Hardwood Bottomland Forests

and their management…

Heath Hagy
Advanced Wetlands Ecology
13 October 2011

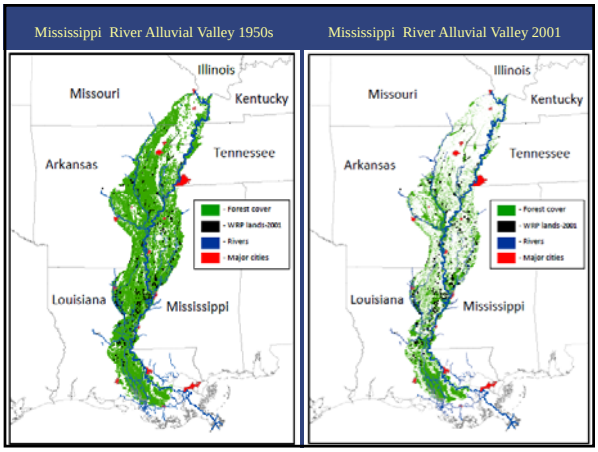
Bottomland Hardwood Forests

- Periodically flooded stands of mature river-bottom trees
  – Baldassarre and Bolen
- Bottomland hardwood forests (BHF) are forested, alluvial wetlands occupying broad floodplain areas that flank large river systems
  – 2005 Louisiana conservation of habitats and species assessment
- BHF are found in low-lying areas often near rivers and streams which occasionally flood. In the Southeastern United States, mature BHF are dominated by deciduous trees such as oaks (*Quercus* sp.), gums (*Nyssa* sp.), and baldcypress (*Taxodium distichum*) which tolerate seasonal or semipermanent water.

Bottomland Hardwood Forest – History of Loss

South Carolina Drains the Cawcaw Swamp	1754
George Washington and the Dismal Swamp Land Company drain Dismal Swamp	1763
Swamp Lands Act (Federal acquisition of swamps for "reclamation")	1850
Widespread use of drainage tiles for agriculture	1880
First National Drainage Congress	1912
Age of the Levees	1920-Present

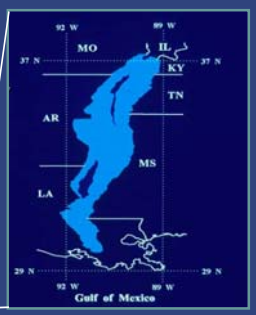
Lockaby 2009 (Wetlands)



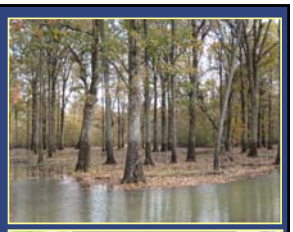
Bottomland Hardwood Forests

MAV
10 million ha
↓
2 million ha

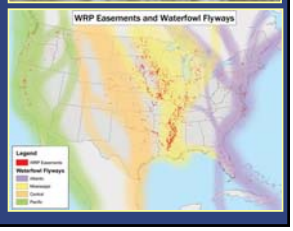
Southeast
52 million ha
↓
< 10 million ha



Today's BHF



- National Wildlife Refuges / Forest Service / Park Service
- Remnant Patches
- WRP lands
- Hunting Clubs



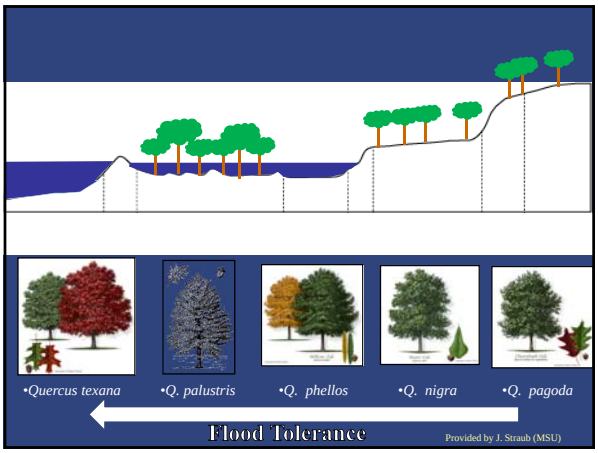
Bottomland Hardwood Forest Conservation

- Recent impetuses
  - Louisiana black bear
  - Ivory-billed woodpecker
  - Declines in neotropical migrant populations
  - Carbon sequestration
  - Global climate change
  - Dead zone
  - NAWMP

Tree Species Composition

Hyrdo-period

- Frequency = how often (within and among years) ?
- Duration = (How long remains flooded) ?
- Depth = How deep?
- Timing = what time of year ?



Hydrology Indicates Composition

Naturally Flooded River Bottoms	Greentree Reservoirs	Natural Depressions / Cypress Swamps

Seasonal ⟷ Semipermanent

Q. nigra Q. phellos L. styraciflua U. americana C. aquatica F. pennsylvanicum	Q. nigra Q. phellos N. sylvatica L. styraciflua U. americana C. aquatica	Q. lyrata N. sylvatica T. disticum

Duration of Flooding	Herbaceous Plants	Woody Plants
(A) Permanent	Water Milfoil Watershield American Lotus	Common Baldcypress
(B) Semi-permanent Water	American Lotus Duckweed Swamp smartweed	Common Baldcypress Water Tupelo Water Elm Buttonbush
(C) 3 to 8 Months	Swamp smartweed Lizard's Tail Sticktights Arrowarum	Common Baldcypress Overcup Oak Red Maple Waterlocust Possumhaw Holly
(D) 1 to 6 Months	Lizard's Tail Sticktights Sedge	Overcup Oak Willow Oak Pin Oak Cherrybark Oak Sweetgum Blackgum Tupelo
(E) 0 to 2 Months	Spotted Smagweed Nettle Giant Cane Nightshade	Sweetgum Blackgum Tupelo Sugar Hackberry Shagbark Hickory American Elm Swamp Chestnut Oak
(F) Once in 10 Years	Spotted Smagweed Nettle Giant Cane Wildrye Pokeberry	Sweetgum Sugar Hackberry Shagbark Hickory White Oak Flowering Dogwood

Fig. 4. Typical lowland hardwood vegetation profile showing 1) maximum flooding depth, 2) mean annual dormant season flooding depth and 3) mean annual low water depth during the growing season.

Greentree Reservoir Management Manual

Hydrology Influences Animal Community

Table 12. Representative amphibian, reptilian, fish, mammalian and bird faunas in different forest communities of lowland hardwood wetlands.

