Integrating Wildlife Habitat Into a Constrained Optimization Strategy on State-Owned Timberlands in North Carolina

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Overview:

- Prioritizing wildlife habitat objectives in forest management planning requires quantifying the relationship between the structure and composition of a forest stand and the potential habitat it can offer target wildlife species.
- The Forest Vegetation Simulator (FVS) was used to model habitat indicator metrics in addition to standing and removed timber volumes to evaluate tradeoffs in wildlife habitat and timber production objectives on the timberlands owned and managed by the North Carolina Wildlife Resources Commission.
- Habitat was evaluated for 16 wildlife species, which were identified by agency staff and grouped into four focal guilds (i.e., Open Forest Associates, Longleaf Pine Associates, Shrubland Associates, and Ruffed Grouse), based on commonalities in habitat preference and subsequent targets for forest structure and composition through silvicultural treatments.
- Woodstock models formulated to maximize wildlife objectives tended to thin stands multiple times before scheduling final harvests and production possibilities analyses indicated that worthwhile gains could be achieved in revenue objectives with minimal impacts to wildlife habitat objectives.

Summary:

Integrating wildlife management goals into forest planning presents multiple complex challenges. Forest growth and yield models that use different metrics than the habitat suitability models wildlife managers use to estimate habitat quality for wildlife species. Moreover, integrating wildlife habitat requirements into forest management planning requires future forest conditions to be linked quantitatively to the habitat requirements of specific wildlife species. Further, for a methodology to gain widespread acceptance, the analytical platform it is constructed on must be readily available to forest planning practitioners. We used a modified Delphi method to qualitatively relate measured or predicted values within parameterized ranges of 11 vegetation structure and composition metrics (table 1) to the potential of a forest stand to provide habitat for 16 focal wildlife species (table 2). We chose predictive metrics from traditional timber inventory data (e.g., stand and stock data) and simulated outcomes across a 50-year horizon using the Forest Vegetation Simulator. We quantitatively related predicted conditions in a given forest stand to its potential to provide habitat for a combination of the selected focal species using an index

derived from the metrics relevant to the focal wildlife species (tables 3, 4, 5, 6). We integrated the index values as accounting variables in a linear programming framework using the Woodstock Optimization Studio (the standard platform for planning analysis in the forest industry worldwide), which allows them to be tracked over the 50-year model horizon, constrained, or optimized directly as part of the model's objective function. We applied the model to study area of 49,453 hectare across 2,836 timber stands on public lands managed by the North Carolina Wildlife Resource Commission and evaluated the trends in the harvest scheduling, habitat index values, and revenue under 13 formulations of the objective function maximizing habitat (MAX HABITAT) and revenue objectives (MAX CASHFLOW). By scheduling more thinning treatments, index values under the habitat formulation increased faster and higher than those realized under the maximized revenue formulation, which scheduled more final harvest treatments to maximize undiscounted cashflows across the modelled horizon. In the case study, production possibilities analysis indicated worthwhile gains could be achieved for revenue objectives with minimal impacts to wildlife habitat objectives (fig. 1).

Key Concepts for FVS Users:

- Prioritizing wildlife habitat objectives in forest management planning requires quantifying the relationship between the structure and composition of a forest stand and the potential habitat it can offer target wildlife species.
- The Forest Vegetation Simulator (FVS) was used to model habitat indicator metrics in addition to standing and removed timber volumes to evaluate tradeoffs in wildlife habitat and timber production objectives on the timberlands owned and managed by the North Carolina Wildlife Resources Commission.
- Habitat was evaluated for 16 wildlife species, which were identified by agency staff and grouped into four focal guilds (i.e., Open Forest Associates, Longleaf Pine Associates, Shrubland Associates, and Ruffed Grouse), based on commonalities habitat preference and subsequent targets for forest structure and composition through silvicultural treatments.

Management Applications/Future Directions:

- By including wildlife habitat indices in the harvest scheduling model, thinning final harvest treatments are scheduled at the most appropriate timings and intensities to meet wildlife habitat management objectives.
- Thinning treatments followed by prescribed burning will increase the potential for most forest types in the southeastern U.S. to offer habitat to the focal species described in this study.
- More knowledge is needed to link habitat preferences of potential focal species to the structural and compositional characteristics of forest stands, so habitat objectives could be evaluated for a wider range of wildlife species using FVS.

