CHAPTER 11.

Assessing Wildlife Habitat from a Large-Scale Forest Inventory

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INTRODUCTION

Large-scale forest inventory data sets are widely available today and include the USDA Forest Service programs Forest Inventory and Analysis (FIA, Phase 2, or P2) and Forest Health Monitoring (FHM, Phase 3, or P3) (Woodall and others 2011). Such data sets can be used to evaluate other aspects besides forest management, including wildlife management (Rudis 1991, Trani and others 2001) and tree and shrub diversity (Torras and others 2012). FIA data are the basis of State-level (Maine Forest Service 2010) and national-level strategic forest assessments. Allen and Plantinga (1999) explored biodiversity and wildlife habitat using FIA data, identifying tree diameter distribution, snags, downed woody debris, stand age, and shrub and herb cover as useful indicators.

Our principal objective was to use existing large-scale forest inventory data to describe the quality of wildlife habitat in Maine's forests particular to several wildlife species. Trani and others (2001) suggested that we might find important trends based on stand successional stages of plots in the current database. Three aspects were involved: (1) categorization of forest stands (subplots) into five successional categories, (2) application of inventory data variables into existing species specific habitat suitability index models, and (3) relation of successional categories in an ordination that emphasizes percent cover of tree species and select understory plants important to wildlife.

METHODS

Data

FIA phase 2 (P2) and phase 3 (P3) data from 2007 were used, representing 46 plots, 48 unique conditions, and 161 subplots. The subplot level, rather than plot or condition, was selected to maximize sample size. Bechtold and Patterson (2005), Schulz and others (2009), and Woodall and others (2011) provide details of FIA sampling design, measurement procedures, and variables. Two of the P3 sampling protocols used in our analysis are the Down Woody Material indicator (DWM) and the Vegetation Structure and Diversity indicator (VEG).

To contrast habitat stages, we used the term "successional category" and assigned FIA conditions according to criteria related to stand age, stand size class, and all live-tree stocking (table 11.1). The number of subplots per successional category is more or less evenly distributed. From an initial dataset that included 23 environmental variables, we used a Discriminant Functions Analysis (DFA) in SYSTAT to determine a subset of variables that had potential to distinguish successional categories.

P2 Variables

P2 variables included tree diameter at breast height (d.b.h.), species, tree history (live/dead/cut), tree class, forest type, elevation, site index, stand size class, stand age, physiographic class, stocking class, stand origin, and land use.

Table 11.1—Successional category definitions, criteria, and number of subplots

Definition	Number of subplots (n=161)
1 – Early succession (ES)—Stand age ≤30 years, stand size class is small diameter (saplings), and all live-stocking class is either well-stocked or overstocked; representing young trees or saplings, with a canopy closure at 4.9 m.	31
2 – Tending toward early succession (TES)	35
3 – Intermediate (INT), broadly defined with a possibly unrelated grab bag of forest types and stocking conditions	34
4 – Tending toward late succession (TLS)	38
5 – Late succession (LS)—Stand age is >60 years, stand size class is large diameter (sawtimber), and all live-stocking class is either moderately stocked, well-stocked, or overstocked	23

P3 Indicators

For DWM we linked decay class for dead wood, duff depth, and features of understory vegetation from both transect and microplot data to habitat requirements of animals that are known to require some specified volume or average piece size. Ground variables from the P3 VEG data and percent cover for vascular plants on the subplot were used by species and by species group (e.g., shrubs, trees, graminoids, etc.).

Habitat Suitability Index Models

To test applicability of the FIA data in assessing wildlife habitat quality, we sought Habitat Suitability Index models (HSI) developed for animals, with habitat preferences that represented a range of successional categories. Three species (ruffed grouse, American woodcock, and snowshoe hare) typically associated with early-succession habitats, one species (red spotted newt) linked to an intermediate successional stage, and four species (barred owl, pine marten, fisher, and pileated woodpecker) associated with later successional habitats were selected (Allen 1982, Allen 1983, Allen 1987, Schroeder 1982). In an effort to use the P3 VEG data, the eastern wild turkey was included and can be associated with either early or later successional categories. The pine marten HSI required percent cover estimates of coarse woody debris (CWD) (≥7.62-cm diameter at the line intersect). We visualized each CWD piece as a shadow on the ground at noon and calculated the area of each piece using the formula for a trapezoid: A = a*(b1+b2)/2, in which a = length, b1 = small diameter, and b2 = large diameter; totaling piece area by subplot, and then calculated its percent of the 168.1-m^2 subplot area.

