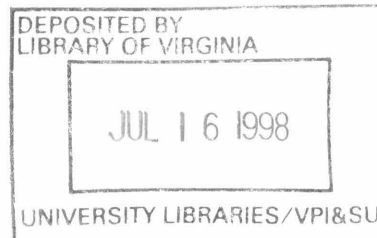
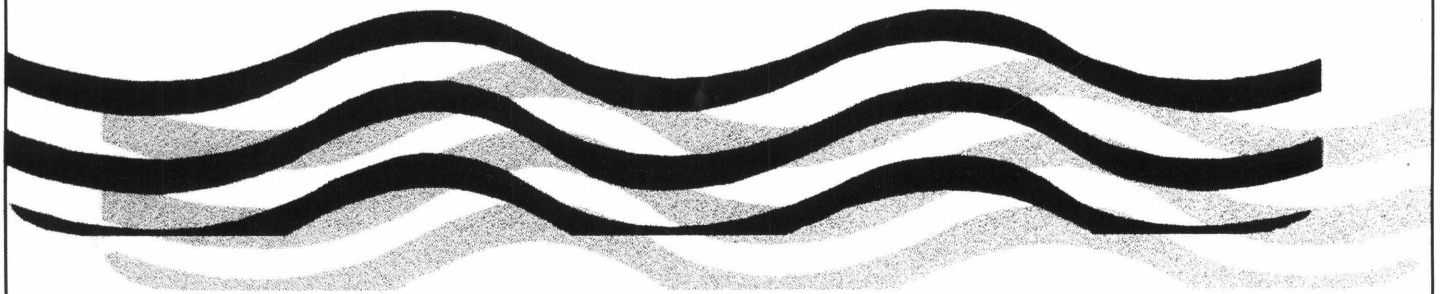


**Restoration of the Lower Mississippi Delta  
Bottomland Hardwood Forest:  
Economic and Policy Considerations**

**Gregory Amacher  
Jay Sullivan  
Leonard Shabman  
Laura Zepp**



**VIRGINIA POLYTECHNIC INSTITUTE  
AND STATE UNIVERSITY**



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**Gregory Amacher  
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**Research Bulletin 185**

**Virginia Water Resources Research Center  
Virginia Tech  
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Blacksburg, VA 24060**

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## Executive Summary

Historically, water and related land resources management has been accomplished by engineering controls over rivers and adjacent lands in order to advance the material prosperity of the nation. One result desired from these projects was that wetlands could be drained and cleared so that their fertile and cultivable soils would add to the nation's agricultural base. Today we recognize that these activities necessarily disrupted the existing ecosystems, often diminishing their capacity to provide environmental services (terrestrial and aquatic wildlife habitat, sediment and nutrient trapping, mediation of hydrologic extremes of flood and drought). Recent recognition of these environmental consequences of our water management history has resulted in calls for ecological "restoration" as a new objective for water management (National Research Council 1993).

At some scales restoration may be quite costly and disruptive of current land and water management regimes. In the Lower Mississippi River delta states, however, an opportunity exists for wetlands restoration on flood prone agricultural lands that will not be disruptive of the economic conditions in the area. The return of frequently flooded agricultural lands in the Mississippi Alluvial Plain (the Delta) to their original condition as forested wetlands has the potential to be a wetlands restoration option that can provide significant environmental gains at low cost.

### **Reforestation as a Wetlands Restoration Measure in the Mississippi Delta**

The economic costs of restoration through the reforestation of converted wetlands are computed as the establishment and maintenance costs of timber production plus the cash returns forgone from abandoning soybean production. On the more flood prone fields found in the Delta, reforestation costs associated with forgone soybean production are relatively low. These soybean fields are created from drained and cleared wetlands and are marginally productive relative to other lands in the Delta. They are suited only for soybean production due to their vulnerability to prolonged periods of flooding that extend late into the growing season (Sternitzke 1976).

Furthermore, reforestation provides the landowner with several opportunities for realizing a return to the

land through the sale of timber and pulp products and hunting leases, as well as payments through government conservation and cost sharing programs.

Despite the income opportunities available, reforestation as a restoration measure may still impose a net cost on landowners. Such costs can act as a disincentive to restoration, deterring private landowners from adopting restoration measures and leaving local and regional policy makers hesitant to lend their support to the effort. Achieving wetlands restoration through reforestation on flood prone soybean lands in the Mississippi Delta requires that the costs of this restoration measure be recognized and, when possible, mitigated.

### The Economic Consequences of Reforestation – the Landowner's Perspective

In the case of the Mississippi Delta, the economic consequences of pursuing alternative reforestation strategies as a means of restoring current agricultural land to its original condition as forested wetlands were assessed for both individual landowners and for the Delta regional economy. To assess the economic consequences of reforestation from the landowner's perspective, an analytical model was developed that fully incorporated the policy, market and technical factors determining landowners' financial returns from reforestation. A computer simulation model was then developed based on the analytical model.

To establish a Base Case situation for the simulation, a representative site was created using production costs and practices, flooding regimes, and site characteristics that might reasonably be found on flood prone Delta agricultural lands. Changes in landowner income from reforestation were determined by computing and comparing the net present values of timber and soybean production for seven different tree species on ten different soil types in the states of Mississippi, Louisiana and Arkansas.<sup>1</sup>

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<sup>1</sup> Plantations of 1) cottonwood only, 2) mixed cottonwood with interplanted Nuttall oak, 3) green ash, 4) sycamore, 5) sweetgum, 6) Nuttall oak, and 7) water oak were considered. The costs and timber revenues represented appropriate silvicultural / planting regimes for each species, differences in growth and yield and differences in rotation age.

For landowners, it was found that the net present value (NPV) of computed returns to reforestation varied according to site characteristics and tree species. For some combinations, computed net returns to reforestation were greater than forgone soybean returns (e.g., Nuttall Oak on Alligator, Amagon, Dundee, Mhoon and Newellton soils, and cottonwood - oak intercrop on Dundee soils). In other cases, soybean returns were slightly more profitable (see tables II-20 through II-22).

Sensitivity analyses indicated that the computed economic returns to reforestation varied according to the physical characteristics of a site, landowners' expectations concerning future market and policy conditions, landowner type (i.e. owner-operator vs. owner-landlord) and underlying assumptions concerning product quality as well as future forestry and soybean prices. Therefore, care must be exercised in interpreting and transferring the "representative" situations to any specific site in the Delta.

The utility of the simulation model could be expanded by adding a "data entry" section that would provide an interface through which the value of determinants such as flooding frequencies, production practices and costs and soybean and timber prices and yields, could easily be modified. Using the data entry section, analysis could be conducted on an individual landowner basis, custom fitting the simulation model to the unique characteristics of a particular site. Additionally, policy makers could use the data entry section to examine policy effects under alternative future scenarios.

### The Consequences of Reforestation -- Non-Economic Considerations

In addition to the computed economic returns, it was found that a landowner's decision to reforest is also influenced by cash flow considerations and risk aversion.

#### *Cash Flow Constraints*

Engaging in commercial forestry ties up much of the equity in a landowner's land for at least the length of a single rotation. At a minimum, for a cottonwood plantation, a rotation lasts 15 years. At a maximum, a single rotation can last 60 years for oak and other hardwoods. With total reforestation costs in the Delta range from \$150 to \$250 per acre depending on the

tree species, if a large number of acres is reforested the total costs of reforestation that are immediately realized can be substantial. Therefore, even when the net present value for reforestation is favorable the landowner may be discouraged by the amount of cash necessary for land preparation and tree establishment.

The most attractive reforestation regimes for the landowner who can not wait for a cash flow are the mixed cottonwood-oak and cottonwood plantations because the landowner receives periodic income earlier in the rotation. Also, expanded loan and cost sharing should be viewed as means to increase net returns and to overcome a "cash flow" barrier to adoption.

Forest production taxes can act as another cash flow constraint faced by landowners. Under agricultural production, required property taxes can be paid from current farm income earned on the land. However, in forest production taxes must be paid before income is realized and modest increases in property tax payments have significant detrimental effects on net returns.

Reforestation may be encouraged by shifting the tax burden to better correspond with the receipt of timber and pulpwood sales revenues. This may suggest movement from a property tax to a severance tax system. Additional examination of other aspects of the tax treatment of forestry and agriculture may be warranted.

Cash flow constraints can be further mitigated through the sale of leases for the recreational services of forestlands, such as hunting or fishing. The potential return from hunting leases combined with the silvicultural returns from a forested tract may be greater than the returns from a soybean field. Net hunting lease income of \$5 - 30 per acre per year, depending on the circumstances, might provide an annual cash flow that would sufficiently increase the net returns to favor reforestation.

The opportunity to realize income from hunting lease sales is available to all landowners. However, the market price of hunting leases is site specific. Bottomland hardwoods, or mixed cottonwood-oak forests, provide the greatest potential for huntable wildlife production. Landowners who are nearer to urban centers have a greater potential for the sale of hunting leases. Also, for the landowner to be

successful leasing land, a substantial amount of acres need to be reforested, especially for deer habitat. If neighboring landowners also reforest, then there is increased chance of securing high price for hunting leases. However, if these same landowners also sell hunting leases then the price may be depressed.

The creation of markets for the environmental services of reforested farmlands has also been suggested as a source of landowner income. Market possibilities include sales of carbon sequestration credits, wetlands mitigation credits and pollution reduction credits. The operation of such markets requires public initiative and oversight to 1) define the product that will be bought and sold; often called an environmental "credit," 2) create the demand for the credits and 3) create and manage a system of exchange of credits for money between buyers and sellers. There has been little progress in the Delta in setting up the conditions for these markets to succeed.

The potential for these markets to motivate reforestation is significant and their development has long term promise. Actions to promote such markets should continue to be pursued. However, individual landowner investment decisions at this time may need to be based on more certain current markets and public policies.

Finally, government conservation programs offer landowners the opportunity to earn an up-front easement payment or annual rental payments to help ease cash flow constraints or bridge any existing gap between forestry profits and the forgone returns to soybean production.

Payments from the current Wetlands Reserve Program (WRP) and the Conservation Reserve Program (CRP) shift net returns toward reforestation. Both have the benefit of addressing the cash flow concerns and concerns over uncertain timber yields and prices by making payment to landowners prior to forest harvest.

The WRP and CRP can offer a significant inducement to reforestation but there are unresolved issues related to species that can be planted, harvest rules and tax treatment of program payments that need to be addressed if they are to be an effective reforestation incentive.

Current WRP payments appear to be in excess of the amount calculated to make net returns to reforestation favorable. While this makes the attractiveness of the program to an individual landowner clear, these high payments are made from a limited WRP budget and so reduce the number of acres that can be enrolled.

### *Risk Aversion*

The risks associated with a long term enterprise such as commercial forestry can reduce the value of the computed economic returns to reforestation. An adjustment in the discount rate was made to demonstrate the effects of risk on the returns to forestry production. The adjustment reduced the present values of reforestation returns by two thirds. These reductions are most dramatic for the longer rotation oak regimes. For cottonwood plantations, the impact of increased risk on the forest landowner is less. Also, differences in risk are most important for poorer quality sites.

Actions and public policies that will reduce income risk by securing a future timber price or by insuring against yield loss may be essential to encouraging landowners to consider reforestation.

Landowner's perceptions of the riskiness of reforestation relative to soybean production is also affected by the availability of federally subsidize crop insurance covering soybean production. Acquiring basic (CAT) crop insurance coverage increases the net returns to soybean production, thereby decreasing the economic returns to reforestation, all else held equal. The effect on soybean returns of buying additional coverage depends upon the farm situation. However, because the federal crop insurance program is undergoing continuing reform, it is difficult to draw conclusion about potential future contribution of crop insurance to the profitability of soybean production on marginal Delta agricultural lands.

With such significant reforms occurring as late as the 1995 crop year and the possibility of further reforms in the future, the simulation results may not hold for future conditions. Given the intent of recent modifications made to the program, crop insurance may play a diminishing role in contributing to soybean returns on marginal agricultural lands.

## Regional Economic Impacts of Reforestation

Both local and state policy makers have the capability of implementing or amending policies that can address both economic and non-economic barriers to reforestation, providing landowners with significant incentives (or disincentives) to adopt reforestation. For example, property taxes on forest land, silvicultural cost share payments and many of the eligibility rules of the federal Wetlands Reserve Program (WRP) and Conservation Reserve Program (CRP) are determined by state or local level decision makers. The willingness of policy makers to lend support to a restoration effort, however, depends in part upon their assessment of the regional economic effects of reforestation.

To provide information needed to assist policy makers in gauging the extent of public support reforestation warrants as a wetlands restoration measure, an assessment of the regional economic impacts of reforestation was also conducted.

From the perspective of the regional policy maker, it was found that the net positive impact of

reforestation on the regional economy was not sizable enough to offset the losses of forgone agricultural production, when considering only raw material production. If additional processing is assumed to occur, then, in some cases, reforestation generated a positive net impact.

Additional, non-timber income sources such as hunting and recreation lease sales or payments through government conservation programs (e.g., WRP, CRP) may also have a positive impact on the regional economy through increased household income. However, the extent of the impact these non-timber economic activities may have is highly uncertain. Expenditures on such activities only contribute to the economy if they are new to the region; spending merely transferred from another activity within the region does not count towards the net impacts of reforestation. Determining whether non-timber spending is new to the region is difficult. Furthermore, there is much uncertainty concerning the level of payments that can be expected through conservation programs or markets for environmental services.

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technical aspects of reforestation in the Delta was greatly enhanced by the opportunity to observe commercial timber operations, managed forests, and flood prone agricultural lands. Additionally, the meetings arranged with farmers, WRP participants, and representatives of the forest products industry provided us with the chance to hear multiple perspectives on both the incentives and deterrents to reforestation in the Delta.

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## I. INTRODUCTION

Historically, water and related land resources management has been accomplished by engineering controls over rivers and adjacent lands in order to advance the material prosperity of the nation. One result desired from these projects was that wetlands could be drained and cleared so that their fertile and cultivable soils would add to the nation's agricultural base. Today we recognize that these activities necessarily disrupted the existing ecosystems, often diminishing their capacity to provide environmental services (terrestrial and aquatic wildlife habitat, sediment and nutrient trapping, and mediation of hydrologic extremes of flood and drought). Recent recognition of these environmental consequences of our water management history has resulted in calls for ecological "restoration" as a new objective for water management (National Research Council 1992).

The term restoration has been defined in numerous ways. The National Research Council (NRC) suggests that restoration can be described as the return of an aquatic ecosystem to a close approximation of its *structure* and *function* prior to significant human modification. "Structure" refers to the physical attributes of an aquatic ecosystem including: water quality, soil conditions and its diversity, and density and viability of native plant and animal species (National Research Council 1992). An ecosystem's "function" includes such capabilities as the supply, storage, and recharge of surface and ground water, floodwater retention, mitigation of erosion and sedimentation, and the transport of organisms, nutrients and sediments (National Research Council 1992).

To a large extent, the functional capabilities of an ecosystem are dependent upon the integrity of its structural attributes. Recently, ecologists have argued that the successful re-establishment of the structural features of an ecosystem may be the best measure we have of the degree of success in restoring its functional attributes (Barinaga 1996). In such cases, the assertion is that returning the structural components of an aquatic ecosystem to their original condition ensures the restoration of the environmental functions and services that were present prior to any disturbances generated by man.

At some scales restoration may be quite costly and disruptive of current land and water management regimes. For example, restoration might include disassembling a dam to restore the original timing and direction of a river flow. This might affect a complex of economic activities (navigation, urban location, hydro-electric power, etc.) that depend upon the engineered river system for their continuation. In other cases, restoration might mean ceasing agricultural production on some former wetlands to allow the return of their natural hydrology and land cover in a limited area. The flood prone soybean fields of the Lower Mississippi River Delta states may offer an opportunity for restoration that will not be disruptive of the economic conditions in the area, but can provide significant environmental gains.

### **The Lower Mississippi River Delta Area**

Prior to settlement, the dominant feature of the Mississippi Alluvial Plain (the Delta) was swampland and bottomland hardwood forests located in sumps and basins formed among the waterways and tributaries of the Mississippi. A national focus on economic growth and development meant that these lands were primarily valued for the agricultural potential of their fertile alluvial soils. Beginning in the early 1800s, thousands of acres were cleared, drained, and cultivated (along with the Delta uplands) in corn, cotton, rice, and soybeans (MacDonald 1979).

