Appendix C. Habitat capability index for Warbling Vireo (*Vireo gilvus*)

Developer: Brenda C. McComb

Reviewers: Joan Hagar, Robert Altman, Josh Lawler

Background

The warbling vireo occurs throughout the Oregon Coast Range physiographic province (Gardali and Ballard 2000). In the Oregon Coast Range, warbling vireos nest in mature hardwood stands from 1-37 m above ground (Gardali and Ballard 2000). Structural characteristics of the stand, with the exception of having tall hardwoods, are quite variable among nest sites (Gardali and Ballard 2000). Although most common and abundant in mature hardwood stands, they may also be found in young deciduous stands that develop following a clearcut (Ward and Smith 2000). There does not appear to be a strong effect of landscape pattern on abundance or productivity of this species (McGarigal and McComb 1995, Tewksbury et al. 1998, Gardali and Ballard 2000). However, this species does experience high levels of nest parasitism by brown-headed cowbirds, especially near agricultural areas (Ward and Smith 2000).

Warbling vireos forage on insects from just above the surface of the ground to the top of the canopy (Gardali and Ballard 2000). Caterpillars, bugs (Hemiptera) and beetles (Coleoptera) tend to dominate their diet (Gardali and Ballard 2000). Abundance of the species is positively correlated with the amount of hardwood forest in a landscape and the more mature the hardwood stand, the more detections that are noted (Stiles 1980).

Habitat capability index model

The habitat capability model developed for the Coast Range is based primarily on nesting habitat requirements and secondarily on foraging requirements. A Habitat suitability index (HSI) model was developed by Banks et al. (1999) for use in Alberta, Canada. The Banks et al. (1999) model was informative and helped us structure the Coast Range model, but their model was not directly applicable to the Oregon Coast Range environment.

We assumed that minimum patch sizes must be greater than the territory size, which is 1-2 ha (Gardali and Ballard 2000). We included two sub-indices, one for nesting and another for foraging habitats. The nesting habitat capability score assigned to the focal pixel is dependent on hardwood canopy cover and density. The foraging habitat score is dependent on the dominance by hardwoods in a 2-ha window surrounding the focal pixel. The final capability score is the minimum of the two sub-index scores. That is, we hypothesize that overall habitat suitability can be no greater than the most limiting habitat component.

We assume that nesting habitat capability for warbling vireos improves with increasing canopy cover of hardwoods > 25 cm dbh per ha (Figure C1). These relationships are based on the findings of research on the species in Washington red alder (*Alnus rubra*) stands (Stiles 1980) and summary information provided by Gardali and Ballard (2000). Since the species is

occasionally detected in mixed conifer-hardwood stands, we scaled this relationship to peak at 70% hardwood cover in stands with trees > 25 cm dbh.

We assume that optimum foraging areas occur in mature hardwood patches of a size sufficient to support a territorial nesting pair. The foraging capability sub-index in the HCI model is based upon the proportion of a 1-ha patch around the focal pixel that is dominated by hardwoods.

Habitat capability index

$$\textit{Warbling vireo } HCI_f = \textit{minimum}(NCI_f, LCI_f) \quad \text{(C.1)}$$

Where

HCI = Habitat capability index
NCI = Nesting capability index
LCI = Landscape capability index
f = focal patch

Nesting capability index

All metrics for this index are calculated for each pixel.

$$NCI_f = \frac{(HWCC_f * 2) + (DEN25_f * TreeSp_f)}{3} \quad \text{(C.2)}$$

Where

NCI = Nesting capability index
f = focal pixel
HWCC = hardwood canopy closure index
DEN25 = Density of trees >25 cm index
TreeSp = Tree species subindex

The HWCC index is based on predicted canopy closure in a pixel. The index is 0 from 0-40% canopy closure by hardwoods (Figure C1). The index increases linearly from 0 to 1 as hardwood canopy closure increases from 40-70%, then stays at 1 from 70-100%. This index is weighted twice as much as tree dbh since composition seems to be more important than structure for this species (Gardali and Ballard 2000).

