Forest and Wildlife Management Planning

An Annotated Bibliography

by

Rebecca J. Barlow

and

Stephen C. Grado

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INTRODUCTION

This annotated bibliography is a compilation of selected journal articles, books, extension publications, conference proceeding articles, Internet publications, and academic theses and dissertations from 1960 to present. They are related to the topics of forest and wildlife management planning, with specific application to the effects of manipulating timber growing stock to provide more or less wildlife habitat. Sources were identified using computer databases available through Mississippi State University Libraries, and on the Internet's World Wide Web. Additional resources were also found in the reference sections of articles located in these initial searches.

To help readers determine the usefulness of each publication, article summaries discuss details of methodology and results for each publication. When appropriate, the author's abstract was used as a basis for the summary and is indicated by the use of an "*" at the end of the synopsis. Keywords are listed at the end of each abstract. Topics summarized include, but are not limited to, forestry, wildlife management, forest economics, geographic information systems, and linear programming. A keyword index is located in the front of the publication to help readers locate specific topics of interest. This index is organized by author, year, and article reference number.

This bibliography does not include every article related to forest and wildlife management planning, however, it does represent a broad sampling of current, application oriented publications on the topic. This bibliography will continue to be updated in the future. Please forward suggestions for articles that were not included or published after 2000 to:

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[Lockwood, 1993 #99; Lockwood, 1992 #100; Tarp, 1997 #150; Van Deusen, 1999 #162]

SIMULATION
[Thompson, 1971 #153]

SIMULATION MODELING
[Brown, 1994 #13]

SIMULTANEOUS STAND AND FOREST LEVEL OPTIMIZATION
[Rosie, 1990 #131]

SITE-SPECIFIC PLANNING
[Jones, 1991 #81]

SITE-SPECIFIC OPTIMIZATION
[Jones, 1991 #81]

SIZE CONSTRAINTS
[Lockwood, 1992 #100]

SOUTHERN FORESTS
[Sharitz, 1992 #134]

SOUTHERN PINE
[Siry, 1999 #137]

SOUTHEASTERN UNITED STATES
[Yarrow, 1999 #173]

SOUTHERN UNITED STATES
[Johnson, 1987 #77; Joyce, 1986 #83; Miller, 1999 #108]

SOUTH TEXAS
[Stewart, 2000 #147]

SPATIAL ALLOCATION
[Weintraub, 1994 #169]

SPATIAL ANALYSIS
[Hof, 1997 #65]

SPATIAL CONSTRAINTS
[Richards, 2000 #127]

SPATIAL OPTIMIZATION
[Hof, 2000 # 63; Hof, 1997 #65]

SPATIAL SCALE
[Murray, 1999 #113]

SPECIES RICHNESS
[Hof, 1994 #64; Hof, 1993 #66; Spackman, 1995 #139]

SPECTRUM
[USDA Forest Service, 1999 #158]

SPRING GOBBLER SURVEY
[Mississippi Department of Wildlife, Fisheries and Parks, 2000 #110]

SQUIRREL (*Sciurus* spp.)
[Dickson, 1987 #36]

STAND GROWTH
[Ware, 1971 #166]

STAND STRUCTURE
[Hansen, 1991 #56]

STATISTICAL ANALYSIS
[Weintraub, 1994 #168]

STRIP DISKING
[Stewart, 1998 #143; Stewart, 1998 #144]

Strix occidentalis caurina
[Hof, n. date #62]

STREAM BANK
[Spackman, 1995 #139]

STREAM CORRIDOR
[Spackman, 1995 #139]

STREAMSIDE MANAGEMENT ZONES
[Mississippi Forestry Commission, 2000 #111]

STUMPAGE PRICES
[Brazee, 2000 #10]

SUBJECTIVE PROBABILITY
[Thompson, 1971 #153]

SUBTROPICAL THORN WOODLAND
[Stewart, 2000 #147]

SUCCESSION
[Gustafson, 2000 # 54]

SUPERIOR NATIONAL FOREST
[Nichols, 2000 #119]

SUPPOSE
[Crookston, 1999 #31]

SUSTAINABILITY
[Hof, 2000 # 63]

SUSTAINED YIELD
[Loucks, 1964 #101]

TABU SEARCH
[Thomson, 1995 #155]

TACTICAL PLANNING
[Richards, 2000 #127]

TIMBER
[Joyce, 1986 #83]

TIMBER HARVESTING
[Bordelon, 2000 #8; Carroll, 1995 #20; Carter, 1999 #22; Johnson, 1977 #79; Kidd, 1966 #88; Loucks, 1964 #101; McConnell, 1983 #104; Snyder, 1996 #138]

TIMBER HARVEST PLANNING
[Carroll, 1995 #20; USDA Forest Service, 1999 #158]

TIMBER INVENTORY
[Short, 1997 #136]

TIMBER MANAGEMENT
[Hall, 1980 #55; Opper, 1988 #123]

TIMBER PRODUCTION
[Wear, 1996 #167; Yin, 1995 #174]

TIMBER ROTATION
[Hardie, 1984 #58]

TIMBER SALES
[Niemi, 1999 #120]

TIMBER STAND IMPROVEMENT (TSI)
[Porterfield, 1979 #125]

TIMBER VALUATION
[Gan, n. date #47]

TIMBER-WILDLIFE COOPERATIVES
[Shaw, 1981 #135]

TIMBER YIELD
[Leuschner, 1975 #94]

TIME SERIES MODELING
[Reams, 1999 #126]

TRADE-OFF ANALYSIS
[Connaughton, 1984 #27; Richards, 2000 #127; Schaberg, 1999 #132]

TRAVEL COST
[Glass, 1998 #49; Willis, 1990 #171]

TREE PLANTING
[Mississippi Forestry Commission, 2000 #111]

UNEVEN-AGED MANAGEMENT
[Blair, 1980 #6; Faustmann, 1849 #41; Miller, 1999 #107]

UNITED KINGDOM
[Willis, 1990 #171]

Ursus americanus
[Holt, 1990 #70; Van Manen, 1997 #163]

USDA FOREST SERVICE
[Carroll, 1995 #20; Crookston, 1999 #31; Faulkner, 1994 #39; Faulkner, 1994 #40; Flather, 1989 #43; Hall, 1980 #55; Hansen, 1992 #56; Kent, 1989 #86; Reams, 1999 #126; Swanson, 1996 #149; USDA Forest Service, 1999 #159]

UTILITY THEORY
[Thie, 1979 #152]

VALUATION
[Glass, 1998 #49]

VORONOI TESSELLATIONS
[Barrett, 1997 #3]

WASHINGTON STATE
[Oliver, 1992 #122; Lippke, 1996 #96]

WATER QUALITY
[Mississippi Forestry Commission, 2000 #111]

WATERSHED ECOSYSTEM ANALYSIS
[Hornbeck, 1992 #69]

WATERSHEDS
[Church, n. date #25; Hornbeck, 1992 #69]

WETLAND LOSS
[Burke, 1995 #17]

WETLANDS
[Flather, 1989 #43]

WESTVACO
[Woods, 1987 #172]

WEYERHAEUSER
[Woods, 1987 #172]

WHITE-TAILED DEER
[Blair, 1980 #6; Brooks, 1979 #12; Carley, 1999 #19; Conover, 1997 #28; Flather, 1989 #44; Hall, 1980 #55; Hughes, 1991 #72; Hurst, 1980 #73; McKee, 1982 #105; McKee, 1983 #106; Roseberry, 1998 #130; Stewart, 1980 #142; Stewart, 2000 #147]

WILDLIFE
[Conover, 1997 #28; Fredericksen, 2000 #46; Hall, 1980 #55; Joyce, 1986 #83; Kuhnke, 1999 #92; Miller, 1999 #108; U. S. Department of the Interior and U. S. Department of Commerce (USDI and USDC), 1998 #160]

WILDLIFE BENEFITS
[Johnson, 1987 #77]

WILDLIFE CONSTRAINTS
[Cox, 1995 #30; Thomson, 1995 #155]

WILDLIFE HABITAT
[Bordelon, 2000 #8; Burke, 1995 #17; Demarchi, 1985 #35; Dickson, 1987 #36; Flather, 1989 #43; Flather, 1989 #44; McKee, 1982 #105; Miller, 1999 #107; Miller, 1999 #108; Nichols, 2000 #119; Staten, 1997 #140; Stewart, 1997 #146]

WILDLIFE HABITAT PLANNING
[Harris, 1980 #59; Kuhnke, 1999 #92]

WILDLIFE/LOGGING CONFLICTS
[Brown, 1994 #13]

WILDLIFE MANAGEMENT
[Allen, 1987 #1; Bishop, 1981 #5; Brennan, 1991 #11; Brynaert, 1985 #14; Burger, 1995 #15; Burger, 1995 #16; Connaughton, 1984 #27; Davey, 1989 #34; Demarchi, 1985 #35; Fox, 1985 #45; Goodrum, 1971 #51; Harris, 1980 #59; Hay, 1984 #60; Hof, 1994 #64; Hurst, 1980 #73; Hynard, 1985 #74; Innes, 1985 #75; Johnson, 1987 #77; Jones, 1999 #80; Karr, 1981 #84; Landres, 1983 #93; McComb, 1982 #103; Opper, 1988 #123; Shaw, 1981 #135; Stewart, 1980 #142; Stewart, 1998 #143; Stewart, 1998 #144; Stewart, 1998 #145; Stewart, 1997 #146; Thompson, 1973 #154; Walton, 1981 #164; Woods, 1987 #172; Yarrow, 1999 #173]

WILDLIFE RECREATION
[Hay, 1984 #60]

WILDLIFE WATCHING
[U. S. Department of the Interior and U. S. Department of Commerce (USDI and USDC), 1998 #160]

WILD TURKEY
[Flather, 1989 #44; Grado, 1997 #52; Hall, 1980 #55; Mississippi Department of Wildlife, Fisheries and Parks, 2000 #110; Stewart, 1980 #142; Stewart, 1997 #144]

WOOD PROCUREMENT
[Thompson, 1971 #153]

WORLD WIDE WEB
[Carter, 1999 #22]

Annotated Bibliography

1. Allen, C. E. 1987. **Wildlife management by Champion International Corporation.** In: J. G. Dickson and O. E. Maughan eds. *Managing Southern Forests for Wildlife and Fish: A Proceedings.* USDA Forest Service General Technical Report SO-65. pp. 79-82.

Champion International Corporation is developing a multi-faceted wildlife program aimed at integrating wildlife and forest management. The program includes: 1) forest management prescriptions to accommodate wildlife, 2) developing land classification and fee access systems, and 3) cooperative research to test wildlife management practices. Champion leased approximately 626 thousand ha. (1.55 million ac.) in the South in 1985. Income varies per ha. depending on region and tract desirability. Wildlife management is funded mainly through hunting lease fees generated primarily from local hunting clubs. Indirect returns include customer entertainment on company lands, promotion of a positive public image, and public recognition for its wildlife management practices.*

Keywords: Champion International Corporation, forest management, hunting leases, wildlife management

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2. Bare, B. B., and B. F. Anholt. 1976. **Selecting forest residue treatment alternatives using goal programming.** *USDA Forest Service General Technical Report* PNW-43. 25 p.

The use of goal programming for selecting forest residue treatment alternatives within a multiple goal framework is described. The basic features of goal programming are reviewed and illustrated with a hypothetical problem involving the selection of residue treatments for 10 cutting units. Twelve residue-regeneration treatment combinations are evaluated, using physical, economic, and environmental goals. Empirical results are reported for four different goal priority sets. An interpretation of the sensitivity of the optimal treatment schedule associates with each priority set is also presented. Results indicate that goal programming offers considerable promise as an operational decision-making tool. Unresolved problems include: the selections of decision variables and the quantification of goal attainment levels, goal preferences, and the relationships between forest residue treatment methods and managerial goals.*

Keywords: forest management, forest residues, goal programming

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3. Barrett, T. M. 1997. **Voronoi tessellation methods to delineate harvest units for spatial forest planning.** *Canadian Journal of Forest Research.* 27: 903-910.

Spatial forest planning requires delineation of potential harvest units, and the size, shape, and spatial arrangement of harvest units can affect forest values such as aesthetics, harvest volumes, and wildlife habitat. When the desired harvest unit size is smaller than the size of polygons created with a GIS (geographic information system) overlay then some method of subdividing polygons into smaller units is required. This paper presents three methods that might be used to divide stands (polygons) into potential harvest units for forest planning. The methods compared are (1) simple overlay with a rectangular lattice, and Voronoi tessellations with travel cost as a distance metric and either (2) regularly spaced generator points or (3) generator points created with a max.-min. procedure. Each of the three methods provides a different distribution of harvest unit size and a different spatial arrangement of potential harvest units over the landscape. Interviews with industrial forest planners indicate that the usefulness of an automated delineation method for an individual company would depend on the method of stand mapping, the silvicultural methods used, money and personnel committed to planning and GIS implementation, and site-specific conditions such as topography, roads, and forest types.*

Keywords: forest planning, geographic information system, Voronoi tessellations

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4. Bell, E. F. 1977. **Mathematical programming in forestry.** *Journal of Forestry.* 75: 317-319.

Since the 1950's the use of linear programming techniques have increasingly been used to aid in forest planning and budgeting. When setting up a forest management problem in a linear programming format, the objective, alternative activities, resource allocation, constraints, and production functions must be specified. In doing this, the planner must be aware of the tradeoffs between using linear programming and solving the problem using another method. This paper discusses the basic assumptions underlying linear programming and how they may influence the model's suggested solution.

Keywords: forest planning, goal programming, linear programming

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5. Bishop, R. C. 1981. **Economic considerations affecting landowner behavior.** In: R. T. Dumke, G. V. Burger, and J. R. March eds. *Wildlife Management on Private Lands.* La Crosse Printing Co., Inc., La Crosse, Wisconsin. pp. 73-86.

This paper examines how wildlife related market failures discourage private landowners from managing for wildlife resources, and how taxes, subsidies, and regulation can be effectively used to increase incentives. Wildlife move from location to location and are therefore owned by no one. Unlike cattle, which the market signals farmers how to manage their land through increased or decreased prices, there is no "signal" to increase or decrease wildlife production. Economically justifiable levels of wildlife production may require public acquisition of land or partnerships between the private and public sector.

Keywords: economics, market failure, wildlife management

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6. Blair, R. M., and L. E. Brunett. 1980. **Seasonal browse selection by deer in a southern pine-hardwood habitat.** *Journal of Wildlife Management.* 44(1): 79-88.

Seasonal browse preference by white-tailed deer (*Odocoileus virginianus*) and timber stand dynamics were evaluated at three levels of controlled deer stocking for 11 years after a selective harvest in an uneven-aged pine-hardwood habitat in Louisiana. Many woody species were browsed, but only a few of these comprised most of the browse diet. Green leaves appeared to be preferred over twigs. Two years after logging, when browse production was highest, the summer and winter selection of high and medium choice species varied little between levels of deer stocking. But seven years after logging, browse production had declined by 52%, and deer at the high stocking level were browsing pine seedlings and several other nonpreferred species, especially in winter. Use on several low-preference species was also increasing. These changes in species use indicated excessive pressure on the food supply.*

Keywords: browse, Odocoileus virginianus, pine-hardwood management, uneven-aged management, white-tailed deer

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7. Block, W. M., L. A. Brennan, and R. J. Gutierrez. 1987. **Evaluation of guild-indicator species for use in resource management.** *Environmental Management.* 11(2): 265-269.

We followed selection guidelines commonly used by management agencies to select mountain quail (*Oreortyx pictus*) as an indicator species for an ecological guild of birds. We then evaluated the ability of mountain quail to indicate the presence of other species for the guild and to index the quality of the habitat for other species. The ability of quail to indicate the presence of species from the ecological guild varied widely within and among vegetation types. Species compositions of the ecological guild were more consistent in comparisons of sites within vegetation types that they were in comparisons of sites between vegetation types. Mountain quail habitat was significantly different from the habitats of sympatric species from the guild for 14 of 15 multivariate contrasts. We suggest that managers use indicator species with caution. If indicators are used, they should be applied to guilds composed of species that closely share ecological affinities. The habitat of the indicator species should overlap extensively with those of all other guild members. The use of indicators should be restricted to very similar sites within the same general vegetation type.*

Keywords: guilds, guild indicator-species, habitat monitoring, mountain quail, Oreortyx pictus, population monitoring

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8. Bordelon, M. A., D. C. McAllister, and R. Holloway. 2000. **Sustainable forestry Oregon style**. *Journal of Forestry.* 98(1): 26-34.

Since 1995, the Oregon Department of Forestry has developed a new management plan for the state forests of northwest Oregon. This ecosystem-based approach advocates the view that managing for both timber and wildlife is compatible. Using a structure-based management approach, variations in stand density are created through various harvesting techniques such as patch, shelterwood, and group selection cuts. This variation provides a full range of wildlife habitats, or interior habitat areas (IHA), at many spatial scales across the landscape. At the same time, this system is cost effective and flexible enough to allow Oregon land managers to address changes through time.

Keywords: forestry, IHA, interior habitat area, Oregon, timber harvesting, wildlife habitat

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9. Brazee, R. J., and G. S. Amacher. 2000. **Duality and Faustmann: Implications for the evaluation of landowner behavior.** *Forest Science.* 46(1): 132-138.

This paper examines the behavioral consequences when landowners seek to minimize costs rather than maximize profits. We derive a cost function that is dual to the net present value function in the Faustmann Model. This cost function provides a theoretical foundation for studies that estimate forest production costs. We use comparative statics methodology to derive qualitative results for changes in selected policies and exogenous parameters. We find that the qualitative impacts under cost minimization are usually *unambiguous*. Qualitative impacts under profit maximization are usually *ambiguous*. This implies that behavioral impacts are usually easier to assess *a priori*, when landowners minimize costs rather than maximize profits.*

Keywords: comparative statics analysis, cost minimization, forest taxes, landowners, planting subsidies

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10. Brazee, R. J., and E. Bulte. 2000. **Optimal harvesting and thinning with stochastic prices.** *Forest Science.* 46(1): 23-31.

This article rigorously incorporates optimal thinning decisions for an even-age stand into an optimal harvesting model with fluctuating stumpage prices. The theoretical model optimally determines how often and at what ages to thin when stumpage prices are independently drawn from a stationary distribution. New theoretical results include increases in the net present value of both land and stumpage, and increases in some harvest reservation prices from introducing thinning. A simplified model is numerically simulated using parameters estimated from Dutch data for *Pinus sylvestris* to determine when to thin. The simulation results suggest that the gains from incorporating thinning are significant when compared to the Faustmann approach and at least modestly important when compared to optimal harvesting models without thinning. The simulation results also indicate that expected thinning age may decrease significantly while the expected harvest age increases, when compared to the Faustmann approach.*

Keywords: Faustmann, flexible management model, Pinus sylvestris, price risk, stumpage prices

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11. Brennan, L. A. 1991. **How can we reverse the northern bobwhite population decline?** *Wildlife Society Bulletin.* 19: 544-555.

Since the early 1960's, northern bobwhite quail (*Colinus virginianus*) populations have declined by more than 70%. Possible research and land management objectives should be outlined so that this decline may be reversed. This paper strives to do just that by 1) describing probable causes for the population decline, 2) outlining a research program that will solve habitat management problems, and 3) describing strategies for educating the public about bobwhite quail habitat and population management. Although the northern bobwhite is one of the most studied game birds in the world, there are still many basic questions that need to be addressed through experimentation.

Keywords: Colinus virginianus, forestry, habitat management, northern bobwhite quail, wildlife management

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12. Brooks, M. B. 1979. **Effects of precommercial thinning, fertilizing, and controlled burning on vegetative composition and white-tailed deer (*Odocoileus virginianus*) food on 7- and 8-year-old loblolly pine (*Pinus taeda*) plantations.** Master's Thesis. Mississippi State University. 95 pp.

The effects of precommercial thinning, control burning, and fertilizing on vegetative composition and biomass, and white-tailed deer (*Odocoileus virginianus*) food abundance in 7- and 8-year-old loblolly pine (*Pinus taeda*) populations were studied. Thinned and thinned and fertilized plots in Kemper County, Mississippi, were dominated by vines, mostly blackberry (*Rubus* spp.). In August, 1977, in the first growing season after treatment, desirable (as deer food) vine biomass (500 kg/ha, oven-dry weight) was significantly ($P<0.05$) greater on thinned and fertilized plots than on thinned plots (373kg/ha) and untreated plots (210kg/ha). In July, 1978, in the second growing season after treatment, thinned (457 kg/ha) and thinned and fertilized (450 kg/ha) plots had significantly ($P<0.05$) more desirable vine biomass than on untreated (202kg/ha) plots. Pooled means for 1977 and 1978 showed that thinned (647 kg/ha) and thinned and fertilized (668 kg/ha) plots had significantly ($P<0.05$) more total desirable deer food than untreated (336 kg/ha) plots. In another plantation, burned and burned and thinned plots had significantly more ($P<0.05$) desirable vine biomass, total desirable biomass and total biomass than on untreated plots, in August, 1978, in the first growing season after treatment.*

Keywords: loblolly pine, Odocoileus virginianus, Pinus taeda, silviculture, white-tailed deer

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13. Brown, S., H. Schreier, W. A. Thompson, and I. Vertinsky. 1994. **Linking multiple accounts with GIS as decision support system to resolve forestry/wildlife conflicts.** *Journal of Environmental Management.* 42(4): 349-364.

With shrinking forest resources and increasing demands for timber, conflicts between forestry and wildlife become more contentious and more frequent. New decision support methods are needed to address complex multiple land use conflicts. Multiple accounts methods linked with GIS and production models enable us to address trade-offs between timber and non-timber values, thus facilitating the evaluation and comparison of different management scenarios in a rapid and spatially referenced manner. The approach is documented in a case study in the trans-boundary zone between two national parks in British Columbia, where caribou/logging conflicts are widespread.*

Keywords: caribou habitat, decision support system, Geographic Information System, geo-referenced database, GIS, multiple accounts, simulation modeling, wildlife/logging conflicts

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14. Brynaert, K. A. 1985. **Recreational and cultural use of the forests.** *The Forestry Chronicle.* 61(2): 166-167.

