasalArea: includes all direct measurements and estimations in field for basal area for each plot, and total calculations	
	Futures: desktop exercise to assess mitigation area need; best professional opinion of best case and worst case scenario	
		developed futures for each model; compared loss to existing; based on concurrent mitigation
	FuturesExcess: this tab is a scenario in which mitigation is set to begin at 10 years old at time of project impact	
	CAUTION: futures are best case, preliminary/subject to review/revision, actual habitat value may vary with mitigation timing, actual performance,	
		as well as other factors not reflected in HEP models (e.g., adjacency to water/ag, connectivity, location/position on landscape, etc.)

Models chosen based on general characteristics, dominated by shrub/understory vegetation, some larger willows, a few larger trees
snags suspected; high bird use noted in March 2021 site visit (raptors, songbirds, woodpeckers, hummingbirds, others);
proximity to ag fields, water via ag drainage ditch, and separation from human activity (levee, restricted access) enhances wildlife use

1. modified Yellow Warbler (Schroeder 1982) - FWS "bluebook" model; derived from earlier Morse studies;
V1- percent deciduous shrub crown cover, total as measured on two transects in each plot. Optimal at 60-80% cover
note: herbaceous, including tall stiff herbaceous, are not included as shrub, that is, it is woody only; frequently estimated to nearest 5 or 10 feet.
V2 - average height of deciduous shrub canopy, in meters; average of shrubs along or nearest to two transects. Optimal at 2+ meters.
V3 - % deciduous shrub canopy cover composed of hydrophytic shrubs, ft cover along two transects converted to %. Min SI = 0.1; Max SI at 100% cover
V4 - % cover of tall trees (> 30 feet tall), measured as the canopy greater than 30 feet over two transects in each plot
Note: V4 is a modification, an added variable first developed by local sponsor in a 1988 HEP for the upper Guadalupe River
The 1988 version had a minimum of zero for 0% tall trees, optimum of 1.0 from 50-75% tall trees, and decline to 0.75 at 100% tall trees
This original modification was further modified in the 1998, USFWS HEP, to have a minimum value of 0.5 at 0% tall trees.
This further modified model, with 4 variables was again used in the 2009 Reach 12 HEP on the Guadalupe River
Use of tall trees, for occasional forage beats, or nest protection from cowbird parasitism, is consistent with yellow warbler observations
since Morse and the 1982 Schroeder model, and is particularly applicable to yellow warbler populations in the western USA

HSI (yellow warbler modified) = (siV1 x siV2 x siV3 x V4)^1/2

2. Riparian Songbird Guild (Roberts 1986)

V1 - % shrub cover: by transect intercept method (feet cover of woody vegetation 1-3 m tall along transect/total transect length * 100)

V2 - % tree cover: by transect intercept method (feet cover of woody vegetation > 3m tall along transect/total transect length * 100)

V3 - average height of overstory trees: A minimum of 3 overstory trees were selected within each 300 x ~100 ft plot, and measured using a clinometer

In some instances, a clear line of sight to the treetop and tape could not be established, so these trees were estimated visually

note: clinometer and visual estimates are noted in the data sheets with "c" or "v"; clinometer estimates are in feet calculated from the slope angle

percentage multiplied by ground distance, however, these angles and distances are not recorded, only the height in feet

V4 - Canopy Layering Category: 1-none (SI=0); 2-shrubs only (SI=.25); 3=tall shrubs only (SI=.5); 4=trees only (SI=.75); 5=multiple layers (SI=1)

V5 - number of snags > 4 inches per acre: snags were identified for the entire plot, roughly 1/14 acre

assuming 300 ft X 100 ft wide plots (3000 sq ft), the suitability index is maximized by 1 snag observed in a plot

dead limbs of trees were counted as snags if at least breast height (4.5 feet) above the ground.

V6 - Percent of site in woody vegetation; this was measured directly by all woody vegetation over a transect ("feet woody" on data sheets)

note: herbaceous, including tall stiff herbaceous, are not included as shrub, that is, it is woody only; frequently estimated to nearest 5 or 10 feet.

HSI = {[(V1+ V2 + (2 X V3)/4)X V4]^0.5 + V5}*V6/2

3. Riparian Forest Cover type (USFWS. 2001. Sacramento Fish and Wildlife Office in-house model)

V1 - Average tree height, in feet; optimal at 60 feet and greater; same data as rip. songbird guild V3, converted to feet, different SI curve

V2 - Average canopy width of riparian trees, measured as intersection along transect across riparian zone. min SI = 0.2 at 30 or less ft; opt SI = 1 at 70+ ft.

field estimate by taking total transect length, and subtracting tape-measured outer herbaceous, if any.

V3 - Tree Canopy Closure, measured as percent of tree cover over transect; optimal at 60-80%; SI=0.8 at 100%, SI=0.0 at 0%

Note: 5M criterion (16.5 ft) for trees, so may not be same as rip. songbird guild variables V2 (tree cover, 3M+) or V6 (all woody cover, which includes shrubs)

Rationale is that low shrubs (1-3 M) are not considered "canopy", nor "tree"; notation made on all data sheets that rip. songbird guild V2 is to be used.

V4 - number of tree or shrub species; optimal at 4+ species; minimum value of 0.6 for 1 species

V5 - Average Understory Vegetative Density in %, this calculated from the feet of interception of vegetation at planes at 2, 6, and 14 feet, estimated at each transect

Note: One such overall estimate at each transect, then average of transects within a plot

A (non-native adjustment factor): If tree canopy dominated by non-natives, HSI is reduced by 40%, so A=.6; if native-dominated tree canopy, A = 1.0

B (separation from surface water): If riparian edge begins further than 20' from water, reduce by 1/3, so B=2/3; otherwise B =1.0 (not applied in this study)

HSI (riparian forest cover type) = A*B*(((siV1 * siV3 * siV4)^1/3 + (siV2 * siV5)^.5)/2)

4. Hairy Woodpecker (Sousa 1987)

Note: model applicability states a minimum of 4 ha (~11 acres) of habitat and 40 M width, marginal for TS_30_L, but other forested habitat is present south.

Note: variables V1-3 measured with Biltmore stick

V1	snags>25cm/acre	optimized at 2+/acre; due to rarity of this size snag, and use in nesting, average of all plots is applied for this variable (total ~1.4 ac)
V2	nest component; SI=0 at >8", 1.0 at 16+"; mean dbh of overstory tree; overstory trees in each plot as could be reasonably estimated;	
V3	cover component; SI=.5<6", 1.0>10"; mean dbh of overstory tree; plot specific as with V2	
V4	% tree canopy cover; from trees 6+M, above songbird guild/RFCT models; coarse estimate (nearest 5-10% or feet recorded)	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
79	HSI = (V1 +.75V2) X (V3 X V4)															
80																
81	5. Downy Woodpecker (USFWS. 1983. FWS/OBS-82/10.38)															
82	V1 - Basal area; at 4.5' height, optimal (SI=1) from 10-20 sq M/hectare (2.71 ac), SI=0 at 0 basal area; SI=.5 at 30+sq M.															
83	Note: alternative method to cruz-all needed for this study due to obscured visibility from shrubs, did stem count/diameter coarse estimate of basal area of entire plot															
84	V2 - density of snags > 6" in diameter, per acre; optimal at 5+ snags/acre															
85		optimized at 5+/acre; due to use in nesting, average of all plots is applied for this variable (total ~1.4 ac for 21 plots)														
86	Note: a constant snag density is used (all plots) with a plot-specific basal area															
87																
88	HSI (downy woodpecker) = the mininum SI of V1 and V2															

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	THIS IS THE "HSIdatacalc" TAB															
2	Yellow Warbler Modified															
3	note: for V3, essentially all deciduous shrub canopy cover is by hydrophytic species, thus V3 = 1.0 unless specified otherwise															
4	Plot	1		2		3		4		5		6		7		
5	transect	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
6	length	65	100	100	100	120	100	100	100	100	100	100	100	100	100	
7	feet dsc	18	79	72	82	60	100	50	90	90	100	70	90	90	90	
8	V1trans	0.28	0.79	0.72	0.82	0.5	1	0.5	0.9	0.9	1	0.7	0.9	0.9	0.9	
9	V1avg	0.59		0.77		0.73		0.70		0.95		0.80		0.90		
10	SI(V1)avg	0.98		1.00		1.00		1.00		0.70		1.00		0.80		
11	V2	2		2		2		1.6	2	1.88	1.92	1.45	1.5	1.79		
12	V2avg	2		2		2		1.8		1.9		1.475		1.79		
13	SI(V2)	1.00		1.00		1.00		0.80		0.94		0.73		0.90		
14	V3	1.00		1.00		1.00		1.00		1.00		1.00		1.00		
15	SI(V3)	1.00		1.00		1.00		1.00		1.00		1.00		1.00		
16	V4	0	0	0	0	0.6	0.1	0.6	0.1	0.3	0.3	0	0.3	0	0.2	
17	V4avg	0		0		0.35		0.35		0.3		0.15		0.1		
18	SI(V4)	0.5		0.5		1		1		0.8		0.5		0.5		
19																
20	HSI-ywmod	0.70		0.71		1.00		0.89		0.73		0.60		0.60		
21	HSI-yworig	0.99		1.00		1.00		0.89		0.81		0.85		0.85		
22																
23	Plot	8		9		10		11		12		13		14		
24	transect	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
25	length	100	100	60	50	100	100	100	100	100	100	100	100	100	100	
26	feet dsc	85	100	60	50	60	100	90	100	95	75	80	80	77	74	
27	V1trans	0.85	1	1	1	0.6	1	0.9	1	0.95	0.75	0.8	0.8	0.77	0.74	
28	V1avg	0.93		1.00		0.80		0.95		0.85		0.80		0.76		
29	SI(V1)avg	0.75		0.60		1.00		0.70		0.90		1.00		1.00		
30	V2	1.76	1.88	1.6	2	2	1.8	1.6	2	2	2	1.1	2	1.65	1.22	
31	V2avg	1.82		1.8		1.9		1.8		2		1.55		1.435		
32	SI(V2)	0.88		0.80		1.00		0.80		1.00		0.55		0.83		
33	V3trans	1.00	1.00	1.00	1.00	1.00	1.00	0.40	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
34	V3avg	1.00		1.00		1.00		0.70		1.00	1.00	1.00		1.00		
35	SI(V3)avg	1.00		1.00		1.00		0.73		1.00		1.00		1.00		
36	V4	0	0	0	0	0	0.1	0.2	0	0.2	0	0	0	0.2	0	
37	V4avg	0		0		0.05		0.1		0.1		0		0.1		
38	SI(V4)	0.5		0.5		0.5		0.7		0.7		0.5		0.7		
39																
40	HSI-ywmod	0.57		0.49		0.71		0.53		0.79		0.52		0.76		
41	HSI-yworig	0.81		0.69		1.00		0.64		0.95		0.74		0.91		
42																
43	Plot	15		16		17		18		19		20		21		

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
44	transect	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
45	length	100	100	150	120	100	100	80	75	100	90	80	80	80	80	
46	feet dsc	50	50	135	90	50	85	60	30	30	0	45	60	75	60	
47	V1	0.50	0.5	0.9	0.75	0.5	0.85	0.75	0.4	0.3	0	0.5625	0.75	0.9375	0.75	
48	V1avg	0.50		0.83		0.68		0.58		0.16		0.66		0.84		
49	SI(V1)avg	0.83		0.93		1.00		0.97		0.26		1.00		0.91		
50	V2	0.5	0.81	2	1.466667	1.75	1.647059	2	2	1.25	0	2	1.8	2	1.75	
51	V2avg	0.655		1.733333		1.698529		2		0.625		1.9		1.875		
52	SI(V2)	0.25		1.00		0.88		1.00		0.63		1.00		1.00		
53	V3	1.00	1.00	1.00	1.00	1.00	1.00	0.40	1.00	1.00	0.00	1.00	1.00	1.00	0.69	
54	V3avg	1.00		1.00		1.00		0.70		0.50	0.10	1.00		0.84		
55	SI(V3)avg	1.00		1.00		1.00		0.73		0.55		1.00		0.86		
56	V4	0	0	0	0.1	0	0	0	0.533333	0	0	0	0	0	0.2	
57	V4avg	0		0.05		0		0.266667		0		0		0.1		
58	SI(V4)	0.5		0.5		0.5		0.5		0.5		0.5		0.5		
59																
60	HSI-ywmod	0.32		0.68		0.66		0.59		0.21		0.71		0.63		
61	HSI-yworig	0.46		0.97		0.94		0.84		0.30		1.00		0.89		
62																
63	Riparian Songbird Guild															
64	note: for variables V1 and V2, these are considered non overlapping, as "trees" being >3M only generally have lower limbs that go 1-3M as well															
65	note: this non-overlapping assumption may modestly underestimate foliage SIs and overall HSI but is deemed appropriate for this site															
66	note: V4 is the maximum, not the average, of both transects, considering that multiple layers anywhere in a plot applies															
67	Plot	1		2		3		4		5		6		7		
68	transect	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
69	length	65	100	100	100	120	100	100	100	100	100	100	100	100	100	
70	ftshrub<3m	18	79	77	82	60	100	50	90	90	100	40	45	30	30	
71	V1	27.69230769	79	77	82	50	100	50	90	90	100	40	45	30	30	
72	V1avg	53.34615385		79.5		75		70		95		42.5		30		
73	SI(V1)avg	1.00		1.00		1.00		1.00		0.63		0.81		0.50		
74	fttree>3m	12	70	77	82	80	80	20	70	80	80	50	55	70	60	
75	V2	18.46153846	70	77	82	66.66667	80	20	70	80	80	50	55	70	60	
76	V2avg	44.23		79.5		73.33333		45		80		52.5		65		
77	SI(V2)avg	0.21		1		1		0.25		1		1		1		
78	V3	7.66		7.10		10.8966		13.716		8.5344		9.492343		5.7912		
79	SI(V3)	1		1		1		1		1		1		0.95824		
80	V4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	
81	V4max	5.00		5.00		5.00		5.00		5.00		5.00		5.00		
82	SI(V4)max	1		1		1		1		1		1		1		
83	snags>4"	1		3		1		4		0		1		6		
84	V5	1.76		4.356		1.32		5.808		0		1.452		8.712		
85	SI(V5)	0.59		1.00		0.44		1.00		0.00		0.48		1.00		
86	allwoodyft	18.00	79	77.00	82	120.00	90	70.00	90	90.00	100	70.00	90	90.00	90	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
87	V6%allwoody	27.69	79.00	77.00	82.00	100.00	90.00	70.00	90.00	90.00	100.00	70.00	90.00	90.00	90.00	
88	V6avg	53.35		79.50		95.00		80.00		95.00		80.00		90.00		
89	SI(V6)avg	0.51		0.78		0.95		0.79		0.95		0.79		0.89		
90																
91	HSI-rsg	0.38		0.78		0.68		0.75		0.45		0.58		0.86		
92																
93	Plot	8		9		10		11		12		13		14		
94	transect	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
95	length	100	100	60	50	100	100	100	100	100	100	100	100	100	100	
96	ftshrub<3m	40	25	60	0	30	60	40	100	65	40	80	80	32	40	
97	V1	40	25	100	0	30	60	40	100	65	40	80	80	32	40	
98	V1avg	32.5		50		45		70		52.5		80		36		
99	SI(V1)avg	0.56		1.00		0.88		1.00		1.00		1.00		0.65		
100	fttree>3m	60	75	0	40	70	40	40	0	30	30	5	5	45	30	
101	V2	60	75	0	80	70	40	40	0	30	30	5	5	45	30	
102	V2avg	67.50		40		55		20		30		5		37.5		
103	SI(V2)avg	1.00		0.75		1.00		0.25		0.50		0.00		0.69		
104	V3	8.26		7.62		6.096		8.382		6.477		7.112		6.2992		
105	SI(V3)	1		1		1		1		1		1		1		
106	V4	5		5		5	5	5	5	5	5	5	5	5		
107	V4max	5.00		5.00		5.00		5.00		5.00		5.00		5.00		
108	SI(V4)max	1		1		1		1		1		1		1		
109	snags>4"	2		0		1		3		4		4		3		
110	V5	2.904		0		1.452		4.356		5.808		5.808		4.356		
111	SI(V5)	0.97		0.00		0.48		1.00		1.00		1.00		1.00		
112	allwoodyft	85	100	60	50	100	100	100	100	100	75	85	85			
113	V6%allwoody	85	100	100	100	100	100	100	100	100	75	85	85	77	74	
114	V6avg	92.50		100.00		100.00		100.00		87.50		85.00		75.50		
115	SI(V6)avg	0.92		1.00		1.00		1.00		0.87		0.84		0.74		
116																
117	HSI-rsg	0.88		0.48		0.73		0.95		0.84		0.79		0.71		
118																
119	Plot	15		16		17		18		19		20		21		TEST
120	transect	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
121	length	100	100	150	120	100	100	80	75	100	90	80	80	80	80	
122	ftshrub<3m	40	30	10	60	35	85	40	29	30	0	20	40	30	20	
123	V1	40	30	6.666667	50	35	85	50	38.66667	30	0	25	50	37.5	25	
124	V1avg	35		28.33333		60		44.33333		15		37.5		31.25		
125	SI(V1)avg	0.63		0.46		1.00		0.86		0.13		0.69		0.53		1
126	fttree>3m	0	20	130	30	10	30	20	50	0	0	25	20	45	55	
127	V2	0	20	86.66667	25	10	30	25	66.66667	0	0	31.25	25	56.25	68.75	
128	V2avg	10.00		55.83333		20		45.83333		0		28.125		62.5		
129	SI(V2)avg	0.00		1.00		0.25		0.90		0.00		0.45		1.00		1

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
130	V3	8.26		7.18		7.3152		9.0424		5.588		8.1788		6.94944		
131	SI(V3)	1		1		1		1		0.9176		1		1		1
132	V4	1	5	5	5	5	5	5	5	2	1	5	5	5	5	
133	V4max	5.00		5.00		5.00		5.00		2.00		5.00		5.00		
134	SI(V4)max	1		1		1		1		0.25		1		1		1
135	snags>4"	4		2		1		2		4		1		1		
136	V5	5.808		2.151111		1.452		3.747097		6.113684		1.815		1.815		
137	SI(V5)	1.00		0.72		0.48		1.00		1.00		0.61		0.61		1
138	allwoodyft	50	50	135	90	50	85	60	65	30	0	45	60	75	75	
139	V6%allwoody	50	50	90	75	50	85	75	87	30	0	56	75	94	94	
140	V6avg	50.00		82.50		67.50		80.83		15.00		65.63		93.75		
141	SI(V6)avg	0.47		0.82		0.66		0.80		0.11		0.64		0.93		1
142																
143	HSI-rsg	0.43		0.67		0.46		0.79		0.07		0.48		0.72		1.00
144																
145	Riparian Forest Cover Type															
146	note: V1 is in feet; V2 is feet over transect; V3 is % estimate over transect; V5 is % visual estimate over transect, at 3 planes, averaged, recorded on datasheet (entered here)															
147	Plot	1		2		3		4		5		6		7		
148	transect	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
149	length	65	100	100	100	120	100	100	100	100	100	100	100	100	100	
150	V1treehtft	21		23		21		27		24		24		30		
151	SI(V1-RFCT)	0.35		0.39		0.34		0.45		0.39		0.40		0.49		
152	V2ripwdthft	20	80	77	82	120	100	100	90	90	100	85	90	90	90	
153	V2avg	50		79.5		110		95		95		87.5		90		
154	SI(V2-RFCT)	0.6		1		1		1		1		1		1		
155	V3canopy%	0	20	20	0	80	50	20	70	80	80	5	50	60	40	
156	V3avg	10		10		65		45		80		27.5		50		
157	SI(V3-RFCT)	0.2		0.2		1		0.9		1		0.55		1		
158	V4#spp	4		3		4		5		4		4		5		
159	SI(V4-RFCT)	1		0.9		1		1		1		1		1		
160	V5undstry	5	55	60	70	50	85	40	75	90	90	60	75	80	55	
161	V5avg	30		65		67.5		57.5		90		67.5		67.5		
162	SI(V5-RFCT)	1.00		0.94		0.91		1.00		0.63		0.91		0.91		
163	Nnadjfctr	1		1		1		1		1		1		1		
164																
165	HSI-RFCT	0.59		0.69		0.83		0.87		0.76		0.78		0.87		
166																
167	Plot	8		9		10		11		12		13		14		
168	transect	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
169	length	100	100	60	50	100	100	100	100	100	100	100	100	100	100	
170	V1treehtft	23.5		25		20		27.5		21.25		23.33333		20.66667		
171	SI(V1-RFCT)	0.39		0.42		0.33		0.46		0.35		0.39		0.34		
172	V2ripwdthft	85	100	60	50	100	100	100	100	100	100	100	100	100	100	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
173	V2avg	92.5		55		100		100		100		100		100		
174	SI(V2-RFCT)	1		0.7		1		1		1		1		1		
175	V3canopy%	50	30	0	25	90	30	40	0	20	30	5	0	40	30	
176	V3avg	40		12.5		60		20		25		2.5		35		
177	SI(V3-RFCT)	0.8		0.25		1		0.4		0.5		0.05		0.7		
178	V4#spp	5		4		5		3		4		5		7		
179	SI(V4-RFCT)	1		1		1		0.9		1		1		1		
180	V5undstry	70	70	50	80	90	80	60	60	60	70	35	35	55	30	
181	V5avg	70		65		85		60		65		35		42.5		
182	SI(V5-RFCT)	0.88		0.94		0.69		1.00		0.94		1.00		1.00		
183	Nnadjfctr	1		1		1		1		1		1		1		
184																
185	HSI-RFCT	0.81		0.64		0.76		0.77		0.76		0.63		0.81		
186																
187	Plot	15		16		17		18		19		20		21		
188	transect	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
189	length	100	100	150	120	100	100	80	75	100	90	80	80	80	80	
190	V1treehtft	27		24		24		30		18		27		23		
191	SI(V1-RFCT)	0.45		0.39		0.40		0.49		0.31		0.45		0.38		
192	V2ripwdthft	90	60	135	90	65	75	60	70	50	0	45	60	75	80	
193	V2avg	75		112.5		70		65		25		52.5		77.5		
194	SI(V2-RFCT)	1		1		1		0.9		0.2		0.65		1		
195	V3canopy%	0	0	135	90	5	35	20	65	0	0	20	10	50	62.5	
196	V3avg	0		112.5		20		42.5		0		15		56.25		
197	SI(V3-RFCT)	0		0.59375		0.4		0.85		0		0.3		1		
198	V4#spp	7		6		2		5		6		6		6		
199	SI(V4-RFCT)	1		1		0.8		1		1		1		1		
200	V5undstry	15	30	85	40	30	65	40	40	25	0	45	50	75	50	
201	V5avg	22.5		62.5		47.5		40		12.5		47.5		62.5		
202	SI(V5-RFCT)	0.80		0.97		1.00		1.00		0.53		1.00		0.97		
203	Nnadjfctr	1		1		1		1		1		1		1		
204																
205	HSI-RFCT	0.45		0.80		0.72		0.86		0.37		0.72		0.85		
206																
207	Downy Woodpecker															
208	see BasalArea TAB of this spreadsheet for V1, SI(V1-dw) calculations															
209	Plot:	1	2	3	4	5	6	7	8	9	10					
210	SI(V1-dw)	0.27	1.00	0.99	0.50	0.50	0.80	0.19	0.05	0.16	1.00					
211	plot 10"snag	1	3	1	2	0	1	6	0	0	1					
212	V2-snag/ac	1.5	4.4	1.5	2.9	0.0	1.5	8.7	0.0	0.0	1.5					
213	SI(V2-dw)	0.29	0.87	0.29	0.58	0.00	0.29	1.00	0.00	0.00	0.29					
214	HSI-dw	0.27	0.87	0.29	0.50	0.00	0.29	0.19	0.00	0.00	0.29					
215																

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
216	Plot:	11	12	13	14	15	16	17	18	19	20	21				
217	SI(V1-dw)	0.20	0.74	0.71	0.16	0.34	0.59	0.77	0.30	0.14	0.78	0.71				
218	plot 10"snag	3	3	0	2	2	1	0	1	1	0	0				
219	V2-snag/ac	4.4	4.4	0.0	2.9	2.9	1.5	0.0	1.5	1.5	0.0	0.0				
220	SI(V2-dw)	0.87	0.87	0.00	0.58	0.58	0.29	0.00	0.29	0.29	0.00	0.00				
221	HSI-dw	0.20	0.74	0.00	0.16	0.34	0.29	0.00	0.29	0.14	0.00	0.00				
222																
223	Test calculation (average snag density)			1.16			Test calculation (average basal area)				38.14					
224	associated snag SI(V1-dw)			0.23			associated BA SI(V2-dw)				0.87					
225	Test calculation, HSI-dw from average snag and BA				0.23											
226	Test calculation, HSI-dw as average HSI across plots				0.23											
227																
228	Hairy Woodpecker															
229	see BasalArea TAB of this spreadsheet for V1-hw (DbH of overstory trees) calculations															
230	Plot:	1	2	3	4	5	6	7	8	9	10					
231	trans1length	65	100	120	100	100	100	100	100	60	100					
232	trans2length	100	100	100	100	100	100	100	100	50	100					
233	plot10"snag	1	2	0	0	0	0	3	0	0	0					
234	V1-snag/ac	1.5	2.9	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0					
235	SI(V1-hw)	0.29	0.58	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.00					
236	meandbhov	8.8	1.0	13.8	8.8	4.7	6.5	12.5	6.0	1.3	12.5					
237	SI(V2-hw)	0.11	0.00	0.83	0.11	0.00	0.00	0.65	0.00	0.00	0.65					
238	SIN	0.37	0.58	0.63	0.09	0.00	0.00	1.36	0.00	0.00	0.48					
239	Testcalc SINavgsng	0.26	0.18	0.80	0.27	0.18	0.18	0.66	0.18	0.18	0.66					
240	SI(V3-hw)	0.86	0.50	1.00	0.87	0.50	0.57	1.00	0.51	0.50	1.00					
241	cancovtree1	10	20	80	20	60	0	60	50	0	15					
242	cancovtree2	25	20	20	50	70	30	30	25	25	25					
243	cancovtree%total	21	20	45	35	65	15	45	38	23	20					
244	SI(V4-hw)	0.09	0.07	0.44	0.29	0.71	0.00	0.43	0.32	0.11	0.07					
245	SIC	0.08	0.04	0.44	0.25	0.36	0.00	0.43	0.16	0.06	0.07					
246	HSI(hw)	0.03	0.02	0.27	0.02	0.00	0.00	0.58	0.00	0.00	0.03					
247	testcalc HSIavgsng	0.02	0.01	0.35	0.07	0.06	0.00	0.28	0.03	0.01	0.05					
248																
249	Test calculation: average snag density =			0.90												
250	Test calculation: average SI(V1-hw)=			0.18												
251	using avg snagSI															
252																
253	Plot:	11	12	13	14	15	16	17	18	19	20	21				
254	trans1length	100	100	100	100	100	150	100	80	100	80	80				
255	trans2length	100	100	100	100	100	120	100	75	90	80	80				
256	plot10"snag	3	2	0	0	1	1	0	0	0	0	0				
257	V1-snag/ac	4.4	2.9	0.0	0.0	1.5	1.5	0.0	0.0	0.0	0.0	0.0				
258	SI(V1-hw)	0.87	0.58	0.00	0.00	0.29	0.29	0.00	0.00	0.00	0.00	0.00				

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
259	meandbhov	5.0	12.5	14.0	7.7	12.5	25.0	12.3	17.0	5.7	17.9	10.6				
260	SI(V2-hw)	0.00	0.65	0.86	0.00	0.65	1.00	0.62	1.00	0.00	1.00	0.37				
261	SIN	0.87	1.07	0.65	0.00	0.78	1.04	0.46	0.75	0.00	0.75	0.28				
262	Testcalc SINavgsng	0.18	0.66	0.83	0.18	0.66	0.93	0.64	0.93	0.18	0.93	0.46				
263	SI(V3-hw)	0.50	1.00	1.00	0.72	1.00	1.00	1.00	1.00	0.50	1.00	1.00				
264	cancovtree1	30	20	0	30	0	10	0	15	0	0	10				
265	cancovtree2	0	20	0	20	10	20	25	40	0	5	40				
266	cancovtree%total	15	20	0	25	5	11	13	35	0	3	31				
267	SI(V4-hw)	0.00	0.07	0.00	0.14	0.00	0.00	0.00	0.29	0.00	0.00	0.23				
268	SIC	0.00	0.07	0.00	0.10	0.00	0.00	0.00	0.29	0.00	0.00	0.23				
269	HSI(hw)	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.06				
270	testcalc HSIavgsng	0.00	0.05	0.00	0.02	0.00	0.00	0.00	0.27	0.00	0.00	0.11				
271																
272	Test calculation (average snag density)			0.90												
273	associated snag SI(V1-hw)			0.18												
274																
275	Summary of HEP:	HSImean	HSImax	HSImin												
276	Model															
277	YellowWarblerMod	0.64	1.00	0.21												
278	YellowWarblerOrig	0.83	1.00	0.30												
279	RipSongbirdGuild	0.64	0.95	0.07												
280	RipForestCovertyp	0.73	0.87	0.37												
281	DownyWoodpckr	0.23	0.87	0.00												
282	HairyWoodpckr	0.06	0.58	0.00												
283	Hwtestcalcavgsnag	0.06	0.35	0.00												
284																
285	Area estimate (rough, average width X 300 ft, summed)															
286	Plot	1		2		3		4		5		6		7		
287	transect	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
288	length	65	100	100	100	120	100	100	100	100	100	100	100	100	100	
289	area, acres	0.57		0.69		0.76		0.69		0.69		0.69		0.69		
290	Plot	8		9		10		11		12		13		14		
291	transect	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
292	length	100	100	60	50	100	100	100	100	100	100	100	100	100	100	
293	area, acres	0.69		0.38		0.69		0.69		0.69		0.69		0.69		
294	Plot	15		16		17		18		19		20		21		
295	transect	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
296	length	100	100	150	120	100	100	80	75	100	90	80	80	80	80	
297	area, acres	0.69		0.93		0.69		0.53		0.65		0.55		0.55		

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	THIS IS THE "TreeHts" TAB												
2	Tree height calculation for Riparian Songbird model, variable V3; Riparian Forest Cover Type model variable V1												
3	for December 2021 HEP of Lower San Joaquin River Feasibility Study, Reach TS_30_L												
4	note: method identifier c, refers to clinometer, calculated in field; v means visual estimate by eye												
5	note: some numbers represent "synthetic" values to reflect visual estimates recorded on data sheets and verified by photos												
6	Data sheet:		1	2	3	4	5	6	7	8	9	10	11
7			14	55	30	55	29	53	10	20	25	18	30
8			60	16	47	35	30	25	10	21	25	22	25
9			20	16	25		25	26	10	30			30
10			22	18	41			27	40	25			25
11			20	18				28	30	20			
12			20	20				29	18	25			
13			20	20				30	15				
14	Ht feet (V1 RFCT)		25.1	23.3	35.8	45.0	28.0	31.1	19.0	23.5	25.0	20.0	27.5
15	Ht meters (V3 RSG)		7.7	7.1	10.9	13.7	8.5	9.5	5.8	7.2	7.6	6.1	8.4
16													
17	Data sheet:		12	13	14	15	16	17	18	19	20	21	
18			33	38	25	25	15	30	45	21	18	20	
19			20	25	25	25	12	35	25	14	22	18	
20			20	14	20	30	35	20	25	15	48	35	
21			20	20	20	22	22	20	40	20	28	20	
22			20	30	20	22	40	44	25	13	25		
23			20			12	25	20		18			
24			25			55		20		20			
25						40		20		25			
26						25		20					
27								20					
28								20					
29								25					
30								25					
31													
32	Ht feet (V1 RFCT)		21.3	23.3	20.7	27.1	23.6	24.0	29.7	18.3	26.8	22.8	
33	Ht meters (V3 RSG)		6.5	7.1	6.3	8.3	7.2	7.3	9.0	5.6	8.2	6.9	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	THIS IS THE "Species" TAB														
2	This TAB records the species observed in each plot:														
3	Plot:	1		2		3		4		5		6		7	
4		BB		BB		BB		BB		BB		BB		buttonwillow	
5		ash		willow		willow		red willow		red willow		willow		BB	
6		willow		buttonwillow		buttonwillow		silver willow		silver willow		elderberry		red willow	
7		unk. compd leaf				walnut		buttonwillow		buttonwillow		silver willow		unid hanging seed	
8								walnut						green unid Fig?	
9															
10	Plot:	8		9		10		11		12		13		14	
11		buttonwillow		buttonwillow		BB		california rose		buttonwillow		buttonwillow		BB	
12		red willow		red willow		buttonwillow		willow		BB		hackberry		silver willow	
13		silver willow		compnd leaf unid		unid willow		BB		red willow		silver willow		red willow	
14		BB		red oak seedling		red willow				valley oak		red willow		unid	
15		Fig				elderberry						unk brownfuzzybush		compnd leaf unid	
16						unid near top								unk brownfuzzybush	
17														buttonwillow	
18															
19	Plot:	15		16		17		18		19		20		21	
20		red willow		silver willow		buttonwillow		willow		valley oak		willow1		pecan	
21		BB		live oak		silver willow		buttonwillow		willow		willow2		valley oak	
22		buttonwillow		buttonwillow				valley oak		2nd willow spp		BB		willow	
23		2nd willow spp		BB				BB		unid treewithgalls		pecan		BB	
24		cork oak		coyote bush				2nd willow spp		fig		live oak		unid hanging seed	
25		black locust		walnut						live oak		valley oak		live oak	
26		walnut								BB					

