HYPOTHESES FOR COMMON PERSIMMON STAND DEVELOPMENT IN MIXED-SPECIES BOTTOMLAND HARDWOOD FORESTS

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Abstract—Common persimmon (*Diospyros virginiana* L.) is a shade-tolerant tree species found in southern bottomland hardwood forests. It is a desired species due primarily to its large fruit used by many wildlife species. While it has been observed as a component in natural reproduction, persimmon is rarely found as an overstory species in maturing bottomland hardwood stands. Unfortunately, little information exists regarding persimmon ecology and silviculture to develop silvicultural prescriptions to increase its stand density and development. Results from an archived dataset of stem analysis from a variety of bottomland hardwood species, personal observations of persimmon, and a conceptual model of tree species to plant with red oaks (*Quercus rubra* L.) in bottomland hardwood afforestation were used to develop hypotheses for future persimmon stand development research. These hypotheses are based on development in even-aged stands.

INTRODUCTION

Common persimmon (*Diospyros virginiana* L.) (hereafter referred to as persimmon) is a dioecious, shade-tolerant tree that occurs on a variety of sites throughout the Southeastern United States (Halls 1990, Skallerup 1953). Its best growth occurs on the rich, moist alluvial soils of river flood plains, where it can reach 70 to 80 feet tall and 20 to 25 inches d.b.h. (Halls 1990, Nix 2008). In the Lower Mississippi Alluvial Valley (LMAV), persimmon is most often found on clay or loamy flats (Putnam and Bull 1932).

Persimmon produces a true berry, also called a persimmon, that is highly desired by wildlife species (Perry and others 1999). Persimmon fruits are also edible for human consumption following ripening in the fall. They were a staple in the diets of Native Americans (Ohio Public Library Information Network 2001). Currently, the fruits are used in jellies, pudding, and pies (Anonymous 2008, Fletcher 1942). Persimmon also has a dense, hard, smooth wood suitable for golf club heads and shuttles for textile weaving (Das and others 2001, Maisenhelder 1971), but the loss of the golf club head market has reduced persimmon timber demand. Persimmon was also used for making flat-sliced veneer as face material in furniture (Maisenhelder 1971).

Interest in managing persimmon is increasing. It is commonly mentioned in forest management plans (Wilson and others 2007). In natural stand management, persimmon is considered a "hands off" species, or one usually left for wildlife habitat.[2] It is also a common, but minor, component of afforestation and reforestation efforts to meet wildlife habitat objectives (Aikman and Boyd 1941, Schweitzer and others 1999, Twedt 2004).

Persimmon, while sometimes establishing abundant natural reproduction, is rarely found as a component of the overstory canopy in a mature bottomland hardwood forest (Hepting 1935, Lentz 1929, Putnam and Bull 1932, Skallerup 1953). Early reports indicate that presettlement forests contained pure stands of persimmon, but this is no longer the case (see Skallerup 1953). A review of the literature reveals little information on persimmon ecology (especially stand development) and silviculture for developing silvicultural prescriptions to ensure development of this species to overstory prominence in bottomland hardwood forests. The objective of this study is to determine persimmon development patterns using an archived dataset that included stem analysis data from a variety of bottomland hardwood species. These results and personal observations will be used to develop hypotheses for future research in persimmon stand development.

METHODS

A hardwood growth-and-yield dataset developed between 1975 and 1977 is archived at the Southern Hardwoods Laboratory in Stoneville, MS. Dr. Bryce Schlaegel published a series of individual tree species volume and weight tables from this data (Schlaegel 1981, 1984a, 1984b, 1984c, 1984d; Schlaegel and Wilson 1983). Twenty-five stands were located in the LMAV and the adjacent Brown Loam Bluffs in westcentral Mississippi. A circular 0.2-acre plot was located in each stand. Four additional 0.2-acre plots were randomly located within a 5-acre circular area of the center of the first plot such that each plot fell within one of four quadrants of the first plot without overlapping any of the other plots. All trees >4.5 inches d.b.h. (diameter at breast height 4.5 feet above the ground) were tallied for species; d.b.h. (inches); crown class (dominant, codominant, intermediate, and suppressed); and distance and azimuth from plot center.