Initially, the conversion took place primarily on higher elevation, loamy soils. Eventually, however, agricultural development progressed into the more frequently flooded and poorly drained forested wetlands at lower elevations, prompting the construction of channels by drainage districts and by the federal government to allow for successful on-farm drainage systems. The expansion of cropping was further encouraged by favorable tax treatment for land clearing and drainage, by widespread technical assistance to those who wished to cultivate bottomland areas, and by the assurances that crop prices would be supported by federal farm policy.

Today, the extent of bottomland hardwood forests along the Mississippi Alluvial Plain has been reduced from 21 million acres (pre-settlement) to approximately 4.9 million acres<sup>1</sup>. The bulk of the remaining bottomland forests (95 percent) are in the lower Delta states of Arkansas, Louisiana, and Mississippi (Nature Conservancy 1992).

A particularly intensive period of wetlands conversion occurred in the 1970s, prompted by a dramatic increase in soybean prices. Thousands of acres of bottomland hardwoods were cleared for the cultivation of soybeans on sites that were subject to a high frequency of flooding, and with soil conditions that made their yields lower than lands elsewhere in the region. These lands, relative to other lands in the Delta, are marginally productive and suited only for soybean production due to their vulnerability to prolonged periods of flooding that extend late into the growing season (Sternitzke 1976). As the real prices for soybeans declined later in the 1970s and into the early 1980s, the economic return of farming these lands fell substantially. Today, these areas might be economically marginal for continued agricultural production (See Box 1).

### **Restoration Through Reforestation Of Delta Farmland**

As the ecological contributions of forested wetlands became widely recognized, the initial response was for the federal government to sharply curtail spending on new construction that would facilitate drainage of forested bottomlands (See Box 2). Additionally, the Tax Reform Act of 1986 eliminated the tax advantages for clearing and draining bottomlands. In that same year, the wetland conservation provisions of Title XII of the Food Security Act of 1985 (the 1985 farm bill), commonly referred to as “swampbuster”, denied all farm program benefits to farm operators who drained delineated wetlands or removed woody vegetation from such areas in order to produce an agricultural crop. Available research indicates that the combination of falling agricultural prices, rising costs for land clearing, and these two policy reforms were effective in radically reducing the rate of bottomland conversion (Kramer and Shabman 1993).

Corresponding with these efforts to discourage further conversion, there also was a strong public policy interest in restoring these lands to a forested state (Mitsch and Gosselink 1993; Sharitz and Mitsch 1993). As was noted above, in many areas the term “restoration” implies a need for hydrologic modification and reforestation. However, restoration in the Delta often does not require recreating wetland hydrology. Indeed, many of the soils retain wetlands characteristics. Restoration only requires reforestation and abandonment of farm activity. Several federal agencies (e.g., the U.S. Army Corps of Engineers, Fish and Wildlife Service, Forest Service, Natural Resource Conservation Service, and Tennessee Valley Authority) and conservation organizations (e.g., the Nature Conservancy, Ducks Unlimited, and DELTA Land Trust) have achieved ecological success in reforesting poorly drained soybean fields.

### **Making Restoration Happen**

Effective efforts to promote restoration through the reforestation of frequently flooded agricultural lands must take into consideration the economic costs of this restoration measure, alongside the anticipated ecological benefits. The lands available for reforestation are owned by private businesses and individuals. This means that, whatever the ecological gains, reforestation relative to continued soybean production must be deemed profitable by landowners or reforestation will not occur.

Some forest products businesses (e.g., International Paper Company, Westvaco Corporation, and Crown Vantage) and a few landowners have anticipated a financial payoff from timber and pulpwood sales and have initiated reforestation efforts. Sometimes these same businesses have considered the possible cash returns from the sale of hunting leases as another income source. Another encouragement to reforestation has been federal initiatives such as the Wetlands Reserve Program (WRP) and the Conservation Reserve Program (CRP). These programs make cash payments to landowners who agree to cease farm activity on a land parcel and replace agricultural crops with some permanent cover, often trees. Finally, long standing forestry cost-sharing programs that offset production costs may also offer an incentive to reforestation.

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<sup>1</sup> The Delta consists of sixty-four counties located in the states of Arkansas, Louisiana, and Mississippi (Map 1).

### **Box 1: Soybean Cultivation on Converted Wetlands**

Soils of the Mississippi Alluvial Plain are composed of water-borne sediment originating from upstream portions of the watershed, an area encompassing all or portions of 20 states. Over time, changes in stream flow patterns and flood events have produced a complex mosaic of soil texture, chemical composition, and depth across the region. In the region the primary limitation to agriculture is frequent flooding or poor internal soil drainage due to a high clay content. These lands consist primarily of soils formed on former natural levees or backswamps of prehistoric stream channels. Many soils are periodically inundated during the winter and early spring. Flooding and excessive soil moisture are significant impediments to agricultural production on these heavy, alluvial clay soils. They are slow to dry out after a heavy rainfall or as floodwaters recede, making them vulnerable to flash flooding. Additionally, low lying fields in close proximity to major tributaries of the Mississippi River are vulnerable to backwater flooding which occurs as spring floodwaters from the Mississippi River back up the tributaries, overflowing their banks and inundating the surrounding land.

While flooding or soil saturation can occur at any point during the growing season, sites prone to such problems are particularly vulnerable during the spring and early summer. Along with springtime's warmer temperatures comes an onrush of melted ice and snow from the north, causing the Mississippi to rise to levels that result in backwater flooding along its major Delta tributaries, such as the Yazoo, Big Sunflower, and Little Sunflower Rivers in Mississippi; and the Red River in Louisiana. Springtime is also a rainy season for the Delta region. Spring rainstorms can cause saturation and flooding on lands not already inundated from backwater flooding.

This particular vulnerability to springtime flooding renders land virtually unusable for any other agricultural purpose besides soybean production. Extended periods of flooding and/or soil saturation during the spring and early summer prevent farmers from working a field and planting a crop. By the time the fields are sufficiently dry to be accessed, the planting period for most major Delta crops, such as corn, cotton, and rice, has already passed. Only soybeans can be planted as late as early July and still be expected to produce some yield. Although still cultivable, the late planted soybeans produce lower yields than would be expected of a crop planted earlier in the growing season. When planting is delayed due to flooding or soil saturation, the soybean plants are exposed to shorter days before they are fully matured, resulting in early flowering, short plants, and consequently, reduced yields. Furthermore, the root systems of late planted soybeans tend to be limited, and the plants are more vulnerable to drought. As a result, these frequently flooded, soybean-only types of fields were considered to be potentially "marginal" for agriculture.

Ten soil series where soybean cultivation is commonly practiced were selected for study. These soils are described as having the following characteristics: 1) poor drainage, 2) flooding frequency ranges from occasional to frequent, and 3) the soil classification is hydric. All soils selected for evaluation in this study meet each of these criteria, with the exception of Dundee soils, which are not hydric (Soil Conservation Service 1991).

The ten soil series meeting the established criteria cover nearly 30 percent of the Delta region included in this study (See map). Total acreage represented by the ten selected soil series are in excess of two million acres in each of the target states, for a total of greater than 7.5 million acres across the three state region. The majority of the area covered by these ten soils have a predominantly clay texture.

### **Box 2: Environmental Gains From Reforestation**

Soybean production can offer cover and a growing season food source for deer and small mammals. However, reforestation will increase and improve cover, nesting sites, and brood-rearing habitat (Wesley et al. 1981). Also, newly established forests can act as corridors to connect existing forest habitat, increase edge, and eventually forest interior habitat (Peterken and Hughes 1995). Of course, reforestation benefits to wildlife will vary by stand composition and reforestation approach. Cottonwood plantations show rapid growth resulting in rapid stand closure, thereby quickly providing interior habitat. Oak plantings, unlike cottonwood, produce potentially large quantities of hard mast in the form of acorns in stands aged 20 years and greater. Hard mast is a preferred food source for both wild turkey and deer (Wesley et al. 1981).

Reforestation can benefit water quality. For soybeans, post-harvest tilling, bedding, and residue shredding contribute to sediment load increases during winter flooding (McDowell et al. 1981). Sediment removal from crop land has a direct effect on water quality in terms of increasing turbidity. Indirect effects include acting as a transport mechanism for nutrients and pesticides. Sediment runoff for a Sharkey silty clay in soybeans averaged 4.9 tons/acre per year over a six-year period. Extremes ranged from 3.8 to 7.9 tons/acre (Murphree and McGregor 1991). Sediment yield was found to be a function of rainfall and runoff with maximum values achieved during the period between final tillage and early spring.

## Box 2: Environmental Gains From Reforestation (continued)

Estimates of sediment yield for soils of various textures have been calculated for Delta states under agricultural and forestry scenarios (Gianessi et al. 1986). In most cases, erosion losses from forest land were between 1 percent and 10 percent of the losses from agricultural land. In some cases, forest lands have no net erosional losses of sediment and, instead, may act as a sediment sink, removing more suspended soil particles from flood water and runoff than they contribute (Aust et al. 1991). As stands mature, the number of tree stems decreases due to self thinning and understory vegetation is reduced in density as light availability is reduced (Klimas 1988). For these reasons, sediment accumulation decreases over the length of a rotation. Reforestation scenarios resulting in the largest number of woody and herbaceous stems will remove more sediment than stands with fewer stems and a sparse understory.

Riparian forests and streamside management zones have been shown to remove nutrients applied to adjacent agricultural lands, reducing their influx to rivers (Jordan et al. 1993). High denitrification rates in functioning wetlands result in removed nitrate conversion to gaseous nitrogen, the primary constituent of the atmosphere. Denitrification is carried out by microorganisms that thrive under conditions of high soil carbon and high nitrate availability (Lowrance et al. 1985). One of the consequences of forest growth is increased soil organic matter content due to leaf, twig, and fine root accumulation, facilitating high denitrification rates throughout the life of the stand.

Forestry-related activities have considerably fewer chemical inputs than most agricultural systems. Some forest cropping systems may rely on herbicides for weed control during the first growing season of the rotation. In contrast, row crop agriculture usually involves applications of several chemicals throughout the growing season every year. Insecticide is applied to forest crops only rarely and under the most intensive management scenarios. In the Delta, soybean farmers typically use 24.1 and 28.9 oz herbicide active ingredient annually for conventional and stale seedbed methods, respectively (M.A.F.E.S. 1995; Ahrens 1994). In contrast, forestry applications total 19.2 oz active ingredient for the first growing season, but with no inputs projected for the remainder of the rotation.

Cottonwood is the most chemical intensive of the forest crops proposed here due to its sensitivity to weeds and short rotation length. Assuming one application per rotation, cottonwood may require as many as 5 applications per 100 years while other species would require only 2 or 3, depending on rotation length. Lower application rates are possible for oak and other hardwood species. Intensity of weed competition will dictate actual application rates.

Reforestation in riparian zones may affect flood water retention (Smith 1992). Increased soil organic matter, improved infiltration, and transpiration by forest vegetation act to slow and decrease the flow of water off site. If flooding in the Mississippi Delta occurs primarily during the dormant season, then the primary benefits of reforestation regarding flood water retention will be through changes to soil characteristics resulting from litter production and increased soil organic matter production.

Reforestation can contribute to the policy objective of reducing atmospheric carbon dioxide concentrations by sequestering atmospheric carbon in tree biomass. (Brown and Lugo 1982). Also, conversion of land from agricultural use to forestry typically results in a doubling of soil organic carbon. Although carbon content remains at a steady state in an intact forest, estimates across a range of different forest types suggest that the time and value of this steady state vary greatly (Johnson 1992; Row 1990).

To accomplish a reduction in atmospheric carbon through reforestation, decomposition of biomass and subsequent release of carbon to the atmosphere must be delayed. Woody material used for construction purposes, recycling paper, and paper stored in landfills will retain carbon in an inert state for a considerable period of time. According to one estimate, 60 percent and 37 percent of wood-based carbon is in an inert form 5 and 100 years following harvest, respectively (Row and Phelps 1990).

Despite the income opportunities available through the sale of timber and pulp products and hunting leases, as well as payments through government conservation and cost-sharing programs, reforestation of wetland soils as a restoration measure may still impose a net cost on landowners. The economic costs of reforestation are computed as the establishment and maintenance costs of timber production plus the cash returns forgone from abandoning soybean production. The extent to which

these costs are offset by the returns from the sale of timber and pulp, as well as returns from government payments (WRP) and sales of related services of the forest (hunting leases), determines whether or not the landowner realizes positive net economic returns to reforestation. Because the returns from reforestation are realized in future years, while costs occur in all years, the calculation of net returns is done in present value terms.

Although changing market conditions for soybean agriculture and recent public policy reforms may have diminished the returns to continued soybean production on frequently flooded soils in the Mississippi Delta, soybean returns may still exceed the net returns from forestry. As a consequence, many of the environmental services of Delta wetlands can be restored through reforestation but often at a cost to the landowner. While potentially small, the presence of costs may be a barrier to widespread reforestation. In addition, non-financial considerations (for example, price risk for future timber sales or need for an annual cash flow) may also be a barrier to reforestation.

Achievement of wetlands restoration through the reforestation of privately owned agricultural lands comprised of wetland soils requires the participation of the landowners. Any successful policy or promotional efforts to encourage reforestation must address the economic costs faced by landowners, as well as any other noneconomic concerns that may serve as a disincentive to reforest. This paper provides an examination of both the economic costs of reforestation incurred by the landowner as well as noneconomic considerations that factor into a landowner's decision to reforest.

To explore the economic consequences of reforestation from the landowner's perspective, an analytical model is developed that fully incorporates the policy, market and technical factors determining landowner financial returns from reforestation. An examination of the costs of reforestation for the representative landowner can:

- help identify the economic, hydrologic, and soil situations where restoration is most likely to impose only modest costs on landowners. Such information can be used to target the landowners with the greatest potential interest in reforestation when allocating limited public funds.
- provide landowners, as well as state, local, and regional policy makers, with credible evidence of the costs and returns to reforestation; the advantages of different incentive payment programs; and supplemental income sources, such as hunting lease sales.
- provide federal and non-federal policy makers with insights into the design of landowner incentive policies for encouraging reforestation.

Both local and state policy makers have the capability of implementing or amending policies that can provide landowners with significant incentives (or disincentives) to adopt reforestation. For example, property taxes on forest land, silvicultural cost share payments, and many of the eligibility rules of the federal Wetlands Reserve Program (WRP) and Conservation Reserve Program (CRP) are determined by state or local level decision makers. The willingness of policy makers to lend support to a restoration effort, however, depends in part upon their assessment of the regional economic effects of reforestation.

An assessment of the regional economic impacts of reforestation is conducted to provide information to assist policy makers in gauging the extent of public support reforestation warrants as a wetlands restoration measure.

## Objectives

1. To estimate the net present value (NPV) of returns for alternative Delta reforestation strategies on flood prone farmlands under representative soybean farming situations (e.g., hydrology, soils, prices, and costs).

Changes in landowner income from reforestation are determined by computing and comparing net present values of the land in alternative uses. A computer simulation model is developed based on the analytical model representing the economic returns to reforestation. The net income simulation model is built using equations that represent the key financial relationships for the landowner. To establish a Base Case situation, a representative site is created using production costs and practices, flooding regimes and site characteristics that might reasonably be found on flood prone Delta agricultural lands. The inherent productivity of the soil and the flooding regimes at the site are investigated to determine whether the model results are sensitive to data inputs selected for the representative situation. If these physical features are key determinants of the NPV of reforestation, then lands with particular yield potential and flooding regimes might be targeted for technical and financial reforestation assistance. The computer simulation model could be modified to allow

individual landowners to input data that reflect the unique characteristics of their site and production experiences.

2. To discuss how considerations other than net present value can influence landowner decisions to reforest frequently flooded farmlands and landowner responses to alternative public policy designs.