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	THIS IS THE "BasalArea" TAB															
2	Note: Basal Area was determined from DbH measurements of larger trees, plus estimates of stem number X approximate DbH of dense stems															
3	this calculation can be seen in the cells for rows "BA ft/ac", recorded exactly as noted in field on data sheets.															
4	Note: overstory trees shown in bold															
5	Note: plots 2, 4, and 5, were not done by stem count due to extremely high willow density, in these plots, estimated 3 or 6 inches															
6		per square yard (9 sq ft), and applied that density to the shrub portion of the plot, that is 300 ft x shrub cover in V1-yellow warbler model														
7		to get an estimate of basal area in feet, per acre														
8	Note: missing data/not measured in plot 10, so assumed 3"/yard X 50 ft shrub cover average / 9 ft per yard x (30,000 plot size/43,560 sq ft per acre)															
9		estimate based on field photos 196, 197, 198														
10	Note: some plots (2,4,5) where average stem densities per square meter were included, yielded very large basal areas, and may be overestimates															
11	NOTE: 4/15/22 - SOME BASAL AREAS ARE MISRECORDED AS SUM OF DIAMETERS, THESE INDIVIDUAL DIAMETERS MUST BE CONVERTED TO AREAS BEFORE SUMMING															
12	NOTE: 4/27/22 - ALL BASAL AREAS CHECKED, RECALCULATED, RESUME EDITING 6/24/22															
13	Plot:	1	2	3	3-BA sq ft	4	5	6	7	8	9	10				
14		**9**	8000	**26**	**3.687008**	**30**	**4**	**20**	**10**	**6**	**8**	**15**				
15		**10**		**16**	**1.396263**	**7**	**4**	**6**	**15**	**6**	**20**	**10**				
16		**10**		**16**	**1.396263**	**4**	**6**	**6**		**6**	**10**					
17		**6**		**16**	**1.396263**	**4**		**6**		**6**	**10**					
18				**14**	**1.069014**	**6**		**6**		**6**	**8**					
19				**4**	**0.087266**	**6**		**6**		**6**						
20				**4**	**0.087266**	**8**		**6**		**6**						
21				**11**	**0.659953**	**7**		**6**								
22				**15**	**1.227185**	**6**		48								
23				**16**	**1.396263**	**10**										
24				60												
25						14000	16000				40					
26					12.40275											
27	Basal Area estimation notes for plots 1-10:															
28	Note: all square inches linear converted to square feet by dividing by 144															
29	plot 1: estimate wooded northern half of site is 8" per 100 sq ft, or 960" (80') BA, site area is ~.57 ac (300*(65+100/2)															
30		1/2 of site is 150 x 80 feet wide = 12,000 sq ft so if 8" per 100 feet, that is 960" BA (or 960/144= 6.7 sq ft) in whole plot.											BA per ac = 6.7/.57=11.7'			
31	plot 2: note estimate wooded area, 80% of site (24,000 sq ft, 2667 sq yds) has 3"(3/144 = .0208') BA per yard, or 667 sq ft BA; 43560/30000*55.5=80.5'/ac BA															
32	plot 3: data sheets recorded 10 tree diameters, and "2x20 - 2x40" notation, meaning 2" X 20 to 40 willow shrubs, and "est, several feet/10th acre"															
33		Total for trees only is 12.4 ft sq; but if est, above is for willows, that is 3 ft/tenth acre is 30 sq feet/ac BA; overall guess 43.4/ac BA														
34	plot 4: data sheet notes "likely high, 6" per sq M", which is 0.0417sq ft; assuming 80% (average of "all woody", RSG V6) reduces this to 0.033 ft BA per 9 sq ft															
35		.033 ft/sq M ~.033 ft/9 sq ft; expanding to an acre 0.033/9*43560 sq ft/ac = 161.5'/ac BA														
36	plot 5: data sheet notes " est thick willow stems 6" per sq M + trees. Likely high [BA]." This would calculate out to at least plot 4, or more; 161.5' ac BA															
37																
38	plot 6: data notes "15 willows x 6" = 90 sq in trees alone + willows; dense willows 1/3 site 6+"/sqM"; 20" willow, willow 6-8 stems 6"															
39		species	diameter	BA	assumption											

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
40		willow	6	1.374447	7 stems this size											
41		willow	20	2.181662												
42		thicket		20.83333	((100x45/9)x 6)/144 =			20.83333								
43		total BA in plot		24.38944		total per acre		35.41347								
44		(300 x45/9)/3x 6/144=46.3 sq ft BA in 30,000 sq ft site. 46.3*43560/30000=67.2/ac BA														
45	plot 7: data notes "4-6"/10 sq M for 1/2 site; 0"/sq M [for other 1/2?]";															
46		data note calculation, assume "10 sq M" is 90sqft, not 900.														
47		so overall is 2"/sqM; 2"/144=.014'; .014/9*43560=67.8'/ac BA														
48		overall average of "4-6" and zero, is 2.5", (5+0)/2														
49		estimate calculation of BA per sq ft, therefore, is (2.5/144)/90						0.000193								
50		the BA for 1 acre is the above per foot x 43560						8.402778								
51		this was one of the few sites with a cruz-all estimate, 2 x 5 BAF, or 10'/ac BA														
52		select the lower of the two estimates for the HEP														
53	plot 8: notes say "not possible ~1 x 5?", in likely reference to a cruz-all measurement; the seven, 6" trees are 28" BA each or 196" total															
54		169"/144=1.36 sq ft in the plot. 1.36*43560/30000=1.98'/ac BA														
55	plot 9:	notes indicate 10, 4" stems; thats pi x 2 squared,x 10, or 125.6 inches or 0.872' BA in plot (125.6/144); 0.872*43560/30000=1.27/ac BA														
56		individual trees measured additionally														
57		species	diameter	BA	assumption											
58		ash	8	0.349066												
59		buttonW	20	2.181662	multiple stems of same species											
60			10	0.545415												
61			10	0.545415												
62			8	0.349066												
63		total BA in plot		3.970624		total per acre		5.765346	plus 1.27 above =		7.035346					
64	plot 10: "missing data", post field photo interp: min 2" dia/yd=(~3" BA) per yard x 50' wooded x 300' long /144 sq in per ft)/9 ft per yd *43560/30000 = 50.4'/ac BA															
65	Plot:	1	2	3	4	5	6	7	8	9	10					
66	meanDbH	8.8	1.0	13.8	8.8	4.7	6.5	12.5	6.0	1.3	12.5					
67	BA ft/ac	11.7	80.5	43.4	161.5	161.5	35.4	8.4	2.0	7.0	50.4					
68	SI(V1-dw)	0.27	1.00	0.99	0.50	0.50	0.80	0.19	0.05	0.16	1.00					
69																
70	Plot:	11	12	13	14	15	16	17	18	19	20	21				
71		**6**	**14**	**10**	**4**	**16**	**16**	**8**	**14**	**6**	**11**	**15**				
72		**6**	**13**	**9**	**18**	**8**	**29**	**8**	**12**	**5**	**18**	**10**				
73		**4**	**32**	**12**	**6**	**13**	**30**	**8**	**18**	**6**	**34**	**8**				
74		**3**	**4**	**8**	**6**	**8**		**20**	**16**		**22**	**11**				
75		**3**	**4**	**10**	**6**	**7**		**12**	**25**		**28**	**21**				
76		**8**	**8**	**15**	**6**	**23**		**6**			**26**	**11**				
77				**30**				**24**			**22**	**9**				
78				**18**							**6**	**9**				

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
79											**6**	**9**				
80											**6**	**8**				
81												**8**				
82												**8**				
83	meanDbH	5.0	12.5	14.0	7.7	12.5	25.0	12.3	17.0	5.7	17.9	10.6				
84	BA ft/ac	8.6	32.7	31.1	6.9	15.0	26.1	33.9	13.1	6.2	34.2	31.1				
85	SI(V1-dw)	0.20	0.74	0.71	0.16	0.34	0.59	0.77	0.30	0.14	0.78	0.71				
86	Basal Area estimation notes for plots 11-21:															
87	plot 11: notes for this plot have a list of species and diameters, and a guess of "10-20" for 1/3 plot", likely in reference to sum of diameters															
88		photos show a foreground of rose, with sufficiently separated trees in the background to conclude the stem/diameter counts are accurate														
89		species	diameter	BA	assumption											
90		walnut	8	0.349066	individual											
91		buttonW	10	0.545415	individual											
92		buttonW	5	0.545415	20 inch sum of diameters recorded, guess 5 inches, 4 stems											
93		hollyoak	6	0.19635	individual											
94		willow	10	1.090831	individual											
95		willow	8	1.047198	25 inch sum of diameters recorded, guess 8 inches, 3 stems											
96		willow	4	0.698132	30 inch sum of diameters recorded for bush, guess 4 inches, 8 stems											
97		elderberry	8	0.349066	individual											
98		elderberry	3	0.147262	individual, overstory measurement says "4,3,3" so guess 3 inches, 3 stems											
99		3-4 willow	5	0.545415	20 inch sum of diameters recorded, "3-4 willows, 20' total", guess 5 inches 4 stems											
100		2 willows	5	0.409062	recorded "2 more willows, 15" total", guess 5 inches, 3 stems											
101		total BA in plot		5.923211		total per acre		8.600503								
102	plot 12: notes for this plot have a list of diameters, or diameter classes and numbers of stems, by species.															
103		species	diameter	BA	assumption											
104		willow	14	1.069014												
105		willow	13	0.921752												
106		willow	32	5.585054												
107		willow	4	0.087266												
108		willow	20	8.726646	4 of these											
109		willow	20	2.181662	1 of these											
110		willow	5	0.545415	4 of these											
111		buttonW	20	2.181662	1 of these											
112		buttonW	15	1.227185	1 of these											
113		total BA in plot		22.52566		total per acre		32.70725								
114	plot 13:	species	diameter	BA	assumption											
115		buttonW	6	0.19635	5 of these											
116		hackberry	18	1.767146												
117		willow	20	2.181662												

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
118		buttonW	6	0.785398	4 of these											
119		hackberry	9.5	0.984475	2, actually 2 stems 10 and 9"											
120		buttonW	12	1.570796	24", assume 2 12"											
121		buttonW	24	1.668971	24" assume 15 and 9"											
122		willow	45	12.27185	30 and 15"											
123		total BA in plot		21.42664		total per acre		31.11149								
124	plot 14:	notes - reconstructed/estimated stems from basal area and overstory dbh lists as best possible														
125		buttonW	4	0.349066	4 of these											
126		buttonW	8	0.785398	3 of these, 20" total, 8" x2, 4"x1											
127		willow		0.19635	2,4, and 4"; 10" total											
128		willow	15	1.227185	individual											
129		willow	18	1.767146	individual											
130		thicket	2	0.261799	25" total dia recorded; assume 12, 2 inch stems											
131		fuzzytree	6	0.19635	individual											
132		total BA in plot		4.783293		total per acre		6.945341								
133	plot 15	notes - reconstructed/estimated stems from basal area and overstory dbh lists as best possible														
134		species	diameter	BA	assumption											
135		corkoak	16	1.396263												
136		willow	8	0.370882	8 and 2" stems											
137		willows	1	0.1309	24x1" stems											
138		buttonW	6	0.19635												
139		willow	20	2.181662												
140		redberry	18	1.767146												
141		willows	1	0.163625	30x1" stems											
142		walnut	13	2.405282	13 and 12" stems											
143		locust	7	0.267254												
144		unid	23	2.885247												
145		total BA in plot		11.76461		total per acre		17.08221								
146	plot 16	notes - reconstructed/estimated stems from basal area and overstory dbh lists as best possible														
147		willow	16	1.396263												
148		willow	29	4.586943	recorded "28-30" willow"; assume 29											
149		willow	30	4.908739	recorded "28-32" willow"; assume 30											
150		willow	1	1.041667	100's of 1" stems; assume 1.5" BA per stem											
151		buttonW	8	0.349066												
152		walnut	20	2.181662												
153		walnut	18	1.767146												
154		walnut	18	1.767146												
155		total BA in plot		17.99863		total per acre		26.13401								
156	plot 17	notes - reconstructed/estimated stems from basal area and overstory dbh lists as best possible														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
157		species	diameter	BA	assumption											
158		willow	30	14.72622	3, 9" stems											
159		willow	2	1.636246	thicket, assume 25, 2 inch stems											
160		willow	8	0.349066												
161		liveoak	20	2.181662												
162		willow	1	0.327249	thicket, assume 20, 1 inch stems											
163		buttonW	24	3.141593												
164		buttonW	18	0.981748	12, 6 inch stems total 18 dia											
165		total BA in plot		23.34378		total per acre		33.89517								
166	plot 18	notes - reconstructed/estimated stems from basal area and overstory dbh lists as best possible														
167		species	diameter	BA	assumption											
168		willow	2	0.392699	thicket, 35" total , 18, 2 inch stems											
169		buttonW	14	1.069014	each stem in two bushes measured individually											
170			12	0.785398												
171			8	0.349066												
172			16	1.396263												
173		buttonW	5	0.136354												
174			3	0.049087												
175			3	0.049087												
176			3	0.049087												
177			8	0.349066												
178		valloak	25	3.408846												
179		willow	2	0.327249	thicket, 30" total , 15, 2 inch stems											
180		willow	5	0.681769	small bush, 25" dbh total, assume 5 stems 5"											
181		total BA in plot		9.042987		total per acre		13.13042								
182	plot 19	notes - reconstructed/estimated stems from basal area and overstory dbh lists as best possible														
183		species	diameter	BA	assumption											
184		willow	5	0.818123	"large thicket"; 30", assume six, 5 inch stems											
185		willow	2	0.283616	thicket; 25", assume 13, 2 inch stems											
186		valloak	3	0.049087	individual stems on two trees measured											
187			6	0.19635												
188			4	0.087266												
189		valloak	6	0.19635	individual											
190		willow	1	0.109083	thicket; 20"; smaller stature, assume 20, 1" stems											
191			1	0.109083	thicket; 20"; smaller stature, assume 20, 1" stems											
192			1	0.109083	thicket; 20"; smaller stature, assume 20, 1" stems											
193			1	0.109083	thicket; 20"; smaller stature, assume 20, 1" stems											
194		fig	20	2.181662	individual											
195		total BA in plot		4.248786		total per acre		6.169237								

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
196	plot 20	notes - reconstructed/estimated stems from basal area and overstory dbh lists as best possible														
197		species	diameter	BA	assumption											
198		pecan	11	0.659953												
199		willow	18	1.767146	very large willow with many individually measured stems											
200			34	6.305002												
201			22	2.63981												
202			28	4.276057												
203			26	3.687008												
204			22	2.63981												
205		valloak	6	0.19635												
206		liveoak	6	0.19635												
207		pecan	12	0.785398												
208		willow	1	0.218166	thicket; 40"; assume 40, 1" stems											
209		willow	1	0.163625	thicket; 30"; assume 30, 1" stems											
210		total BA in plot		23.53467		total per acre		34.17235								
211	plot 21	notes - reconstructed/estimated stems from basal area and overstory dbh lists as best possible														
212		species	diameter	BA	assumption											
213		valloak	15	1.227185	individual											
214		pecan	10	0.545415	two stems, measured individually											
215			8	0.349066												
216		unid	6	1.178097	6, 6" stems											
217		corkoak	21	2.405282												
218		corkoak	11	0.659953												
219		pecan	5	0.136354												
220		unid	4	1.570796	18 stems											
221		willow	8	2.792527	large stems, 60" , estimate 8, 8" stems											
222		total BA in plot		10.86467		total per acre		31.13587								

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	THIS IS THE "Futures" TAB																				
2	This TAB estimates best case futures in mitigation site, that could be theoretically used to estimate mitigation ratio.																				
3	Assume a site, such as agriculture, which has no value/woody currently.																				
4																					
5	Warbler Model - Best Case Scenario										Warbler Model - Worse Case Scenario										
6	V1-shrub cover: estimate this would be optimized (60-80%) in 5 years; with lots of planting/watering										V1-shrub cover: maxes out at 40% due to water variability/dieoff after year 5										
7	V2-shrub height: estimate it would take 5 years to get to 2M tall average, with watering, ideal site										V2-shrub height: 1.2 M max due to alot of herbaceous										
8	V3-percent deciduous shrub cover: presume this would be 100%, determined by planting pallette										V3- percent deciduous shrub cover: same as best case										
9	V4-percent tall tree cover, optimized at 50-75%, is 30 feet tall, estimate 15 years										V4- percent tall tree cover, takes longer due to variable water, 40% maximum										
10																					
11		TY0	TY1	TY5	TY15	TY25	TY51					TY0	TY1	TY5	TY15	TY25	TY51				
12	V1	0	0.1	0.6	0.8	0.8	0.8				V1	0	0.1	0.6	0.5	0.5	0.5				
13	V2	0	0.1	2	2	2	2				V2	0	0.1	0.6	1.2	1.2	1.2				
14	V3	0	1	1	1	1	1				V3	0	1	1	1	1	1				
15	V4	0	0	0	0.3	0.5	0.75				V4	0	0	0	0.3	0.4	0.4				
16																					
17	SI(V1)	0.00	0.17	1.00	1.00	1.00	1.00				SI(V1)	0.00	0.17	1.00	0.83	0.83	0.83				
18	SI(V2)	0	0.05	1	1	1	1				SI(V2)	0	0.05	0.3	0.6	0.6	0.6				
19	SI(V3)	0.1	1	1	1	1	1				SI(V3)	0.1	1	1	1	1	1				
20	SI(V4)	0.5	0.5	0.5	0.8	1	1				SI(V4)	0.5	0.5	0.5	0.8	0.9	0.9				
21	HSI-ywm	0.00	0.06	0.71	0.89	1.00	1.00				HSI-ywm	0.00	0.06	0.39	0.63	0.67	0.67				
22																					
23	TY	0	1	5	15	25	51				TY	0	1	5	15	25	51				
24	HSIw/o	0.00	0.00	0.00	0.00	0.00	0.00				HSIw/o	0.00	0.00	0.00	0.00	0.00	0.00				
25	HSI w/	0.00	0.06	0.71	0.89	1.00	1.00				HSI w/	0.00	0.06	0.39	0.63	0.67	0.67				
26	area w/o	10	10	10	10	10	10				area w/o	10	10	10	10	10	10				
27	area w/	10	10	10	10	10	10				area w/	10	10	10	10	10	10				
28	HUs w/o		0	0	0	0	0				HUs w/o		0	0	0	0	0				
29	HUs w/		0.322749	15.43313	80.0767	94.72136	260				HUs w/		0.322749	9.036961	50.98769	65.1638	174.4133				
30	AAHUs without						0				AAHUs without						0				
31	AAHUs with						8.834391				AAHUs with						5.880873				
32	change due to project						8.834391				change due to project (mitigation gain)						5.880873				
33																					
34	TY	0	1	5	15	25	51														
35	HSIw/o	0.64	0.64	0.64	0.64	0.64	0.64														
36	HSI w/	0.64	0.00	0.00	0.00	0.00	0.00														
37	area w/o	13.88	13.88	13.88	13.88	13.88	13.88														
38	area w/	13.88	13.88	13.88	13.88	13.88	13.88														
39	HUs w/o		8.867974	35.4719	88.67974	88.67974	230.5673														
40	HUs w/		4.433987	0	0	0	0														
41	AAHUs without						8.867974														
42	AAHUs with						0.086941														
43	change due to project (project impact loss)						-8.78103														
44									Compensation Ratio estimate: CR = loss at impact site/gain at mitigation site X 10/13.88 acres												
45	I set the area of the mitigation site at 10 acres; so this suggests the habitat value								Best case scenario: CR =			0.71611									
46	is compensated roughly at a ratio of slightly less than 1:1 with perfect mitigation								Worst case scenario: CR =			1.075757									
47																					
48					compensation area best case:			9.94													
49																					
50					compensation area worst case:			14.93151													
51																					
52	Riparian Songbird Model - best case scenario										Riparian Songbird Model - worst case scenario										

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
53	V1- % shrub cover, 1-3M;optimal 50-75%; this will take 10 years to achieve										V1 - takes 14 years, maxes out at 50%										
54	V2- % tree cover, 3+M; optimal 50-75%; takes about 15 years										V2 - takes 15 years, maxes out at 40%										
55	V3- ht of trees, optimal 6+M; takes about 10 years, with watering										V3 - takes 14 years to reach 6+M										
56	V4- layering category; 1-none, 2-low shrub, 3-tall shrubs, 4- trees only, 5- multiple layers; TY1 low only (.3); TY5-51 - multiple (1.0)													V4 - not all "5", some "2","3","4"; max SI .7							
57	V5- snags 4"+ ; optimal at 3+/ac; none for TY0-14; then optimal TY15-51										V5 - not optimal throughout; max average is 1.2 snags/ac										
58	V6- % of site as woody riparian; TY1-5%; TY5-30%; TY10-50%; TY15to51-75%										V6 - lower, max is 60%										
59																					
60	TY	0	1	5	10	14	15	51			TY	0	1	5	10	14	15	51			
61	V1	0	10	30	50	50	60	75			V1	0	10	30	40	50	50	50			
62	V2	0	0	0	30	30	50	75			V2	0	0	0	30	40	40	40			
63	V3	0	1	3	6	6	6	6			V3	0	1	3	5	6	6	6			
64	V4	1	2	3	5	5	5	5			V4	1	2	3	(assume SI of 0.7, mix of categories 2-5)						
65	V5	0	0	0	0	0	3	3			V5	0	0	0	0	0	1.2	1.2			
66	V6	0	5	30	50	75	75	75			V6	0	5	30	50	60	60	60			
67																					
68	SI(V1)	0	0	0.5	1	1	1	1			SI(V1)	0	0	0.5	0.75	1	1	1			
69	SI(V2)	0	0	0	0.5	0.5	1	1			SI(V2)	0	0	0	0.5	0.75	0.75	0.75			
70	SI(V3)	0	0	0.4	1	1	1	1			SI(V3)	0	0	0.4	0.8	1	1	1			
71	SI(V4)	0	0.3	0.5	1	1	1	1			SI(V4)	0	0.3	0.5	0.7	0.7	0.7	0.7			
72	SI(V5)	0.00	0.00	0.00	0.00	0.00	1.00	1.00			SI(V5)	0.00	0.00	0.00	0.00	0.00	0.40	0.40			
73	SI(V6)	0.00	0.00	0.26	0.47	0.74	0.74	0.74			SI(V6)	0.00	0.00	0.26	0.47	0.58	0.58	0.58			
74	HSI-rsg	0.00	0.00	0.06	0.22	0.34	0.74	0.74			HSI-rsg	0.00	0.00	0.06	0.18	0.26	0.37	0.37			
75																					
76	TY	0	1	51																	
77	HSIw/o	0.64	0.64	0.64																	
78	HSI w/	0.64	0	0.00																	
79	area w/o	13.88	13.88	13.88																	
80	area w/	13.88	13.88	13.88																	
81	HUs w/o		8.9	445.5																	
82	HUs w/		4.5	0.0																	
83	AAHUs without			8.9																	
84	AAHUs with			0.1																	
85	change due to project			-8.8																	
86																					
87	TY	0	1	5	10	14	15	51			TY	0	1	5	10	14	15	51			
88	HSIw/o	0	0	0	0	0	0	0			HSIw/o	0	0	0	0	0	0	0			
89	HSI w/	0.00	0.00	0.06	0.22	0.34	0.74	0.74			HSI w/	0.00	0.00	0.06	0.18	0.26	0.37	0.37			
90	area w/o	10	10	10	10	10	10	10			area w/o	10	10	10	10	10	10	10			
91	area w/	10	10	10	10	10	10	10			area w/	10	10	10	10	10	10	10			
92	HUs w/o		0	0	0	0	0	0			HUs w/o		0	0	0	0	0	0			
93	HUs w/		0.00	1.25	7.10	11.32	5.41	265.26			HUs w/		0.00	1.25	6.12	8.78	3.15	134.16			
94	AAHUs without							0.00			AAHUs without							0.00			
95	AAHUs with							5.69			AAHUs with							3.01			
96	change due to project							5.69			change due to project							3.01			
97																					
98	In this case it would take more than 10 acres to compensate the losses of value									Compensation Ratio estimate: CR = loss at impact site/gain at mitigation site X 10/13.88 acres											
99	to riparian songbird guild; the estimated compensation area would be:							15.50		Best case scenario: CR =			1.11646								
100	which is somewhat more than 1:1 with perfect mitigation									Worst case scenario: CR =			2.112309								
101	with "worst case" futures; the estimated compensation area would be:							29.31885													
102																					
103	Riparian Forest Cover Type - Best Case Scenario									Riparian Forest Cover Type - Worst Case Scenario											
104																					

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
105	V1 - tree height; optimum 60+ feet; takes about 20 years to get this									V1 - tree height; optimum 60+ feet; max avg of 40 feet after 20 years											
106	V2 - stand width; optimum assumed if 70+ feet wide site									V2 - stand width; optimum assumed if 70+ feet wide site, same as best case											
107	V3-tree canopy closure; optimum 50-80%, may barely get there in 20 years									V3-tree canopy closure; optimum 50-80%, scenario max is 40%											
108	V4- # species; assume can be optimally planted at 4+ species, all survive									V4- # species; 3 of 4 planted species survives											
109	V5 - average understory density; optimal 30-60% this will evolve over time									V5 - average understory density; overshoots optimum after year 20											
110	TY5=20%; TY10-51 - optimal (i.e., 30-60%)									* - discount overall HSI by 1/3 per model assumes most not adjacent to water											
111																					
112	TY	0	1	5	10	15	20	51		TY	0	1	5	10	15	20	51				
113	V1	0	3	15	25	35	60	75		V1	0	3	15	25	30	40	40				
114	V2	0	70	70	70	70	70	70		V2	0	70	70	70	70	70	70				
115	V3	0	0	10	30	40	50	60		V3	0	0	10	30	35	40	40				
116	V4	0	4	4	4	4	4	4		V4	0	4	4	3	3	3	3				
117	V5	0	0	20	30	50	60	60		V5	0	0	20	25	50	70	70				
118																					
119	SI(V1)	0.00	0.05	0.25	0.42	0.58	1.00	1.00		SI(V1)	0.00	0.05	0.25	0.42	0.50	0.67	0.67				
120	SI(V2)	0.2	1	1	1	1	1	1		SI(V2)	0.2	1	1	1	1	1	1				
121	SI(V3)	0	0	0.2	0.6	0.8	1	1		SI(V3)	0	0	0.2	0.6	0.7	0.8	0.8				
122	SI(V4)	0	1	1	1	1	1	1		SI(V4)	0	1	1	1	1	1	1				
123	SI(V5)	0.20	0.20	0.73	1.00	1.00	1.00	1.00		SI(V5)	0.20	0.20	0.73	0.87	1.00	0.88	0.88				
124	HSI-rfct	0.10	0.22	0.61	0.81	0.89	1.00	1.00		HSI-rfct*	0.07	0.15	0.41	0.52	0.57	0.59	0.59				
125																					
126	TY	0	1	51																	
127	HSIw/o	0.73	0.73	0.73																	
128	HSI w/	0.73	0	0																	
129	area w/o	13.88	13.88	13.88																	
130	area w/	13.88	13.88	13.88																	
131	HUs w/o		10.1	507.4																	
132	HUs w/		5.1	0.0																	
133	AAHUs without			10.1																	
134	AAHUs with			0.1																	
135	change due to project			-10.0																	
136																					
137	TY	0	1	5	10	15	20	51		TY	0	1	5	10	15	20	51				
138	HSIw/o	0	0	0	0	0	0	0		HSIw/o	0	0	0	0	0	0	0				
139	HSI w/	0.10	0.22	0.61	0.81	0.89	1.00	1.00		HSI w/	0.07	0.15	0.41	0.52	0.57	0.59	0.59				
140	area w/o	10	10	10	10	10	10	10		area w/o	10	10	10	10	10	10	10				
141	area w/	10	10	10	10	10	10	10		area w/	10	10	10	10	10	10	10				
142	HUs w/o		0	0	0	0	0	0		HUs w/o		0	0	0	0	0	0				
143	HUs w/		1.62	16.72	35.68	42.57	47.20	310.00		HUs w/		1.08	11.20	23.33	27.35	28.90	181.36				
144	AAHUs without							0.00		AAHUs without							0.00				
145	AAHUs with							8.90		AAHUs with							5.36				
146	change due to project							8.90		change due to project							5.36				
147																					
148	In this case it would take more than 10 acres to compensate the losses of value									Compensation Ratio estimate: CR = loss at impact site/gain at mitigation site X 10/13.88 acres											
149	to riparian forest covertype; the estimated compensation area would be:							11.29		Best case scenario: CR =			0.813662								
150	which is somewhat more than 1:1 with perfect mitigation									Worst case scenario: CR =			1.351352								
151	with "worst case" futures; the estimated compensation area would be:							18.75677													
152																					
153	Downy Woodpecker model - Best Case Scenario											Downy Woodpecker model - Worst Case Scenario									
154	V1- Basal Area, this will take awhile to maximize (44'/acre); guess is at least 20 years, remains optimal through TY51											V1 = less, slower, basal area, site heterogeneity, limits max SI to 0.7									
155	V2- 6+" snags, these take longer than 4" snags; guess 20 years for this exercise; will max out at 1.5 snags/ac											V2 = snags slightly less abundant at year 20, 1.0 snags/ac									
156																					

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
157																					
158	TY	0	1	5	10	19	20	51		TY	0	1	5	10	19	20	51				
159	V1	0	5	10	20	40	44	90		V1	0	5	10	20	24	25	31				
160	V2	0	0	0	0	0	1.5	1.5		V2	0	0	0	0	0	1	1				
161																					
162	SI(V1)	0.00	0.11	0.23	0.45	0.91	1.00	0.97		SI(V1)	0.00	0.11	0.23	0.45	0.55	0.57	0.70				
163	SI(V2)	0.00	0.00	0.00	0.00	0.00	0.30	0.30		SI(V2)	0.00	0.00	0.00	0.00	0.00	0.20	0.20				
164	HSI-dw	0.00	0.00	0.00	0.00	0.00	0.30	0.30		HSI-dw	0.00	0.00	0.00	0.00	0.00	0.20	0.20				
165																					
166	TY	0	1	51																	
167	HSIw/o	0.23	0.23	0.23																	
168	HSI w/	0.23	0	0.00																	
169	area w/o	13.88	13.88	13.88																	
170	area w/	13.88	13.88	13.88																	
171	HUs w/o		3.2	160.5																	
172	HUs w/		1.6	0.0																	
173	AAHUs without			3.2																	
174	AAHUs with			0.0																	
175	change due to project			-3.2																	
176																					
177	TY	0	1	5	10	14	15	51		TY	0	1	5	10	14	15	51				
178	HSIw/o	0	0	0	0	0	0	0		HSIw/o	0	0	0	0	0	0	0				
179	HSI w/	0.00	0.00	0.00	0.00	0.00	0.30	0.30		HSI w/	0.00	0.00	0.00	0.00	0.00	0.20	0.20				
180	area w/o	10	10	10	10	10	10	10		area w/o	10	10	10	10	10	10	10				
181	area w/	10	10	10	10	10	10	10		area w/	10	10	10	10	10	10	10				
182	HUs w/o		0	0	0	0	0	0		HUs w/o		0	0	0	0	0	0				
183	HUs w/		0.00	0.00	0.00	0.00	1.50	108.00		HUs w/		0.00	0.00	0.00	0.00	1.00	72.00				
184	AAHUs without							0.00		AAHUs without							0.00				
185	AAHUs with							2.15		AAHUs with							1.43				
186	change due to project							2.15		change due to project							1.43				
187																					
188	Best case it would take more than 10 acres to compensate the losses of value									Compensation Ratio estimate: CR = loss at impact site/gain at mitigation site X 10/13.88 acres											
189	to downy woodpecker; the estimated compensation area would be:							14.81		Best case scenario: CR =		1.066869									
190	which is more than 1:1 with perfect mitigation									Worst case scenario: CR =		1.600304									
191	Note: this assumes higher snag density (1.5/ac) than seen natural (1.08)									Note: lower overall snag densities possible where easements restrict woody plantings/height											
192	which could occur if larger trees were set as goal; may be unrealistic																				
193	with "worst case" futures; the estimated compensation area would be:							22.21222													
194																					
195	Hairy Woodpecker - best case scenario											Hairy Woodpecker - worst case scenario (shrub emphasis, encroachments, cover/dbh more limited)									
196	V1 - snags >10"; optimum at 2+/acre; begin to form at year 20											V1 - snags >10"; optimum at 1/acre; begin to form at year 30									
197	V2 - mean dbh, nesting, has value at 8+ inches (year 15), opt at 15+" (year 25)											V2 - mean dbh, nesting, has value at 8+ inches (year 15), opt at 10+" due to encroachment limits (year 20)									
198	V3 - mean dbh, cover, min value SI .5, then increases with dbh 6 to 12" (years 10 to 20); max 15 (year 25+)											V3 - mean dbh, cover, min value SI .5, then increases with dbh 6 to 10" (years 10 to 20)									
199	V4 - % canopy cover, begins to have value >15%,then increases with cover to 55% (years 5 to 25), max 60% (yr 51)											V4 - % canopy cover, begins to have value >15%,then increases with cover to 40% (years 5 to 25)									
200																					
201	TY	0	1	5	10	15	19	20	25	51		TY	0	1	5	10	15	25	29	30	51
202	V1	0	0	0	0	0	0	1	2	2		V1	0	0	0	0	0	0	0	1	1
203	V2	0	1	3	6	8	9	12	15	15		V2	0	1	3	6	8	9	10	10	10
204	V3	0	1	3	6	8	9	12	15	15		V3	0	1	3	6	8	9	10	10	10
205	V4	0	0	0	30	40	48	50	55	60		V4	0	0	0	30	35	40	40	40	40
206																					
207	SI(V1)	0	0	0	0	0	0	0.2	0.4	0.4		SI(V1)	0	0	0	0	0	0	0	0.2	0.2
208	SI(V2)	0.00	0.00	0.00	0.00	0.00	0.14	0.57	1.00	1.00		SI(V2)	0.00	0.00	0.00	0.00	0.00	0.14	0.29	0.29	0.29

