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Wildlife linkages: volumes and values of residual timber in riparian zones in eastern Texas

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Abstract

In regenerating southern pine, maintenance of riparian zones (RZs) is a major land concession for soil and water protection and wildlife habitat enhancement. However, there are few data quantifying the volume and value of residual timber in such areas. We inventoried merchantable timber in nine RZs of three widths in sapling-class East Texas pine plantations. Present, discounted, and projected volumes and values of residual timber were determined. Average per-acre volumes of narrow, medium, and wide RZs were 337, 1438, and 2542 board feet (Doyle log rule) and 4.6, 8.2, and 7.2 cords, respectively. At US$ 154.00 and US$ 57.00 per thousand board feet for pine and hardwood saw timber, respectively, and US$ 15.00 and US$ 5.00 per cord for pine and hardwood pulpwood, respectively, average present per-acre values were US$ 46.41, US$ 209.93 and US$ 352.75 for narrow, medium, and wide RZs. Interest rates for the growth of trees from 1981 to 1989 ranged 3.7%–23.5% for pine and 2.2%–6.1% for hardwood. For the 1981–1989 discount period, average per-acre net annual equivalents of narrow, medium, and wide RZs were US$ 4.52, US$ 20.46, and US$ 34.38, respectively. Stumpage values at the time of harvest projected at 7% compound interest for 30 years ranged US$ 10.66–US$ 3547.54 per acre and for 80 years ranged US$ 313.93–US$ 104 499.95 per acre. The impact of these results on wildlife is discussed. © 1999 Elsevier Science B.V. All rights reserved.

1. Introduction

Increased demand for wood products in the southern United States has resulted in many natural pine–hardwood stands being converted to even-age pine plantations. Strips of mature trees, however, are usually retained along streams when adjacent upland stands are harvested. Such areas are referred to as streamside management zones, stringers, streamers and/or riparian zones (RZs). Riparian zones can buffer streams from erosion and non-point water pollution. They offer protection to stream banks and beds and act as sediment filters. Wildlife habitat is also enhanced by these corridors and by the increase in habitat diversity (Dickson, 1989).

In most RZs, the moisture regime is favorable for rapid tree growth, the site index is high, and substantial timber resources may be present. However, there are few quantitative data on timber volumes and values or timber-wildlife relationships in RZs. This

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study focused on volumes and values of residual timber in RZs of three widths along first- and second-order intermittent streams in eastern Texas.

2. Methods

2.1. Study areas

Personnel with the United States Forest Service (USFS), Southern Forest Experiment Station, Nacogdoches, TX, selected three sites in eastern Texas to evaluate the impacts of RZs on wildlife (Dickson and Bosch, 1990). Within each site, Forest Service biologists established a narrow (<85 ft), a medium (98–131 ft), and a wide (>164 ft) RZ study area, thus, a total of nine study areas. All study areas were in RZs that bisected young pine plantations. Within each study area, two sample transects, each 656 ft long, were created. Each transect was divided into four equal-length compartments and in all but one study area, a short buffer existed between transects. Buffers ranged 57–209 ft in length (Dickson and Huntley, 1987). For the purpose of this study, the transects were as wide as the RZs.

The RZs were on property owned by forest industry. When the study areas were established in 1984, all pine plantations were less than 5 years old. The pine plantations resulted when second growth pine–hardwood stands were clearcut and the areas mechanically site-prepared and planted to 1-0 loblolly pine (*Pinus taeda*) seedlings. Some timber was selectively harvested within the RZs and usually more trees per acre were removed from narrow RZs than from wide RZs. Soils of all the nine study areas were broadly defined as sandy loams.

2.2. Field procedures

In each study area, a 100% inventory of all merchantable timber in the transects and in the between-transect buffers was conducted; species, dbh, merchantable height, and product class were recorded for each merchantable tree. All trees were measured using USFS (1985) guidelines. Lengths of the transects and between-transect buffers had been previously measured (Dickson and Huntley, 1987); widths were measured by pacing from the edge of one plantation perpendicularly across the RZ to the edge of the other. At least four such measurements were made along each transect.

To determine growth, age, and form class, prism points were established in the center of every other compartment. Then, rotating clockwise from the bearing of the transect, the first pine and hardwood included in the 10-factor variable radius plot were measured to determine form class and radial growth. Form class was estimated with Wiant form class wedges. Tree age and radial growth data were gathered from increment cores taken at breast height. For determining the age, 3 and 2 years were added to the age at dbh for pines and hardwoods, respectively (USFS, 1985). These data were grouped as either pine or hardwood.

2.3. Data analyses

Merchantable trees in each RZ were categorized as pulpwood or saw timber using USFS (1985) guidelines. Present, past, and projected merchantable volumes of timber in each RZ were calculated. Present volumes were those at the time of the inventory, past volumes were those 8 years previous to the inventory at approximately the time of the prior harvest, and projected volumes were those 8 years following the inventory.