Natural renewable resources are valuable national assets, which form a part of Canadian culture and afford the opportunity for recreational and economic pursuits. The direction, however, in which our wildlife and forestry management practices and technology has taken us, over the past thirty-five to forty years, is fraught with serious pitfalls. If our country is to recover and restore the viability of our renewable natural resources, it is essential to seek a new approach whereby the utilization and management of these resources are founded upon the principles contained in the World Conservation Strategy. Inherent in that approach must be a clear understanding of all forest values, none of which may be discounted for single-interest benefits. The forestry industry must recognize that exercising its right to utilize timber resources embodies a responsibility not to degrade or infringe upon the legitimate interests of other resource users.*

Keywords: cultural values, forest management, recreation, wildlife management

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15. Burger, L. W., T. V. Dailey, E. W. Kurzejeski, and M. R. Ryan. 1995. **Survival and cause specific mortality of northern bobwhite in Missouri.** *Journal of Wildlife Management.* 59(2): 401-410.

Efforts to understand fluctuations in northern bobwhite (*Colinus virginianus*) abundance illustrate inadequate knowledge of demographic processes. Therefore, we estimated seasonal survival, annual survival, and cause-specific mortality of 1,001 radio-marked bobwhite in northern Missouri. Annual survival was 5.3 $\pm$ 0.5% and did not differ between ages ($P = 0.33$) or sexes ($P = 0.48$). Fall-spring survival (15.9 $\pm$ 0.8%) was less than spring-fall survival (33.2 $\pm$ 2.7%, $P < 0.001$). Females had lower fall-spring survival (13.7 $\pm$ 1.1%) than males (17.6 $\pm$ 1.1% $P = 0.02$). Male-biased sex ratios likely result from differential fall and winter survival. Avian (28.7%) and mammalian (25.7%) predators were primary natural mortality agents. Hunter-retrieved (22.9%) and -unretrieved (5.3%) kill resulted in 28.2% harvest-related mortality. During spring-fall, males experienced higher avian mortality (26.5%) than females (20.0%) ($P = 0.09$). Greater vulnerability of males to avian predators may represent the cost of displaying. Each incubation and brood-rearing attempt reduced survival by 16% when compared with

nonreproductively active birds during a similar period. Bobwhites must be highly productive to replace natural population losses.*

Keywords: Colinus virginianus, northern bobwhite quail, radio telemetry, wildlife management

16. Burger, L. W., M. R. Ryan, T. V. Dailey, and E. W. Kurzejeski. 1995. **Reproductive strategies, success, and mating systems of northern bobwhite in Missouri.** *Journal of Wildlife Management.* 59(3): 417-426.

To better understand the reproductive mechanisms that enable northern bobwhite (*Colinus virginianus*) to recover from high annual mortality, we studied the reproductive strategies, success, and mating systems of 321 radio-marked bobwhite in northern Missouri during 1990-1992. Seventy-four female and 43 male bobwhite incubated 159 nests. Females exhibited apparent monogamy during 60% of nesting attempts, and apparent polyandry during 40%. Over the entire nesting season, 71% of females were polyandrous. Of those birds alive 15 April (n = 112 F, n = 148 M), 40.2% of females and 13.5% of males successfully hatched ≥ 1 nest. Seventy-four percent of females (n = 42) and 26% of males (n = 50) surviving until 1 September successfully hatched ≥ 1 nest. Nesting females that survived the nesting period incubated a mean of 1.8 nests (SE = 0.13), and males incubated 1.0 nests (SE = 0.04). Of those birds that failed on an initial nesting attempt, 57.9% of females (n = 38) and 2 of 23 males incubated ≥ 1 renest. Of those females that were successful on their initial nesting attempt, 25.7% attempted second nests. Female first nests represented 45.9%, female renests 20.1%, female double-clutch attempts 5.7%, and male-incubated nests 28.3% of all nests located. Nest survival was 43.7% (SE = 3.9). The reproductive system of northern bobwhite enables recovery from low annual survival or periodic catastrophic declines and may be an adaptation to fluctuating resources in ephemeral, dynamic habitats.*

Keywords: Colinus virginianus, male incubation, nest success, northern bobwhite quail, reproductive effort, reproductive strategy, wildlife management

17. Burke, V. J., and J. W. Gibbons. 1995. **Terrestrial buffer zones and wetland conservation: A case study on freshwater turtles in a Carolina bay.** *Conservation Biology.* 9(6): 1365-1369.

Because freshwater wetlands often support diverse and unique species assemblages, wetland loss is a primary concern in biological conservation. U. S. federal statutes protect many wetlands by deterring development within delineated borders that segregate wetland habitats from upland regions. In addition, some state and local jurisdictions mandate buffer zones that afford varying levels of protection to upland habitats adjacent to wetlands. We used geographic information system analysis to test the adequacy of federal and state wetland protection statutes by determining the degree to which protected acreage encompassed the habitats freshwater turtles needed to complete their life cycles. Two critical life-cycle stages, nesting and terrestrial hibernation, occurred exclusively beyond wetland boundaries delineated under federal guidelines. The most stringent state buffer zone insulated 44% of nest and hibernation sites. Our data indicate that the freshwater turtles examined in this study required a 275-m upland buffer zone to protect 100% of the nest and hibernation sites. Insulating 90% of the sites required a 73-m buffer zone. We suggest that the habitat needs of freshwater turtles demonstrate the dependence of wetland biodiversity on the preservation of adequate amounts of upland habitats adjacent to wetlands.*

Keywords: buffer zones, freshwater turtles, geographic information system, wetland loss, wildlife habitat

18. Callicott, J. B. 2000. **Aldo Leopold and the foundations of ecosystem management.** *Journal of Forestry.* 98(5): 5-13.

Evolving from both Gifford Pinchot and his utilitarian philosophy of wise use, and John Muir and the preservation philosophy of wilderness, Aldo Leopold espoused - and practiced -- integrating a degree of wildness into the working agricultural landscape. As newly published essays show, his articulation of "land health" prefigures current definitions of ecosystem health, and the practices he preached anticipate today's prescriptions for ecosystem management. Although the science of ecology has evolved, and terminology has changed, Leopold's formulation may help both standardize and institutionalize the concept of ecosystem health, and his example may inspire an ambitious new goal in public and private land management.*

Keywords: Aldo Leopold, conservation, ecosystem management, forestry

19. Carley, T. J. 1999. **Tradeoffs in loblolly pine plantations and white-tailed deer management in the middle coastal plain.** Master's thesis. Mississippi State University. 53 pp.

Silvicultural applications focus on timber production, habitat production, or a combination of both. Thinning, prescribed burning, and herbicide applications are common silvicultural practices used in loblolly pine (*Pinus taeda*) plantations in the southern United States. The tradeoffs associated with multiple-use management focusing on the production of white-tailed deer (*Odocoileus virginianus*) habitat in Mississippi's Middle Coastal Plain using thinning, prescribed burning, and herbicide applications in loblolly pine plantations are examined from an ecological and monetary standpoint. Thinning and prescribed fire favorably impact the quality and quantity of available browse for white-tailed deer. Increased intensities of thinning and prescribed burning, above levels needed to maximize timber production, further increase the amount of quality deer browse available. The Land Expectation Value (LEV) of pine plantations managed at this level may be decreased if only costs and timber revenues are considered. However, a decrease in available lands managed intensively for white-tailed deer habitat offers opportunities for increased lease payments for managers controlling such lands. When LEVs were calculated using American Cyanamid Optimal

Reforestation Manager (ACORM™), compensatory lease payments ranged from $0.00 to $24.75 per acre, depending on the site index and discount rate chosen. When LEVs were derived using Cutover Loblolly Plantation Model (MSUGY©), compensatory lease payments ranged from $0.00 to $7.15 per acre, depending on the site index and discount rate chosen. Studies concerning lease payments in Mississippi reveal that realized lease payments on a per acre basis are more comparable to those compensatory lease payments suggested by MSUGY. Lease payments, when included in LEV calculations, will offset to some degree losses in timber revenue.*

Keywords: Land Expectation Value, multiple-use management, Odocoileus virginianus, white-tailed deer, American Cyanamid, ACORM™, MSUGY©

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20. Carroll, B., V. Landrum, and L. Pious. 1995. **Timber harvest scheduling with adjacency constraints: using ArcInfo to make FORPLAN realistic.** *ESRI User Conference.* n. pag. Online. Internet. 13 May 2000. Available http://www.esri.com/library/userconf/proc95/to300/p299.html.

FORPLAN is used by the U. S. Forest Service and private industry to schedule the management of forestland over time. However, FORPLAN is non-spatial and cannot model Oregon, Washington, and California regulations that constrain timber harvesting based on whether adjacent stands have been recently harvested. Therefore, FORPLAN may produce solutions that cannot be implemented in the field. To resolve this problem, Boise Cascade Corporation retained Pacific Meridian Resources to link ARC/INFO with FORPLAN to produce an application (the Spatial Feasibility Test, or SFT) that tests the feasibly of FORPLAN solutions against adjacency constraints. SFT applies a FORPLAN solution to a coverage of timber stands (up to 100,000 polygons have been tested). The user specifies a maximum adjoining size for any set of silvicultural treatments (e.g., maximum of 120 acres for clearcuts) in any period. SFT can also apply a regulation in which stands that are adjoining for less than a given percent (e.g., 10% in Washington) of their perimeter are not considered adjacent. SFT produces reports and coverages that itemize how well SFT was able to apply the FORPLAN solution to the ground. Boise Cascade will use SFT in an iterative manner: run FORPLAN; run SFT to apply adjacency constraints; re-run FORPLAN and SFT; and continue until SFT is fully able to allocate the FORPLAN solution. The resulting FORPLAN solution will then be implementable under adjacency constraints.*

Keywords: ARC/INFO, Boise Cascade Corporation, forestry, FORPLAN, Pacific Meridian Resources, SFT, timber harvesting, timber harvest planning, USDA Forest Service

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21. Carter, D. R., M. Vogiatzis, C. B. Moss, and L. G. Arvanitis. 1997. **Ecosystem management of infeasible guidelines? Implications of adjacency restrictions for wildlife habitat and timber production.** *Canadian Journal of Forest Research.* 27: 1302-1310.

The impacts of adjacency restrictions as a component of a set of ecosystem management guidelines are assessed for a public forest in Florida using an integer programming harvest scheduling model. Results show that depending upon the nature of jointly administered flow constraints, guidelines as prescribed are highly infeasible and will lead to extensive guideline violations over time. Under the most restrictive scenario examined, average volume is overestimated by 20% and value, by 37%, over the adjacency unconstrained model. Further, nearly one-fourth of the forest area will need to be left unmanaged to maintain adjacency and flow restrictions under the most restrictive scenario, which is a result of the biophysical nature of the system examined. Finally, the opportunity cost of adjacency restrictions is shown to be increasing function of the restrictiveness of various flow constraints, ranging from $2587 to $7085 per adjacency violation avoided.*

Keywords: ecosystem management, forestry, harvest scheduling, integer programming

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22. Carter, D. R., L. G. Arvanitis, D. Brackett, V. Boycheva, and S. Sager. 1999. **A decision support system for timber.** *Journal of Forestry.* 97(6): 12-18.

A World Wide Web interface has been developed for an integrated geographic information system (GIS) and timber harvest scheduling model. The interface builds on the Austin Cary Memorial Forest GIS, which was developed to enhance teaching, research, and extension in GIS and related technologies for students, professors, and professional foresters. This Web-based decision support system includes applications for browsing data, displaying maps and images, and modeling timber harvests. The timber harvest scheduling model allows users to experiment with different scenarios by observing how economic and physical parameter changes affect forest timber outputs and structure.*

Keywords: Austin Cary Memorial Forest, forest management, Geographic Information System, GIS, harvest scheduling, timber harvesting, World Wide Web

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23. Chang, S. J. 1983. **Rotation age, management intensity, and the economic factors of timber production: Do changes in stumpage price, interest rate, regeneration cost, and forest taxation matter?** *Forest Science.* 29(2): 267-277.

This paper presents a rigorous analysis of the impact of changes in timber price and cost of production factors on the optimal rotation age and planting density. With the exception of the site preparation cost, changes in the price of other factors always lead to the possibility of uncertain results. Applying the results obtained to forest taxation shows that replacing an ad valorem property tax with a combination of site value tax and yield tax may produce results that are not intended.*

Keywords: comparative statics analysis, forestry, land expectation value, rotation age

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24. Chang, S. J. 1984. **Determination of the optimal rotation age: A theoretical analysis.** *Forest Ecology and Management.* 8: 137-147.

This paper systematically analyzes the problem of the determination of the optimal rotation age. Using the land expectation value model, it shows that at the optimal rotation age *t**, the marginal revenue product (MRP) of letting the stand grow one more year must equal the marginal input cost (MIC) of doing so. The relationships between regeneration cost (C), interest rate (*r*), stumpage price level *P(t)*, and the optimal rotation age are then analyzed graphically. The relationships between the land expectation value model, the present net worth model, the forest rent model, and the traditional biological models are also examined. It is shown that the last three models are special cases of the land expectation value model.*

Keywords: forest rent model, forestry, land expectation value, optimal rotation age, present net worth

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25. Church, R., D. Stoms, F. Davis, and B. J. Okin. n. date. **Planning management activities to protect biodiversity with a GIS and an integrated optimization model.** n. pag. Online. Internet. 13 May 2000. Available http://www.ncgia.ucsb.edu/conf/SANTA_FE_CD-ROM/sf_papers/church_richard/my_paper.html.

We present the details of a general spatial model that was developed for the selection of biodiversity management areas in the Sierra-Nevada Region. This model is loosely integrated with a GIS. The basic modeling approach begins by first identifying those plant communities that are vulnerable due to land use activities in current management plans. The level of vulnerability is assessed for each element of interest on a spatial basis using ARC/INFO. The planning problem involves selecting an efficient set of watersheds for biodiversity management through specially developed heuristics and the Optimization Subroutine Library of IBM. Results of this approach are given for the northern region of the Sierra Nevada of California. The BMAS model represents a significant advance in GIS-based conservation planning, both in sophistication of the algorithms used and in the integration of cultural and land use data with biological data.*

Keywords: ARC/INFO, biodiversity, Biodiversity Management Area, Geographic Information System, GIS, habitat loss, watersheds

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26. Clements, S. E., Dallain, P. L., and Jamnick, M. S. 1990. **An operational, spatially constrained harvest scheduling model.** *Canadian Journal of Forest Research.* 20: 1438-1447.

A Monte Carlo integer programming algorithm was developed to generate short-term (25-year), spatially feasible timber harvest plans for a New Brunswick Crown license. Solutions for the short-term plan are considered feasible if they meet spatial and temporal harvest-flow and adjacency constraints. The solution search procedure integrates a randomly generated harvesting sequence and checks of harvest-flow and adjacency constraints. The model was used to determine the annual allowable cut under three constraint formulations. The three formulations represented increasing levels of adjacency constraints, from no constraints to levels similar to current provincial requirements. The annual allowable cut under the most strict constraint formulation was reduced by 9% from the unconstrained formulation, for a given mapping strategy of a long-term harvest schedule. These applications of the model indicate that it is suitable for spatially constrained harvest scheduling on Crown licenses in New Brunswick.*

Keywords: adjacency constraints, harvest scheduling, Monte Carlo integer programming

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27. Connaughton, K. P., and R. D. Fight. 1984. **Applying trade-off analysis to National Forest planning.** *Journal of Forestry.* 82(11): 680-683.

A trade-off analysis is required for National Forest planning. Trade-offs between outputs can be computed with the same linear programming mode of the forest used to prepare land-management alternatives. By systematically varying the objective for one of the outputs of an alternative, the resulting trade-off with the output measured by the objective function of the linear program is determined. Trade-offs cannot be reliably computed from the differences between land-management alternatives. Trade-offs may be overstated when inputs such as land are manipulated instead of outputs. A similar overstatement of trade-offs may occur when a sufficiently wide range of management regimes is not provided to the model. Since a trade-off analysis is only as good as the fundamental production relationships on which it is based, misleading trade-offs can result for alternative producing a mix of outputs outside the range of historical experience and supporting data.*

Keywords: land management, linear programming, National Forest planning, trade-off analysis, wildlife management

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28. Conover, M. R. 1997. **Monetary and intangible valuation of deer in the United States.** *Wildlife Society Bulletin.* 25(2): 298-305.

The value of wildlife to people can be measured by how a person's economic circumstances, or quality of life is affected. These effects can be both positive and negative. Positive values include recreational values to hunters and wildlife watchers. Negative values could include property damage and injuries that result from deer-vehicle collisions, or damage to agricultural crops and timber stands. The net value of the resource is the sum of all positive values minus the sum of all negative values. In this paper a theoretical approach is used to estimate the value of deer in the United States. Both monetary and non-monetary benefits and costs of deer to society are considered. A relationship between the valuation of deer and their populations is then hypothesized to determine optimum management numbers. This concept estimates that deer populations should be kept at that point where the positive value of deer is at the highest, as opposed to the biological carrying capacity for the species.

Keywords: economics, mule deer, Odocoileus hemionus, Odocoileus virginianus, white-tailed deer, wildlife

29. Cox, B. M., and I. A. Munn. 1999. **An input-output analysis of the incremental contributions of timber harvests to the regional economies of the South and Pacific Northwest.** In: *Timberland Investments: Improving the Odds. Proceedings of the 1999 Southern Forest Economics Workshop.* Biloxi, Miss. pp. 213-216.

An input-output analysis using IMPLAN was employed to quantify the incremental contributions of timber harvests to the regional economies of the South and Pacific Northwest United States. The primary objective was to compare the economic impacts of a one-million board foot (MMBF) change in harvest on the respective regional economies. Output, value added, personal income, and employment multipliers were used to evaluate the economic impacts of incremental change in harvest levels. Regional comparisons were based on incremental impacts per MMBF of timber delivered instead of the standard per dollar of output used in most input-output analyses. Because of dramatically different stumpage and delivery prices between regions, examining the incremental contributions to the regional economies from changes in harvest levels on a per MMBF basis more accurately illustrates the effects of changes in the national timber harvest policy. Incremental impacts per MMBF harvested are substantially greater in the Pacific Northwest than in the South: $280,708 more output; $149,762 more value added; $86,328 more personal income; and 2.05 more jobs.*

Keywords: economics, forestry, Impact Analysis for Planning System, IMPLAN, input/output analysis

30. Cox, E. S., and J. Sullivan. 1995. **Harvest scheduling with spatial wildlife constraints: An empirical examination of tradeoffs.** *Journal of Environmental Management.* 43(4): 333-348.

The impact of imposing spatial wildlife constraints on long-range timber management schedules is examined for a public forest in northern Virginia under varying levels of a wildlife habitat constraint. Linear programming-based timber management scheduling models are solved using (1) standard linear programming, (2) mixed integer programming with computer-determined stand allocations, and (3) mixed-integer programming with predetermined stand allocations in order to determine the extent to which the failure to consider explicitly the spatial aspects of a forest management problem with wildlife concerns may lead to an overestimation of timber production capacity. Findings indicate that present net value is overestimated by 1.8% to 21.4% and annual sawtimber harvest volume is overestimated by 2.6% to 13.5% when the standard linear programming approach is used.*

Keywords: allowable cut, area planning, forest fragmentation, harvest scheduling, linear programming, mixed-integer programming, wildlife constraints

31. Crookston, N. L. 1999. **Suppose: An interface to the Forest Vegetation Simulator.** USDA Forest Service. n. pag. Online. Internet. 26 May 2000. Available http://www.fs.fed.us/fmsc/fvs/suppose_overview.htm.

Suppose - a graphical user interface for the Forest Vegetation Simulator - simplifies the task of simulating the changes in forest vegetation for a long time span and a landscape spatial scope. This introduction of Version 1 of Suppose presents the system's goals and the applications in forestry it addresses. It illustrates the process of using Suppose, describes the input and output data, summarizes the program's features including those planned for future versions, and describes how you can get your own copy. Suppose runs under Windows 3.1, Windows 95, and Version 4 of AIX, IBM's version of Unix.*

Keywords: Forest Vegetation Simulator (FVS), forestry, Suppose, USDA Forest Service

32. Curtis, F. H. 1962. **Linear programming the management of a forest property**. *Journal of Forestry.* 60(9): 611-616.

This paper assesses linear programming as a forest management technique. A basic definition and history of linear programming is given. Its application to forest harvest scheduling is illustrated through two example problems based on property managed by Buckeye Cellulose Corporation. The first problem's objective is to develop a harvest schedule that maximizes total tonnage removed, while the second problem's goal is to maximize present value of the property at a five-percent discount rate. Optimum solutions for each problem are presented. The author points out that these solutions do not reduce the need for good judgement on the point of the land manager, but are a tool to guide decision-making.

Keywords: Buckeye Cellulose Corporation, forest management, forestry, linear programming, operations research

33. Dane, C. W., N. C. Meador, and J. B. White. 1977. **Goal programming in land-use planning.** *Journal of Forestry.* 75: 325-329.

The land-use planning process on the Mount Hood National Forest involves nine steps designed to identify needs, determine the complex interaction of effects from fulfilling these needs, and providing a means by which decision makers can see the tradeoffs required to achieve the various levels of need satisfaction. Goal programming, a variation of linear programming, has been experimentally used to assist in this process. As different alternatives were explored, the planners were able to determine (1) how land allocation shifted when goals were changed, (2) what outputs were the most sensitive, (3) how sensitive each goal was, and (4) the tradeoffs in choosing one goal over another.*

Keywords: forest management, goal programming, linear programming, Mount Hood National Forest

34. Davey, S. M. 1989. **Thoughts toward a forest wildlife management strategy.** *Australian Forestry.* 52(2): 56-67.

Wildlife management is becoming increasing important in Australian forestry and this paper presents the conceptual framework for a relevant wildlife strategy. Wildlife management in Australian forests might best be coordinated nationally. Because of the changing public perceptions of the role forestry must play in wildlife management in native forests, suggestions are made for the modification of present practice which will benefit both timber and wildlife management. The paper also reviews information requirements, the issues and the concerns important in the determination of such a strategy. Information bases are necessary for sound forest wildlife management. The concepts of minimum viable population and optimum habitat are discussed as well as wildlife management design in terms of zoning and the two integrated methods of core population and dispersed population techniques. It is argued that the standards of forest management have to improve to achieve the necessary balance between timber production and wildlife management. This will require an understanding of the aforementioned two concepts and the options available for integrating wildlife and timber management. Priority should be given to the determination of optimum habitat of species, forest site classification, and the ranking of wildlife species according to management need.*

Keywords: Australian forestry, forest management, optimum habitat, minimum viable population, wildlife management

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35. Demarchi, R. A. 1985. **What the wildlife manager expects from foresters - new initiatives in forestry and wildlife management in Canada.** *The Forestry Chronicle.* 61(2): 137-139.