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
209	SI(V3)	0.50	0.50	0.50	0.51	0.77	0.89	1.00	1.00	1.00		SI(V3)	0.50	0.50	0.50	0.51	0.77	0.89	1.00	1.00	1.00
210	SI(V4)	0.00	0.00	0.00	0.21	0.36	0.47	0.50	0.57	0.64		SI(V4)	0.00	0.00	0.00	0.21	0.29	0.36	0.36	0.36	0.36
211	HSI(hw)	0.00	0.00	0.00	0.00	0.00	0.05	0.32	0.66	0.74		HSI(hw)	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.15	0.15
212																					
213	TY	0	1	51																	
214	HSIw/o	0.06	0.06	0.06																	
215	HSI w/	0.06	0	0																	
216	area w/o	13.88	13.88	13.88																	
217	area w/	13.88	13.88	13.88																	
218	HUs w/o		0.9	43.6																	
219	HUs w/		0.4	0.0																	
220	AAHUs without			0.9																	
221	AAHUs with			0.0																	
222	change due to project			-0.9																	
223																					
224	TY	0	1	5	10	15	19	20	25	51		TY	0	1	5	10	15	29	30	25	51
225	HSIw/o	0	0	0		0	0	0	0	0		HSIw/o	0	0	0	0	0	0	0	0	0
226	HSI w/	0.00	0.00	0.00	0.00	0.00	0.05	0.32	0.66	0.74		HSI w/	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.15	0.15
227	area w/o	10	10	10	10	10	10	10	10	10		area w/o	10	10	10	10	10	10	10	10	10
228	area w/	10	10	10	10	10	10	10	10	10		area w/	10	10	10	10	10	10	10	10	10
229	HUs w/o		0	0	0	0	0	0	0	0		HUs w/o		0	0	0	0	0	0	0	0
230	HUs w/		0.00	0.00	0.00	0.00	0.91	1.80	24.32	181.54		HUs w/		0.00	0.00	0.00	0.00	2.41	0.56	-5.63	38.58
231	AAHUs without									0.00		AAHUs without									0.00
232	AAHUs with									4.09		AAHUs with									0.70
233	change due to project									4.09		change due to project									0.70
234																					
235	Best case it would take far less than 10 acres to compensate the losses of value											Compensation Ratio estimate: CR = loss at impact site/gain at mitigation site X 10/13.88 acres									
236	to hairy woodpecker; the estimated compensation area would be:							2.11				Best case scenario: CR =			0.152019						
237	which is less than 1:1 with perfect mitigation											Worst case scenario: CR =			0.882875						
238	Note: this assumes higher snag density (1.5/ac) than seen natural (1.08)											Note: lower overall snag densities possible where easements restrict woody plantings/height									
239	which could occur if larger trees were set as goal; may be unrealistic											Also less than 1:1 with lower futures, although HSI (0.15 after yr 25) much better than baseline (0.06)									
240	With "worst case" futures; the estimated compensation area would be:							12.2543													
241																					
242	Summary Table of Futures-based compensation area and ratio for best/worse case scenarios																				
243					mitigation need		mitigation ratio														
244	scenario		best	worst	best	worst	best	worse													
245		project	mitigation	mitigation																	
246		loss	gain, 10ac	gain, 10ac																	
247	MODEL	AAHUs	AAHUs	AAHUs																	
248	mWarblr	-8.8	8.8	5.9	9.9	14.9	0.72	1.08													
249	RSG	-8.8	5.7	3.0	15.5	29.3	1.12	2.11													
250	RFCT	-10.0	8.9	5.4	11.3	18.8	0.81	1.35													
251	DW	-3.2	2.1	1.4	14.8	22.2	1.07	1.60													
252	HW	-0.9	4.1	0.7	2.1	12.3	0.15	0.88													

	A	B	C	D	E	F	G	H	I	J	K	L
1	THIS IS THE "FuturesExcess" TAB											
2	In this TAB: a simplified future test is done, in which the starting point of the mitigation site is advanced by 10 years											
3	This scenario informs how excess mitigation might apply to a future project phase, or if mitigation is started before impact.											
4	For the purpose of this exercise, it is assumed the impact site is similar to TS_30_L in baseline value and impact											
5	The 10 year advance is done by creating a TY0 and 1 which has the same as the TY10 (or next higher TY) in the "Futures" Tab.											
6	NOTE:	ONLY using the worse case scenario for mitigation sites, however, in this future test										
7												
8	10 YEAR HEADSTART WORST CASE SHOWN BELOW											
9	NOTE: proofed 10/31/22											
10	THESE ARE THE RELEVANT COLUMNS											
11	TO SHOW VALUE OF MITIGATION "LEFT OVER" OR STARTED EARLY.											
12												
13	WARBLER MODEL											
14	Warbler Model - Worse Case Scenario											
15	V1-shrub cover: maxes out at 40% due to water variability/dieoff after year 5											
16	V2-shrub height: 1.2 M max due to alot of herbaceous											
17	V3- percent deciduous shrub cover: same as best case											
18	V4- percent tall tree cover, takes longer due to variable water, 40% maximum											
19												
20		TY0	TY1	TY5	TY15	TY25	TY51					
21	V1	0.5	0.5	0.5	0.5	0.5	0.5					
22	V2	1.2	1.2	1.2	1.2	1.2	1.2					
23	V3	1	1	1	1	1	1					
24	V4	0.3	0.4	0.4	0.4	0.4	0.4					
25												
26	SI(V1)	0.83	0.83	0.83	0.83	0.83	0.83					
27	SI(V2)	0.6	0.6	0.6	0.6	0.6	0.6					
28	SI(V3)	1	1	1	1	1	1					
29	SI(V4)	0.8	0.9	0.9	0.9	0.9	0.9					
30	HSI-ywm	0.63	0.67	0.67	0.67	0.67	0.67					
31												
32	TY	0	1	5	15	25	51					
33	HSIw/o	0.00	0.00	0.00	0.00	0.00	0.00					
34	HSI w/	0.63	0.67	0.67	0.67	0.67	0.67					
35	area w/o	10	10	10	10	10	10					
36	area w/	10	10	10	10	10	10					
37	HUs w/o		0	0	0	0	0					
38	HUs w/		6.51638	26.83282	67.08204	67.08204	174.4133					
39	AAHUs without						0					
40	AAHUs with						6.704443					
41	change due to project (mitigation gain)						6.704443					
42												
43	TY	0	1	5	15	25	51					
44	HSIw/o	0.64	0.64	0.64	0.64	0.64	0.64					
45	HSI w/	0.64	0.00	0.00	0.00	0.00	0.00					
46	area w/o	13.88	13.88	13.88	13.88	13.88	13.88					
47	area w/	13.88	13.88	13.88	13.88	13.88	13.88					
48	HUs w/o		8.867974	35.4719	88.67974	88.67974	230.5673					
49	HUs w/		4.433987	0	0	0	0					
50	AAHUs without						8.867974					
51	AAHUs with						0.086941					
52	change due to project (project impact loss)						-8.78103					
53	Compensation Ratio estimate: CR = loss at impact site/gain at mitigation site X 10/13.88 acres											
54												
55	worst case scenario, future with mitigation started 10 years prior to impact: CR =									**0.943612**		
56	Compare with worst case scenario, future with mitigation started same time of impact: CR=									1.075757		
57												

	A	B	C	D	E	F	G	H	I	J	K	L
58	compensation area worst case, mitigation started 10 yrs before impact:							13.09733				
59	compensation area worst case, mitigation started same time as impact:							14.93151				
60												
61	RIPARIAN SONGBIRD MODEL											
62	Riparian Songbird Model - worst case scenario											
63	V1 - takes 14 years, maxes out at 50%											
64	V2 - takes 15 years, maxes out at 40%											
65	V3 - takes 14 years to reach 6+M											
66				V4 - not all "5", some "2","3","4"; max SI .7								
67	V5 - not optimal throughout; max average is 1.2 snags/ac											
68	V6 - lower, max is 60%											
69												
70	TY	10	10	10	10	14	15	51				
71	V1	40	40	40	40	50	50	50				
72	V2	30	30	30	30	40	40	40				
73	V3	5	5	5	5	6	6	6				
74	V4	3	3	3	(assume SI of 0.7, mix of categories 2-5)							
75	V5	0	0	0	0	0	1.2	1.2				
76	V6	30	30	30	50	60	60	60				
77												
78	SI(V1)	0.75	0.75	0.75	0.75	1	1	1				
79	SI(V2)	0.5	0.5	0.5	0.5	0.75	0.75	0.75				
80	SI(V3)	0.8	0.8	0.8	0.8	1	1	1				
81	SI(V4)	0.7	0.7	0.7	0.7	0.7	0.7	0.7				
82	SI(V5)	0.00	0.00	0.00	0.00	0.00	0.40	0.40				
83	SI(V6)	0.26	0.26	0.26	0.47	0.58	0.58	0.58				
84	HSI-rsg	0.10	0.10	0.10	0.18	0.26	0.37	0.37				
85												
86	TY	0	1	51								
87	HSIw/o	0.64	0.64	0.64								
88	HSI w/	0.64	0	0.00								
89	area w/o	13.88	13.88	13.88								
90	area w/	13.88	13.88	13.88								
91	HUs w/o		8.9	445.5								
92	HUs w/		4.5	0.0								
93	AAHUs without			8.9								
94	AAHUs with			0.1								
95	change due to project			-8.8								
96												
97	TY	0	1	5	10	14	15	51				
98	HSIw/o	0	0	0	0	0	0	0				
99	HSI w/	0.10	0.10	0.10	0.18	0.26	0.37	0.37				
100	area w/o	10	10	10	10	10	10	10				
101	area w/	10	10	10	10	10	10	10				
102	HUs w/o		0	0	0	0	0	0				
103	HUs w/		1.01	4.05	7.09	8.78	3.15	134.16				
104	AAHUs without							0.00				
105	AAHUs with							3.10				
106	change due to project							3.10				
107												
108	Compensation Ratio estimate: CR = loss at impact site/gain at mitigation site X 10/13.88 acres											
109												
110		worst case scenario, future with mitigation started 10 years prior to impact: CR =								**2.048404**		
111	Compare with worst case scenario, future with mitigation started same time of impact: CR=									**2.112309**		
112												
113	compensation area worst case, mitigation started 10 yrs before impact:							28.43185				
114	compensation area worst case, mitigation started same time as impact:							29.31885				

	A	B	C	D	E	F	G	H	I	J	K	L
115	Note: slightly lower than mitigation concurrent, 10 yr headstart makes little difference											
116												
117	RIPARIAN FOREST COVER TYPE MODEL											
118	Riparian Forest Cover Type - Worst Case Scenario											
119												
120	V1 - tree height; optimum 60+ feet; max avg of 40 feet after 20 years											
121	V2 - stand width; optimum assumed if 70+ feet wide site, same as best case											
122	V3-tree canopy closure; optimum 50-80%, scenario max is 40%											
123	V4- # species; 3 of 4 planted species survives											
124	V5 - average understory density; overshoots optimum after year 20											
125	* - discount overall HSI by 1/3 per model assumes most not adjacent to water											
126												
127	TY	0	1	5	10	15	20	51				
128	V1	25	25	25	25	30	40	40				
129	V2	70	70	70	70	70	70	70				
130	V3	30	30	30	30	35	40	40				
131	V4	3	3	3	3	3	3	3				
132	V5	25	25	25	25	50	70	70				
133												
134	SI(V1)	0.42	0.42	0.42	0.42	0.50	0.67	0.67				
135	SI(V2)	1	1	1	1	1	1	1				
136	SI(V3)	0.6	0.6	0.6	0.6	0.7	0.8	0.8				
137	SI(V4)	0	1	1	1	1	1	1				
138	SI(V5)	0.87	0.87	0.87	0.87	1.00	0.88	0.88				
139	HSI-rfct*	0.31	0.52	0.52	0.52	0.57	0.59	0.59				
140												
141	TY	0	1	51								
142	HSIw/o	0.73	0.73	0.73								
143	HSI w/	0.73	0	0								
144	area w/o	13.88	13.88	13.88								
145	area w/	13.88	13.88	13.88								
146	HUs w/o		10.1	507.4								
147	HUs w/		5.1	0.0								
148	AAHUs without			10.1								
149	AAHUs with			0.1								
150	change due to project			-10.0								
151												
152	TY	0	1	5	10	15	20	51				
153	HSIw/o	0	0	0	0	0	0	0				
154	HSI w/	0.31	0.52	0.52	0.52	0.57	0.59	0.59				
155	area w/o	10	10	10	10	10	10	10				
156	area w/	10	10	10	10	10	10	10				
157	HUs w/o		0	0	0	0	0	0				
158	HUs w/		4.17	20.92	26.15	27.35	28.90	181.36				
159	AAHUs without							0.00				
160	AAHUs with							5.66				
161	change due to project							5.66				
162												
163	Compensation Ratio estimate: CR = loss at impact site/gain at mitigation site X 10/13.88 acres											
164												
165		worst case scenario, future with mitigation started 10 years prior to impact: CR =								**1.278279**		
166	Compare with worst case scenario, future with mitigation started same time of impact: CR=									**1.351352**		
167	compensation area worst case, mitigation started 10 yrs before impact:							17.74252				
168	compensation area worst case, mitigation started same time as impact:							18.75677				
169	Note: Again, a 10 year headstart on mitigation slightly lowers worst case CR											
170												
171	DOWNY WOODPECKER MODEL											

	A	B	C	D	E	F	G	H	I	J	K	L
172			Downy Woodpecker model - Worst Case Scenario									
173			V1 = less, slower, basal area, site heterogeneity, limits max SI to 0.7									
174			V2 = snags slightly less abundant at year 10, 1.0 snags/ac									
175												
176	Note: for the 10 year headstart, shifted TY10 to TY0, and TY20 to TY10 and higher											
177	TY	0	1	5	9	10	20	51				
178	V1	0	20	20	24	25	25	31				
179	V2	0	0	0	0	1	1	1				
180												
181	SI(V1)	0.00	0.45	0.45	0.55	0.57	0.57	0.70				
182	SI(V2)	0.00	0.00	0.00	0.00	0.20	0.20	0.20				
183	HSI-dw	0.00	0.00	0.00	0.00	0.20	0.20	0.20				
184												
185	TY	0	1	51								
186	HSIw/o	0.23	0.23	0.23								
187	HSI w/	0.23	0	0.00								
188	area w/o	13.88	13.88	13.88								
189	area w/	13.88	13.88	13.88								
190	HUs w/o		3.2	160.5								
191	HUs w/		1.6	0.0								
192	AAHUs without			3.2								
193	AAHUs with			0.0								
194	change due to project			-3.2								
195												
196	TY	0	1	5	10	14	15	51				
197	HSIw/o	0	0	0	0	0	0	0				
198	HSI w/	0.00	0.00	0.00	0.00	0.20	0.20	0.20				
199	area w/o	10	10	10	10	10	10	10				
200	area w/	10	10	10	10	10	10	10				
201	HUs w/o		0	0	0	0	0	0				
202	HUs w/		0.00	0.00	0.00	4.00	2.00	72.00				
203	AAHUs without							0.00				
204	AAHUs with							1.53				
205	change due to project							1.53				
206												
207	Compensation Ratio estimate: CR = loss at impact site/gain at mitigation site X 10/13.88 acres											
208												
209		worst case scenario, future with mitigation started 10 years prior to impact: CR =								**1.49772**		
210	Compare with worst case scenario, future with mitigation started same time of impact: CR=									**1.600304**		
211	Note: lower overall snag densities possible where easements restrict woody plantings/height											
212	Note: again, slightly lower CR with 10 year headstart on mitigation site											
213	compensation area worst case, mitigation started 10 yrs before impact:							20.78836				
214	compensation area worst case, mitigation started same time as impact:							22.21222				
215												
216	HAIRY WOODPECKER MODEL											
217	Hairy Woodpecker - worst case scenario (shrub emphasis, encroachments, cover/dbh more limited)											
218	V1 - snags >10"; optimum at 1/acre; begin to form at year 20											
219	V2 - mean dbh, nesting, has value at 8+ inches (year 5), opt at 10+" due to encroachment limits (year 10)											
220	V3 - mean dbh, cover, min value SI .5, then increases with dbh 6 to 10" (years 0 to 10)											
221	V4 - % canopy cover, begins to have value >15%,then increases with cover to 40% (years 0 to 15)											
222												
223	TY	0	1	5	10	15	19	20	25	51		
224	V1	0	0	0	1	1	1	1	1	1		
225	V2	0	1	8	10	10	10	10	10	10		
226	V3	6	6	8	10	10	10	10	10	10		
227	V4	30	30	35	40	40	40	40	40	40		
228												

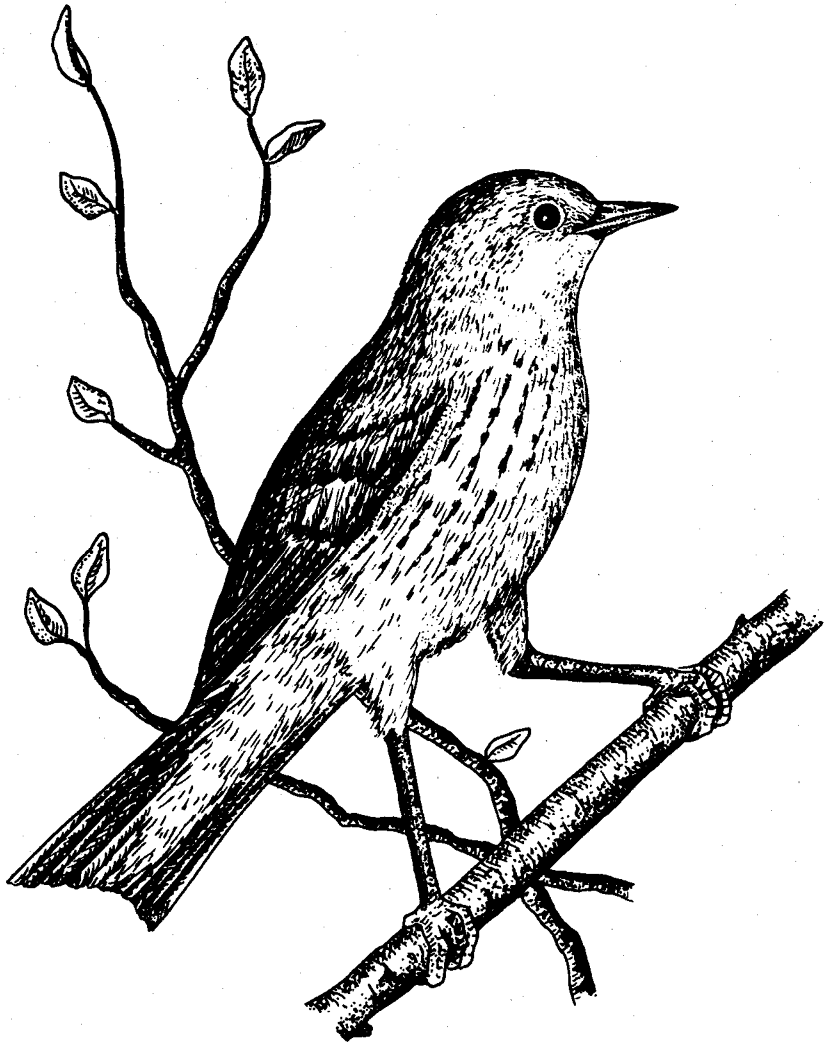
	A	B	C	D	E	F	G	H	I	J	K	L
229	SI(V1)	0	0	0	0.2	0.2	0.2	0.2	0.2	0.2		
230	SI(V2)	0.00	0.00	0.00	0.29	0.29	0.29	0.29	0.29	0.29		
231	SI(V3)	0.51	0.51	0.77	1.00	1.00	1.00	1.00	1.00	1.00		
232	SI(V4)	0.21	0.21	0.29	0.36	0.36	0.36	0.36	0.36	0.36		
233	HSI(hw)	0.00	0.00	0.00	0.15	0.15	0.15	0.15	0.15	0.15		
234												
235	TY	0	1	51								
236	HSIw/o	0.06	0.06	0.06								
237	HSI w/	0.06	0	0								
238	area w/o	13.88	13.88	13.88								
239	area w/	13.88	13.88	13.88								
240	HUs w/o		0.9	43.6								
241	HUs w/		0.4	0.0								
242	AAHUs without			0.9								
243	AAHUs with			0.0								
244	change due to project			-0.9								
245												
246	TY	0	1	5	10	15	19	20	25	51		
247	HSIw/o	0	0	0	0	0	0	0	0	0		
248	HSI w/	0.00	0.00	0.00	0.15	0.15	0.15	0.15	0.15	0.15		
249	area w/o	10	10	10	10	10	10	10	10	10		
250	area w/	10	10	10	10	10	10	10	10	10		
251	HUs w/o		0	0	0	0	0	0	0	0		
252	HUs w/		0.00	0.00	3.71	7.42	5.94	1.48	7.42	38.58		
253	AAHUs without									0.00		
254	AAHUs with									1.27		
255	change due to project									1.27		
256												
257	Compensation Ratio estimate: CR = loss at impact site/gain at mitigation site X 10/13.88 acres											
258												
259		worst case scenario, future with mitigation started 10 years prior to impact: CR =								**0.49115**		
260	Compare with worst case scenario, future with mitigation started same time of impact: CR=									**0.882875**		
261	Note: lower overall snag densities possible where easements restrict woody plantings/height											
262	Also less than 1:1 with lower futures, although HSI (0.15 after yr 19) much better than baseline (0.06)											
263	compensation area worst case, mitigation started 10 yrs before impact:							6.817155				
264	compensation area worst case, mitigation started same time as impact:							12.2543				
265	NOTE: Above boldface value shows significant reduction compared to without 10 years											
266												
267	Summary Table of Futures-based compensation area and ratio for worst case scenario, 10 year advance mitigation											
268				hab value		comp		mitigation ratios				
269				10 yr adv		area		this TAB	from prior TAB			
270	scenario			worst		worst		worst	mitigation starts same			
271		project		mitigation		10 yr adv		10y adv	year as impact			
272		loss		gain, 10ac								
273	MODEL	AAHUs		AAHUs				COMPARE THESE				
274	mWarblr	-8.8		**6.7**		**13.1**		**0.94**	1.08			
275	RSG	-8.8		**3.1**		**28.4**		**2.05**	2.11			
276	RFCT	-10.0		**5.7**		**17.7**		**1.28**	1.35			
277	DW	-3.2		**1.5**		**20.8**		**1.50**	1.60			
278	HW	-0.9		**1.3**		**6.8**		**0.49**	0.88			
279												
280	Note: in the columns A-H, above left, the boldfaced values show the effect of the 10 year headstart											
281	If mitigation area were "left over" from a larger than needed site for TS_30_L, the compensation											
282	for a next reach exactly the same as TS_30_L, would be slightly less, due to greater AAHUs											
283	gained per 10 acres of mitigation site, which would be 10 years ahead and of higher value											
284	It isn't a huge difference, however, and the highest ratio of all models still rounds to 2:1											

APPENDIX B: Models

Biological Services Program
and
Division of Ecological Services

FWS/OBS-82/10.27
JULY 1982

HABITAT SUITABILITY INDEX MODELS: YELLOW WARBLER



Fish and Wildlife Service

U.S. Department of the Interior

The Biological Services Program was established within the U.S. Fish and Wildlife Service to supply scientific information and methodologies on key environmental issues that impact fish and wildlife resources and their supporting ecosystems. The mission of the program is as follows:

- To strengthen the Fish and Wildlife Service in its role as a primary source of information on national fish and wildlife resources, particularly in respect to environmental impact assessment.
- To gather, analyze, and present information that will aid decisionmakers in the identification and resolution of problems associated with major changes in land and water use.
- To provide better ecological information and evaluation for Department of the Interior development programs, such as those relating to energy development.

Information developed by the Biological Services Program is intended for use in the planning and decisionmaking process to prevent or minimize the impact of development on fish and wildlife. Research activities and technical assistance services are based on an analysis of the issues, a determination of the decisionmakers involved and their information needs, and an evaluation of the state of the art to identify information gaps and to determine priorities. This is a strategy that will ensure that the products produced and disseminated are timely and useful.

Projects have been initiated in the following areas: coal extraction and conversion; power plants; geothermal, mineral and oil shale development; water resource analysis, including stream alterations and western water allocation; coastal ecosystems and Outer Continental Shelf development; and systems inventory, including National Wetland Inventory, habitat classification and analysis, and information transfer.

The Biological Services Program consists of the Office of Biological Services in Washington, D.C., which is responsible for overall planning and management; National Teams, which provide the Program's central scientific and technical expertise and arrange for contracting biological services studies with states, universities, consulting firms, and others; Regional Staffs, who provide a link to problems at the operating level; and staffs at certain Fish and Wildlife Service research facilities, who conduct in-house research studies.

This model is designed to be used by the Division of Ecological Services in conjunction with the Habitat Evaluation Procedures.

FWS/OBS-82/10.27
July 1982

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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CONTENTS

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YELLOW WARBLER (Dendroica petechia)

HABITAT USE INFORMATION

General

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 and 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 wetland 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 population 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 habitat 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.

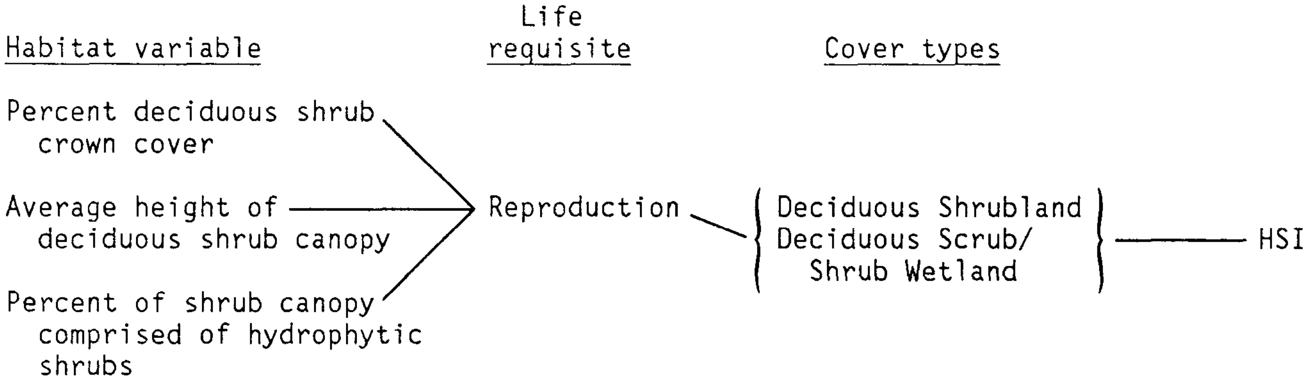


Figure 1. Relationship between habitat variables, life requisites, cover types, and the HSI for the yellow warbler.

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 the variables 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.

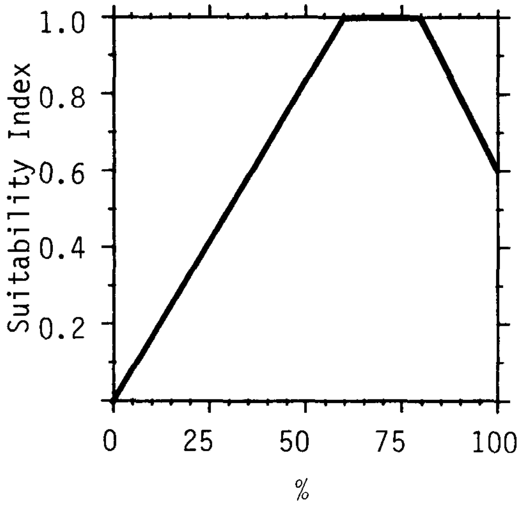
Reproduction component. Optimal nesting habitat for the yellow warbler is provided in wet areas with dense, moderately tall stands of hydrophytic deciduous shrubs. Upland shrub habitats on dry sites will provide only marginal suitability.

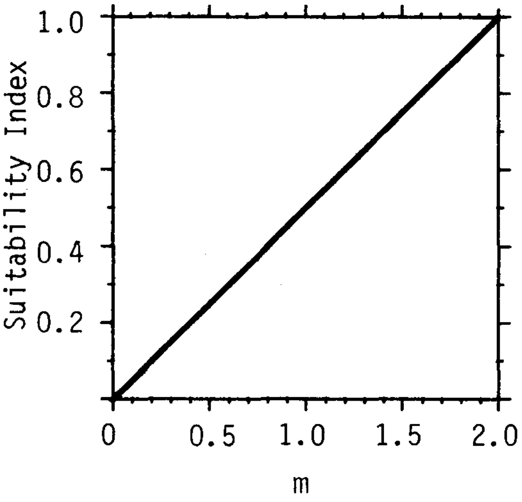
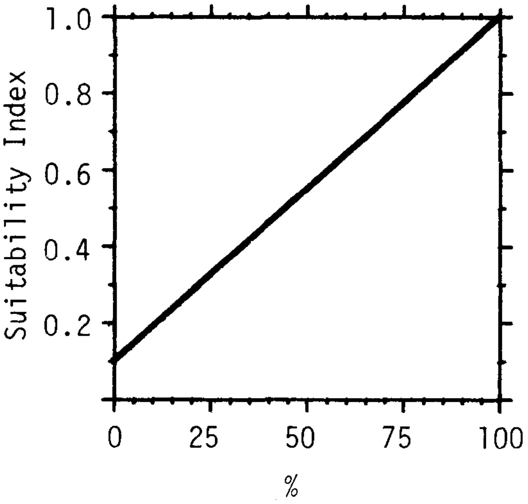
It is assumed that optimal habitats contain 100% hydrophytic deciduous shrubs and that habitats with no hydrophytic shrubs will provide marginal suitability. Shrub densities between 60 and 80% crown cover are assumed to be optimal. As shrub densities approach zero cover, suitability also approaches zero.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

Variable (definition)		Cover types	Suggested technique
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 shrub canopy).	DW,DSW	Graduated rod
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).	DS,DSW	Line intercept

Figure 2. Definitions of variables and suggested measurement techniques.

SOURCES OF OTHER MODELS

No other habitat models for the yellow warbler were located.

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Habitat preferences of the yellow warbler (Dendroica petechia) are described in this publication. It is one of a series of Habitat Suitability Index (HSI) models and was developed through an analysis of available information on the species-habitat requirements of the species. Habitat use information is presented in a review of the literature, followed by the development of an HSI model, designed for use in impact assessment and habitat management activities.