Present volumes were estimated using dbh and height at the time of inventory; the Doyle log rule and the average form class for each species group and product class were also used. For discounted and projected volumes, diameters were estimated by subtracting or adding the average 8-year diameter growth of the appropriate species group to the current diameter of each merchantable tree. The resulting diameter was then paired with the average merchantable height for that diameter class to determine the volume of the tree. Neither ingrowth nor mortality were considered.

Timber values were estimated using 10-year average stumpage prices (1980–1989) as reported by the Texas Forest Service (1989). The values used were US$ 5.00 per cord for hardwood pulpwood, US$ 15.00 per cord for pine pulpwood, US$ 57.00 per thousand board ft for hardwood saw timber, and US$ 154.00 per thousand board ft for pine saw timber. Neither fluctuations in timber prices nor inflation were

considered in computing discounted and projected values.

Compound interest rates were computed for the discounted and projected per-acre residual timber values by species product class. The values represent the rate earned on the capital investment in the marketable timber. The formula used to calculate the compound interest rate (r) was:

$$r = n\sqrt{\frac{\mathrm{FV}}{\mathrm{PV}}} - 1$$

where

n number of years in the period,
FV future value,
PV present value.

The net annual equivalents (NAE), the annual payment that will equal the net present value of an asset during its lifetime, were also determined. The NAE is useful in comparing an investment that yields a periodic return with one that yields an annual return and in comparing alternatives having unequal lives. The formula used, which is identical to the installment payment formula, was:

$$\mathrm{NAE} = \mathrm{NPV}\left(\frac{i(1+i)}{(1+i)^n - 1}\right)$$

where

NPV net present value,
i investment interest rate available,
n number of years in the period.

The interest rate (i) used was 7% and the period (n) was the average number of years elapsed between the time the adjoining stand was harvested and the data were gathered for this study (i.e. 8 years). The NAEs were computed to include the value of the growth of the merchantable timber.

3. Results

Form classes of pine and hardwood saw timber averaged 81 and 77, respectively; pulpwood form classes averaged 82 for pine and 77 for hardwood. Diameter growth ranged from 0.13 to 0.40 in per year for pines and 0.10–0.33 in per year for hardwoods. Average annual diameter growth was 0.30 in for pine and 0.18 in for hardwood. Total tree ages ranged from 36 to 93 years for pine and 34–134 years for hardwood. Average ages for pine and hardwood were 59 and 63 years, respectively.

The narrow RZs had very few merchantable stems and thus little saw timber, especially pine saw timber (Table 1). Virtually all the pine had been harvested and most of the standing pulpwood volume was hardwood. Some saw timber had been selectively harvested from all medium RZs, but all had saw timber volume remaining, thus all had substantially more volume than did the narrow RZs. One wide RZ had no trees harvested and another had only a few trees removed. As a result, the wide RZs had almost twice as much saw timber volume as did the medium ones. All RZs had pulpwood volume and most had much more hardwood than pine pulpwood (Table 1).

As would be expected, the narrow RZs had the lowest average merchantable timber value per acre and the wide RZs had the highest. Present value of the merchantable timber in the narrow RZs averaged US$ 46.42 per acre (range US$ 2.25–US$ 114.20).

Table 1
Average numbers of stems per acre and volume per acre of pine and hardwood saw timber and pulpwood trees in RZs of three widths in eastern Texas, 1989

RZ width	Saw timber						Pulpwood					
	Stems/acre			Vol./acre (bd. ft.)			Stems/acre			Vol./acre (cords)		
	Pine	Hardwood	Total	Pine	Hardwood	Total	Pine	Hardwood	Total	Pine	Hardwood	Total
Narrow	<1	8	8	9	327	336	8	44	52	0.4	4.2	4.6
Medium	6	9	15	747	691	1438	15	69	84	1.5	6.7	8.2
Wide	6	12	18	1648	894	2542	13	67	80	1.2	6.0	7.2

The Doyle log rule was used to determine saw timber volumes.