The effects of different policies on landowner NPV from reforestation of flood prone lands are examined. However, it is also the case that other considerations might adversely affect the interest in reforestation, including attitudes and perceptions of income risk, immediate cash flow needs, and the “fit” of the forestry enterprise into the rest of the farm business. Often personal interest in hunting or fishing or altruistic motives may motivate reforestation, despite low prospective NPV. These factors are described and their possible influence on the reforestation decision considered.

3. To describe policies and programs that can be developed for encouraging landowner adoption of reforestation on wetland soils as a restoration measure, including a discussion of the potential contributions and limitations of alternative income sources for increasing the adoption of reforestation.

From the landowner's perspective, some income may be realized from the non-timber effects of reforestation (e.g., hunting leases, payments for carbon sequestration, etc.). Potential policies to encourage reforestation are forgiveness of forest taxes and tax credits for nonindustrial and industrial landowners, cost sharing payments for regeneration, payments for land parcels devoted to forest production or other set asides (e.g., through the CRP or the wetlands reserve program). “Speculative” policy options are also considered. These include payments made for carbon sequestration, possible programs to increase the demand for hunting leases, and futures markets in timber sales that will overcome cash flow concerns of landowners.

4. To describe the effects of reforestation on the regional economy.

An assessment is provided of the region-wide economic impacts of reforestation. This assessment can be used to assist state, local, and regional policy makers in determining the extent and nature of policy support warranted by the restoration effort. Additional regional impacts of non-timber economic activities expected to occur with reforestation, such as the sale of hunting and recreational leases, are also considered.



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## II. LANDOWNER PERSPECTIVES ON REFORESTATION

While reforestation benefits may extend to the nation and indeed the world, the decision to reforest rests with the private landowner. A landowner's willingness to reforest is determined both by the economic profitability of reforestation, as well as many "non-economic" considerations. This section addresses only the economic aspects of a landowner's decision to reforest, leaving the discussion of all other considerations for Section III.

### Considering the Economic Returns to Reforestation

For owners of "potentially marginal" agricultural land (as defined in Section I), considering the economic profitability of reforestation involves comparing the expected financial returns from forest production to the agricultural returns foregone when the land is reforested. In this section, a simulation model is developed for the purpose of making this comparison for a hypothetical acre of frequently flooded soybean land using prices and production costs deemed to be representative of those faced by Delta landowners.

Silvicultural returns are realized many years in the future when the tree stand is harvested and sold. Agricultural returns are realized each year. Therefore, the comparison between agriculture and forestry must be made by simulating annual net returns for both land uses over the length of a forestry rotation. Future revenues and costs are discounted to present values at a 5 percent interest rate and summed to calculate the net present value (NPV) of both silvicultural and agricultural production.<sup>1</sup> The difference between the NPV of silvicultural and agricultural returns is referred to as the "economic" returns to reforestation (NPV<sub>Ref</sub>).

<sup>1</sup> All prices, costs, and interest rates are inflation adjusted and expressed in 1996 dollars. The net present value (NPV) of future silvicultural and agricultural returns are discounted according to the following equation:

$$NPV = \sum_{t=0}^n \frac{R_t - C_t}{(1+i)^t}$$

R<sub>t</sub> = Revenues generated in year t

C<sub>t</sub> = Costs incurred in year t

i = Real interest rate

n = Length of forestry rotation in years

The NPV<sub>Ref</sub> from converting flood prone agricultural lands to forest production for a representative soybean producer is a measure of the profitability of reforestation under the simulated conditions. The most general form of this computation is:

$$\begin{aligned} (1) \text{ NPV of Economic} \\ \text{Returns to Reforestation} = \\ & \text{(Revenues from} \\ & \text{Future Sales of} \quad \textit{minus} \\ & \text{Forest Products)} \\ & \\ & \text{(Discounted} \\ & \text{Costs for} \quad \textit{minus} \\ & \text{Reforestation)} \\ & \\ & \text{(Discounted Foregone} \\ & \text{Agricultural} \textit{Net} \\ & \text{Returns)} \end{aligned}$$

According to equation (1), if the landowner reforests he / she captures forest returns but also incurs reforestation costs. In addition, the landowner gives up the opportunity to earn a return from producing soybeans.

To compare the potential profitability of alternative reforestation strategies, the NPV<sub>Ref</sub> is simulated for six different silvicultural regimes considered feasible for the ten, "marginal" soil series described in Section I. In the first half of this section, a "Base Case" simulation of the NPV<sub>Ref</sub> for the six different reforestation regimes is developed for the states of Mississippi, Louisiana, and Arkansas.

First, a forestry module is developed, following a brief discussion of three assumptions underlying the Base Case simulation. In the forestry module, the net returns for the six different reforestation strategies on each of the ten soils are computed and reported by state.<sup>2</sup> Existing federal and state cost sharing programs are included in the Base Case simulation because they represent direct payments to landowners to defray the

<sup>2</sup> As will be discussed in the development of the forestry simulation, some of the reforestation regimes are not feasible on all ten of the soil types examined in this study.

costs of planting. Potentially, forest revenues can include non-timber income such as hunting leases, carbon storage payments, and payments through government programs like the Wetlands Reserve Program. However, the Base Case simulation revenues are limited exclusively to income obtained from timber harvests and government cost share payments. In Section IV, alternative income sources will be considered in the context of the Base Case NPV<sub>Ref</sub>.

Next, the returns to soybean production are computed in an agricultural module that accounts for the effects of soils, flooding regimes, and location in the region (location affects the crop insurance program structure). For the Base Case analysis, a situation that is representative of the farming conditions on frequently flooded soils across the whole region is developed.

In the second half of this section, a computation of equation (1) is made for the six different reforestation options and the Soybean Base Case, in each of the three states. The most favorable NPV<sub>Ref</sub> for reforestation are reported and the sensitivity of the computed NPV<sub>Ref</sub> to critical assumptions in the forestry and soybean simulations is examined. Finally, general findings and conclusions about the economic returns to reforestation on flood prone soils are discussed, based on the results of the simulation and sensitivity analyses.

#### Limiting Assumptions Underlying the Forestry and Agricultural Modules

Three assumptions, common to both the forestry and agricultural modules, should be understood before proceeding with the development of the Base Case simulations.

#### *Establishing a Time Horizon*

To compare the simulated NPV<sub>Ref</sub>, a common time horizon must be used for all reforestation regimes. A 60-year period, equaling the length of the longest forestry rotation is used for the NPV analysis in both the forestry and agricultural modules. Although some of the reforestation regimes modeled have rotation ages that are shorter than the designated 60-year planning horizon; the computed returns for these shorter rotations are adjusted so that the reported NPV<sub>Ref</sub> is for the full 60-year period.

#### *Determining a Discount Rate*

From a survey of local lenders and the Federal Land Bank, a real interest rate of 5 percent was selected as the discount rate for both the forestry and agricultural modules. As a consequence, many possible differences between forestry and agriculture that would normally be captured in the discount rate, are factored out of the Base Case NPV<sub>Ref</sub> computation. Such differences might include differing perceptions of risk between forestry and agricultural production and differing capital costs. These issues are considered in Section III. However, it should be remembered that these differences are not necessarily captured in the Base Case NPV<sub>Ref</sub>.

#### *Returns to Landowner Labor, Capital, Overhead, and Management*

For the agricultural and forestry modules in the Base Case, charges to land ownership, interest on operating capital, and landowner labor are not included in the annual operating budget. Additionally, the management and overhead costs associated with running a farm or silvicultural operation are excluded from estimates of annual production costs. Thus, under the Base Case, the net returns to both forestry and agriculture are the payment to management, land ownership, equity, and overhead. The effects of including labor, management, and overhead costs are examined through sensitivity analyses of the Base Case results in the second part of this section.

#### **Computing the Present Value of Returns to Reforestation**

The forestry component of the net returns in equation (1) incorporates the costs and timber revenues of implementing various reforestation strategies. Seven possible bottomland hardwood reforestation scenarios were deemed feasible for an owner of flood prone soybean land in the Delta. These scenarios included plantations with the following species: 1) cottonwood only, 2) mixed cottonwood with interplanted Nuttall oak, 3) green ash, 4) sycamore, 5) sweetgum 6) Nuttall oak, and 7) water oak.

The net returns evaluation for each scenario was completed for different soil series in the states of Mississippi, Louisiana, and Arkansas. The scenarios differed according to the silvicultural/planting regime

appropriate for each species, differences in growth and yield, and differences in rotation age. Also, not all production scenarios were feasible on all soils.

To model the net returns for each scenario, information was needed on the amount of product produced over the time horizon. Specifically, information was needed for each species on each soil type for a) growth and yield, b) rotation age, as the length of time between planting and final harvest, and c) the mix of merchantable saw timber and pulp at harvest. Production is the result of silvicultural practices, ranging from site preparation and stand establishment to weed control. The management regime for each scenario was developed by defining the particular silvicultural production practices that occur at each point in the time horizon.

The NPV of reforestation for each soil type was computed using state-specific cost and return information. Estimates of the expected future prices for forest products and cost estimates for the silvicultural regimes were made. Most of these costs and returns varied over soil types, but some were state specific. All price and cost estimates were made in constant dollars.

### Growth and Yield

Cottonwood and mixed cottonwood-oak growth and yield data are available from several published surveys. Most important is an ongoing cooperative study between Crown Vantage and the U.S. Forest Service Stoneville Lab, as well as recent work by Cao and Durand (1991). Table II-1 presents cottonwood yields for each soil series where cottonwood regeneration was considered feasible. These yields were simulated from growth and yield data collected through the collaborative research project between Crown Vantage and the U.S. Forest Service and using the model in Cao and Durand (1991).

**Table II-1. Cottonwood Yields**

<i>Soil Type</i>	<i>Volume to a 3-inch top (ft<sup>3</sup>/ac) at year 10</i>
Alligator	584
Tunica	1340
Sharkey	1527
Dundee	2875

However, there is limited published information on growth and yield for bottomland hardwoods in the

Mississippi Delta. For bottomland oaks and other hardwoods, published data on mean annual increment yields are found in Baker and Broadfoot (1979) and USCS Soil Surveys for the region.

Baker and Broadfoot (1979) assigned point values for several soil and site criteria. For each criterion, point values are given in accordance to the relative importance of the criterion for the growth of a particular species. When values have been assigned for each criterion, point values are summed to provide an estimate of the site index for the given species and site conditions. In order to make generic estimates for abandoned soybean fields, several assumptions were made (see Table II-2).<sup>3</sup> Using these assumptions, the site indices in Table II-3 were obtained by reducing the Baker and Broadfoot site indices reported in Table II-A at the end of Section II. The new site index number is an adjustment to reflect the lower site index expected for tree growth on former soybean fields.

Using the Baker and Broadfoot (1979) site productivity estimates and the assumptions in Table II-2, site indices for former soybean land were consistently lower than estimates published in county and parish soil surveys (Table II-A). Discrepancies between site index values published in soil surveys and estimates based on soils data and assumptions for former soybean fields typically ranged from 10 percent to greater than 20 percent. Differences between soil survey and the Baker and Broadfoot-based estimates likely reflect differences in assumptions made in forest condition. Estimates made by Broadfoot (1976) and those incorporated in soil surveys assume natural regeneration of natural, well-stocked stands with no evidence of cutting or burning.

While reforested agricultural land is likely to have lower productivity relative to regenerated, continuously forested land, these differences are likely to be most drastic during the first rotation. As the stand develops, soil properties such as bulk density, soil organic matter, rooting depth, and topsoil thickness will become more advantageous for tree growth. For these reasons, and other unforeseen cultural and genetic improvements, subsequent rotations will almost certainly produce stands with greater productivity than the first.

<sup>3</sup> Site index is a measure of site productivity for each soil type and is defined as the height of dominant and co-dominant trees at age 50.

**Table II-2. Criteria used by Baker and Broadfoot (1979) for site evaluation in bottomland hardwoods. Values for soil type-dependent variables (SD) were obtained from soil surveys.**

<i>Criterion</i>	<i>Assumption</i>
Soil depth	SD (all soils are deep)
Presence of a pan	SD (no soils have an inherent pan, assume deep plowing to disrupt plow pans)
Soil texture	SD
Soil compaction	SD
Soil structure	SD
Past use and present cover	assume more than 20 years continuous cultivation, assume soybean cultivation is the equivalent of annual fertilization
Water table depth	SD
Topographic position	all sites are floodplain
Microsite	assume all microsites are flat due to leveling associated with cultivation
Flooding	SD
Geologic origin	all soils are derived from Mississippi River alluvium
organic matter content	assume less than 1 percent due to repeated cultivation
Depth of topsoil	SD
Soil age	SD
pH in rooting zone	SD
Swampiness	SD
Depth to mottling	SD
Soil color	SD

**Table II-3. Growth Rates (m<sup>3</sup> /ha/yr) and Site Indices (feet at 50 years) for Bottomland Species**

<i>Series</i>	<i>Sycamore</i>		<i>Green Ash</i>		<i>Sweetgum</i>		<i>Nuttall Oak</i>		<i>Water Oak</i>	
Alligator	5	75	3	74	5	78	5.5	80	6	83
Amagon	6	82	3	76	6	82	6	83	5	77
Bowdre	4	71	3	74	5	78	5	77	4	71
Dundee	6	82	3	79	6	88	6	83	5	80
Forestdale	n.a.		3	71	n.a.		5	76	n.a.	
Mhoon	4	71	3	78	4	76	5.5	82	n.a.	
Newellton	5	76	3	77	6	81	5.5	81	4	72
Sharkey	4	70	2	72	4	75	5	78	4	70
Tensas	4	70	3	73	4	76	5.5	79	4	72
Tunica	n.a.		2	71	n.a.		5	77	n.a.	

A summary of bottomland hardwood growth rates are presented in Table II-3. The first number in each column represents the annual growth in m<sup>3</sup>/ha/yr at culmination of Mean Annual Increment (MAI). MAI is defined as the highest rate of growth attainable by a species during a rotation (Davis and Johnson 1987). The second number in each column is the site index for each soil type. This is the modification of the Baker and Broadfoot site indices reported in Table II-A. Delta soils which are most productive include the Dundee and Amagon soil series.

The total yield at harvest for the bottomland hardwoods is obtained by multiplying the MAI figure in Table II-3 times the rotation age for each species-soil type combination. One potential problem with the estimation of volumes based on mean annual increment is the implicit assumption of linear growth. Without growth and yield information for bottomland hardwoods, there was no alternative. A problem with the linear growth assumption is that yield at rotation age may be overstated. Another problem is that linear growth penalizes good sites with shorter rotations and favors poor sites with longer rotation ages. As a check for whether these problems were serious, the yields in Table II-3 were cross checked against published upland oak yields and found to be accurate to within 20 percent (Southern Foresters Handbook 1981).

Because information does not exist for mixed oak-cottonwood yields, except on plantations that are only 1-3 years old, yields were simulated according to initial planting densities. The Crown Vantage and the US Forest Service's recommendations that oak be interplanted among a fully stocked cottonwood plantation at year 3 were used. The interplanting assumes 50 percent stocking of Nuttall oak. Therefore, the yield at final harvest age for the oaks is estimated to be 50 percent of the yield computed using the MAI in Table II-3, and the cottonwood yields are equivalent to those presented in Table II-1. An important assumption for the mixed reforestation regimes is that the effects of established cottonwood on oak yields are insignificant. This is a reasonable assumption given the established tolerance and slow growth of Nuttall oak seedlings.

### Rotation Age

Rotation age is the length of time between establishing a plantation and final harvesting. Rotation ages for a given species of tree will vary by soil type, since tree growth on higher site index soils is

more rapid than lower site index soils. A rotation age for each reforestation regime was estimated using the site index and soil productivity data for soil series in the Delta. The assumed relationship between site index and rotation age is presented in Table II-4. The average site index for soils in the Delta is 70 - 80 feet, with rotations of 50-60 years. Table II-5 presents the rotation ages for soils in the Delta. These were obtained using the assumptions in Table II-4 and the site index figures in Table II-3.

### Merchantable Volume

After MAI and rotation ages are used to determine yields at harvest, another conversion is required to compute the yield at harvest that can actually be merchandised by the landowner. There is a discrepancy between gross yield and merchantable yield because some parts of a tree, such as bolewood, can not be sold as sawtimber. Sawtimber yields are measured in board feet (bd ft) units [1 bd ft = 1"x12"x12"] per acre, while pulpwood yields are measured in cords per acre.