$HWCC_f$ = If *HWCanopyClosure* < 40%, then $HWCC_f = 0$ (C.3)
Else if *HWCanopyClosure* ≥ 40% and < 70%,
Then $HWCC_f$ = (*HWCanopyClosure* * 0.0333) – 1.3333
Else $HWCC_f = 1$

Where
HWCanopyClosure = Percent canopy closure * $TreeSp_f$ (tree species subindex).
f = focal pixel

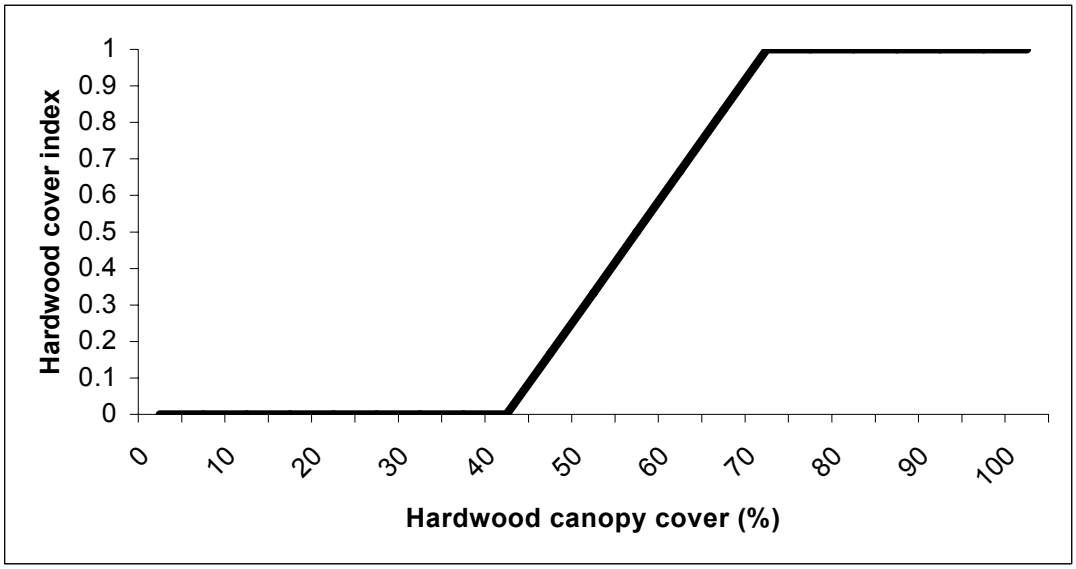

FIG C1. Relationship between hardwood canopy cover index and hardwood canopy cover.

Hardwood canopy closure is estimated based on the canopy closure of all trees is multiplied by the following tree species subindex. Breaks between species were designed by Dr. Janet Ohmann, PNW Research Lab, US Forest Service, based on examination of ground plot data. The 0.20 and 0.65 thresholds were chosen to approximate 30% and 70% thresholds based on canopy cover (Figure C2).

This tree species subindex is multiplied by total canopy cover to create hardwood canopy cover used in the previous index.

$TreeSp_f$ = If $BahProp_f < 0.2$, then $TreeSp_f = 0$ (C.4)
Else if $BahProp_f \geq 0.2$ and < 0.65,
Then $TreeSp_f = (BahProp_f * 2.2222) - 0.4444$
Else $TreeSp_f = 1$