Table 2
Estimated stumpage values (US$/acre) of merchantable timber in RZs of three widths in eastern Texas

RZ width	Saw timber			Pulpwood			Total
	Pine	Hardwood	Subt.	Pine	Hardwood	Subt.	
Present (1989)							
Narrow	1.44	18.66	20.10	5.30	21.02	26.32	46.42
Medium	115.09	39.37	154.46	21.90	33.57	55.47	209.93
Wide	253.79	50.94	304.65	18.15	29.90	48.10	352.75
Discounted (1981)							
Narrow	0.82	13.11	13.93	1.45	16.50	17.95	31.88
Medium	74.38	31.10	105.48	10.80	26.00	36.80	142.28
Wide	163.14	37.76	200.90	11.00	23.78	34.78	235.68
Projected (1997)							
Narrow	2.41	31.10	33.51	11.15	22.22	33.37	66.88
Medium	200.56	57.23	257.79	23.00	38.60	61.60	319.39
Wide	352.15	65.87	417.98	24.40	36.47	60.87	478.85

The average merchantable timber value of the medium RZs was US$ 209.93 per acre (range US$ 98.77–US$ 349.34) and that of the wide RZs was US$ 352.75 per acre (range US$ 92.72–US$ 699.85) (Table 2). Trends in discounted and projected values paralleled those of present values (Table 2). For both sets, lowest values were in the narrow RZs and highest values were in the wide RZs. For an individual RZ, the lowest discounted value was US$ 1.40 per acre and the highest projected value was US$ 914.21 per acre (Burns, 1993).

Average discounted compound interest rates (1981–1989) for pine saw timber values were 7.2%, 6.6%, and 8.5% in the narrow, medium, and wide RZs, respectively; average projected compound interest rates (1989–1997) were 6.7%, 7.7%, and 8.8%, respectively. Discounted hardwood saw timber rates were 4.2%, 3.1%, and 3.7%, respectively; projected rates were 8.5%, 4.8%, and 3.1%, respectively.

Net annual equivalents of the total timber value (i.e. original timber volume and the timber growth) for the discount period (1981–1989) ranged US$ 0.22–US$ 68.21 per acre. Average values were US$ 4.52 for the narrow RZs, US$ 20.46 for the medium RZs, and US$ 34.38 for the wide RZs. Except for the narrow RZs, most of the value was in the saw timber component.

Stumpage values at the time of the harvest projected at 7% compound interest for 30 years, approximately the length of the rotation used by forest industry, ranged US$ 10.66–US$ 3547.55 per acre of RZ. Average values were US$ 242.60, US$ 1083.07, and US$ 1794.06 per acre for narrow, medium, and wide RZs, respectively. For 80 years, which is similar to a USFS rotation, values ranged US$ 313.93–US$ 104 499.95 per acre and averaged US$ 7148.59, US$ 31 904.07, and US$ 52 847.56 per acre for narrow, medium, and wide RZs, respectively.

4. Discussion

Although the width of the RZ has been generalized as an indicator of harvesting intensity, the RZ is merely the area not site prepared and planted to pine. The width of the RZ may not be as important to timber and wildlife values as the harvesting intensity within it. In this study, most narrow RZs had been heavily harvested, leaving few trees with little commercial value. The medium RZs usually had more volume per acre, but most trees present were hardwoods. The wide RZs generally had the most pine timber and thus the highest per-acre value. However, a wide RZ in which most merchantable timber is harvested will contain lower timber volumes and thus values than will a narrow RZ where the timber is left intact.

By leaving merchantable timber in the RZs, the landowner sacrifices present and future income streams. In a Georgia study, Caulfield et al. (1993) found that although RZs comprised only 8.2% of the land area, the opportunity costs were 14.4%. In this

study, the landowner may have sacrificed a NAE of as much as US$ 68.21 per RZ acre per year in the wide RZs. If such RZs average 8% of the total forested area, this equates to US$ 5.46 per forested acre per year. This exceeds the current average per-acre value for an unimproved hunting lease in eastern Texas. The value of such a lease on industrial forest lands is approximately US$ 2.60 per acre per year (R.M. Whiting, unpublished data).

Medium RZs are the transition from the wide to the narrow RZs. In these RZs, the landowner may have sacrificed a NAE of as much as US$ 34.05 per RZ acre per year. There are no known data relating the proportion of the stand occupied by RZs to the width of the RZs, but if we assume that medium RZs occupy only 6% of the total forested area, this represents US$ 2.04 per forested acre per year. At the time that the adjacent stands were harvested, that value exceeded the per-acre rate that hunting clubs were paying to lease the lands.

Although the narrow RZs generally had the least merchantable timber, the landowner may still have been sacrificing as much as US$ 11.13 per RZ acre per year. Narrow RZs had the greatest relative variability in NAEs, with a range-to-mean ratio of 240% compared to ratios of 119% and 172% for the medium and wide RZs, respectively (Burns, 1993).

Obviously landowners sacrifice significant economic returns by retaining RZs, and all else being equal, the wider the RZ, the greater the potential economic loss. However, wide, lightly-harvested or unharvested RZs have a wide range of ecological benefits, which, unfortunately, are less easily quantifiable than financial benefits (Caulfield et al., 1993).

