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AN APPROACH TO QUANTIFYING LONG-TERM HABITAT CHANGE ON MANAGED FOREST LANDS

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Abstract. **Forest land managers must determine the effects of their management on nontarget resources, resources for which no current inventory is available, and for which no past trend information exists. The tools available to managers to make these determinations consist of the inventory information gathered for those commodities desired to be produced, i.e., the target resources. A method is proposed here, using available land use records and bid data sets for the Savannah River Site, to reconstruct past land use conditions and bird community composition and distribution. In addition to describing habitat change and resource response, the method can estimate the amount of uncertainty inherent in assessing implications of land management decisions for nontarget resources.**

Key Words: bird-habitat relationships, forest history, forest management, habitat modeling, land management planning.

Forest land managers need to make rapid and accurate decisions to be effective natural resource stewards. The quality of these decisions depends upon several factors, one of which is the accuracy of inventory information available. Unfortunately, land managers rarely have the staff to inventory resources other than those they produce intentionally. Inventories that are completed focus on a few critical elements relevant to commodity production. Such inventory work is typically carried out in a cyclical fashion, in which managers return to individual forest stands on a regular basis.

Information available to the decision-maker often is only the current inventory. Unless this individual has a long history of management responsibility on the site, little information from the previous inventories will be available to them. Unfortunately, the details of earlier inventories often are not archived in a retrievable fashion. Because timber harvest rotation ages often are longer than the careers of managers, it is unlikely that managers will have much information on the history of a stand or its historical productivity.

If the absence of resource inventory information was the primary problem faced by managers, their tasks would be difficult enough. However, as conditions change over time, additional resources often are identified as important products of the forest. As these resources are identified, forest managers become responsible for producing and monitoring them.

This addition of resources to the targets of production is the problem of interest here. Academically trained to produce one set of resources, managers later in their careers find themselves required to produce other, nontarget resources as well. The managers cannot have been trained to produce these nontarget resources nor, more importantly, can they have adequate inventory information for these nontarget resources. The resource management nightmares that result from these circumstances are numerous. The Spotted Owl (*Strix occidentalis*; Thomas and Raphael 1993) of the Pacific Northwest; the Bachman's Warbler (*Vermivora bachmanii;* Evenden et al. 1977, Hooper and Hamel 1977, Remsen 1986), the pondberry (*Lindera melissifolia*; DeLay et al. 1993), and the Red-cockaded Woodpecker (*Picoides borealis;* Hunter et al. 1994, Conner et al. 1996) of the Southeast are all examples of such resource management nightmares. Ultimately, without an accurate understanding of the habitats for these species and others, creatures of considerable value economically, like the Passenger Pigeon (*Ectopistes migratorius*), aesthetically, like the Carolina Parakeet (*Conuropsis carolinensis),* or ecologically, like the Ivory-billed Woodpecker (*Campephilus principalis),* are lost to future generations.

In this brief paper, we propose a mechanism to address this problem using the lands of the Savannah River Site (SRS) managed by the Savannah River Natural Resource Management and Research Institute (SRI) as a model. We suggest exploring potential effects of land management planning by looking not for more sophisticated means to anticipate the future but by taking advantage of current technology and understanding of ecological processes to reinterpret the historical record of land use. The objectives of this paper are to (1) outline a process to retrofit current land-use information into a history of the SRS, and (2) suggest methods to apply existing bird-habitat relationships to develop predictions of past bird communities. A by-product of this process will be a method for forest land management planners to evaluate consequences of decision-making processes on birds and to use those evaluations to guide future decision-making.

THE RECONSTRUCTION PROCESS

The proposed process involves a reconstruction of the past land use environment. The reconstruction uses available information projected back into the past, assesses the accuracy of those backward projections based upon examination of past records, makes predictions of later conditions of nontarget resources from the reconstructions of the past, and compares those predictions to subsequent measurements of those resources. We outline several methods to conduct the reconstructions. The several bird community studies presented by others in this volume provide the "nontarget resources" for which the projections can be made.