Flooding regime[a]	Characteristic forest community types	Flood duration	Fish	Amphibians and reptiles	Birds[b]	Mammals
Permanently flooded (II)	Bald cypress/water tupelo	Usually 12 months except for extreme drought	Topminnow Killifish Swamp darter Bowfin Redfin & chain pickerels	Lesser siren Congo eel Water snakes Cottonmouth Many-lined & southern dusky salamanders	Prothonotary & parula warblers Tufted titmouse Green-backed heron Great blue heron Yellow-crowned night-heron Red-shouldered hawk	Mink Beaver River otter
Semipermanently flooded (III)	Overcup oak/water hickory Overcup oak/red maple	6–8 months, winter, spring & well into growing season	Mosquitofish Topminnow	Spotted, Marbled & two-lined salamanders	Grackle Swainsons warbler	Mink Raccoon
Seasonally flooded (IV)	Pin oak/sweetgum Diamond-leaf oak/willow oak	4–6 months, winter, spring & up to 1–2 months of the growing season	Banded pygmy sunfish Flyer sunfish Mosquitofish Topminnow	Box turtle Rat snakes Leopard frog Mud salamander	Red-bellied & downy woodpeckers Barred owl Cardinal Carolina wren	Swamp rabbit White-tailed deer Golden and cotton mouse Short-tailed shrew
Temporarily flooded (V)	Willow oak/cherrybark oak Water oak	1–4 months, up to 1 month of the growing season		Copperhead Canebrake rattlesnake Spadefoot toad Mole salamander	Yellowthroat Pine warbler Wood thrush Wood pewee Wild turkey	Cougar Bobcat Gray fox White-tailed deer

[a] Corresponds to zones II-IV developed by National Wetlands Technical Countil (Larson, et al. 1981).
[b] Exclusive of waterfowl.

Greentree Reservoir Management Manual

Natural Flooding

- Infuses forest with nutrients and organic matter
- Flooding can slow decay of vegetative matter, allowing nutrients to build up.
- Filtration
- Groundwater recharge and downstream flood amelioration
- Seed dispersal
  - Water
    - Baldcypress, Overcup oak

The Great Mississippi River Flood of 1927, photographed in Illinois on March 25.

"The Floods of 1927 in the Mississippi Basin," Frankenfeld, H.C., 1927 Monthly Weather Review Supplement No. 29

Natural Flooding vs. Impoundments

The Flood-Pulse Concept

- Flooding is a critical component of the functioning floodplain system
- Nutrients added to floodplain
- Nutrients removed from floodplain
- Dynamic interaction between water and land

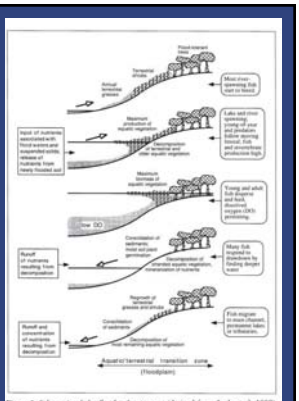


Figure 1. Schematic of the flood-pulse concept (derived from Junk et al. 1989) showing a vertically exaggerated section of a floodplain in five snapshots of an annual hydrological cycle. Right-hand column indicates typical life-history traits of fish. DO = dissolved oxygen.

Bayley 1995 (Bioscience)

Effects of "Flood Control"

- Levees result in:
  - Drier floodplains
  - Higher nutrient pooling
  - Greater herbaceous biomass
  - Lower water tables
  - Lower redox potential
- Reduced disturbance in floodplains (heterogeneity)

Franklin et al. 2009 (Wetlands)

Wildlife in Bottomland Forests

Neotropical Migrants

Herpetofauna

Mammals

Fish

Bears in Bottomland Forests

- Needs
  - Large cavities of denning sites (e.g., brush piles on hummocks)
  - Dense ground cover (understory)
  - Large habitat tracts and connectivity
  - Hard and soft mass
    - Acorns are very important in fall
- Bald cypress trees surrounded by water
- Sanctuaries' are extremely important
  - Pocosins

A. Crook (LSU 2008); Dickson 2001

Bats in Bottomland Forests

Candice Stevenson (MSU 2008)

- Stand age
- >50 cm DBH

Table 4.1 Results of logistic regression analysis used to compare use and non-use cavity tree characteristics for roosting Rafinesque's big-eared bat at Noxubee National Wildlife Refuge during 2005-2007.

Cavity Tree Measurements (cm)	Use		Non-use		Logistic Regression Statistics		
	$\bar{x}$	SE	$\bar{x}$	SE	SE	χ^2	*P*-value
DBH	99.6	5.45	48.8	0.92	0.02	30.42	<0.001
Cavity width	40	4.52	22.9	0.76	0.05	2.06	0.1517
Cavity height	70.2	9.38	57.2	1.96	0.01	0.71	0.3990
Canopy height	574.4	45.55	264.7	9.55	0.01	6.13	0.0133

Table 4.2 Results of logistic regression analysis used to compare use and non-use cavity tree characteristics for roosting southeastern myotis at Noxubee National Wildlife Refuge during 2005-2007.

Cavity Tree Measurements (cm)	Use		Non-use		Logistic Regression Statistics		
	$\bar{x}$	SE	$\bar{x}$	SE	SE	χ^2	*P*-value
DBH	78.5	3.92	50.6	1.11	0.02	16.91	<0.001
Cavity width	33.1	2.53	23.1	0.81	0.02	2.45	0.1172
Cavity height	53.7	4.68	58.2	2.06	0.01	5.56	0.0184
Canopy height	343.6	38.11	266.3	9.80	0.01	10.07	0.0015

Table 3.4 Percentage of the densities of trees found with and without cavities at Noxubee National Wildlife Refuge, Mississippi. Percentage compares cavity trees located in pilot surveys to trees found during prism cruises in four study sites during 2005-2007.

Tree species found to have cavities		Tree Species found to have no cavities	
Tree Species	Percentage with cavities	Tree Species	Percentage with cavities
American beech *Fagus grandifolia*	92.9	Black willow *Salix nigra*	0
American holly, *Ilex opaca*	25.8	Loblolly pine, *Pinus taeda*	0
American sycamore *Platanus occidentalis*	18.7	Red mulberry *Morus rubra*	0
Black tupelo *Nyssa sylvatica*	17.8	Nuttall oak *Quercus nuttallii*	0
Sweetgum *Liquidambar styraciflua*	15.6	Northern red oak *Quercus rubra*	0
Green ash *Fraxinus americana*	10.8	Red hickory *Carya glabra var. glabra*	0
Sugarberry *Celtis laevigata*	9.5	Scarlet oak *Quercus coccinea*	0
Pignut hickory *Carya glabra*	7.5	Sassafras *Sassafras albidum*	0
Shagbark hickory *Carya ovata*	5.0	Slippery elm *Ulmus rubra*	0
Persimmon *Diospyros virginiana*	4.0	Swamp laurel oak *Quercus laurifolia*	0
Overcup oak *Quercus lyrata*	3.4	Sugar maple *Acer saccharum*	0
White oak *Quercus alba*	3.3	Shumard oak *Quercus shumardii*	0
American elm *Ulmus americana*	2.6	Southern red oak *Quercus falcata*	0
Water oak *Quercus nigra*	2.1		
Mockernut hickory *Carya tomentosa*	2.1		
Swamp chestnut oak *Quercus michauxii*	2.0		
Winged elm, *Ulmus alata*	1.7		
Yellow-Poplar *Liriodendron tulipifera*	1.7		
Willow oak *Quercus phellos*	1.6		
Red maple, *Acer rubrum*	1.4		
Baldcypress *Taxodium distichum*	1.3		
American hornbeam *Carpinus caroliniana*	1.1		
Chestnut oak *Quercus prinus*	0.5		