Obtaining merchantable yield from harvest yield requires three steps. First, cubic meter yield per hectare is converted to cubic feet per hectare. Second, the cubic feet per hectare is converted to cubic feet per acre. Finally, cubic feet per acre is converted to board feet per acre using a factor that adjusts for wood that can not be merchandised by the landowner. This last conversion depends on estimates of the average diameter of trees harvested, and an assumption about measurement scales used at the mill where the wood is sawn into lumber. The details of this conversion are beyond the scope of this report. Equation (2) presents a summary of the conversions for bottomland hardwood yields,<sup>4</sup>

$$(2) \text{ Board feet /acre} = \begin{aligned} & [\text{MAI in Table II-3}] * \\ & [\text{rotation age in Table II-5}] \\ & * [14.291(\text{ft}^3/\text{acre}/\text{yr})/(\text{m}^3/\text{acre}/\text{yr})] \\ & * [7 \text{ bdf}/\text{ft}^3] \end{aligned}$$

<sup>4</sup> Details of these conversions can be found on pages 26-28 in the Southern Foresters Handbook (1986).

**Table II-4. Relationship between Site Index (ft at 50 years) and Rotation Age**

<i>Site Index</i>	<i>40-49</i>	<i>50-59</i>	<i>60-69</i>	<i>70-79</i>	<i>80-89</i>
Rotation Age	90	80	70	60	50

**Table II-5. Rotation ages by Silvicultural Regime and Soil Type**

<i>Soil Types</i>	<i>Green Ash</i>	<i>Sycamore</i>	<i>Sweet-gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood</i>	<i>Cottonwood &amp; Nuttall Oak</i>
Alligator	60	60	60	50		10	53
Amagon	60	50	50	50	60		
Bowdre	60	60	60	60	60		
Dundee	60	50	50	50	50	10	53
Forestdale	60			60			
Mhoon	60	60	60	50			
Newellton	60	60	50	50	60		
Sharkey	60	60	60	60	60	10	60
Tensas	60	60	60	60	60		
Tunica	60			60		10	60

The third bracketed term on the right hand side summarizes the conversion from cubic meter of gross volume per hectare to cubic feet of gross volume per acre, while the fourth term in brackets is the conversion from cubic feet to merchantable board feet.

Once board feet yields are computed, pulpwood yields can be obtained through a standard conversion (Husch et al. 1982).

$$\text{Cords/acre} = (\text{Board Feet/acre})/1536$$

When forest sites are harvested, landowners typically merchandise their products by selling larger logs as sawtimber and smaller pieces of wood as pulpwood. The proportions of these products depend on site quality. On high quality sites, the proportion of sawtimber is higher. For computing NPV of forestry returns, the proportion of sawtimber to pulpwood on high quality sites is 75 percent sawtimber and 25 percent pulpwood. On poorer sites, for oak species the proportion is 66.7 percent sawtimber and 33.4 percent pulpwood for the oak species. For all other species, the proportion of sawtimber to pulpwood is 50 percent of each on poorer sites.

### Silvicultural Regimes

Each reforestation scenario requires different tasks for establishment of plantations. The tasks generally include:

- Site Preparation -- mechanical ripping of the soil (machine and labor)
- Chemical Treatment -- spraying chemical herbicide in early spring prior to planting for weed control (labor and materials)
- Planting -- the hand planting of seedlings (labor)
- Disking -- mechanical weeding using a tractor (cottonwood only)
- Cultivation -- breaking the top layer of soil, but not as deeply as ripping (cottonwood only).

Thinning is not included in any of the silvicultural regimes. There is currently no published work that establishes the financial feasibility of thinning bottomland hardwood stands. In addition, thinning can lead to epicormic branching which reduces wood quality.

Tables II-6 to II-8 describe the silvicultural requirements for all reforestation regimes. The requirements shown for cottonwood and mixed cottonwood - oak are identical to those employed in the cooperative research effort between Crown Vantage, NCASI, and the US Forest Service Lab at Stoneville, Mississippi.

**Table II-6. Silvicultural Regime for All Pure Species Plantation.**

<i>Activity</i>	<i>Year of Occurrence</i>
Site Preparation	Year zero
Winter Herbicide Spray	Year one
Planting	Year one
Final Harvest	Rotation age

**Table II-7. Silvicultural Regime for Cottonwood Plantations.<sup>5</sup>**

<i>Activity</i>	<i>Year of Occurrence</i>
Site Preparation and chemical treatment	Year zero
Cultivation	Year one
Planting	Year one
Cultivation	Year two
Harvest	Year ten
Disking	Year eleven
Disking	Year twelve
Harvest	Year twenty

Note: This silvicultural regime was developed by Crown Vantage, Inc.

From Table II-5, the rotation age recommended for cottonwood is ten years. There is no planting after the first harvest because coppicing of root collars and other sprouts provides the basis for the second rotation of cottonwood. (Coppicing refers to sprouting from roots and stumps. Cottonwood is a prolific sprouter.) This 20-year cycle of planting cottonwood, harvesting, coppicing and harvesting again is repeated three times for Alligator, Tunica, Sharkey and Dundee soils. Repeating the 20-year cycle by conducting site preparation and planting once again allows for the introduction of new and improved varieties of cottonwood. However, genetic improvement is not assumed to affect yields in this study.

<sup>5</sup> Some cottonwood regimes do not include disking following the first harvest, as is done in years eleven and twelve of the Crown Vantage regime. The discounted value of the cost savings from eliminating these disking activities for all pure cottonwood scenarios equals \$14.84 over the 60 year time horizon. This means that, if disking costs were not included as part of the cottonwood regime, the reported returns for all cottonwood scenarios would increase by \$14.84. Similarly, the reported returns to cottonwood / oak intercropping would increase by \$10.00 on Alligator and Dundee soils and by \$9.77 on Sharkey and Tensas soils as a consequence of eliminating disking costs in years eleven and twelve of each 20 year cottonwood cycle.

**Table II-8. Silvicultural Regime for Mixed Cottonwood & Nuttall Oak Plantations.<sup>6</sup>**

<i>Activity</i>	<i>Year of Occurrence</i>
Site Preparation and chemical treatment	Year zero
Cultivation	Year one
Planting	Year one
Cultivation	Year two
Planting of nuptial Oak	Year three
Harvest	Year ten
Disking	Year eleven
Disking	Year twelve
Property tax	Year zero to year twenty
Final Harvest	Year twenty
Harvest of Oak	Rotation age (dependent on soil type)

Note: This silvicultural regime was developed by Crown Vantage, Inc.

In the mixed oak-cottonwood regime (Table II-8), cottonwood is assumed to be planted at full stocking on a 12' x 12' spacing (304 trees per acre). Oak is then planted at 50 percent of full stocking (12' x 24' spacing, or 152 trees per acre) in the third year of the first cottonwood rotation. It is conjectured that cottonwood provides enough light protection in the early life of the oak to reduce epicormic branching patterns and, thus, increase the quality of harvested oak logs.

#### Reforestation Costs

The costs of reforestation were estimated for each of the steps in the silvicultural regimes outlined in Tables II-6 to II-9.<sup>7</sup> Average costs reported in Forest Farmer, "Costs and Trends in the Southeast," (Dubois, 1995) were used to determine the total yearly cost of reforestation. Because the analysis is in real dollar terms, the costs of each element in reforestation are the same over time.

Table II-9 presents the costs that are used for the NPV calculation. The estimated total costs for each

<sup>6</sup> See footnote five.

<sup>7</sup> In earlier analyses, the application of herbicide was not included in either the cottonwood or cottonwood-oak regimes. The results presented in this report do include the costs of herbicide applications for both regimes.

management regime, using tables II-6 - II-9 are as follows:<sup>8</sup>

*oak and hardwoods:*

site prep + herbicide + planting + seedlings = \$204.34 per acre

*cottonwood plantations:*

site prep + herbicide + first cultivation + planting + seedlings + second cultivation = \$199.54 per acre

Similarly, the mixed cottonwood/Nuttall oak plantation cost is \$234.24 per acre.

Differences in planting costs are primarily due to variations in seedling costs, required site preparation, and initial planting densities.

**Table II-9. Silvicultural Cost Data (not including applicable cost sharing). Costs for seedlings assume initial planting densities of 304 trees per acre (12x12 foot spacing) 1996 dollars**

<i>Costs</i>	<i>\$ per acre</i>
Cottonwood Planting (labor)	16.00
Oak/hardwood Planting (labor)	37.64
Site Preparation (mechanical + labor)	56.77
Chemical Treatment (labor + materials)	64.39
Disking (labor + mechanical)	8.56
Cultivation (labor plus mechanical)	3.42
Seedling costs	
oak (\$0.15 ea)	45.60
other hardwood (\$0.15 ea)	45.60

Source: Dubois et al. 1995.

*Existing Financial Assistance Programs*

A landowner can draw from a number of existing state and federal financial assistance programs that provide direct payments for reforestation. Cost-sharing programs pay the landowner a fixed fee per acre depending on the type of reforestation (i.e., intensity of site prep) and the species. In the NPV computation for reforestation, returns, costs, and applicable cost sharing payments were included. Cost share payments for each state were determined from

<sup>8</sup> Seedling costs were obtained for the Delta from NRCS WRP guidelines, and were cross checked with several calls to local nurseries (NRCS TGH notice 135, August 1992). There are currently no published data on planting labor and mechanical costs specific to the Delta. However, the source used to construct costs was specific to the Southeast, and is likely to closely approximate costs in the Delta region.

U.S. Forest Service and state extension publications. Under current legislation, the federal government pays between 40 percent and 75 percent of the costs of reforestation, depending on the state and species. While landowners in all states are eligible for federal cost sharing, Mississippi also offers a state cost sharing program that is similar to the federal program. Louisiana and Arkansas do not have programs that provide direct payment to landowners for reforestation costs; however, they do have other state assistance programs. In states where there are both federal and state cost sharing payment programs, landowners typically are only eligible for one. In the case of Mississippi, the average federal cost sharing payment is similar to the state payment.

To determine the payment a representative landowner in each state would receive for reforestation, published state averages were collected (Haines, 1995). In Mississippi, oak reforestation with heavy site preparation is eligible for payments of \$85/acre. Other hardwood reforestation with heavy site preparation can receive \$62/acre. However, in Mississippi, the maximum annual cost share for all acres is \$5,000, which is 59 acres when regenerated into oak. The cost share payment used in the model for all tree species in Mississippi is \$85/acre. The cost share used for all tree species in Louisiana is \$53.49/acre and in Arkansas is \$60.12/acre.<sup>9</sup>

Landowners who reforest may also be eligible for federal reforestation tax credits, where the landowner can write off a portion of reforestation costs against pretax income during some specified period. In other cases, the landowner receives free technical advice from state appointed consulting foresters through a "stewardship program." However, the extent of tax incentives each landowner receives depends on the landowner's income position, thereby making it difficult to simulate these credits for a representative land owner. Forest stewardship, while valuable, also was not included in the NPV due to the difficulty in placing a monetary value on the advice.

<sup>9</sup> If a landowner is ineligible for cost share payments, the NPV of the returns to all reforestation scenarios *except* cottonwood will be lower by \$85 in Mississippi, by \$53.49 in Louisiana, and by \$60.12 in Arkansas. Ineligibility for cost sharing causes a larger decline in the NPV of cottonwood returns because cost share payments are received three times during the course of the 60-year time horizon. In the absence of cost share payments, the NPV of cottonwood returns falls by \$129.11 in Mississippi, by \$81.25 in Louisiana and by \$91.32 in Arkansas.

## Forest taxes

Forest owners in the Delta must pay property taxes to county and municipal governments. Property tax annual payments are based on the assessed value of the land and must be paid every year, even if there is no income earned from the land until harvest. Table II-10 reports property tax payments per acre for forest land in the three states under consideration. The payments reported were collected from tax assessor information in each state and compiled by Greene (USFS Southeastern Station).<sup>10</sup>

**Table II-10. Property Taxes in Arkansas, Louisiana and Mississippi**

<i>Taxes</i>	<i>Arkansas</i>	<i>Louisiana</i>	<i>Mississippi</i>
Property taxes by state (\$/acre)	\$4.50	\$1.44	\$1.83

Arkansas, Louisiana, and Mississippi all have some type of harvest tax assessed on the price received by the logger at the mills. Since loggers pay these taxes, the price data reported by Timber Mart South (described below) are prices net of this harvest tax (Personal communication, J. Greene, U.S. Forest Service Southern Experiment Station). Forest capital gains taxes are a component of the federal income tax paid by each landowner at harvest time. The capital gains tax is levied on the appreciation in the value of the forest stand between establishment and final harvest. However, the capital gains tax rate and its application depend both on specific income characteristics of the forest landowner and how the landowner chooses to report income from forestry operations. Therefore, it is not possible to model a representative capital gains tax situation. Other ordinary income taxes are similar between forest landowners and agricultural landowners and will not be included in the base comparisons.<sup>11</sup> In computing

<sup>10</sup> Arkansas has substantially higher average property taxes than Mississippi and Louisiana. However, Arkansas has lower yield taxes applied to harvests than the other states (personal communication, John Greene).

<sup>11</sup> For more information concerning the role of income tax considerations in landowners' land use decisions, see Heimlich, Ralph E. 1986. "Economics of wetland conversion: Farm programs and income tax." National Wetlands Newsletter 8 (4):7-10., Watts, M.J., L.D. Bender, and J.B. Johnson. 1983. "Economic Incentives for Converting Rangeland to Cropland." Bulletin 1302 Cooperative Extension Service, Montana State University,

the net returns to forest production, only forest property tax payments are included.

## Prices

The current price reporting system for the Southeast is Timber Mart South (TMS). TMS reports average prices for "hard hardwoods" and "soft hardwoods" by state. Prices reported are net of logging costs and state harvest taxes where applicable. Prices for bottomland hardwoods vary widely according to wood quality, the time of year harvesting takes place, species mixes, and other characteristics of the forest site that affect ease of harvesting such as soil drainage and size of the tract. However, there is no published price information specific to the Delta region. For this project, TMS data were used to define prices of sawtimber and pulpwood. These prices were averaged for the months in which harvesting of marginal lands is expected (i.e., July - October). Table II-11 presents these price data. However, using statewide averages abstracts from quality differences between species and differences in prices between regions. It is quite possible that prices for high quality Nuttall oak logs are substantially higher than the averages reported for TMS. Since TMS does not report standard deviations or high/low prices, there was no way to determine how prices should be adjusted. However, later we will perform sensitivity analysis by increasing sawtimber prices by 20 percent over the Base Case prices. This will effectively address the impact of higher quality wood.

For the NPV analysis, future prices were determined by adjusting the current prices in Table II-11 using the most current U.S. Forest Service Resources Planning Act (RPA) price forecasts for the Southeastern U.S. (Cubbage et al. 1995). These adjustments were made using the predicted rate of increase in real sawtimber prices between the year 2000 and the year 2020, the last period predicted in the RPA assessment.<sup>12</sup> Since the RPA study predicts stable (and even slightly decreasing) real pulpwood prices, pulpwood prices were assumed to remain constant. Using the RPA assessment, sawtimber

Bozeman, MT, Nov. and Ward, J.R. F.K. Benfield, and A.E. Kinsinger. 1989. Reaping the Revenue Code: Why We Need Sensible Tax Reform for Sustainable Agriculture. Natural Resources Defense Council, Washington, D.C.

<sup>12</sup> The U.S. Forest Service forecast for average real sawtimber prices in 2000 is \$70/mbf (mbf = thousand board feet) and \$94/mbf in 2020.