Trees for destructive sampling were selected after trees on all five plots in a given stand were measured. About 15 trees per stand were selected for sampling with no fewer than 13 trees

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per stand. Tables of limiting distances by tree diameters for different basal area factors (BAF) were used to select sample trees. An initial BAF 35 was used to determine the number of trees to be sampled from the five plots. If fewer than 13 trees were selected, then a BAF 30 was used and tree selection redone. A BAF 25 was used to gather the minimum number of trees if efforts with the BAF 30 were unsuccessful. Trees were selected as part of a bottomland hardwood growth-and-yield study, and not for stand development research objectives.

Each selected tree was mechanically felled and marked at 5-foot intervals to the top of the tree. One to one and one-half-inch thick discs were cut at each mark beginning at the base of the tree. Discs were labeled as to tree number and disc number and sealed in polyethylene bags. Discs for each tree were then placed in a burlap bag and labeled as to location and tree number, then taken to the laboratory for further analysis. Stem analysis followed standard techniques (Oliver 1978, 1982). Age was determined for each disc, then subtracted from the stump disc age to determine tree age at each 5-foot length interval. This data was plotted to determine individual tree length development and compared with the development of other trees sampled from the plot. Distances between the persimmon and the other selected trees were calculated using the law of cosines (Selby 1969):

$$a^2 = b^2 + c^2 - 2bc(\text{cosine } A) \quad (1)$$

where

a = distance between two trees
b = distance from plot center to persimmon
c = distance from plot center to other selected tree
A = angle between the two trees calculated as the difference between the two azimuths

Crown radii were calculated using d.b.h. and equations developed by Francis (1986). A general species equation was used for willow oak (*Quercus phellos* L.), while equations by crown class were used for overcup oak (*Q. lyrata* Walter). The sweetgum (*Liquidambar styraciflua* L.) general equation was used for persimmon. Lockhart and others (2008) developed a conceptual model for trees that may act as trainers for bottomland red oaks (*Q. rubra* L.) during stand development. Sweetgum was used as the model species. Persimmon scored well as a potential trainer tree; therefore, it may have crown characteristics similar to sweetgum.

In reviewing the dataset, two plots were found that contained a destructively sampled persimmon. One plot was located on the Delta National Forest in Sharkey County, MS (32°57' N, 90°43' W). Soil is a Forestdale silty clay loam (fine, smectitic, thermic Typic Endoaqualfs). The stand was mature willow oak with 143 trees per acre (62 percent willow oak), 80 square feet of basal area per acre (69 percent willow oak), and an average stand diameter of 9.3 inches (9.8 inches for willow oak) (table 1).

Table 1—Tree species composition, number per acre, basal area per acre, and average d.b.h. for stands containing persimmon used in stem analysis

	Delta National Forest			Mahannah Plantation		
Species	*n*	Basal area	Average d.b.h.	*n*	Basal area	Average d.b.h.
	trees per acre	*square feet per acre*	*inches*	*trees per acre*	*square feet per acre*	*inches*
American elm	6.0 (1.0)	6.0 (1.1)	13.0 (4.2)	—	—	—
Bitter pecan	—	—	—	3.0 (0.7)	6.6 (0.1)	20.9 (5.4)
Cottonwood	—	—	—	2.0 (<0.1)	7.0 (0.8)	25.3 (2.8)
Green ash	15.0 (2.9)	4.8 (0.9)	7.5 (2.6)	39.0 (4.4)	17.8 (1.8)	8.5 (1.1)
Nuttall oak	5.0 (2.1)	1.4 (0.8)	6.2 (1.9)	1.0 (—)	0.5 (—)	9.1 (—)
Overcup oak	19.0 (1.9)	11.3 (0.8)	10.1 (2.3)	219.0 (16.4)	58.1 (4.5)	6.7 (0.1)
Persimmon	5.0 (0.6)	1.1 (0.1)	6.5 (1.3)	6.0 (0.6)	2.0 (0.3)	7.6 (0.4)
Sugarberry	3.0 (0.7)	0.5 (0.1)	5.4 (0.4)	3.0 (0.7)	2.3 (0.8)	13.8 (7.4)
Sweetgum	1.0 (—)	0.7 (—)	11.1 (—)	—	—	—
Willow oak	89.0 (5.6)	54.2 (3.9)	9.8 (2.2)	—	—	—
Stand[a]	143.0 (37.4)	80.0 (20.1)	9.3 (1.4)	273.0 (77.3)	94.7 (14.1)	7.4 (0.3)

Numbers in parentheses represent one standard deviation.