While young pine plantations can provide suitable habitat for many early-succession wildlife species such as white-tailed deer (*Odocoileus virginianus*), northern bobwhite (*Colinus virginianus*), and cottontails (*Sylvilagus floridanus*), they do not provide adequate habitat for species requiring hardwoods, snags, cavity trees, and large down woody material (Thill, 1990). The habitat requirement of such species may be satisfied by wide RZs in which mature forests are maintained. Also, such RZs provide travel corridors connecting forest fragments and may enhance faunal diversity.

In young pine plantations, wide RZs are essential for gray squirrels (*Sciurus carolinensis*) and fox squirrels (*S. nigra*) (Dickson and Huntley, 1987) because they usually contain large, mast-bearing trees. In fact, both species may be restricted to RZs until pines in the adjacent plantations bear cones; gray squirrels may be restricted through much of a 30-year rotation.

The mast trees in such RZs are also important to wild turkeys (*Meleagris gallopavo*) (Dickson, 1989) and white-tailed deer (Harper, 1990). Research by Burk et al. (1990) in Mississippi suggested that wild turkeys use RZs for traveling, feeding, roosting, and loafing. The open understory in such areas is particularly attractive to turkeys. Poteet (1990) found that white-tailed deer significantly preferred RZs during fall and winter; he did not evaluate the width of the zones, however.

Other species benefited by wide RZs with mature-forest components include short-tailed shrews (*Blarina brevicauda*) (Dickson and Williamson, 1988), several species of herptiles (i.e. reptiles and amphibians) (Rudolph and Dickson, 1990), and a wide variety of birds. Shrews and herptiles benefit from the intact overstory and midstory, sparse shrub and herbaceous vegetation, and abundant leaf litter (Dickson and Williamson, 1988; Rudolph and Dickson, 1990).

Such RZs also benefit some species of song birds (Whiting, 1978). While bird communities are generally abundant and diverse in young and old forest stands, they may be reduced in dense, middle-aged pine plantations that lack vegetational diversity (Whiting, 1978; Dickson and Bosch, 1990). Bird abundance and diversity are positively correlated with habitat patchiness and foliage diversity (Whiting, 1978) and wide RZs containing unharvested or lightly harvested mature forests usually provide such habitat characteristics. They also provide large, old trees and snags for cavity-nesting birds. As would be expected, the value of such RZs to song birds declines as the adjacent stands age and acquire mature-forest characteristics (Murray and Stauffer, 1995).

Narrow, heavily harvested RZs do favor some species. Some small mammals (i.e. fulvous harvest mice, *Reithrodontomys fulvescens*) need the low-growing vegetation, logs, and logging slash found in narrow RZs. Populations of such species may be higher in the RZs than in the adjacent young pine plantations (Dickson and Williamson, 1988). The understory in narrow RZs is usually more dense than

that in the adjacent young pine plantation. It also may contain more blackberry (*Rubus sp.*) thickets and thus provide escape cover for a variety of species, including northern bobwhite, American woodcock (*Scolopax minor*), and white-tailed deer. However, there are no studies suggesting that narrow RZs are critical habitat for a particular wildlife species.

The wildlife-related values of medium RZs lie somewhere between these extremes. The way they function is very dependent on the harvesting regime used in them. In lightly harvested medium RZs, some squirrels will be present as will some late-successional bird species. Conversely, animal communities in heavily harvested medium RZs may resemble those in narrow RZs (Dickson and Williamson, 1988).

Riparian zones also provide protection for soil and water attributes. However, there is little agreement on the necessary width or the acceptable harvesting regimes in RZs to provide such protection. In fact, medium-width, partially harvested RZs may be adequate for protecting most intermediate streams in the southeastern United States. For example, Pritchett and Fisher (1987) wrote that partial harvests seldom decrease water quality and that directional tree felling can minimize debris entering streams; Hunter's (1990) comments were similar. Conversely, in areas of steep topography, wide, unharvested RZs may be necessary to slow overland water flow and filter large sediment loads (Peare, 1992). Obviously, characteristics of RZs necessary to protect soil and water are dictated by site conditions.

5. Conclusions

Currently all states in the nation have regulatory or nonregulatory best management practice (BMP) programs for forestry-related activities (Ice et al., 1997). All BMPs include stream protection, thus directly or indirectly require RZs. However, this study demonstrates that land owners may sacrifice significant economic returns by retaining RZs, with wider RZs having greater potential economic losses.

There are financial considerations for managing timber in RZs, but there are also ecological concerns. Plant communities in RZs are not static, and succession may lead to communities comprised of tree species with low economic values, especially in the southeastern United States. Likewise, climax or near-climax communities may have lower overall wildlife-related values than do the midsuccessional communities that are currently present in most southern RZs. Unfortunately, there is a paucity of information on managing timber in southern RZs. This study strongly demonstrates the need for such information.

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