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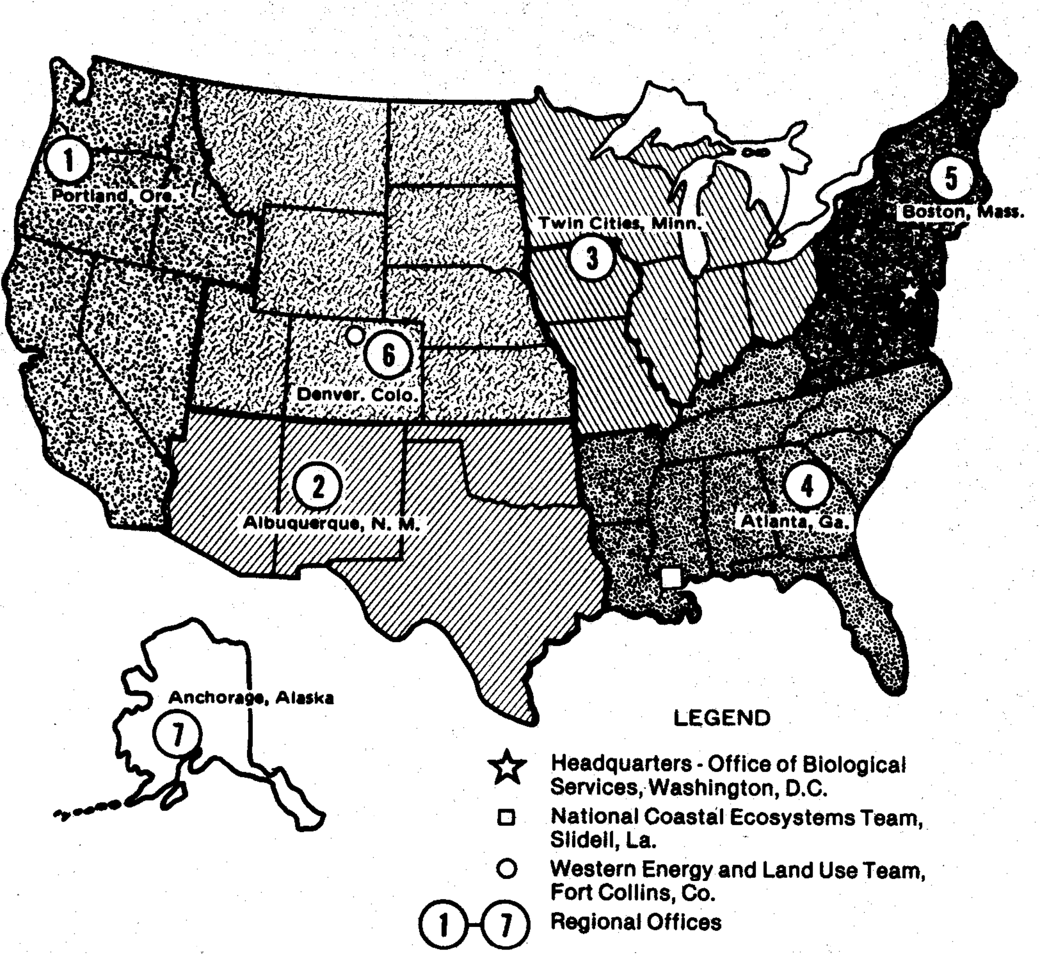

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DEPARTMENT OF THE INTERIOR

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HABITAT SUITABILITY INDEX MODEL

RIPARIAN SONGBIRD GUILD

HUMBOLDT BAY, CALIFORNIA

Prepared for:

California State Coastal Conservancy
County of Humboldt, Department of Public Works
Humboldt Bay Working Group

Prepared by:

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August 1986

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HABITAT SUITABILITY INDEX MODEL

RIPARIAN SONGBIRD GUILD

HUMBOLDT BAY, CALIFORNIA

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INTRODUCTION

This is a habitat suitability index model for songbird species that use forested or scrub-shrub wetlands (Cowardin *et al.* 1979) in the Humboldt Bay watershed in northern California; these wetlands are defined further below. The model can be used in determining existing habitat values, and in projecting habitat values at sites restored as wetlands. In addition, the model can be used to determine mitigation requirements for developments proposed to be sited in wetlands.

The model may be useful in determining habitat suitability in other wetland areas along the Pacific coast. Such application will require that users examine the model in order to determine whether local use necessitates model modification.

The model is based upon a review and synthesis of existing information, derived from the scientific literature, unpublished research reports available from Humboldt State University, comments from local biologists, and the author's personal observations. It is an hypothesis of species/habitat relationships, and is not a statement of proven cause and effect. It represents suspected relationships between habitat factors and the carrying capacity of the habitat for species in the guild. The model is scaled to produce a Habitat Suitability Index (HSI) value between 0.0 (unsuitable habitat) and 1.0 (optimally suitable habitat). Further discussion of HSI models may be obtained from part 103 of the Ecological Services Manual (see references).

This model has not been reviewed by species experts. The model has been reviewed by individuals familiar with HSI modelling, and modified according to their comments. The model has not been tested in the field.

The model is based on the perception that songbird species of riparian or swamp wetlands in the Humboldt Bay watershed form a guild in the sense used by Root (1967), Holmes *et al.* (1979), and Verner (1984). Further discussion of this use of the guild concept will be provided separately. This use of the term does not correspond to that advanced by Short (1983, 1984; Short and Burnham 1982).

Riparian habitat is used by a number of bird species, from a variety of avian families. This model is restricted to species that use the plants within this habitat directly for food, either through consumption of plant materials or through consumption of invertebrates that consume the plants, and that also nest (or potentially nest) within the habitat type. Most such species are members of the avian order Passeriformes. This model also addresses habitat needs of species in the order Piciformes (woodpeckers), at least two of which may be encountered foraging with passerines during the winter.

LIFE HISTORY OVERVIEW

Bird species potentially covered by this model include resident (i.e., remaining in the watershed all year), breeding visitor (here from spring through early fall), and winter visitor (here from fall through early spring) species. Examples of the three groups include: (i) resident - Chestnut-backed Chickadee (scientific names of all species are included in Attachment A), Downy Woodpecker, and Winter Wren; (ii) breeding visitor - Wilson's Warbler, Swainson's Thrush, and Tree Swallow; and (iii) winter visitor - Ruby-crowned Kinglet, Yellow-rumped Warbler, and Fox Sparrow. Additional species (such as the American Robin) are present all year, but probably are represented by different individuals in the winter and breeding seasons.

A vast quantity of ornithological and ecological literature exists covering the use of riparian wetlands by passerine and other birds; it is inappropriate to cite or synopsize it all here, but interested readers may wish to review Stevens et al. (1977), Hehnke and Stone (1979), Gaines (1980), Swift et al. (1984), and a number of papers in Warner and Hendrix (1984). There are currently two Master's thesis projects underway at Humboldt State University that include investigations of use of riparian and/or swamp habitats by songbirds in the Humboldt Bay area; one has resulted in interim reports that are useful in this analysis (Kelly 1983).

The specific habitat requirements of the species in this guild are rather varied. It is not the purpose of the model to address the conditions that would make riparian habitat more or less desirable for the individual species. The ecological backgrounds of the species are also varied; some species are almost completely "insectivorous" (consumers of arthropods), while some are primarily seed-eaters, and yet others consume both arthropods and seeds, as well as other plant material (see Martin et al 1951).

In order to address this variability, attention must be restricted to common elements in the ecology of the species. James (1971) demonstrated a "niche gestalt" for each of a number of passerine species. This interpretation is commonly adopted by ornithologists, and a number of "guild" studies (e.g., Holmes et al. 1979) utilize the concept of habitat conformation as a major element in defining guild membership. That approach is used in this model.

The bird species covered here are generally associated with deciduous tree and shrub species. It appears that the annual burst of production in the spring provides food for arthropods that compose the primary diet of most species, or food for the birds themselves. There is a general recognition that the diversity of bird species in an area generally is correlated with the vertical and horizontal foliage distribution (MacArthur and MacArthur 1961, Roth 1976, Holmes et al. 1979, Niemi and Hanowski 1984, Swift et al. 1984, and many others). Greater diversity in foliage distribution thus generally leads to greater bird species diversity. This correlation essentially ignores the actual relationship between productivity and reproductive success that presumably underlies the evolution of the habitat preferences.

It has been noted (e.g., Sturman 1968) that one of the species in this guild that is present in this watershed (the Chestnut-backed Chickadee) may respond to the presence or abundance of coniferous tree species. Observations in this region, and in other parts of California in which this species occurs, indicate that the chickadee does in fact use deciduous vegetation regularly. However, inclusion of conifers in riparian wetlands in the vicinity of Humboldt Bay has been recognized as the natural condition in these wetlands prior to settlement by European man (see Ray et al. 1984). For the purposes of this model, no differentiation will be made between deciduous and coniferous vegetation.

The distribution of foliage provides nesting substrate for the birds (each according to the appropriate niche gestalt). Some species in the guild are primary or secondary cavity nesters (secondary = using holes made by primary excavators). Cavity nesters generally use dead wood, rather than nesting in live trees. Thus, the presence of snags or other dead substrate is an important element for some species in the guild (see Schroeder 1982b, 1982c).

HABITAT REQUIREMENTS

This model addresses life requisites of food and foraging, reproduction (nesting), and cover. It is assumed that water is not limiting for any species, and no explicit element for water is included in this model. Food and foraging substrate are considered to be provided by woody vegetation. Shrubs are considered to be live woody stems up to 3 meters (10 feet) tall. Live woody stems greater than 3 m tall are considered to be trees. This model will not differentiate between single and multiple tree canopy layers, with possibly higher habitat values because of the presence of additional layers, primarily for logistical reasons.

Stem diameter is not considered for foraging purposes, although it is clear that scansorial (trunk- and limb-foraging) birds will experience greater habitat value as basal area increases (e.g., see Schroeder 1982c).

Similarly, cover is considered to be provided by vegetation; separate variables to differentiate between foraging and cover substrates are not included in the model.

Reproduction substrate is provided for these species by the plants that also provide cover and foraging substrate. The volume of space that potentially offers nesting sites increases proportionally with the total volume of plant leaf area. A further consideration for nesting substrate is the availability of snags of suitable size, to accommodate cavity nesters.

HABITAT SUITABILITY INDEX [HSI] MODEL

Model Applicability. This model was developed to address habitat needs within the Humboldt Bay watershed. The model is also expected to apply to coastal wetlands elsewhere on California's northern coast, although the full range of geographical applicability is not defined. The model may be applicable (with suitable modifications) to other coastal and noncoastal wetland areas in California and Oregon; many northwestern California wetlands are more similar to those of Oregon than to wetlands farther south in California. There is no intended seasonal applicability, inasmuch as the habitats covered by the model are used by different members of the guild in all four seasons.

Wetlands included in the habitats that could be evaluated by this model are: (i) riparian woodlands along streamcourses that enter the bay; (ii) swamps dominated by willows (*Salix* spp.), alders (*Alnus oregona*), and waxmyrtles (*Myrica californica*), most of which occur in saturated or poorly drained soils; and (iii) similar wetlands with emergent woody vegetation. Cowardin *et al.* (1979) note that scrub-shrub and forested wetlands are restricted to "palustrine" and "estuarine" wetlands; in Humboldt Bay, only palustrine wetlands include these habitats. Readers should review Cowardin *et al.* (1979) for additional information regarding classification of wetlands, and examples of wetland habitats.

One variable used in the model (number six, below) requires information that may be obtained from maps or aerial photographs. All other variables require field sampling. Model users are expected to exercise adequate rigor in sampling and analysis, so that statistical validity is ensured. Although there is no mandatory season for sampling, it is recommended that sampling be conducted when tree and shrub canopies are in leaf.

The model is intended to be applied to habitat areas that may not be entirely one cover type (i.e., a site may contain emergent wetland as well as woody vegetation). This formulation accommodates changes in wetland area through time, as would be expected in wetland restoration or enhancement projects; suitability is related to the fraction of the area presenting appropriate habitat conditions. A functionally similar (but not exactly identical) model would result if the sixth variable were omitted and the model applied only to ripa[illegible]ar wetlands. As noted below, the model includes a "minimum area" assumption, a requirement that the model only be applied to habitat areas with at least 20 square meters of riparian vegetation.

Description of the Model. This model is based upon the two basic habitat parameters noted above, the presence and volume of foliage and the presence of suitable snags. The model uses several variables to account for foliage characteristics. This is considered appropriate, in view of the presumed importance of foliage in providing foraging area, cover, and nesting substrate for most of the species in this guild. The model includes one variable covering snag availability. It also includes a variable scaling the suitability of an evaluation site according to the fraction of the site that has appropriate vegetation.

The first and second variables relate suitability to the percent of canopy closure in two vegetational layers. Canopy closure is directly related to canopy foliage volume (see, for example, Hays et al. 1981). Each variable relates to foliage volume in two horizontal dimensions within a specific "layer" of the habitat (see next section). Site suitability increases with foliage volume, until there is enough foliage to begin shading lower layers, thus reducing ecological productivity in those layers. It is to be expected, therefore, that intermediate values for canopy closure provide optimal habitat. The third variable scales foliage volume in the vertical dimension.

The first and second variables are expressed as canopy cover, which is the percentage of the ground surface covered by a vertically downward projection of aerial foliage. While some ecological studies express cover in terms of specific layers or of total numbers of foliage layers, this model will use cover in the botanical sense as just defined.

The assumption that intermediate cover values are optimal follows from the use of ground-level vegetation by species that should be evaluated by this model. Complete canopy closure generally leads to a loss of live ground cover. Ground cover vegetation is not measured by this model; however, incomplete canopy cover in the shrub and tree layers is anticipated to lead to appropriate live plants at ground level.

All of the above variables are scaled by the fourth variable to reflect the overall canopy "layering" within the vegetation. Habitat value increases as the amount of layering increases (see next section for details).

The fifth variable in this model is a measure of the density of snags of minimally acceptable size for cavity nesters. Site suitability increases with snag density until optimal conditions are reached. This may not address site suitability adequately for some habitat conditions, as both more snags and larger snags may improve a site for some bird species. However, it is believed that the variable incorporated into this model addresses the needs of the small passerine and woodpecker species primarily covered by this model.

The sixth variable scales the habitat value in direct proportion to the fraction of the site that provides the other variables. If there is no woody riparian vegetation, the site cannot be habitat. It is presumed that a vegetation patch must have a minimum area of approximately 20 square meters (about 215 square feet) to provide habitat utility.

Suitability Index [SI] Graphs for Model Variables. Following in Figure 1 are graphic representations of presumed relationships between habitat variables and habitat suitability. The SI values are read directly from the graph (1.0 = optimal suitability; 0.0 = no suitability) for each variable. The rationale for developing each graph is presented below.

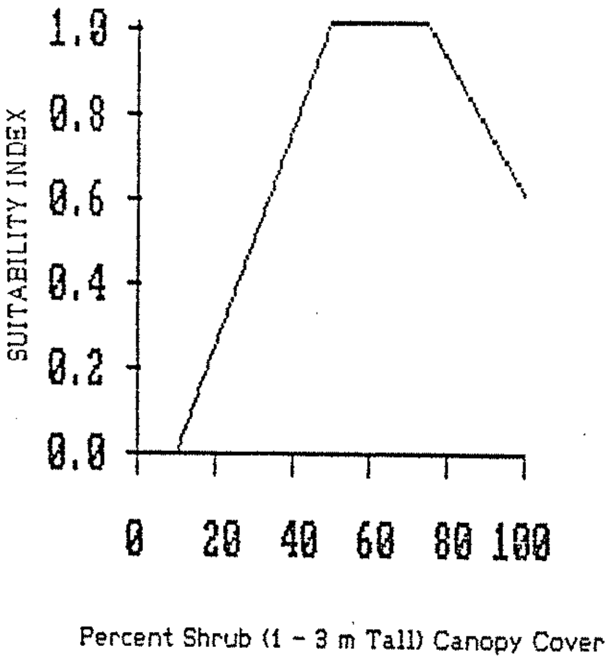
Variable 1: DSCCP - Percent shrub (1 - 3 meter tall) canopy cover. The model assumes that foliage must be present before the habitat is suitable at all. This variable is structured to reflect habitat utility when the foliage in the shrub canopy covers at least 10 percent of the ground surface (see previous section). Suitability increases to an optimum when 50% - 75% of the site has shrub canopy cover. These cover levels provide relatively dense foliage within the shrub layer, while allowing some light to pass through to the ground level.

As the canopy closes, lower light levels at the ground surface restrict vegetation growth. It appears that there will be a tradeoff between increased suitability for species that use the shrub canopy and decreased suitability for species that use the forest floor. The SI value is assumed to decrease to 0.6 at 100% canopy closure. This value greater than one-half should reflect the contribution to habitat of the foliage volume in three dimensions above the ground, as contrasted with the two dimensions at ground level. It should be noted that this variable is modified from Schroeder (1982a).

Variable 2: CC3MP - Percent tree (greater than 3 meter tall) canopy cover. This variable is similar to variable 1. At least 10% of the site's ground surface must lie under tree canopy for any suitability to exist. Suitability increases to optimum levels at 50% to 75% cover, then decreases to intermediate values as canopy cover approaches 100% (for identical reasoning).

This variable does not differentiate the canopy into lower and higher levels, as the expected use of the model is within riparian or swamp habitats near Humboldt Bay, where canopy heights rarely exceed 6 m and one canopy layer. Were the model to be applied to other riparian forests, where canopy heights can reach 10 m, and where there may be more than one distinct tree canopy layer, it would be appropriate to restructure this variable (or the entire model) to reflect the additional layering. This variable is modified from Schroeder (1982b).

Variable 3: NAHOT - Average height of overstory trees (in meters). This variable reflects the vertical dimension of the foliage; habitat utility should increase with the value of the variable. As with other variables in the model, a threshold exists; vegetation must be at least 1 m tall before it provides habitat value. The SI increases with canopy height until the height



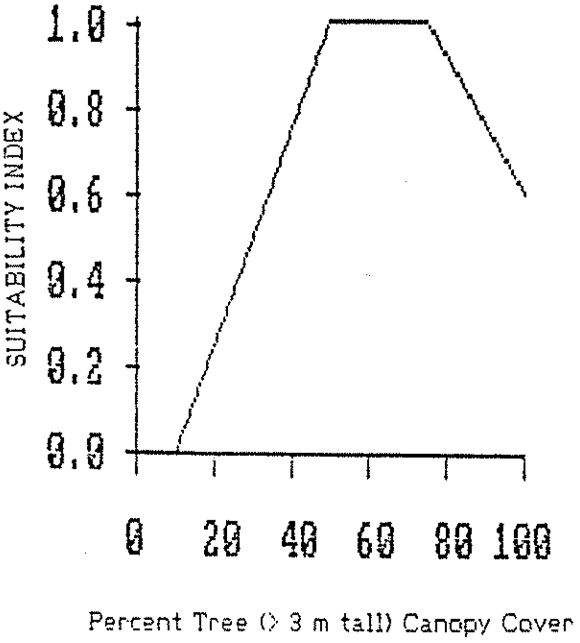
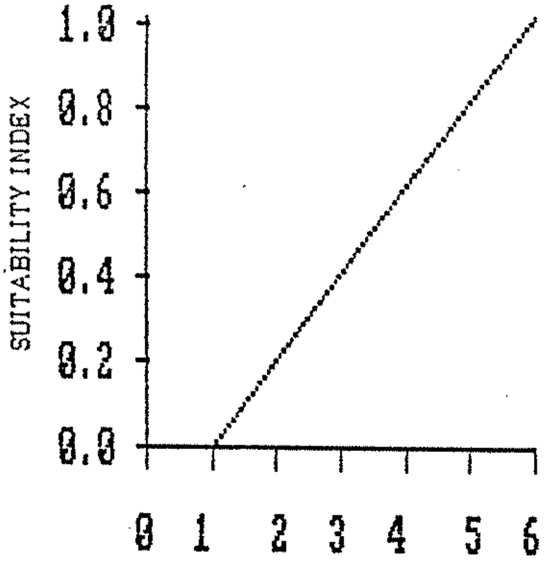
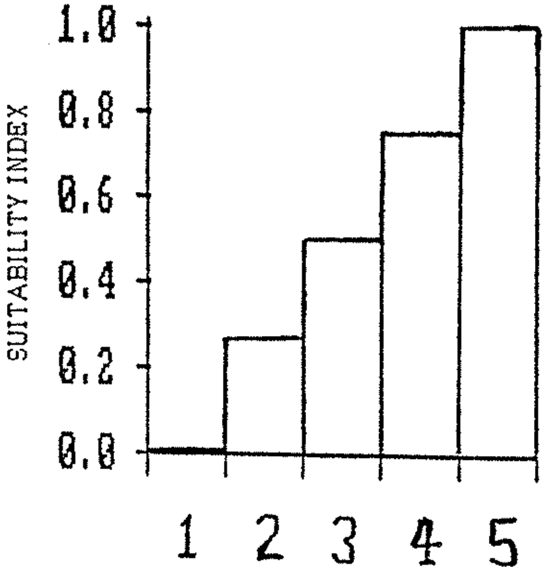


FIGURE 1A - SUITABILITY INDEX GRAPHS



Average Height (m) of Overstory Trees



Canopy Layering Category (1 = None; 2 = Low Shrubs Only; 3 = Tall Shrubs Only; 4 = Trees Only; 5 = Multiple Layers)

FIGURE 1B - SUITABILITY INDEX GRAPHS

reaches 6 m (20 feet). Willows and other trees in Humboldt Bay riparian habitats seldom exceed this height, and it thus represents an approximate maximum value. This variable is modified from Schroeder (1982b).

Variable 4: **CNLAY - Canopy layering categories (1, 2, 3, 4, or 5).** This variable requires an input scalar value from the user, depending upon the general conformation of the habitat. The scalar values and the associated SI values are shown in Figure 1: Category 1 - no woody vegetation; Category 2 - low shrubs, less than a meter tall; Category 3 - tall shrubs, 1 to 3 m tall; Category 4 - trees, more than 3 m tall but without woody understory; and Category 5 - multiple layers of woody vegetation, with both trees and shrubs present.

This variable is used in the model to scale vertical habitat heterogeneity. Greater value follows from more diverse habitat. Alternate measures of this variable are available (e.g., MacArthur and MacArthur 1961), but this formulation is more direct and is easier to measure.

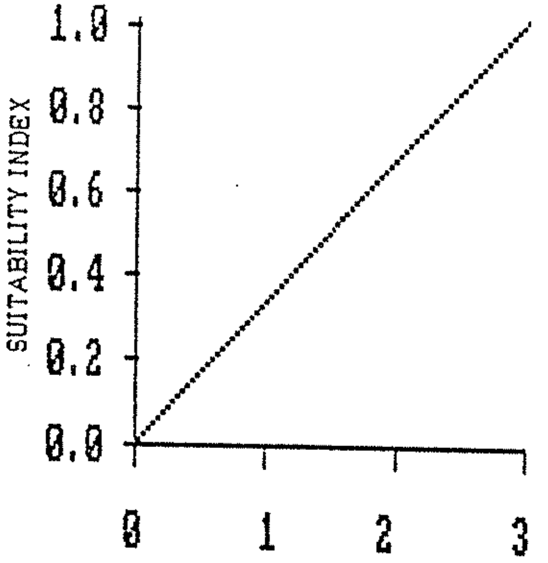
Variable 5: DSNAG10 - Number of snags greater than 10 cm diameter at breast height (dbh) per 0.4 hectare (greater than 4 inches dbh per acre). Since several members of this guild require cavities, the suitability of a site increases with the density of snags of appropriate size. This variable produces a linear increase in suitability if any snags at least 10 cm in diameter are present, reaching an optimum when three or more are present per acre.

Were this model to be applied to more diverse riparian habitats than Humboldt Bay, this variable should be modified to require larger snags for optimum suitability. Small trees and snags are adequate for small bird species, but do not serve for large birds, or for mammals and other potential cavity users. This variable is modified from Schroeder (1982b, 1982c); the optimum level of 3 snags per acre is a compromise from the two previous models.

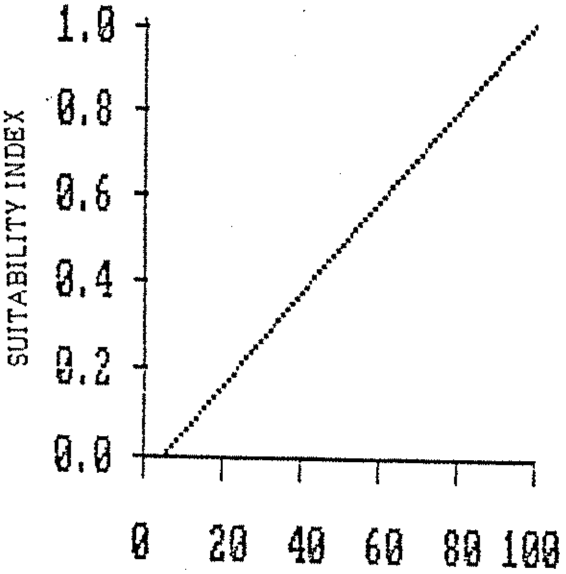
Variable 6: APWRV - Percent of the site in woody riparian vegetation. This variable scales the habitat suitability of a site according to the fraction that provides appropriate vegetation. From a threshold value at 5% of the site, the value increases linearly to optimality when 100% of the site provides riparian vegetation. As noted above, a presumed threshold size of 20 square meters of woody vegetation is required for this variable to be applicable.

HSI Determination. The riparian songbird guild model is shown in Figure 2; a printout of the electronic version of the model is included in Attachment B.

The overall suitability of a riparian or swamp wetland for the species in Attachment 1 is evaluated by this model in terms of the distribution of foliage, by the presence and number of snags, and by the fraction of the evaluation site containing such vegetation. Variables 1 through 4 in the model address vegetation, and the remaining parameters are addressed by

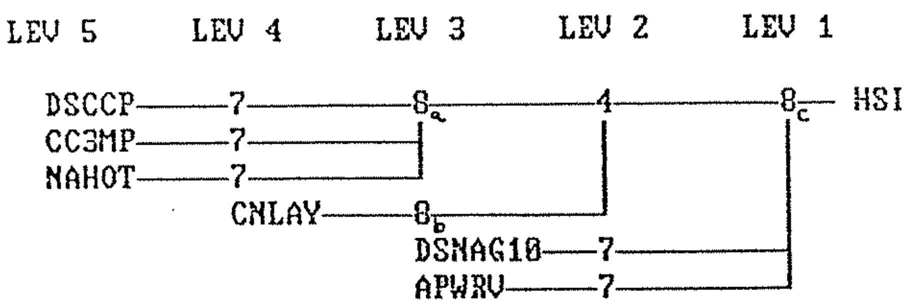


Number of Snags > 10 cm DBH per 0.4 ha (> 4 inches DBH per acre)



Percent of Site in Woody Riparian Vegetation

FIGURE 1C - SUITABILITY INDEX GRAPHS



TREE DIAGRAM FOR THE RIPARIAN SONGBIRD GUILD MODEL

DOCUMENTATION

1. Values of input variables are entered according to variable definitions and Table 1.

2. Function code "4" is a geometric mean; e.g., $Y = (X_1 * X_2)^{\frac{1}{2}}$.

3. Function code "7" is a graph; see Figure 1. Output from graph is a value $0.0 \leq Y \leq 1.0$.

4. Function code "8" is a user-specified function. Input values (left side of function code in figure) are numbered 1, 2, etc., from top down.

Equations are: 8_a: $Y = (X_1 + X_2 + 2.0 * X_3)/4.0$.

8_b: see Figure 1b.

8_c: $HSI = ((X_1 + X_2)/2.0) * X_3$.

FIGURE 2 - MODEL TREE DIAGRAM AND DOCUMENTATION

variables 5 and 6 respectively.

Variables 1, 2, and 3 are combined in the model to reflect the volume of foliage present. The first two variables reflect horizontal foliage distributions, and the third the vertical distribution. Foliage in the shrub and tree canopy layers of the relatively low thickets in the watershed is assumed to be continuous, and the values for the two variables are deemed to be compensatory; a single value reflecting horizontal foliage dimensions is achieved by averaging the two variables.

The vertical dimension is incorporated into this model as part of the averaging calculation, to reflect the compensation between "layers." This variable is weighted at twice the value of the former variables, however, so that suitability calculations emphasize the vertical foliage distribution. Half of the output from the user-specified function thus relates to horizontal, and half to vertical, foliage distribution (see Fugure 2).

The intermediate suitability index value provided by the calculation above is modified in the model by the suitability index derived from the canopy layering present. The model combines the foliage variables via a geometric mean function. This is used to reflect the partial compensation between foliage volume and layering criteria, and the increased departure from optimum conditions when either of the factors is much less than optimum. The output from this computation thus emphasizes any departure from optimum foliage distribution conditions.

The habitat suitability index (HSI) is computed in the model with a user specified function. The function calculates the arithmetic mean of the foliage and snag variable values. This is appropriate when the variables are fully compensatory, so that high values of one offset low values of the other. This appears reasonable in this case; good foraging area might not provide many snags for nesting (or vice versa), but the favorability of the site for foraging still maintains a relatively high utility for the habitat. The function also reduces the index value according to the fraction of the site that is not in appropriate vegetation.

In general terms, the HSI value is determined approximately half by foliage value and half by snag value. About a quarter of the value relates to canopy layering, and a quarter to the combination of cover values and total canopy height.

FIELD USE OF THE MODELS - SAMPLING

Suggested sampling techniques for the variables in the riparian songbird guild HSI model are indicated in Table 1. Readers should consult Hays et al. (1981) for specific discussion of sampling techniques useful in determining habitat suitability. Other sampling techniques may be substituted if equivalent results are produced.

Table 1. Suggested measurement techniques for variables in the riparian songbird guild model.

Variable	Suggested Measurement Technique
DSCCP: percent shrub (1-3 m tall) canopy cover.	Establish a baseline transect through the habitat area. At regular intervals, establish sample transects perpendicular to the baseline. Using a random sampling procedure (such as random numbers to determine distances along transects), establish sample plots at least 1 square meter in area. Estimate percentage shrub canopy cover (the area on the ground surface covered by aerial foliage of woody-stemmed plants 1 to 3 meters tall) to the nearest 5% interval. Recommended: sample at least 20 points. Compute average coverage for all samples.
CC3MP: percent tree (>3 m tall) canopy cover.	Establish a baseline transect as above, with sampling transects perpendicular to baseline. Sample as for DSCCP, except that percentage cover should be estimated for trees (woody plants >3 m tall). Recommended: sample at least 20 points. Compute average coverage for all samples.
NAHOT: average height (m) of overstory trees.	Use sample points identified for CC3MP. Obtain a single measurement of tree canopy height for each point. Measure canopy height as the tallest (highest) vegetation in the quadrat sampled. Compute average of all sampled values. [Note: if there are no trees (plants >3 m tall), measure the canopy height of shrubs.]
CNLAY: canopy layering category (1, 2, 3, 4, or 5).	For each sample point for DSCCP and CC3MP, record the presence or absence of trees, shrubs (as defined above), and woody stems <1 m tall. When sampling is complete, inspect these records. Assign an ordinal value (1, 2, 3, 4, or 5) according to these records, considering all data together. [Note: this variable is intended to involve the user's judgement about the entire site. The value assigned should be biologically justifiable.]
DSNAG10: number of snags >10 cm diameter at breast height (dbh) per 0.4 ha (>4 inches dbh per acre).	For each sample point for DSCCP and CC3MP, record the number of snags in the quadrat meeting this screening criterion (>10 cm dbh). Compute the total number of snags observed and the total area sampled. Convert to 0.4 ha (acre) density value.
APWRV: percent of the site in woody riparian vegetation.	Using aerial photo or map of entire evaluation area, compute total area. Also compute area covered by woody "riparian" vegetation. Divide latter area by total and multiply by 100. Alternatively, lay out a grid of points over entire evaluation area; ensure that grid covers the entire study area, but exclude all areas outside study boundary. Tally the number of grid points falling in appropriate vegetation, divide by the total number of grid points, and multiply by 100.

OTHER MODELS

The U.S. Fish & Wildlife Service has published HSI models for the Yellow Warbler (Schroeder 1982a), the Black-capped Chickadee (Schroeder 1982b), and the Downy Woodpecker (Schroeder 1982c). The third species is resident in the Humboldt Bay watershed, and the first uses habitats here during migration. The Chestnut-backed Chickadee uses habitats somewhat like those used by the Black-capped Chickadee (see above and Sturman 1968). The three published models were reviewed in preparing this model, and portions were incorporated. The author is not aware of other published or unpublished HSI models for species in this guild, or of models in any stage of development for the guild as a whole.

ACKNOWLEDGEMENTS

This model was prepared under contract with the California State Coastal Conservancy. Preliminary research regarding habitat variables was conducted under contract with the County of Humboldt. Assistance from Liza Riggle of the Conservancy and from Don Tuttle and Andrea Pickart of the County of Humboldt Department of Public Works made model development possible. HSI modelling software was obtained from the Western Energy and Land Use Team, U.S. Fish & Wildlife Service, Fort Collins, Colorado.

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ATTACHMENT A

The following species are expected to derive habitat utility from the riparian or "swamp" habitat type covered by this model. This is considered a minimum list; other species not recorded here also should benefit. Listing order is taxonomic, and does not imply importance, abundance, or degree of benefit. The list is based upon references cited in the model.

Taxonomic Name	Common Name
Picoides pubescens	Downy Woodpecker
Picoides villosus	Hairy Woodpecker
Empidonax difficilis	Western Flycatcher
Tachycineta bicolor	Tree Swallow
Parus rufescens	Chestnut-backed Chickadee
Troglodytes troglodytes	Winter Wren
Turdus migratorius	American Robin
Ixoreus naevius	Varied Thrush
Catharus guttatus	Hermit Thrush
Catharus ustulatus	Swainson's Thrush
Regulus calendula	Ruby-crowned Kinglet
Vermivora celata	Orange-crowned Warbler
Dendroica petechia	Yellow Warbler
Dendroica coronata	Yellow-rumped Warbler
Wilsonia pusilla	Wilson's Warbler
Carduelis tristis	American Goldfinch
Passerella iliaca	Fox Sparrow
Melospiza melodia	Song Sparrow

ATTACHMENT B

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                                                            LIBRARY:   B:HUMBAY.LIB
                                                                       07-26-1986


MODEL # 5
MODEL NAME:  RIPARIAN SONGBIRD GUILD     AUTHOR DRAFT     04-15-1986

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See written version for further references.


LEV 5      LEV 4      LEV 3      LEV 2      LEV 1
  DSCCP-----7---------8---------4---------8-- HSI
  CC3MP-----7---------|         |         |
  NAHOT-----7---------^         |         |
            CNLAY-----8---------^         |
                      DSNAG10---7---------|
                      APWRV-----7---------^


DSCCP    Percent shrub (1-3m tall) canopy cover.
CC3MP    Percent tree (>3m high) canopy cover.
NAHOT    AVERAGE HEIGHT OF OVERSTORY TREES (M)
CNLAY    Canopy layering categories (1,2,3,4, or 5) - see model documentation.
DSNAG10  Number of snags >10cm dbh per 0.4 ha (>4 in dbh per acre).
APWRV    Percent of site in woody riparian vegetation.