TECHNIQUES SUGGESTED FOR RECONSTRUCTING FOREST HISTORY

Three techniques are outlined for reconstructing forest history. They are (a) strict backtracking from present inventory coverage, (b) successive backtracking using past inventory coverage, and (c) re-evaluation of old aerial photographs. Each of these techniques is capable of projecting a past forest condition that can be mapped. The utility of using several of these techniques on the SRS is that with the extensive history of forests and bird communities maintained by researchers on the site, it will be possible to develop several depictions of the history and compare them with each other. The result of the comparison will be information useful to managers in other locations who may have only one of these methods at their disposal to reconstruct the history of the forest.

Strict backtracking from present inventory coverage

The most straightforward method of reconstructing the history of the forest on the SRS is to use the current inventory of existing tabular files and maps of stands. These data are maintained in a management information system, the Continuous Inventory of Stand Conditions (CISC), and a set of maps maintained in a geographic information system (GIS). By associating characters of age and composition with the mapped stands, it is possible to estimate the mosaic of forest conditions in approximately 10-yr intervals into the past from the present to the establishment of the SRS in the 1940s. This technique should be relatively easy to apply, and is limited only by the unavailability of information on the previous composition of stands recently harvested or otherwise modified, as by fire. Where stands are regenerated, the previous CISC data for that stand can be used to continue the projection of history in the stand. One important qualifier for this process will be the extent to which this stand information is actually available. Much of it may have been lost or destroyed as no longer relevant information. A second qualifier is the extent of the area that can be typed by this method. If the area that cannot be typed is large, this technique will be less useful than if that area is small.

The steps in this process are

1. Quantify age-condition-structure relationships using a cross-sectional approach, given the existing CISC data.
2. Backtrack in lo-year time intervals to estimate expected situation during each interval.
3. Overlay bird-habitat affinity information (e.g., Hamel 1992) onto the projected habitat situations for specific time periods.

The result of applying this process will be a set of maps of distribution of habitats for particular bird species, with associated suitabilities, for the entire SRS at specified times. From these maps can be derived summaries of extent of habitats believed to be present at the specified times. Empirical associations of relative abundance with habitat condition (e.g., Hamel 1992, Hamel et al. 1988) will indicate relative abundance of species at specified times. Comparison of the abundance and quality of habitats and relative abundance of the birds suggested by this process for the specified times will indicate the suggested trend in habitat availability and relative abundance for the species during the period of time since establishment of SRS. The individual snapshots of habitat availability and suggested relative abundance are the outcomes available for comparison among methods for projecting the past conditions on SRS.

Using past inventory coverage-successive backtracking

To the extent that they are available, historical CISC records also will permit construction of the forest for stands at particular times in the past. This is the equivalent of using the current CISC data base for depicting the forest at the present time. Although perhaps the most effective way to reconstruct the management view of the forest at some time in the past, this method likely suffers from lack of available records, an unfortunate casualty of the management focus on current conditions and the next management action. Useful for monitoring and managing intended resource uses, such a focus reduces the managers' ability to inventory and monitor the nontarget resources in their care.

From each of these sets of historical records, a past history can be developed as in the first technique. Comparison of these histories is a useful check on the use of management data to depict history. Differences between the maps projected from the first technique and actual past maps from this technique reflect at least two sorts of errors, both of which are relevant to predicting occurrence of nontarget resources from stand inventory information. The differences confound error introduced by the projection process with error introduced by the variation in individuals who did the initial inventories and prepared silvicultural prescriptions for the areas. Comparison of retrofit projections with actual past estimates, however, does provide an important measure of change, despite problems with observer variability in preparing stand maps from inventory information (stand typing).

As in the first technique, projections of bird communities can be overlain onto the projections of habitat conditions to estimate bird communities at particular times in the past. Comparisons of bird community estimates derived from retrofitting current stand information with estimates derived from using actual past estimates is again a measure of observer variability in typing. Until this sort of error can actually be measured, however, it will not be possible to ascertain whether it exists at an acceptable level.