The demands for land are increasing. Destructive forms of land use threaten the renewable resource base for both wood products and wildlife. The first order of cooperation between foresters and wildlife managers must be to protect the productive land base from destructive uses. The second order deals with how this land base and the timber resource are to be managed. The third order of cooperation between foresters and wildlife managers requires an appreciation of this fundamental problem. The dialogue between foresters and wildlife managers is increasing. Foresters should assist wildlife managers in encouraging economists to begin applying the economic benefits of wildlife as incentives to the private sector for improving wildlife habitat protection and management.*

Keywords: forestry, multiple use management, wildlife habitat, wildlife management

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36. Dickson, J. G., and J. C. Huntley. 1987. **Riparian zones and wildlife in southern forests: The problem and squirrel relationships.** In: J. G. Dickson and O. E. Maughan eds. *Managing Southern Forests for Wildlife and Fish: A Proceedings.* USDA Forest Service General Technical Report SO-65. pp. 37-47.

Mature woody vegetation along intermittent streams is often retained when upland stands are harvested and are planted inpine. These riparian zones bisecting pine plantations reduce non-point pollution and enhance wildlife habitat. Riparian zones produce forage and hard and soft mast, provide habitat diversity, function as habitat corridors, and serve as limited mature forest habitat. Studies are underway to assess the relationships of size and composition of riparian zones to populations of deer, squirrels (*Sciurus* spp.), wild turkeys (*Meleagris gallopavo*), furbearers, small mammals, breeding and wintering birds, and reptiles and amphibians. In eastern Texas, squirrels were abundant in riparian zones wider than 55 m but were rare in riparian zones narrower than 40 m. Studies of the other vertebrate groups continue.*

Keywords: forage, habitat corridor, mast, riparian zones, squirrel (Sciurus spp.), wildlife habitat

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37. Dyer, A. A., J. G. Hof, J. W. Kelly, S. A. Crim, and G. S. Alward. 1979. **Implications of goal programming in forest resource application.** *Forest Science.* 25(4): 535-543.

Goal programming, utilizing a preemptive priority formulation, is described and compared to linear programming to evaluate its effectiveness in solving public forest resource allocation problems. The logic used is that of welfare economics. It is concluded that goal programming does not, in general, generate the theoretically desirable solution to the public resource allocation problem. Goal programming is then analyzed as a "satisficing" algorithm and as a production feasibility test. The possibilities of failure in these applications are also pointed out. A sensitivity analysis on an example problem is included to demonstrate the theoretical conclusions made. Finally, policy-oriented conclusions are drawn and recommendations concerning the use of goal programming are presented.*

Keywords: land management planning, linear programming, operations research

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38. Dyer, A. A., J. G. Hof, J. W. Kelly, G. S. Alward, and S. A. Crim. 1983. **Implications of goal programming in forest resource application: A reply.** *Forest Science.* 29(4): 837-840.

Comments by Hrubes and Rensi (1981) comparing goal programming with linear programming for calculating welfare optima are discussed. It is agreed that linear programming solutions are rarely empirically perfect, but it is concluded that goal programming (utilizing a preemptive priority formulation) involves some additional logical inadequacies.*

Keywords: applied welfare theory, forest economics, goal programming, land management planning, linear programming

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39. Faulkner, J. L. 1994. **Hardwood timber in Mississippi: Recent trends in the resource and its use.** Master's Thesis. Mississippi State University. 129 pp.

USDA Forest Service Forest Inventory and Analysis data from 1977 and 1987 surveys were used to analyze the status of the hardwood resource in Mississippi. Significant differences between the data were determined for volume, growth, removals, and mortality. Examples illustrating differences between inventory and available volume were provided using operability constraints. Mississippi severance tax removals were used to determine differences in removals since 1987. Results from the 1994 survey of North Mississippi were analyzed to assess the latest inventory and compare severance tax removals. The 1977 and 1987 surveys indicate an increasing inventory. Severance tax removals, particularly for pulpwood in northeast Mississippi, have increased considerably since 1985. Trends evident in severance tax removals were also evident in the results of the 1994 North Mississippi survey. A shortage of hardwood timber in Mississippi is possibly due to the large increases in removals and small increases in hardwood regeneration.*

Keywords: economics, Forest Inventory and Analysis, hardwood resource, Mississippi, severance tax, USDA Forest Service

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40. Faulkner, J. L., P. E. Miller, A. J. Hartsell, J. D. London. 1994. **Forest statistics for central Mississippi counties - 1994.** Resource Bulletin SO-188. New Orleans, LA: U. S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 41 pp.

The Southern Forest Experiment Station, Forest Inventory and Analysis (SO-FIA) unit of the Forest Service conducts forest inventories of states in the southern United States including Alabama, Arkansas, Louisiana, Mississippi, east Oklahoma, Tennessee, east Texas, and the Commonwealth of Puerto Rico. Forest resource information is tabulated for the central counties of Mississippi from the 1994 USDA Forest Service inventory of Mississippi and is then analyzed and maintained for use in the development of forest policy and programs. Comparisons are made between the results of the 1994 inventory and the previous inventories conducted in 1987 and 1977.

Keywords: forest inventory, Mississippi, USDA Forest Service

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41. Faustmann, M. 1849. **Calculation of the value which forest land and immature stands possess for forestry.** Rpt. in *Journal of Forest Economics.* 1(1): 7-43.

In this paper the process for determining the value of land when it is managed for "forestry use", that is, growing a stand of timber, is discussed. The forest land rent formula is presented with examples for both even and uneven aged management regimes. Forest land rent is the net annual income that forest land will produce in perpetuity when normal forest yields are expected. Therefore, values of forest stands are calculated based on their future value when mature, rather than the sale price at their current age. Calculations of the forest land rent formula are discussed for land that is currently growing timber and tracts that are bare land, with the greatest application to management of tracts that are currently forested. These results are compared to the earlier work of von Gehren (1849) who when using the same examples determined that land values on bare land would be approximately three times higher than the Faustmann calculations. This difference is due to the fact that von Gehren used the geometric mean of interest rather than compound interest that is used by Faustmann.

Keywords: compound interest, even-aged management, Faustmann, forest land rent, forest management, uneven-aged management

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42. Field, D. B. 1973. **Goal programming for forest management.** *Forest Science.* 19(2): 125-135.

Goal programming is a mathematical procedure for the determination of a plan of action which offers a minimum aggregate deviation from a set of quantitative goals. The method is a modification of conventional linear programming and is motivated by two major weaknesses of that more familiar technique. This paper presents the technical details of the goal programming model, a review of its published use, and an illustration of a possible application to a forest management problem.*

Keywords: forest management, goal programming, linear programming, resource allocation

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43. Flather, C. H., and T. W. Hoekstra. 1989. **An analysis of the wildlife and fish situation in the United States: 1989-2040.** USDA Forest Service General Technical Report RM-178. 146 pp.

As part of the Forest and Rangeland Renewable Resources Planning Act, the USDA Forest Service has the responsibility of reporting the results of a national assessment of the country's wildlife and fish resources. Recent historical trends for wildlife and fish populations and habitat, projected inventories, and results of resource management programs are reported. This report states that recent trends show wildlife and fish habitat in decline. While forestland and rangeland have declined only slightly, wetland habitat has declined by as much as 14%. Current trends in wildlife and fish populations are closely associated with habitat trends. Large and small game populations associated with forest habitats have increased across the country, while small game species associated with agricultural lands have significantly decreased in the last 20 years. Waterfowl and fish are also in decline. In the ten-year period from 1970 to 1980, breeding duck populations declined from 44 million to 30 million birds. While fish populations are often difficult to determine, the capacity of the country's waters to support warm and cold water fish has also declined. While much of the country's wildlife and fish resources are in decline, the number of outdoor recreationists participating in fishing and non-consumptive activities is expected to double by 2040. These imbalances in recreational supply and demand will make managing the wildlife and fish resource challenging in the future. Careful management of wildlife and fish habitat, populations, and recreationists will be necessary.

Keywords: recreation, USDA Forest Service, wetlands, wildlife habitat

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44. Flather, C. H., T. W. Hoekstra, D. E. Chalk, N. D. Cost, and V. A. Rudis. 1989. **Recent historical and projected regional trends of white-tailed deer and wild turkey in the Southern United States.** USDA Forest Service General Technical Report RM-172. 22 pp.

Large-scale resource assessments are required by the Forest and Rangeland Renewable Resources Planning Act of 1974. This report describes the wildlife component of a regional modeling framework used to analyze multiple resource response to land management. The modeling framework, as applied in the southern United States, links fish, forage, water, and wildlife resources to land use and timber models. White-tailed deer (*Odocoileus virginianus*) and wild turkey (*Meleagris gallopavo*) were selected for analysis and their recent historical status reviewed. Habitat-based wildlife models were developed to analyze the impacts of land use and timber management. Discriminate function analysis was used to model the relationship between deer and turkey density classes with aerial estimates of cropland, rangeland, urbanland, timber management types, and forest age classes within a county. Projected changes in the land base for a baseline and several alternative scenarios were applied to the wildlife models. Over a 50-year projection period, deer and turkey densities declined in response to increasing urbanization and conversion of natural forests to pine plantations. This research has improved the capability to assess wildlife over large geographic areas and has demonstrated the feasibility of developing regional multiple resource analysis systems from existing land base inventories.*

Keywords: discriminate function analysis, Meleagris gallopavo, Odocoileus virginianus, white-tailed deer, wildlife habitat, wild turkey

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45. Fox, R. 1985. **Integration of wilderness values in forestry and wildlife management.** *The Forestry Chronicle.* 61(2): 163-165.

The paper defines wilderness from a naturalist's point of view. It argues the need to preserve pure wilderness by reserving intact ecosystems where no human disturbance is allowed, and in wildlands generally, to implement forestry and wildlife management practices that maintain the natural diversity of species of a region. It addresses the problem of protecting wilderness values from overuse by recreationists, and the need to manage wilderness areas to avoid such overuse.*

Keywords: cultural values, forest management, recreation, wildlife management

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46. Fredericksen, T. S., B. D. Ross, W. Hoffman, E. Ross, M. L. Morrison, J. Beyea, M. B. Lester, and B. N. Johnson. 2000. **The impact of logging on wildlife - a study in Northeastern Pennsylvania.** *Journal of Forestry.* 98(4): 4-16.

Nonindustrial private landowners in the eastern United States value seeing and conserving wildlife on their lands. They want profitable timber harvest, but also want to know how harvesting will affect wildlife. This study examines associations between stand characteristics and wildlife abundance on 40 stands in northeastern Pennsylvania. These oak-hickory or northern hardwood stands include a wide variety of topographic features, harvesting methods, and land uses. Stands were sampled for wildlife, including songbirds, small mammals, amphibians, and reptiles, as well as vegetation structure and composition. Correlation analysis was used to determine relationships between vegetation and structural characteristics and wildlife responses. In general, it was determined that small mammals and amphibians have the greatest species abundance in lightly harvested stands, while birds and reptiles have maximum abundance in more heavily logged stands. This study illustrates that landowners have some control over wildlife habitat development through harvesting.

Keywords: forestry, logging, nonindustrial private forestlands, Pennsylvania, wildlife

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47. Gan, J., S. H. Kolison, Jr., and J. P. Colletti. n. date. **Efficient and sustainable forest stock and harvest when nontimber benefits are valued.** Online. Internet. 13 May 2000. Available http://econ.usfs.msu.edu/ssaft/abstracts.htm.

This paper investigates the efficient steady-state forest stock, and harvest when both timber and non-timber benefits are valued. The results indicate that forest stock should be increased when non-timber benefit is valued in addition to timber benefit. In addition, the effect of the discount rate and the ratio of the marginal non-timber benefit to the marginal timber benefit on the optimal steady-state stock and harvest is of the same magnitude with opposite directions. The theoretical model is applied to the U.S. coniferous forests.*

Keywords: forest economics, forestry, linear programming, non-timber benefits, shadow price, timber valuation

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48. Gibbs, J. P. 1998. **Amphibian movements in response to forest edges, roads, and streambeds in southern New England.** *Journal of Wildlife Management.* 62(2): 584-589.

If management of landscape linkages is to be promoted as a means of conserving amphibian populations, it must be demonstrated that amphibian dispersal does not occur independently of ecosystem edges and other salient landscape features. I used drift fences and pitfall traps to intercept dispersing amphibians and examine amphibian movements relative to roads, forest edges, and streambeds in a forest tract in southern Connecticut. Capture rates of three species (marbled salamander, *Ambystoma opacum*; red-spotted newt, *Notophthalmus viridescens*; pickerel frog, *Rana palustris*) were influenced by forest borders and streambeds, whereas captures of three other species (spotted salamander, *Ambystoma maculatum*; redback salamander, *Plethodon cinereus*; wood frog, *R. sylvatica*) were not. Across all species, the relative permeability of forest -road edges was much reduced in comparison to the forest interior and to edges between forest and open land. The data suggest that landscape-

level conservation strategies aimed at amphibians should account for such filters and conduits to amphibian movement.*

Keywords: Ambystoma maculatum, Ambystoma opacum, amphibians, dispersal, edge effect, Notophthalmus viridescens, Plethodon cinereus, Rana palustris, Rana sylvatica, roads

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49. Glass, R. J., T. H. Stevens, and T. A. More. 1998. **Incorporating broad-based values into natural resource decision making: conceptual and measurement challenges.** In: *Proceedings of the 1998 Northeastern Recreation Research Symposium.* USDA Forest Service General Technical Report NE-255. pp. 204-209.

Optimal resource allocation requires meaningful measures of the values involved. Traditionally, resource managers have relied on economic values or surrogate measures of economic value such as willingness to pay. However, many commodities with which natural resource managers must deal are common property resources that lie outside traditional markets and are not suited to neoclassical economic analysis. This paper reviews the different conceptions of value and valuation techniques that have been developed to incorporate broad-based public values into decision-making.*

Keywords: contingent valuation, economics, existence values, natural resource economics, recreation, travel cost, valuation

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50. Golden, E. A. 1962. **Linear programming in harvesting forest products.** In: W. C. Hopkins, Ed. *Proceedings of the Annual Forestry Symposium: Producing, harvesting, and marketing high quality southern timber.* Louisiana State University Press, Baton Rouge, La. pp. 53-59.

A basic discussion of the history of linear programming and operations research and applications to forestry is presented. The components and expected outcomes of linear programs are also described. Using a sample problem of a forest products operation that produces both peeled fence posts and charcoal wood in the same operation, three methods of solution: algebraic, graphic, and simplex are illustrated.

Keywords: forest management, forestry, linear programming, logging, operations research

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51. Goodrum, P. D., V. H. Reid, and C. E. Boyd. 1971. **Acorn yields, characteristics, and management criteria of oaks for wildlife.** *Journal of Wildlife Management.* 35(3): 520-532.

Yields of acorns by seven species of oak (*Quercus* spp.), indigenous to forests of the upper coastal plain, were investigated in relation to tree characteristics and climatological variables in Louisiana and east Texas. Three species were studied from 1950 through 1967, three species from 1950 through 1955, and one species from 1950 through 1954. The amount of seed produced was related to bole diameter and size of crown, and the expected yields for six species were calculated by size-classes of boles and crowns. Radial growth was not a reliable indicator of seed yield. Some trees were inherently poor producers. Few trees below the age of 20 years produced seed. One freeze in late March during the flowering period affected seed production. There was no apparent relationship between amount of rainfall and seed production. The moisture content of acorns and the mean number of acorns required to weigh one pound was determined for each species. Forest dwellers, both mammalian and avian, made ready use of acorns of all species. In normal production years, the seed was usually gone from ground quadrants about the time seedfall was complete in early February, but in bumper years, some seed remained for longer periods. An estimate was made of the pounds of acorns required for five game species for a given period of time. The number of oak trees required to fulfill these needs, by species and size-classes of boles and crowns, can be determined from the expected yield tables.*

Keywords: acorn yields, forest management, mast, wildlife management

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52. Grado, S. C., G. A. Hurst, and K. D. Godwin. 1997. **Economic impact and associated values of the wild turkey in Mississippi.** In: *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies.* 51: 438-448.

The wild turkey (*Meleagris gallopavo*) has ecological, aesthetic, recreational, and economic values. Gross expenditures of hunters have been used to estimate economic values of game species. We examined the economic impact and associated values of the wild turkey in Mississippi. Expenditures of wild turkey hunters were obtained from a mail survey (N = 2,143, 69.6% response to economic section) and were used in an input-output model to determine economic impacts for the state. There were 39,775 hunters engaged in 334,856 activity-days in 1993. Wild turkey hunters spent an estimated $14.8 million or $44.27 per hunter day in 1993. Total sale impacts were $16.7 million. The value-added component of the economic impact totaled $10.4 million and supported 385 jobs. We also examined the structure of the economy in relation to the wild turkey. Expenditures and revenue in the state that related to the wild turkey were derived from industries, institutions, organizations, agencies, and associations. Revenues and income of these groups totaled $11.4 million in 1996. The wild turkey is a valuable resource in Mississippi, but the state's economy can further benefit by increasing the turkey population and expanding industries that manufacture equipment of materials associated with turkey hunting.*

Keywords: economics, hunting, input-output analysis, Meleagris gallopavo, Mississippi, wild turkey

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53. Greenberg, M. R. 1978. **Applied linear programming for the socioeconomic and environmental sciences.** Academic Press, Inc. New York, New York. 327 pp.

The basics of linear programming are explained without using corollaries and other mathematical techniques with which many

individuals may not be familiar. Basic concepts of optimization and matrix algebra are presented in early chapters. Later chapters provide information on applications of interest to planners economists, environmental scientists, geographers, engineers, and public servants; giving a broad overview of linear programming applications, example problems, and a bibliography. Areas of application covered include topics such as solid waste disposal, water quality, allocation of resources, land-use applications, and economic development, and transportation. This text seeks to appeal to a large number of readers who are more interested in the application of linear programming rather than the mathematics.

Keywords: economics, environmental sciences, linear programming, matrix algebra

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54. Gustafson, E. J., S. R. Shifley, D. J. Mladenoff, K. K. Nlmerfro, and H. S. He. 2000. **Spatial simulation of forest succession and timber harvesting using LANDIS.** *Canadian Journal of Forest Research.* 30: 32-43.

The LANDIS model simulates ecological dynamics, including forest succession, disturbance, seed dispersal and establishment, fire and wind disturbance, and their interactions. We describe the addition to LANDIS of capabilities to simulated forest vegetation management, including harvest. Stands (groups of cells) are prioritized for harvest using one of four ranking algorithms that use criteria related to forest management objectives. Cells within a selected stand are harvested according to the species and age cohort removal rules specified in a prescription. These flexible removal rules allow simulation of a wild range of prescriptions such as prescribed burning, thinning, single-tree selection, and clear-cutting. We present a case study of the application of LANDIS to a managed watershed in the Missouri (U.S.A.) Ozark Mountains to illustrate the utility of this approach to simulate succession as a response to forest management and other disturbance. The different cutting practices produced differences in species and size class composition, average patch sizes (for patches defined by forest type or by size class), and amount of forest edge across the landscape. The capabilities of LANDIS provide a modeling tool to investigate questions of how timber management changes forest composition and spatial pattern, providing insight into ecological response to forest management.*

Keywords: forest management, forest succession, LANDIS, Ozark Mountains, succession

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55. Hall, L. K., and H. L. Holbrook. 1980. **Wildlife management on Southern National Forests.** In: R. C. Chabreck and R. H. Mills, eds. *29th Annual Forestry Symposium: Integrating Timber and Wildlife Management in Southern Forests.* Louisiana State University. pp. 33-40.

Southern National Forests contain about 5% of the total forest acreage in the 14 southeastern states. These forests provide the public with both consumptive and non-consumptive wildlife related recreation opportunities. In Southern National Forests, wildlife habitat improvement for a given species is usually the result of timber management practices. Therefore, it is important that wildlife needs, such as food and cover, be addressed in the timber management regime. Although, a management compartment may be targeted for management of one particular species, other species are not excluded from the area. For example, white-tailed deer (*Odocoileus virginianus*) may also find habitat managed for wild turkey (*Meleagris gallopavo*) suitable. This flexible system helps the Forest Service manage their land to produce the wildlife species on an area that is best suited to that species.

Keywords: habitat management, Meleagris gallopavo, Odocoileus virginianus, timber management, USDA Forest Service, white-tailed deer, wildlife, wild turkey

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56. Hansen, A. J., T. A. Spies, F. J. Swanson, and J. L. Ohmann. 1991. **Conserving biodiversity in managed forests: lessons from natural forests.** *BioScience.* 41(6): 382-392.

Increasingly it is believed that biodiversity will not be conserved on "reserved" lands alone, such as federal and state lands. Lands managed for both commodity production and species diversity are needed to supplement the amount of available habitat. However, there is some question regarding how much managed lands differ in structure and species composition from natural or old growth stands. This article reviews stand structure, habitat diversity, and forest fragmentation in natural forests of the Coastal Northwest, and compares them to managed forests. It seems that intensively managed stands lack natural disturbances that create complex stand structures and biodiversity. Old growth is only one of several seral stages, and each stage provides habitat for many species. It is important that all stages be represented across a landscape to increase species diversity. Finally, land management must occur on a landscape scale to encourage native species diversity that is often influenced by the size, amount of edge, and distribution of stands. Although these stand characteristics are illustrated in the context of the Coastal Northwest, it is suggested that these management strategies can be adapted to local conditions and implemented in other areas where multiple-use management is a priority.

Keywords: biodiversity, forest fragmentation, forest management, habitat diversity, multiple-use management, stand structure

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57. Hansen, M. H., T. Frieswyk, J. F. Glover, and J. F. Kelly. 1992. **The Eastwide forest inventory database: Users manual.** Gen. Tech. Rep. NC-151. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 48 pp.

The USDA Forest Service completes periodic forest inventories for each state in the United States. In the East, this is usually done every five to 15 years. The results of this inventory are compiled into what is known as the Eastwide database (EWDB). This publication describes basic sampling and estimation procedures and accuracy standards. The standard EWDB computer file structure, which was developed to provide consistent data on the forest resources of the eastern United

States, is discussed in detail. Variable definitions and sample calculations all aid the reader in using the information in the database. These data files are available to the public.

Keywords: data management, data processing, information management systems, inventory methods, plot measurements, USDA Forest Service

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58. Hardie, I. W., J. N. Daberkow, and K. E. McConnell. 1984. **A timber harvesting model with variable rotation lengths.** *Forest Science.* 30(2): 511-523.