**Table II-11. Current Price Data from Timber Mart South and Projected Prices (in 1996 dollars)**

<i>Revenues</i>	<i>Arkansas</i>		<i>Louisiana</i>		<i>Mississippi</i>	
	Current	Projected	Current	Projected	Current	Projected
Price of sawtimber of oak (\$/MBF Doyle)	226	296.06	219	286.89	223	292.13
Price of sawtimber of other hardwoods (\$/MBF Doyle)	123	161.13	118	154.58	151	197.81
Price of hardwood pulpwood (\$/Std. Cord)	11.99	same	15.67	same	16.33	same

prices were assumed to increase by 31 percent by harvest age.<sup>13</sup>

The assumption that prices in the Delta will increase at the same rate as forecasted in the RPA assessment may not be consistent with anticipated changes in the Farm Bill. The 1996 Farm Bill promulgates phasing out of various crop and income support programs over time. If this occurs, it is possible that the long run supply of timber could increase throughout the U.S. as forest production replaces some farm land. In this situation, timber and pulp prices might eventually decrease in the long run for the Delta region and throughout the country as a response to increased supplies.

Net Present Values for Forest Production

Once the forest costs and returns were defined throughout the rotation, the net present value (NPV) of each reforestation regime was computed. In the NPV analysis the time horizon is 60 years, the length of the longest rotation age.<sup>14</sup> For cottonwood, this implies that six rotations are completed within the landowner's time horizon. Extending the model to longer time horizons (e.g., two rotations for bottomland oaks or longer) would probably not change the results of the study because costs and returns discounted beyond 60 years become relatively small.

The net present value was computed for each feasible regeneration regime / soil type combination using a real interest rate of 5 percent. The interest rate

was determined through a survey of local lenders in the Delta including the Federal Land Bank.

Tables II-B, II-D, and II-F (found at the end of Section II) present the computed net present values for each reforestation scenario. The results are reported by state. With the exception of green ash plantations, the net present value of forest production is generally positive across all soil types within the Delta.<sup>15</sup> The differences in net present values between the most productive Delta soils (Dundee, Amagon) and the least productive Delta soils (Sharkey, Forestdale) across all three states average about \$277 for Nuttall oak, \$152 for water oak and \$232 for cottonwood plantations. The regeneration regimes with some of the highest computed NPV include plantations of Nuttall oak and mixed plantations of Nuttall oak and cottonwood. Across all three states, Nuttall oak averages roughly \$415 per acre in NPV for good sites and \$137 per acre for poor sites, while the mixed plantations average net present values of \$371 per acre for good sites and \$109 per acre for poor sites.

There are also important differences in these net present values across states and soil types. Nuttall oak plantations are most profitable in Mississippi given the relatively high prices and low harvest taxes. In fact, in Mississippi, the highest net present values for forest production occur on Dundee soils supporting Nuttall oak and mixed cottonwood-oak plantations. Net present values are lowest in Arkansas. This reflects the relatively high property tax burdens faced by forest landowners in Arkansas. There are also significant differences in net present values across soil types. These differences reflect the varying proportions of sawtimber-pulpwood production on good and poor sites, as well as the different growth rates and rotation

<sup>13</sup> Using the year 2020 prediction is consistent with the procedure used to determine future soybean prices, which are described later in this section.

<sup>14</sup> Shorter, fifty and fifty-three year rotations were adjusted to the 60 year time horizon by calculating the annual equivalent value of the NPV generated by the first rotation. The computed annual equivalent value was then credited to the remaining years of the 60 year time horizon.

<sup>15</sup> The problem with green ash is that the published growth rates predicted in Table II-3 are low, giving yields at harvest that are 20 percent lower than the yields predicted for Nuttall oak.

ages appropriate for different sites. For example, on the Dundee, Alligator, and Amagon sites, NPVs are generally twice as high for most species compared to NPVs for Sharkey and Tensas soils. These differences are most dramatic for the pure oak and cottonwood plantations.

Cottonwood plantations allow more frequent returns due to their short rotations, but the value of harvested material is lower since it must be sold entirely as pulpwood fiber. However, on the best soils (Dundee), cottonwood plantations in Louisiana and Mississippi yield some of the highest NPV of \$284 - 347 per acre.<sup>16</sup>

A comparison of mixed oak-cottonwood intercropping and pure cottonwood regeneration regimes shows that the differences in net present values between them are small, especially for the poorer soils. One possible explanation is that a final oak harvest adds substantially to revenues only for mixed plantations on relatively good soils given the assumptions about growth and yield in Table II-3. This is expected since the mixed oak stand is probably less well stocked at rotation age than a pure oak stand would be at rotation age. However, it is difficult to predict how intercropped stands will mature since there are currently no published growth and yield studies that focus on this reforestation regime. Finally, the intercropped oak-cottonwood regime requires more intensive site preparation (one to establish the cottonwood, and then another to release the oak understory) after the cottonwood is harvested.

### Computing the Present Value of Returns from Soybean Agriculture

As was noted in equation (1), a cost of reforestation is the net present value (NPV) of the foregone returns to continued soybean production on each of the soil types. The soybean agriculture component of the net returns equation in (1) incorporates the annual costs and revenues of soybean production in the Delta.

The annual net returns to soybean production (ANRsb) on an acre of land equal the difference

between the revenues and costs of soybean production in a given year,  $t$ .

$$(3) \text{ ANRsb}_t = \text{Annual Revenues}_t - \text{Annual Costs}_t$$

Annual revenues are determined by the farm price of soybeans ( $Pb_t$ ) times annual soybean yields ( $Yld_t$ ).

$$(4) \text{ Annual Revenues}_t = Pb_t * Yld_t$$

The costs of production ( $Cost_t$ ) include such items as fuel, machinery, and herbicide expenses. The federal crop insurance program also is a factor in determining annual costs of production. The net cost of crop insurance is determined by considering premiums ( $Prem_t$ ) and expected indemnities ( $Indem_t$ ).

$$(5) \text{ Annual Costs}_t = Indem_t - Cost_t - Prem_t$$

Therefore, the annual net return to soybean production is computed as

$$(6) \text{ ANRsb}_t = (Pb_t * Yld_t) + Indem_t - Cost_t - Prem_t$$

The projected soybean prices in (6) are expected to apply throughout the region. Otherwise, all the determinants of annual returns to soybean production in (6) are site specific. These site specific determinants are affected by particular physical characteristics of a site which may differ from location to location, including (1) the geographic location of the site within the Delta, (2) the productive potential of the soil, and (3) the frequency, timing, and duration of any flooding or soil saturation to which the site is vulnerable.

It is not practical to account for the effects of such site characteristics on the determinants of net returns for every landowner. In lieu of such detail, a "representative" Base Case situation is developed using a combination of site characteristics that might reasonably be found anywhere in the Delta region on an acre of this frequently flooded agricultural land. Sensitivity of the overall study results to variations in site conditions and geographic location (counties) is considered after the Base Case is developed.

<sup>16</sup> The reported net present values of reforestation include the cost share payments. At current cost share payment assumptions, sweetgum and sycamore would not be profitable without the subsidy.

## Soybean Prices

The price per bushel of soybeans is based on a ten-year baseline projection of the annual farm price of soybeans prepared by the Food and Agricultural Policy Research Institute (see Table II-12) (FAPRI, 1996). The projected farm prices are adjusted for inflation, putting prices in 1996 dollar terms. These prices represent the price the farmer receives after accounting for quality discounts and premiums.<sup>17</sup>

**Table II-12. Soybean Prices (1996 Dollars)**

<i>Year</i>	<i>Projected Soybean Price Per Bushel</i>
1996	6.59
1997	6.36
1998	6.00
1999	5.37
2000	5.10
2001	4.95
2002	4.95
2003	4.98
2004	4.99
2005-2056	5.03

## Soybean Yields

Expected soybean yields depend upon two site characteristics: 1) the inherent productive potential of the land, and 2) the expected incidence of flooding and/or soil saturation at a site. The inherent productivity is determined by soil quality and susceptibility to drought. Inherent productivity is measured by the number of bushels per acre that potentially could be produced under “ideal” growing conditions (i.e., in the absence of problems caused by flooding or excessive soil wetness).<sup>18</sup>

Interviews with agronomists and county and state extension agents indicate that county average yields range between 25 - 35 bushels per acre on all ten of the

<sup>17</sup> The projected soybean prices are adjusted for inflation using January 1996 WEFA (Wharton Econometric Forecasting Associates) forecasts of the GNP implicit price deflator and are expressed in terms of 1996 dollars (WEFA, January 1996 forecasts).

<sup>18</sup> Other environmental limitations, such as drought, are considered part of the soils’ inherent productive potential and are captured in the estimate of yield under “ideal” conditions. “Ideal” conditions refer to years when flooding or soil wetness does not interfere with cultivation of soybeans.

soil types considered marginal in this study (Section I). However, these averages include the deleterious effects of flooding on soybean production. For years in which flooding or soil wetness do not interfere with soil cultivation, these soils can produce approximately 10 bushels more per acre than the reported average values indicate (Bouquet 1996). The “best possible” yield estimate of 35 bu/ac used in the simulation was determined by adding 10 bushels to the lower bound of the range of reported county average yields.

Because the range of variation in yield estimates across all ten soil types was small, (10 bu/ac), a single “best possible” yield estimate was selected to represent all soils. It was deemed that the extent of the variation in soybean returns between soil types due to differences in the yield estimate, was not large enough to warrant the calculation of soybean returns by soil type. Selecting a single, approximate value for the “best possible” soybean, minimizes the number of permutations of soybean and forestry returns to be compared. The sensitivity of the model results to this decision is tested in the subsequent section, “Sensitivity of Calculated NPV<sub>Ref</sub> to Site Characteristics.”

The soybean plant is photosensitive, which means it relies on the length of day to initiate flowering. At less than 14-1/2 hours of sunlight a day, flowering is triggered (Bouquet 1996). Therefore, the optimal planting period for soybeans in a region is determined by whether or not a sufficient number of days remains after planting for the soybeans to fully mature before the days grow shorter than 14-1/2 hours. Therefore, expected soybean yields are affected when flooding or soil saturation delays planting or destroys an original planting, requiring replanting late in the season. Seeding after the optimal planting period exposes the soybean plants to shorter days before they are fully matured, resulting in early flowering, short plants and, consequently, reduced yields that are less than the “best possible” yield. Additionally, late planted soybeans tend to have limited root systems and are vulnerable to drought. For the Delta region, the approximate end of the optimal planting period is June 15th.

Delta agronomists and soybean experts suggest two, approximately equivalent, rules of thumb for calculating the decrease in yield due to late planting:

- a 1/2 to 1 bushel decline in yields for each day after the optimal planting period the crop is planted, or
- a 2 percent reduction in soybean yields for every day late the crop is planted.

In the simulation of net returns from soybean agriculture, soybean yields are expected to decline from the “best possible” estimate by 2 percent for every day late the crop is planted after June 15<sup>th</sup>.

To represent the yield effects of flooding, different flooding scenarios are defined for the simulation. For any flooding scenario that results in the crop being planted or replanted late, the number of days the crop is planted or replanted late is specified. The yield determinant is then adjusted by reducing the optimal yield by 2 percent times the number of days late specified for the particular flooding scenario. Flooding scenarios will be described in the subsequent “Frequency of Flooding” section.

#### Production Practices and Costs

Over time, production practices have been developed to cope with several specific problems of soybean production on clay soils, including:

- **Late Planting** - As noted, alluvial clay soils are prone to flooding and / or wetness during the springtime. Therefore, timely planting of the crop is often difficult.
- **Drought Vulnerability** - Clay soils are prone to excessive drying during mid to late summer.
- **Suitable Seedbed Preparation** - Wet clay soils tend to break up into large clods that require additional rainfall to smooth out and create a suitable medium for planting. Additionally, if the soil was wet during the previous year's harvest, the harvest machinery creates ruts in the soil requiring additional work to smooth and level the land in preparation for seeding.
- **Weed Control** - The problem of weed competition is not unique to clay soils. With a mild winter, long growing season and periods of high soil moisture, the entire delta region supports an extensive number of weed species, including non-native tropical varieties (Sanders 1996).

To address these problems on clay soils, soybean farmers have moved away from conventional techniques involving the use of a chisel or moldboard

plow along with disking to tear up and turn under stubble remaining from a previous crop and to control weeds. Instead, “low-till” practices are used. The low-till field operations minimize the amount of soil disturbance necessary for preparing a smooth seedbed. By minimizing disturbance of the soil surface, low-till practices prevent soil clodding and help retain moisture during periods of drought. The low-till technique also minimizes the number of trips made across the field with ground breaking and cultivating equipment. This means that, for years in which flooding has prevented timely planting, by using low-till practices, farmers can reduce the amount of time required for seedbed preparation prior to planting the crop. Weed control is accomplished through the use of strong “burndown” herbicides (Morrison 1996).

A variation of the low-till technique is the “stale-seedbed.” In this technique, a field is tilled and smoothed immediately following the fall harvest instead of in the springtime. The tilled field stays fallow and is smoothed by the wind and rain during the course of the winter. Then, when the field is accessible for planting the following spring, the seeds can be planted immediately or, if necessary, following an application of herbicide to control any early weed growth (Morrison 1996).

A third option is the use of “no-till” practices. No-till completely eliminates soil cultivation, instead using burndown herbicides for weed control and special equipment, a “no-till” planter”, to plant the seed with minimal soil disturbance. The no-till technique is used more frequently for purposes of erosion control on moderately to well drained soils. Under the right conditions, however, a farmer may choose to use no-till on his clay soils. If, for example, flooding has lasted late into the growing season and has prevented the establishment of an extensive weed cover and the field is sufficiently smoothed, the farmer might use no-till, eliminating tillage costs and minimizing the amount of time required to get the seed in the ground (Morrison 1996).

Agronomists and extension agents interviewed for this study indicated that farmers modify their field practices from year to year according to the flooding conditions they encounter in a given year. On the same field over time, a farmer may move along the spectrum of planting techniques from pure no-till for years in which late flooding prevents the emergence of weeds, to years of relatively short lasting flooding

requiring low-till practices involving several passes over the field with a disk harrow to control weeds and to smooth the seedbed.

For the simulation, production costs reflect low-till practices. The costs are based on information provided through interviews with agronomists and extension agents from Mississippi, Arkansas, and Louisiana and crop budgets for each of the three states showing low-till field operations and production costs for soybean cultivation on clay and loam soils. Although the amount of tillage used and the types of herbicides applied varied slightly from state to state, total per acre production costs were nearly identical.

The production costs used for the simulation reflect only cash outlays made by the farmer in each year for production inputs including herbicides, fuel, seed, and repair and maintenance costs. Additionally, depreciation on machinery is included as a cost that is incurred by the farmer every year, regardless of whether or not a crop is successfully planted. Charges to land ownership, interest on operating capital and landowner labor are not annual cash outlays and thus are not included in the budget. Finally, the management and overhead costs associated with running a farming operation are excluded from the estimate of annual production costs. Thus, consistent with the forestry calculation, net returns are the payment to management, land ownership, equity, and overhead.

For any year in which flooding or excessive soil wetness does not interfere with soybean cultivation, the annual production costs for the simulation equal \$108.04 per acre and include the field operations shown in Table II-14.

Production costs will differ from this total of \$108.04 under two situations that may arise due to flooding or soil wetness. First, for any year in which flooding prevents planting altogether, the farmer only incurs the fixed costs of machinery depreciation, \$30.98 per acre.

Second, for any year in which the farmer must replant the crop due to flooding, annual production costs will be higher in the amount of the costs of replanting. Each time the crop is replanted, the producer incurs an additional \$21.06 in replanting expenses, equaling the costs of an additional two

passes over the field with a disk harrow (\$6.84) and reseeding (\$14.22).

The per acre property tax is not included in the production cost estimate shown above. Property tax payments are based on USDA, Economic Research Service, Agricultural Real Estate Tax Survey Data Average Tax per acre in of agricultural land levied in 1994, adjusted for inflation and expressed in 1996 dollars. For purposes of the simulation model, an average across the three states is used (\$2.64 per acre). Property taxes, like the price of soybeans, are assumed to be the same from site to site (Table II-13).

**Table II-13. Agricultural Property Taxes**

<i>State</i>	<i>1994 Average Per Acre Property Tax for Agricultural Land in 1996 Dollars</i>
Arkansas	2.96
Louisiana	2.57
Mississippi	2.39

Crop Insurance Indemnities

Soybean production on flood prone soils can be adversely affected by flooding regimes. The Federal Crop Insurance Corporation (FCIC) offers insurance policies to soybean producers to help mitigate the financial risk. By purchasing multiple-peril crop insurance coverage for a unit of land, the farmer obtains a guarantee of compensation (indemnification). The amount of compensation depends upon the amount by which his harvested yield falls short of a yield guarantee level (ygl).