— = No trees for this species were present in the sampling for this stand.

[a] Stand values are based on plot averages and not the addition of individual species trees per acre, basal area per acre, or average d.b.h.

Four trees were utilized for stem analysis—one persimmon and three willow oaks (table 2).

The second plot was located on the Mahannah Plantation in Issaquena County, MS (32°32' N, 90°5' W), on what is now the Mahannah Wildlife Management Area. Soil in the stand is undifferentiated Sharkey clay (very-fine, smectitic, thermic Chromic Epiaquerts) and Dowling clay (very-fine, smectitic, nonacid, thermic Vertic Endoaquepts). The stand was largely composed of young overcup oak, probably resulting from an abandoned agriculture field or a complete harvest of the previous stand. The stand contained 273 trees per acre (80 percent overcup oak), 94.7 square feet of basal area per acre (61 percent overcup oak), and an average stand diameter of 7.4 inches (6.7 inches for overcup oak) (table 1). Six trees were utilized for stem analysis—one persimmon and five overcup oaks (table 3).

RESULTS

The plot age structure on the Delta National Forest contains multiple age classes (table 2). Willow oak 1 and willow oak 2 represent one age class, the persimmon represents a second age class, and willow oak 3 represents a third age class (fig. 1). The persimmon initiated 16 and 10 years after the first two willow oaks, respectively, and 14 years before the third willow oak. This persimmon was 73 percent smaller in d.b.h. than the two older willow oaks, and 56 percent smaller in d.b.h. than the younger willow oak. Further, the persimmon was 35 percent shorter in height than the willow oaks. All four trees showed steady length development, although the persimmon was slowing in growth during the 1960s and 1970s (fig. 1). Willow oak 4 displayed impressive growth throughout its life, averaging nearly 2 feet in length per year. Willow oak 1 was the closest to the persimmon at 14.9 feet, while the other two willow oaks were 24.8 feet away. Willow oak 1's crown was probably over the persimmon at the time of sampling, while the other two willow oaks were too far away (table 2).

Three trees showed a 5-foot difference between height (table 2) and length (fig. 1). Willow oak 3 had a difference of 10 feet. These differences are the result of comparing heights measured for standing trees using standard equipment, such as a clinometer (table 2), to adding the number of discs cut at 5-foot intervals during stem analysis. Tree length above the

Table 2—Tree characteristics on a destructively sampled stem analysis plot on the Delta National Forest, Sharkey County, MS, in 1977

Species	Age	D.b.h.	Height	Crown class	From plot center: Azimuth	From plot center: Distance	Distance from persimmon	Crown radius
	years	*inches*	*feet*		*degrees*	*feet*	*feet*	*feet*
Persimmon	53	5.6	50	Suppressed	60	10.4		6.5
Willow oak 1	69	22.6	80	Codominant	128	19.6	14.9	20.1
Willow oak 2	63	18.8	75	Codominant	77	34.6	24.8	17.0
Willow oak 3	39	12.8	75	Intermediate	215	15.0	24.8	12.0

Table 3—Tree characteristics on a destructively sampled stem analysis plot on the Mahannah Plantation, Issaquena County, MS, in 1977

Species	Age	D.b.h.	Height	Crown class	From plot center: Azimuth	From plot center: Distance	Distance from persimmon	Crown radius
	years	*inches*	*feet*		*degrees*	*feet*	*feet*	*feet*
Persimmon	42	10.6	66	Codominant	170	17.3		10.1
Overcup oak 1	44	6.4	58	Intermediate	36	35.6	49.2	7.1
Overcup oak 2	42	5.5	52	Intermediate	129	6.6	13.1	6.3
Overcup oak 3	44	10.8	66	Codominant	219	15.1	13.6	13.7
Overcup oak 4	44	7.5	60	Intermediate	276	10.0	17.4	8.0
Overcup oak 5	44	7.7	62	Codominant	340	7.7	24.9	11.6