Bats in Bottomlands

Table 4.5 Manly's alpha selectivity index for cavity tree species used by Rafinesque's big-eared bat as roosting habitat at Noxubee National Wildlife Refuge in Mississippi during 2005-2007.

Cavity Tree Species	n	No. of Checks	No. of Bat Detections	Selectivity	Indicator[a]
Green Ash	7	33	0	0	N[b]
Red Maple	4	24	0	0	N
Sweetgum	105	627	16	0.012	U[c]
Shagbark Hickory	5	31	1	0.015	U
American Beech	37	182	7	0.018	U
Overcup Oak	16	93	7	0.035	U
Water Oak	4	57	13	0.117	S[d]
Swamp chestnut Oak	9	100	23	0.118	S
Pignut Hickory	4	58	14		
Black Tupelo	19	228	66		
American Sycamore	6	38	11		
Baldcypress	10	182	77		

[a]Selectivity index is 0.083; tree species with a selectivity indicator > 0.083 [illegible]
[b]N = Non-use
[c]U = Use
[d]S = Selected

Table 4.6 Manly's alpha selectivity index for cavity tree species used by southeastern myotis as roosting habitat at Noxubee National Wildlife Refuge in Mississippi during 2005-2007.

Cavity Tree Species	n	No. of Checks	No. of Bat Detections	Selectivity	indicator[a]
Green Ash	7	33	0	0	N[b]
Red Maple	4	24	0	0	N
Shagbark Hickory	5	31	0	0	N
Overcup Oak	16	93	2	0.023	U[c]
Swamp Chestnut Oak	9	100	4	0.043	U
Pignut Hickory	4	58	3	0.056	U
Baldcypress	10	182	12	0.072	U
American Beech	37	182	13	0.079	U
Sweetgum	105	627	57	0.101	S[d]
Water Oak	4	57	6	0.118	S
Black Tupelo	19	228	36	0.182	S
American Sycamore	6	38	10	0.324	S

[a]Selectivity index is 0.083; tree species with a selectivity indicator > 0.083 are more often selected
[b]N = Non-use
[c]U = Use
[d]S = Selected

Candice Stevenson (MSU 2008)

Fish in Bottomlands

- Spawning sites
- Nursery sites for juveniles
- Foraging sites
  - Acorns
  - Invertebrates
    - crayfish
  - Soft mass
- Catfish, sunfish, paddlefish, etc.

Kwak 1988 (AMN)

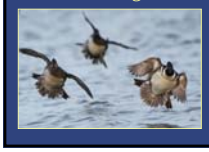
BHF for Waterfowl

Mallard

Wood duck

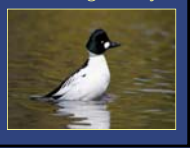
Black duck

Hooded merganser



Common merganser

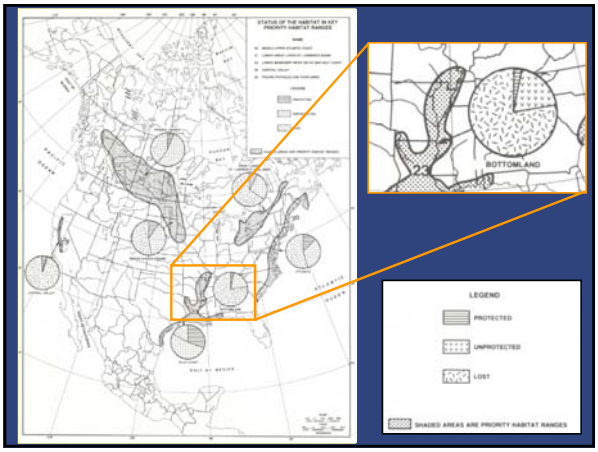
Common goldeneye



NAWMP Goals

1. Restore waterfowl breeding habitat…

2. To protect 686,000 additional acres of mallard and pintail migration and wintering habitat in the lower Mississippi River-Gulf Coast region and increase the carrying capacity for wintering birds on lands and waters already acquired for waterfowl.



BHF and Waterfowl

- Isolation (pairing)
- Breeding
- Foods
- Protection and shelter

BHF and Waterfowl - Foods

- Acorns
- Seeds
- Tubers
- Invertebrates
- Fish

Values of BHF

- Carbon sequestration
- Water quality
- Groundwater recharge
- Timber production
- Nutrient cycling
- Wildlife habitat

Values of BHF

Management of BHF

- Beaver impoundments
- Selective timber harvest
  - Create openings
  - Leave brush piles
  - Uneven-age management

- Moist-soil clearings

- Water control
  - Greentree Reservoirs

Beaver Pond Management

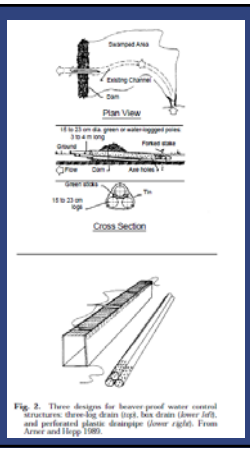


Fig. 2. Three designs for beaver-proof water control structures: three-log drain (top), box drain (*lower left*), and perforated plastic drainpipe (*lower right*). From Arner and Hepp 1989.