A generalization of the Faustmann soil rent model is offered which allows for changing rotation lengths over time. Optimization conditions are analyzed and a solution procedure suggested. The variable rotation length model is used to determine whether the Faustmann formulation can be modified or used in situations where prices and production costs vary temporally. Results from both constant and variable rotation models and from an alternative proposed by Bare and Waggener are compared for loblolly pine plantations in the Mid-Atlantic region.*

Keywords: economic optimization, Faustmann, forest economics, timber rotation

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59. Harris, L. D., and P. J. Skoog. 1980. **Some wildlife habitat-forestry relations in the southeastern coastal plain.** In: R. C. Chabreck and R. H. Mills, eds. *29th Annual Forestry Symposium: Integrating Timber and Wildlife Management in Southern Forests.* Louisiana State University. pp. 103-119.

Forest land is the most important wildlife habitat type in the southeastern United States. Wildlife habitat must include food, water, cover, areas to reproduce, and open space for successful management of any given species. Regional characteristics of these forests can act as constraints on forest-wildlife management activities. Wildlife habitat has been affected in recent years due to four major changes that have occurred in southeastern forests. These changes include: 1) a reduction in total forest acreage, 2) a reduction in stand acreage, 3) conversion of hardwood and longleaf pine (*Pinus palustris*) sites to other uses, and 4) intensive pine management. To overcome these constraints and integrate timber and wildlife management, planning must be done at the landscape level.

Keywords: forest management, wildlife habitat planning, wildlife management

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60. Hay, M. J., and K. E. McConnell. 1984. **Harvesting and non-consumptive wildlife recreation decisions.** *Land Economics.* 60(4): 388-396.

This paper examines the relationship between non-consumptive wildlife activities, such as wildlife watching, and harvesting-oriented wildlife activities, such as hunting and fishing. It has long been believed that there is an antagonistic relationship between non-consumptive users and hunters, because non-consumptive users are frustrated by the focus by federal agencies on game species. Through analysis of the 1975 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation and the 1971 National Outdoor Recreation Survey this relationship was examined. Overall it was determined that hunting and wildlife observation are complementary. Policy that affects natural resources available for an activity of interest, such as duck hunting, is likely to also affect non-consumptive activities that are complementary, such as bird watching. Therefore, natural resource planners should include a broad range of activities when striving to meet future demands for wildlife recreation.

Keywords: fishing, hunting, non-consumptive uses, wildlife management, wildlife recreation

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61. Haynes, R. W., and J. F. Weigand. 1997. **The context of forest economics in the 21st Century.** In: Kathryn A. Kohm and Jerry F. Franklin (Eds.). *Creating a forestry for the 21st Century: The science of ecosystem management.* Washington, D. C.: Island Press. pp. 285-301.

The problems and controversies surrounding forestry and ecosystem management will not be corrected by economics alone. However, economics will be able to provide insight into the question of how to meet the natural resource needs of the public, and still provide for future generations. This paper makes four key points regarding the role of economics in ecosystem management. First, the future ecosystem management goals will be driven by public supply and demand. Second, in some cases, ecosystem management may sacrifice the good of the local or rural communities to increase regional or national welfare. Third, the goods and services that the public values need to be linked to the expected outputs from ecosystem management. Finally, ecosystems can only be sustained if the public's economic demands are accounted for in those systems.

Keywords: ecosystem management, forest economics, forestry, natural resources

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62. Hof, J., and M. Bevers. n. date. **Linear approaches to spatial optimization.** 11 pp. Online. Internet. 19 May 2000. Available http://econ.usfs.msu.edu/ssafr/abstracts.htm.

This paper documents formulations for four different spatial optimization problems that use linear (continuous-variable) programming. The first problem examines estimated population growth rates of captive bred and released black-footed ferrets (*Mustela nigripes*), one of the world's most endangered animals. The second problem models black-tailed prairie dog (*Cynomys ludovicianus*) recovery strategies for the Conata basin area of South Dakota. The possibility of using optimization methods to develop a management strategy for exotic pest control is examined in the third section. Finally, in the fourth section, habitat availability and carrying capacity for the northern spotted owl (*Strix occidentalis caurina*) were examined. In each case the optimization model is presented with formulae and discussions of variables. However, for more discussion on case study results, the reader is referred to Bevers et al (1997), Hof et al. (in preparation), Hof (in review), and Hof and Raphael (in press).*

Keywords: black-footed ferrets, black-tailed prairie dog, Cynomys ludovicianus, exotic pest control, linear programming, Mustela nigripes, northern spotted owl, operations research, Strix occidentalis caurina

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63. Hof, J., and M. Bevers. 2000. **Optimizing forest stand management with natural regeneration and single-tree choice variables.** *Forest Science.* 46(2): 168-175.

This article addresses the any-aged forest management problem with individual trees as the choice variables in integer programming models. In order to sustain the forest using natural regeneration, spatial proximity of seed trees is required for harvesting to take place in these models. This problem requires integer variables to avoid harvesting part of a tree, but is remarkably integer-friendly. Solvability of large models is thus explored, along with the patterns of solution that can be recognized in smaller models. Results from these exploratory models are sensitive to initial forest conditions and do not display the steady state conditions typically assumed for uneven-aged management in the literature.*

Keywords: integer programming, seed trees, spatial optimization, sustainability

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64. Hof, J., M. Bevers, L. Joyce, and B. Kent. 1994. **An integer programming approach for spatially and temporally optimizing wildlife populations.** *Forest Science.* 40(1): 177-191.

This paper presents mixed integer linear programming formulations that optimize the spatial layout of management actions for providing wildlife habitat over time. The formulations focus on wildlife growth and dispersal as a dynamic, probabilistic process. Habitat fragmentation/connectivity is thus modeled indirectly. Multiple timber age classes are accounted for as different wildlife habitat types, which define carrying capacity limitations that are tracked spatially. A variety of objective functions are specified, including those based on piecewise-approximated nonlinear functions that relate wildlife populations to the probability of species viability. All of the formulations and objective functions are demonstrated with a case example.*

Keywords: habitat fragmentation, linear programming, species richness, wildlife management

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65. Hof, J. G., M. B. Bevers, and B. Kent. 1997. **An optimization approach to area-based forest pest management over time and space.** *Forest Science.* 43(1): 121-128.

This paper discussed spatial optimization approaches to managing aggressively reproducing and dispersing pests. The relevant land planning area is divided into cells, and pest growth and dispersal across those cells are accounted for in integer programs that include choice variables for applying control treatments to those cells. Two model formulations are developed and demonstrated in a simple case example: one assumes no limit to host capacity and one that assumes a limit to host capacity accumulated over time. The formulation with no host capacity limit is shown to be potentially unrealistic if control treatments are not limited. Different objective functions and amounts of control treatment result in optimal strategies that vary from immediate containment near the pest's origin to delayed containment at an area away from the pest's origin. Both formulations are difficult to solve, reflecting the exploratory nature of this paper.*

Keywords: integer programming, spatial analysis, pest dispersal, spatial optimization

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66. Hof, J., and L. A. Joyce. 1993. **A mixed integer linear programming approach for spatially optimizing wildlife and timber in managed forest ecosystems.** *Forest Science.* 93(4): 816-834.

This paper presents a mixed integer linear programming formulation for land allocation that optimizes the spatial layout for a single time period and that have the property that the number of integer variables is a linear function of the level of spatial resolution. The formulations focus on timber, edge-dependent wildlife, and area-dependent wildlife. They account for the amount of edge, the fragmentation of habitat area, and a habitat area threshold for minimum viable population size. Habitat area connectivity is modeled as a probabilistic condition. A case example demonstrates the approaches and includes landscape characteristics such as terrain, hiking trails, campgrounds, and rivers, which result in different productivities over the landscape and obstacles to wildlife habitat area connectivity.*

Keywords: edge effects, habitat connectivity, habitat fragmentation, probabilistic optimization, species richness

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67. Hof, J. G., and M .G. Raphael. 1993. **Some mathematical programming approaches for optimizing timber age-class distributions to meet multispecies wildlife population objectives.** *Canadian Journal of Forest Research.* 23: 828-834.

We investigated three approaches for finding optimum allocations of forest age-classes to meet multi-species conservation objectives for a community of terrestrial vertebrate species. We illustrate our approaches using data on relative abundances of 92 species of amphibians, reptiles, birds, and mammals sampled from five habitat types (age-classes) of Douglas-fir (*Pseudotsuga menziesii* (mirb.) Franco) forests in northwestern California. Our three approaches involved in maximizing (1) the expected number of viable species; (2) the minimum probability of viability among all species; and (3) the joint probability of viability across all species. Each approach was demonstrated using an assumption that viability is linearly related to abundance or that viability is logistically related to abundance. We discuss limitations of our approach focusing on assumptions of data quality, relative conservation priority among taxa, relationships between estimated abundance of a population

and its probability of viability, interspecific interactions, and the need for evaluation of spatial distribution of habitats.*

Keywords: forest management, habitat, multi-species conservation, Pseudotsuga menziesii

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68. Hokans, R. H. 1983. **Evaluating spatial feasibility of harvest schedules with simulated stand-selection decisions.** *Journal of Forestry.* 81(9): 601-613.

Harvest schedules that require the cutting of adjacent stands within a limited time period may create openings of sizes that exceed policy restrictions. A procedure has been developed to assist in identifying these excesses within the spatial pattern of a proposed harvest schedule. Further, the system is capable of evaluating the extent of these openings sized for alternative spatial patterns of harvesting, and for the effects of current selections in future planning periods. A pilot study was completed on an 82,000-acre portion of the Chattahoochee National Forest. Due to maximum opening size restrictions, it was found that over 50-percent of the forest's mature hardwood stands would be unavailable for harvest in the first ten-year planning period, and that in the second ten-year period only 45-percent would be available. This process allows forest planners to evaluate alternative harvest schedules and evaluate current harvest plans based on spatial feasibility when size restrictions are in place.*

Keywords: adjacency constraints, Chattahoochee National Forest, harvest scheduling

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69. Hornbeck, J. W., and W. T. Swank. 1992. **Watershed ecosystem analysis as a basis for multiple-use management of eastern forests.** *Ecological Applications.* 2(3): 238-247.

There is an ever-increasing competition for the many uses and natural resources of forests in the eastern United States. Multiple-use management has long been a stated goal for these forests, but application has been problematic and seldom satisfactory to all users. There is a need to incorporate more science into management decisions for Eastern forests, and thereby convincingly demonstrate to forest managers and the public why certain combinations of users may or may not be compatible. One proven approach for doing this is to use watershed ecosystem analysis. Small watersheds, usually <100 ha in area, serve as a convenient ecosystem for studying how forests function in terms of cycling energy, nutrients, and water. Results of these studies allow assessments for forest health and productivity, and evaluations of impacts of both natural and human-related disturbances. This paper provides illustrations of how watershed ecosystem analysis can be used to study the effects of current harvesting practices, acidic deposition, and past land use. The paper also shows how recommendations for land use are derived from watershed ecosystem analysis, and how they are put into practice.*

Keywords: eastern forests, ecosystem, logging, multiple-use management, watersheds, watershed ecosystem analysis

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70. Holt, S. 1990. **Human encroachment on bear habitat.** In: *GIS Applications in Natural Resources.* M. Heit and A. Shortreid Eds. pp. 319-321.

Land use alterations in western Massachusetts has had significant impacts on black bear (*Ursus americanus*) populations. Increases in human populations and fragmentation of forest habitats have caused suitable habitat to be extremely limited. This paper assesses how these changes have affected black bear habitat through examination of historical landcover data and current telemetry work. With this information, range sizes, habitat preference, and population dynamics are determined and updated on a Geographic Information System (GIS). Managing these data on a GIS will provide land managers with a tool for making decisions regarding black bear populations. When development is anticipated, the GIS can be consulted to determine the possible impacts on habitat as well as suggest alternate sites for development.

Keywords: black bear, Geographic Information System, GIS, habitat analysis, Ursus americanus

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71. Hrubes, R. J., and G. Rensi. 1981. **Implications of goal programming in forest resource allocation: Some comments.** *Forest Science.* 27(3): 454-459.

Goal programming (G.P.) and linear programming (L.P.) solutions are compared with respect to their proximity to the welfare optimum. The conditions under which L.P. yields Pareto optima are discussed; these conditions generally do not hold in the wildland political economy. In economies with market imperfections, neither G.P. nor L.P. categorically lead to Pareto optimal allocations.*

Keywords: applied welfare theory, forest economics, goal programming, linear programming

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72. Hughes, J. W., and T. J. Fahey. 1991. **Availability, quality and selection of browse by white-tailed deer after clearcutting.** *Forest Science.* 37(1): 261-270.

We evaluated the effect of large-scale forest harvest on the production, nutritive quality, twig size, and use of four preferred species of browse by white-tailed deer (*Odocoileus virginianus*) in a spruce-fir forest in New Hampshire. Red maple (*Acer rubrum*) produced the most new twigs (44-fold increase three years after harvest), and 99% of these were sprouts from stumps. Mountain maple (*Acer spicatum*) and mountain ash (*Sorbus americana*) twig production increased by factors of 3.5 and 1.9 respectively, and most twigs were borne on stems that survived the clearcutting. Most yellow birch (*Betual alleghaniensis*) (4-fold increase after three years) colonized from newly dispersed seed. For all species of browse except yellow birch, clearcutting resulted in (1) significantly larger, heavier twigs, and (2) significantly higher concentrations of protein and soluble carbohydrates. Deer removed a higher proportion of twigs from the clearcut than from the uncut forest. Mountain ash and mountain maple were the preferred species on both sites. Management implications are discussed.

Keywords: forest management, Hubbard Brook Experimental Forest, nutrition, Odocoileus virginianus, white-tailed deer

73. Hurst, G. A., and R. C. Warren. 1980. **Intensive pine plantation management and white-tailed deer habitat.** In: R. C. Chabreck and R. H. Mills, eds. *29th Annual Forestry Symposium: Integrating Timber and Wildlife Management in Southern Forests.* Louisiana State University. pp. 90-102.

Loblolly pine (*Pinus taeda*) plantations and natural pine-hardwood forests in Kemper County, Mississippi were studied to determine the effects of intensive pine plantation management on white-tailed deer (*Odocoileus virginianus*) habitat. Three site preparation methods were studied including mist-blown and tree-injected, tree-crushed and burned, and bedded. In addition, controlled burning, spraying, fertilizing, and thinning were examined. It was found that all plantations between one and nine years old had significantly higher amounts of deer food, such as vines, forbs, wood plants and soft mast, than pine-hardwood stands in the summer months. By the time the plantation was 10-12 years old, there was no difference in the forage found in the plantations and the pine-hardwood tracts. All tracts, both plantation and pine-hardwood had much lower quantities of deer forage in winter. Pine plantations from ages one through seven had more deer forage, such as grass, forbs, and vines, than pine-hardwood stands in the winter, regardless of site preparation type. When considering the amount of soft and hard mast in the natural forest, pine-hardwood stands provide more total deer food during the winter months by age three. Overall, it was found that more intensive pine management produced more forage for deer.

Keywords: forest management, loblolly pine, Mississippi, Odocoileus virginianus, Pinus taeda, white-tailed deer, wildlife management

74. Hynard, P. P. 1985. **Integrating forestry and wildlife management: The view of the private land timber resource user.** *The Forestry Chronicle.* 61(2): 156-158.

Timber resource user views of integrating timber and wildlife management on private lands vary considerably. The users of private timberland include the private landowner, the logger, and mills dependent on local timber supply. Private landowner's objectives vary considerably, whether the land is used primarily for recreation or income from timber sales. Loggers tend to view forest-wildlife integration unfavorably especially if it results in increased logging costs. Individuals in local mills often share loggers' negative views due to perceptions of increased wood procurement costs and dwindling log supply. Each viewpoint is presented separately and in depth. This discussion is followed by a review of a case study of Haliburton County, which is located south of Algonquin Park, Ontario. Haliburton County is 90% forested and relies heavily on both the timber industry and seasonal big game hunting for revenue.

Keywords: forest management, integrated land management, private forest lands, wildlife management

75. Innes, M. R. 1985. **The problems of integrating forestry and wildlife management: The foresters' viewpoint.** *The Forestry Chronicle.* 61(2): 134-136.

The long-established professions of biology and forestry harbour conscientious and intelligent practitioners. Communication between the two professions has traditionally been poor but is slowly improving. For integrated resource management to be successful, an acceptable planning framework must be established; there must be clearly enunciated and agreed-to objectives; cooperation between biologist and forester will be mandatory; and abnormally heavy commitment of time will be necessary. The cost of implementation will be a stumbling block.*

Keywords: forestry, multiple-use management, wildlife management

76. Jamnick, M. S., and K. R. Walters. 1993. **Spatial and temporal allocation of stratum-based harvest schedules.** *Canadian Journal of Forest Research.* 23: 402-413.

Stratum-based timber harvest schedules must be disaggregated into operational plans prior to implementation. In most cases this is an expensive and time-consuming manual task that does not ensure consistency between the long-term harvest schedule and short-term operational activities. This paper presents the results of applying the CRYSTAL algorithm, which automates the disaggregation and allocation of a stratum-based harvest schedule into harvest blocks, to a small forest in New Brunswick. The results indicate that it is possible to use a set of allocation guidelines to quickly delineate harvest blocks in a consistent, reproducible manner. We also discuss how the algorithm is used in conjunction with a Monte Carlo integer programming model to estimate the potential losses in timber harvest volumes attributable to deviations from the stratum-based schedule and the addition of adjacency constraints.

Keywords: CRYSTAL algorithm, harvest scheduling, integer programming

77. Johnson, A. S. 1987. **Pine plantations as wildlife habitat: A perspective.** In: J. G. Dickson and O. E. Maughan eds. *Managing Southern Forests for Wildlife and Fish: A Proceedings.* USDA Forest Service General Technical Report SO-65. pp. 12-18.

Pine (*Pinus spp.*) forests in various stages of succession provide important seasonal habitat for many wildlife species, and open, frequently burned pine forests are crucial habitat for some species. But extensive unbroken tracts of pure pine are not good habitat for wildlife in general. Historical evidence indicates that the great abundance of wildlife in pre-colonial southern forests resulted from a mixture of forest types with abundant old growth and substantial areas of openings and early successional forests interspersed. Extensive pine barrens supported relatively little wildlife. On pine sites, the diversity of age classes provided by modern, even-age forest management can provide good habitat for more vertebrate species than some of the original pine forests, but much depends on how forests are managed. Hardwoods are essential for most wildlife species. The

conversion and attempted conversion of hardwood sites to pine often has been counter to wildlife interests, but the current trend toward less intensive timber management on marginal sites probably is beneficial. The vagaries of economics will determine the place of wildlife in southern forests. In recent years the economic position of game animals relative to timber has improved and may provide additional incentives for incorporating wildlife enhancement measures into forest management plans.*

Keywords: forestry, habitat management, Southern United States, wildlife benefits, wildlife management

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78. Johnson, K. N. 1976. **Optimizing timber sales during the conversion period.** *Canadian Journal of Forest Research*. 6: 462-466.

A perennial problem in the timber management concerns the rate at which timber should be sold while a forest is converted from an unregulated to a regulated condition. An analysis of this problem was recently undertaken for a private timber company in the western United States. Study of alternative timber flows over the first half of the conversion period revealed that the firm faced a definite trade-off between stability and amount of income. Because the firm faced a downward-sloping demand for its stumpage, immediate liquidation of all available timber, as indicated by classical financial maturity techniques, was not appropriate. Quadratic programming was used to find an income-maximizing harvest rate that recognized this downward-sloping demand.*

Keywords: forest economics, forest management, quadratic programming

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79. Johnson, K. N., and H. L. Scheurman. 1977. **Techniques for prescribing optimal timber harvest and investment under different objectives - discussion and synthesis.** *Forest Science Monograph 18*. 31 pp.

Numerous techniques have been suggested for optimizing timber harvest and investment on public and private forests managed on an even-aged basis. Two models are presented which appear to be the basis for techniques commonly used to solve this optimization problem. A number of these techniques are presented as formulations of the linear or quadratic objective forms of the two models. Techniques covered in the discussion on the linear objective form include simple financial maturity, soil rent, and financial maturity including land holding costs. The relation of Timber Resources Allocation Method (Timber RAM) to this linear objective form is discussed, and a number of iterative allowable cut techniques, such as area-volume check, Simulating Intensively Managed Allowable Cut (SIMAC), and Short Run Allowable Cut (SORAC), are formulated as linear objective versions of the models. Techniques covered in the discussion on the quadratic objective form of the models include simple financial maturity and financial maturity including land holding costs. The Economic Harvest Optimization Model (ECHO) is formulated as a quadratic objective version of one of the models.*

Keywords: financial maturity, Kuhn-Tucker theorem, linear programming, quadratic programming, timber harvesting

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80. Jones, D. W., I. Munn, S. Grado, and J. Jones. 1999. **Fee-hunting and wildlife management activities by nondindustrial, private landowners in the Mississippi Delta.** Proceedings of the *29th Annual Southern Forest Economics Workshop*. Biloxi, Miss. pp. 69-74.

Hunting and related wildlife management activities represent a relatively untapped source of income to bottomland hardwood landowners. Landowners in four Mississippi Delta counties were surveyed to determine hunting and wildlife management activities and related revenues and expenses permitted on their land. A total of 1,161 questionnaires were mailed to a random sample of Mississippi nonindustrial, private landowners who owned at least 40 acres in Issaquena, Sharkey, Warren, and/or Washington counties. A total of 567 useable questionnaires were returned (49% response rate). Thirty-four percent of Delta landowners managed wildlife on at least some of their land. Deer and waterfowl were the two most commonly managed wildlife species. Average annual costs of wildlife management practices includes vegetation management ($766), plantings for food and cover ($1,568), installation and maintenance of concealment blinds and stands ($445), and plantings and flooding for waterfowl ($693). Although forest land, which is predominately bottomland hardwood, represented 33% of the total landholdings sampled, it accounted for 52% of the land committed to fee-hunting. Most landowners permitted hunting (67%), but less than 14% charged for hunting privileges. Annual lease payments per landowner averaged $4,007 ($5.41/ac). When gun fees or permits were used, annual revenues averaged $8,339 ($4.14/ac). Mean fee-hunting revenues and profits were $5.15/ac and $2.63/ac, respectively.*

Keywords: fee-hunting, Mississippi Delta, wildlife management

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81. Jones, J. G., B. J. Meneghin, and M. W. Kirby. 1991. **Formulating adjacency constraints in linear optimization models for scheduling projects in tactical planning.** *Forest Science*. 37(5):1283-1297.