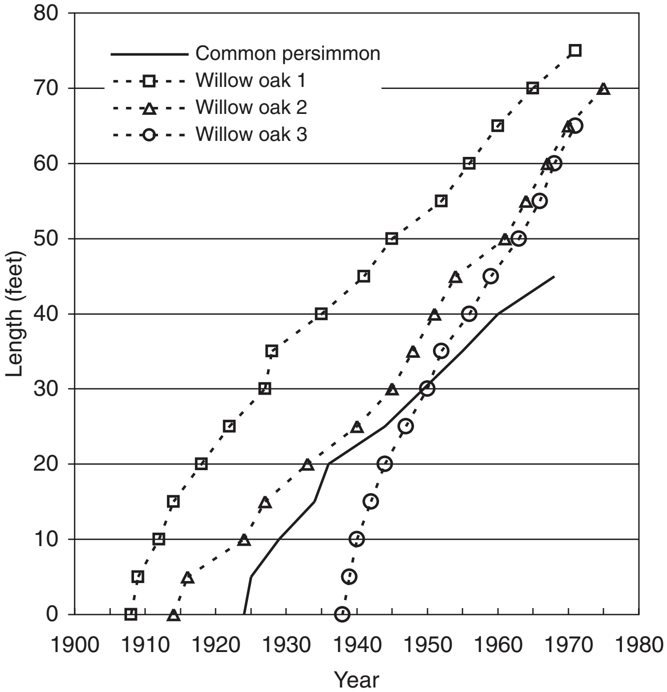

Figure 1—Persimmon and willow oak length development measured in a destructively sampled stem analysis plot on the Delta National Forest, Sharkey County, MS, in 1977.

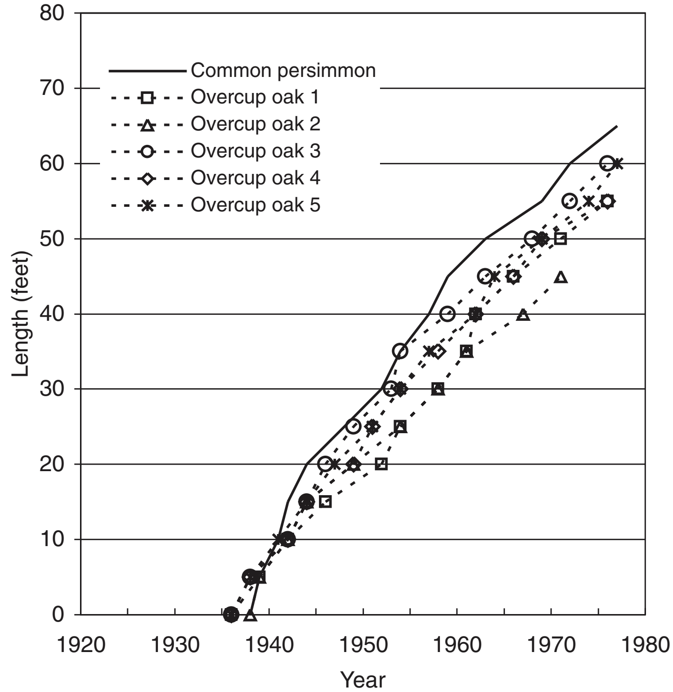

Figure 2—Persimmon and overcup oak length development measured in a destructively sampled stem analysis plot on the Mahannah Plantation, Issaquena County, MS, in 1977.

last disc, but <5 feet, is not used in stem analysis. Differences >5 feet are probably the result of a crooked main stem near the top of the tree or measurement error.

The plot age structure on the Mahannah Plantation differed by only 2 years among the six trees indicating an even-aged structure. The persimmon and overcup oak 3 were about 37 percent greater in d.b.h. than the other trees and slightly taller in height (table 3). All six trees were located in the main canopy based on their crown class. The persimmon, although 2 years younger than four of the five overcup oaks, has maintained canopy position throughout its life (fig. 2). Three overcup oaks were within 13 to 17 feet of the persimmon, while one overcup oak was nearly 50 feet away. The three closest overcup oaks were possibly in direct competition with the persimmon since their crown radii overlapped those of the persimmon (table 3). Tree height (table 3) and stem length (fig. 2) differences ranged from 1 to 7 feet.