- Advantages
  - Natural
  - Habitat complexity
  - Economical
- Disadvantages
  - Tree kill
  - Dynamic
  - Facilitate increase in beaver activity (snow ball)

Waterfowl Management Handbook

Beaver Pond Management

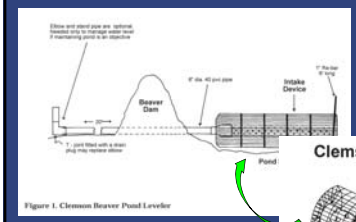


Figure 1. Clemson Beaver Pond Leveler

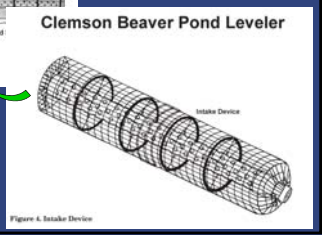
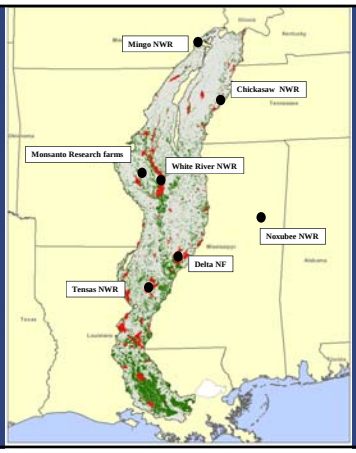


Figure 4. Intake Device

Waterfowl Management Handbook; Clemson Extension 1994

Selective Harvest – Mast producers for waterfowl



Replenishment of winter food resources!

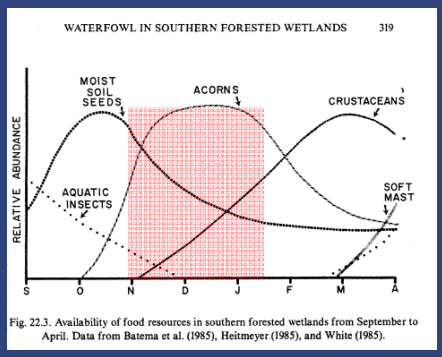
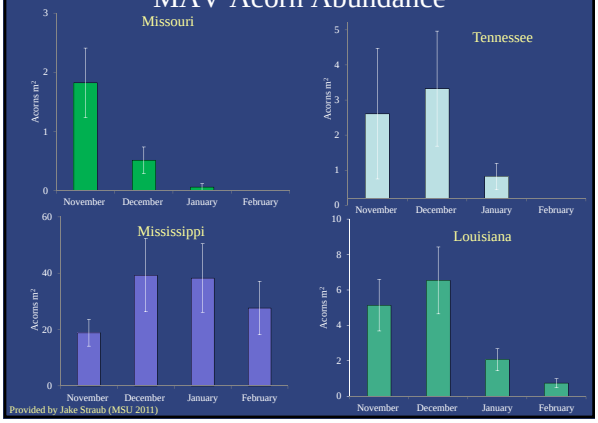


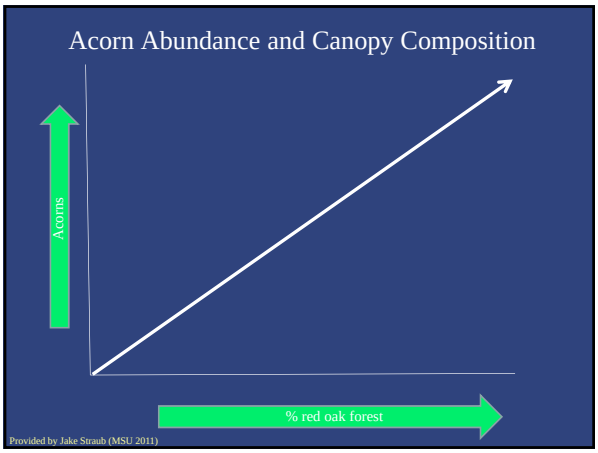
Fig. 22.3. Availability of food resources in southern forested wetlands from September to April. Data from Batema et al. (1985), Heitmeyer (1985), and White (1985).

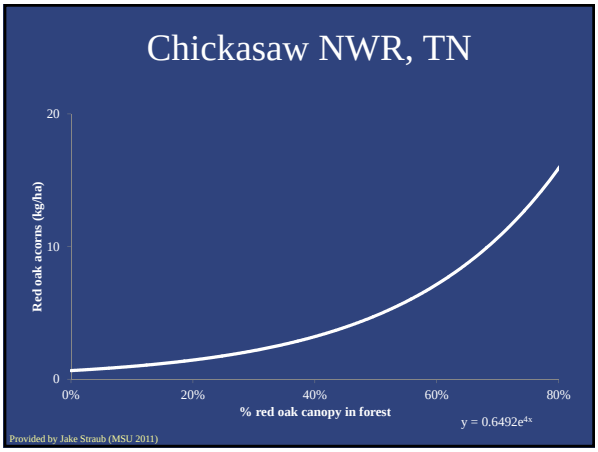
Fredrickson and Heitmeyer (1988)

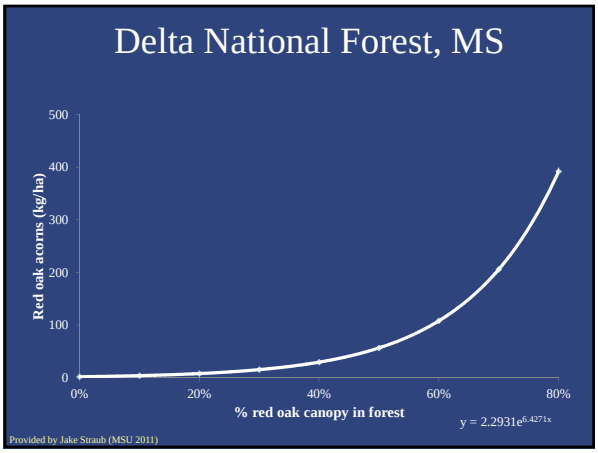
MAV Acorn Abundance



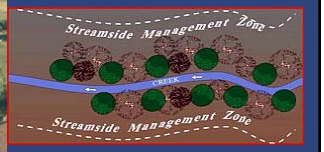
Provided by Jake Straub (MSU 2011)


Acorn Abundance and Canopy Composition
Acorns
% red oak forest
Provided by Jake Straub (MSU 2011)


Chickasaw NWR, TN
Red oak acorns (kg/ha)
20
10
0
0%
20%
40%
60%
80%
% red oak canopy in forest
y = 0.6492e^4x
Provided by Jake Straub (MSU 2011)


Delta National Forest, MS
Red oak acorns (kg/ha)
500
400
300
200
100
0
0%
20%
40%
60%
80%
% red oak canopy in forest
y = 2.2931e^6.4271x
Provided by Jake Straub (MSU 2011)

Streamside Zones



Streamside Zones

- Reduces sediment loss
- Discourages travel in stream bed
- Reduces excessive input of debris
- Retains canopy to maintain suitable water temperature
- Provides habitat diversity
  - Edge
  - Herbaceous vegetation and scrub-shrub strata
- Travel corridors (habitat connectivity)

Greentree Reservoirs (GTRs)

- Stuttgart, AR
  - Grand Prairie
  - 1930's
  - Noxubee 1960's
- ~ 180 nationwide (most in the MAV)