A potentially appealing use of past inventory infor-

TABLE 1. SCHEMATIC OF USE OF CURRENT AND PAST VEGETATION AND BIRD DATA SETS TO RECONSTRUCT AND TEST LAND USE HISTORY

	Prediction data set (test data set)					
		CISC data gathered (air photos) pest				
Time Period	current	10	20	30	40	50
Current	A(T)[a]	P	P	P	P	P
10 yrs ago	F	A(T)	P	P	P	P
20 yrs ago	F	F	A(T)	P	P	P
30 yrs ago	F	F	F	A(T)	P	P
40 yrs ago	F	F	F	F	A(T)	P
50 vrs ago	F	F	F	F	F	A(T)

[a] Symbols in the table reflect whether the vegetation maps are A — actual, or F — forecasts of the future based upon actual measurements in the pest, or P historical projections into the past of measurements made later. (T) — indicates that aerial photographs can be used to test measurements made on the ground; they can also be used to evaluate both Projected and Forecast maps.

mation will be the use of earlier CISC inventories to project both backward and forward in time (Table 1). Each of the past CISC data sets can be used to project both forward and backward in time to establish a set of predictions of habitat conditions for all the time periods to be examined. The utility of this approach will be that it provides a method to compare the accuracy of predictions made with data of different lag times, i.e., in which the predictions are one, two, etc. re-entry cycles removed from the actual inventory information on which they are based.

Retyping old aerial photographs

A series of aerial photographs exists for the SRS, as they do for many areas. It is possible to conduct an inventory of forest resources from each of these sets of photographs, and to identify individual stands and map them. This method, called forest typing, involves interpretation of the photographs and determination of the extent of stands of similar conditions of composition (forest type) and structure or successional stage (stand condition class). Although a respected method of forest inventory and management work, it suffers in that it takes a great deal of time to retype old aerial photographs.

The strength of this approach is that it will allow comparison of the projections of CISC with replicable, objective data sets compiled from the aerial photos. Observer variation is potentially controllable by having a single individual conduct the silvicultural prescriptions from the photographs themselves. Groundtruthing of the old photographs obviously will not be possible. Bird data can be overlain onto the projections of the aerial photos as well, as in the other methods.

SRS-AN IDEAL CASE STUDY AREA

SRS is an ideal area on which to test this approach or apply this model. The size, forest mix, location, and forest management activity conducted by SRI on SRS are representative of National Forests or of other managed forest lands in the South. The advantage of SRS is the availability of relatively long-term investigations of resources other than timber. This array of biological data provides the opportunity to evaluate how well managers might anticipate effects of management activities on nontimber resources.

APPLICATION OF THE F&CONSTRUCTION PROCESS

As an example of this process, we analyzed the 1988 CISC database for the SRS to estimate changes in habitat from 1950-1988. We used the 1988 CISC database because it was the oldest complete database available to us. As mentioned above, information on prior history is lost when stands are regenerated and data on new stand conditions are inserted into the CISC database. Thus use of more current databases would result in the loss of more information on prior history.

We selected 4-7 compartments in each of three regions of the SRS, regions devoted primarily to Forest Service management. We excluded heavily industrialized areas from this test. The selected compartments also were located away from the Savannah River floodplain, which has different soils, hydrology, and forest types than the upland portions of the SRS. We excluded areas within the compartments identified in the CISC database as deciduous forest because studies of these forest types have shown little temporal change in distribution on the SRS since the 1950s (J. Pinder, pers. comm.). The following amounts of pine forest and open habitats remained for analysis: northwest (NW) region (compartments 14-17, 2,227 ha), northeast (NE) region (compartments 24-29, 4,475 ha), and southeast (SE) region (compartments 76, 80-85, 4,812 ha) (Table 2). We classified the remaining pine forest and open habitat stands in these regions by 10-yr age class using the year of planting recorded in the CISC database.