GRAPH FUNCTION AT LEVEL 4 . POSITION 1
  Title:  DSCCP
    X=        0.000     Y=       0.000
             10.000              0.000
             50.000              1.000
             75.000              1.000
            100.000              0.600
            110.000              0.600

GRAPH FUNCTION AT LEVEL 4 . POSITION 2
  Title:  CC3MP
    X=        0.000     Y=       0.000
             10.000              0.000
             50.000              1.000
             75.000              1.000
            100.000              0.600
            110.000              0.600
```

```
odel:  RIPARIAN SONGBIRD GUILD (continued)


RAPH FUNCTION AT LEVEL 4 . POSITION 3
 Title:  HOT
   X=       0.000    Y=       0.000
            1.000             0.000
            6.000             1.000
            7.000             1.000

SER-SPECIFIED FUNCTION AT LEVEL 3 . POSITION 1
SUB = (X(1)+X(2)+2.*X(3))/4.

SER-SPECIFIED FUNCTION AT LEVEL 3 . POSITION 2
F X(1)<>1 AND X(1)<>2 AND X(1)<>3 AND X(1)<>4 AND X(1)<>5 THEN PRINT:PRINT"***
ERROR IN INPUT***":PRINT"VALUE FOR CNLAY MUST BE 1. 2. 3, 4, OR 5.":PRINT"PRESS
ANY KEY TO RETURN TO DATA MODIFICATION MENU  -  "::Z$ = INPUT$(1):GOTO 9010
F X(1) = 1 THEN USUB = 0
F X(1) = 2 THEN USUB = .25
F X(1) = 3 THEN USUB = .5
F X(1) = 4 THEN USUB = .75
F X(1) = 5 THEN USUB = 1.

RAPH FUNCTION AT LEVEL 2 . POSITION 2
 Title:  SNAG10
   X=       0.000    Y=       0.000
            3.000             1.000
            4.000             1.000

RAPH FUNCTION AT LEVEL 2 . POSITION 3
 Title:  PWRV
   X=       0.000    Y=       0.000
            5.000             0.000
          100.000             1.000
          110.000             1.000