GTR - Construction

- Hardwood bottomland forest enclosed partially or completely by levees containing water control structures
  - Flat topography for 1 - 18 in flooding
  - 40 yr-old mix of oaks, gums, and ashes
  - Impervious soils or clays
  - Minimum of 4 ha in traditional waterfowl flyways

GTR - Construction

- Levee construction
  - 1:3-6 slope ratio (wider is better)
  - 100 ft wide clearing for levee construction and borrow ditches
  - Plant with perennial grasses and cleared of woody vegetation annually
- Dependable water source
  - Reservoir
  - River diversion
  - Other

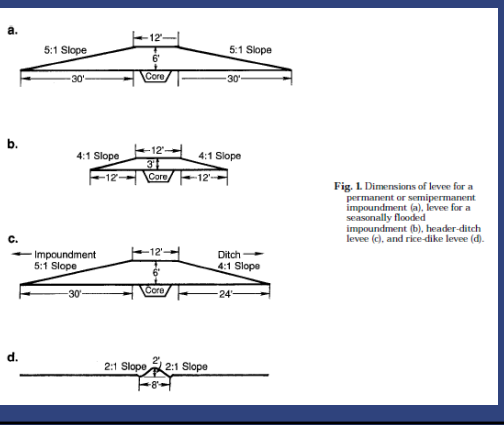


Fig. 1. Dimensions of levee for a permanent or semipermanent impoundment (a), levee for a seasonally flooded impoundment (b), header-ditch levee (c), and rice-dike levee (d).

GTR - Management

- Seasonal flooding (October – March)
  - Latitudinal dependent
    - Leaf drop and bud swelling
  - Emulate natural flooding regimes if possible
- Do not overtop desirable seedlings with water
- Emergency spillway

GTR - Management

- Monitor beaver, muskrat, and nutria damage
  - Trees
  - Control structures
  - Levees
- Rotate flooding events on nearby GTRs
- Maintain or create dead snags

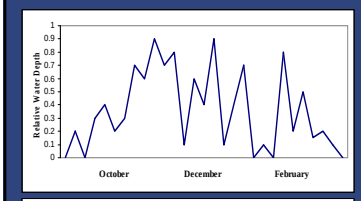
GTR Management - Positives

- Sustained, flooded wildlife habitat
- Flood water control
- Initial increases in waterfowl use, viable acorn production, and radial tree growth
- Recreation and aesthetics
- Simulates “natural” flood inundation in flood controlled areas
  - Can improve composition (from a waterfowl perspective)
  - Encourages some tree mortality

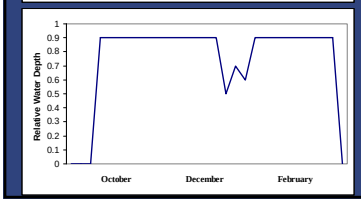
GTR Management - Negatives

- Decreased waterfowl use
- Decreased acorn production and viability (maybe)
- Decreased radial tree growth
- Change in overstory composition (maybe)
- Reduced regeneration of desirable trees
- Increased tree mortality (red oaks)

Traditional GTR Management



Bottomland Hardwood Forests



Greentree Reservoirs

Effects of GTR Management

- Low regeneration rates of seedlings
- Tree mortality
- Wind-throw
- Crown die-back
- Basal swelling
- Scarring by beaver
- Excessive sedimentation

*From Wigley and Filer (1989) – Survey of GTR managers

Effects of GTR Management

Cherrybark and Willow Oak → Overcup Oak

Relative abundances	Hardwood Bottomlands	Greentree Reservoirs
Overcup Oak	27	58
Cherrybark Oak	49	40
Willow Oak	65	21

* From Young (1995) – GTRs 1-2 and 1 UBHF site @ Noxubee NWR

Effects of GTR Management

Continuous vs. Periodic flooding

Continuous	Periodic
Taller seedlings	Higher survival
No density difference	

*Recommendation – Flood GTRs periodically during winter

*From Gray 1996 – GTRs 1-2 @ Noxubee NWR

Effects of GTR Management

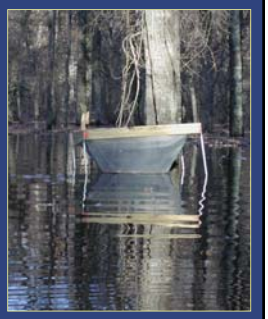
Unimpounded BHF vs. GTRs

Similarities	Differences
Canopy density	Species composition
Mid-story/canopy abundance	
Stress	
Gap frequencies	
Diversity	

*From Ervin et al. 2006 – GTRs 1-4 and 4 UBHF @ Noxubee NWR

Effects of GTR Management

- Changes in species composition
- Willow → Overcup oak
- Reduced survival of planted seedlings
- Acorn production not reduced (short-term)



*From Guttery 2006 – GTRs @ Monsanto Farms

Effects of GTR Management

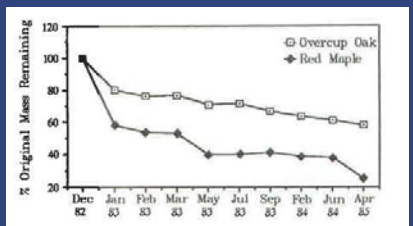


Fig. 5 Decomposition of overcup oak and red maple on naturally flooded sites in southeast Missouri.

Greentree Reservoir Management Manual

Adaptive Management of GTRs and Bottomlands

Table 15. Management practices in greentree reservoirs: causes and mechanisms to minimize impacts.

Impacts	Causes of impacts	Mechanisms to minimize impact	Management practices
Altered hydrology	Constant water levels; water levels too deep	Mimic natural flooding regime; stoplog structure required	Precise water level control
Shift to more water tolerant plant community	Water levels too deep; flooding into growing season	Shallow flooding; flooding through dormant season only; stoplog structure required	Precise water level control timing of flooding
Loss of productivity	Nutrient loss; nutrients unavailable; reduced decomposition	Mimic natural flooding regime, depth and duration of flooding; stoplog structure required	Control timing of flooding
Decreased acorn production	Forest stands too dense	Silvicultural treatment	Thin stands
Lack of regeneration	Reduced light; stands too dense	Silvicutural treatment; flooding does not overtop seedlings	Thin stands; unit not flooded deeply year following treatment
Decline in waterfowl use	Reduced productivity, food resources; lack of water; monotypic habitat, lack of diversity	Ensure habitat diversity; provide wetland complex	Variable flooding regimes within and among years

Greentree Reservoir Management Manual

Implications on Timber Value in GTRs

Cherrybark Oak (Sawtimber) $300 / mbf → Overcup Oak (Sawtimber) $138 / mbf, Bald Cypress (Sawtimber) $138 / mbf