Analytical software included SAS® 9.1 and SYSTAT® 12.0, and for data summaries the Microsoft® Excel pivot table function was useful.

The ordination analysis of successional category and important soft mast plants for migratory birds was inspired by a review of HSIs, current literature, and Martin and others (1951) regarding frugivores of Maine. Percent cover of live foliage was used as a rough proxy for soft mast resources, making a link for the supposed availability of fleshy fruits of understory plants such as *Rubus* spp., Northern fly honeysuckle, low sweet blueberry, viburnum, etc. We also included some P2 variables (e.g., stocking for all live trees, stand age). Three subplots lacked required data and were dropped, and to reduce noise in the 425 species x 158 subplot matrix, we excluded plant species present in <10 of 158 subplots, and all ferns and their allies, grasses, sedges, rushes, and a few herbs. The revised matrix included 57 seed-producing plants, including 14 fleshy-fruited plants. Ordination was conducted using PC-ORD™ 5.0 (MJM Software™, Gleneden Beach, OR) and Nonmetric Multidimensional Scaling (NMS). This technique has been well established as a robust approach toward identification of structure in community data and does not require assumption of normally distributed data. Quantitative variables were log-transformed to relativize data. A joint biplot was used to visualize relationships because some of the environmental variables, shown as vectors, better explain the relationship of species and successional category.

RESULTS

Discriminant functions analysis on the reliability of assigning the succession categories suggests imperfect classifications across all categories, with lowest confidence for the late successional category, with percent correct classification based on 8 variables varying from 18 percent to 100 percent (table 11.2).

Table 11.2—Results of discriminant functions analysis to classify subplots into successional categories

Succession category	1	2	3	4	5	Row total	Percent correct
1	31	0	0	0	0	31	100
2	4	22	0	5	4	35	63
3	1	4	22	0	5	32	69
4	0	3	0	29	4	36	81
5	0	0	8	10	4	22	18
Column total	36	29	30	44	17	156	69

Note: Only a match-up between row and column are a correct classification.

Habitat Suitability Index Models

The four animal species associated with mature forest conditions differed at least slightly in their habitat suitability index values for the two later-successional categories (fig. 11.1). Medians ranged from a low of 0.0, indicating poor habitat for pileated woodpeckers in both these successional categories, to a high of 0.39 for fishers in the late successional category, and overall the models indicate a scarcity of suitable habitat. We were unable to run all HSI models because (1) HSI methods were not specified to enable a match-up to FIA data; and (2) variables essential to some models were not available in the FIA datasets.

In the NMS analysis, the ordination of Axes 1 and 3 is shown with vectors for the six environmental variables and their relationship to species and subplots by their successional category (fig. 11.2). Longer vectors have more explanatory power than shorter ones, and when distance increases in a direction opposite the arrow and beyond the centroid, negative association is then assumed to increase. The ordination suggests a weak relationship between successional category and the plant species favored by migratory frugivores, because subplots within a successional category are scattered and do not form a cohesive group.

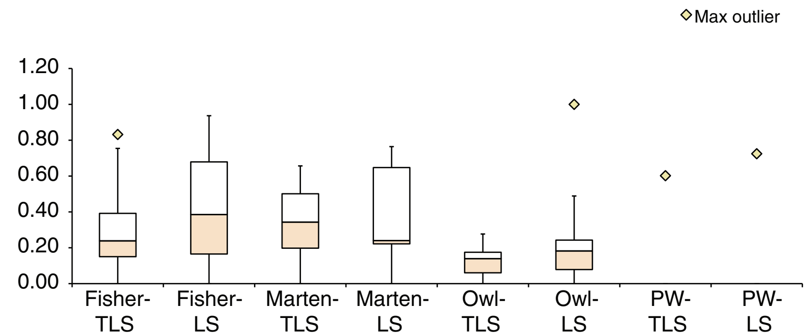

Figure 11.1—Box-whisker plot of the Habitat Suitability Index values for four species (fisher, pine marten, barred owl, and pileated woodpecker) in the "Tending toward late succession" (TLS) and "Late Succession" (LS) categories. PW= pileated woodpecker.