The ygl is established at the time the farmer acquires the policy. The ygl is expressed as a percentage of the actual production history (APH) on the insured unit of land.

A land unit's actual production history is calculated as the simple average of the yields harvested over the past four to ten years, when at least four years' worth of production records exist (CFSA 1996). For this simulation, it is assumed that sufficient production records exist for the land such that the APH used in calculating premiums and indemnities is the simple average of the annual yields.

**Table II-14. Soybean Production Costs**

<i>Field Operation</i>	<i>Total Costs/Acre</i>
<u>Disk Field Twice</u> Fuel @ \$0.95, Repair and Maintenance @ \$1.84 and Machinery Cost @ \$4.05	\$ 6.84
<u>Field Cultivate Once and Incorporate Herbicides</u> Fuel @ \$0.38, Repair and Maintenance @\$0.80, Machinery Cost @ \$ 2.00, Treflan E.C. (2 pt. @ \$3.81 / pt.) = \$7.62, Scepter 70 DG (2.86 oz. @ \$6.01 / oz.) = \$17.19	\$ 27.99
<u>Final Field Cultivate</u> Fuel @ \$0.36, Repair and Maintenance @ \$0.70, Machinery Costs \$1.72	\$ 2.78
<u>Plant Seeds (50 lb / acre)</u> Fuel @ \$0.75, Repair and Maintenance @\$1.40, Machinery Costs @ \$3.43, Seed \$8.64 (50 lb @ \$0.173/lb)	\$ 14.22
<u>Broadcast Spray Application of Herbicide</u> Fuel @ \$0.32, Repair and Maintenance @ \$0.33 Machinery Costs @ \$0.76, Storm (1.5 pt. @ \$8.56 / pt.) = \$12.84, Surfactant (.5 pt. @ \$0.91 / pt) = \$0.46	\$ 14.71
<u>Spot Spray Application of Herbicide</u> Fuel @ \$0.32, Repair and Maintenance @ \$0.32, Machinery Costs @ \$0.75, Fusilade Dx (1.2 oz @ \$0.87/oz) = \$1.04, Crop Oil (.2 pt. @ \$0.81/pt) = \$0.16	\$ 2.59
<u>Field Cultivate Once</u> Fuel @\$0.36, Repair and Maintenance @ \$0.70, Machinery Costs @ \$1.72	\$ 2.78
<u>Application of Insecticide by Air</u> Air Application @ \$1.25, Larvin 3.2 (9 oz. @ \$0.39/oz) = \$3.51	\$ 4.76
<u>Combine and Haul</u> Fuel @ \$0.50, Repair and Maintenance @ \$9.42, Machinery Cost @ \$16.55, Hauling @ \$4.90	\$ 31.37
<b>Total Cost of Production per acre</b>	<b>\$108.04</b>

Indemnities are calculated as follows. If the actual yield in a given year falls short of the yield guarantee level, the farmer receives a payment calculated as the difference between the yield guarantee level and the actual harvested yield times the “price election” (pe). The pe is a percentage of the FCIC established market price specified by the farmer at the time the crop insurance policy is purchased (CFSA 1996). The FCIC established market price for all Delta counties is \$5.80 per bushel for the 1996 crop year (FCI-35 1996).

An example can illustrate the indemnification calculation. A farmer establishes an actual production history (APH) of 35 bushels of soybeans per acre. The farmer then selects a crop insurance policy that has a 50 percent yield guarantee level (ygl) with a price election (pe) of 60 percent of the FCIC established market price. In this case, the ygl of 50 percent on 35 bushels per acre equals 17.5 bushels per acre. Now suppose that harvested yield is 12 bushel per acre, or

5.5 bushels short of the ygl. The farmer is compensated for the 5.5 bushels shortfall at 60 percent of the \$5.80 per bu. established market price (\$3.48 per bu). The indemnity per acre would equal 5.5 bu. \* \$3.48 = \$19.14.

Because inherent soil productivity and flooding vulnerability affect annual yields, they also affect crop insurance indemnities. However, flooding or soil saturation also affects the timing of planting. Thus provisions in the crop insurance program address circumstances where the purchaser has a less than optimal planting schedule. At the time the crop insurance policy is acquired, a final planting date is specified, establishing the end to the “official” planting period. For all Delta counties considered in this study, the end of the official planting period is June 15th (FCI-35 1996). The yield guarantee level is reduced by a certain percentage for every day between the end of the official planting period and the day the

crop is actually planted. If the final planting falls anywhere from one to ten days after the end of the official planting period, the yield guarantee is reduced 1 percent for every day late. From 11 to 25 days after the official planting period, the yield guarantee is reduced 10 percent for the first 10 days (1 percent per day) and then 2 percent for every additional day late. If a planting is delayed for more than 25 days past the end of the official planting period, it is considered to be a “prevented planting.” At this point, since there is no actual harvest, the farmer receives a “prevented planting payment” based on a computation using 50 percent of the original yield guarantee<sup>19</sup> (CFSA 1996).

Both the direct and secondary affects of soil quality and vulnerability to flooding, (through the effects on yield and timing of planting) mean that crop insurance indemnification will change with changes in site characteristics. The effects of flooding on crop insurance indemnities are captured in the simulation model for the Base Case soybean field. The flooding scenarios themselves will be defined in a subsequent section on flooding frequencies. Given the flooding scenario, if the farmer plants the crop after the official planting period of June 15, an appropriate reduction is made to the original yield guarantee level. The effects of flooding on crop insurance indemnities for actual yield are captured in the simulation model by adjusting expected annual yields to account for the effects of flooding. For any flooding scenario in which the farmer is compelled to replant at least once, one replant payment is added to the total indemnity, *if* the coverage includes eligibility for a replant payment.

### Crop Insurance Premiums

Farmers have a choice of two types of multi-peril coverage, Catastrophic (CAT) or Additional (commonly called “Buy-Up”) coverage. Catastrophic coverage provides a 50 percent yield guarantee at 60 percent the FCIC established market price (the 60 percent level is expected to drop to 55 percent in 1999). Premiums for catastrophic policies are paid entirely by the government. The landowner makes a \$50 per year payment to enter the program. Buy-up policies provide higher levels of coverage. When

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<sup>19</sup> Another feature of the crop insurance program is that, depending upon coverage, the producer may receive a “replanting payment” as partial compensation for the costs of replanting a crop ruined by flooding or excess moisture. This feature was not considered in the Base Case analysis, but is evaluated in later sections of the report.

acquiring a buy-up policy, the farmer may choose to be covered at a 50 percent, 55 percent, 60 percent, 65 percent, 70 percent, or 75 percent yield guarantee and his price election can range from 50 percent to 100 percent of the established market price, depending upon the yield guarantee selected. Premiums for buy-up levels of coverage are partially subsidized by the government, so the producer pays a share of the total premium.

The FCIC program has established criteria for defining high risk lands. For these lands catastrophic coverage is available, but the premiums for buy up coverage are significant. After considering the criteria used by the FCIC for designating high risk lands, it was determined that, for the purposes of the Base Case simulation, any agricultural land limited to exclusively soybean production due to frequent flooding and / or soil saturation will be classified as “high-risk” land for crop insurance purposes. Under the current crop insurance program, producers have the option of insuring their high risk lands under a catastrophic policy, separate from the coverage they acquire for the remainder of the land in their unit (Catastrophic Risk Protection Handbook 1997). Because the premiums for a catastrophic policy are fully subsidized by the government, by opting for the high risk exclusion, producers avoid paying high premiums to obtain coverage for land that has been designated as high risk by the FCIC<sup>20</sup>. Although an administrative fee of \$50 per unit is charged for catastrophic policies, it is considered negligible when divided across the large number of acres that might be included in a single unit, and is not included as a cost in the model.

By assuming that the farmer chooses to cover his high risk land under a separate catastrophic policy, the effects of insuring a field of flood prone soils as part of a larger unit comprised of more productive soils and more complex insurance premiums setting is ignored. One possible effect of including frequently flooded lands as part of a larger unit, is that the annual yields produced on the more productive soils in the unit will offset even significant losses on the flood prone lands, making indemnification less likely than if the flood prone land had been covered under a separate policy. Offsetting this is the higher APH (“actual production history”) expected on a unit including more productive

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<sup>20</sup> Though complicated, the simulation model is capable of calculating premiums for any level of coverage selected on any lands. Such analyses are provided in a later section of the report.

lands along with the flood prone land. Because the yield guarantee is calculated as a proportion of the APH, the higher the APH, the greater the likelihood of indemnification. It is not clear which of these two effects is greater, thus the net effect of covering the high risk land as a separate unit are uncertain.

### Frequency of Flooding

The timing and duration of flooding are determined by variables such as the elevation of the land and its proximity to waterways, man-made flood control structures, the timing and intensity of precipitation over the whole basin and winter snow melt in the Upper Mississippi River. Because flooding affects soybean yields, production costs, and crop insurance premiums and indemnities, annual net returns to soybean production on the same site will vary from year to year. For example, consider soybean yield effects of flooding. Suppose that, in one year, severe flooding results in a complete crop loss. Under this “production experience,” no yield is produced and the annual value of the yield in the net returns calculation equals zero. In the next year, however, the farmer may encounter no flooding, realizing a yield of 45 bushels of soybeans per acre.

To calculate the NPV of the returns to soybean production requires consideration of the effect of flooding on yield, crop insurance indemnification and production costs over the 60-year planning horizon. This is accomplished by calculating the “expected value” of each model determinant, which is the *probability weighted average* of all the annual values for the determinant. Suppose, for example, over a ten-year period, the farmer has only the two production experiences (1) flooding that results in a complete crop loss, yielding zero yield, and (2) ideal growing conditions in which the best possible yield of 45 bu/ac is produced. In four out of ten years, the producer encounters ideal growing conditions and in the remaining six years flooding results in a complete crop loss. This producer is harvesting 45 bu. per acre four years out of ten, or 40 percent of the time and realizing zero yield six years out of ten, or 60 percent of the time. The producer's, average yield harvested over the ten-year period, or the “expected yield” will be  $45 \text{ bu/ac} * .4 + 0 \text{ bu/ac} * .6 = 18 \text{ bu/ac}$ . The 18 bushels per acre is the probability weighted average yield for the ten-year period.

By using expected values to calculate net returns, the effects of changes in the frequency, timing, and duration of flooding on the estimates of net returns to soybean production can be observed and quantified. Isolating the effects of flooding through the use of expected values will provide insight as to what types of flooding regimes produce the highest and lowest soybean returns, and hence the greatest and least opportunity cost of reforestation.

In the simulation, the net present value of the “expected” returns to soybean production is the difference between the expected revenues and expected costs of soybean production. The expected revenues and costs are comprised of the expected values of the five determinants from equation (6) and are shown in equation (7) below.

$$(7) E [ ANRsb_t ] = (Pb_t * E[Yld_t]) + E [Indem_t] - E [Cost_t] - E [Prem_t]$$

In order to use expected values, flooding scenarios possible at a site are assigned a probability of occurrence. The yield, production costs, and indemnity values produced under the scenario are multiplied by the assigned probability. Then, all annual values for each determinant are summed across all flooding scenarios to equal the expected determinant value. Using the expected determinant values, the expected net returns to soybean production in each year are calculated. These values are then discounted and summed over a 60-year period (corresponding to the reforestation calculation) to compute the NPV of the returns to soybean production.

The calculation of expected returns averages a farmer’s returns over time, but does not reflect the cash flow risks associated with the timing of occurrences of years of low productivity. Over a given period, say twenty years, the expected value calculation does not distinguish between a farmer that experiences five years of flooding induced losses in a row from a farmer who experiences five years of losses spread evenly across the twenty year period. From a purely economic perspective, both realize the same returns to soybean production. In reality, however, the financial consequences of incurring five unprofitable years in a row can be catastrophic for a farming operation. A farming operation is far more likely to survive five unprofitable years interspersed among fifteen profitable years, than it is to survive five unprofitable years in a row. Such financial constraints

are an important consideration in evaluating the feasibility of soybean production on a site and will be dealt with in greater detail in Section III.

The Representative Case: Definition and Results

The simulation model calculates the net returns to soybean production by accounting for the direct and indirect effects of three site specific characteristics on the determinants of the returns to soybean production: inherent soil productivity, geographic location (county), and flooding regime. Table II-15 summarizes these linkages.

A Base Case situation is established after making judgments about the site characteristics that are representative on an acre of frequently flooded agricultural land in the Delta. The judgment was based on information gathered during the course of interviews with agronomists, and county extension agents from all three states, as well as information

provided by an FCIC underwriter, an Army Corps of Engineers hydrologist, and the data available through state crop budgets and the Louisiana Soybean Production Handbook. Table II-16 describes the possible production experiences in the Base Case and the assigned probability of their occurrence. Using the projected annual soybean prices and the expected determinant values for yield, production costs and crop insurance premiums and indemnities, the expected annual net returns to soybean production are calculated for each of the 60 years included in the forestry returns. The expected annual net returns are then discounted and summed to equal \$304.10, the NPV of the returns to soybean production for the Base Case.

The calculated NPV of returns to soybean production under the Base Case will be used as the initial reference in computing the net returns to reforestation, inclusive of the opportunity cost of foregone soybean production. Detailed discussion of the net returns calculation is found in the next section.

**Table II-15: Soybean Model Relationships**

<i>Site Characteristic</i>	<i>Determinants Affected</i>	<i>Effects in the Simulation</i>
Inherent Soil Productivity	<ul style="list-style-type: none"> <li>• Yield</li> <li>• Crop Insurance Indemnity</li> <li>• Crop Insurance Premium</li> </ul>	Soil productivity is reflected in the “best possible” yield specified for a site. The Base Case “best possible” yield, as a measure of soil productivity on the representative acre in the Base Case, is 35 bu/ac. This yield affects APH and crop insurance indemnity. In the Base Case, catastrophic coverage is selected so premiums are not affected by yield and APH.
Geographic Location	<ul style="list-style-type: none"> <li>• Crop Insurance Premium</li> </ul>	The effects of county location are reflected in the actuarial tables used in calculating the crop insurance premiums. For the Base Case, the “geographic location” site characteristic does not factor into the net returns to soybean production because it is assumed that the producer has acquired catastrophic coverage for the representative acre under the high risk exclusion option.
Susceptibility to Flooding and Soil Saturation	<ul style="list-style-type: none"> <li>• Yield</li> <li>• Crop Insurance Indemnity</li> <li>• Crop Insurance Premium</li> <li>• Production Costs</li> </ul>	The effects of flooding are captured in two steps. First, the entire range of production experiences encountered on the site is identified. A “production experience” is defined by the effects flooding has within the model. The flooding regime for the Base Case representative acre results in six different production experiences. The frequency with which each production experience is encountered over time assigns a probability to each production experience. These six different flooding experiences are defined in Table II-16 according to the differing affects of flooding on the model determinants. Additionally, the probability of a production experience occurring in any year is specified.

**Table II-16: Base Case Production Experiences**

<i>Production Experiences</i>	<i>Probability of Occurrence</i>	<i>Description</i>	<i>Effects on Determinants</i>		
			<i>Yield</i>	<i>Indemnity</i>	<i>Costs of Production</i>
Optimal	15%	Ideal growing conditions. Flooding does not interfere with soybean cultivation.	Highest possible yield produced, i.e., the "Optimal Yield"	No indemnity received No replanting payment received	Costs of initial planting. No replanting costs incurred.
Prevented Planting	5%	Initial planting prevented altogether	Zero yield produced.	Indemnified at 50% original yield guarantee.	Only fixed costs of production incurred.
Initial Planting Late	40%	Initial planting occurs 15 days after the end of both the Optimal and Official planting periods. Crop is successfully harvested.	Yield is reduced by 30% of the "Best Possible" Yield.	Original yield guarantee is reduced. According to the number of days after the end of the Official planting period the final replanting takes place.	Costs of initial planting. No replanting costs incurred.
Replant	10%	Crop is replanted at least once before the end of the Optimal and Official planting periods. Crop is successfully harvested.	Highest possible yield produced, i.e., the "Optimal Yield"	Original yield guarantee is not reduced. Indemnified if the harvested yield falls short of the initial yield guarantee. Replant payment received if covered at a buy-up level.	Costs of initial planting plus, additional costs of replanting.
Replant Late	20%	Crop is replanted 20 days after the end of both the Optimal and Official planting periods. Crop is successfully harvested.	Yield is reduced by 40% of the "Best Possible" Yield.	Original yield guarantee is reduced. According to the number of days after the end of the Official planting period the final replanting takes place. Replant payment received if covered at a buy-up level.	Costs of initial planting plus additional costs of replanting
Lose Crop	10%	Crop is not successfully harvested.	Zero yield harvested.	Indemnified at 100% original yield guarantee.	Costs of initial planting. No replanting costs incurred.