DISCUSSION

The dataset used in this paper was developed for a bottomland hardwood growth-and-yield study. Trees selected for destructive sampling were not selected to test hypotheses of bottomland hardwood stand development. The nonpersimmon trees may or may not have been in competition with the persimmon. Further, trees that appear to be competing with persimmon at the time of sampling may not have been competing with persimmon earlier in stand development. Regardless, this dataset, along with a conceptual model of tree species to plant with red oaks in bottomland hardwood afforestation and personal observations of persimmon, does present interesting questions for further study involving persimmon stand development. Three hypothesis statements for further testing are listed below.

Hypothesis no. 1: Persimmon will not stratify above bottomland red oaks (section Erythrobalanus) during development in even-aged stands.

A conceptual model of species to plant in intimate mixtures with red oaks in bottomland afforestation indicates persimmon may be a useful species to “train” red oaks to develop better quality boles (Lockhart and others 2008). Concurrently, development of persimmon would probably be hindered in the presence of red oaks. The qualities of persimmon that are beneficial to red oaks include tree form, branching patterns, and relative twig diameter and durability. These characteristics would allow bottomland red oaks to stratify above persimmon and eventually suppress them. Therefore, persimmon may not be able to maintain overstory canopy position in competition with bottomland red oaks.

Hypothesis no. 2: Persimmon will maintain overstory canopy position with bottomland white oaks (*Q. alba* L.) (section Lepidobalanus) through early and midstages of development in even-aged stands.

Figure 2 shows persimmon was able to maintain canopy position in the presence of overcup oak in an even-aged stand. Overcup oak, as with the white oaks in general, are slower growing than bottomland red oaks. This slower growth, especially early height growth, may give persimmon a competitive advantage to stay slightly above the crowns of these species. In later stages of development, the white oaks will probably suppress persimmon through crown abrasion since these oaks have stouter twigs than persimmon.

Hypothesis no. 3: Persimmon will stratify above smaller diameter twig species, such as *Ulmus* spp. and sugarberry (*Celtis laevigata* Willd.), during development in even-aged stands.

The Sugarberry Natural Area (SNA) on the White River National Wildlife Refuge in eastcentral Arkansas has old-growth structure, with large trees and numerous canopy gaps (Lockhart and Kellum 2006). I have observed 5 to 10 persimmon trees per acre along low flats with strong intermediate or codominant canopy positions, a persimmon stand structure not often found in today's bottomland hardwood forests. Many of these trees had high-quality boles, and one tree had a measured 31-inch d.b.h. An obvious question is "How did these trees develop into the overstory canopy?" These trees were in the overstory canopy with American elm (*U. americana* L.) and sugarberry, species noted for small-diameter twigs. Persimmon may be able to maintain canopy position or even stratify above these species similar to stand development patterns found with cherrybark oak (*Q. pagoda* Raf.) and sweetgum (Clatterbuck and Hodges 1988, Lockhart and others 2006). Interspecific competition between these species would force persimmon trees to grow in height to maintain canopy position, resulting in high-quality boles. My observation though represented a snapshot of stand development. Individual trees and species that may have competed with persimmon in early stand development are now gone. Further, what is the age structure of the persimmon and competing species, or did these trees develop as an even-aged stand following a major disturbance?

In developing these hypotheses for future persimmon stand development research, I have focused on even-aged development in mixed-species stands. Additional persimmon stand development research questions involve development in pure, even-aged stands and development in uneven-aged stands.

Persimmon is often found as scattered individuals in natural bottomland hardwood forests. Is this the result of competitive pressure during stand development or past discriminate harvesting of persimmon when forest product markets for large, quality persimmon trees were good? Research is needed in the ecology of persimmon, especially stand development, to provide a basis for silvicultural decisions to promote the development of persimmon in future bottomland hardwood forests. Greater ecological knowledge is a prerequisite to successful management of this species.

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