DISCUSSION AND CONCLUSIONS

The subplot was chosen as the primary sampling unit because the other options (plot, condition) delivered more aggregated information. We ignored the potential lack of independence of the subplots for increased replication in the HSI models, and given our objectives in this study, we consider that decision acceptable.

There is strong potential in the overall ability of a large-scale inventory to indicate wildlife habitat, especially for animal species that frequent mature forests. Index values

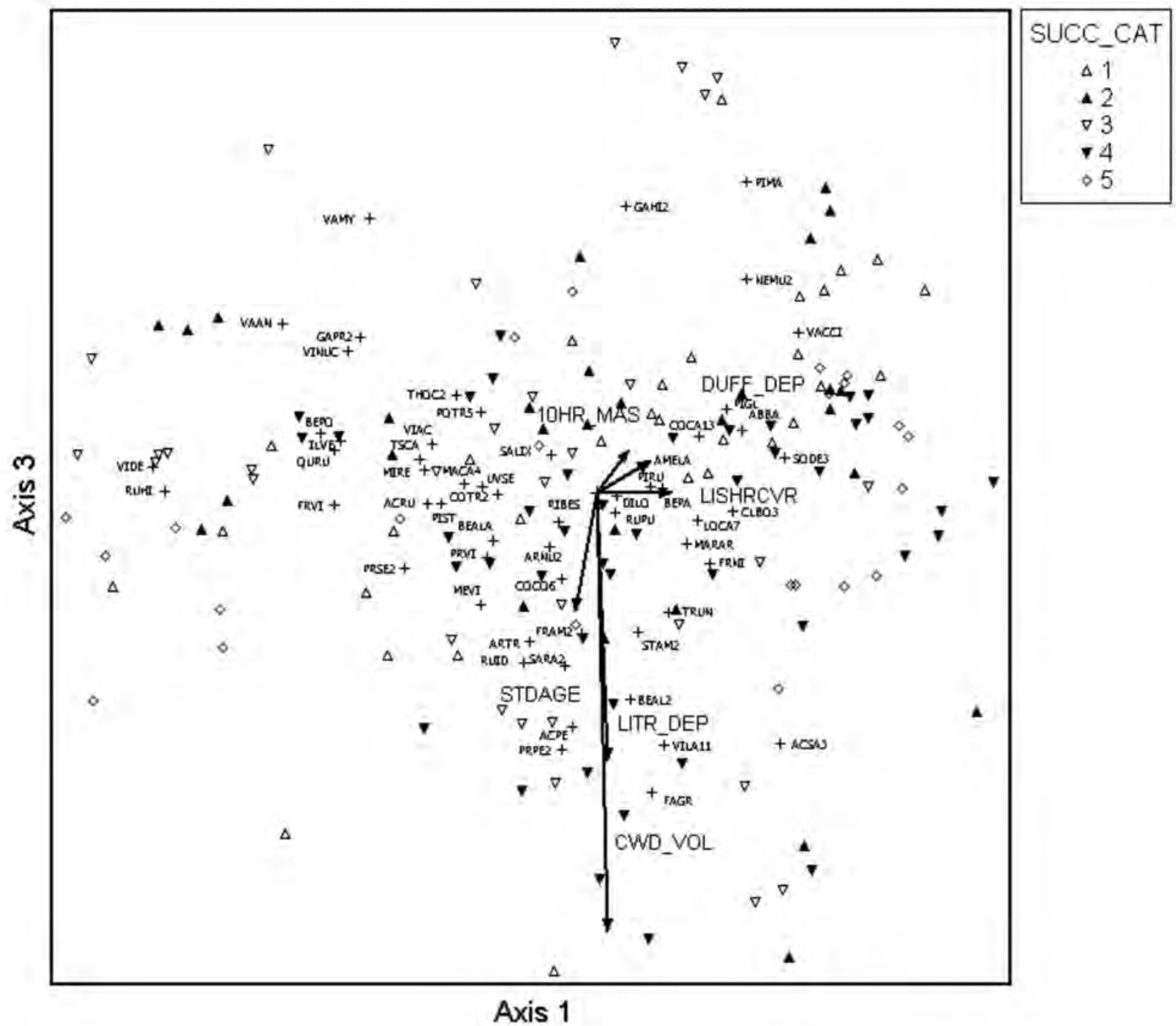

Figure 11.2—Joint biplot (first and third axes) of an ordination resulting from Nonmetric Multidimensional Scaling (NMS) of data from 158 subplots. Symbols are for subplots, by "Successional Category" (SUCC_CAT), and explained in table 11.1. Six select environmental variables, shown as vectors, (10HR_MAS = 10 Hour Fuel Loading; DUFF_DEP = Duff Depth; LISHRCVR = Live Shrub Cover; LITR_DEP = Litter Depth; CWD_VOL = Course Woody Debris Volume; and STDAGE = Stand Age) and 57 vascular plant species are displayed.

were higher in stands categorized as “late successional” compared to the “tending towards late successional” category. Even for pileated woodpeckers, the maximum value was greatest in late successional. The HSI failed to identify suitable habitat for pileated woodpecker due to very low frequency of live trees ≥50.8 cm d.b.h. and for snags ≥38.1 cm d.b.h. This finding is correlated by a real biodiversity benchmark (Maine Forest Service 2010). The pileated woodpecker HSI has such a major focus on large live trees and snags that FIA data within this model might be more appropriately analyzed at the condition or plot level in future studies. For fisher, a few subplots had highly suitable habitat, shown as outliers in figure 11.1. We think this demonstrates that HSI indices based on FIA data are sensitive enough to detect relatively subtle variation in habitat quality.

The needs of early successional species should not be overlooked, many of which are undergoing declines at a continental scale, and some of which are valued as game species. Trani and others (2001) used FIA data for 33 States to assess trends in availability of early successional wildlife habitat from 1946 through 1998. The available HSI models for early successional species require data not encompassed by FIA, such as cover of mature staminate aspen trees (catkins are winter food for ruffed grouse). HSI models for many early successional species have not been developed, presenting an opportunity for researchers to incorporate variables collected by FIA into new model development efforts.