SER-SPECIFIED FUNCTION AT LEVEL 1 . POSITION 1
SUB = ((X(1)+X(2))/2.)*X(3)
```

COMMUNITY-BASED
HABITAT SUITABILITY INDEX MODEL
FOR THE RIPARIAN FOREST COVER-TYPE
ALONG LLAGAS CREEK

Adapted from a model used by the HEP team evaluating impacts of proposed riprap bank protection along the lower Sacramento River

As Revised
September 2001

BACKGROUND: The cover-type model described here is for Riparian Forest Cover. This cover-type is defined as a stand of woody vegetation composed of primarily trees greater than 20-feet-tall. The Riparian Forest cover-type model identifies and quantifies characteristics of this cover type which are important to a wide array of wildlife. The model does not attempt to portray exactly the needs of any one species, but rather it broadly portrays the needs of many species or species groups of riparian zones along Llagas Creek.

For example, many birds, including nesting raptors such as red-tailed hawks and re-shouldered hawks require tall trees, and thus tree height, with taller trees being more favorable, has been included as a key model variable. Also, many songbirds, such as the northern oriole and least Bell's vireo, require relatively dense canopies, thus canopy closure, with greater closure providing greater value, is included as a model variable. Similarly, riparian water birds such as herons an egrets have specific needs relating to canopy closure, width of stand, and density of vegetative understory, so these needs have been met as much as possible with the appropriate model variables.

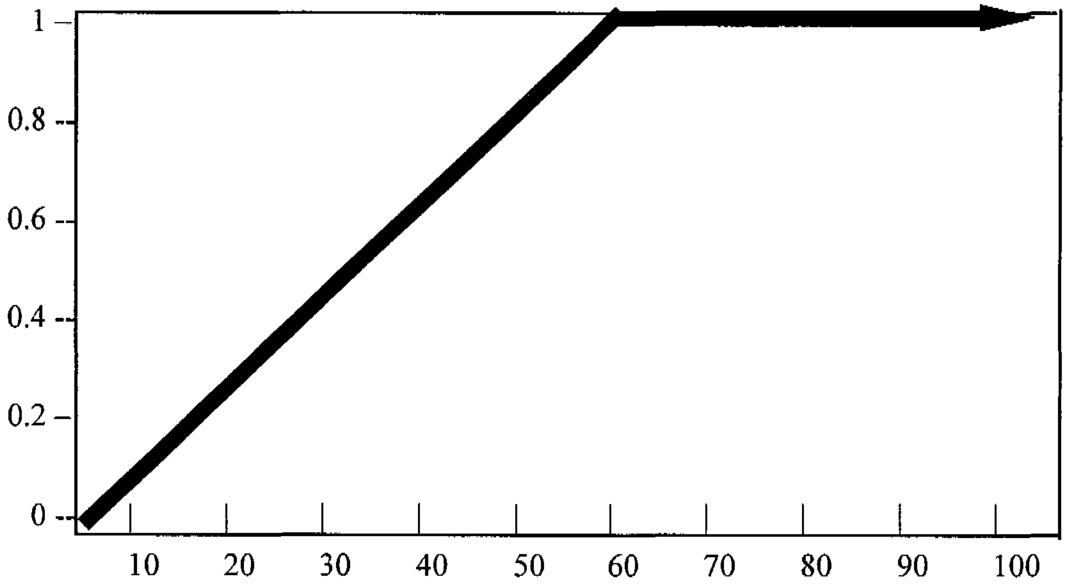
The single Habitat Suitability Index (HSI) value which is derived using the Riparian Forest cover-type model is therefore, not an exact measure of the habitat value of any single wildlife species. Instead, the HSI indicates the overall, broad quality of the cover-type to a broad array of the most important species which inhabit the creek's riparian zone. As such, the use of this single HSI value in the HEP process is assumed to provide the same results (i.e., estimates of relative impacts and compensation needs) as if the HEP were completed using a number of individual wildlife species models. Past comparisons using actual HSI data collected from Riparian Forest Cover along the Sacramento River suggest the validity of this assumption.

AREA OF APPLICABILITY: Riparian Forest Cover along Llagas Creek, a tributary of the Pajaro River.

VARIABLE

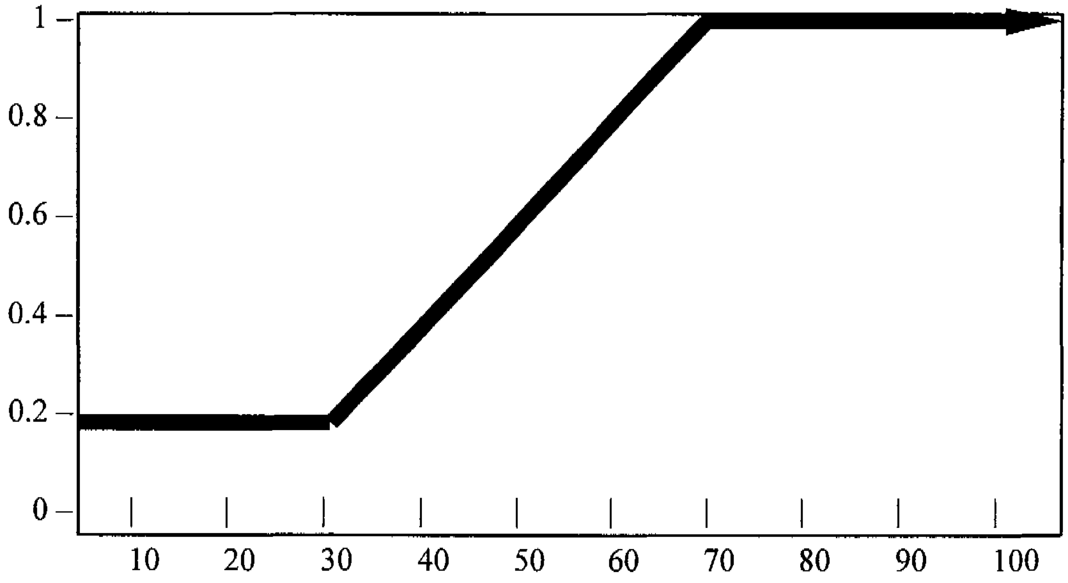
V_1 – Average tree height.
V_2 – Average canopy width of the stand.
V_3 – Tree canopy closure.
V_4 – Number of tree or shrub species.
V_5 – Understory vegetative density.

V_1 – Average tree height. Suitability Index (SI) determination. Assumptions: For most wildlife species of concern, the taller the trees, the better the habitat value. Nesting raptors in particular require relatively tall trees. A tree height, on average, of about 60 feet or greater is optimum.



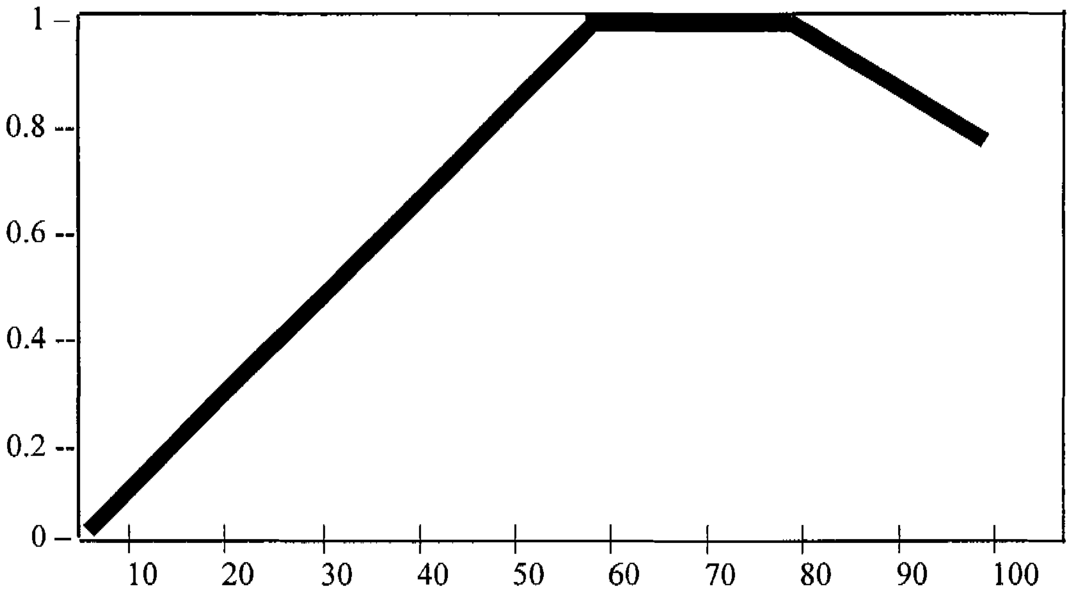
V_1 – Average Tree Height (Ft.)

V_2 – Average canopy width of the stand. Suitability Index (SI) determination. Assumptions: Generally, the wider the stand, the better the values for most key fish and wildlife. Stands less than 30-feet-wide have relatively low values; stands over 70 feet in width are best.



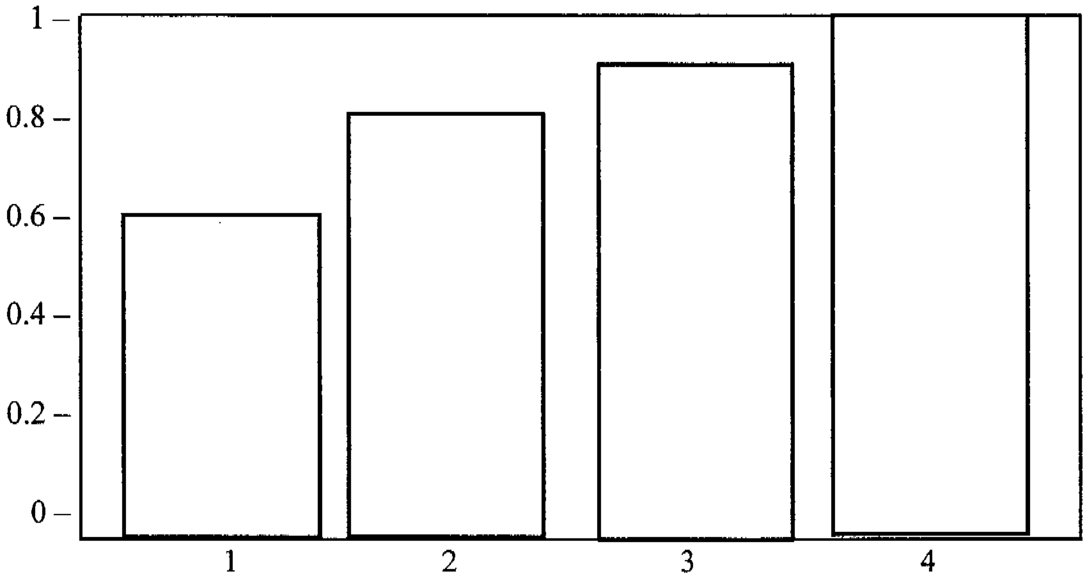
V_2 – Average Canopy Width of the Stand (Ft.)

V_3 – Tree canopy closure. Suitability Index (SI) determination. Assumptions: In general, the greater the forest density, as determined by percent of canopy closure, the greater the values of the forest. However, if the stand becomes too dense, habitat values frequently decline. The optimal condition is with percent canopy closure of 50 to 80 percent.



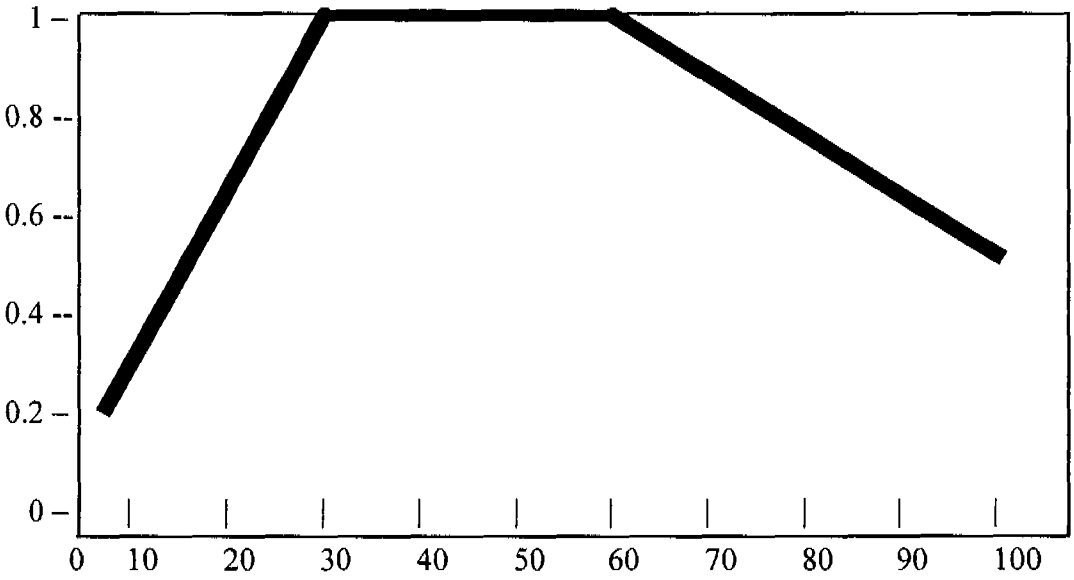
V_3 – Tree canopy closure (%)

V_4 – Number of tree or shrub species. Suitability Index (SI) determination. Assumptions: Habitat diversity improves carrying capacity. Generally, the more tree or shrub species present, the more diverse th forest, and the greater the values to fish and wildlife. The optimal condition is when the forest is composed of at least four species of trees.



V_4 – Number of Tree or Shrub Species

V_5 – Understory vegetative density. Suitability Index (SI) determination. Assumptions: The best Riparian Forest habitat occurs when both overstory and understory canopies are relatively dense. the understory should generally have a moderate density of vegetation at various elevations. By estimating the understory of the forest for the horizontal planes at 2, 6, and 14 feet above ground, and then averaging these three figures (i.e., the three estimates of percent vegetative cover), a good index of overall understory density can be derived.



V_5 – Average Understory Vegetative Density (%)
(At 2. 6. and 14 Feet Above Ground)

HABITAT SUITABILITY INDEX (HSI): Average canopy width and understory density are believed to be slightly more important variables than the other three variables. The five variables are thus combined as follows:

$$HSI = \frac{(V_1 \text{ x } V_3 \text{ x } V_4)^{1/3} + (V_2 \text{ x } V_5)^{½}}{2}$$

Variables are generally measured or estimated during periods of maximum vegetative leaf-out.

The calculated HSI is reduced by 40% when the majority of the tree canopy closure is from non-native species such as eucalyptus. In addition, this adjusted (or if not adjusted) HSI is further reduced by 33% if the edge of the riparian forest occurrence begins 20 feet or more away from the edge of the streambed, since riparian forest in close association with the stream has highest values.

FWS/OBS-82/10.38
APRIL 1983

HABITAT SUITABILITY INDEX MODELS: DOWNY WOODPECKER

Fish and Wildlife Service

U.S. Department of the Interior

This model is designed to be used by the Division of Ecological Services in conjunction with the Habitat Evaluation Procedures.

FWS/OBS-82/10.38
April 1983

HABITAT SUITABILITY INDEX MODELS: DOWNY WOODPECKER

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Project Officer

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Western Energy and Land Use Team
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This report should be cited as:

Schroeder, R. L. 1982. Habitat suitability index models: Downy woodpecker. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-82/10.38. 10 pp.

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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CONTENTS

ACKNOWLEDGMENTS

We gratefully acknowledge Richard Conner and Lawrence Kilham for their review of this habitat model. Funds for the development of this model were provided by the U.S. Fish and Wildlife Service Regional Office in Portland. Publication costs of this model were partially paid for by the U.S. Army Corps of Engineers. The cover of this document was illustrated by Jennifer Shoemaker. Word processing was provided by Carolyn Gulzow and Dora Ibarra.

DOWNY WOODPECKER (Picoides pubescens)

HABITAT USE INFORMATION

General

Downy woodpeckers (Picoides pubescens) inhabit nearly all of North America where trees are found (Bent 1939). They are rare or absent in arid desert habitats and most common in open woodlands.

Food

The downy woodpecker is primarily an insectivore; 76% of the diet is animal foods, and the remainder is vegetable food (Beal 1911). Beetles, ants, and caterpillars are the major animal foods, and vegetable foods include fruits, seeds, and mast. Downy woodpeckers feed by digging into the bark with the bill, by gleaning along the bark surface, and, infrequently, by flycatching (Jackson 1970).

Downy woodpeckers in Illinois foraged more in the lower height zones of trees than in the tree canopies and foraged more often on live limbs than on dead limbs (Williams 1975). Similarly, downy woodpeckers in Virginia foraged primarily on live wood in pole age and mature forests (Conner 1980). Downy woodpeckers in New York spent 60% of their foraging time in elms (Ulmus spp.) (Kisiel 1972). They foraged most frequently on twigs 2.5 cm (1 inch) or less in diameter, and drilling was the foraging technique used most often. Downy woodpeckers are not strong excavators and do not excavate deeply to reach concentrated food sources, such as carpenter ants (Camponotus spp.) (Conner 1981).

Downy woodpeckers in Virginia foraged in the breeding season in habitats with a mean basal area of 11.3 m^2/ha (49.2 ft^2/acre). Habitats used for foraging during the postbreeding and winter seasons had significantly higher mean basal areas of 21.4 m^2/ha (93.2 ft^2/acre) and 17.2 m^2/ha (74.9 ft^2/acre), respectively. Downy woodpeckers in New Hampshire fed heavily in stands of paper birch (Betula papyrifera) that were infected with a coccid (Xylococchus betulae) (Kilham 1970). The most attractive birches for foraging were those that were crooked or leaning, contained broken branches in their crown, and had defects, such as cankers, old wounds, broken branch stubs, and sapsucker drill holes. Downy woodpeckers invaded an area in Colorado in high numbers during the winter months in response to a severe outbreak of the pine bark beetle (Dendroctonus ponderosae) (Crockett and Hansley 1978). This outbreak of beetles had not resulted in increased breeding densities of the woodpeckers at the time of the study.

Downy woodpeckers foraged more on tree surfaces during summer than in winter (Conner 1979). They increased the amount of time spent in subcambial excavation in winter months, probably in response to the seasonal availability and location of insect prey. Downy woodpeckers appear to broaden all aspects of their foraging behavior in the winter in order to find adequate amounts of food (Conner 1981).

Downy woodpeckers in Ontario extracted gall fly (Eurosta solidaginis) larvae from goldenrod (Solidago canadensis) galls growing near forest edges (Schlichter 1978). Corn stubble fields supported small winter populations of downy woodpeckers in Illinois (Graber et al. 1977).

Water

Information on the water requirements of the downy woodpecker was not located in the literature.

Cover

The cover requirements of the downy woodpecker are similar to their reproductive requirements, which are discussed in the following section.

Reproduction

The downy woodpecker is a primary cavity nester that prefers soft snags for nest sites (Evans and Conner 1979). These woodpeckers nest in both coniferous and deciduous forest stands in the Northwest. Nests in Virginia were common in both edge situations and in dense forests far from openings (Conner and Adkisson 1977). Downy woodpeckers in Oregon occur primarily in deciduous stands of aspen (Populus tremuloides) or riparian cottonwood (Populus spp.) (Thomas et al. 1979). The highest nesting and winter densities in Illinois were in virgin or old lowland forests (Graber et al. 1977).

Downy woodpeckers in Virginia preferred to nest in areas with high stem density, but with lower basal area and lower canopy heights than areas used by the other woodpeckers studied (Conner and Adkisson 1977). They preferred sparsely stocked forests commonly found along ridges (Conner et al. 1975). Preferred nest stands had an average basal area of 10.1 m^2/ha (44 ft^2/acre), 361.8 stems greater than 4 cm (1.6 inches) diameter/ha (894/acre), and canopy heights of 16.3 m (53.5 ft) (Conner and Adkisson 1976). Downy woodpeckers in Tennessee were frequently seen feeding in the understory and apparently selected habitats with an abundance of understory vegetation (Anderson and Shugart 1974).

Downy woodpeckers excavate their own cavity in a branch or stub 2.4 to 15.3 m (8 to 50 ft) above ground, generally in dead or dying wood (Bent 1939). There was a positive correlation between downy woodpecker densities and the number of dead trees in Illinois (Graber et al. 1977). Downy woodpeckers rarely excavate in oaks (Quercus spp.) or hickories (Carya spp.) with living cambium present at the nest site (Conner 1978). They apparently require both sap rot, to soften the outer part of trees, and heart rot, to soften the interior, when hardwoods, and possibly pines, are used for nesting. Downy woodpeckers in Virginia nested mainly in dead snags with advanced stages of fungal heart rot (Conner and Adkisson 1976).

Downy woodpeckers "search image" of an optimal nest site is a live tree with a broken off dead top (Kilham 1974). Suitable nest trees are in short supply in most areas and appear to be a limiting factor in New Hampshire. Downies in Montana appeared to prefer small trees, possibly to avoid the difficulty of excavating through the thick sapwood of large trees (McClelland et al. 1979). The average dbh of nest trees (n = 3) in Montana was 25 cm (10 inches). All 11 nests in an Ontario study were in dead aspen, and the average dbh of four of these nest trees was 26.2 cm (10.3 inches) (Lawrence 1966). Fourteen of 19 nest trees in Virginia were dead, the average dbh of nest trees was 31.8 cm (12.4 inches), and nest trees averaged 8.3 m (27.2 ft) in height (Conner et al. 1975).

Thomas et al. (1979) estimated that downy woodpeckers in Oregon require 7.4 snags, 15.2 cm (6 inches) or more dbh, per ha (3 snags/acre). This estimate is based on a territory size of 4 ha (10 acres), a need for two cavities per year per pair, and the presence of 1 useable snag with a cavity for each 16 snags without a cavity. Evans and Conner (1979) estimated that downies in the Northeast require 9.9 snags, 15 to 25 cm (6 to 10 inches) dbh, per ha (4 snags/acre). Their estimate is based on a territory size of 4 ha (10 acres), a need for four cavity trees per year per pair, and a need for 10 snags for each cavity tree used in order to account for unuseable snags, a reserve of snags, feeding habitat, and a supply of snags for secondary users. Conner (pers. comm.) recommended 12.4 snags/ha (5 snags/acre) for optimal downy woodpecker habitat.

Interspersion

Downy woodpeckers occupy different size territories at different times of the year (Kilham 1974). Fall and winter territories consist of small, defined areas with favorable food supplies and the area near roost holes. Breeding season territories consist of an area as large as 10 to 15 ha (24.7 to 37.1 acres) used to search out nest stubs, and a smaller area around the nest stub itself. Breeding territories of downies in Illinois ranged from 0.5 to 1.2 ha (1.3 to 3.1 acres) (Calef 1953 cited by Graber et al. 1977). Male and female downy woodpeckers retain about the same breeding season territory from year to year, while their larger overall range has more flexible borders (Lawrence 1966).

Downy woodpeckers occupy all portions of their North American breeding range during the winter (Plaza 1978). There is, however, a slight, local southward migration in many areas.

Special Considerations

Conner and Crawford (1974) reported that logging debris in regenerating stands (1-year old) following clear cutting were heavily used by downy woodpeckers as foraging substrate. Timber harvest operations that leave snags and trees with heart rot standing during regeneration cuts and subsequent thinnings will help maintain maximum densities of downy woodpeckers (Conner et al. 1975). Foraging habitat for the downy woodpecker in Virginia would probably be provided by timber rotations of 60 to 80 years (Conner 1980).

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This model was developed for the entire range of the downy woodpecker.

Season. This model was developed to evaluate the year-round habitat needs of the downy woodpecker.

Cover types. This model was developed to evaluate habitat in Deciduous Forest (DF), Evergreen Forest (EF), Deciduous Forested Wetland (DFW), and Evergreen Forested Wetland (EFW) areas (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 habitat areas for downy woodpeckers was not found in the literature. However, based on reported territory and range sizes, it is assumed that a minimum of 4 ha (10 acres) of potentially useable habitat must exist or the HSI will equal zero.

Verification level. Previous drafts of this model were reviewed by Richard Conner and Lawrence Kilham and their comments were incorporated into the current draft (Conner, pers. comm.; Kilham, pers. comm.).

Model Description

Overview. This model considers the ability of the habitat to meet the food and reproductive needs of the downy woodpecker as an indication of overall habitat suitability. Cover needs are assumed to be met by food and reproductive requirements and water is assumed not to be limiting. The food component of this model assesses food quality through measurements of vegetative conditions. The reproductive component of this model assesses the abundance of suitable snags. The relationship between habitat variables, life requisites, cover types, and the HSI for the downy woodpecker is illustrated in Figure 1.

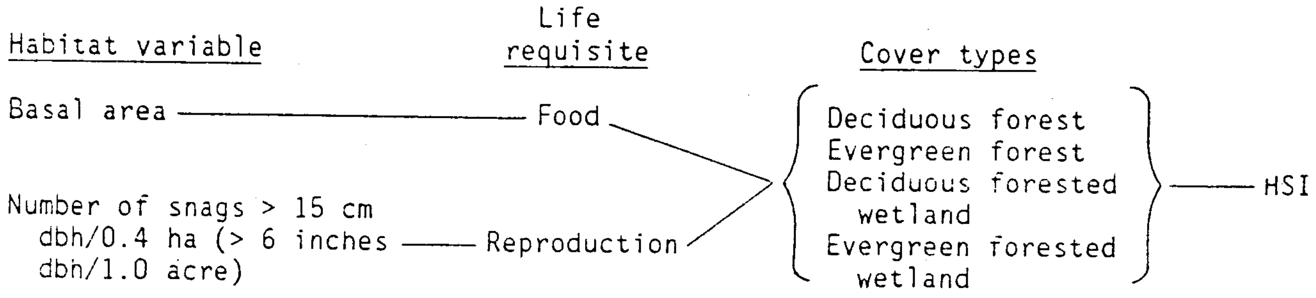


Figure 1. Relationships of habitat variables, life requisites, and cover types in the downy woodpecker model.

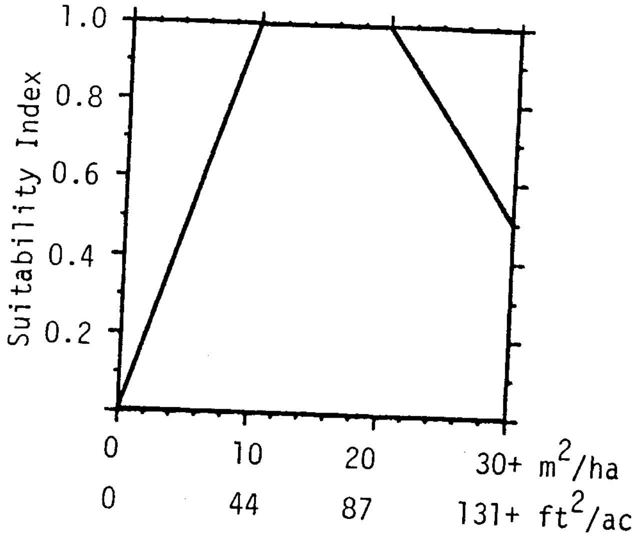
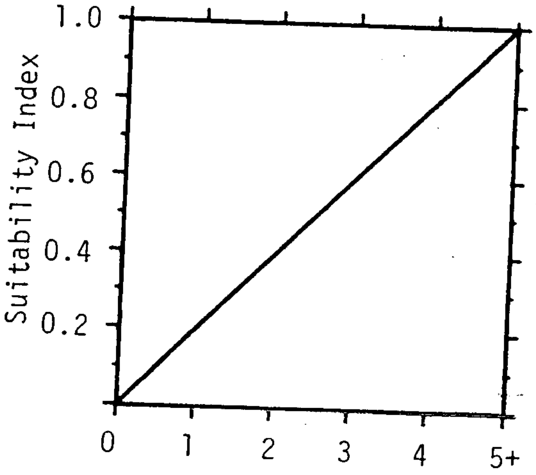
The following sections provide a written documentation of the logic and assumptions used to interpret the habitat information for the downy woodpecker in order to explain the variables and equations that are used in the HSI model. Specifically, these sections cover the following: (1) identification of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

Food component. Food for the downy woodpecker consists of insects found on trees in forested habitats. Downy woodpeckers occupy a wide variety of forested habitats from virgin bottomlands to sparsely stocked stands along ridges. The highest downy woodpecker densities were most often reported in the more open stands with lower basal areas, but it is assumed that all forested habitats have some food value for downies. Optimal conditions are assumed to occur in stands with basal areas between 10 and 20 m^2/ha (43.6 and 87.2 ft^2/acre), and suitabilities will decrease to zero as basal area approaches zero. Stands with basal areas greater than 30 m^2/ha (130.8 ft^2/acre) are assumed to have moderate value for downy woodpeckers.

Reproduction component. Downy woodpeckers nest in cavities in either totally or partially dead small trees. They require snags greater than 15 cm (6 inches) dbh for nest sites. Optimal habitats are assumed to contain 5 or more snags greater than 15 cm dbh/0.4 ha (6 inches dbh/1.0 acre), and habitats without such snags have no suitability.

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		Suitability graph
EF,DF, EFW,DFW	V_1	Basal area.	
EF,DF, EFW,DFW	V_2	Number of snags > 15 cm dbh/0.4 ha (> 6 inches dbh/ 1.0 acre).	

Life requisite values. The life requisite values for the downy woodpecker are presented below.

Life requisite	Cover type	Life requisite value
Food	EF,DF,EFW,DFW	V_1
Reproduction	EF,DF,EFW,DFW	V_2

HSI determination. The HSI for the downy woodpecker is equal to the lowest life requisite value.

Application of the Model

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

Variable (definition)		Cover types	Suggested technique
V_1	Basal area [the area of exposed stems of woody vegetation if cut horizontally at 1.4 m (4.5 ft) height, in m^2/ha ($ft^2/acre$)].	EF,DF,EFW,DFW	Bitterlich method
V_2	Number of snags > 15 cm (6 inches) dbh/0.4 ha (1.0 acre) [the number of standing dead trees or partly dead trees, greater than 15 cm (6 inches) diameter at breast height (1.4 m/4.5 ft), that are at least 1.8 m (6 ft) tall. Trees in which at least 50% of the branches have fallen, or are present but no longer bear foliage, are to be considered snags].	EF,DF,EFW,DFW	Quadrat

Figure 2. Definitions of variables and suggested measurement techniques.

SOURCES OF OTHER MODELS

Conner and Adkisson (1976) have developed a discriminant function model for the downy woodpecker that can be used to separate habitats that possibly provide nesting habitat from those that do not provide nesting habitat. The model assesses basal area, number of stems, and canopy height of trees.

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A review and synthesis of existing information was used to develop a habitat model for the downy woodpecker (*Picoides pubescens*). The model is scaled to produce an index of habitat suitability between 0 (unsuitable habitat) and 1 (optimally suitable habitat) for areas of the continental United States. Habitat suitability indexes are designed for use with Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service.

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b. Identifiers/Open-Ended Terms
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Habitat Suitability Indexes (HSI)

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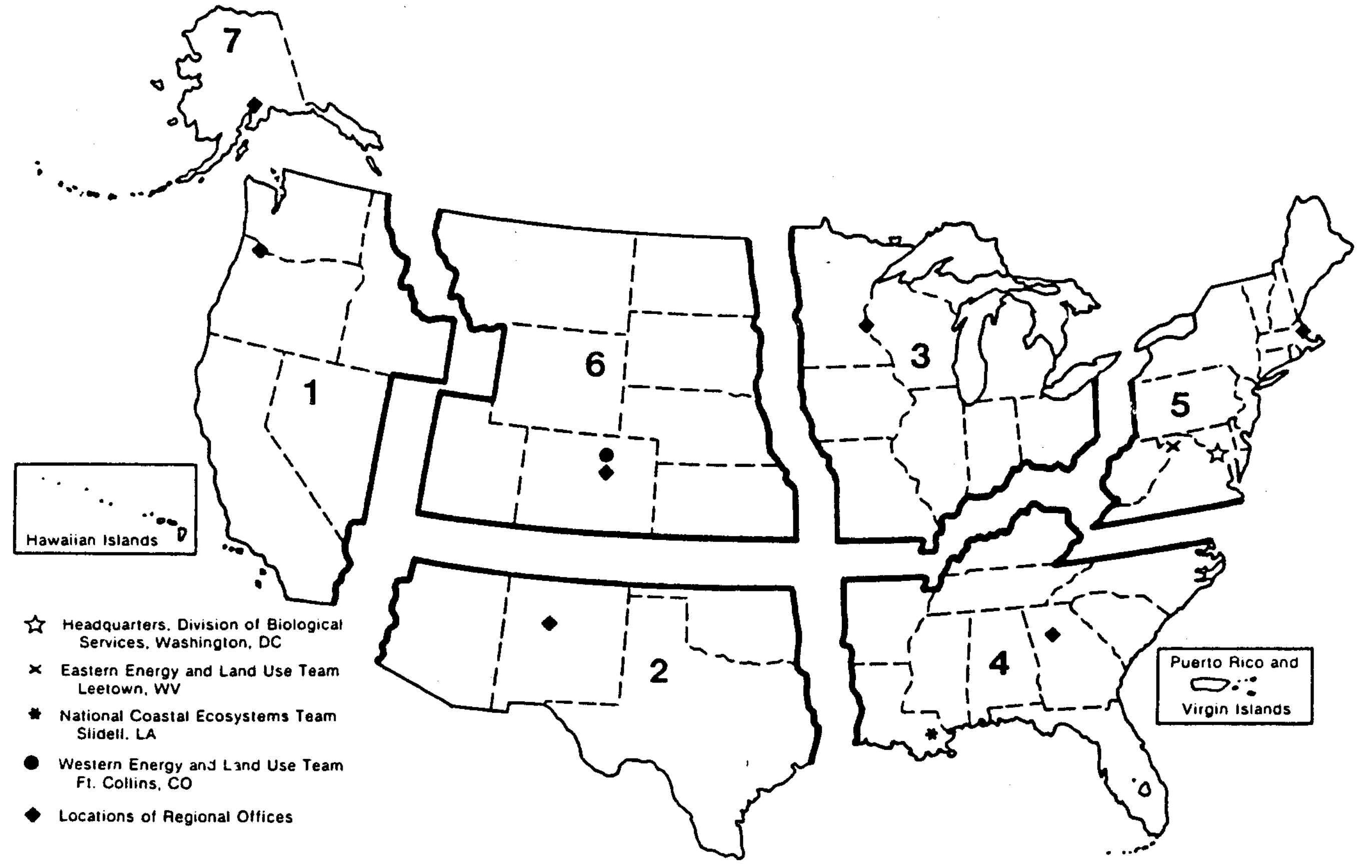

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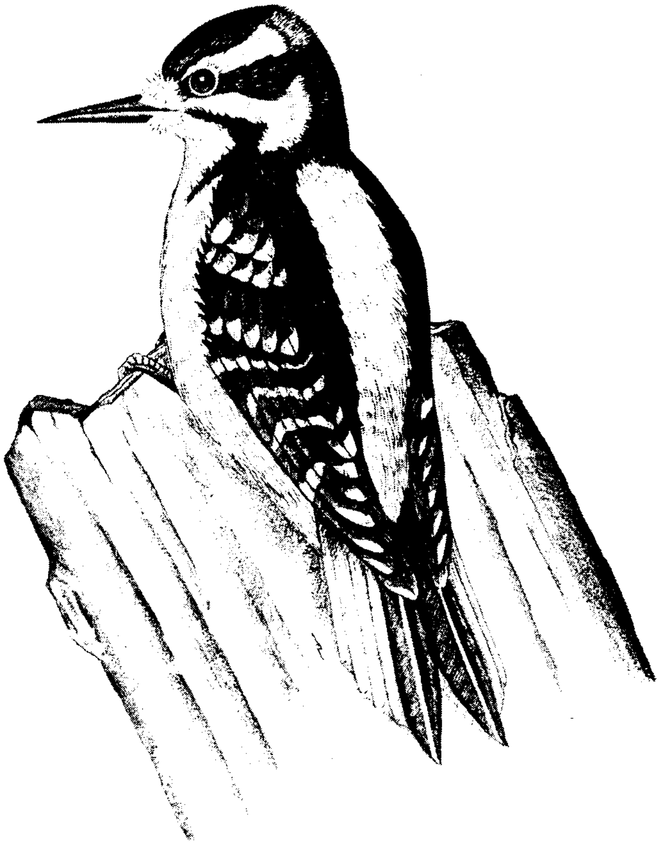
BIOLOGICAL REPORT 82(10.146)
SEPTEMBER 1987

HABITAT SUITABILITY INDEX MODELS: HAIRY WOODPECKER



Fish and Wildlife Service

U.S. Department of the Interior

MODEL EVALUATION FORM

Habitat models are designed for a wide variety of planning applications where habitat information is an important consideration in the decision process. However, it is impossible to develop a model that performs equally well in all situations. Assistance from users and researchers is an important part of the model improvement process. Each model is published individually to facilitate updating and reprinting as new information becomes available. User feedback on model performance will assist in improving habitat models for future applications. Please complete this form following application or review of the model. Feel free to include additional information that may be of use to either a model developer or model user. We also would appreciate information on model testing, modification, and application, as well as copies of modified models or test results. Please return this form to:

Habitat Evaluation Procedures Group
U.S. Fish and Wildlife Service
2627 Redwing Road, Creekside One
Fort Collins, CO 80526-2899

Thank you for your assistance.

Species ______________ Geographic Location ______________________________

Habitat or Cover Type(s) ______________________________

Type of Application: Impact Analysis ____ Management Action Analysis _____
Baseline _____ Other ______________________________

Variables Measured or Evaluated ______________________________

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Was the species information useful and accurate? Yes ____ No ____

If not, what corrections or improvements are needed? ____________________

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____

Were the variables and curves clearly defined and useful? Yes ____ No ____

If not, how were or could they be improved? ______________________________

Were the techniques suggested for collection of field data:
Appropriate? Yes ____ No ____
Clearly defined? Yes ____ No ____
Easily applied? Yes ____ No ____

If not, what other data collection techniques are needed? ______________

Were the model equations logical? Yes ____ No ____
Appropriate? Yes ____ No ____

How were or could they be improved? ______________________________

Other suggestions for modification or improvement (attach curves, equations, graphs, or other appropriate information) ______________

Additional references or information that should be included in the model:

Model Evaluator or Reviewer ______________________ Date ____________

Agency ____

Address ____

Telephone Number Comm: ____________________ FTS ________________

Biological Report 82(10.146)
September 1987

HABITAT SUITABILITY INDEX MODELS: HAIRY WOODPECKER

by

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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 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. 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 model 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 a species, as well as in providing an estimate of the relative suitability of habitat for that species. User feedback concerning model improvements and other suggestions that may increase the utility and effectiveness of this habitat-based approach to fish and wildlife planning are encouraged. Please send suggestions to:

Resource Evaluation and Modeling Section
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CONTENTS

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A field validation of an earlier version of the HSI model for the hairy woodpecker was conducted under the direction of Ms. L. Jean O'Neil, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS. The field validation was based on habitat evaluation by the following individuals:

Dr. F.J. Alsop, III, East Tennessee State University, Johnson City

Dr. C.E. Bock, University of Colorado, Boulder

Dr. R.N. Conner, U.S. Forest Service, Nacogdoches, TX

Dr. J.A. Jackson, Box Z, Mississippi State, MS

Dr. F.C. James, Florida State University, Tallahassee

Dr. B.J. Schardien Jackson, Mississippi State, MS

Mr. J. Teaford and Dr. T. Roberts, Waterways Experiment Station, and Dr. J. Wakeley, Pennsylvania State University, assisted in the study design, data collection, data analysis, and model modification. The field validation resulted in several improvements in the model. The efforts of all of those involved in the field validation are very much appreciated.

Earlier drafts of the model were reviewed by Dr. R.N. Conner and Dr. C.E. Bock. Their review comments led to significant improvements in the model and are appreciated.

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HAIRY WOODPECKER (Picoides villosus)

HABITAT USE INFORMATION

General

The hairy woodpecker (Picoides villosus) breeds and winters throughout most of North America (American Ornithologists' Union 1983). The species is a primary cavity nester in "deciduous or coniferous forest, well-wooded towns and parks, and open situations with scattered trees ..." (American Ornithologists' Union 1983:391).

Food

Animal matter, such as beetle larvae (Coleoptera), ants (Hymenoptera), caterpillars (Lepidoptera), and adult beetles, accounted for 78% of the hairy woodpecker's annual diet, based on 382 stomachs collected throughout North America (Beal 1911). The diet is supplemented by fruit and mast (Beal 1911; Hardin and Evans 1977). Hairy woodpeckers forage extensively for seeds in winter (Jackman 1975); in Colorado, they foraged extensively during the non-reproductive season on the seeds of ponderosa pine (Pinus ponderosa) (Stallcup 1966). Hairy woodpeckers may concentrate in areas of insect outbreaks in response to the increased food source (Koplin 1967; Massey and Wygant 1973). The hairy woodpecker was considered to be a primary predator of the Southern pine beetle (Dendroctonus frontalis) in east Texas (Kroll and Fleet 1979).

Hairy woodpeckers are considered opportunistic foragers (Raphael and White 1984); they forage on a variety of substrates, including tree trunks, stumps, exposed roots (Lawrence 1966), snags, downed logs, the ground (Mannan et al. 1980), and logging debris in recent clearcuts (Conner and Crawford 1974). In California, hairy woodpeckers foraged on snags 51% of the time and on live trees 47% of the time (Raphael and White 1984). During winter, hairy woodpeckers in Virginia foraged most often on dead trees or dead parts of live trees (Conner 1980). Hairy woodpeckers in New York exhibited a sexual difference in the selection of winter foraging sites; males foraged on dead trees significantly more often than females, and females foraged significantly more often on live trees (Kisiel 1972). Both sexes used a variety of tree species for foraging sites. A variety of tree species was also used for foraging by hairy woodpeckers in Sierra Nevada forests (Raphael and White 1984). Snags used for foraging in Douglas-fir (Pseudotsuga menziesii) forests in Oregon averaged 61 cm dbh and ranged from 13 to 173 cm dbh (Mannan 1977). The average foraging height of hairy woodpeckers in Iowa was 8.8±1.55 m, and the average diameter of limbs used for foraging was 6.52±1.04 cm (Gamboa and Brown 1976). Hairy woodpeckers in New York typically foraged on limbs 5 to 10 cm in diameter (Kisiel 1972).

Hairy woodpeckers in southwestern Virginia foraged in "... habitats with relatively dense vegetation near the ground" (Conner 1980:121) in comparison to foraging habitat selected by other species of woodpeckers, especially the downy woodpecker (P. pubescens).

Water

No specific information on water requirements of the hairy woodpecker was found in the literature.

Cover

Hairy woodpeckers inhabit a wide variety of forest cover types. For example, they inhabit Douglas-fir forests (Mannan et al. 1980), ponderosa pine forests (Diem and Zeveloff 1980), pinyon-juniper (Pinus edulis - Juniperus spp.) woodlands (Balda and Masters 1980), eastern deciduous forests (Conner et al. 1975), and riparian communities (Stauffer and Best 1980). Winter population densities of hairy woodpeckers in Illinois were positively correlated with the number of trees >56 cm dbh and with a diversity of genera and species of large trees (Graber et al. 1977). Hairy woodpeckers in Oregon use the shrub/sapling (8 to 15 yr) and second-growth (16 to 40 yr) stages of Douglas-fir forests, but they do not nest in these younger stages (Meslow and Wight 1975). Jackman (1975) stated that hairy woodpeckers inhabit second-growth, partially thinned, and other altered forest types; however, hairy woodpeckers were reported more frequently (95% of 40 breeding bird censuses) in mature undisturbed habitats in the northern hardwoods region than in disturbed and successional habitats (43% of 30 censuses) (Noon et al. 1979).

Hairy woodpeckers use tree cavities for roosting and winter cover, as well as for nesting and rearing young (Thomas et al. 1979), and they will excavate new cavities in the fall to be used for roosting (Jackman 1975).

Reproduction