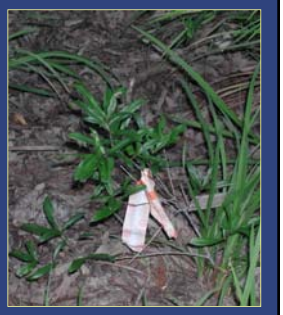
*Values - MSU Timber Price Report, Fall 2002

Concerns for Waterfowl Management in GTRs

- Reduced waterfowl use
- Lack of regeneration of understory trees
- Reduced hunting success
- Reduced public and waterfowl "satisfaction"

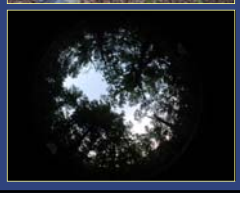
GTR Management

- Create Gaps…
  - Growing season flooding
  - Soil saturation and wind throw
  - Selective timber harvest
  - Regeneration cuts



GTR Management for Waterfowl

- Selective regeneration cuts
  - Hack and squirt seedling competition
  - Manually thin undesirables
  - Plant desirable seedlings
- Clear understories of large oaks (≥ 60 ft)
- Hack and squirt undesirables and leave as snags



GTR Management for Waterfowl

- Rotationally maintain timber harvest openings for waterfowl
  - mowed or disked woodland regeneration
  - moist-soil plots
  - semipermanent wetland depressions
  - waterfowl food plots (crops)

Table 5. Carrying capacity of selected foraging habitats (expressed as duck-use days/ac [DUDs/ac]) for mallards wintering in the Lower Mississippi Valley Joint Venture area.

Habitat	Food available (kg/ha) [a]	True metabolizable energy (TME; kcal/g) [b]	DUDs/ac [c]
Moist-soil	600 [d]	2.47 [e]	1,883
Harvested crops			
Rice	80 [f]	3.34 [g]	139
Soybean	60 [h]	2.65 [g]	37
Unharvested crops			
Rice	5,240 [i]	3.34 [g]	24,025
Soybean	1,334 [i]	2.65 [g]	4,716
Milo	3,811 [j]	3.49 [j]	18,192
Corn	5,716 [j]	3.67 [k]	28,820
Japanese millet	1,500 [l]	2.61 [m]	5,245
Bottomland hardwoods			
30% red oak	81 [n]	2.67 [o]	115
40% red oak	93 [n]	2.67 [o]	161
50% red oak	106 [n]	2.67 [o]	207
60% red oak	118 [n]	2.67 [o]	253
70% red oak	131 [n]	2.67 [o]	299
80% red oak	143 [n]	2.67 [o]	345
90% red oak	156 [n]	2.67 [o]	391
100% red oak	168 [n]	2.67 [o]	436

GTR Management for Waterfowl

- Initial investment saves on maintenance
- Maintain refuge areas
- Micro-complex
  - Use natural topography

GTR Management

- "…GTR management is an expensive, labor intensive, and long-term commitment."
  - Funding
  - Willing and cooperative staff
  - Ever-evolving
- **Conclusion:** "Naturally flooding BHF should not be impounded except under unusual circumstances (e.g., T & E species at risk)."

*From King and Allen (1996) - published in Wetlands

Summary

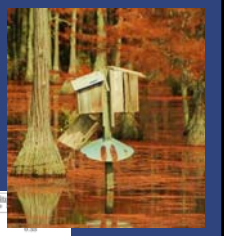
- BHF have declined substantially
- Private entities and conservation initiatives have slowed the trend (e.g., WRP, Environmental Edge, etc.), but species compositions are altered
- BHF may not ever be truly replaced
  - Altered flooding regimes
  - Timber demand
  - Cellulosic ethanol
  - People
  - Pests and pathogens
- Patience and active/intensive management required to simulate historic BHF with GTRs

Wood Duck Management

Dugger and Fredrickson 1992

Wood Duck Management

- Nesting
  - Tree cavities or nest boxes
  - 5 ft – 65 ft above ground
  - 5 suitable cavities per acre
    - >50 total cavities per acre
    - No "wood duck box clusters"

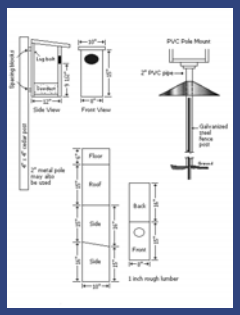


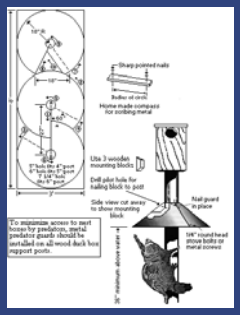
Location	Species	Cavities Number/acre	
Southeastern Missouri	Blackgum, green ash, pumpkin ash, red maple	0.15	[illegible]
Illinois	Black oak, bitternut hickory, mockernut hickory, blackjack oak, red oak, American elm, hackberry	0.21	0.51
Massachusetts	Apple, ash, maple	—	—
New Brunswick	Silver maple, American elm	2.23	5.50
Indiana	American beech, American sycamore, red maple	0.50	1.23
Minnesota	Quaking aspen, American elm, sugar maple, basswood	1.70	4.20
Wisconsin	Silver maple, sugar maple, basswood, quaking aspen	0.26	0.65
Mississippi	American sycamore, American beech, blackgum, shagbark hickory, water oak, cherrybark oak	0.08	0.19
	Overcup oak, slippery elm, sugarberry	0.09	0.23

Northern Prairie Wildlife Research Center; Dugger and Fredrickson 1992

Wood Duck Management

Nesting





Northern Prairie Wildlife Research Center

Wood Duck Management

Nesting

116 WOOD DUCK BREEDING • *Ryan et al.* J. Wildl. Manage. 62(1):1998

Table 2. Nest trees used by radiomarked wood ducks at LaRue Swamp, Oakwood Bottoms, and Union County in southern Illinois during springs 1993–95.

Tree species	Floodplain n	Floodplain %	Upland n	Upland %	All nests n	All nests %
Populus deltoides	3	43	0	0	3	8
Platanus occidentalis	3	43	1	3	4	11
Fagus grandifolia	0	0	14	48	14	39
Quercus alba	0	0	3	10	3	8
Quercus coccinea	0	0	1	3	1	3
Quercus rubra	0	0	2	7	2	6
Quercus shumardii	0	0	2	7	2	6
Quercus velutinea	0	0	2	7	2	6
Nyssa sylvatica	0	0	3	10	3	8
Dead	1	14	1	3	2	6
Total	7	100	29	98	36	101

Table 3. Canonical discriminant analyses of nest tree and cavity characteristics measured to compare floodplain with upland nest sites used by radiomarked wood duck females in southern Illinois during springs 1993–95.