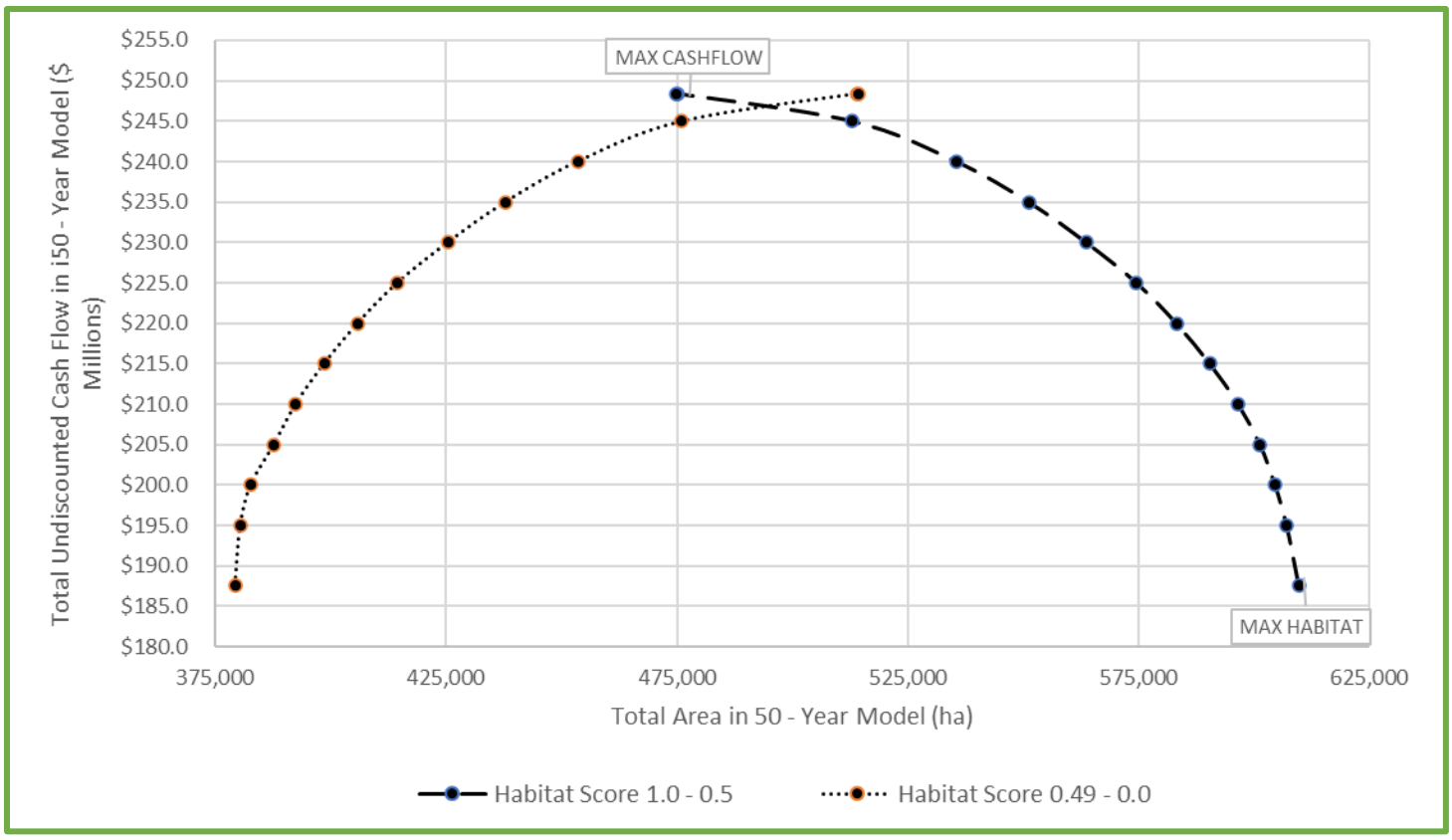

Figure 1—Production possibilities frontier comparing the tradeoffs in total revenue and the number of hectares in the top and bottom halves of potential habitat index scores (Q 0.0–2.0) across all 50 years in MAX HABITAT, MAX CASHFLOW, and MAX HABITAT + CASHFLOW constrained by a set cashflow maximums (CFM) in $5 million increments.

Table 1—Forest condition metrics used to assess quality of habitat for focal wildlife species on game lands in North Carolina.