We then made a series of assumptions to extrapolate 1950 habitat distributions from the current (1988) database. For all stands identified in 1988 as pine forest (including stands of forest types = loblolly pine, *Pinus taeda,* longleaf

TABLE 2. 1988 HABITAT DISTRIBUTIONS IN SELECTED SRS COMPARTMENTS, EXPRESSED AS PERCENTAGE OF TOTAL PINE/OPEN HABITAT WITHIN THE COMPARTMENTS

	Age Classes					
Region	pre-1945	1946–1950	1951–1960	1961–1970	1971–1980	1981–1988
Northeast	**32**	**5**	**26**	**1.5**	**3**	**19**
Northwest	**13**	**7**	**52**	**3**	**15**	**10**
Southeast	**10**	**6**	**53**	**2**	**9**	**20**

pine, ***P. palustris,*** and slash pine, ***P. elliottii) we*** assumed that:

1. Stands with year of planting of 1945 or earlier were forested in 1950. Current studies of forest maturation and avian response show that 5-yr-old pine stands (especially loblolly and slash pine stands) are likely to consist of 4-5 m tall trees, and be dominated by forest-associated birds (Dunning and Watts 1990; J. B. Dunning, unpubl. data).

2. Stands with a year of planting between 19461950 were in regeneration in 1950, and therefore consisted of old-field successional habitat.

3. Stands with a year of planting between 1951-1980 were active or fallow agricultural fields. Within these age classes the stands aged 1971-1980 are the most problematic. At this time, most of the initial conversion of farmland to planted forest was completed, and some harvest of older forest may have been occurring. We treat this age class as part of the agricultural conversion because we have found no sources indicating that substantial timber harvest took place in the compartments we used during this decade.

4. Stands with a year of planting between 1981-1988 represent potential error in the analysis, as the history of these stands prior to planting is unknown.

By this analysis the three regions differed substantially in their 1950 distributions of pine forest and open habitats (Table 2). At least 32% of the NE region was forested in 1950 (as identified by pre- 1945 year-of-planting designations) while only 10–13% of the NW and SE regions were in pine forest. In all three regions, we estimate that 5-7% of the regions were in regeneration. Between 45-70% of each region was in agriculture in 1950, as indicated by planting years between 1951-1980 in the 1988 CISC database. The NE region had the lowest estimated proportion of farmland, and also the lowest proportion in the problematic 1971-1980 age class. Error rates in the 1950 habitat reconstruction varied from 10–20% as estimated by the 1981-1988 age class.

From this initial analysis, we estimate that 10–32% of the SRS was forested in 1950, while 50–70% was more open. If needed, a decade-by-decade portrait of the conversion from agriculture to managed forest could be developed. About 5% of the SRS was probably similar to regeneration stands today.

As loss of information in the CISC databases associated with the most recent habitat conversions totaled 10–20%, use of even older databases would likely improve confidence in this type of reconstruction. Thus the use of older CISC data as outlined in the second technique would build upon the process we have initiated here. A major improvement in our ability to conduct this type of analysis would be to change the CISC database structure so that prior history is not lost when stands are harvested and replanted. Information is also lost with the current database structure when stand boundaries are redrawn (for instance, when small, similar stands are combined into a single stand). At such times, stands are often renumbered, resulting in the loss of all historical information associated with the former stand numbers. We strongly urge that managers be receptive to the need for historical information on their management lands by retaining such information in their stand databases.

The final step in the process of quantifying long-term habitat change using the CISC databases was to overlay avian habitat requirements onto the projected habitat conditions for different time periods, and estimate change for specific bird species. We compared avian surveys conducted by E. Odum in the early 1950s (summarized by Meyers and Odum *this* volume) with J. B. Dunning's studies of birds of open habitats (clearcuts) and pine forest during the late 1980s and early 1990s (for methods see Dunning and Watts 1990, Dunning et ***al. this volume).*** With few exceptions, we found that breeding densities and species lists from Odum's "pine" and "pine scrub" habitat categories were similar to modem avifaunas in mature longleaf pine forest stands (Table 3). The active and fallow agricultural fields surveyed by Odum (Meyers and Odum *this volume)* contained an avifauna distinct from those in open habitats present on the SRS today (Kilgo et al. ***this volume;*** J. B. Dunning, pers. obs.). Thus a first approximation of changes in the avian communities on the SRS can be tracked by reconstructing changes in open and pine-dominated habitats in different regions of the SRS.