Models for scheduling projects in tactical planning often must contain relationships that restrict activities on adjacent lands. Conventional formulations of these relationships require large numbers of constraints. Minimizing the number of constraints permits modeling larger areas when faced with software and hardware limitations on number of constraints. This paper presents an approach for efficiently formulating adjacency relationships in mixed-integer programming models. The approach typically results in one-half to one-quarter of the number of equations required by formulations used in the past.*

Keywords: dispersion constraints, linear programming, site-specific planning, site-specific optimization

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82. Josephson, H. R. 1976. **Economics and National Forest timber harvests.** *Journal of Forestry*. 74: 605-608.

Proposals that the Forest Service use economic models in lieu of an "even-flow" policy in scheduling national forest timber harvests assume a goal of maximizing the present net worth of

monetary incomes. Economic calculations, however, must also consider costs and benefits of indirect "external" effects, and must identify an appropriate social rate of discount. An illustration of alternative harvest schedules, based on current indications of timber demand and supply elasticity and trends, suggests that acceleration of harvests would increase the present net worth for "other" owners. Political acceptability is also a highly relevant consideration.*

Keywords: forest economics, forest management, harvest scheduling, present net worth

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83. Joyce, L. A., T. W. Hoeksta, and R. J. Altig. 1986. **Regional multiresource models in a national framework.** *Environmental Management.* 10: 761-772.

The design and integration of models projecting the effects of management on environmental systems is one step in the environmental planning process. Interactions between resources produced on the same unit of land under current and future management can be examined only when assumptions and processes of these dynamic environmental systems are qualified. Multiresource interaction models have generally been large and cumbersome while also suffering from an inadequate amount of detail. This article presents a conceptual framework for integrating individual resource models to project multiresrouce interactions at a regional scale. Land management impact projections require common definitions of the total land base and common definitions of management activities applied to the same unit. A case example focusing on the resources of timber, forage, wildlife, fish and water for the southern United States is presented.*

Keywords: fish, forage, land management, multiresource planning, southern United States, timber, wildlife

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84. Karr, J. R. 1981. **An integrated approach to management of land resources.** In: R. T. Dumke, G. V. Burger, and J. R. March eds. *Wildlife Management on Private Lands.* La Crosse Printing Co., Inc., La Crosse, Wisconsin. pp. 164-192.

The decline of many wildlife species in recent years has been a result of a decrease in the quality of habitat available, especially in agricultural areas. Several programs such as conservation plans developed by the Soil Conservation Service, Resource Conservation Act, and Section 208 Water Quality Act have been developed to address the issue of resource quality, but have done so with mixed success largely because they have been applied in piecemeal. Natural resource management is a long-term process, and private market values often do not accurately reflect the social values of these resources. Resources should be managed at the landscape level, and best management systems developed for a variety of resources in the management unit. A classification of the land and its capabilities must be developed and their functional uses defined. These functional uses can be divided into four categories: 1) productive environments (e.g., forestry and agriculture), 2) protective environments (natural areas, preserves), 3) compromise environments, which give the benefits of both 1) and 2) but are not exclusive, and 4) urban-industrial environments.

Keywords: forestry, natural resource management, wildlife management

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85. Keefer, B. J., D. M. Long, and D. S. Mullen. 1996. **Integrating GIS with spatially constrained harvest scheduling.** In *Proceedings of the 1996 Southern Forestry GIS Conference.* p. 20-29.

The need to incorporate spatial constraints such as an upper limit on clear-cut size into harvest schedules has been recognized by many forest management planners within the forest industry. GIS is a necessary tool to facilitate these scheduling activities. This paper describes an approach to tactical harvest planning used by Rayonier on its 870,000 acres of timberland in Florida and Georgia. This approach integrates GIS, linear programming models, and heuristic simulation approaches to produce 15-year tactical harvest schedules. Initially, GIS is used to generate maps displaying a traditional optimized stand level schedule produced using a linear programming solution. Using these maps, harvest unit boundaries are then designed to conform to clear-cut size restrictions and operational harvest units. This layer is unioned with the original timber stand layer to resummarize stand inventory information by harvest unit. GIS is also utilized to output a matrix of harvest unit adjacencies. This data is input into a heuristic simulation model that enforces a user specified lag period between adjacent harvest units to accomplish green-up restrictions. The final schedule solution is then analyzed using GIS and presented in various mapping formats. This is an operational procedure incorporating spatial constraints using GIS that has been implemented and under which Rayonier's forest lands are currently being managed.*

Keywords: geographic information system, harvest scheduling, heuristic simulation, linear programming, Rayonier

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86. Kent, B. M.., 1989. **Forest Service land management planners' introduction to linear programming.** USDA Forest Service General Technical Report RM-173. 36 pp.

This report provides a detailed explanation of basic concepts of linear programming (LP) for forest planners and others who must use the techniques to develop national forest land management plans. The role of LP in national forest planning analysis is presented. Basic algebraic concepts needed to understand LP are reviewed. The various components of an LP model are described and the advantages and limitations of the technique are discussed. Examples are presented in order to illustrate the technique, how it is used to formulate forest planning models, and how it is used in the Forest Service land management planning process. Procedures for solving LP models and the technique known as goal programming are also discussed. No prior background in LP is assumed on the part of the reader.*

Keywords: forest management, forest planning, goal programming, linear programming, USDA Forest Service

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87. Kessler, W. B., H. Salwasser, C. W. Cartwright, Jr., and J. A. Caplan. 1992. **New perspectives for sustainable natural resources management.** *Ecological Applications.* 2(3): 221-225.

The USDA Forest Service is taking a new direction in its research and management programs in response to changing views of land and natural resources. The changes reflect the complexity of society's concerns and expectations for national forest management, including biological diversity, ecological function and balance, product yields, social values, and the beauty and integrity of natural environments. The new direction involves a shift in management focus for sustaining yields of competing resource outputs to sustaining ecosystems. More than ever, management of public lands and resources requires knowledge about ecosystems, including relationships to human values, activities, and patterns of resource use. Also required are new roles for scientists, including closer partnerships with managers to achieve large-scale studies and adaptive management of public lands and resources.*

Keywords: adaptive management, biodiversity, ecosystem sustainability, forestry, land management, multiple-use management, national forests

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88. Kidd, W. E., Jr., E. F. Thompson, and P. H. Hoepner. 1966. **Forest regulation by linear programming - A case study.** *Journal of Forestry.* 64(9): 611-613.

The applicability of linear programming to the regulation of timber harvests from a specific forest property is demonstrated. The primary conclusion is that linear programming can presently be used to provide optimum solutions to forest regulation problems. Also, linear programming can allow a forest manager to assess the impact of a change in managerial constraints prior to actually making the change.*

Keywords: forest management, linear programming, regulated forest, timber harvesting

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89. Killcreas, W. E. 1976. **A computerized system for estimating the economic value and growth of natural timber stands in Mississippi.** Dissertation. Mississippi State University. 135 pp.

Nearly 57% of Mississippi's land resource is classified at commercial forest land. The majority is privately owned tracts averaging less than 100 acres each. Small private timberland tracts have historically produced less timber per acre than have other classifications of land ownership. One possible explanation for the "low" productivity from these lands is that their owners lack the resources necessary to practice the same level of forest management as the "large" landowners. The objective of this study was to make available to owners of "small" Mississippi timber tracts some of the same forest management tools currently utilized by "large" commercially oriented landowners. Five study areas were defined in the major land resource areas. Regression models were developed to estimate current timber volumes, values, and future growth. The regression models and volume formulae were combined into a timber evaluation system that provided estimates of standing timber volumes, growth, future timber volumes, and economic values for any natural timber stand in Mississippi using data from a sample stand. The use of annual equivalent values allows landowners to compare timber production with alternative land uses that may also produce annual revenue.*

Keywords: economics, forestry, growth and yield, Mississippi, regression analysis

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90. Kline, J. D., R. J. Altig, and R. L. Johnson. 2000. **Fostering the production of nontimber services among forest owners with heterogeneous objectives.** *Forest Science.* 46(2): 302-311.

Programs to enhance nontimber services increasingly focus on nonindustrial private forest (NIPF) owners. These owners are believed to possess multiple objectives, causing them to respond to economic forces and policies in complex and unpredictable ways. We examine NIPF owners in western Oregon and western Washington, using a survey to document their forest ownership objectives and willingness to accept incentive payments to forgo harvesting to improve wildlife habitat. An empirical model is developed describing owners' willingness to accept incentive payments to delay harvest, as a function of their forest ownership objectives and socioeconomic characteristics. Mean incentive payments necessary to induce owners to forgo harvest are higher for owners possessing primarily timber objectives ($301-314/ha/yr), than for owners possessing both timber and nontimber objectives ($254-257/ha/yr) or primarily recreation objectives ($185-210/ha/yr). An estimated supply curve describing the area of NIPF land on which owners would forego harvesting for 10 years varies from relatively flat to fairly steep. Although many owners would require little to no incentive to forgo harvest, others would require a significant incentive. Nontimber services likely could be enhanced by targeting incentive programs or technical assistance toward NIPF owners possessing nontimber objectives.*

Keywords: carbon sequestration, endangered species, forest policy, nonindustrial private forest owners

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91. Koskela, E., and M. Ollikainen. 1999. **Timber supply, amenity values and biological risk.** *Journal of Forest Economics.* 5(2): 285-304.

This paper uses the Kreps-Porteus-Selden non-expected utility approach to study the effects of biological risk on harvesting behavior when forest owners have a quasi-linear utility function, linear in harvest revenue and concave in amenity services. Biological risk is assumed to be associated with either forest growth or the initial forest stock, and it may show up either in multiplicative or additive form. It is shown that a rise in multiplicative forest growth risk increases current but decreases future harvesting, which can be interpreted as a precautionary motive due to riskier return on future harvesting. Higher timber stock risk decreases current timber supply because it lessens the

certainty equivalent value of random-forest stocks and thereby increases the marginal utility of amenity services. Moreover, the source and type of biological risk also matters for the marginal propensity to harvest out of stock. It is between zero and unity for multiplicative stock risk and unity in the other cases. In the former case, the marginal propensity to harvest is not usually constant thus suggesting that the size distribution of forest stock affects aggregate timber supply.*

Keywords: amenity valuation, biological risk, forest economics, non-expected utility

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92. Kuhnke, D. H., and W. Watkins. 1999. **Selecting wildlife species for integrating habitat supply models into forest management planning in Manitoba.** Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, Edmonton, Alberta. Information Report NOR-X-357. 56 pp.

In selecting wildlife species for integrating habitat supply models into forest management planning in Manitoba, the underlying principle is that the habitat requirements of most species found in the boreal forest will be satisfied if habitats are maintained for a carefully selected mix of species. The selection methods and 13 basic steps used by the Manitoba Forestry/Wildlife Management Project to arrive at 19 species of wildlife are described. The provincial forest inventory was used as the basis for identification of major habitat types. Emphasis was placed on species for which habitat suitability index models were developed elsewhere in North America, and on ensuring that all major habitat types have at least one species that is dependent on it for its life requisites.*

Keywords: forest management, habitat suitability index, Manitoba Forestry/Wildlife Management Project, wildlife, wildlife habitat planning

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93. Landres, P. B. 1983. **Use of the guild concept in environmental impact assessment.** *Environmental Management.* 7(5): 393-398.

The purpose of this paper was to clarify and expand several ideas concerning use of the guild concept in environmental impact assessment. Background material on the concept and examples of its use are given. It is argued that for purposes of environmental assessment a resource-based guild approach is preferable to a taxonomic-based approach. Validity of the guild concept, problems in classifying species into guilds, implication of guild membership, and usefulness of guild analyses are discussed. I conclude that only with a thorough knowledge of both its limitations and benefits will it be possible to fully use the guild concept for understanding organizational processes in communities and ecosystems and for assessing environmental impacts.*

Keywords: environmental impact assessment, guilds, wildlife management

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94. Leuschner, W. A., J. R. Porter, M. R. Reynolds, and H. E. Burkhart. 1975. **A linear programming model for multiple-use planning.** *Canadian Journal of Forestry Research.* 5: 485-491.

Multiple-use planning is useful in matching forest production possibilities and social desires. A linear programming model for multiple-use planning is presented. Planning is approached as a set of production objectives, which have a set of management activities to help achieve them, and a set of constraints, which limit the management activities. Timber yield is the objective function and other multiple-use objectives are stated as constraints. Size of the area cut is the choice variable and the solution is tied to 21.6-acre (8.74-ha) grid cells thereby identifying the geographical location of management and production activities. The model was tested on a planning unit and sensitivity analyses were performed on the initial optimal solution. These indicated that on this planning unit, there is a wide range of production alternatives, which will not affect other multiple-use production possibilities, and that production is sensitive to budget changes.*

Keywords: forest management, forestry, linear programming, multiple-use planning, sensitivity analysis, timber yield

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95. Leuschner, W. A. 1990. **Forest regulation, harvest scheduling, and planning techniques.** John Wiley and Sons, Inc. New York, New York.

Traditionally, forest planning included only harvest scheduling, but with the advent of multiple-use management, many activities including wildlife management and recreation must also be included in the planning process. This book covers three major topics: 1) traditional forest regulation, 2) timber harvest scheduling, and 3) multiple objective planning. In the area of traditional forest regulation, the classical concepts of area and volume control are covered. Discussions of linear programming and binary search models are used to illustrate timber harvest scheduling. Finally, forest wide or multiple-objective planning techniques are illustrated using the USDA Forest Service planning model, FORPLAN. Examples of all techniques are carried out on the same Douglas-fir forest throughout the book so methodologies can be compared.

Keywords: forest management, forest planning, FORPLAN, harvest scheduling

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96. Lippke, B. R., J. Sessions, and A. B. Carey. 1996. **Economic analysis of forest landscape management alternatives.** CINTRAFOR Special Paper 21. College of Forest Resources, University of Washington. Seattle, Washington.

An economic and biological analysis of how changes in forest landscape management affect wildlife and wildlife habitat in Washington state. Measures for commercial management alternatives, preservation areas, and "biodiversity management pathways" are developed, and economic impacts on landowners that choose to manage for both timber and non-timber outputs

are examined. Overall it was found that landscape management alternatives could effectively meet commodity and non-commodity goals. Traditional management regimes, which use short rotations of approximately 50 years, optimize financial returns, but reduce the amount of "old growth" forests that are believed important to many wildlife species. By encouraging landowners to manage timber for longer rotations, and grow higher quality wood products such as sawtimber, late seral forest structures will increase significantly and costs offset. Incentive systems can also be used to motivate landowners and managers to manage for stand structures that produce non-market benefits. It is suggested that an additional 25% of the private lands with high-production potential could be managed for longer rotations at a cost of less than $1,000.00 per acre. These additional acres will increase the total land in late seral stages for an estimated cost of $28 million per year in western Washington. In addition, the region will benefit from increased employment, income, and tax revenue that is produced by forest management activities.

Keywords: forest economics, forest management, incentive programs, Washington state

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97. Liu, A., A. Collins, and S. Yao. 1998. **A multi-objective and multi-design evaluation procedure for environmental protection forestry.** *Environmental and Resource Economics.* 12: 225-240.

A unique and important application of a comprehensive and practical multi-objective evaluation framework is presented which goes far beyond traditional cost-benefit analysis (CBA). It is characterized by transparency, which is not always the case for methods beyond CBA. The application is geared to the evaluation of environmental protection forestry with several alternative designs. The framework suggested consists of five key steps integrating orthodox cost-benefit analysis and the analytical hierarchy process developed by Saaty (1980). It is shown to be a flexible framework, which can coherently function with a mixture of both monetary and physical units of measurement. The framework is applied to a consideration of alternative designs for the Three Norths Shelter Belt (TNSB) in China.*

Keywords: agroforestry system, China, environmental protection, project evaluation

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98. Liu, G., and L. S. Davis. 1995. **Interactive resolution of multi-objective forest planning problems with shadow price and parametric analysis.** *Forest Science.* 41(3): 452-469.

Forest management planning is a joint process of decision synthesis and tradeoff analysis. We present an interactive method of multi-objective linear programming for supporting the planning process. In the proposed procedure, emphasis is placed on reducing uncertainty that surrounds the resolution of goal conflicts. Parametric analysis is iteratively performed to shed insights into the question of what happens to goal tradeoffs if a particular criterion is achieved at alternative levels. The composite objective function guiding the parametric analysis is updated as the decision-maker replaces a previous choice with an improved one. Central to this step is the induction of criterion weights implied by a decision instance, through the use of shadow prices. Finally, ordinal goal priority is employed to generate initial solution and decompose a multi-objective planning problem into more tractable subproblems. The interactive procedure is illustrated by a land-use planning model containing five forest-related outputs, including noncommercial grazing, commercial grazing, timber, camping, and profit.*

Keywords: forest management, linear programming, parametric analysis, shadow price

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99. Lockwood, C., and T. Moore. 1993. **Harvest scheduling with spatial constraints: A simulated annealing approach.** *Canadian Journal for Forest Research.* 23: 468-478.

Simulated annealing is a stochastic approach to solving large combinatorial problems. This approach was used to model a harvest scheduling problem having block size constraints (no limit, 100-200, and 200-400 ha), a 20-year adjacency delay, and objectives to meet harvest volume targets on the minimum area possible. Spatially explicit harvest schedules complying with the constraints were successfully generated on test data sets of 6,148 and 27,548 forest stands.*

Keywords: adjacency constraints, harvest scheduling, simulated annealing

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100. Lockwood, L., and T. Moore. 1992. **Harvest scheduling with spatial constraints: A simulated annealing approach.** *Canadian Journal of Forest Resources.* 23: 468-478.

Simulated annealing is a stochastic approach to solving large combinatorial problems. This approach was used to model a harvest scheduling problem having block size constraints (no limit, 100-200 ha, and 200-400 ha), a 20-year adjacency delay, and objectives to meet harvest volume targets on the minimum area possible. Spatially explicit harvest schedules complying with the constraints were successfully generated on test data sets of 6,248 and 27,548 forest stands.*

Keywords: harvest scheduling, simulated annealing, size constraints

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101. Loucks, D. P. 1964. **The development of an optimal program of sustained-yield management.** *Journal of Forestry.* 62(7): 485-490.

Two mathematical models are presented to aid foresters in developing sustained-yield cutting schedules. In the first model the volume to be cut is maximized subject to the various conditions imposed by nature and required by the management plan. In the second model the area to be cut is minimized while assuring a specified yield for each cutting period. The solution of a hypothetical management problem is presented to illustrate the usefulness as well as the limitations of these models. Various management alternatives are considered and evaluated in terms of the increase or decrease in the total yield produced. Thus, it

is shown how the information available from this type of analysis can aid in the development of better cutting schedules and in the evaluation of proposed management practices.*

Keywords: forest management, linear programming, operations research, sustained-yield, timber harvesting

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102. Lu, F., and L. Eriksson. 1999. **Formation of harvest units with genetic algorithms.** *Forest Ecology and Management.* 130: 57-67.

Operational planning is normally based on stands as the primary unit of treatment. In recent years, interest has been directed towards the use of smaller area units such that the formation of treatment units becomes part of the operational planning. Here the method of genetic algorithms was used in order to delineate harvesting units in a forest described as a grid of 20 m X 20 m pixels. Remote sensing data and inventory plots were employed to derive pixel estimates of forest variables. Appropriate parameter settings for the algorithm were investigated for two cased that consisted of 26 X 25 pixels. Based on the experience from these tests, the algorithm was employed in forming treatment units in an area encompassing 100 X 100 grid cells, or 400 ha. Due to the size of the problem, a two-stage procedure was suggested. The solutions of the genetic algorithm were compared with a heuristic a cell removal algorithm, that was proposed in earlier studies of treatment unit formation. The genetic algorithm performed better than the heuristic for all the cases that were tested.*

Keywords: genetic algorithms, operational planning, remote sensing

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103. McComb, W. C. 1982. **Forestry and wildlife habitat management in central hardwoods.** *Journal of Forestry.* 80(8): 490-492.

Improvement cutting, or removal of undesirable stems by silvicide or girdling, can foster the integration of forestry and wildlife management in the central hardwood region. Group selection or small, narrow clearcuts are recommended for attaining uneven-aged and even-aged management objectives, respectively. Reforestation of surface mines should continue if a diversity of wildlife is to be maintained. Single-species hardwood plantations should be small, narrow, and adjacent to mixed hardwoods. The diversity of federal, state, and private organizations involved in forest wildlife management and research makes coordination of activities difficult.*

Keywords: central hardwoods, forest management, silviculture, wildlife management

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104. McConnell, K. E., J. N. Daberkow, and I. W. Hardie. 1983. **Planning timber production with evolving prices and costs.** *Land Economics.* 59(3): 292-299.

In traditional Faustmann timber harvesting, solution prices, costs, and technology are constant, and it is assumed that land will be in forestry production forever. However, such stability rarely exists. This paper discusses a model that determines the approximate harvesting age for a stand when prices and costs vary. Optimal harvest length is allowed to vary over time, as well as land uses. Decisions by the landowner to convert from timber to agriculture are also allowed. It was found that when discounted stumpage price is constant and establishment costs increase over time, harvest length increases. Conversely, when prices are constant and establishment costs decrease, the optimal harvest length decreases.

Keywords: Faustmann, forest economics, timber harvesting

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105. McKee, C. W. 1982. **Timber and habitat tradeoffs in an intensively managed loblolly pine forest.** Dissertation. Mississippi State University.

A method for evaluating timber and wildlife habitat tradeoffs was developed. Although the techniques developed are oriented toward the management of even-aged loblolly pine (*Pinus taeda*) forests in the southeastern United States, basic concepts are applicable to other commercial timber species. Discounting models were used to estimate the relative profitablilties of alternative rotations and thinning schedules for planted loblolly pine. The management regime, rotation, and thinning schedule that produced the highest capitalized present net value was used to define activities for the linear programming model. Department of Wildlife and Fisheries personnel helped develop four levels of habitat diversity based on carrying capacity requirements for the white-tailed deer (*Odocoileus virginianus*). Habitat levels I-IV were defined as one deer per 100 acres (very poor), one deer per 60 acres (poor), one deer per 30 acres (good), and one deer per 15 acres (excellent), respectively. The linear programming model was used to estimate cutting schedules over a 60-year planning period for the four levels of wildlife habitat diversity on a 17,932 acre forested tract in east central Mississippi. The model is designed to maximize capitalized present net worth of the sample forest area subject to wood flow, acreage regenerated and wildlife habitat restrictions. Various combinations of enhancing wildlife habitat diversity were evaluated for the sample forest area. Using a 10% discount rate, habitat diversity of the sample forest area will cost the firm between $0.84 and $12.43 per acre per year over the 60-year planning period. It should be noted that these cost estimates are not applicable to all loblolly pine forests. Cost estimates can be determined, however, for selected forests by incorporating forest inventory data and management restrictions of the selected forest into the model.