Variables	Canonical coefficients*	r	P
Cavity height	1.391	0.683	0.001
Bole diameter at cavity	−0.114	0.471	0.005
Entrance width	−0.616	−0.364	0.034
Entrance length	−0.340	−0.276	0.115
Tree dbh	−0.884	−0.471	0.005
Cavity depth	−0.800	−0.078	0.661
No. entrances to nest	0.333	0.071	0.688

* Standardized canonical coefficients for the total sample.

82% of nests in uplands = 3 km from water!

Ryan et al. 1998 (JWM)

Wood Duck Management

Nesting

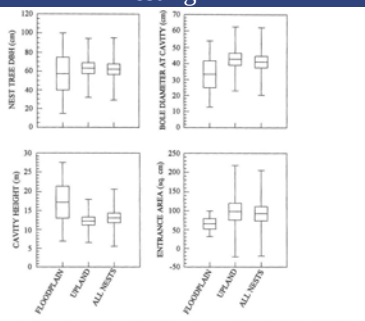


Fig. 1. Nest tree and cavity measurements (*X*, SE, range) of nest sites used by radiomarked wood duck females in floodplain ($n = 6$) and upland forests ($n = 29$) in southern Illinois during springs, 1993–95.

Ryan et al. 1998 (JWM)

Wood Duck Management

- Brood Rearing
  - 50 – 70% cover
  - 50 – 30% open water
  - **Scrub-shrub**
  - Beaver ponds, cypress-tupelo swamps, streams
  - Invertebrates important
  - Isolated wetlands, away from other broods and aggregations of nest boxes
  - Post-hatching movement to other wetlands / permanent waters (complexes important)

Table 1. Frequencies (n) of agents of wood duck duckling mortality at Noxubee National Wildlife Refuge (NNWR), Mississippi, 1996–1999, and the Tennessee-Tombigbee River Waterway (TTRW, Aliceville Lake), Alabama, 1998–1999.

Cause	NNWR	TTRW
Avian predator		
Red-shouldered hawk (*Buteo lineatus*)	18	3
Wading bird (*Ardea* spp.)	14	11
Barred owl (*Strix varia*)	6	0
American bald eagle (*Haliaeetus leucocephalus*)	0	1
Unknown	69	33
Aquatic predator		
Spotted gar (*Lepisosteus oculatus*)	3	0
Snapping turtle (*Chelydra serpentina*)	2	1
American alligator (*Alligator mississippiensis*)	4	0
Unknown	48	21
Snake		
Cottonmouth (*Agkistrodon piscivorus*)	18	3
Mammalian predator		
Unknown	13	5
Other causes		
Unknown	33	11
Exposure	6	1
Total	234	90

Davis et al. 2009 (Wetlands); Northern Prairie Wildlife Research Center

Wood Duck Management

Nesting and Brood Rearing – avoid clustering

Wood Duck Management

- Molting
  - Permanent water
  - Emergent marshes (aquatic plant seeds / inverts)
  - Large wetlands or complexes with many wetlands in close-proximity (e.g., aquaculture ponds, forested backwaters and oxbows)

Northern Prairie Wildlife Research Center

Wood Duck Management

Molting

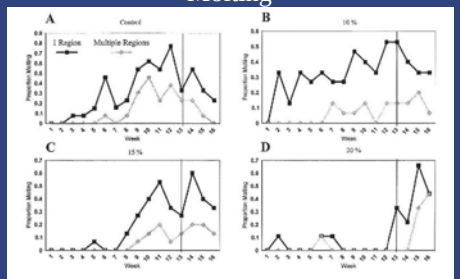


Figure 1. Proportion of captive female wood ducks ($N = 15$/group) fed either (A) a high-protein ration *ad libitum* (control group), (B) a 10%-restricted diet, (C) a 15%-restricted diet, or (D) a 20%-restricted diet that molted in 1 and multiple regions during winter 1991–92. Vertical line denotes inspection date 1 week following resumption of *ad libitum* diets in all

Barras et al. 2001 (SEAFWA)

Wood Duck Management

- Winter
  - Bottomland hardwood wetlands
  - River backwaters
  - Downed woody debris and timber
    - Loafing
    - Pair bonding
    - Thermoregulation
  - Scrub shrub (buttonbush)
  - Small creeks and streams
  - Acorns are the primary winter foods
    - bald cypress, hickory, sweet gum, buttonbush, arrow-arum, bur-reed, and wild rice are also common winter foods

Northern Prairie Wildlife Research Center

Wood Duck Management

Winter

828 FOOD AVAILABILITY AFFECTS WOOD DUCKS • *Demarest et al.* J. Wildl. Manage. 61(3):1997

Table 5. Frequency (*n* and %) of mortality of captive wood ducks fed high protein ration either ad libitum (control) or at 1 of 3 restricted levels, Mississippi State University, winter 1991–92.

Diet treatment[a]	*n*	%[b]	*P*[c]
Control	0	0.0	NA
−10%	2	6.7	0.5432
−15%	2	6.7	0.4053
−20%	8	26.7	0.0318

[a] Wood ducks fed restricted diets were given 10, 15, or 20% less food daily than amount consumed during the previous 24 hours by a control group fed ad libitum.
[b] % mortality was the number of deaths during the diet treatment period divided by initial group size (*n* = 30).
[c] *P* for linear pairwise comparisons of frequency data between control and diet-restricted groups (SAS Inst. Inc. 1985:175).

Table 6. Frequency (*n* and %) of pair formation by captive wood ducks fed high protein ration either ad libitum (control) or at 1 of 3 restricted levels, Mississippi State University, winter 1991–92.

Diet treatment[a]	*n*	%[b]	*P*[c]
Control	10	66.7	NA
−10%	9	60.0	0.6891
−15%	8	53.3	0.4561
−20%	4	26.7	0.0492

[a] Wood ducks fed restricted diets were given 10, 15, or 20% less food daily than amount consumed during the previous 24 hours by a control group fed ad libitum.
[b] % pair formation was the number of females paired with a male at the end of diet restriction (21 Mar 1992) divided by the original number of females in each experimental group (*n* = 15).
[c] *P* for linear pairwise comparisons of frequency data between control and diet-restricted groups (SAS Inst. Inc. 1985:175).

Demarest et al. 1997 (JWM)

Wood Duck Management

Winter

Table 2. Numbers of willow, cherrybark, and Nuttall oak acorns eaten by 27 female wood ducks during 3 feeding trial periods between 24 February 1992 and 3 March 1992, Mississippi State University.