EXISTING SRS DATA SETS

A rich and relatively long historical set of databases on the flora and fauna is available for

TABLE 3. MOST COMMON BIRDS RECORDED ON SURVEYS IN 1950s (ODUM[a]) AND 1980-1990 (DUNNING[b]) OF THE SRS

	Census Period, Habitat Sampled, Species Richness			
Rank Abundance	1950s Agricultural Fields (S = 8)	1950s Pine & Pine Scrub (S = 18)	1990s Clearcuts (S = 27)	1990s Mature Pine
1	Eastern Meadowlark	PINE WARBLER	**Prairie Warbler**	EASTERN TOWHEE
2	Field Sparrow	**PRAIRIE WARBLER**	**Eastern Towhee**	PINE WARBLER
3	**PRAIRIE WARBLER**	**BACHMAN'S SPARROW**	Indigo Bunting	BACHMAN'S SPARROW
4	Eastern Kingbird	**NORTHERN CARDINAL**	**Bachman's Sparrow**	Indigo Bunting
5	**MOURNING DOVE**	**EASTERN TOWHEE**	Yellow-breasted Chat	PRAIRIE WARBLER
6	RED-HEADED WOODPECKER	Brown-headed Nuthatch	Northern Bobwhite	MOURNING DOVE
7	Eastern Bluebird	Summer Tanager	**Northern Cardinal**	Carolina Wren
8	Orchard Oriole	Tufted Titmouse	**Mourning Dove**	EASTERN WOOD-PEWEE
9		EASTERN WOOD-PEWEE	Blue Grosbeak	NORTHERN CARDINAL
10		Great Crested Flycatcher	Brown-headed Cowbird	RED-HEADED WOODPECKER

Notes: Species found in either of the 1950s surveys and 1980–1990 clearcut surveys are indicated with boldface; species in either of the early surveys and late surveys in mature pine stands are indicated with CAPITALS. Note that 6 of the species most common in early pine/pine scrub habitat occur in both clearcuts and mature forest from later survey period, while only 3 of the species most common in agricultural fields in the 1950s appear on the 1990s lists. Scientific names are in Appendix 1.

[a] For list of sources see Meyers and Odum *(this volume).*

[b] J.B. Dunning, pets. comm.

SRS. Extensive vegetation and bird data sets (Meyers and Odum this volume) are among those available. Additional data on climate, physiography, topography, and soils also may be useful. For simplicity, we reconstruct land-use histories without reference to these other data sets. The approach depends upon use of the existing and past vegetation data bases to reconstruct past land-use, a bird-habitat association model to predict past bird communities, and a group of validation vegetation and bird data sets to compare estimates of past land use and bird communities to those actually measured at the time.

VEGETATION

Several vegetation coverages exist for the site, four of which are important as reconstruction tools. These are the existing USDA Forest Service (USFS) Geographic Information System coverage (GIS), the set of current and past records of the Continuous Inventory of Stand Conditions data base (CISC), current and past aerial photographs, and the Forest Inventory and Analysis (FIA) survey data.

Existing GIS coverage

This is a thorough, accurate map of the boundaries of the existing compartments and stands, digitized to high standards of accuracy. Boundaries of management compartments are expected to be stable over time, while boundaries of stands reflect the different timber staff assistants and their views of management options.

Advantages.-The high quality of existing GIS coverage for SRS means that reconstruction will be relatively easy to accomplish. Manipulation of CISC data for existing stands in the GIS is relatively direct and rapid. Use of the GIS to identify larger scale units of habitat for particular bird species is easy.

Disadvantages.-A large investment in quality control and digitizing initial information, as well as in maintenance of equipment and data, is involved in use of the GIS. GIS lacks the flexibility to change stand boundaries that is inherent in individual typing of aerial photographs because the GIS is a depiction digitized from other sources rather than the primary data source.