Keywords: discounting models, forest economics, forest management, forestry, linear programming, Odocoileus virginianus, opportunity cost, white-tailed deer, wildlife habitat

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106. McKee, C. W., W. E. Killcreas, and J. E. Waldrop. 1983. **Methodology for assessing timber and white-tailed deer habitat tradeoffs.** In: *Proceedings of the Annual Conference of the Southeast Association of Fish and Wildlife Agencies.* 37: 103-117.

A linear programming model was used to examine trade-offs between timber returns and white-tailed deer (*Odocoileus*

virginianus) habitat in East-Central Mississippi. The model was designed to maximize capitalized present net worth of a sample forest subject to white-tailed deer habitat, wood flow, and acreage regenerated restrictions. Four levels of habitat diversity were evaluated. Enhancing habitat diversity will cost, in terms of timber revenue forgone, between $2.08 and $30.71/hectare per year. These cost estimates are not applicable to all loblolly pine (*Pinus taeda*) forests. However, the methodology is applicable for other forests when appropriate forest inventory data and wildlife habitat restrictions are specified.*

Keywords: economics, forest management, forestry, linear programming, loblolly pine, net present value, Odocoileus virginianus, Pinus taeda, white-tailed deer

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107. Miller, D. A., B. D. Leopold, L. M. Conner, and M. G. Shelton. 1999. **Effects of pine and hardwood basal areas after uneven-aged silvicultural treatments on wildlife habitat.** *Southern Journal of Applied Forestry.* 23(3):151-157.

Uneven-aged management (UEAM) is becoming increasingly popular in the southeastern United States. However, effects of UEAM on wildlife habitat have not been adequately documented. We examined response of habitat within stands of varying levels of pine and hardwood basal area under an uneven-aged management regime in southern Mississippi. Summer and winter trends in understory biomass were similar across treatments. Time since disturbance influenced plant productivity. Stands with lower basal areas tended to have higher browse production, denser and higher vertical habitat structure, more woody, vine, and fern biomass, greater total biomass, and higher plant species diversity and richness. Pine basal area had little influence on browse production relative to effects of hardwood basal area. Although stands with higher basal area had less biomass, a higher proportion of biomass was composed of preferred browse. We recommend that forest managers create stands of varying levels of pine and hardwood basal areas to provide for diverse needs of many wildlife species.*

Keywords: biomass, forest management, forestry, uneven-aged management, wildlife habitat

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108. Miller, J. H., and K. V. Miller. 1999. **Forest plants of the southeast and their wildlife uses.** Southern Weed Science Society: Auburn, Alabama. 454 pp.

This book is a guide to the plant species that are found in the forests, forest openings, edges, and right-of-ways of the Southeastern United States. Plants included have wildlife value, occur in wetlands, are non-native invasives, or have aesthetic value. This book is organized by plant genera with sections for forbs, grasses, woody vines, semi-woody plants, shrubs, palms, cane, cactus, ferns, and ground lichen. For each species detailed information is given including scientific and common name, growth habit, range, and ecology. Color photographs aid the identification process. Descriptions of wildlife uses for the plants are given when understood.

Keywords: forest plants, southern United States, wildlife, wildlife habitat

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109. Mills, T. J., and G. E. Dixon. 1982. **Ranking independent timber investments by alternative investment criteria.** USDA Forest Service Research Paper PSW-166. 8 pp.

A sample of 231 independent timber investments were ranked by internal rate of return, present net worth per acre, and benefit/cost ratio - the last two discounted by 3, 6.4, 7.5, and 10% - to determine if the different criteria had a practical influence on timber investment ranking. The samples in this study were drawn from a group of timber investments partially financed by Forestry Incentive Program cost-share funds. The investment rankings were quite similar among the three criteria. Under constrained investment budgets, the benefit/cost criteria produced the investment selection with the greatest cumulative present net worth. Under less severe budget constraints, all three criteria produced investment selections with essentially the same cumulative present net worth.*

Keywords: benefit/cost ratio, internal rate of return, marginal investments, perpetual rotations, present net worth

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110. Mississippi Department of Wildlife, Fisheries and Parks. 2000. **Mississippi wild turkey management program 2000 report.** Mississippi Department of Wildlife, Fisheries and Parks, Wildlife Bureau. Jackson, Mississippi. 77 pp.

This comprehensive report about the Mississippi Department of Wildlife, Fisheries and Parks' (MDWFP) statewide turkey program provides the public with data regarding the state's wild turkey (*Meleagris gallopavo*) resource. Articles that provide information on topics such as predation, disease, law enforcement, and research are featured. Results of statewide brood surveys are also included, and provide information on population trends. The spring gobbler survey, which was initiated in 1996, provides both harvest and population data from hunters who record information about their hunts each spring turkey season. These data are used for monitoring and managing Mississippi's wild turkey population.

Keywords: brood survey, Meleagris gallopavo, Mississippi, spring gobbler survey, wild turkey

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111. Mississippi Forestry Commission. 2000. **Mississippi's BMP's Best Management Practices for forestry in Mississippi.** MFC publication no. 107. 35 pp.

Best Management Practices, although non-regulated guidelines, are practices which have been found to be most effective in preventing or reducing the amount of pollution generated by non-point sources. This handbook presents those methods that all forest managers and landowners should follow when practicing silvicultural and other forestry-related activities so they will be in compliance with Section 319 of the Water Quality Act of 1987. The practices discussed in this handbook include the following categories: streamside management zones, woodland

trails and roads, forest harvesting, site preparation, and tree planting.

Keywords: Best Management Practices, BMP's, forestry, forest roads, non-point source pollution, silviculture, streamside management zones, tree planting, water quality

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112. Munn, I. A. 1998. **Forestry in Mississippi. The impact of the forest products industry on the Mississippi economy: An input-output analysis.** Forestry and Wildlife Research Center Bulletin # 087. Mississippi State University, Mississippi State, Miss.

This study evaluates the importance of the forest products industry to the economy of the state of Mississippi. Forests cover over 62% of the state, and over one billion dollars worth of forest products are harvested annually from these forest lands. Through the resulting increased employment, production, and value added products that are the result of forest industry, Mississippi's economy benefits in many ways. The economic impacts of the industry were modeled using the Impact Analysis for Planning (IMPLAN) System, originally developed by the USDA Forest Service in cooperation with the Federal Emergency Management Agency and the University of Minnesota. IMPLAN data for 1993 were used for this study since they were the most current available. For this study, four primary sectors are examined separately and then combined to determine the impacts of the industry as a whole. Overall, the forest products industry employed 63,873 people in 1993, or approximately 5% of the state's total employment. Each of the four sectors: logging, solid wood products, pulp and paper, and wood furniture industries made considerable contributions to the state's economy. The largest contributor being the solid wood products sector with $4.9 billion in total industry output, 52,841 in jobs, and $1.1 billion in wages.

Keywords: economics, forest products industry, forestry, Impact Analysis for Planning System, IMPLAN, Mississippi

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113. Murray, A. T. 1999. **Spatial restrictions in harvest scheduling.** *Forest Science.* 45(1): 45-52.

Forest resource use has traditionally been multifaceted. To ensure that these resources continue to be available for use by current and future generations, sustainable management practices are essential for striking a balance between the varied and often competing demands associated with forest use. This had meant that analysis incorporate specific objectives and considerations aimed at minimizing the impacts of forest activities. One such management planning approach had been the inclusion of spatial restrictions in harvest scheduling analysis. This article reviews two basic harvest scheduling models which may be used for imposing spatial restrictions. Distinctions between the alternative methods are highlighted and operational considerations are discussed. This article established and outlined priority areas for future harvest scheduling research.*

Keywords: adjacency constraints, harvest scheduling, integer programming, spatial scale

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114. Murray, A. T., and R. L. Church. 1995. **Measuring the efficacy of adjacency constraint structure in forest planning models.** *Canadian Journal of Forest Research.* 25: 1416-1424.

This paper examines various structural representations of adjacency conditions in forest planning problems. It will be shown that alternative representations can rival traditional approaches, which is counter to much of the mathematical modeling and formulation literature. Analysis was conducted on a number of forest planning problems to draw some general conclusions on adjacency constraint representations. This is the first time that these structures have been compared in a comprehensive way. This paper provides insights into solution performance using different constraint structures and will help further the development of improved methodologies for analyzing environmental problems that must incorporate increased spatial detail.*

Keywords: adjacency constraints, forest planning

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115. Murray, A. T., and R. L. Church. 1996. **Analyzing cliques for imposing adjacency restrictions in forest models.** *Forest Science.* 42(2): 166-175.

Adjacency considerations have a significant impact on the acceptability of forest planning alternatives and have forced analysts to look for effective methods for incorporating such concerns. Various attempts have been suggested for representing adjacency restrictions within planning problem formulations. This paper investigates the use of cliques for representing adjacency conditions. Several approaches are presented for generating and incorporating cliques into operational level forest planning formulations. Properties of the various clique sets are detailed, which form a basis for understanding why certain clique sets outperform others. A number of forest planning problems are solved, demonstrating the superior performance of the clique approach presented in this paper. This work has broad implications on the types of planning problems that can be effectively modeled.*

Keywords: adjacency constraints, forest planning, integer programming, operational planning

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116. Murray, A. T., and R. L. Church. 1996. **Constructing and selecting adjacency constraints.** *INFOR.* 34(3): 232-248.

Maintaining spatial integrity is an important concern in both the tactical and operational levels of forestry planning. Spatial relationships are typically represented by adjacency constraints. The number of needed adjacency constraints for even a small number of planning units, if not kept to a minimum, may be too large to include in a mathematical programming formulation. Several approaches have been developed to "minimize" the number of adjacency constraints used. These approaches involve either constraint subset selection or constraint aggregation. We demonstrate that with constraint aggregation the theoretical minimum of necessary adjacency constraints is

one. However, the range of coefficients of one aggregated adjacency constraint is impractical for actual application. As an alternative, we explore the approach of identifying a minimal subset of a class of structural adjacency constraints. As a part of this approach, we develop a two-stage procedure to identify and fine tune a minimal subset of constraints for representing adjacency conditions so that there is no loss of spatial detail. Concise mathematical formulations are presented for each stage. This process is easy to implement and yields a relatively small number of "tight" adjacency constraints.*

Keywords: adjacency constraints, constraint aggregation, forest planning, integer programming, linear programming

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117. Nelson, J., and J. D. Brodie. 1990. **Comparison of a random search algorithm and mixed integer programming for solving area-based forest plans.** *Canadian Journal of Forest Research.* 20: 934-942.

An area-based forest plan is formulated and solved by mixed integer programming and a random search algorithm. This is a computationally difficult problem because operational and environmental constraints require that harvest units and road projects be defined as strict binary variables. It was found that the random search algorithm could easily identify several solutions with objective function values within 10-percent of the true optimum. The best solution found was within three-percent of the optimum. The random search algorithm is simple and can be readily implemented on the microcomputer. It is concluded that the random search algorithm is an effective technique for generating acceptable alternatives to complex area-based planning problems.*

Keywords: area-based forest planning, mixed integer programming, random search algorithm

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118. Nelson, J., J. D. Brodie, and J. Sessions. 1991. **Integrating shore-term, area-based logging plans with long-term harvest schedules.** *Forest Science.* 32(1): 101-122.

Procedures are developed and evaluated for integrating short-term, area-based plans with long-term, strata-based harvest schedules. A combination of these two approaches to forest planning provides a spatially feasible, short-term solution that can also incorporate strategic harvest goals over a long-term period. Three basic steps are used to combine the area and strata-based plans: (1) a 15-decade strata-based plan is solved with linear programming (LP) to establish strategic harvest goals; (2) with these goals as guidelines, 3-decade, area based-plans are generated with a random search technique called Monte-Carlo integer programming (MCIP); and (3) those area-based plans become the first 3-decade solution within 15-decade integrated plans that are solved with LP. Both the harvest units and the road projects within the area-based plan are specified as strict binary variables. MCIP is an effective technique for generating feasible solutions to integer problems encountered in area-based planning. Although no guarantee of optimality can be assured, the technique is a major improvement over manual methods, and it is a practical alternative to mixed-integer programming for identifying feasible alternatives. In comparison to the integrated plans, it was found that the strata-based model consistently overestimate long-term revenues, and consistently underestimated long-term volumes. The integrated plans produced net revenue and volume levels within 10% of the strategic goals established by the strata-based linear program. The case study was conducted in 1987-88 on a forest located in British Columbia.*

Keywords: forest economics, linear programming, Monte-Carlo integer programming, operations research

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119. Nichols, J., S. A. Husain, and C. Papadas. 2000. **Integrating GIS technology with forest management and habitat assessment efforts on our national forests.** n. pag. Online. Internet. 19 May 2000. Available http://econ.usfs.msu.edu/ssafr/ abstracts.htm.

Research was conducted on a section of the superior National Forest to develop and examine potential methods or approaches that may be used to integrate non-timber resources in multiple-use planning. An indicator species for old-growth conifer forests, pine marten (*Martes americana*), was chosen to examine potential conflicts between specific forest management practices and habitat values. This research explored an approach to combine spatially scheduled timber production and the impacts on marten habitat for a large area, examining simple management scenarios in the form of delayed harvesting. The results of the analysis indicate that clearcutting over the 50-year planning horizon had a significant impact on the martin habitat conditions of the study area only in specific management simulations.*

Keywords: forest management, geographic information system, GIS, Martes americana, pine marten, Superior National Forest, wildlife habitat

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120. Niemi, E., and E. Whitelaw. 1999. **Assessing economic tradeoffs in forest management.** Revised. Gen. Tech. Rep. PNW-GTR-403. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 78 pp.

Method is described for assessing the competing demands for forest resources in a forest management plan by addressing economics values, economic impacts, and perceptions of fairness around each demand. Economics trends and forces that shape the dynamic ecosystem-economy relation are developed. The method is demonstrated through an illustrative analysis of a forest-management decision in the southern Appalachian Mountains.*

Keywords: economics, endangered species, forestry, natural amenities, recreation, timber sales

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121. O'Hara, A. J., and B. H. Faaland. 1989. **Spatially constrained timber harvest scheduling.** *Canadian Journal of Forest Research.* 19: 715-724.

Multiple-use management of forests often requires imposition of spatial constraints on the selection of units for harvest. To satisfy such constraints, harvest units much be treated as integral units. A biased sampling search technique is used to find integer solutions to operationally sized problems. Solutions found for the sample problems are within 8% of the upper bound of the corresponding linear programming solution and less than 4% below the upper bound on the true optimum as defined by a confidence interval estimator.*

Keywords: bias sampling, forestry, linear programming, multiple-use management

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122. Oliver, C. D. 1992. **A landscape approach - Achieving and maintaining biodiversity and economic productivity.** *Journal of Forestry.* 90(9): 20-25.

Much of the recent attention by environmentalist groups has been directed at stand level forest operations. However, it is through forest management at a landscape scale that biodiversity, environmental protection, and economic productivity for the state of Washington can be achieved. Long term goals for managing the forests of the Pacific Northwest, and policies to reach those goals, are presented. For example, silvicultural practices, such as carefully planned thinnings of even-aged stands, can remove low value products, create employment, and rapidly create "old-growth features" such as large boles and crowns, many canopy layers, and enhanced wildlife habitat. To achieve these goals and make the transition from the current situation, several activities must occur: 1) give incentives to private landowners to encourage responsible management; 2) create regulations to manage incentive programs, target landscape patterns, stand structures, and operational constraints; 3) manage National Forests for stand structure; and 4) create innovative approaches to promote multiple-use management. Once implemented, forest management will be more efficient and profitable, fewer environmental regulations will be needed, and wildlife habitat will be created.

Keywords: biodiversity, forest management, landscape scale management, silviculture, Washington state

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123. Opper, M. 1988. **What's in the future? - The forest industry viewpoint.** *The Forestry Chronicle.* 64(3): 280-282.

The forest industry in Ontario makes a large contribution to both national and provincial economies. Withdrawal of productive forest for purposes other than timber production along with constraints upon logging to manage for other uses are tending to erode the competitiveness of the forest industry. To effect a practical integrated approach to forest land use management the following items are discussed. First, the question of who pays the additional cost of management for uses other than timber production needs to be resolved. Second, the planning process requires strengthening particularly in the data base management at the field level. Third, practical results-oriented scientific research reflecting the Ontario situation is needed to validate fish and wildlife guidelines used in the timber management planning process. Finally, more cooperation and better communication between all disciplines involved in the timber management planning process is required.*

Keywords: forest economics, integrated resource planning, timber management, wildlife management

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124. Pacific Meridian Resources, and USDA Forest Service. n. date. **Forest Vegetation Simulator (FVS) - ARC/INFO prototype application.** n. pag. Online. Internet. 15 June 2000. Available http://www.innovativegis.com/services/projects/fvs_app.html.

The FVS*ARC prototype was developed as a joint project between the USDA Forest Service and Pacific Meridian Resources to integrate the Forest Service's Forest Vegetation Simulator (FVS) with ARC/INFO. FVS is an individual tree growth and yield model designed to make timber growth and yield estimates across a broad range of ecosystems and planning scales using forest inventory data. FVS*ARC links FVS with ARC/INFO so that FVS output can be easily transferred to ARC/INFO and illustrated in customized maps, tables, reports, and charts.

Keywords: ARC/INFO, forestry, Forest Vegetation Simulator (FVS), growth and yield

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125. Porterfield, R., K. Utz, and W. Balmer. 1979. **Analyzing alternative hardwood management strategies**. *Southern Journal of Applied Forestry.* 3(1): 7-12.

An analysis of the per cubic foot investment costs associated with hardwood production under each of three management alternatives is presented: (1) plantation establishment; (2) a harvest cut followed by natural regeneration; and (3) rehabilitation through timber stand improvement (TSI). The indication is that the vast majority of southern hardwood stands will continue to be naturally regenerated given landowner objectives, ownership patterns, and current stumpage prices.*

Keywords: economics, hardwood management, timber stand improvement (TSI)

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126. Reams, G. A., and P. C. Van Deusen. 1999. **The Southern Annual Forest Inventory System.** *Journal of Agricultural, Biological, and Environmental Statistics.* 4(4): 346-360.

The Southern Annual Forest Inventory System (SAFIS) is in various stages of implementation in seven of the 13 southern states serviced by the Southern Research Station. The SAFIS design is an interpenetrating design where the *n* units (1/6 acre

plots) are divided into $k = 5$ panels, each panel containing $m = n/k$ units. Panel 1 plots are measured in year 1, panel 2 in year 2, etc., such that all plots have been visited by the end of year 5. The panel cycle is repeated into perpetuity. Each panel, in effect, is a 5-year periodic survey with complete overlap of sample units. Numerous estimation schemes are possible, and we explore five possible options. The five options are (1) use existing periodic inventory programs to produce 5-year survey estimates by adjusting all five panels to a common year, (2) analyze each annual panel independently, (3) produce 5-year estimates by combining the five panel estimates by varying the weight given to each panel, (4) base inventory estimates on mixed estimation where actual and predicted values are combined, and (5) use imputation techniques such that unmeasured plots are filled in with imputed plots. A two-phase method for forest area estimation that uses the known map margins from a thematic map is presented as an alternative to photo interpretation-based estimates.

Keywords: area estimation, Forest Inventory and Analysis (FIA), time series modeling, USDA Forest Service

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127. Richards, E. W., and E. A. Gunn. 2000. **A model and tabu search method to optimize stand harvest and road construction schedules.** Forest Science. 46(2): 188-203.

An important function of tactical planning in forest management is to choose spatially and temporally explicit schedules for both harvesting and road construction activities. In addition to maintaining consistency with goals of the strategic planning process, harvesting decisions are subjected to spatial, environmental constraints. At the same time, planning and cost of road access over the medium-term planning horizon must be considered. This article presents a model and heuristic solution methodology to address stand level harvest scheduling and the associated road construction scheduling problem. The model is formulated to determine minimal cost schedules, for stand harvests and road construction, that achieve recommended timber harvest volume targets and that comply with environmental regulations. The harvest decisions are made at the stand level of resolution. Graph structures are used to formulate the spatial restrictions on clear-cut opening size and location. Road construction projects are scheduled to create a feasible road network at minimum net present capital cost. The optimization problem is solved using a tabu search heuristic, which includes special constructs to cope with the complexity of this problem. An efficient frontier of solutions is produced, which may be utilized to analyze tradeoffs between lost forest productivity, due to timing of harvests, and the capital cost of road construction.*

Keywords: forest management, heuristic simulation, roads, spatial constraints, tactical planning, tradeoff analysis

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128. Robak, E. W. 1984. **Toward a microcomputer-based DSS for planning forest operations**. *Interfaces.* 14(5): 105-111.

For a decision support system for operations planning of forest operations to be effective it should be based upon contemporary deterministic planning procedures and should improve a planner's ability to evaluate the effects of the decision alternative on the entire plan's budget. The computational and information-handling function of microcomputers would allow sensitivity analysis to be performed by those most likely to understand the alternatives and their probable effects: the operating managers.*

Keywords: decision analysis, decision support system, forest operations

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129. Rohweder, M. R., C. W. McKetta, and R. A. Riggs. 2000. **Economic and biological compatibility of timber and wildlife production: An illustrative use of production possibilities frontier.** *Wildlife Society Bulletin.* 28(2): 435-447.

Considering multiple objectives is an important aspect of modern forestry, but quantifying the trade-offs among commodity and non-commodity resources remains an obstacle to efficient forest planning. We illustrate how production possibilities frontier (PPF) methodology can be used for multiple-objective analysis, focusing on trade-offs between timber production and several non-commodity resources as functions of timber harvest strategy. To do this, we modeled forest structure as a consequence of six silvicultural strategies that differed in harvest intensity and we used existing resource models to project responses of selected wildlife habitat attributes, resistance of forest stands to insects and fire, and long term financial returns. Graphing resource outputs against one another illustrates the nature and extent of the trade-offs among our silvicultural alternatives. To illustrate the utility of PPF methodology, we assume a *priori* that all of our non-commodity resources would exhibit incompatible relationships with timber harvesting. However, incompatible relationships were rare. Instead, competitive and complementary relationships were common in our long-term projections. Competitive and complementary relationships are defined by continuous trade-off functions that can lead to "optimum" management solutions with multiple outputs. Knowing the PPF relationship helps quantify biological and economic trade-offs from silvicultural designed modifications to stands. Our results demonstrate that management costs exert a substantial influence on the feasibility of any strategy regardless of its biological merit and that optimizing between timber and non-commodity resources would require explicit knowledge of their relative values.*

Keywords: forest economics, multiple-use management, production possibilities frontier, resource trade-offs

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130. Roseberry, J. L., and A. Woolf. 1998. **Habitat-population density relationships for white-tailed deer in Illinois.** *Wildlife Society Bulletin.* 26(2): 252-258.