Forest condition metric	Unit	Definition
Stand age	Years	Number of years since a regeneration harvest occurred, or a stand was planted, whichever is shorter.
Timber regime	Description	Selected timber regime applied to a given stand, which is indicative of the dominant tree species.
Aspect	Direction	Degree from which a stand is exposed to environmental factors, as calculated from a digital elevation model.
Total basal area	M^2/ha	Cross sectional area of stems ≥ 2.54 cm DBH.
Pine BA >35.56 cm	M^2/ha	Cross sectional area of pine stems >35.56 cm DBH
Oak BA >25.4 cm	M^2/ha	Cross sectional area of Oak stems >25.4 cm DBH
Canopy cover	Percent	Percent of the ground area directly covered by overstory tree crowns
BA oak >25.4 cm	Percent	Percent of total BA made up of oak stems >25.4 cm DBH.
BA midstory	Percent	Percent of total BA consisting of stems > 2.54 cm and < 12.7 cm DBH.
Fire return interval	Years	Number of years between planned applications of prescribed fire.

Table 2—Focal species promoted through current forest management practices on NCWRC Game Lands, as determined by agency management staff.

Focal Species	Associated guild
Bachman's sparrow (*Peucaea aestivalis*)	Longleaf pine associates
Carolina gopher frog (*Rana capito capito*)	Longleaf pine associates
Northern pine snake (*Pituophis melanoleucus*)	Longleaf pine associates
Red-cockaded woodpecker (*Leuconotopicus borealis*)	Longleaf pine associates
Fox squirrel (*Sciurus niger*)	Longleaf pine associates
Northern bobwhite (*Colinus virginianus*)	Shrubland associates
E. cottontail rabbit (*Sylvilagus floridanus*)	Shrubland associates
Indigo bunting (*Passerina cyanea*)	Shrubland associates
Prairie warbler (*Dendroica discolor*)	Shrubland associates
American woodcock (*Scolopax minor*)	Shrubland associates
Red-headed woodpecker (*Melanerpes erythrocephalus*)	Open forest associates
Eastern wild turkey (*Meleagris gallopavo silvestris*)	Open forest associates
Timber rattlesnake (*Crotalus horridus*)	Open forest associates
White-tailed deer (*Odocoileus virginianus*)	Open forest associates
Black bear (*Ursus americanus*)	Open forest associates
Ruffed grouse (*Bonasa umbellus*)	Individual evaluation

Table 3—Reported forest structural characteristics important to species in the longleaf pine associate guild and a qualification matrix with ranges for the entire guild across all applicable game lands and timber regimes in North Carolina.

Characteristic	Best	Good	Poor
Basal area (m^2/ha)	9–13	14–18	< 9 or > 18
Pine BA DBH >35.5 cm (m^2/ha)	> 4.5	1 – 4.4	< 4.5
Percent canopy cover	40–60%	20–40 %	< 20 or > 60%
Percent BA hardwoods	5–9%	10–15 %	< 5 or > 15%
Oak BA DBH >25.4 cm (m^2/ha)	1–2	2.1 -3.5	> 3.5 or < 1
Percent BA midstory	< 20%	20–40 %	> 40%
Fire return interval (years)	≤ 3	4	> 4

Table 4—Reported forest structural characteristics related to evaluation metrics for species in the shrubland associate's guild and a qualification matrix with ranges for the entire guild across all applicable game lands and timber regimes in North Carolina.

Structural Characteristic	Best	Good	Poor
Stand age (years)	2–4	5–6	1 and > 6
Basal area (m^2/ha)	< 9	< 13	≥ 13
Percent canopy cover	< 30%	31%–50%	> 50%
Fire return interval (years)	3–4	2 or 5	< 2 or > 5

Table 5—Reported forest structural characteristics related to evaluation metrics for species in the open forest associate's guild and a qualification matrix with ranges for the entire guild across all applicable game lands and timber regimes in North Carolina.

Structural Characteristic	Best	Good	Poor
Basal area (m2/ha)	9–13	7–9 OR 13 – 18	< 7 or > 18
Percent canopy cover	2550	50–60	< 25 or > 60
Percent of total BA oak >10"	> 20	5–20	< 5
Percent midstory	< 20	20–40	> 40
Fire return interval (years)	3	2 OR 4–5	< 2 or > 5

Table 6—Reported forest structural characteristics related to evaluation metrics for ruffed grouse and a qualification matrix with ranges across all applicable game lands and timber regimes in North Carolina.

Structural Characteristic	Best	Good	Poor
Stand age (years)	10–15	5–10 or 15–20	< 5 or > 20
Timber regime	Cove Hardwood / Northern Hardwood	Oak Hickory	Pine Regimes / Spruce Fir
Oak BA >25.4 cm (m^2/a)	2.25–6	1–2.25	> 6 or < 1
Aspect	North	East or West	South