Current CISC data

The CISC data base includes information identifying the individual stands within compartments. Associated with each stand is a tabular data set that reflects the management information concerning the vegetation of each stand. Forest type and site index data, stand condition class, intended management type and associated site index for that management type, stand age expressed as the stand birthdate, a modest number of quantitative measurements of the vegetation, and some indication of the management actions taken during the current entry cycle form the data in CISC. CISC data are gathered by staff foresters and reflect a minimal amount of effort consistent with classification to the appropriate forest type.

Advantages.—CISC data are the inventory data on which land management decisions are based. Using them directly ties information on nontarget resources like birds to the best representation of the conditions on the ground. All members of land management and management planning teams are familiar with the data, their use, and limitations.

Disadvantages.-CISC data have uneven accuracy from place to place, period of time to period of time, and are subject to certain kinds of observer variation that can be frustrating. Some preparers of CISC data are prone to interpret the field information on stand composition with a bias toward economically important trees in the stands. Others will have relatively less bias to commercial species. Variation in typing is due to such biases. The relatively small number of actual biological descriptors in the CISC data creates difficulties for workers wishing to infer the presence or absence of other attributes of stands, such as snag densities, presence of certain volumes of downed woody material, and the like.

Current and past aerial photographs

At approximately 10-yr intervals, complete coverage of low altitude aerial photographs has been taken to permit foresters to develop type maps for managed forest lands as part of the reentry cycle. An evaluation of existing sets of aerial photographs will permit development of an independent map of forest stands from each set of photographs.

Advantages.-Each available set of aerial photographs is a document of conditions existing at a particular time. As such, these records are a most useful documentation of actual conditions. As remotely sensed data, the photographs cover areas much larger than stands, and landscape features can be measured from them. Observer variation in developing forest type maps can be examined by having several different observers produce type maps from the same set of aerial photographs.

Disadvantages.-The major disadvantage of using aerial photographs is the very time-consuming process of examination required for observers to interpret them. Because the time required is great, it may be cost prohibitive to use complete sets of past photographs to reconstruct land use history.

FIA plot data

The FIA Unit of the Southern Research Station, USFS, maintains a set of permanent plots in forest throughout the South. A number of permanent plots are on the SRS. Each of these plots has been measured at least one time, and some as many as three or four times, at approximately 7-12 year intervals. Data from these plots can be used to estimate the amount of forest on the SRS. Location information is also available for the plots, permitting limited spatial analyses. It is also possible to use the measurements on the FIA plots to estimate certain quantitative measures of vegetation composition and structure not available in CISC.

Advantages.—FIA data are gathered to very high standards of accuracy, and involve a large number of quantitative measures of vegetation structure. The relatively large number of FIA plots on the SRS makes this an ideal site to use the FIA datasets as a means to quantify measurements of vegetation structure at the larger scale of the stands on a site of reasonable extent. Current FIA data sets are a vastly underused resource for tasks such as this one.

Disadvantages.-Because FIA data are gathered at randomly located plots, the measurements made on FIA plots are representative of forest types. Consequently, they are not mappable directly as are CISC and GIS data, and the forest type boundaries made on aerial photographs. Sensitivity of location data associated with FIA plots may make certain kinds of uses difficult for others wishing to use them for purposes of historical land use reconstruction.

BIRD PREDICTION DATA SETS

Two primary data sets exist for development of estimates of bird occurrence associated with land use reconstructions, Hamel (1992) and the USFS Region 8 BIRDHAB model (U.S. Forest Service 1994). Both are derived from the matrices of species by vegetation type associations developed in Hamel et al. (1982), in which the authors developed a set of species-by-habitat matrices for bird occurrence in the Southeast. These were tested in limited way by Hamel (1984, Hamel et al. 1988) and currently are being tested extensively by USFS Southern Research Station personnel using bird census data from SRS. The BIRDHAB model has been extensively modified to provide a user-friendly method for wildlife biologists and others in Region 8 to be able to use the GIS to associate bird species to mapped habitat conditions as found in CISC. Each of these data bases is sufficient to associate a group of bird species with a mapped stand.