The hairy woodpecker is a primary cavity nester that is able to adapt to a wide variety of habitats (Kilham 1968). In the Pacific Northwest, hairy woodpeckers require standing dead trees and live trees with rotted heartwood (Jackman 1975). Similarly, hairy woodpeckers in Virginia exhibited a definite preference for trees with heartrot (Conner et al. 1975; Conner et al. 1976). Thomas et al. (1979), however, listed the hairy woodpecker as a species that usually excavates in sound wood. Runde and Capen (1987) found that the amount of sound wood varied widely (based on a visual estimate) in live trees used for nesting by hairy woodpeckers; 11 of 21 nests were in live trees. A possible exception to the apparently general use of live or dead trees for nest sites is that hairy woodpeckers do not nest in Engelmann spruce (Picea engelmannii) forests in the Pacific Northwest (Jackman 1975). Haapanen (1965 cited by Smith 1980:264) found that "of all the woodpeckers found in spruce-fir forests, apparently only the Northern 3-toed Woodpecker [Picoides tridactylus] is capable of making holes in the dense wood of living spruce trees." R.N. Conner (U.S. Forest Service, Nacogdoches, TX; letter dated February 19, 1986) suggests, however, that Engelmann spruce and other North American spruces are relatively soft-wooded trees (compared to oaks) that can be easily excavated by some species of woodpeckers. He suggests that the lack of use may be due to the absence of heartwood decay or to resin produced by spruce rather than to the density of the spruce wood. Whatever the reason for the observed lack of use, Conner believes that insufficient data exist to categorically classify live spruces as unsuitable for excavation by hairy woodpeckers.

Preferred nesting areas of hairy woodpeckers in east Tennessee were characterized by a large number of trees >23 cm dbh and associated high canopy biomass (Anderson and Shugart 1974). Hairy woodpeckers in Virginia apparently preferred areas with high stem density, but nested in areas with a wide range of basal areas, canopy heights, stem densities, and distances from cleared areas (Conner and Adkisson 1977). In northwestern Washington, hairy woodpecker nests were found in a variety of successional stages, though most were in, or at the edge of, old-growth forests (Zarnowitz and Manuwal 1985). Hairy woodpeckers in Washington are found in open rather than dense stands of timber (Larrison and Sonnenberg 1968), and in California's Sierra Nevada they prefer forests of low to moderate canopy closure (<70%) (Verner 1980). Both understocked and fully stocked stands in Virginia were suitable nesting areas as long as decayed trees were present (Conner et al. 1975). Hairy woodpeckers have even been reported nesting in the grass-forb stage of mixed coniferous forest regeneration by using stumps <1.5 m tall (Verner 1980).

Hairy woodpeckers require trees with a minimum dbh of 25 cm and a minimum height of 4.6 m for nesting (Thomas et al. 1979). Raphael and White (1984:24) found that "...diameter was the tree characteristic most closely correlated with nesting use" for 17 cavity-nesting birds. Conner and Adkisson (1976) found that canopy height had a greater influence on distinguishing between "possible nesting habitat" and "not nesting habitat" than did either basal area or stem density. In Vermont, no significant difference in mean tree height was detected between nest trees and adjacent non-nest trees (Runde and Capen 1987). Diameter at breast height (dbh) and diameter at nest height (dnh) were significantly greater for nest trees than non-nest trees ($\bar{x}$ dbh:27.1±1.3 cm vs. 23.9±0.7 cm, $P<0.05$; $\bar{x}$ dnh:22.4±1.1 cm vs. 13.2±9.6 cm, $P<0.01$). The probable optimum diameter range for hairy woodpecker nest trees is 25 to 35 cm dbh, and the probable optimum height range for nest trees is 6 to 12 m (Evans and Conner 1979). In Douglas-fir forests, however, hairy woodpeckers nest in older second-growth (41 to 120 yr) and mature (120+ yr) forests (Meslow and Wight 1975); these age classes are presumably taller than the optimum range suggested by Evans and Conner (1979). The average height of eight trees used for nesting in a Colorado aspen forest was 18 m, and ranged from about 11 to 21.3 m (Scott et al. 1980). Ten trees used for nesting in Virginia averaged 13.0 m tall and ranged from 4 to 26.5 m (Conner et al. 1975). The diameter of the tree at the cavity level in these 10 trees averaged 25.2 cm and ranged from 20 to 46 cm. In California, 19 nest trees averaged 13.7 m tall with an average diameter at the cavity level of 36.3±2.09 cm (Raphael and White 1984). Table 1 summarizes tree condition, nest heights, and nest tree diameter from several studies.

Table 1. Characteristics of nest sites selected by hairy woodpeckers in several study areas.

Source	Number of nests (n)	Tree condition		Average nest height (range)	Average nest tree dbh (range)
		Dead	Live		
Lawrence (1966) (NH)	11 (n=7 for dbh)	1	10	10.5 m (4.5-14 m) 34.9 ft (15-45 ft)	28 cm (25.4-34.8 cm) 11.1 inches (10-13.7 inches)
Conner et al. (1975) (VA)	10	5	5[a]	8.8 m (2.4-19.8 m) 28.9 ft (7.9-65 ft)	40.6 cm (20-64 cm) 16 inches (7.9-25.2 inches)
Jackman (1975) (OR)	33	?	?	7.6 m (5-10 m) 24.9 ft (16.4-32.8 ft)	?
Graber et al. (1977) (IL)	17	6	11[b]	4.6-10.7 m 15-35 ft	?
Mannan (1977) (OR)	7	?	?	18.2 m (7.9-41.8 m) 59.4 ft (25.9-137.1 ft)	92 cm (48-172 cm) 36.2 inches (18.9-67.8 inches)
Scott et al. (1980) (CO)	8	2	6	10 m (6.7-15.2 m) 33 ft (22-50 ft)	38 cm (25.4-58.4 cm) 15 inches (10-23 inches)
Raphael and White (1984) (CA)	19	16	3[c]	4.9±0.69 m 16.1±2.26 ft	43.8 cm 17.2 inches
Zarnowitz and Manuwal (1985) (WA)	16	16[d]	-	13±12 m 42.6±39.4 ft	41±13 cm 16.1±5.1 inches
Runde and Capen (1987) (VT)	21	10	11[e]	17.5±1.2 m 57.4±3.9 ft	27.1±1.3 cm 10.7±0.5 inches

[a] Four of the five nests in live trees were located in dead portions of the trees; the fifth was located in a totally live oak tree with a decayed heartwood (Conner, unpubl.).

[b] About one-half of these nests were located in dead portions of the trees.

[c] Located in dead portions of live trees.

[d] All nests located in broken-top trees.

[e] All 11 cavities were drilled through live wood.

Hairy woodpeckers will excavate in both hard and soft snags (Evans and Conner 1979); however, hairy woodpecker breeding densities were significantly positively correlated ($P \leq 0.01$) with soft snags in Iowa riparian forests (Stauffer and Best 1980). The hairy woodpecker was categorized as a soft snag excavator in Sierra Nevada forests (Raphael and White 1984). Evans and Conner (1979) estimated that 200 snags were necessary in order to support the maximum population of hairy woodpeckers on 40 ha of forest. Their estimate was based on a minimum annual need of four cavities per pair, and an assumption that only 10% of the available snags would be suitable for use. Snag density requirements decreased in direct proportion to the percentage of maximum population desired; e.g., 160 snags are required to support 80% of the maximum population, and 100 snags would support 50% of the maximum population. A similar estimate for the Blue Mountains of Oregon and Washington was that 180 snags/40 ha are necessary to support maximum populations of hairy woodpeckers (Thomas et al. 1979). Raphael and White (1984) distinguished between hard and soft snags in estimating the density of snags required to support the maximum density of hairy woodpeckers. They assumed a maximum density of 16 pairs/40 ha, an annual rate of excavation of 4 cavities/pair, and a reserve of 3 suitable cavities per pair to arrive at an estimate of 192 suitable snags/40 ha to support the maximum density. They further estimated that 4 hard snags are required to produce 1 soft snag, resulting in an estimate of 768 "hard snag equivalents" (Raphael and White 1984:56) per 40 ha. Although low numbers of snags can, in theory, support low-density woodpecker populations, enough snags to support 40% of the maximum population was assumed to be the minimum that will support a self-sustaining population of hairy woodpeckers in the Pacific Northwest (Bull 1978).

Interspersion and Composition

Territory size in a mature bottomland forest in Illinois averaged 1.1 ha and ranged from 0.6 to 1.5 ha (Calef 1953 cited by Graber et al. 1977). Reported territory size of hairy woodpeckers in the Blue Mountains of Washington and Oregon averaged 2.4 to 3.6 ha (Thomas et al. 1979). Evans and Conner (1979), however, reported an average territory size of 8 ha based on available literature, whereas territories reported for two hairy woodpeckers in Kansas were 9 and 15 ha (Fitch 1958). Home range and territory size are strongly influenced by habitat quality and, therefore, can be quite variable (Conner, unpubl.).

In a study of bird use of various sized forested habitats in New Jersey, hairy woodpeckers did not occur in areas of <2 ha (Galli et al. 1976). A minimum width of riparian forest necessary to support breeding populations of hairy woodpeckers in Iowa was 40 m (Stauffer and Best 1980). Robbins (1979) compared frequency of occurrence of hairy woodpeckers at Breeding Bird Survey stops in Maryland to the amount of contiguous forested area. The greatest decrease in frequency of occurrence was recorded at 4 ha of contiguous forested habitat, and Robbins (1979) proposed this value as a preliminary estimate of the minimum area necessary to support a viable breeding population of hairy woodpeckers. Conner (unpubl.), however, believes that 4 ha may represent the minimal area that hairy woodpeckers will use, but that such a small area could not support a viable breeding population, which he considers to be a minimum of 250 pairs. He suggested a minimum habitat area of 12 ha to support several breeding pairs of hairy woodpeckers (R.N. Conner, U.S. Forest Service, Nacogdoches, TX; letter dated December 1, 1981).

Although the hairy woodpecker is considered a resident species throughout its range, altitudinal migrations between mountainous areas and lower elevations do occur (Bailey and Niedrach 1965).

Special Considerations

The hairy woodpecker has been classed as a "tolerant species" to habitat alteration in Iowa (Stauffer and Best 1980), but also has been suggested as a sensitive environmental indicator of the ponderosa pine community (Diem and Zeveloff 1980).

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This model was developed for application within forested habitat throughout the entire range of the hairy woodpecker. Use of the model differs, however, between forests in the eastern United States and the western United States. The differences in application are described in the model.

Season. This model was developed to evaluate the year-round habitat of the hairy woodpecker.

Cover types. This model was developed to evaluate habitat in the following forested cover types: Deciduous Forest (DF), Evergreen Forest (EF), Deciduous Forested Wetland (DFW), and Evergreen Forested Wetland (EFW) (terminology follows U.S. Fish and Wildlife Service 1981).

Minimum habitat area. A minimum of 4 ha of forested habitat has been estimated to be necessary to support a viable breeding population of hairy woodpeckers (Robbins 1979), although Conner (unpubl.) believes that such a small area may represent the minimum needed to support one pair rather than a viable breeding population. Conner (unpubl.) suggested 12 ha as a reasonable estimate of the area needed to support several pairs of hairy woodpeckers. Additionally, forested riparian zones should be at least 40 m wide to be considered as potential breeding habitat for hairy woodpeckers (Stauffer and Best 1980).

Verification level. An earlier draft of the HSI model for the hairy woodpecker was used in a field evaluation of model outputs compared to expert opinion (O'Neil et al. 1988). The following species experts participated in the field evaluation:

Dr. F.J. Alsop, III, East Tennessee State University, Johnson City

Dr. C.E. Bock, University of Colorado, Boulder

Dr. R.N. Conner, U.S. Forest Service, Nacogdoches, TX

Dr. J.A. Jackson, Box Z, Mississippi State, MS

Dr. F.C. James, Florida State University, Tallahassee

Dr. B.J. Schardien Jackson, Mississippi State, MS

Initial results indicated that outputs from the earlier model were poorly correlated (r=0.07, P>0.50) with habitat ratings by experts for 40 sites in eastern Tennessee (O'Neil et al. 1988). Important habitat criteria identified by the experts were used to modify the model in an attempt to more closely mimic the procedures used by experts to rate habitats. The major changes to the model as a result of the field evaluation were (1) optimum suitability for the average diameter of overstory trees was changed from 25 to 38 cm; (2) snags were assigned greater importance than live trees for nesting; (3) the variable "percent canopy cover of pines" was added to reflect a strong negative correlation (r=-0.91, P<0.001) between this variable and habitat ratings by species authorities; (4) the mathematical function used to calculate the cover suitability index was changed from a geometric mean to a multiplicative function; and (5) the suitability relationship for tree canopy closure was changed from a preference for moderate canopy closure to a preference for dense forest canopy. Correlation of outputs from the modified model to habitat ratings by species authorities improved considerably (r=0.82, P<0.001) (O'Neil et al. 1988).

All of the changes to the model as a result of the field evaluation were based on input from species experts and reflect hairy woodpecker ecology in forests in the eastern United States. The variable "percent canopy cover of pines" is not recommended as an appropriate variable in western forests; use of the model in western vs. eastern forests is described below. The current model is the direct result of the field evaluation; it has not been field tested.

Model Description

Overview. The hairy woodpecker can satisfy all of its habitat requirements within any one of the forested cover types listed above. Reproductive and cover needs are evaluated in this model. Although sufficient food is an obvious life requisite of the hairy woodpecker, I assume in this model that food will never be more limiting than cover and reproductive requirements and that water is not a limiting factor.

The following sections identify important habitat variables, describe suitability levels of the variables, and describe the relationships between variables.

Reproduction component. The hairy woodpecker is able to adapt to a variety of habitats, but suitable reproductive habitats must (1) be dominated by trees of sufficient size and decay for nesting, (2) have adequate snag densities, or (3) have some combination of the two.

The number of snags ≥25.4 cm dbh necessary to support maximum densities of hairy woodpeckers has been estimated to range from 180/40 ha (Thomas et al. 1979) to 200/40 ha (Evans and Conner 1979), or 4.5 to 5 snags/ha; a snag density of 5/ha is assumed to represent optimal conditions for reproduction (Figure 1a). This estimate refers specifically to nesting and roosting requirements and may not adequately satisfy foraging needs (Conner, unpubl.). Potential population density is assumed to decrease proportionally with a decrease in snag density. Although I assume in this model that low snag densities will support low woodpecker densities, Bull (1978) assumed that snag densities <40% of those needed for maximum population density would not support a self-sustaining population.

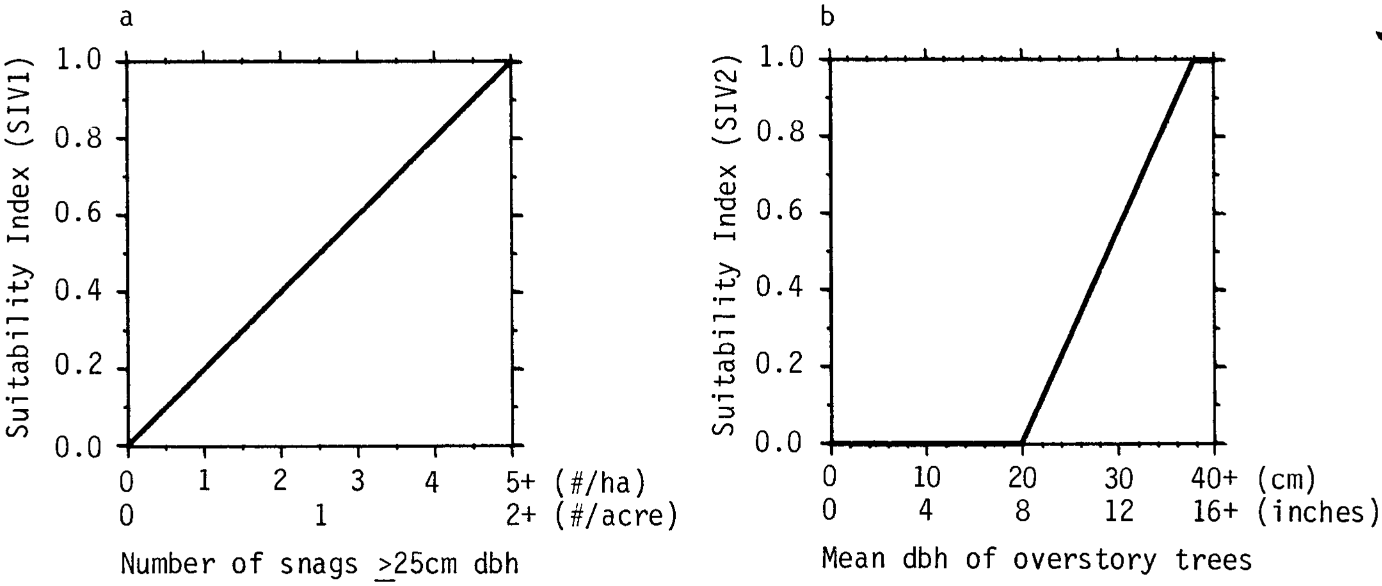

Figure 1. Relationships between variables used to evaluate reproductive habitat for the hairy woodpecker and suitability levels for the variables.

Hairy woodpeckers can excavate cavities in live trees provided that heartrot is present, and thus may inhabit a forested area even in the absence of snags. Runde and Capen (1987) believed that trees >30 cm dbh would be most useful to hairy woodpeckers, downy woodpeckers, and yellow-bellied sapsuckers (Syphrapicus varius). For this model, I assume that if the average dbh of overstory trees is ≥38 cm, then trees will be of optimum size for nesting. I assume that an adequate number of available (i.e., with heartrot) live trees will be present if the average dbh of overstory trees is ≥38 cm. There is little evidence correlating tree diameter and presence of heartrot, but the alternative is to physically examine trees for heartrot; this level of detail is presumed to be too great for the typical application of this model. Use of the average dbh of overstory trees does not consider the absolute number of available live trees. I assume that if an area meets the minimum requirements to be classified as a forest and is >4 ha, then the total number of trees available for potential nesting will be optimal. Assuming that adequate numbers of trees are present, the size and condition of the trees will determine whether the nesting potential will be low or high. The minimum reported dbh of a tree used for nesting by hairy woodpeckers is 20.1 cm (Conner et al. 1975). Thus, I assume that optimal conditions for this variable exist when the average dbh of overstory trees is ≥38 cm, and that conditions are unsuitable when the average dbh of overstory trees is ≤20 cm (Figure 1b). The values defining optimum and suitable levels of this variable are based on results of the field test mentioned earlier.

Overall nesting suitability is a function of the availability of snags or live trees. In the field test, experts consistently rated habitats without snags lower than habitats with snags (O'Neil et al. 1988), presumably because hairy woodpeckers cannot excavate in undecayed trees and prefer to forage on dead snags (Conner, unpubl.). Habitat suitability ratings in habitats without snags that were otherwise suitable were generally between 0.7 and 0.8 (on a 0-1 scale). I assume, therefore, that habitats without snags (i.e., all potential nest sites are in live trees) will have a maximum suitability rating of 0.75. An overall suitability index for nesting (SIN), based on the relationships described above, can be determined with Equation 1.

$$SIN = SIV1 + (0.75 \times SIV2) \qquad (1)$$

[Note: If the value resulting from Equation 1 exceeds 1.0, it should be set to 1.0.]

Cover component. Besides having sufficient potential nest sites, at least three other habitat factors affect the overall suitability of a habitat for hairy woodpeckers. These three factors are the seral stage of a forest stand, the degree of canopy cover of the forest, and the proportion of pines in the canopy. These variables are assumed to influence food availability, foraging, nesting suitability, and cover, but are aggregated into a cover component in this model. Because these factors affect overall habitat suitability, they will be used in this model as modifiers of the reproductive value.

A measure of the seral stage of a forest is the average diameter of the overstory trees. Hairy woodpeckers may inhabit young forests, but at lower densities than in older forests. Because they do inhabit forests in a variety of seral stages, however, this habitat variable should not be strictly limiting. I assume in this model that the optimal seral stage exists when the average dbh of overstory trees is >25 cm (Figure 2a). When the average dbh of overstory trees is <15 cm, suitability is assumed to be one-half of optimum, i.e., a suitability index of 0.5.

The literature suggests that hairy woodpeckers apparently prefer forests of moderate canopy cover. Habitat ratings by species experts in the field test, however, tended to be higher in forest stands with a dense canopy, except that closed canopy stands were generally rated lower than stands with <100% canopy cover (O'Neil et al. 1988). I assume that optimal conditions for this variable occur at 85% to 90% (Figure 2b) with complete canopy cover representing less than optimal habitat. I further assume that canopy cover <15% will provide unsuitable habitat conditions. Since the definition of a forest is a cover type with at least 25% tree canopy cover, any forest will have canopy conditions of some positive suitability level for hairy woodpeckers.

Hairy woodpeckers inhabit a variety of deciduous, coniferous, and mixed deciduous-coniferous habitats. Habitat ratings by experts were negatively correlated ($r=-0.91$, $P<0.001$) with the percent canopy closure of pines; sites completely dominated by pines received relatively low habitat ratings (O'Neil et al. 1988). I assume in this model that an increase in the canopy cover of pines in a stand will generally reflect a decrease in habitat suitability for the hairy woodpecker, although a small amount of pines (≤10% canopy cover) is assumed to contribute to the diversity of cover and prey (Figure 2c). Sites completely dominated by pines are assumed to have a suitability index for this variable of 0.2. The apparent influence of pines on hairy woodpecker habitat suitability described above probably does not apply in western coniferous forests (C.E. Bock, Environmental, Population and Organismic Biology, University of Colorado, Boulder; letter dated February 24, 1986). I recommend that the variable "percent canopy cover of pines" be deleted from the model for application in western coniferous forests. It is unclear whether a similar negative relationship exists between other species of conifers in eastern forests and perceived habitat suitability for the hairy woodpecker.

Results from the field test of the earlier model indicated that the product of the suitability indices (Equation 2) for the cover component variables most closely reflected habitat ratings by species experts (O'Neil et al. 1988).

$$SIC = SIV3 \times SIV4 \times SIV5 \qquad (2)$$

As long as an area is classified as a forested type, all of the variables in Equation 2 will be greater than zero, and the index value for the cover component will likewise be greater than zero.

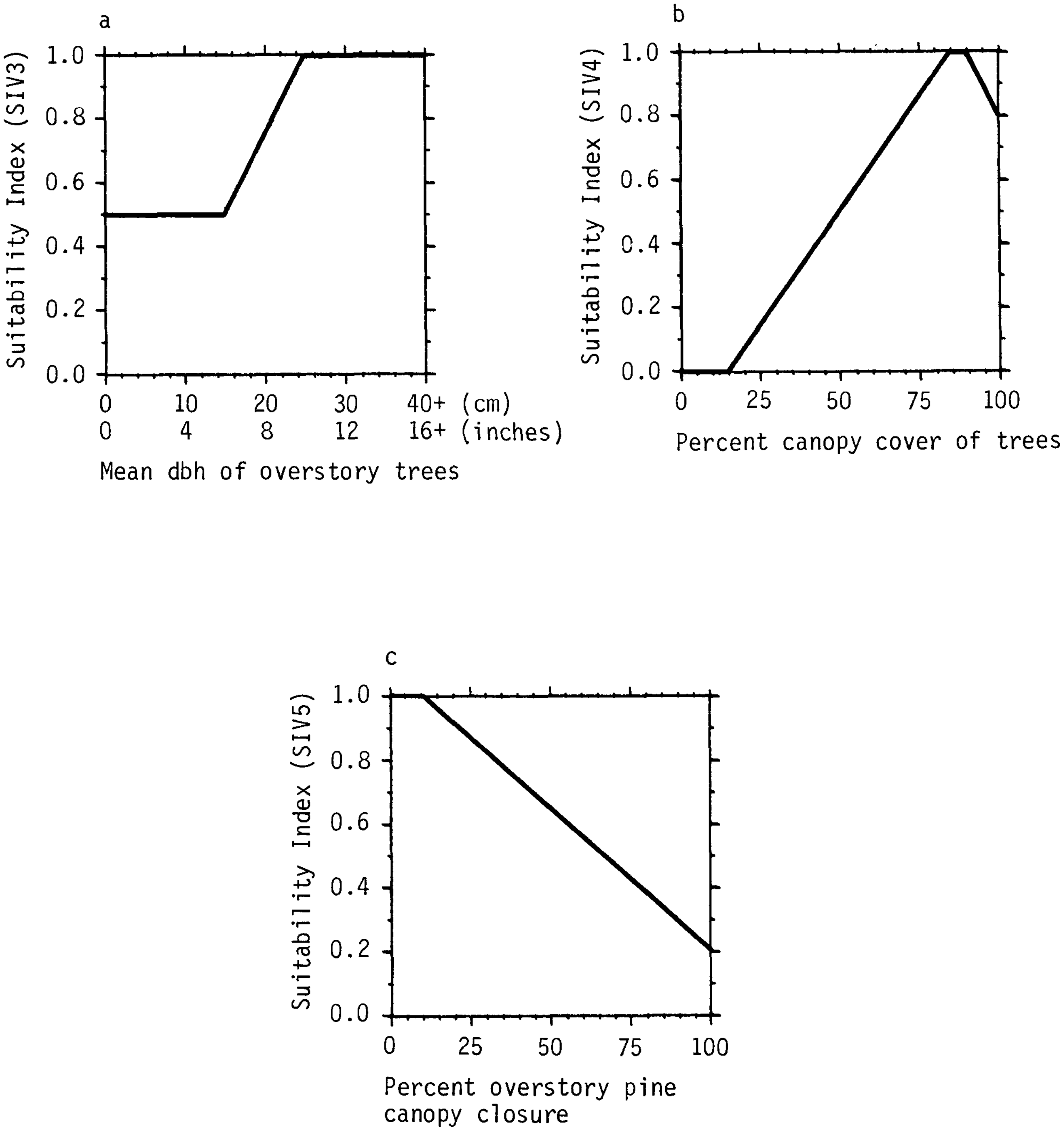

Figure 2. Relationships between variables used to evaluate cover for the hairy woodpecker and suitability levels for the variables.

HSI determination. The suitability index for the cover component is assumed to directly modify the suitability index for the reproduction component (Equation 3) to yield an overall HSI value for the hairy woodpecker in the habitat being evaluated. At optimal cover component conditions (i.e., SIC=1.0), the reproduction component will determine the habitat suitability index. If cover conditions are anything less than optimum, then the reproduction value will be reduced based on the quality of the cover conditions.

$$\mathrm{HSI} = \mathrm{SIN} \times \mathrm{SIC}, \text{ or}$$

$$\mathrm{HSI} = [\mathrm{SIV1} + (0.75 \times \mathrm{SIV2})] \times (\mathrm{SIV3} \times \mathrm{SIV4} \times \mathrm{SIV5}) \qquad (3)$$

[Note: In instances where SIN >1.0, it should be set equal to 1.0 prior to using Equation 3.]

Application of the Model

Summary of model variables. Several habitat variables are used in this model to evaluate habitat suitability for the hairy woodpecker. The relationships between habitat variables, life requisites, cover types, and an HSI are summarized in Figure 3. The definitions and suggested measurement techniques (Hays et al. 1981) for the variables used in this model are listed in Figure 4.

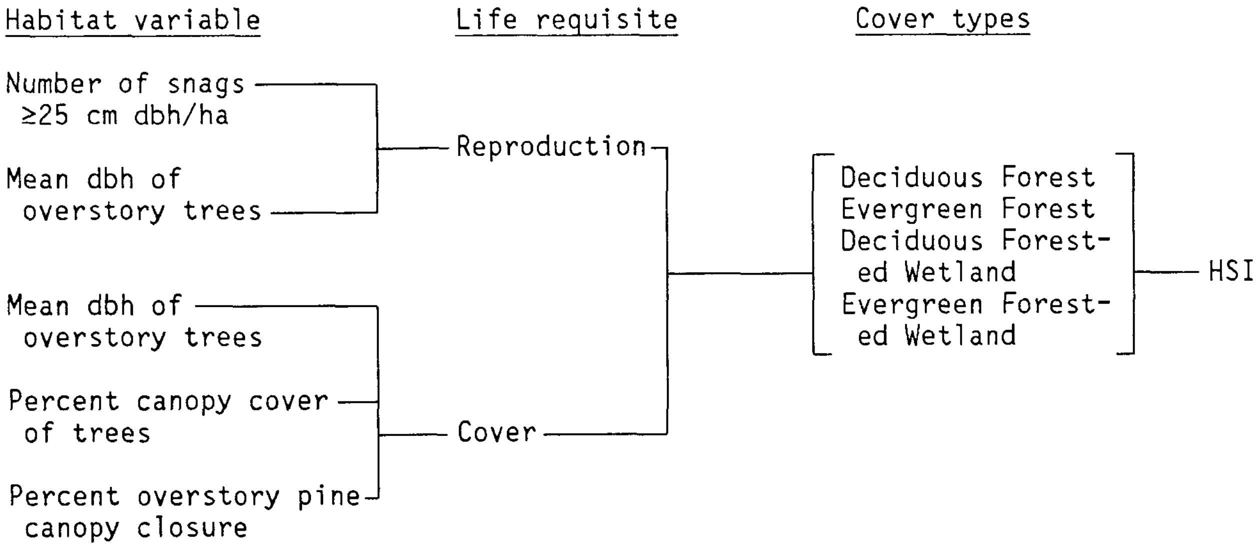

Figure 3. Relationships of habitat variables, life requisites, and cover types to the HSI for the hairy woodpecker.

Variable (definition)	Cover types	Suggested technique
Number of snags ≥25 cm dbh per ha [actual or estimated number of standing dead trees ≥25 cm dbh and ≥1.8 m tall. Trees in which ≥50% of the branches have fallen, or are present but no longer bear foliage, are to be considered snags].	DF,EF,DFW, EFW	Quadrat, remote sensing
Mean dbh of overstory trees [the mean diameter at breast height (1.4 m) above the ground of those trees that are ≥80% of the height of the tallest tree in the stand].	DF,EF,DFW, EFW	Diameter tape
Percent canopy cover of trees [the percent of the ground surface that is shaded by a vertical projection of all woody vegetation >6.0 m tall].	DF,EF,DFW, EFW	Line intercept, remote sensing
Percent overstory pine canopy closure [the percent of the ground surface that is shaded by a vertical projection of all pines (Pinus spp.) >6.0 m tall and ≥80% of the height of the tallest tree in the stand; recommended for use in eastern U.S. forests only (see text for explanation)].	DF,EF,DFW, EFW	Line intercept, remote sensing

Figure 4. Definitions of variables and suggested measuring techniques.

Model assumptions. A number of assumptions were made in the development of this HSI model.

1. The criteria identified for evaluation of hairy woodpecker habitat are generally assumed to be appropriate throughout the range of the species. Many of the variables and variable relationships identified in the model resulted from a field test of an earlier HSI model in eastern Tennessee. As a result, the model is probably best suited for application in the southeastern United States. No information is available to indicate the model's applicability to other parts of the United States, except there is adequate information that the presumed negative influence of pines does not apply to western U.S. forests (see number 7 below).

2. Nest sites can be provided by a combination of snags and live trees, but live trees in the absence of snags cannot provide optimal nesting habitat.

3. A measure of the average diameter at breast height of overstory trees is assumed to be an adequate estimator of the suitability of live trees for nesting. An adequate number of trees in suitable condition (i.e., with decayed heartwood) is assumed to be present as long as the cover type is classified as a forest (i.e., has ≥25% canopy cover) and tree diameter is suitable.

4. All tree species are assumed to be available for excavation by hairy woodpeckers. It is possible that some species may not typically have decayed heartwood and, therefore, will be unsuitable for excavation. It is also possible that some tree species will be unsuitable for excavation because of resins or the density of the wood. Little definitive evidence is available, however, to determine whether some tree species are absolutely unsuitable for excavation by hairy woodpeckers.

5. Hairy woodpeckers can inhabit a variety of forested habitats, but potential nesting in live trees will only be provided by older forest stands with large trees.

6. Hairy woodpeckers prefer forest stands with a dense canopy. This assumption may be valid in the southeastern United States but may be invalid in the western United States, where the forest canopy is generally less dense than in the east. The relationships described for percent canopy cover of trees and habitat suitability (Figure 2b) may need to be redefined for use in western forest habitat if the standard of comparison in such applications is intended to be the best regional habitat. Use of the model without modification will yield outputs based on a standard of comparison developed in the southeastern United States.

7. The presence of pines above a minimal level (10%) is considered to be a negative factor in habitat suitability for the hairy woodpecker in this model (Figure 2c). Pine and other coniferous forests in the western United States, however, are regularly used by hairy woodpeckers. I recommend that this variable be eliminated for application in western coniferous forests.

8. The hairy woodpecker breeds and winters throughout most of North America. I assume in this model that the year-round suitability of a habitat is a function of the habitat suitability during both the reproductive and nonreproductive seasons. Model users who wish to evaluate either of the seasons rather than both can simply use the appropriate portion of this model. Users should be aware that model outputs in such instances will refer only to a portion of the year-round needs of the hairy woodpecker.

SOURCES OF OTHER MODELS

Conner and Adkisson (1976) developed a model to distinguish between "possible nesing habitat" and "not nesting habitat" for the hairy woodpecker in oak-hickory forests of southwestern Virginia. Three variables were included in the model: basal area (m^2/ha), canopy height to crown cover (m), and stem density (number/ha). The model includes coefficients for the three variables, an aggregation function, and a linear decision scale. The model was applied to two groups, the first consisting of stands containing hairy woodpecker nests, and the second consisting of six random plots in each of five habitat types; results of the analysis were significant (P=0.02).

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A review and synthesis of existing information were used to develop a Habitat Suitability Index (HSI) model for the hairy woodpecker (Picoides villosus). The model consolidates habitat use information into a framework appropriate for field application, and is scaled to produce an index between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). HSI models are designed to be used with Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service.

17. Document Analysis a. Descriptors

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Habitability
Mathematical models

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Picoides villosus
Habitat suitability

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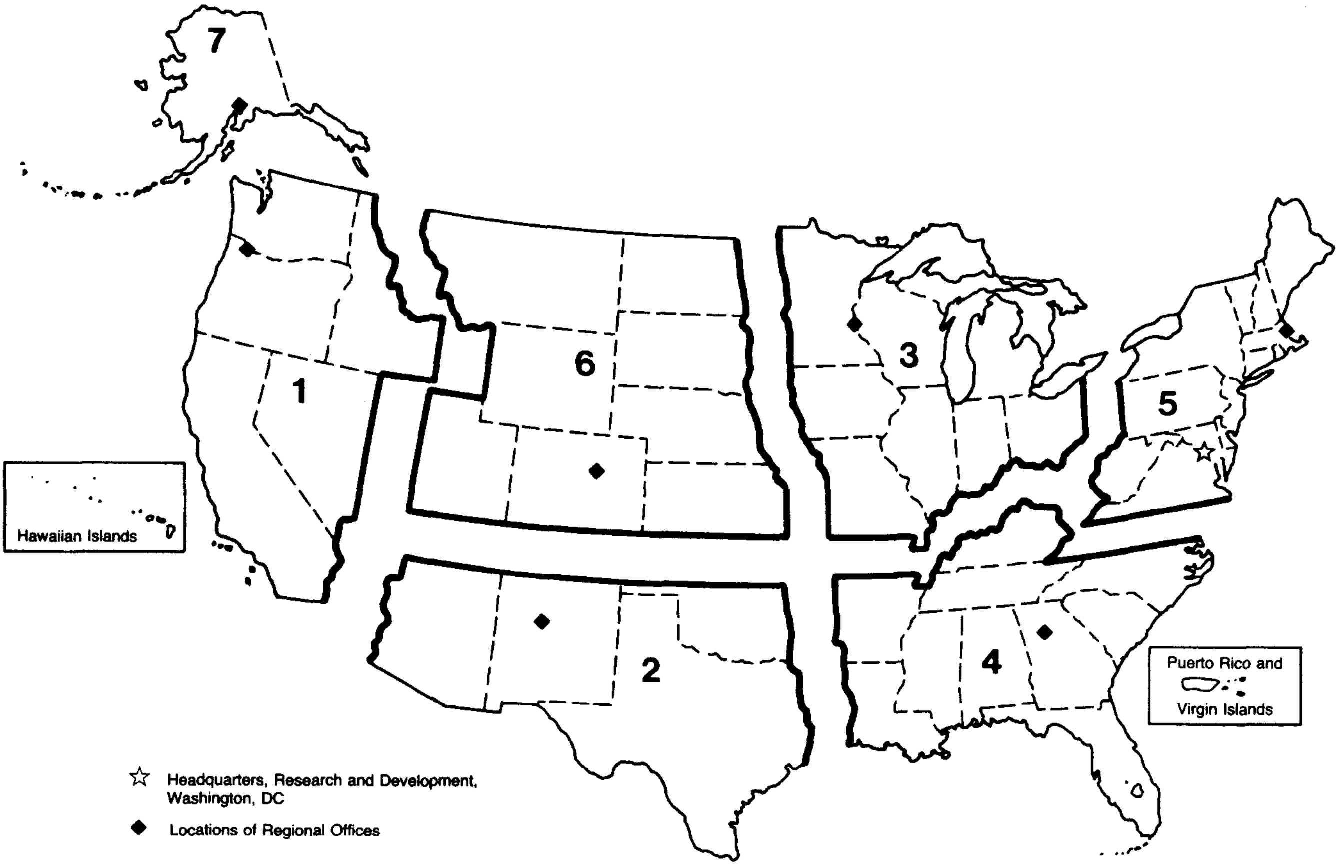

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APPENDIX C: FIELD DATA SHEETS

DATA SHEET TS_30_L HEP P. 21

DATE 12/8/21 TIME 3:15 NAMES Steve Seb, Dan

PHOTO# 229-231 WYPT #40-s end #41-N end PLOT#/LOCATION #2/end of project

TRANSECT TOTAL LENGTH (FT) 80? / 80? / ______

RSG MODEL: V1 (SHRUB<3M) (FT) ~~20~~ 30 / 20 / ______

V~~2~~1 (indiv tree hts, ft) 20 Pecan 18' Pecan 35' VO 20' will ______ ______

V~~3~~2 (TREE>3M) (FT) 45 / 55 / ______

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) [5] / [5] tree/shrubs / ______

SNAG (indv diam, in) 6" — limb above ground N 2m (2 pieces, rootwad >10" 5–7' above ground)

V5, snag count >4" 1

V6 ALL WOODY 75' / 75' / ______

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 75' / 80' / ______

V3 TREE CANOPY CLOSURE 40' / 50 / ______

V4 # SPECIES (list names) Pecan, VO, Willow, BB, unid tree w/ hanging seeds, live oak

V5 UNDERSTORY DENSITY @2FT 80 / 60 / ______ @6FT 70 / 50 / ______
@14FT 50 / 40 / ______ AVERAGE [75] / [50] / ______

YW MODEL: V1 DECID SHRUB COVER 75' / 60' / ______

V2 SHRUB HTS (ft) T1 2+m almost all ______ ______
(nearest .1M) T2 1.5 – 2+m variable ______ ______

Basal area
15
10/8
(6x6) unid
21"
18x4 groupy
UNID
80" willstree
5' pecan

V3 hydrophytic SHRUB COVER 75' / 55' / ______

V4 tall tree 0 / 20'

DW MODEL: V1 SNAG COUNT >6", see above 0

V2 BASAL AREA (cruz-all or see HW, below) ______ / ______ / ______

HW MODEL: V1 SNAG COUNT >10", see above 0

V2/V3 DbH overstory 15" VO 10/8 pecan 11" pecan 21" live oak 11' live oak