White-tailed deer (*Odocoileus virginianus*) have reached population densities in the agricultural Midwest that would not have been predicted 20-30 years ago. To help explain this phenomenon, we inventoried and analyzed the potential deer habitat in Illinois, using classified satellite imagery and a proximity-based habitat

model. Statewide prehunt deer densities (ca 1992) were estimated at 4-5 deer per km² of total area and 30-37 deer per km² of forest based on population reconstruction and modeling. Habitat suitability indices explained 81% of the variation in deer population densities at the county level. The amount and distribution of deer habitat in Illinois was primarily dependent on intensity of agricultural land use, which in turn was dictated by soil productivity and terrain. We found no evidence that relative use of available habitat at the county level was adversely affected either by habitat fragmentation or human presence on the landscape.*

Keywords: fragmentation, habitat management, habitat modeling, Illinois, Odocoileus virginianus, population density, remote sensing, white-tailed deer

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131. Rosie, J. P. 1990. **Multicriteria nonlinear programming for optimal spatial allocation of stands.** *Forest Science.* 36(3): 487-501.

The forest planning problem is formulated using stand level variables for each management unit. It is shown that harvests can be spatially allocated to stands to meet nonadjacency requirements by using a nonlinear programming formulation. A penalty function form of the mathematical program is used to find solutions. This study represents a first attempt at a possibly robust technique. It appears to be applicable to small forest areas. For larger forest areas containing many stands (>200 acres) the method is predicted to converge too slowly for practical use. The considerable conflict between achieving optimal present net value of the forest and meeting nonadjacency requirements is illustrated for example cases.*

Keywords: forest management, four-color theorem, habitat diversity, multiple objective, nonadjacency, penalty function, simultaneous stand and forest level optimization

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132. Schaberg, R. H., T. P. Holmes, K. J. Lee, and R. C. Abt. 1999. **Ascribing value to ecological processes: An economic view of environmental change.** *Forest Ecology and Management.* 114: 329-338.

Decisions made by individual landowners and public land managers can have a significant impact on the rates of ecological change. Interdisciplinary cooperation is desirable if economists and ecologists are to correctly interpret the impacts of individual choices for landscape management. This paper reports results from two studies of the residents of North Carolina, which contrast individual preferences for utilitarian forest benefits and financial returns with less tangible benefits of forest amenities and ecosystem stability. One study reports preliminary findings from a forest-benefit mail survey on the Nantahala and Pisgah National Forests; the second study presents an analysis of harvest decisions by private landowners. Economic methods pertinent to valuation of environmental goods are briefly considered. Individual behavior is described which suggests that segments of the public recognize welfare benefits specifically from forest amenities, and from 'natural' production of environmental goods and services. The two studies suggest how economic tools may be extended to help quantify complex social and biological values associated with ecological processes.*

Keywords: environmental economics, non-market benefits, trade-off analysis

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133. Schuler, A. T., H. H. Webster, and J. C. Meadows. 1977. **Goal programming in forest management.** *Journal of Forestry.* 75: 320-324.

Managing resources for multiple use requires complex decisions that involve many diverse goals. Goal programming provides a way of analyzing such decisions and evaluating tradeoffs. The method was used in a pilot study to prepare a management plan for a 10,000-acre area on the Mark Twain National Forest in Missouri. It proved valuable both in maximizing the attainment of diverse goals and in showing that one goal was unrealistic.*

Keywords: forest management, goal programming, Mark Twain National Forest, multiple-use management

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134. Sharitz, R. R., L. R. Boring, D. H. VanLear, and J. E. Pinder, III. 1992. **Integrating ecological concepts with natural resource management of southern forests.** *Ecological Applications.* 2(3): 226-237.

Natural resource management must integrate commercial development and use of forest resources with the maintenance of ecological values. The "New Perspectives" program of the U.S. Forest Service is responding to increased public environmental awareness and legislative mandates in placing a greater emphasis on ecosystem sustainability and non-traditional utilization of national forestlands. The forest of the southern United States is a complexity of associations developed along topographic and environmental gradients and shaped by natural disturbances and anthropogenic perturbations. It is highly fragmented as a result of past clearing for agriculture and timber harvesting and patterns of land ownership. Southern forests, in contrast to those in other regions, are mostly privately owned. This fragmentation is being maintained by current urbanization and industrialization as the population of the South increases. Our purpose is to identify ecological themes and concepts compatible with the stewardship philosophy of the Forest Service's New Perspectives that can be applied to the management of sustainable southern forest resources. Of special concern are the maintenance of biological diversity, watershed and water quality protection, and the assessment of regional land-use effects on the integrity of forest ecosystems and on continued forest productivity. Ecological principles must be integrated with natural resource management on landscape and regional scales to achieve sustainability of the southern forest ecosystem.*

Keywords: biodiversity, ecological values, forest management, forest sustainability, fragmentation, landscape diversity, landscape ecology, riparian forests, southern forests

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135. Shaw, S. P. 1981. **Wildlife management on private nonindustrial forestlands.** In: R. T. Dumke, G. V. Burger, and J. R. March eds. *Wildlife Management on Private Lands.* La Crosse Printing Co., Inc., La Crosse, Wisconsin. pp. 36-41.

A plan is discussed for increasing wildlife management on private nonindustrial forestland, which would increase the amount of money landowners made off their land through timber production and hunting leases. Because most individual private landowners own small blocks of land that are not conducive to large scale land management, it is suggested that timber-wildlife cooperatives be formed by adjacent landowners. Their combined acreage would be managed as one unit for both timber and wildlife habitat. These management units should be at least 1,000 acres in size, and harvested based on habitat requirements of wildlife species in the area, or preferred game species. Eventually, these cooperatives would provide increased recreation opportunities and forest land under active management, while at the same time increase income to rural landowners.

Keywords: forest management, timber-wildlife cooperatives, wildlife management

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136. Short, P. H., S. M. Edwards, and O. V. Harding. 1997. **Mississippi's timber resources. Marketing enhancement publication series: No. 1.** Mississippi State University Extension Service. Mississippi State University. 40 pp.

This publication is designed to provide a perspective on the status of Mississippi's timber resources, and to assist in the economic development of the state's forest products industries. Descriptions of Mississippi's hardwood and softwood inventory and the major species that compose this inventory are given. Also provided is detailed information on 40 tree species, their growing regions in Mississippi, and availability and relative cost within the state.

Keywords: Mississippi, timber inventory

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137. Siry, J. P., F. W. Cubbage, and A. J. Malmquist. 1999. **Potential impacts of increased management intensities on planted pine growth and yield and timber supply modeling in the South.** In: *Timberland Investments: Improving the Odds. Proceedings of the 1999 Southern Forest Economics Workshop.* Biloxi, Miss. pp. 236-242.

The South can increase pine productivity on its forest lands as increased timber prices make returns from intensified forest management more profitable. We determine the most likely management intensities on industrial lands resulting in five management intensity classes. They are used to estimate the potential growth and yield levels, and compare these to empirical pine yields, developed as part of the Subregional Timber Supply (SRTS) model inputs and based on Forest Inventory and Analysis (FIA) data. These comparisons indicate that projected plantation yields are much greater than empirical FIA data - almost 100% greater that current empirical yields. Projected yields were also up to 90% higher than those used in the 1995 Rangeland Renewable Resource Act (RPA) assessment. If realized, such productivity increases could prevent timber shortages. Financial analyses indicate that intensified forest management is economically feasible and offers attractive returns.*

Keywords: economics, Forest Inventory and Analysis (FIA), forest management, growth and yield, southern pine

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138. Snyder, S., and C. ReVelle. 1996. **Temporal and spatial harvesting of irregular systems of parcels.** *Canadian Journal of Forest Research.* 26: 1079-1088.

Spatial management issues have assumed a central position in planning for forest ecosystems in the United States on both public and private lands. The arrangement of management activities, especially harvesting activities, can often have adverse impacts on other neighboring areas of the forest. Thus, spatially explicit programming models, which can account for or present certain arrangements of activities or land allocations through the use of harvest adjacency constraints, have received considerable attention in the literature. The need for spatial specificity in programming models has led to the development of integer programming or mixed integer programming models. Given that integer-programming problems are often viewed as a difficult class of problems to solve, heuristic solution methods have most often been used to solve spatially constrained forest management models. In this paper, a discrete (0-1) integer-programming model that maximizes harvested timber volume over a multiperiod time horizon subject to harvest adjacency constraints is developed and tested for irregular, realistic systems of parcels. This model performed well computationally for many example configurations and was solved exactly using the simplex algorithm and limited branching and bounding. Certain spatial configurations with long time horizons did, however, require a nontrivial amount of branching and bounding. The model was tested using both contrived and real spatial data sets.*

Keywords: adjacency constraints, forestry, integer-programming, timber harvesting

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139. Spackman, S. C., and J. W. Hughes. 1995. **Assessment of minimum stream corridor width for biological conservation: Species richness and distribution along mid-order streams in Vermont, USA.** *Biological Conservation.* 71: 325-332.

Mammal and vascular plant species were censused on 200-m long plots at varying distances from six mid-order streams in Vermont, USA to determine how wide corridors need to be to conserve biological richness. Use of stream corridors by most mammal species occurred below or just above the annual high water mark (HWM). Distribution of plant and bird species within corridors was more variable, however, and differed from stream to stream. For example, to include 90% of the streamside

plant species, minimum corridor widths ranged from 10 to 30 m above HWM, depending on the stream. Minimum corridor widths of 75-175 m were needed to include 90% of the bird species. Thus, no standard minimum corridor width for conserving species was identified. Virtually all annual, biennial, nonnative and ruderal (reedy) plant species were restricted to the streamside of HWM, suggesting that the annually flooded zones may serve as refugia and travel corridors for these groups. No analogous relationships were identified for birds or mammals. In summary, distribution of species along streams varied greatly by taxon, stream, and location of high water mark. Use of a standard corridor width to conserve species is a very poor substitute for individual, stream-specific assessments of species distributions.*

Keywords: biodiversity, riparian zones, species richness, stream bank, stream corridor

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140. Staten, M., and J. Hodges. 1997. **An industrial approach to managing for wildlife and timber.** *Journal of Forestry.* 95(8): 35-37.

There has long been concern regarding the effects industrial forest management has on wildlife habitat. Anderson-Tully Company manages timber land in one of the Nation's most ecologically sensitive areas, along the floodplains and uplands along the Mississippi River from Cairo, Illinois to Baton Rouge, Louisiana. This concern has prompted Anderson-Tully to combine economic and ecological practices so that habitat management is accomplished with little change in silvicultural practices. Economic goals of producing high quality hardwood trees for sawlogs and veneer are met through uneven-aged management techniques of group selection, shelterwood, and small clear cuts. Maintaining habitat for a diverse number of wildlife species, including threatened and endangered and game species, is the primary focus of the company's ecological goals. Companies with different goals may not have the long rotations associated with hardwood management, but may still find the concepts presented here to be useful when attempting to combine wildlife and timber management.

Keywords: Anderson-Tully Company, economics, habitat management, silviculture, wildlife habitat

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141. Steuer, R. E., and A. T. Schuler. 1978. **An interactive multiple-objective linear programming approach to a problem in forest management.** *Operations Research.* 26(2): 254-269.

In many situations it is under legislative mandate to manage publicly owned forest resources for multiple uses (e.g., timber production, hunting, grazing). The major obstacle that has been encountered in applying previously developed mathematical programming procedures to multiple-use forest management has been the difficulty in assessing the appropriate criterion weights required. To avoid the criterion weight estimation problem, an interactive multiple-objective linear programming approach, which does not require criterion weights of any kind, was developed in response to the needs of the multiple-use forest management problem. The procedure uses a combination of linear programming and vector-maximum techniques. At each iteration the cone generated by the gradients of the multiple objectives is contracted. On the last two iterations the most acceptable efficient extreme point is identified with the aid of a filtering device. As illustrated, the method has been applied to prepare preliminary management plans for a 10,000-acre sub-unit of a national forest.*

Keywords: forest management, linear programming, multiple-objective linear programming, multiple-use management

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142. Stewart, C. A. 1980. **Forest-wildlife management programs on National Wildlife Refuge lands in the Southeast.** In: R. C. Chabreck and R. H. Mills, eds. *29th Annual Forestry Symposium: Integrating Timber and Wildlife Management in Southern Forests.* Louisiana State University. pp. 27-32.

National Wildlife Refuges in the United States contain approximately 2.5 million acres of forest land, and about one-half million of these acres are located in the southeastern states. Although these lands comprise less than 1% of the nation's total forest land, refuge management programs are highly visible to the public. Therefore, there is an opportunity to favorably influence forest and wildlife management on other public and privately owned lands. In this paper, the Piedmont National Wildlife Refuge near Macon, Georgia is used to illustrate basic management principles on all forested refuges. Through timber harvests and prescribed burning a variety of forest habitats are created in the Piedmont's pine-hardwood forests, where management of red-cockaded woodpecker (*Dendrocopos borealis*), wild turkey (*Meleagris gallopavo*), and white-tailed deer (*Odocoileus virginianus*), and waterfowl is emphasized. In addition to hunting opportunities on the refuge, many nature trails exist to help meet the rising demand for non-consumptive recreation opportunities.

Keywords: Dendrocopos borealis, forest management, Meleagris gallopavo, Odocoileus virginianus, Piedmont National Wildlife Refuge, red-cockaded woodpecker, white-tailed deer, wildlife management, wild turkey

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143. Stewart, D. 1998. **Forest management strategies for bobwhite quail.** Mississippi State University Extension Service. Mississippi State University. Publication 2087.

Although northern bobwhite quail are normally associated with farmland and open areas, bobwhite can also be successfully managed on forest land. To do this, forests should be kept open, and hardwood brush controlled. Longleaf pine is recommended as the best suited pine tree for bobwhites because it is open grown and adapted to fire for early burns to control leaf litter and underbrush. Detailed descriptions are given of how forest management techniques such as thinning, clear-cutting, prescribed burning, and reforestation can be used to enhance quail habitat. Food plantings and strip disking techniques in forested stands are also discussed.

Keywords: food plantings, forest management, forestry, habitat management,

northern bobwhite quail, strip disking, wildlife management

144. Stewart, D. and W. Burger. 1998. **Strip disking and other valuable bobwhite quail management techniques.** Mississippi State University Extension Service. Mississippi State University. Publication 2023.

Bobwhite quail numbers have been declining for the last several decades, and in the last 10 years populations have been declining by as much as 7% in some places. Changes in land use and habitat, as well as increased predation and disease have all contributed to the decline. However, in some parts of the South bobwhite quail have been successfully managed so that their numbers have remained stable. To help landowners develop a bobwhite quail management plan for their own lands, this paper gives a basic overview of quail life history, food habits, and habitat requirements. Benefits of specific management practices such as burning, bush-hogging, and strip disking are also discussed. Details of strip disking techniques to enhance habitat quality are given.

Keywords: Colinus virginianus, habitat management, northern bobwhite, strip-disking, wildlife management

145. Stewart, D., D. Godwin, and W. Burger. 1998. **Ecology and management of the northern bobwhite.** Mississippi State University Extension Service. Mississippi State University. Publication 2179.

Over the last 30 years, bobwhite populations in Mississippi have declined by more than 70%. This decline is primarily attributed to a reduction of the mosaic of early successional habitat that was prevalent in the early 20th century. Increased numbers of large farms, intensive forest management, and limited prescribed burning have contributed to the decline in habitat quality. This publication gives thorough descriptions of northern bobwhite's physical characteristics, diet, and life history including courtship, nesting, and brood rearing. Although bobwhite populations are declining, quail do respond well to certain habitat-management practices. Habitat needs for nesting, brood rearing, escape, and loafing cover are discussed at length. Frequent soil and vegetation disturbance is crucial to good quail habitat. Management techniques and prescriptions to get these results are explained. Further resources for bobwhite quail assistance are listed.

Keywords: forest management, habitat management, northern bobwhite quail, wildlife management

146. Stewart, D. and G. Hurst. 1997. **Wild Turkey.** Mississippi State University Extension Service. Mississippi State University. Information Sheet 636. 4 pp.

Mississippi has one of the largest turkey populations in the United States with an estimated 250,000 to 400,000 birds. Information on characteristics, habitat needs of wild turkey are discussed. Basics for forest management plans and habitat improvements are also outlined for wild turkey management in Mississippi.
Keywords: gobbler, hen, Meleagris gallopavo, Mississippi, wildlife habitat, wildlife management, wild turkey

147. Stewart, K. M., T. E. Fulbright, and D. L. Drawe. 2000. **White-tailed deer use of clearings relative to forage availability.** *Journal of Wildlife Management.* 64(3): 733-741.

Use of woodland clearings by white-tailed deer (*Odocoileus virginianus*) may be in response to increased availability of forage within open patches or increased ability of deer to locate predators. We tested predictions, based upon the forage-maturation hypothesis, that white-tailed deer used areas with the greatest availability of high quality forage, and that habitat use changed seasonally depending upon availability and quality of major types of forage in there diet. We tested those predictions in subtropical thorn woodlands in South Texas, United States. Treatments included: 1) areas with continuous woody cover as controls, 2) clearings with high availability of forbs and shrub sprouts, 3) clearings with low availability of shrub sprouts, 4) clearings with low availability of forbs, and 5) clearings with low availability of forbs and shrub sprouts. Intensity of use by deer during summer and autumn increased with increasing biomass of shrub sprouts and then declined with increasing shrub biomass as areas became dominated by mature shrubs with less accessible, usable forage. During spring, intensity of deer use increased in clearings with increased in forage availability and quality, indicated by an index to carrying capacity, then declined as vegetation matured. Responses of white-tailed deer to clearings supported the forage-maturation hypothesis in which herbivore responses to clearings resulted, in part, from the presence of shrub sprouts of high nutritional quality, particularly during summer and autumn when forage availability was low. Maintenance of clearings that are interspersed in a woodland matrix and maintaining high levels of immature shrub sprouts may alter the spatial distribution of white-tailed deer on the landscape.*

Keywords: forage-maturation process, forage quality, Odocoileus virginianus, South Texas, subtropical thorn woodland, white-tailed deer.

148. Swallow, S. K., P. Talukdar, and D. N. Wear. 1997. **Spatial and temporal specialization in forest Ecosystem Management under sole ownership.** *American Journal of Agricultural Economics.* 79: 311-326.

"Ecosystem Management" complicated forest management considerably. In this paper we extend the economic analysis of forestry to capture both the temporal and spatial dimensions, allowing optimization of timber harvest decisions throughout an ecosystem. Dynamic programming simulations illustrate the implications for the simplest ecosystem, consisting of two forest management units. Results indicate that explicit recognition of ecological interactions, even between identical forest stands, may prescribe specialization through time and across space. Such spatial and temporal specialization leverages opportunities to provide ecosystem goods that may be foregone through reliance on "rules of thumb" derived from models that focus on a single stand.*

Keywords: ecological economics, economics, ecosystem management, forest management

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149. Swanson, C. S., and J. B. Loomis. 1996. **Role of non-market economic values is benefit-cost analysis of public forest management options.** Gen. Tech. Rep. PNW-GTR-361. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 32 pp.

Recreation in the Pacific Northwest is a valuable resource. A method is described that puts an economic value on recreation in USDA Forest Service and U.S. Department of the Interior, Bureau of Land Management lands in northern California, western Oregon, and western Washington. By assigning recreation to land use types (using the Forest Service recreation opportunity spectrum classification), the economic value associated with various land use changes can be identified. Results indicated that those land use changes resulting in more non-roaded recreational opportunities provide the greatest economic benefits. This is encouraging given the move toward ecosystem management that many agencies are making because more non-road opportunities will become available. This paper also considers values associated with maintaining old growth and wildlife and fisheries resources regardless of current or future recreation use existence values.*

Keywords: benefit/cost ratio, ecosystem management, non-market economic values, recreation, USDA Forest Service

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150. Tarp, P., and F. Helles. 1997. **Spatial optimization by simulated annealing and linear programming.** *Scandinavian Journal of Forest Research.* 12: 390-402.

Forest management planning comprises selection among treatment alternatives in management units. A traditional linear programming (LP) approach may effectively account for a profit maximization objective combined with sustainability constraints, e. g., on the temporal distribution of harvest volume flows, cashflow, and net present value development, but it fails to account for spatial constraints, especially those associated with the final felling. By applying a simulated annealing adjacency model based on net present value maximization and combined with an LP consequence computation model, it is possible to delineate optimal strategies of final felling scheduling. Evaluation is made of the trade-off between (1) the incremental cost (determined by the use of the LP model) of an optimal adjacency model solution, and (2) the potential damage cost resulting from adjacency characteristics such as windthrow and bark injuries. The decision support system may contribute significantly to reduce damage costs and may improve the reliability of forest management planning.*

Keywords: adjacency constraints, forest management, forest planning, linear programming, simulated annealing

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151. Tarp, P., G. Paredes V. and F. Helles. 1997. **A dual approach to policy analysis in multiple-use forest management planning.** *Canadian Journal of Forest Research.* 27: 849-858.

A multiple-use forest management planning system is presented enabling an optimal and efficient incentive or tax (price) level and an ethically justified compensation level combined with an optimal allocation of resources to uses (in an economic, political, and environmental sense). Extensions of the use of linear programming in multiple-use forest management planning are presented with focus on duality and opportunity costs in decision making. A dynamic linear programming model is presented where results are applied in a green account analysis. The model includes political, economic, and biological goal elements. Resource allocation issues related to nonmarket outputs are addressed. The model encompasses a multicriteria decision support system applicable in a private environment based on profit maximization as well as in a public setting based on cost-benefit analysis. The green account analysis pertaining to legislative regulations may be performed on the basis of an evaluation of production costs, producer's surplus, and consumer's surplus. The model bridges the gap between planning philosophy, rational economic behavior of decision makers, societal concerns, and practical forest management planning, a gap that is often observed in a traditional context.*

Keywords: green account analysis, policy analysis, resource allocation

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152. Thie, P. R. 1979. **An introduction to linear programming and game theory**. John Wiley & Sons, Inc. New York. 335 pp.