Period	Willow oak		Cherrybark oak		Nuttall oak	
	$\bar{x}$[a]	95% CL[b]	$\bar{x}$	95% CL	$\bar{x}$	95% CL
24–26 Feb	20.31A[c]	18.14–22.59	10.44B	8.44–12.64	0.26C	0.12–0.41
27–29 Feb	16.81A	14.26–19.55	9.79B	7.94–11.82	0.12C	0.03–0.22
1–3 Mar	19.65A	17.30–22.14	11.51B	9.55–13.64	0.20C	0.09–0.33
Grand mean	18.89	17.52–19.61	10.57	9.46–11.74	0.19	0.13–0.26

[a] $n = 54$ ($n = 27$ wood ducks × 2 patch types = 54/period).
[b] CLs based on back-transformed data (Sokal and Rohlf 1969:381–382).
[c] Means within rows with unlike letters differ ($P \leq 0.05$).

Demarest et al. 1997 (JWM)

Wood Duck Management

Winter

Table 3. Dimensional variables of willow, cherrybark, water, and Nuttall oak acorns used in wood duck foraging experiments, Mississippi State University, winter 1991–92.

Variable	Willow oak $\bar{x}$[a]	Willow oak 95% CL[b]	Cherrybark oak $\bar{x}$	Cherrybark oak 95% CL	Water oak $\bar{x}$	Water oak 95% CL	Nuttall oak $\bar{x}$	Nuttall oak 95% CL
Shell thickness (mm)	0.38A[c]	0.37–0.39	0.40B	0.39–0.42	0.55C	0.53–0.57	0.44D	0.43–0.46
Experiment I								
Width (cm)	1.16A	1.15–1.17	1.39B	1.38–1.40	1.26C	1.26–1.27	[d]	
Length (cm)	1.16A	1.15–1.16	1.18B	1.17–1.19	1.10C	1.10–1.11		
Experiment II								
Width (cm)	1.15A	1.15–1.17	1.34B	1.31–1.36			1.50C	1.47–1.53
Length (cm)	1.16A	1.14–1.18	1.14A	1.12–1.16			1.90B	1.85–1.95

[a] n = 100 acorns for shell thickness; n = 420 acorns for acorn width and length in Experiment I; n = 60 for these variables in Experiment II. See Methods for computation of n in Experiments I and II.
[b] CLs based on back-transformed data (Sokal and Rohlf 1969:381–382).
[c] Means within rows with unlike letters differ ($P \leq 0.05$).

Table 4. Percentages of nutrients and tannin for 100-g samples of willow, cherrybark, water, and Nuttall oak acorns assayed at Mississippi State University, winter 1991–92.

Acorn constituent	Willow oak $\bar{x}$[a]	Willow oak 95% CL[b]	Cherrybark oak $\bar{x}$	Cherrybark oak 95% CL	Water oak $\bar{x}$	Water oak 95% CL	Nuttall oak $\bar{x}$	Nuttall oak 95% CL
Nutrients								
Fat	14.13A[c]	13.86–14.40	15.85B	15.56–16.14	13.15C	12.81–13.49	7.60D	7.17–8.05
Protein	3.52A	3.34–3.64	4.33B	4.22–4.44	3.27C	3.16–3.38	3.01D	2.92–3.10
NFE	33.92A	32.25–35.58	31.79B	30.13–33.45	35.17A	33.33–37.01	37.80C	36.73–38.88
Fiber	18.78A	17.39–20.22	18.30A	16.52–20.16	19.53A	17.85–21.27	13.15B	12.42–13.89
Moisture	28.36A	27.89–28.83	28.34A	27.55–29.15	27.77A	27.06–28.48	37.32B	36.67–37.97
Ash	1.28A	1.21–1.29	1.36B	1.28–1.44	1.06C	1.02–1.10	1.11C	1.05–1.17
Tannin indices								
Catechin	0.85A	0.75–0.95	1.01A	0.73–1.35	0.76A	0.69–0.83	2.33B	1.66–3.10
Tannic acid	3.88A	3.06–4.80	1.52B	1.28–1.35	1.36B	1.29–1.43	1.52B	1.28–1.77

[a] n = 10 for all means.
[b] CLs based on back-transformed data (Sokal and Rohlf 1969:381–382).
[c] Means within rows with unlike letters differ ($P \leq 0.05$).

Demarest et al. 1997 (JWM)

Wood Duck Management

Year-Round

Table 4. Matrix of mean (± SE) log-ratio differences of all habitat pairings for proportions of habitats within home ranges compared to proportions of available habitats in our study area (second-order selection) for female wood ducks at Eufaula National Wildlife Refuge in Alabama and Georgia, USA, 1999–2000. Significant differences ($P \leq 0.05$) are marked with an asterisk.

Habitat type[a]	MI $\bar{x}$[b]	MI SE	LI $\bar{x}$	LI SE	BP $\bar{x}$	BP SE	LK $\bar{x}$	LK SE	CR $\bar{x}$	CR SE	FP $\bar{x}$	FP SE	TW $\bar{x}$	TW SE
MI			0.79	0.56	1.35*	0.55	1.86*	0.66	4.03*	0.49	5.16*	0.59	5.19*	0.61
LI	−0.79	0.56			0.55	0.65	1.06	0.59	3.24*	0.53	4.37*	0.67	4.40*	0.62
BP	−1.35*	0.55	−0.55	0.65			0.51	0.59	2.69*	0.50	3.81*	0.56	3.84*	0.59
LK	−1.86*	0.66	−1.06	0.59	−0.51	0.59			2.18*	0.57	3.30*	0.65	3.33*	0.60
CR	−4.03*	0.49	−3.24*	0.53	−2.69*	0.50	−2.16*	0.57			1.12*	0.32	1.15*	0.40
FP	−5.16*	0.59	−4.37*	0.67	−3.81*	0.56	−3.30*	0.65	−1.12*	0.32			0.03	0.55
TW	−5.19*	0.61	−4.40*	0.62	−3.84*	0.59	−3.33*	0.60	−1.15*	0.40	−0.03	0.55		
Rank[c]	1		2		3		4		5		6		7	

[a] MI = managed impoundment; LI = lake influenced wetland; BP = beaver pond; LK = lake; CR = creek; FP = farm pond; TW = temporary wetland.
[b] A positive log-ratio value indicates that the row habitat (proportion within home ranges) was used more than the column habitat (proportion available in the study area). A negative log-ratio value indicates the opposite.
[c] Smallest ranking value indicates the most preferred habitat.

Hartke and Hepp 2004 (JWM)

Wood Duck Management

Year-Round - Summary

- Wetland complexes
- Maintain snags and dead trees
- Maintain older, mature trees
- Adjacent upland forests are important!
- Boxes are important, but can be an ecological trap
- Management is necessary because historical floodplain forest conditions will likely never return

Hartke and Hepp 2004 (JWM)


Pictures courtesy of Fred Greenslade, Matthew Gray,
Michael Guttery, Rory Thornton, Rick Kaminski,
Aaron Pearse, Josh Stafford, and others…