We encountered many areas in which the FIA data suggest stands did not meet described thresholds. For example, the pine marten model ideally calls for 20–50 percent ground surface cover in coarse woody debris (≥7.62-cm diameter), but not >50 percent cover. We had a maximum of only 18 percent, implying that (1) there is inadequate CWD downfall for marten in our sample, (2) the model might not reflect conditions adequately, or (3) our calculations of CWD cover differed from methods used by Allen (1982), which were not specified.

The data were highly adaptable to the ordination technique, suggesting that other studies should follow. Individual subplot summaries reflect the scale at which a plant detects its light environment and vegetative competition. Importance of the shrub layer to some mammals and birds surely varies by animal species, shrub species, canopy conditions, and season. Shrub species are not clustered in the ordination (fig. 11.2), and this suggests that the P3 VEG data are especially important for understanding shrub cover at the level of subplot. Additional research in wildlife habitat should examine not only Maine’s add-on P2 live shrub variables, but the P3 VEG data as well. There are many more opportunities for exploration of questions related to wildlife habitat using ordination techniques and the P3 VEG data. The national scope of FIA data provides a probabilistic sample, and is available across large regions of the country.

Our result that coarse woody debris volume is clearly important in explaining seed-bearing plant distribution is a start toward sorting out the relationship.

While FIA data are strong in quantification of components that represent the vertical structure, there is low emphasis on horizontal diversity, or patchiness (DeGraaf and others 2006). Wherever there is a distinct change in vegetation, that edge represents a different set of opportunities for wildlife, and these edges and openings tend to increase wildlife diversity. In the FIA data, a change in condition within a subplot or between subplots comes closest to delineating the desired edge feature.

We think that other crucial aspects of wildlife habitat can be addressed through the FIA data. For example, Meneguzzo and Hansen (2009) demonstrated the utility of Geographic Information Systems and FIA data in a study of fragmentation at three sites in Michigan, comparing plot data to two resolutions of satellite imagery. They concluded that FIA plot data have potential as an alternative to the use of imagery for assessing forest fragmentation. The other P3 core indicators include crown condition, lichen communities, forest soils, and ozone. Each of these could have implications for wildlife habitat quality. We hope to stimulate further research using the FIA data for wildlife habitat projects. This study provides analytical methods and results with wide applicability in other States or regions. Despite some limitations, we found the FIA data highly useful for exploring specific wildlife habitat questions.