Provides an introductory discussion of the theoretical concepts and computations of linear programming and game theory, and how they apply to the social, life, and managerial sciences. The linear programming sections use "real-world" examples that involve a single decision-maker. The simplex method, duality, and sensitivity analysis are explained. Additional chapters on the topic of game theory emphasize the development of models with two participants with opposing interests in a conflict situation. Problem sets containing additional computational exercises are at the end of each chapter.

Keywords: game theory, linear programming, sensitivity analysis, utility theory

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153. Thompson, E. F., and R. W. Haynes. 1971. **A linear programming-probabilistic approach to decision making under uncertainty.** *Forest Science.* 17(2):224-229.

An approach, termed partially stochastic linear programming, combines linear programming with subjective probability estimates to quantitatively recognize uncertainty in forestry decision making. The approach is applied to minimizing wood procurement costs over an industrial firm's planning period. The future availability of land and raw materials are considered random variables rather than point estimates. Subjective probability distributions on each random variable are developed

from information obtained from the firm's forestry personnel. Alternative resource availability situations are simulated and least-cost linear programming solutions obtained. The results are a distribution of solutions, which can be described by its mean and variance. The approach provides the manager with decision-making information, such as the probability of the cost being above or below a specified level, which is not available from deterministic linear programs. Limitations of the approach along with suggestions for application and additional study are discussed.*

Keywords: forestry, linear programming, simulation, subjective probability, wood procurement

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154. Thompson, E. F., B. G. Halterman, T. J. Lyon, and R. L. Miller. 1973. **Integrating timber and wildlife management planning.** *The Forestry Chronicle.* 49(6): 247-250.

The goal of most public forests, as well as many privately owned ones, is multiple-use management. However, managing for multiple uses such as wood, water, recreation, and wildlife, can often make planning much more cumbersome. This is especially true when the production functions (input-output relationships) for these outputs are not known. Problems also arise when trade-offs between outputs are not known. This paper seeks to explain how two forest outputs, timber and wildlife, can be integrated in the planning process. Maryland's Pocomoke State Forest was used as a case study area to implement this planning approach, but the methodology should have a wider application for multiple-use planning.

Keywords: forestry, input-output analysis, linear programming, multiple-use management, Pocomoke State Forest, wildlife management

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155. Thompson, W., M. Halme, S. Brown, I. Vertinsky, and H. Schreier. 1995. **Timber harvest scheduling subject to wildlife and adjacency constraints.** n. pag. Online. Internet. 13 May 2000. Available http://www.esri.com/library/userconf/proc95/ to300/p261.html.

Forest management planning in British Columbia requires consideration of numerous restrictions on timber harvesting. The tabus search algorithm for solving combinatorial programming problems was implemented to solve the harvest scheduling problem of the Tangier watershed in southeastern B. C. The problem included 1616 adjacency, one even-flow and 12 wildlife constraints on 491 blocks of forest land for a planning horizon of twelve 10-year periods. The method was found to be computationally practical and efficient for this problem.*

Keywords: adjacency constraints, British Columbia, even-flow constraints, harvest scheduling, tabu search, wildlife constraints

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156. Thomson, T. A. 1992. **Optimal forest rotation when stumpage prices follow a diffusion process.** *Land Economics.* 68(3): 329-342.

A key assumption in the Faustmann rule for financial maturity is that stumpage prices are consistent over time. Timber price series, however, exhibit wild fluctuations over time, which this paper models as a lognormal diffusion process. Comparing the diffusion results modeled here to the fixed-price Faustmann results show: (1) the prescribed rotation length is generally longer; (2) computed stand values are higher using the diffusion model with the greatest divergence occurring when a stand is about the midpoint of a rotation; and (3) as the stumpage price volatility increases, the gain in computed net present value (NPV) increases, though in a nonlinear fashion.*

Keywords: Faustmann, forest economics, forestry

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157. Torres-Rojo, J. M., and J. D. Brodie. 1990. **Adjacency constraints in harvest scheduling: An aggregation heuristic.** *Canadian Journal of Forest Research.* 20: 978-986.

An heuristic for adjacency constraint aggregation is proposed. The heuristic is composed of two procedures. Procedure 1 consists of identifying harvesting areas for which it is not necessary to write adjacency constraints. Procedure 2 consists of writing one adjacency constraint for each one of the harvesting areas not identified in procedure 1. Such adjacency constraints consider all the adjacency relations between the harvesting area and its surrounding areas. The heuristic is based on the concept of penalties and the four-color theorem. The aggregated constraints present fewer variables per constraint then the aggregator described by B. J. Meneghin, M. W. Kirby, and J. G. Jones (1988. USDA For. Serv. Rocky Mt. For, Range. Exp. Stn. Gen. Tech. Rep. RM-161. pp. 46-53) and can easily be generated mechanically from the adjacency matrix. In addition, the proposed heuristic does not require the tedious task of identifying type 1 and 2 constraints as with Meneghin's algorithm. Hence the combinational work to compute the aggregated constraint is reduced significantly. Comparisons showed that the proposed heuristic requires about a third of the constraints required by the conventional adjacency constraint formulation and about the same number of constraints as the procedure suggested by B. J. Meneghin, M. W. Kirby, and J. G. Jones (1988).*

Keywords: adjacency constraints, harvest scheduling

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158. USDA Forest Service. 1999. **Spectrum users guide.** USDA Forest Service. n. pag. Online. Internet. 26 May 2000. Available http://www.fs.fed.us/imi/planning_center/download_center.html

Spectrum is a linear programming based forest planning model developed by the USDA Forest Service. Like its predecessor FORPLAN, it is used to optimize land allocation, harvest scheduling, and management over a specific planning horizon. Spectrum consists of a data entry system, model manager, matrix generator, and report software. The commercially available software C-Whiz is used to solve the linear programming matrix generated by Spectrum. The report utility produces reports and

database files, and interprets the linear programming solution developed by C-Whiz.

Keywords: C-Whiz, FORPLAN, linear programming, Spectrum, timber harvest planning

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159. USDA Forest Service. 1999. **National Forests of Mississippi Monitoring and Evaluation Report: Fiscal Year 1998.** United States Department of Agriculture. Forest Service, Southern Region. 65 pp.

The Land and Resource Management Plan (Forest Plan) provides guidance on how national forest land in Mississippi will be managed. The current Forest Plan for Mississippi was adopted in 1985. Monitoring of this plan is completed to determine how well the Forest Plan goals and objectives are being met, if the standards and guidelines are being implemented properly, and if the environmental affects are occurring as predicted. This monitoring and evaluation report is divided into two sections. The Monitoring Results and Recommendations section reports on the monitoring results with regard to 1) ecosystem condition, health and sustainability, 2) sustainable multiple forest and range benefits, and 3) organizational effectiveness. The Action Plan sections present the action plan that was developed from recommendations resulting from evaluation and monitoring results.

Keywords: ecosystem, forest planning, Mississippi National Forests, USDA Forest Service

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160. U. S. Department of the Interior and U. S. Department of Commerce (USDI and USDC). 1998. **1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.** Mississippi.

This survey reports results from interviews with Mississippi residents and non-residents 16 years old and older about their wildlife-related recreation in 1996. These wildlife-related activities included fishing, hunting, and wildlife watching. Of the 680 thousand Mississippi residents who participated in these activities, 431 thousand fished, 301 thousand hunted, and 458 thousand participated in wildlife watching activities such as observing, feeding, and photographing wildlife. Expenditures in Mississippi were also determined. Of the $1.8 billion spent on wildlife recreation, $375 million was spent on trip expenses, $1.0 billion on equipment, and $369 million on goods such as licenses and leases.

Keywords: anglers, economics, fishing, hunters, hunting, Mississippi, wildlife, wildlife watching

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161. Van Deusen, P. C. 1996. **Habitat and harvest scheduling using Bayesian statistical concepts.** *Canadian Journal of Forest Research.* 26: 1375-1383.

A procedure is derived to generate long-term management schedules of habitat and harvest on large land holdings. The method utilizes spatial distributions that are derived using Bayesian statistical concepts. Model-based methods are proposed for incorporating spatial constraints and stochastically creating habitat. Thus, the Bayesian scheduler treats the schedule as a stochastic process rather than a deterministic one and generates virtually an infinite number of potential schedules that share common distributional characteristics. These schedules can then be examined and chosen according to economic or other criteria.*

Keywords: Bayesian statistics, Bayes scheduling algorithm, forest management, habitat management, harvest scheduling

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162. Van Deusen, P. C. 1999. **Multiple solution harvest scheduling.** *Silva Fennica.* 33(3): 207-216.

Application of the Metropolis algorithm for forest harvest scheduling is extended by automating the relative weighting of objective function components. Previous applications of the Metropolis algorithm require the user to specify these weights, which demands substantial trial and error in practice. This modification allows for general incorporation of objective function components that are either periodic of spatial in nature. A generic set of objective function components is developed to facilitate harvest scheduling for a wide range of problems. The resulting algorithm generates multiple feasible solutions rather than a single optimal solution.*

Keywords: Gibb's sampler, harvest scheduling, Metropolis algorithm, simulated annealing

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163. Van Manen, F. T. and M. R. Pelton. 1997. **A GIS model to predict black bear habitat use.** *Journal of Forestry.* 95(8): 6-12.

A predictive model for black bear (*Ursus americanus*) habitat on the Tellico Ranger District, Cherokee National Forest, Tennessee was developed using a Geographic Information System (GIS) to extract the habitat data. Statistical analysis consisting of a logistic regression was used outside the GIS to determine bear habitat use, then, these results were spatially modeled and mapped using the GIS software ARC/INFO®. This model, when expanded to the entire southern Appalachian region, determined that 88% of female and 62% of male bears were within currently occupied bear range with a habitat use probability of >/= 0.5. The results of this study conclude that modeling wildlife habitat using a GIS is an effective way to better understand and predict wildlife-habitat interactions even at different scales and regions.

Keywords: black bear, Cherokee National Forest, Geographic Information System, GIS, logistic regression, Ursus americanus

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164. Walton, M. T. 1981. **Wildlife habitat preservation programs.** In: R. T. Dumke, G. V. Burger, and J. R. March eds. *Wildlife management on Private Lands.* La Crosse Printing Co., Inc., La Crosse, Wisconsin. pp. 193-208.

Wildlife habitat preservation is important on private lands since it provides a disproportionate amount of habitat for many species. There are many programs that have been developed to

protect wildlife habitat on private lands, however there is no one program that can manage all environmental pressures. Purchasing land that encompasses critical habitat is often the best method of protection. However, such purchases can be costly and take long periods of time to close. Easements are cost effective for preserving small areas. Short-term leases are cost effective, and although they are not permanent, may buy time for development of a longer-term solution. Regulation is often ineffective because protection may vary from state to state. Indeed, a national wildlife habitat management program may be needed. For any program to be successful, however, the wildlife consumer and society must be willing to reimburse the landowner for services through compensatory payments or tax incentives.

Keywords: habitat management, incentive programs, wildlife management

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165. Walsh, R. G., J. B. Loomis, and R. A. Gillman. 1984. **Valuing option, existence, and bequest demands for wilderness.** *Land Economics.* 60(1): 14-28.

This paper estimates the benefits and costs of wilderness recreation use by estimating preservation value using the contingent valuation method. Two-hundred-eighteen Colorado households were shown maps of the state with wilderness areas delineated on them. They were asked to write down the maximum amount they would be willing to pay annually to protect the current wilderness areas. Then they were asked to allocate the highest amount reported to four categories of value: recreation, option, existence, and bequest. Overall, it was found that the public may be willing to pay for preservation of natural areas. To determine the total economic value of wilderness; option, bequest, and existence values should be added to the consumer surplus of recreation. The results of this study suggest that the estimation of preservation values should be part of the federal land management agency benefit assessment process.

Keywords: bequest value, contingent valuation, existence values, forest economics, option value, recreation

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166. Ware, G. O., and J. L. Clutter. 1971. **A mathematical programming system for the management of industrial forests.** *Forest Science.* 17(4): 428-445.

The scheduling of harvest operations in an industrial forest determines future growing stock volumes, growth rates, harvest yields, cash flows, present worth, and return on investment. Some inadequacies of previously available techniques for preparing cutting schedules are discussed, and a computerized management planning system based on linear programming techniques is described. The system is designed to maximize present net worth subject to restrictions on harvest volumes and regeneration acreages. Results of a typical application of the system are discussed.

Keywords: forest economics, forestry, harvest scheduling, linear programming, stand growth

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167. Wear, D. N., 1996. **Forest management and timber production in the U.S. South.** Southeastern Center for Forest Economics Research, Research Triangle Park, NC. SCFER Working Paper No. 82. 40 pp.

Reviews the general setting of forestry in the South through a discussion of land use history and demographics, and how this has affected the distribution and quality of the timber inventories. Later sections of the paper address the historic production of timber from the region and long term sustainability of timber production in the South. The author concludes that the South's forest sector is both productive and stable. However, long term implications of concerns over non-market goods provided by southern forests are yet to be seen, and may cause future changes in the timber market.

Keywords: forest economics, forest inventory, forestry, timber production

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168. Weintraub, A, R. Adams, and L. Yellin. 1982. **Land management planning: A method of evaluating alternatives.** USDA Forest Service Research Paper PSW-167. 12 pp.

A method is described for developing and evaluating alternatives in land management planning. A structured set of 15 steps provides a framework for such an evaluation, when multiple objectives and uncertainty must be considered in the planning process. The method is consistent with other processes used in organization evaluation, and allows for the interaction of decision-makers, specialists, analysts and the general public. The method incorporates several novel aspects that help in structuring the decision process. Application of the method is illustrated by replicating the development of an environmental study in the Truckee-Little Truckee Rivers Planning Unit, Tahoe National Forest, California.*

Keywords: land management planning, multiple objectives

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169. Weintraub, A., F. Barahonia, and R. Epstein. 1994. **A column generation algorithm for solving general forest planning problems with adjacency constraints.** *Forest Science.* 40(1): 142-161.

An algorithm is presented for solving general forest planning models when spatial relationships, in particular adjacent constraints, are considered. We solve a master linear program with a column generation approach. The generation of columns is done by solving a stable set problem. To preserve the adjacency properties, fractional solutions in the master problem are rounded off to integrality through a heuristic procedure. Computational experience on medium-sized problems showed that solutions with small deviations from the optimal could be obtained with moderate computational effort.*

Keywords: combinatorial analysis, linear programming, spatial allocation

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170. Weintraub, A., G. Saez, and M. Yadlin. 1997. **Aggregation procedures in forest management planning using cluster analysis.** *Forest Science.* 43(2): 274-285.

Typical linear programming models used in forest planning can be very large. It is often of interest to analyze more compact, less detailed versions. One form of reducing the size of the problem is through an aggregation process. One way in which this has been done is through a column aggregation process, where sets of similar columns are replaced by one representative. A second alternative is to aggregate the original data, in which case the stands and management alternatives are grouped before building a model. Typical approaches for the aggregation processes have been analytical. We present an alternative approach for aggregation based on cluster analysis. Computational results for both types of aggregation show that using cluster analysis can be advantageous.*

Keywords: hierarchical planning, linear programming, statistical analysis

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171. Willis, K. G. 1990. **Valuing non-market wildlife commodities: an evaluation and comparison of benefits and costs.** *Applied Economics.* 22:13-30.

This paper compares the benefits and costs of nature conservation at three Sites of Special Scientific Interest. Benefits are estimated by contingent valuation (expressed preferences) and also the travel cost method (revealed preferences). Opportunity costs are assessed from a financial cost viewpoint, and also in terms of 'shadow' prices or social costs. Results indicate that the valuation of wildlife and nature conservation largely depends upon the frame of reference adopted; that social costs are considerably less than financial costs due to the effect of the Common Agricultural Policy; that user benefits are considerably less than financial costs; and that non-user benefits must be included to cover even the social costs of conservation.*

Keywords: benefit/cost analysis, conservation, contingent valuation, Great Britain, shadow prices, travel cost, United Kingdom

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172. Woods, J. J. 1987. **Commercial forests: Beyond the bottom line.** *American Forests.* 93(9/10): 30-34.

In the past, most commercial timber companies believed that whatever they did as forest management practices took care of the wildlife resource needs at the same time. While it is true that a timber company's primary purpose is to grow timber to produce products and return a profit, many companies now realize the importance of wildlife management concerns. Due to differences in local biological, economic, and social situations, management strategies are often site-specific when it comes to multiple-use programs on industry lands. Every acre will not be maximized for all wildlife species, but in general, forest productivity will be increased thereby benefiting many wildlife species. Companies such as Weyerhaeuser and Westvaco have designated special areas on company owned lands where wildlife habitat is enhanced through special management techniques to provide food and cover for wildlife. Timber companies are interested in understanding the forest management-wildlife relationships, and are striving toward a goal of ecosystem management rather than just product management.

Keywords: ecosystem management, forest management, Westvaco, Weyerhaeuser, wildlife management

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173. Yarrow, G. K., and D. T. Yarrow. 1999. **Managing Wildlife: On private lands in Alabama and the Southeast.** Sweetwater Press, Birmingham, Alabama.

This book is a comprehensive guide for landowners regarding the multiple-use management of timber and wildlife. A basic overview of wildlife management is given, and specific habitat requirements for Alabama's game, non-game, and threatened and endangered species are discussed. Wildlife management recommendations are made based on physiographic region of the state due to differences in soil type, vegetation, and land-use. These recommendations also apply across the Southeast when habitats and physiographic regions are similar. Impacts of forest management, and the opportunity and direct costs associated with them are presented. Examples of alternative management regimes that have varying intensities and costs give landowners the opportunity to choose the management option that will help them best meet their objectives.

Keywords: Alabama, forest management, physiographic regions, Southeastern United States, wildlife management

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174. Yin, R. and D. H. Newman. 1995. **Optimal timber rotations with evolving prices and costs revisited.** *Forest Science.* 41(3): 477-490.

In this paper, we extend previous work that modeled the impact of evolving prices and costs to evaluate the full range of rotation length and input changes resulting from changing prices and costs. Our model suggests that if prices and costs change at the same rate, then production decisions are invariant. Any specific proportionate rate of change in prices and costs acts as an adjustment factor on the discount rate, which corresponds, to a constant rotation length. We also find that in the normal range of changes, namely, rates of any change less than discount rate, the following results hold: if prices rise faster than costs, then the rotation length becomes shorter and establishment inputs increase; on the other hand, if costs rise faster than prices, then the optimal harvest age becomes longer and stand establishment inputs are reduced. These results not only extend and generalize those derived by McConnell et al. and Newman et al., but also further demonstrates the robustness of the Faustmann model.*

Keywords: dynamic optimization, Faustmann, forest economics, timber production

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175. Yoshimoto, A., and J. D. Brodie. 1993. **Comparative analysis of algorithms to generate adjacency constraints.** *Canadian Journal of Forest Research.* 24: 1277-1288.

A mathematical programming formulation of the area-based forest planning problem can result in a large number of adjacency constraints with much potential for redundancy. Two heuristic algorithms have been proposed for reducing redundant adjacency constraints generated by the conventional algorithm. In this paper another analytical algorithm is proposed, and its efficiency and that of the conventional algorithm and the two heuristics are evaluated and compared. Comparison is based on the number of constraints, and on the computation effort needed both to derive the adjacency constraints and to solve the associated planning problem. Evaluation for several adjacency maps shows that the conventional algorithm has the largest number of constraints, with a low degree of effort in derivation of adjacency constraints and a small computational task to find a final solution. The first heuristic algorithm has the smallest number of constraints but involves a high degree of effort and a large computational task. The second heuristic has a small number of constraints with a moderate degree of effort and a large computational task, and the proposed algorithm has a small number of constraints with a low degree of effort and a moderate to large computational task.*

Keywords: adjacency constraints, harvest scheduling, heuristic algorithms

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176. Yoshimoto, A., J. D. Brodie, and J. Sessions. 1994. **A new heuristic to solve spatially constrained long-term harvest scheduling problems.** *Forest Science.* 40(3): 365-396.

Because of capability limitations of the integer programming solution technique, a new heuristic algorithm was developed to solve spatially constrained long-term harvest scheduling problems. The proposed algorithm can handle multiple harvesting for each harvest unit over a long time horizon. The heuristic utilized random ordering heuristic optimization and the PATH algorithm adapted from stand level optimization. Employing the proposed algorithm, a harvest scheduling system was constructed. The performance of the proposed algorithm is presented and compared to the branch-and-bound algorithm in terms of computational time as well as the objective value. Using two example forests, solutions by the proposed algorithm are stable in terms of the objective value and have harvest flow fluctuation much less than 3%. For short-term problems, solutions by the proposed algorithm tend to be optimal. For those problems for which an optimal solution is found by the branch-and-bound algorithm, the solution can produce an objective value with deviation less than 2% from the optimum. The proposed algorithm yields better solutions for long-term problems than the branch-and-bound algorithm with the 1,000,000 limited number of iterations, and the lower bound derived by the proposed algorithm. Computational results reveal that as the time horizon increases, the proposed algorithm significantly and increasingly outperforms the "limited" branch-and-bound algorithm in terms of required computational time. The advantage of the proposed algorithm results from partitioning the problem into subproblems period by period using the PATH algorithm, and defining the objective function of the subproblem by minimizing absolute infeasibility on harvest flow constraints at each period under a two-period sequential feasibility condition.*

Keywords: harvest scheduling, integer programming, PATH algorithm

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177. Zinkhan, F. C. 1995. **Forest economics: The management of options and values.** *Journal of Forestry.* 93(1): 25-29.

Traditional economic approaches to valuing forest resource management alternatives ignore the importance of managerial flexibility. Yet managers' options to abandon, delay, expand, or contract certain practices in response to changing operating, market, and philosophical conditions have value. Failure to recognize this value can lead to non-optimal land-use conversion, poor forest rotation decisions, and other problems. Forest economists should consider integrating option pricing (that recognizes the value of managerial flexibility) and contingent valuation methods (that are applied to estimating nonmarket benefits value) as they develop forest-value approaches consistent with the profession's volatile operating environment, evolution, and increased recognition of public rights.*

Keywords: contingent valuation, forest economics, forestry, land expectation value, option pricing

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***The author's abstract was used as a basis for the summary.**

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