Advantages.-Projections of the data in Hamel (1992) or BIRDHAB is easy to accomplish because each is an automated product. Each includes capability to associate birds with each acre of the SRS or any other southern forest land. Matrices in each were designed specifically to associate birds with forest type and stand condition designations such as those in Table 2.

Disadvantages.-Because the data in Hamel (1992) and BIRDHAB are generally applicable, and designed to associate birds with relatively broad vegetation type or forest type categories, each of these works represents a set of hypotheses of occurrence. Neither is capable of associating species with particular vectors of empirical measurements of vegetation structure, particularly as that vegetation structure may vary among stands that fall within the same forest type-stand condition class combination.

TESTING THE PREDICTIONS

Two kinds of tests are desirable from the data developed in the procedures outlined here. In one kind of test, past projections are compared with each other to identify uncertainty inherent in the reconstruction, hence the planning, process. In the other kind of test, past projections are compared with measurements made in other studies on the site. Each of these sorts of comparisons provides important information for managers on the effectiveness of the planning process.

CONSISTENCY OF PAST RECONSTRUCTIONS MEASURES RELIABILITY OF PREDICTIONS

The several reconstructed land use histories, e.g., one for each interval of CISC coverage, one for each set of aerial photographs, can be compared with each other to assess whether and to what extent the records of land use agree with each other. It is unlikely that they will agree, perhaps not even closely. Differences among the projections of land use is a measure of the uncertainty inherent in projections based on the inventory information that managers must use.

Bird communities based upon the historical projections of land use can be compared among themselves. The differences among these projections are another measure of the uncertainty on which management decisions must be based. Variation observed here is an actual measure of the variation introduced by the planning process. It is variation in possible estimates of nontarget resources based on information designed to monitor target resources.

ACCURACY OF THE PROJECTIONS REFLECTS THE SUFFICIENCY OF MANAGEMENT INFORMATION

Comparison of projected land use history with specific measures of landscape, such as those derived from retyping old aerial photographs or from historical vegetation studies, provides a measure of the accuracy of the land use projections. Testing the accuracy of projections made from data 10- vs. 20- vs. 30-yr distant from the source of the projections is a valid estimate of the uncertainty inherent in the projection process as it extends farther from the current time period. Comparison of bird community projections with those actually observed in the past studies of the SRS avifauna estimates the accuracy of predictions based upon general habitat association models.

Results of these comparisons will be instructive in showing managers the extent to which initial efforts to associate nontarget resources with categories in the management inventory and information system can be adequate for predictive purposes.

DISCUSSION

It has been said that "It is not management unless it is done on purpose." This reasonable standard for managerial activity fails to incorporate the reality that each management action affects not only the target resources, for which the activity was done "on purpose," but also may affect a wide range of nontarget resources as well. Each of these resources is affected in an unintentional way. Consequently, the effect of a management activity on a particular resource, such as a community of birds, may be beneficial, neutral, or detrimental.

Current forest management practices often appear to follow a row-crop agriculture mindset (cf. Garrett and Buck 1997), wherein the process is viewed strictly as a controlled activity leading to production of targeted amounts of specific known commodities. Only quality control measures are needed for a production activity, for which all relevant outcomes are believed to be known. With respect to nontarget resources, forest management is not such a controlled activity, nor is it short-term.

Management of forest succession or timber harvest rotation is a long-term process. Short-term monitoring records of management actions inhibit development of a collective history of that process. Without the collective history from a site, planning is not easily done and effects of management activities on nontarget resources are unavailable for improvement or even examination.

A real missing link in the land management process has been the recognition that each management activity is a manipulative experiment as well as a production activity. These experiments create an historical record of land management on a site. Far too seldom have these "experiments" been documented, so that their results could be used to adjust future management. Far too often the results of these "experiments" have been used by opponents of the manager to discredit the management. Neither of these outcomes is particularly useful to the nontarget resources in question.