CONTACT INFORMATION

Alison Dibble (Email: adibble2@gmail.com) can provide three appendices upon request: Appendix I–Maine Forest Service estimates of trends in mature forest area; Appendix II–Variables extracted from the Maine FIA/FHM data for correspondence to variables in eight HSI models; Appendix III–Summary statistics of select environmental values used in NMS ordination.

LITERATURE CITED

Allen, A.W. 1982. Habitat suitability index models: marten. FWS/OBS-82/10.11. Fort Collins, CO: U.S. Department of the Interior Fish and Wildlife Service. 9 p.

Allen, A.W. 1983. Habitat suitability index models: fisher. FWS/OBS-82/10.45. Fort Collins, CO: U.S. Department of the Interior Fish and Wildlife Service. 19 p.

Allen, A.W. 1987. Habitat suitability index models: barred owl. Biol. Rep. 82/10.143. Fort Collins, CO: U.S. Department of the Interior Fish and Wildlife Service. 17 p.

Allen, T.G.; Plantinga, A.J. 1999. Investigations into the potential of measuring biodiversity in Maine's forests with Forest Inventory and Analysis (FIA) data. Tech. Bull. 171. Orono, ME: Maine Agricultural and Forest Experiment Station. 89 p.

Bechtold, W.A.; Patterson, P.L., eds. 2005. The enhanced Forest Inventory and Analysis Program - national sampling design and estimation procedures. Gen. Tech. Rep. SRS-80. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 85 p.

DeGraaf, R.M.; Yamasaki, M.; Leak, W.B; Lester, A.M. 2006. Technical guide to forest wildlife habitat management in New England. Lebanon, NH: University Press of New England. 305 p.

Maine Forest Service. 2010. Maine State forest assessment and strategies. Augusta, ME: Maine Forest Service, Department of Conservation. 225 p. http://www.maine.gov/doc/mfs/mfs/state_assessment/index.html. [Date accessed: August 1, 2012].

Martin, A.C.; Zim, H.S.; Nelson, A.L. 1951. American wildlife and plants. New York, NY: Dover Publications, Inc. 500 p.

Meneguzzo, D.M.; Hansen, M.H. 2009. Quantifying forest fragmentation using geographic information systems and Forest Inventory and Analysis plot data. In: McRoberts, R.E.; Reams, G.A.; Van Deusen, P.C.; McWilliams, W.H., eds. Proceedings of the eighth annual Forest Inventory and Analysis symposium. Gen. Tech. Rep. WO-79. Washington, DC: U.S. Department of Agriculture Forest Service: 143-147.

Rudis, V. 1991. Wildlife habitat, range, recreation, hydrology, and related research using Forest Inventory and Analysis surveys: a 12-year compendium. Gen. Tech. Rep. SO-84. New Orleans, LA: U.S. Department of Agriculture Forest Service, Southern Forest Experiment Station. 61 p.

Schroeder, R.L. 1982. Habitat suitability index models: pileated woodpecker. FWS/OBS-82/10.39. Fort Collins, CO: U.S. Department of the Interior Fish and Wildlife Service. 15 p.

Schulz, B.K.; Bechtold, W.A.; Zarnoch, S.J. 2009. Sampling and estimation procedures for the vegetation diversity and structure indicator. Gen. Tech. Rep. PNW-GTR-781. Portland, OR: U.S. Department of Agriculture Forest Service, Pacific Northwest Research Station. 53 p.

Torras, O.; Gil-Tena, A.; Saura, S. 2012. Changes in biodiversity indicators in managed and unmanaged forests in NE Spain. Journal of Forest Research. 17(1): 19-29.

Trani, M.K.; Brooks, R.T.; Schmidt, T.L. [and others]. 2001. Patterns and trends of early-successional forests in the Eastern United States. Wildlife Society Bulletin. 29: 413-424.

Woodall, C.W.; Amacher, M.C.; Bechtold, W.A. [and others]. 2011. Status and future of the forest health indicators program of the United States. Environmental Monitoring and Assessment. 177: 419-436.