Where

$BahProp_f$ = The proportion of hardwood basal area to total basal area

f = focal pixel

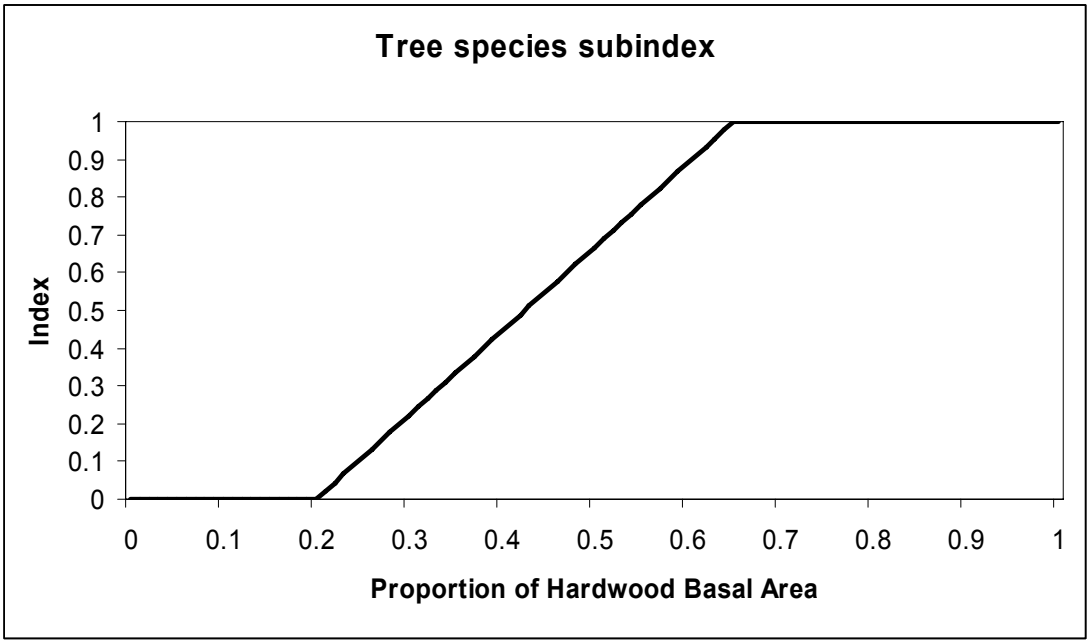

FIG C2. Relationship between tree species subindex and the proportion of hardwood basal area to total basal area.

$DEN25_f$: = If $Trees25_f < 25$ per ha Then $DEN25_f = 0$ (C.5)
If $Trees25_f \geq 25$ per ha and $Trees25_f < 123.55$ per ha
Then $DEN25_f = (0.01015 * Trees25_f) - 0.25368$
Else $DEN25_f = 1$

Where

Trees25 = Density of all trees >25 cm dbh per hectare

f = focal pixel

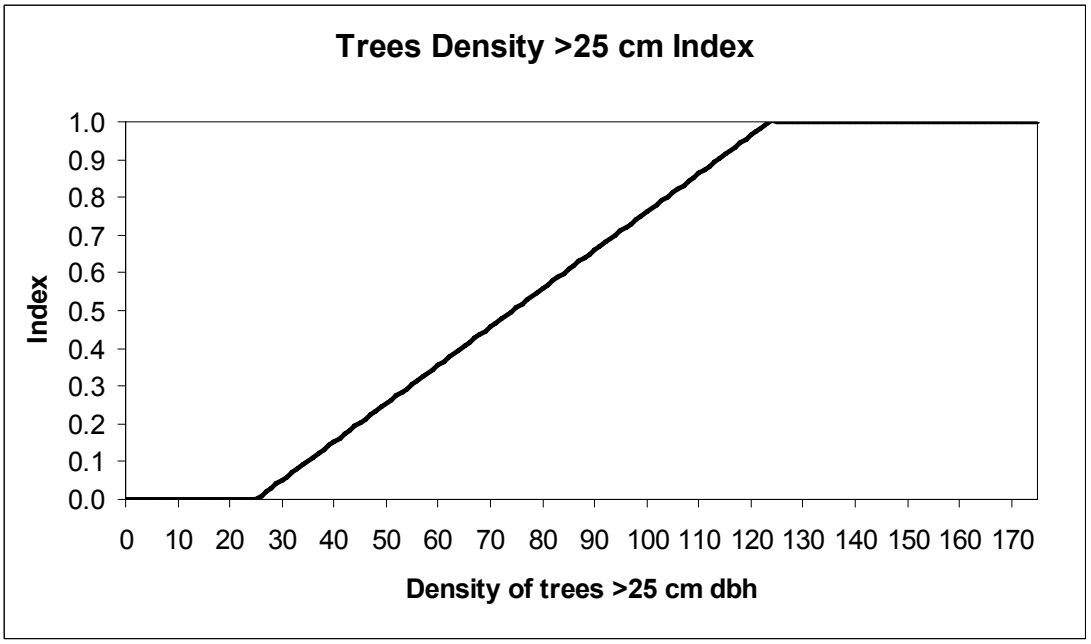

FIG C3. Relationship between Density of Trees >25 cm Index and the density of trees >25 cm dbh.

Landscape capability index

All metrics for this index are calculated within a 56-meter radius window and assigned to the focal pixel.

$$LCI_f = Average(HWCCw) \quad \text{(C.6)}$$

Where

LCI = Landscape capability index.
f = focal pixel
HWCCw = Hardwood canopy cover index averaged over the 56-m radius window

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