Several methods for projecting the past history of the forest stands at the SRS have been described. An example of the use of one of them has been presented. Each ideally will produce a set of maps with associated tabular data. These data reflect several different projections of the actual extent, distribution, and characteristics of the forests of the SRS. The landscape structure of these projections could be estimated to characterize the spatial heterogeneity across the SRS. Comparison of techniques can identify characteristics of accuracy, precision, and efficiency in the projections of habitats. Using a single recent CISC coverage, it was possible to estimate the past extent of age class coverage on the SRS for 80–90% of the sample pine forest area.

Projected bird communities can be compared as well. Differences among them will be instructive of sources of error involved in habitat projections themselves, in associations of vegetation characteristics with habitats, in associations of birds with vegetation characteristics, and in spatial associations of habitats. Projected bird communities can be compared to actual measured communities when study sites for earlier works can be located on the maps. Differences between the actual and the several projected communities can similarly be apportioned into sources of error associated with the different techniques. The entire process can be used as a model for land use planning elsewhere as well, in locations where land use records are less extensive than those maintained at SRS.

Those working at SRI stand in a fairly enviable position of using historical records to establish predicted future conditions of the forest, and then testing the predictions against actual realizations. Differences between current and predicted current conditions are measures of the uncertainty inherent in land management planning. Knowledge of that uncertainty will be a powerful tool a manager can employ during development of a forest plan or other document indicating management intent.

CONCLUSION

Existing data sets for the managed lands of SRS can be summarized and several reconstructions of past habitat conditions made from them. While the task is not trivial, SRS is an ideal area to demonstrate the process described here. Existing data sets on past bird distributions on SRS can be used to assess relationships between birds and habitats on SRS at present and in the past. Habitat and bird community trend information potentially can be developed from these comparisons.

Data and analyses developed for this volume provide an unparalleled opportunity to elaborate and to test a process of forest reconstruction that is applicable to National Forest lands in the South. Although not universally applicable, this approach might even be called a "model" for forest reconstruction.

The process is not without difficulty, however. Lost data will be a potentially debilitating factor to conducting the projections inherent in testing these methods of land use reconstruction. But they will be an even greater debility for application at sites other than SRS. Readers must realize that management applications in actuality are not yet conducted in the same way as are controlled experiments. Managers must recognize the importance of maintaining archives of past inventory information to permit reconstruction of trends in habitats and distributions of nontarget resources.

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APPENDIX 1.

SCIENTIFIC NAMES OF BIRDS MENTIONED IN THE TEXT

Northern Bobwhite	***Colinus virginianus***
Mourning Dove	***Zenaida macroura***
Passenger Pigeon	***Ectopistes migratorius***
Carolina Parakeet	***Conuropsis carolinensis***
Spotted Owl	***Strix occidentalis***
Red-headed Woodpecker	***Melanerpes erythrocephalus***
Red-cockaded Woodpecker	***Picoides borealis***
Ivory-billed Woodpecker	***Campephilus principalis***
Eastern Wood-Pewee	***Contopus virens***
Great Crested Flycatcher	***Myiarchus crinitus***
Eastern Kingbird	***Tyrannus tyrannus***
Tufted Titmouse	***Baeolophus bicolor***
Brown-headed Nuthatch	***Sitta pusilla***
Carolina Wren	***Thryothorus ludovicianus***
Eastern Bluebird	***Sialia sialis***
Bachman's Warbler	***Vermivora bachmanii***
Pine Warbler	***Dendroica pinus***
Prairie Warbler	***Dendroica discolor***
Yellow-breasted Chat	***Icteria virens***
Summer Tanager	***Piranga rubra***
Eastern Towhee	***Pipilo erythrophthalmus***
Bachman's Sparrow	***Aimophila aestivalis***
Field Sparrow	***Spizella pusilla***
Northern Cardinal	***Cardinalis cardinalis***
Blue Grosbeak	***Guiraca caerulea***
Indigo Bunting	***Passerina cyanea***
Eastern Meadowlark	***Sturnella magna***
Brown-headed Cowbird	***Molothrus ater***
Orchard Oriole	***Icterus spurius***