## Computing the Net Economic Returns to Reforestation

The net present value (NPV) of the economic returns to each reforestation scenario is calculated by subtracting the NPV of the opportunity cost of soybean production in the Base Case (\$304.10 per acre) from the NPV of the returns to each forestry scenario. The difference is the NPV of reforestation ( $NPV_{Ref}$ ). When the computed returns to forestry exactly equal the computed returns to soybean production,  $NPV_{Ref}$  is zero. If a landowner only considered  $NPV_{Ref}$  in making a reforestation decision, a zero value would mean that a landowner would be indifferent between the two land uses. Any forestry scenario yielding a computed  $NPV_{Ref}$  greater than zero would be considered to be economically attractive. The next section discusses possible landowner decision criteria other than  $NPV_{Ref}$ .

### $NPV_{Ref}$ Under the Base Case

The  $NPV_{Ref}$  for every rotation and soil type combination in each of the three states is recorded in Tables II-H through II-M, at the end of Section II. After subtracting out the Base Case opportunity cost of foregone soybean production, the Nuttall oak reforestation scenario yielded positive net economic returns ( $NPV_{Ref}$ ) in all three states on Alligator, Amagon, Dundee, Mhoon, and Newellton soils. The cottonwood-oak intercrop reforestation regime produced a positive  $NPV_{Ref}$  on Dundee soils in Louisiana and Mississippi. Also in Louisiana and Mississippi, water oak produced positive net economic returns on Dundee soils. (See Tables II-17 through II-19)

The reported  $NPV_{Ref}$  can be considered in terms of annual equivalent payments. The annual equivalent payment of a  $NPV_{Ref}$  equals the uniform amount that, when received annually, discounted and summed over the 60-year period, will equal  $NPV_{Ref}$ . For example, \$7.37 received in each of the 60 years, when discounted and summed, would equal the  $NPV_{Ref}$  of \$139.44 for a cottonwood-oak plantation on Dundee soils in Mississippi. The annual equivalent values are listed in separate tables following each table presenting the recorded  $NPV_{Refs}$ .<sup>21</sup>

<sup>21</sup> The internal rate of return calculation (IRR) provides another criteria for evaluating the profitability of reforestation, when economic returns are the only consideration in the decision to reforest. The IRR for a reforestation strategy is the discount rate at which the

**Table II-17: Positive  $NPV_{Ref}$  Mississippi**  
(annual equivalent values shown in parentheses)

<i>Net Economic Returns</i>	<i>Reforestation Scenario</i>
\$139.44 (\$7.37)	Cottonwood - Oak intercrop on Dundee soils
\$146.50 (\$7.74)	Nuttall oak on Amagon and Dundee soils
\$43.04 (\$2.27)	Cottonwood on Dundee soils
\$96.35 (\$5.09)	Nuttall oak on Alligator, Mhoon and Newellton soils
\$46.21 (\$2.44)	Water Oak on Dundee Soils

**Table II-18: Positive  $NPV_{Ref}$  Louisiana**  
(annual equivalent values shown in parentheses)

<i>Net Economic Returns</i>	<i>Reforestation Scenario</i>
\$94.86 (\$5.01)	Cottonwood - Oak intercrop on Dundee soils
\$110.26 (\$5.82)	Nuttall oak on Amagon and Dundee soils
\$61.02 (\$3.22)	Nuttall oak on Alligator, Mhoon and Newellton soils
\$11.79 (\$0.62)	Water Oak on Dundee Soils

**Table II-19: Positive  $NPV_{Ref}$  Arkansas**  
(annual equivalent values shown in parentheses)

<i>Net Economic Returns</i>	<i>Reforestation Scenario</i>
\$76.24 (\$4.03)	Nuttall oak on Amagon and Dundee soils
\$25.59 (\$1.35)	Nuttall oak on Alligator, Mhoon and Newellton soils

A  $NPV_{Ref}$  less than zero identifies a reforestation scenario where the returns to continued soybean production are greater than the returns to reforestation.

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present value of the net returns equals zero ( $NPV_{Ref} = \text{zero}$ ) (that is, the NPV of the returns to the project exactly equal the NPV of the costs). This rate is considered to be the rate of return to the investment in reforestation and can be compared against current interest rates to determine whether or not the rate of return on the reforestation strategy exceeds the costs of the capital invested. An IRR greater than the current cost of capital is considered to be indicative of a profitable investment. IRR calculations are reported for every reforestation scenario in Tables II-Z through II-AA at the end of section II.

A negative NPV<sub>Ref</sub> can be interpreted as the present value of a cash amount of additional income that would be required to bridge the gap between computed returns in reforestation and agriculture. Thus, the smallest negative NPV<sub>Ref</sub> identify the reforestation scenarios that would require the least amount of supplemental income to make them economically attractive enterprises. In Tables II-20 - II-22 the three, *least negative*, computed NPV<sub>Ref</sub> are reported for each state. The negative value is the one time cash payment in year one needed to make NPV<sub>Ref</sub> equal zero. The figure in parentheses is the annual constant payment that would make NPV<sub>Ref</sub> equal zero.

### Sensitivity of Calculated NPV<sub>Ref</sub> to Site Characteristics

The net returns to both reforestation and soybean production are affected by specific site characteristics. This means the reported NPV<sub>Ref</sub> will differ with changes in the assumptions made about the site characteristics of the representative acre. In the following section, the sensitivity of the simulation model results to changes in the specified site characteristics is examined.

A sensitivity analysis of the simulated agricultural returns was performed to test the effects of changes in: 1) the specified “best possible yield,” and 2) in the probability set assigned to the flooding scenarios defined in the Base Case.

The simulation model was rerun under five different probability sets, each reflecting different assumptions about the frequency and timing of flooding on the representative acre. The five probability sets tested (Variations I-V) are described in Table II-24. Table II- 23 reports the changes made to the Base Case probability set under each variation. The effects of varying the Base Case best possible yield estimate were tested under each probability set variation by running the model using three different best possible yield estimates: 35 bu/ac (the best possible yield under the Base Case), 30 bu/ac, and 40 bu/ac. The NPV of agricultural returns under the 15 possible combinations of the 5 different probability sets and 3 different best possible yields are reported in Table II-25. The results reported in Table II-25 suggest two important qualifications to the conclusions drawn about the computed NPV<sub>Ref</sub>.

(1) The agricultural returns under the Base Case are sensitive to changes in the specified “best possible” yield. A decline in the Base Case “best possible” yield of 5 bu/ac (from 35 to 30 bu/ac), resulted in a \$349.58 decline in computed returns to soybean production, holding all else constant. (Compare combination 7 (\$304.10) with combination 2 (-\$45.48).) This result occurs because, holding all else constant, the 5 bushel decline in the optimal yield resulted in a decrease in expected yield from the base value of 23.76 bu/ac to 20.37 bu/ac. Additionally, expected indemnities fall from \$5.17/ac to \$4.43/ac.

Because no changes were made to the probabilities assigned to the flooding scenarios, the changes observed in the expected determinant values are entirely attributable to the variation in the productive potential of the site, as is measured by the “best

**Table II-20: Least Negative NPV<sub>Ref</sub> Mississippi**

<i>Net Economic Returns</i>	<i>Reforestation Scenario</i>
- \$45.46 (- \$ 2.40)	Sycamore on Amagon and Dundee soils and Sweet Gum on Amagon, Dundee and Newellton soils
- \$141.30 (-\$7.46)	Cottonwood-Oak Intercrop on Sharkey soils
-\$ 164.94 (-\$8.71)	Cottonwood-Oak Intercrop on Tunica soils

**Table II-21: Least Negative NPV<sub>Ref</sub> Louisiana**

<i>Net Economic Returns</i>	<i>Reforestation Scenario</i>
-\$ 19.75 (-\$1.04)	Cottonwood on Dundee soils
-\$131.21 (-\$6.93)	Nuttall Oak on Tensas soils
-\$159.02 (-\$8.40)	Sycamore on Amagon and Dundee soils and Sweet Gum on Amagon, Newellton and Dundee soils
-\$162.49 (-\$8.58)	Nuttall Oak on Bowdre, Forestdale, Sharkey and Tunica soils and Water Oak on Amagon soils
-\$176.00 (-\$9.30)	Cottonwood-Oak Intercrop on Sharkey soils

**Table II-22: Least Negative NPV<sub>Ref</sub> Arkansas**

<i>Net Economic Returns</i>	<i>Reforestation Scenario</i>
-\$25.06 (-\$1.32)	Water Oak on Dundee soils
-\$32.84 (-\$ 1.73)	Cottonwood-Oak on Dundee soils
-\$173.11 (-\$9.15)	Nuttall Oak on Tensas soils

possible” yield assigned. This means that, if a site's productive potential under ideal conditions is 5 bu/ac less than the 35 bu/ac assumed under the Base Case, the least negative NPV<sub>Ref</sub> in each state (see Tables II-20 through II-22) would all become positive, favoring reforestation. Conversely, a 5 bu/ac increase over the Base Case ideal conditions yield would radically diminish the computed NPV<sub>Ref</sub>.

(2) The expected returns to soybean production are sensitive to both the frequency and timing of flooding. Variations II - V represent four realistic variations of the flooding probabilities represented in the Base Case (See Tables II-23 and II-24). In order to isolate the effects of varying the assigned probability set at each best possible yield level, the results of the sensitivity analyses reported in Table II-25 are broken down by best possible yield in Tables II-26 , II-27, and II-28.

At each of the three Best Possible Yield (BPY) levels, the changes in probabilities that occur under each variation result in significant changes to the Base Case agricultural returns, and hence the NPV<sub>Ref</sub>. At each Best Possible Yield level, Variation IV, representing a higher probability of long lasting backwater flooding, generates agricultural returns lower than those generated under the Base Case (and hence a higher NPV<sub>Ref</sub> for all reforestation scenarios).

For example, at 35 bu/ac, the change from Variation I to Variation IV results in a \$94.22 decline in agricultural returns from \$304.10 to \$209.88. In Mississippi, this \$94.22 decline in agricultural returns would be enough to bridge the gap between forestry and agricultural returns for sycamore on Amagon and Dundee soils and for sweet gum on Amagon, Dundee, and Newellton soils. The \$94.22 would bridge the gap for water oak on Dundee soils in Arkansas and for cottonwood on Dundee in Louisiana.

Conversely, agricultural returns are higher under Variations V, II and III than they are under the Base

Case probability set. Because the flooding conditions represented under these three Variations are more conducive to soybean production than are the Base Case conditions, the opportunity costs of reforestation are greater. At a Best Possible Yield of 35 bu/ac, agricultural returns are \$79.86 greater under Variation V, \$141.34 greater under Variation II, and \$239.61 greater under Variation III than they are under the Base Case Variation I. Increases in agricultural returns of these magnitudes would result in negative NPV<sub>Ref</sub> for many reforestation scenarios that produced positive economic returns under the Base Case.

Two points should be remembered when considering the sensitivity analysis results. For the Base Case, it is assumed that the farmer acquired only catastrophic coverage. This means the effects of the crop insurance buy-up option are not represented in the sensitivity analysis. The effects of buy-up crop insurance coverage on the net returns to soybean production will be examined more closely in the upcoming “Crop Insurance Policy” section. Additionally, the sensitivity of the Base Case net returns to changes in the specific scenario definitions were not reported. For example, a change in the definition of a “Late Planting” from a planting that occurs fifteen days after the Optimal planting period, as is assumed under the Base Case simulation, to one that occurs only five days late, increases the NPV of the Base Case returns to \$542.48 (from \$304.10).

Sensitivity of Calculated NPV<sub>Ref</sub> to Model Assumptions

The calculated NPV<sub>Ref</sub> is sensitive to several assumptions underlying the Base Case simulation concerning sawtimber quality, forestry, and agricultural price projections, the use of herbicides in silvicultural regimes, whether the landowner farms or rents the land and the amount of land considered for

**Table II-23: Variations in Probability Assignments for Variations I-V \***

<i>Probability Sets</i>	<i>Probability of an Optimal Year</i>	<i>Probability of Planting Late</i>	<i>Probability of Replanting</i>	<i>Probability of Replanting Late</i>
Variation I (Base Case)	15%	40%	10%	20%
Variation II	30%	25%	10%	20%
Variation III	30%	40%	10%	5%
Variation IV	5%	50%	10%	20%
Variation V	5%	40%	30%	10%

\* Because the probabilities of the “Lose Crop” and the “Prevented Planting” annual production experiences remain the same in all Variations, they are not reported in this table.

**Table II-24: Probability Set Variations Defined**

<i>Probability Set Combination</i>	<i>Description</i>
Variation I (Base Case)	Refers to the production experiences and flooding probabilities represented in the Base Case scenario. All subsequent variations are variations of the Base Case.
Variation II	Variation II represents the production experiences on a site that is less prone to backwater flooding. This means that, under Variation II, there is a higher probability of encountering an optimal year (30 percent) than there is under the Base Case (15 percent) and a lower probability of backwater flooding that results in a late planted crop (25 percent under Variation II vs. 40 percent under the Base Case).
Variation III	Relative to the Base Case, Variation III represents production on a site less prone to mid- and late summer flash flooding that compels the farmer to replant late in the growing season.
Variation IV	Variation IV represents production on a site that is more prone to backwater flooding than is the site represented in the Base Case. Under Variation IV, backwater flooding results in a late planting 50 percent of the time, compared to a 40 percent probability of a late planting under the Base Case. The probability of an optimal year falls from 15 percent under the Base Case to only 5 percent under Variation IV.
Variation V	The production experiences represented under Variation V differ in two ways from the Base Case production experiences. Variation V represents a site that is more prone to flash flooding early in the growing season than is the site represented by the Base Case. As a result, under Variation V there is a higher probability that the farmer will be compelled to replant the crop before the end of the Official and Optimal Planting period than is found under the Base Case. Because flooding is more likely to occur early in the growing season under Variation V, there is a lower probability of a late replanting (i.e., one that occurs after June 15) under Variation V, than there is under the Base Case.