(8–9 (6–8 stems)) willow ______ ______ ______ ______

V4 CANOPY COVER 10% / 40% / ______
(6m+)

DATA SHEET TS_30_L HEP P. 20

DATE 12/8/21 TIME 1:17pm NAMES Dave F, Steve Sch

PHOTO# #226-228 WYPT #39 Send #40 Nend PLOT#/LOCATION #20

TRANSECT TOTAL LENGTH (FT) 80' / 80' / ______

RSG MODEL: V1 (SHRUB<3M) (FT) 20 / 90 / ______

V2 (indiv tree hts, ft) 18 ① (W) Pecan 22' 48' ① will 28 ① LO 25 ① VO ______

V3 (TREE>3M) (FT) 25 / 20 / ______

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) [✓ 5] / [✓ 5] / ______ tall/short shrubs trees tall/short shrubs

SNAG (indv diam, in) 4+" (6" but <4' off ground) ______ ______
V5, snag count >4" ______

V6 ALL WOODY 45' / 60' / ______

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 45' / 60' / ______

V3 TREE CANOPY CLOSURE 20% / 10% / ______

V4 # SPECIES (list names) Willow, Willow, BB, Pecan, live Oak, Valley Oak

V5 UNDERSTORY DENSITY @2FT 50% / 70 / ___ @6FT 50 / 50 / ___
@14FT 40 / 30 / ___ AVERAGE 45% / 50 / ___

YW MODEL: V1 DECID SHRUB COVER 40' / 60' / ______ Note: inconsistent must be 45ft

V2 SHRUB HTS (ft) T1 all > 2m+ ______
(nearest .1M) T2 almost all > 2m+ (~1.8M avg) ______

V3 hydrophytic SHRUB COVER 45' / 60 / ______
V4 Tall tree 0 / 0
DW MODEL: V1 SNAG COUNT >6", see above (.) 1 marginal, ever 0

V2 BASAL AREA (cruz-all or see HW, below) ______ / ______ / ______

Basal area
Pecan 11"
(18/34/22/28/26/22)
6" VO
6" LO
12" Pecan stems

HW MODEL: V1 SNAG COUNT >10", see above [plot entered, obviously 0]
V2/V3 DbH overstory 11"/pecan (18, 34, 22, 28, 26, 22) large willow
6" VO 6" pecan 6" LO ______ ______ ______

40" large willow thicket

30" large willow thicket

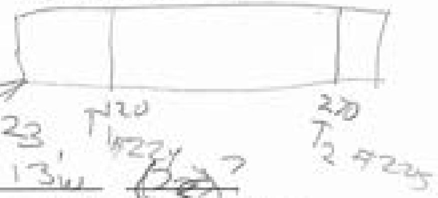
V4 CANOPY COVER 0 / 5% / ______

DATA SHEET TS_30_L HEP P. 19

DATE 12/8/21 TIME 11:21am NAMES Steve Sch, Dave F

PHOTO# 223-225 WYPT #38-S end #39-N end PLOT#/LOCATION #19

TRANSECT TOTAL LENGTH (FT) 100 / 9.2 / ________ all herbaceous stalk



RSG MODEL: V1 (SHRUB<3M) (FT) 30 / 0 / ________

V2 (indiv tree hts, ft) 21' fig ① 14' will ① 15' will ① 20' 18' VO ① 13' w 20' will ① (23) 5? Valley Oaks

V3 (TREE>3M) (FT) 0 / 0 / ________

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) (2) / (1) / ________

SNAG (indv diam, in) 6" 4+" <6" <6" (<4) (<4)

V5, snag count >4" (1)

V6 ALL WOODY 30 / 0 / ________

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 50 / 0 / ________

V3 TREE CANOPY CLOSURE 0 / 0 / ________

V4 # SPECIES (list names) (4+) VO, Will, Will pp 2nd, Unid tree w/ Bells, fig, BB, LiveOak

V5 UNDERSTORY DENSITY @2FT 30 / (0) - herb / ___ @6FT 30 / 0 / ___
@14FT 10 / 0 / ___ AVERAGE (25) / 0 / ___

YW MODEL: V1 DECID SHRUB COVER 30' / 0 / ________

V2 SHRUB HTS (ft) T1 - 1.0-1.5m
(nearest .1M) T2 = 0

V3 hydrophytic SHRUB COVER 30' / 0 / ________

V4 tall Tree 0 / 0

DW MODEL: V1 SNAG COUNT >6", see above (1)

V2 BASAL AREA (cruz-all or see HW, below) ________ / ________ / ________

HW MODEL: V1 SNAG COUNT >10", see above (0)

V2/V3 DbH overstory (6/6/6) 20' Fig 6 5 5 5+ (willows up to 6")

Basal area
(large willow thic 30")
(willow thick 25")
(VO 3/6/4)
(VO 6)
willow thickets 20/20
20/20
Fig 20

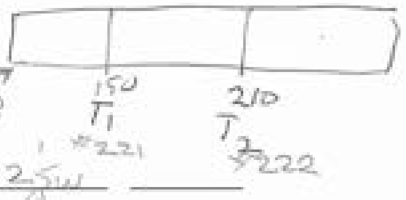
V4 CANOPY COVER 0 / 0 / ________

DATA SHEET TS_30_L HEP P. 18

DATE 12/8/21 TIME 1018am end NAMES Steve Sch, Dave F.

PHOTO# 220-222 WYPT #37S end #38 N end PLOT#/LOCATION #18

TRANSECT TOTAL LENGTH (FT) 80 / 75 / ______



RSG MODEL: V1 (SHRUB<3M) (FT) ~~4~~0 / 20 / #220

V2 (indiv tree hts, ft) 45' VO © 25' will ⓪ 25' will M BW 40' ⓪ 25' SW ⓪ ______

V3 (TREE>3M) (FT) 20 / 30 / ______

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) shrub/tree [✓ 5] / [✓ 5] / ______

SNAG (indv diam, in) (<4) 4.5" (<4)" 6" ______ ______
V5, snag count >4" [✓ 2]

V6 ALL WOODY 60 / 65 / ______

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 60 / 70 / ______

V3 TREE CANOPY CLOSURE 20 / 65 / ______

V4 # SPECIES (list names) Will, BW, V.O., BB, 2nd will sp

V5 UNDERSTORY DENSITY @2FT 50 / 30 / ____ @6FT 50 / 40 / ____
@14FT 20 / 60 / ____ AVERAGE [✓ 40] / [✓ 40] / ____

YW MODEL: V1 DECID SHRUB COVER 60' / 30' / ______

V2 SHRUB HTS (ft) T1 - 2+ m throughout ______ ______ ______
(nearest .1M) T2 - 2+ m - all shrubs ______ ______ ______

V3 hydrophytic SHRUB COVER 60 / 30' / ______
V4 (tall tree Ø / 40'

DW MODEL: V1 SNAG COUNT >6", see above [✓ 1]

V2 BASAL AREA (cruz-all or see HW, below) ______ / ______ / ______

HW MODEL: V1 SNAG COUNT >10", see above Ø
V2/V3 DbH overstory (14/12/8/6) BW; VO 25 ______ ______

______ ______ ______ ______ ______ ______

V4 CANOPY COVER 15 / 40' / ______

Bog Larea
willow thick 35"
BW 14/12/8/6"
5/3/3/3/3
willow thick 30"
VO 25"
sm will - 25" stems

DATA SHEET TS_30_L HEP P. 17

DATE 12/7/21 TIME 3:30 NAMES Steve Sig, Jos, Mir.

PHOTO# #217-219 WYPT #36 end #31 end PLOT#/LOCATION #17

TRANSECT TOTAL LENGTH (FT) 100 / 100 /

RSG MODEL: V1 (SHRUB<3M) (FT) 35 / 85 /

V2 3 (indiv tree hts, ft) BW 30 © 70 BW 35 © 20' W 24 W 44' Co © 6-7 willows 20+ a few 24

V3 2 (TREE>3M) (FT) / 30 /

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) willow/cottonwoods (5) / trees & shrubs (5) /

SNAG (indv diam, in) 4" (willow) { a few others < 4"

V5, snag count >4" (1)

V6 ALL WOODY 60' / 85' /

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 65 / 85' /

V3 TREE CANOPY CLOSURE 5% / 35% /

V4 # SPECIES (list names) BW, silver willow

V5 UNDERSTORY DENSITY @2FT 50 / 85 / @6FT 30 / 60 /
@14FT 10 / 25 / AVERAGE (30) / (65) /

YW MODEL: V1 DECID SHRUB COVER 50 / 85 /

V2 SHRUB HTS (ft) T1 1.5M 2M
(nearest .1M) T2 1.0 30' , 2+M Note: interpret as 30 feet m + 55 feet, 2+ m matches photo 214

V3 hydrophytic SHRUB COVER 50 / 85 /

V4 0 / 0

DW MODEL: V1 SNAG COUNT >6", see above 0

V2 BASAL AREA (cruz-all or see HW, below) / /

HW MODEL: V1 SNAG COUNT >10", see above 0

V2/V3 DbH overstory (3× 8-9") willow 20" Lok 12/6" BW 24" BW

V4 CANOPY COVER 0 / 25% /

Basal area est.

willow 30" multi stem

willow w/ 4 × ~50" multi stem

8" willow

20" Lo

20" willow thicket

20" willow thicket

24" BW

12/6 BW

DATA SHEET TS_30_L HEP Owl in tall willow tree P. 16

DATE 12/7/21 TIME 2:22 NAMES Steve sch; Jess, Mir

PHOTO# # 214-216 WYPT #35-Send Ned PLOT#/LOCATION #16

TRANSECT TOTAL LENGTH (FT) 150' / 120' /

RSG MODEL: V1 (SHRUB<3M) (FT) 10 / 60 /

V2 (indiv tree hts, ft) Will 15 BW 12 W 35 W 22 W 40 mixed 25

V3 (TREE>3M) (FT) 130 / 30 /

Tall/short shrubs, trees tall short shrubs

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) 5 / 5 /

SNAG (indv diam, in) 10"+ 4"), Owl willow

V5, snag count >4" 2

V6 ALL WOODY 135' / 90' /

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 135 / Not Recorded / guess 90' from here and here

V3 TREE CANOPY CLOSURE 80 / Not Recorded / guess 30 maybe less from here

V4 # SPECIES (list names) Silver Will, live Oak, BW, BB, Coyote Brush, walnut.

V5 UNDERSTORY DENSITY @2FT 90 / 85 / @6FT 90 / 30 /

@14FT 80 / 10 / AVERAGE 85 / 40 /

YW MODEL: V1 DECID SHRUB COVER 135' / 90' /

V2 SHRUB HTS (ft) T1 predominantly 2+ M throughout

(nearest .1M) T2 2/3 1.2m, + 1/3 2+m

V3 hydrophytic SHRUB COVER 135' / 90' /

1/4 tall tree 10'/d

DW MODEL: V1 SNAG COUNT >6", see above 1

V2 BASAL AREA (cruz-all or see HW, below) / /

Basal area 1st

willow 15"

30"

100's of 1" stems

BW 8"

walnut 20"

walnut 8"

walnut 18"

HW MODEL: V1 SNAG COUNT >10", see above 1

V2/V3 DbH overstory 16" will est 25-30 will est 28-32 will

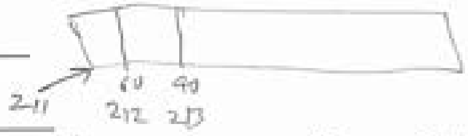
V4 CANOPY COVER 10 / 20' /

DATA SHEET TS_30_L HEP P.#15

DATE 2/7/21 TIME # 12 42p NAMES Stevesole, Jess, Mir

PHOTO# 211-213 WYPT #35 N end #34 S end PLOT#/LOCATION #15 just before Bend

TRANSECT TOTAL LENGTH (FT) 100 / 100 / ______



RSG MODEL: V1 (SHRUB<3M) (FT) 40 / 30 / ______

V2 (indiv tree hts, ft) ✓ will ~~25~~ ✓ will 25' corkoak 30 © 22© will 22© 12' BW © BL 55© BW 48© 25' © red Berry tree

V3 (TREE>3M) (FT) 0 / 20 / ______

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) low shrub only ~~1~~ / 5 tall short shrub / ______

SNAG (indv diam, in) 10" 6" 8" 6" ______ ______

V5, snag count >4" 2

V6 ALL WOODY 50 / 50 / ______

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 90 / 60 / ______

V3 TREE CANOPY CLOSURE 0 / 0 / ______

V4 # SPECIES (list names) Red willow, BB, ButtW, another Will spp. (No Lupine) corkoak elderberry walnut

V5 UNDERSTORY DENSITY @2FT 50 / 70 / ______ @6FT 0 / 30 / ______

@14FT 0 / 5 / ______ AVERAGE 15 / 30 / ______

YW MODEL: V1 DECID SHRUB COVER 50 / 50 / ______

V2 SHRUB HTS (ft) T1 ~ guess, .5m — Note; can't be "half" must be 70% ______ ______ ______

(nearest .1M) T2 ~ half .5m ~~[illegible]~~ >2m 30% ______

V3 hydrophytic SHRUB COVER 40 / 50 / ______

* V4 Tall tree 0/0

DW MODEL: V1 SNAG COUNT >6", see above 2

V2 BASAL AREA (cruz-all or see HW, below) ______ / ______ / ______

Basal area
BW - 16" stems
Will - 10" stems
Will - 24" stems
Bw - 6"
Will - 20"
Red berry vine - 18'
+ numerous shorter willows 30 ft

HW MODEL: V1 SNAG COUNT >10", see above 1

V2/V3 DbH overstory 16" corkoak 8" willow B 30 ft 13"/8" walnut 7" ~~BBF~~ Currant 23" ______

"13/12" walnut ______ ______ ______ ______ ______

V4 CANOPY COVER 0 / 10 very little 6m only / ______

DATA SHEET TS_30_L HEP P. 14

DATE 12/7/21 TIME 1155pm NAMES Steve Sch, Jess, Mir.
#208-210 #33 Send
PHOTO#______ WYPT #34 Nend PLOT#/LOCATION #14

TRANSECT TOTAL LENGTH (FT) 100 / 100 / ______

RSG MODEL: V1 (SHRUB<3M) (FT) 32 / 49 / ______

V~~2~~3 (indiv tree hts, ft) 25 will (Y) 25 (Y) 20 (Y) 20 (Y) BW 20 (Y) ______

V~~3~~2 (TREE>3M) (FT) 45 / 30 / ______

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) tr/sh 5 / 5 / ______ tree/sht shrub

SNAG (indv diam, in) 4" 6" 8" (~4x3', some lower or bigger)
V5, snag count >4" 3+

V6 ALL WOODY 77 / 74' / ______

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 100 / 100 / ______

V3 TREE CANOPY CLOSURE 40% / 30% / ______

Fuzzy brown bush

V4 # SPECIES (list names) BB, willow, RdW, BW, UNID, , 5

V5 UNDERSTORY DENSITY @2FT 80 / 60 / @6FT 50 / 35 / ___
@14FT 40 / 20 / ___ AVERAGE 55 / 30 / ___

YW MODEL: V1 DECID SHRUB COVER 77 / 74 / ______ Basal Area

V2 SHRUB HTS (ft) T1 1.3m BB to 1/2 + 1/2 2m+ willow) ______ BW 4x4
(nearest .1M) ~~T2 0.7 x 60%~~ 60 ~~+ 40% 2m+ willow~~ ______ BW total 20'

willow total 10'

V3 hydrophytic SHRUB COVER 77 / 74 / ______

* (V4 talltree - 20 / 0)

willow ~40' stems

DW MODEL: V1 SNAG COUNT >6", see above 2+ tree/standing (thinning area)

see all method →

V2 BASAL AREA (cruz-all or see HW, below) ______ / ______ / ______ willow 15'

SW willow - 15'

HW MODEL: V1 SNAG COUNT >10", see above 0 sprout thicket 25" stems
V2/V3 DbH overstory (2 4" willow) 18" willow BW, 4-5 stems 8") ______ Fuzzy 6"

______ ______ ______ ______ ______ ______

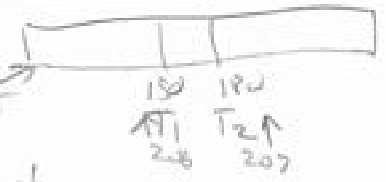
V4 CANOPY COVER 30% / 20% / ______
(6m+)

DATA SHEET TS_30_L HEP P. #13

DATE 12/7/21 TIME 10:47am NAMES Steve Sch, Jess, Mir

PHOTO# #205 #206-209 WYPT #32 S end #33 N end PLOT#/LOCATION #13

TRANSECT TOTAL LENGTH (FT) 100 / 100 / ________



RSG MODEL: V1 (SHRUB<3M) (FT) 80 / 80 / ________

V2 (indiv tree hts, ft) Hackberry 38 Hackberry 25 BW 14' BW 20' 30' ________

V3 (TREE>3M) (FT) 5 / 5 / ________

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) 5 tree shrub / 5 tall/short shrub / ________

SNAG (indv diam, in) 4 4 5 4" ________ ________
V5, snag count >4" 4

V6 ALL WOODY 85 / 85 / ________

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 100 / 100 / ________

V3 TREE CANOPY CLOSURE 5' / 0 / ________

V4 # SPECIES (list names) BW, Hackberry, silver Will, red willow, w/c Brownish fuzzy upp

V5 UNDERSTORY DENSITY @2FT 90 / 90 / ____ @6FT 30 / 50 / ____
@14FT 10 / 0 / ____ AVERAGE 35 / 35 / ____

YW MODEL: V1 DECID SHRUB COVER 80 / 80 / ________

V2 SHRUB HTS (ft) T1 - 1m BB, >3m BB, 2m+ will ________
(nearest .1M) T2 - 2m+ (sometimes ________ ________ ________

V3 hydrophytic SHRUB COVER 80 / 80 / ________
(V4 - tall tree 0/0

DW MODEL: V1 SNAG COUNT >6", see above 0

Basal area
BW 6x5'
Hb ~~Hb~~ 18'
willow 20xff
BW 6x4
Hb 10/9
BW - 24" total
BW 24" total
willow - 45'+

V2 BASAL AREA (cruz-all or see HW, below) ________ / ________ / ________

HW MODEL: V1 SNAG COUNT >10", see above 0
V2/V3 DbH overstory 10/9 12 8 10 15" BW 30" willow
18" ________ ________ ________ ________ ________

V4 CANOPY COVER 0 / 0 / ________

DATA SHEET TS_30_L HEP P. 12

DATE 2/7/21 #202 TIME 9:13 AM #31-Send NAMES Steve Sch, Jess, Mir

PHOTO#_______ WYPT #32-Nend PLOT#/LOCATION #12, just across Rd

TRANSECT TOTAL LENGTH (FT) 100 / 100 / _______

RSG MODEL: V1 (SHRUB<3M) (FT) 45 / 40 / _______

V2 (indiv tree hts, ft) willow 33' © (14) 20' BW w 4x20' 25 BW ______ ______

V3 (TREE>3M) (FT) 30 / 30 / _______

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) 5 / 5 / _______

SNAG (indv diam, in) 28" 22" |-willow spring 4" 4 ______ ______

V5, snag count >4" 4

✓ V6 ALL WOODY 100 / 75 / _______

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 100 / 100 / _______

V3 TREE CANOPY CLOSURE 20 / 30 / _______

V4 # SPECIES (list names) BW, BB, Red Will, Valley Oaky

V5 UNDERSTORY DENSITY @2FT 95 / 80 / ___ @6FT 60 / 60 / ___

@14FT 30 / 50 / ___ AVERAGE 60 / 70 / ___

YW MODEL: V1 DECID SHRUB COVER 95 / 75 / _______

V2 SHRUB HTS (ft) T1 - predominantly 2+ m (taller BB here)

(nearest .1M) ~~T2 - BB (1.8 m) + taller 2+ BW~~

V3 hydrophytic SHRUB COVER 95 / 75 / _______

* (V4) 30 / 0

DW MODEL: V1 SNAG COUNT >6", see above 3

V2 BASAL AREA (cruz-all or see HW, below) ______ / ______ / ______

HW MODEL: V1 SNAG COUNT >10", see above 2

V2/V3 DbH overstory 14 13 32 4" 4 8

______ ______ ______ ______ ______ ______

V4 CANOPY COVER 20 / 20 / _______

Counted stems est total @ each per bush

Basal area calc est

willow (14, 13, 32, 4"

willow thicket/bush

4x20

1x20 } willow

4x15"

30" total BW

15" BW total

DATA SHEET TS_30_L HEP P. 11

DATE 12/3/21 TIME 418pm NAMES Sch, Mcl, Sav

PHOTO# 199→201 WYPT______ PLOT#/LOCATION 4/1 Past Powerline Gate

just before

TRANSECT TOTAL LENGTH (FT) 100 / 100 /______

RSG MODEL: V1 (SHRUB<3M) (FT) 40 / 100 / ______

15 ↑201 ↑60 ~~2/1~~ 199 ↑120 200

V2 (indiv tree hts, ft) 30 25 30 20 ? ______ ______

V3 (TREE>3M) (FT) 40 / 0 / ______

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) 5 / (5) / ______

all shrub 3+3-2

SNAG (indv diam, in) 10"+ 10"+ 10"+ ______ ______ ______

V5, snag count >4" ______

V6 ALL WOODY 100 / 100 / ______

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 100 / 100 / ______

V3 TREE CANOPY CLOSURE 40 / 0 / ______

V4 # SPECIES (list names) Rose, will, BB

V5 UNDERSTORY DENSITY @2FT 70 / 100 / ___ @6FT 70 / 60 / ___

@14FT 40 / 20 / ___ AVERAGE 60 / 60 / ___

YW MODEL: V1 DECID SHRUB COVER 90 / 100 / ______

V2 SHRUB HTS (ft) T1 – 1.5m+ ______ ______ ______ ______

(nearest .1M) T2 – ~~1.8~~ 1.5 – 2.5m ______ ______ ______

V3 hydrophytic SHRUB COVER 40 / 100 / ______

(V4 fall tree 20 / 0

DW MODEL: V1 SNAG COUNT >6", see above 3

* Get next time

V2 BASAL AREA (cruz-all or see HW, below) (No measure) ← green ______ / ______ / ______

HW MODEL: V1 SNAG COUNT >10", see above 3

V2/V3 DbH overstory 6 6 (4, 3, 3) eld, 8" willow ______

______ ______ ______ ______ ______ ______

V4 CANOPY COVER 30 / 0 / ______

Basal area nearest

8 wil

10 Bw

20 Bw (multiple)

6 HD

10 will

25 will Bw

30' will 13

8 elb

3-4 willows

20" total

add up

2 more willows 15" total

<40 20"

1/3 plot

DATA SHEET TS_30_L HEP

P. 10

DATE 12/3/21 TIME 329pm NAMES Steve M+Sch, Sav

PHOTO# 196 197/198 WYPT Nord#30 Sand#29 PLOT#/LOCATION #10 under powerline

TRANSECT TOTAL LENGTH (FT) 100 / 100 / ______

RSG MODEL: V1 (SHRUB<3M) (FT) 30 / 60 / ______

V2 (indiv tree hts, ft) ~15-20 ~20-25 ______ ______ ______ ______

V3 (TREE>3M) (FT) 70 / ~40 / ______

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) multiple layer tree 5 / 5 shrub / ______

SNAG (indv diam, in) 6" Broken limb ______ ______ ______ ______ ______

V5, snag count >4" 1

V6 ALL WOODY 100 / 100 / ______

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 100 / 100 / ______

V3 TREE CANOPY CLOSURE 90+ / 30% / ______

V4 # SPECIES (list names) BB, BW, UNID willow, Red tw [illegible] elderberry, UNID New top

V5 UNDERSTORY DENSITY @2FT 100 / 100 / ___ @6FT 80 / 80 / ___
@14FT 70 / 50 / ___ AVERAGE 90 / 80 / ___

YW MODEL: V1 DECID SHRUB COVER 100 / 100 / ______

V2 SHRUB HTS (ft) T1 - 2+m ______ ______ ______ ______
(nearest .1M) T2 - 20% 1.2-1.5 BB; some taller than 2m avg ~1.8

V3 hydrophytic SHRUB COVER 100 / 100 / ______
(V4 tall tree - 0/10)

DW MODEL: V1 SNAG COUNT >6", see above 1

V2 BASAL AREA (cruz-all or see HW, below) ______ / ______ / ______

HW MODEL: V1 SNAG COUNT >10", see above 0

V2/V3 DbH overstory 15" tall tree 18" willow ______ ______ ______ ______

______ ______ ______ ______ ______ ______

missing data photos 196, 197 show very dense willows,
estimate 2-3" x 50 x 300' shrub
12"/ft = 9' /yd * 30000 / 43560

V4 CANOPY COVER 15 / 25 / ______

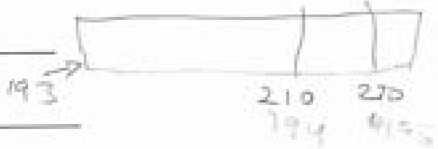
DATA SHEET TS_30_L HEP P. 9

DATE 2/3/29 TIME 2:30pm NAMES Steve Sch; Spec M, Savannah

PHOTO# 193 194, 195 WYPT wt#29 5#28 PLOT#/LOCATION #9

exclude wetland

TRANSECT TOTAL LENGTH (FT) 60 / 50' / ____



RSG MODEL: V1 (SHRUB<3M) (FT) 60 / 0' / ____

V2 (indiv tree hts, ft) 25✓ 25' ____ ____ ____ ____

V3 (TREE>3M) (FT) 0 / 40 / ____

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) (5) / ____ / ____

(Note: Not Recorded - noted obscured ground by thick blackberry)

SNAG (indv diam, in) ____ ____ ____ ____ ____ ____

V5, snag count >4" ____

V6 ALL WOODY 60 / 50 / ____

RFCT MODEL: V1(tree hts, see above) 25✓

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 60 / 50 / ____

V3 TREE CANOPY CLOSURE 0 / 25 / ____

V4 # SPECIES (list names) BW, RW, 8 spd Grinds, Red oak seedling

% V5 UNDERSTORY DENSITY @2FT 100/100/ ____ @6FT 50/80/ ____

@14FT 0 /90/ ____ AVERAGE (50)/(80)/ ____

YW MODEL: V1 DECID SHRUB COVER 60 / 50 / ____

V2 SHRUB HTS (ft) T1 mostly 1.8M BB, Nothing else ____ ____

(nearest .1M) T2 Willows 2+M ____ ____ ____

V3 hydrophytic SHRUB COVER 60 / 50 / ____

(V4 fall tree 0 / 0 /

Occasional tree

DW MODEL: V1 SNAG COUNT >6", see above ____

mostly BB mostly BB

w10x4' from (None more)

V2 BASAL AREA (cruz-all or see HW, below) thi / (1) / ____

view Not Cruz

HW MODEL: V1 SNAG COUNT >10", see above ____

V2/V3 DbH overstory ~8"(ash) (20/10/1), 8+smaller) BW ____

____ ____ ____ ____ ____ ____

V4 CANOPY COVER 0' / 25' / ____

DATA SHEET TS_30_L HEP

P. 8

DATE 2/3/21 TIME 1:20pm NAMES Steve Sch

PHOTO# #190-192 WYPT #273 #28N PLOT#/LOCATION #8 South closer to powerline

TRANSECT TOTAL LENGTH (FT) 100 / 100 / ______

RSG MODEL: V1 (SHRUB<3M) (FT) 40 / 25' / ______

V2 (indiv tree hts, ft) BW, 20 dead; BW 21; Fig 30f; will 20v; BW 25; BW 20; W 25

V3 (TREE>3M) (FT) 60 / 75 / ______

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) [✓ 5] tree shrub/s / ______ / ______

SNAG (indv diam, in) 4+ 4+ ______ ______ ______ ______

V5, snag count >4" ______

V6 ALL WOODY 85 / 100 / ______

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 85 / [Note not Recorded] — assume 100 / ______

V3 TREE CANOPY CLOSURE 50% / 30% / ______

V4 # SPECIES (list names) BW, Will Red Willow Blackberry Fig

V5 UNDERSTORY DENSITY @2FT 85 / 100 / ____ @6FT 60 / 80 / ____
@14FT 55 / 40 / ____ AVERAGE 70 / 70 / ____

YW MODEL: V1 DECID SHRUB COVER 85 / 100 / ______

V2 SHRUB HTS (ft) T1 1.1 1.3 1.2 Rest >2m ______ ______
(nearest .1M) T2 ~~1.6~~ – 1.~~8 shrub BB Rest >2m~~ ______ ______

Note: photointerpret 70% >2m

V3 hydrophytic SHRUB COVER 85 / 100' / ______
V4 tall tree 0 / 0

DW MODEL: V1 SNAG COUNT >6", see above ______

V2 BASAL AREA (cruz-all or see HW, below) Not possible ~ 1x5? ______ / ______ / ______

HW MODEL: V1 SNAG COUNT >10", see above ______
V2/V3 DbH overstory (6,6,6) BW (6,6,6) W5ly ______ ______ ______

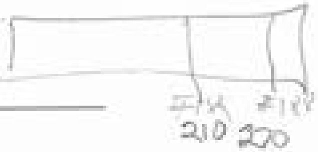
______ ______ ______ ______ ______ ______

V4 CANOPY COVER 50 / 25 / ______

DATA SHEET TS_30_L HEP P. 7

DATE 12/3/21 TIME 11:55 NAMES Steve M, Sch, Sav.

PHOTO# #187 #188-189 WYPT Next #27 Send #26 PLOT#/LOCATION #7, 187→



TRANSECT TOTAL LENGTH (FT) 100 / 100 /

RSG MODEL: V1 (SHRUB<3M) (FT) 30 / [missing datum – assume 10.] /

V2 (indiv tree hts, ft) 10' 10' 10' (15'© -BW) 40' (BB signal) 30' 18'

V3 (TREE>3M) (FT) 70 / 60 /

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) [✓ 5] snag / [✓ 5] sh. /

SNAG (indv diam, in) 10 10 10 8+ 8+ 6"

V5, snag count >4" 6+

V6 ALL WOODY 90 / 90 /

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 90 / 90 /

V3 TREE CANOPY CLOSURE 60 / [Not recorded assume (40)]

V4 # SPECIES (list names) BW, ~~WB~~ BB, Red Wil, unid w/ hanging seeds, green UNID AS?

V5 UNDERSTORY DENSITY @2FT 100 / 80 / @6FT 70 / 50 /

@14FT 60 / 40 / AVERAGE (80) / (65) ✱ → Note mis calc, 170/3=55 not 65

YW MODEL: V1 DECID SHRUB COVER 90 / 90 / 80

V2 SHRUB HTS (ft) T, 30% BB 1.2-1.4, remainder much taller 2+m

(nearest .1M)

V3 hydrophytic SHRUB COVER 90 / 90 /

(V4 tall tree Ø / 20%)

DW MODEL: V1 SNAG COUNT >6", see above 6+

V2 BASAL AREA (cruz-all or see HW, below) No Stick / est ~~10~~ + cruz (25) /

4-6"/10 sq m for 1/2 site stem count 1"/100 sq m

HW MODEL: V1 SNAG COUNT >10", see above 3

V2/V3 DbH overstory 10" 15"

V4 CANOPY COVER 60 / 30 /

DATA SHEET TS_30_L HEP P. 6

DATE 12/3/21 TIME 1102 am NAMES Steve M, Steve Eh, Savannah

PHOTO# 184-186 WYPT N end #26 S end #25 PLOT#/LOCATION Plot 6 (~1/4 mi before power lines.)

TRANSECT TOTAL LENGTH (FT) 100 / 100 / ______

RSG MODEL: V1 (SHRUB<3M) (FT) 40 / 45 / ______

V2 (indiv tree hts, ft) 53' (willow @ dist est) ~5 or 6 willow ~25-30' tall closest by channel

V3 (TREE>3M) (FT) 50 / 55 / ______

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) (5) tall/short shrubs / (5) tree shrubs / ______

SNAG (indv diam, in) ~6-8" (marginal but ~8' above ground) fallen tree at angle

V5, snag count >4" 1

V6 ALL WOODY 70 / 90 / ______

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 85 / 90 / ______

V3 TREE CANOPY CLOSURE 5% / 50% / ______

V4 # SPECIES (list names) Willow, BB, eld, silv will

V5 UNDERSTORY DENSITY @2FT 100 / 100 / ______ @6FT 60 / 75 / ______

@14FT 20 / 55 / ______ AVERAGE (60) / (75) / ______

YW MODEL: V1 DECID SHRUB COVER 70 / 90 / ______

V2 SHRUB HTS (ft) T1-1.1, 1.8, (50% BB) 50% - 2m+ will

(nearest .1M) T2 1.5 (40-50%); 50% 2+ tall willow

V3 hydrophytic SHRUB COVER 70 / 90 / ______

(V4 tall tree - 30% - T2 only)

DW MODEL: V1 SNAG COUNT >6", see above 1

~15 willows stems 6+" = 90 sq in tree stems + willows

V2 BASAL AREA (cruz-all or see HW, below) ______ / ______ / ______

HW MODEL: V1 SNAG COUNT >10", see above 0

V2/V3 DbH overstory willow 20"; dense willows 1/2 site 6"/sq m (T1)

willow rd tree ~6-8 stems (6") (T2)

V4 CANOPY COVER 0 / 30' / ______

6m+

DATA SHEET TS_30_L HEP P. 5

DATE 12/3 TIME 9:30 Am NAMES Steven M, Steve S, Savannah

PHOTO# 181 182 183 WYPT N end 925 S end 924 PLOT#/LOCATION #5

TRANSECT TOTAL LENGTH (FT) 700 / 100 / ____

RSG MODEL: V1 (SHRUB<3M) (FT) 10 / 20 / ____

V2 (indiv tree hts, ft) Bottomwillow @ est 26-32'
Bottomwillow @ 15% × 100 + 5 + 10 drop = 30'
Bw - 15% × 60 = 15 + 5 + 5 = 25'

V3 (TREE>3M) (FT) 8 0 / 80 / ____

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) [illegible] ~~3~~ ⑤ / ~~3~~ ⑤ / ____

later SNAG (indv diam, in) (impenetrable - can't see any)
V5, snag count >4" —

V6 ALL WOODY 90 / 100 / ____

RFCT MODEL: V1(tree hts, see above) ~ 30-35'

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 90 / 100 / ____

Sm V3 TREE CANOPY CLOSURE 80 / 80 / ____

V4 # SPECIES (list names) bttw, Red wil, Sand wil, PB

V5 UNDERSTORY DENSITY @2FT 90 / 100 / ____ @6FT 90 / 80 / ____
@14FT 85 / 90 / ____ AVERAGE 90 / 90 / ____

YW MODEL: V1 DECID SHRUB COVER 90 / 100 / ____

V2 SHRUB HTS (ft) T1 - 20% 1.4, 80% 2+ m
(nearest .1M) T2 20% 1.6 80% 2+ m

V3 hydrophytic SHRUB COVER 90 / 100 / ____
V4 (Note - forgot to record, est ~30% based on measured hts and photos 181 and 182)

later DW MODEL: V1 SNAG COUNT >6", see above ____ est thick willow stems 6+"/sm + trees likely high.

later) V2 BASAL AREA (cruz-all or see HW, below) — / — / ____

HW MODEL: V1 SNAG COUNT >10", see above —
V2/V3 DbH overstory Bttwill (4, 4, 6) est
some with larger - look in Corps Notes

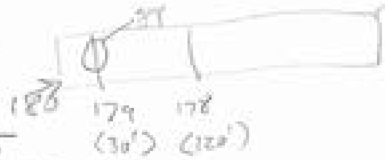
V4 CANOPY COVER 60 est / 70 est / ____

DATA SHEET TS_30_L HEP P. 4

DATE 12/2 TIME 3:30 NAMES Steve, Jess/Sam

PHOTO# 178-180 WYPT 24-N 23-S PLOT#/LOCATION #4

TRANSECT TOTAL LENGTH (FT) 100 / 100 / ____



RSG MODEL: V1 (SHRUB<3M) (FT) 50 / 90 / ____

V2 (indiv tree hts, ft) 55' ⓔ 35'(c) roughly 50% of 60' hts ____ ____ ____ ____

V3 (TREE>3M) (FT) 20 / 70 / ____

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) 5 tree/lowshrub / 5 tall/short shrubs/trees. / ____

SNAG (indv diam, in) 5" 6" 6" 5+" ____ ____
V5, snag count >4" ④

V6 ALL WOODY 70 / 90 / ____

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 100 / 90 / ____

V3 TREE CANOPY CLOSURE 20 / 70 / ____

V4 # SPECIES (list names) BB, Red willow, B.Hw, walnut, Silver

V5 UNDERSTORY DENSITY @2FT 70/ 90/ ____ @6FT 30/ 80/ ____
@14FT 20/ 60/ ____ AVERAGE (40)/ (75)/ ____

YW MODEL: V1 DECID SHRUB COVER 50 / 90' / ____

V2 SHRUB HTS (ft) T1 - predom BB 1.6M ____ ____
(nearest .1M) T2 predom willow 2+M ____

V3 hydrophytic SHRUB COVER 50, 90 / ____

DW MODEL: V1 SNAG COUNT >6", see above ②

V2 BASAL AREA (cruz-all or see HW, below) (No measure made) likely high 6"/m² / ____ / ____

HW MODEL: V1 SNAG COUNT >10", see above ⓪
V2/V3 DbH overstory 30" 7" 4" 4" 6" 6"

8" 7" 6" 10" ____ ____

V4 CANOPY COVER 20 / 50 / ____ [illegible]

non-native dominance? adjustment (NO)

DATA SHEET TS_30_L HEP P. 3

DATE 12/2/21 TIME 1:10 pm NAMES Jessica/Samantha/Steve

PHOTO# 175-177 WYPT 21-Send 22-New PLOT#/LOCATION #3

TRANSECT TOTAL LENGTH (FT) 120 / 100 / ______

RSG MODEL: V1 (SHRUB<3M) (FT) (none shrubs below) / (100% understory) / ______

ⓒ = cottonwood walnut

V2 (indiv tree hts, ft) 30' ⓒ 47' ⓒ 25' ⓒ 41' ⓒ ______ ______

V3 (TREE>3M) (FT) 80' / 80' / ______

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) (5) / (5) / ______ trees/shrubs tall/short shrubs

SNAG (indv diam, in) 6" (1 just under 4") ______ ______ ______

V5, snag count >4" 1

V6 ALL WOODY 120' / 90' / ______

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 120' / [I note not recorded; assume 100 from photo 177] / ______

V3 TREE CANOPY CLOSURE 80' / 50' / ______

V4 # SPECIES (list names) willow, BB, bath, walnut

V5 UNDERSTORY DENSITY @2FT 50/ 100/ ______ 85 @6FT 60/100/ ______
@14FT 40 80 ______ AVERAGE 50 / 90 / ______

YW MODEL: V1 DECID SHRUB COVER 60' / 100' / ______

V2 SHRUB HTS (ft) T1- all 2+ M ______ ______ ______
(nearest .1M) T2- all 2+ M ______ ______ ______

V3 hydrophytic SHRUB COVER 70' / 100' / walnut

(V4 taller than 30') 60% / 0 ← But nearby walnut 10%

DW MODEL: V1 SNAG COUNT >6", see above 1 (or very dense willow for ½ of transect)

V2 BASAL AREA (cruz-all or see HW, below) 2×10 / very difficult est., 2×20 felt/10th cam / ______

HW MODEL: V1 SNAG COUNT >10", see above 0

V2/V3 DbH overstory ~~24~~ 26 16 16 16 14 4

4 4 15 16 ______ ______

V4 CANOPY COVER 80', 20' / ______

↖ not much tree this transect

nonnative dominance - alot but not >50%

DATA SHEET TS_30_L HEP P. 2

DATE 12/2/21 TIME 11:52pm NAMES Steve, Jessica

PHOTO# 172-174 WYPT #5 #20 PLOT#/LOCATION #2 goes out towards big nonnative clump.

TRANSECT TOTAL LENGTH (FT) 100 / 100 / ______ ← estimated 100' from map

Cassurves understory

RSG MODEL: V1 (SHRUB<3M) (FT) 77 / 82 / ______ 174 →

V~~2~~3 (indiv tree hts, ft) T1 - many willows 16-20' tall ; 55'

V~~3~~2 (TREE>3M) (FT) 77 / 82 / ______

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) 5 / 5 / ______

SNAG (indv diam, in) 6" 10" 10"
V5, snag count >4" 3

includes None note

V6 ALL WOODY 77 / 82 / ______

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 77' / 82 / ______

V3 TREE CANOPY CLOSURE 20 / (Not tree) / ______

V4 # SPECIES (list names) BB, willow, buttonwillow

V5 UNDERSTORY DENSITY @2FT 77 / 82 / ______ @6FT 77 / 82 / ______ (includes herb area)
@14FT 30 / 60 / ______ AVERAGE 60% / 70% / ______

YW MODEL: V1 DECID SHRUB COVER 77 / 82 / ______

V2 SHRUB HTS (ft) numerous 2+ will ;
(nearest .1M)

V3 hydrophytic SHRUB COVER 77 / 82 / ______
(V4 - tall tree) - 0

DW MODEL: V1 SNAG COUNT >6", see above 3

V2 BASAL AREA (cruz-all or see HW, below) (Not measurable) / ______ / ______ - guess 3-4'/sq m

HW MODEL: V1 SNAG COUNT >10", see above 2
V2/V3 DbH overstory T1-4 ______ 6 end H 2 50 - 18, 16

V4 CANOPY COVER 20% (>6m) / (Cannot ~~see~~ heterogeneous) / ______
20% if include m grass

nonnative dominant? (NO) overall plot.

DATA SHEET TS_30_L HEP P. 1

DATE 12/2/21 TIME 9-30am NAMES Schoenberg, Jessica, Savannah

PHOTO# 108-0170 100- WYPT #3 - N end #4 - S end PLOT#/LOCATION 1st plot [illegible]

TRANSECT TOTAL LENGTH (FT) 65 / 100 / ______

RSG MODEL: V1 (SHRUB<3M) (FT) 18 / 79 / ______
240+75+155 140 75 15+5+30+5

V~~2~~3 (indiv tree hts, ft) 14' 50' 20' 22' willow other willows 20+

V~~3~~2 (TREE>3M) (FT) 12' / 70 / ______

V4 LAYER CATEGORY (SELECT 1,2,3,4,5) 5 / ______ / ______

SNAG (indv diam, in) 10" ← est visual multi branched ______ ______ ______ ______ ______
V5, snag count >4" 1

V6 ALL WOODY 18 / 79' / ______

RFCT MODEL: V1(tree hts, see above)

V2 RIPARIAN STAND WIDTH (all woody + small gaps) 20 / [photo interpreted est. 20 ft photo 171 / ______

V3 TREE CANOPY CLOSURE 0 / 20 (tall willows) / ______

V4 # SPECIES (list names) BB, ash, / Will, unk 4th WBB (4)

V5 UNDERSTORY DENSITY @2FT 30 / 80 / ___ @6FT 15 / 60 / ___
@14FT 0 / 20 / ___ AVERAGE 15 / 55 / ___

YW MODEL: V1 DECID SHRUB COVER 18 / 79 / ______

V2 SHRUB HTS (ft) 2+ 0.9 1.2 (numerous willows 2+ m)
(nearest .1M) average 2+

V3 hydrophytic SHRUB COVER 18 / 79 / ______
(V4 tall tree - photo interpret [NOT recorded on site] = ∅ thick willow est 8"/10' sp est

DW MODEL: V1 SNAG COUNT >6", see above 1

V2 BASAL AREA (~~cruz~~-all or see HW, below) see [illegible] calc / ______ / ______

HW MODEL: V1 SNAG COUNT >10", see above 1
V2/V3 DbH overstory (9 10 10 6) - 1 willow ______ ______ ______

______ ______ ______ ______ ______ ______

V4 CANOPY COVER 10? / 25 / ______
tall shrub ft? Tallest willows est 22' tall

APPENDIX D. Plates

Plate 1: TS_30_L impact area; 3-41 are plot boundary waypoints (see Appendix C, datasheets).

Plate 2. Adjacent Corridor mitigation option for TS_30_L (Elmwood parcel in figure above).

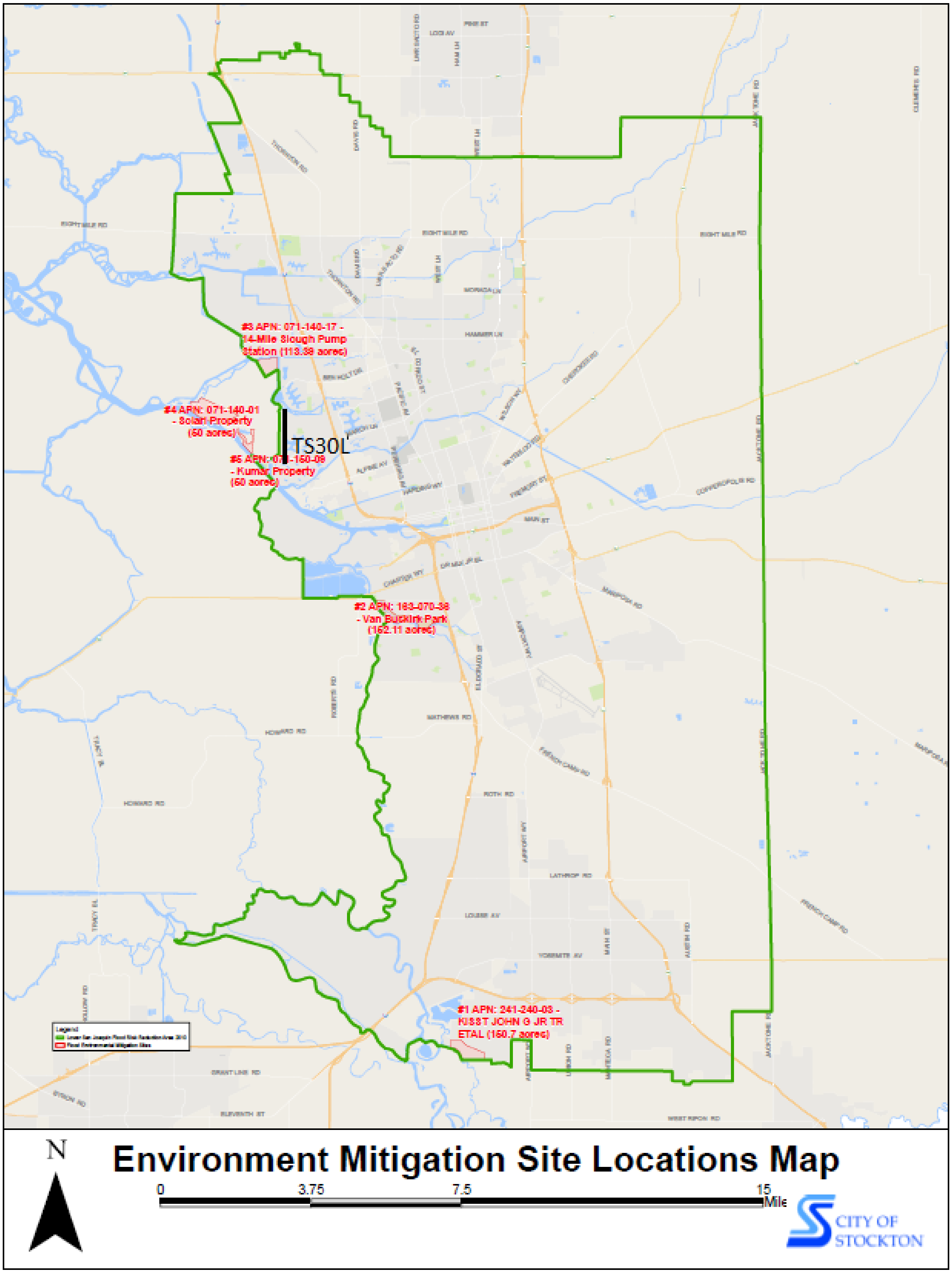


Plate 3: Location of non-adjacent mitigation options for TS_30_L.