**Table II-25: Results of Sensitivity Analyses for Agricultural Returns**

<i>Probability Set Variation</i>	<i>Best Possible Yield (bu/ac)</i>	<i>NPV of Agricultural Returns in Ascending Order</i>	<i>Agricultural Returns in Annual Equivalent Values</i>
1. Variation IV	30	-126.24	-6.67
2. Variation I	30	-45.48	-2.40
3. Variation V	30	17.27	0.91
4. Variation II	30	75.67	4.00
5. Variation III	30	168.46	8.90
6. Variation IV	35	209.88	11.09
7. Variation I (Base Case)	35	304.10	16.07
8. Variation V	35	383.96	20.28
9. Variation II	35	445.44	23.53
10. Variation III	35	543.71	28.72
11. Variation IV	40	545.99	28.84
12. Variation I	40	653.68	34.53
13. Variation V	40	750.65	39.66
14. Variation II	40	815.21	43.07
15. Variation III	40	918.96	48.55

**Table II- 26. Probability Set Variations at a Best Possible Yield of 30**

<i>Probability Set Variation</i>	<i>Best Possible Yield (bu/ac)</i>	<i>NPV of Agricultural Returns in Ascending Order</i>	<i>Difference From Variation I (the Base Case Probability Set)</i>
1. Variation IV	30	- 126.24	- 80.76
2. Variation I	30	- 45.48	0.00
3. Variation V	30	17.27	62.75
4. Variation II	30	75.67	121.15
5. Variation III	30	168.46	213.94

**Table II-27. Probability Set Variations at a Best Possible Yield of 35**

<i>Probability Set Variation</i>	<i>Best Possible Yield (bu/ac)</i>	<i>NPV of Agricultural Returns in Ascending Order</i>	<i>Difference From Variation I (the Base Case Probability Set)</i>
6. Variation IV	35	209.88	-94.22
7. Variation I	35	304.10	0.00
8. Variation V	35	383.96	79.86
9. Variation II	35	445.44	141.34
10. Variation III	35	543.71	239.61

**Table II-28. Probability Set Variations at a Best Possible Yield of 40**

<i>Probability Set Variation</i>	<i>Best Possible Yield (bu/ac)</i>	<i>NPV of Agricultural Returns in Ascending Order</i>	<i>Difference From Variation I (the Base Case Probability Set)</i>
11. Variation IV	40	545.99	-107.69
12. Variation I	40	653.68	0.00
13. Variation V	40	750.65	96.97
14. Variation II	40	815.21	161.53
15. Variation III	40	918.96	265.28

reforestation in total and as a proportion of the total farm acreage. The sensitivity of the model to these underlying assumptions was tested by examining changes in the Base Case NPV<sub>Ref</sub> for Nuttall oak on Dundee soils in Mississippi (\$146.50) under differing assumptions. Table II-29 presents a summary of the modifications made to the model assumptions underlying the Base Case and the resulting NPV<sub>Ref</sub> and annual equivalent value produced for Nuttall oak on Dundee in Mississippi.

#### *Product Quality*

It is well known that higher quality sites can produce trees of superior form. The prices presented in the Base Case assume an average quality and may underestimate the actual price a landowner selling high quality wood can receive. This is particularly true for plantations grown on soils such as Amagon and Dundee.

To investigate the impact of increased wood quality on the reforestation decision, a sensitivity analysis for sawtimber price was performed by recalculating the NPV<sub>Ref</sub> for all reforestation scenarios in each state after increasing the Base Case sawtimber prices by 20 percent. The new NPV<sub>Ref</sub> are reported in Table II-N through Table II- S at the end of Section II.

As expected, the increase in sawtimber prices only increases the profitability of the oak and non-cottonwood regimes where sawtimber is produced.<sup>22</sup> Comparing the results of the sensitivity analyses to the Base Case NPV<sub>Ref</sub> (found in Table II-N through Table II- S), a 20 percent increase in the sawtimber prices is roughly equivalent to an average increase in net present values of \$92 per acre on high quality sites, where the percentage of sawtimber produced relative

<sup>22</sup> Pulpwood product classes are not generally dependent on wood quality since harvested trees are chipped on the site or at the mill.

**Table II- 29 Summary of Modifications to Model Assumptions and Results of Sensitivity Analyses**

<i>Modifications to Model Assumptions</i>	<i>NPV<sub>Ref</sub> for Nuttall oak on Dundee in Mississippi</i>	<i>Annual Equivalent Value</i>
Base Case (no modifications made)	\$146.50	\$7.74
Product Quality: Sawtimber prices used in Base Case are increased by 20 percent	\$265.41	\$14.02
Forest Prices: Projected future sawtimber prices are reduced by 31 percent (i.e., current prices are used)	\$5.81	\$0.31
Soybean Prices: Projected future soybean prices in years 1 - 10 are reduced to \$5.03/bu. Soybean prices in years 11 - 60 remain the same at \$5.03/bu	\$233.92	\$12.36
Herbicide Costs: Herbicide costs of \$64.39 are eliminated for all regimes utilizing herbicides prior to planting.	\$207.82	\$11.14
Landowner Type: \$9.05 of labor costs are added to the annual costs of planting and \$3.45 of labor costs are added to the annual replanting costs.	\$328.84	\$17.37
Amount of Flood Prone Land: An estimated \$58.12 in overhead costs is added to the annual production costs	\$1,246.67	\$65.86

to pulpwood is high, and an average increase of \$32 per acre for poorer quality sites that produce a larger percentage of pulpwood. These changes are less dramatic than those that would occur if the landowners were given increased relief for costs incurred early in the rotation.

The sensitivity analyses of sawtimber prices produced an increase in the Nuttall oak NPV<sub>Ref</sub> on Dundee soils of \$118.91.

*Forestry Prices*

U.S. Forest Service price projections are used in calculating the Base Case net present values of forest returns. In the Base Case, it is assumed that real prices for sawtimber will increase 31 percent over the next 60 years, while pulpwood prices will remain constant. A problem with these forecasts is that they do not incorporate possible future changes in the agricultural sector under the 1996 Farm Bill revision. Under the 1996 Farm Bill, AMTA (Agricultural Market Transition Act) payments replace former price and income support payments. AMTA payments are based

on land’s production history not on the farmer’s current production decisions. The intent of these decoupled payments is to ensure that farmers make their production decisions based on market signals, without the distortion of government transfer payments. It is possible that market forces will prompt the conversion of agricultural lands to forest production on a large enough scale to increase long run timber supplies. In this case, the real price of sawtimber represented in the Base Case may not be realistic.

To examine the possible scenario of increased sawtimber production in the forest sector, a sensitivity analysis was performed on long run prices by assuming they are equivalent to the 1996 prices reported in Table II-11. The results of this analysis are presented in Tables II-T - II-Y.

On average, if current prices prevail in the future, the NPV of forestry returns for all non-cottonwood scenarios on higher quality soils declines by \$109. The impact of using current prices is more critical for the better soils where the proportion of sawtimber

produced to pulpwood is highest. For poorer sites, the decrease in net present values is less; on average, \$38 for non-cottonwood scenarios. Note that use of current prices does not effect the NPV of forestry returns for the pure cottonwood stands since only pulpwood production is assumed from these reforestation regimes.

Although net present values still remain positive for most species under current prices, the more important impact of removing the higher price assumption is the effect on the net economic returns to reforestation ( $NPV_{Ref}$ ). Under current prices, with a few exceptions, agricultural production is always more profitable than forestry production, even for Nuttall oak grown on the best soils. For Nuttall oak in Arkansas, the gap between agricultural and forest returns is approximately \$60-105 per acre for the best soil types (Dundee, Amagon, Alligator), and roughly \$260 per acre for the poorer Forestdale, Sharkey, and Tensas soils. The non-cottonwood reforestation regime that comes closest to the agricultural returns under current prices is the Nuttall oak regime on Dundee soil. The results for Mississippi are most in favor of forest production. There, under current prices, the gap between forestry and agricultural production is \$32 per acre for Nuttall oak on the better soils, and \$206 on average for the poorer sites. Mississippi and Louisiana are the only states where reforestation would be more profitable than soybean production. In both Louisiana and Mississippi, the mixed cottonwood-oak regimes on Dundee soils yield positive economic returns. Additionally, in Mississippi, Nuttall oak produces positive economic returns on Amagon and Dundee soils.

The gap between agricultural production and forestry production on an annual basis is also affected. Now annual cash payments to forestry would need to average over \$10 per acre per year for forestry to be more profitable than soybean production on a range of soils. However, under higher prices, these annual payment requirements were much less (usually under \$10 per acre per year).

For the Nuttall oak  $NPV_{Ref}$  considered in Table II-29, the use of current sawtimber prices results in a \$140.69 decline from the Base Case value of \$146.50 to \$5.81.

### *Agricultural Price Projections*

Because there are many uncertainties associated with projecting soybean prices 60 years into the future, the Base Case results were re-assessed using a per bushel price of \$5.03 in all 60 years, to provided a lower bound to the returns to soybean production. Holding the price at \$5.03 per bushel, the NPV of soybean returns falls from the Base Case \$304.10 to \$216.68, causing an increase in the  $NPV_{Ref}$  for Nuttall oak on Dundee from the Base Case value of \$146.50 to \$233.92.

### *Herbicide Usage in Silvicultural Regimes*

At \$64.39 per acre, the application of herbicides prior to planting is one of the largest production expense. The practice of using herbicides differs across the Delta. If an herbicide application is not made at the beginning of a rotation, a \$64.39 savings is realized one year into the rotation.<sup>23</sup> At a 5 percent discount rate, this is a savings equivalent to \$61.32 in NPV terms. The effect of eliminating an herbicide application can be assessed for all rotations except cottonwood and cottonwood oak (see footnote) simply by adding the costs savings of \$61.32 to the NPV of forestry returns and  $NPV_{Ref}$  reported in results tables found at the end of this section.

In Mississippi, for sycamore on Amagon and Dundee soils and sweet gum on Amagon, Dundee and Newellton soils, a cost saving of \$61.32 is enough to generate a positive  $NPV_{Ref}$  of \$15.89 (up from a value of -\$45.46. Similarly, in Arkansas the  $NPV_{Ref}$  for water oak on Dundee soils would increase from a negative value of -\$25.06 to a positive value of \$36.26 if herbicide costs were eliminated. The next smallest gap between forestry and soybean returns that would be affected by the elimination of herbicide costs is Nuttall oak on Tensas soils in Louisiana. For this rotation, the cost savings of \$61.32 is enough to bring its negative  $NPV_{Ref}$  of -\$131.21 to within \$70 of zero, the point at which soybean and forestry returns are equivalent.

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<sup>23</sup> For the cottonwood and cottonwood-oak regimes, herbicide is applied in year zero. For a 60 year cottonwood-oak rotation, the savings of eliminating the herbicide costs equals the full, undiscounted value of \$64.39. Herbicides are applied three times for the cottonwood plantation during the sixty year time horizon. Therefore, for cottonwood the savings of eliminating herbicide applications is greater. The cottonwood  $NPV_{Ref}$  increases by \$97.81 with the elimination of herbicide costs over the 60 year period.

## Returns to Land Ownership

Over a 60-year period, soybean production is a more labor intensive enterprise than is reforestation. Whereas labor expenditures for reforestation are required primarily at establishment in year one and at harvest in year sixty, labor costs are incurred annually for soybean production over the same period. Under the Base Case, it is assumed that the landowner is also the farm operator. In this case, although the landowner may save approximately 1.175 hours annually of his own labor by reforesting an acre of land, his primary occupation remains farming and he has no opportunity to earn a wage for the small increment of labor time saved by reforestation of a single acre. Also, the Base Case assumes that the farmer reforests only a fraction of his land. For this reason, the value of any labor saving from reforestation is minimal because, as long as the landowner continues to farm the remainder of his land, it is highly unlikely he will be able to earn any return to the increment of labor savings he receives from reforestation.

An absentee landowner, however, receives agricultural returns in the form of rent from farmer-tenants. The market rental rate for agricultural land approximates the value of agricultural returns to the land, net *all* of the costs of production, including operator labor. If the landowner is assumed to be a landlord, the NPV<sub>Ref</sub> calculation should reflect the difference between the returns to forestry and the foregone soybean returns net the labor costs previously assumed to be owner-operator labor and excluded from the Base Case calculations. Adding in the labor costs results in an increase in the expected annual production costs of \$8.60 (from \$104.24 in the Base Case to \$112.84 after including additional labor costs). The expected annual costs of replanting increase from \$6.33 to \$7.36.

After adding the additional annual labor costs, the agricultural returns decrease from the Base Case value of \$304.10/ac to \$121.76/ac, resulting in an increase in the NPV<sub>Ref</sub> for Nuttall oak on Dundee soils in Mississippi, from the Base Case value of \$146.50 to \$328.84.

The assumptions made about landowner type also affect the amount of agricultural management and overhead costs saved on a per acre basis due to reforestation. Under the Base Case assumption of an

owner-operator, management and overhead costs were excluded from the calculation of agricultural returns. Although forestry requires significantly less expenditures for overhead and management than does agricultural production over a 60-year period, in reality, if only a proportion of a larger farming operation is reforested, the owner operator will likely incur the same management and overhead costs to maintain the remainder of the farming operation.

In order to represent the rental rate received by a landlord-landowner, management and overhead costs should be included in the estimate of production costs. The per acre costs of management and overhead, however, differ according to the total farm size and to the amount of frequently flooded land, as a proportion of total farm acreage. Most importantly, at increasingly larger total farm sizes, per acre overhead and management costs grow smaller due to economies of scale as the costs are spread across a larger number of acres. Available estimates of agricultural overhead costs equal \$58.12 per acre, annually. Adding the estimated \$58.12 per acre to the annual production costs results in a significant decline in the returns to soybean production. However, for the scale economy reasons noted above this estimate is not realistic. Without an estimate of overhead and management costs appropriately adjusted to reflect the total farm size, the best estimates of the returns to the land are offered by \$121.76 per acre.

### Sensitivity of NPV<sub>Ref</sub> to Landowner Expectations

The computed NPV<sub>Ref</sub> will vary if landowners' expectations concerning future prices, market conditions, or technological advances differ from those represented in the Base Case. For example, a landowner might expect that the potential productivity of Delta agricultural land (represented in the model by a BPY of 35 bu/ac) will increase gradually due to future scientific or technological advances. This expectation could be represented in the model by increasing the Base Case best possible yield over the first 30 years from 35 bu/ac to 40 bu/ac (an annual increase of 0.462 percent). Under the differing expectation of increasing productivity, the resulting Base Case NPV of soybean returns (\$467.05) is \$162.95 higher than the original Base Case value of \$304.10. Subtracting these new soybean returns from the NPV of forestry returns would result in a net decrease of \$162.95 in the NPV<sub>Ref</sub> for all reforestation scenarios.

## Conclusions

**Finding 1:** *The NPV of the returns to both forestry and soybean production are sensitive to changes in site characteristics. These site characteristics vary by topographic features and not by county/parish jurisdictional boundaries.*

Both the returns to forestry and to agriculture can vary significantly with specific site characteristics. Forestry returns are affected by biological, climatic, and topographical factors that determine a site's potential productivity in various tree species. Similarly, the net returns to soybean production are affected by the soil quality and flooding frequency and duration. Therefore, care must be exercised in interpreting and transferring the “representative” situations for computing  $NPV_{Ref}$  to any specific site in the Delta.

**Implication 1:** *The  $NPV_{Ref}$  generated by any single simulation cannot be used as evidence for or against the economic returns to reforestation for individual landowners. The model is built with enough detail to be used for evaluating the circumstances facing an individual landowner. However, because of the model complexity, use of the model by individual landowners is not practical. For this use to be practical, the addition of a user-friendly “data entry” section to the model, that also offers checks against misinterpretation and misuse of the model, is required.*

Using the data entry section, a landowner would respond to questions about the land and current production experiences, such as how frequently flooding interferes with soybean production and the best possible yield the land is capable of producing under ideal growing conditions. The landowner's responses could then be used to “custom fit” the model by adjusting any of the site specific determinants, such as agricultural and silvicultural yields, to reflect the unique characteristics of the site.

**Finding 2:** *On the most productive soils, some reforestation scenarios result in positive  $NPV_{Ref}$  under the Base Case conditions. However, there are other circumstances where neither forestry nor soybean production will offer high NPV, particularly on the most marginal of the ten soils examined in this study. In no case are the returns in either use substantial.*

The argument for low returns to both land uses is made more evident by considering the returns to both soybean agriculture and forestry in terms of annual equivalent payments. Soybean production in the Base Case generates a total NPV of \$310.04/ac, but when broken down into annual equivalent payments it is actually only producing \$16.07/ac each year. Similarly, the highest forestry returns produce annual equivalent values ranging from \$5.92 to \$23.43.

For the three least negative economic returns in each of the states, the NPV of the gap between the forestry and soybean production ranged from \$-19.75 to \$-176.00. These are relatively small differences when considered in terms of their annual equivalent values. At a range of \$-1.04 to \$-9.30 a year, the difference between agricultural and forestry returns in annual equivalent values is quite small and could easily be offset by any number of changes in either the forestry or agricultural simulations. A small percentage increase in the projected timber market prices, a decline in establishment costs, an increase in the costs of soybean production, or decline in projected soybean prices could each easily tip the scale to forestry's advantage.

**Implication 2:** *Although low economic returns imply that a landowner may not choose to reforest from purely economic motivations, they also suggest that a large infusion of per acre payments would not be required to bridge the gap between computed forestry and agricultural returns. For a forestry scenario producing an annual equivalent of \$-1.32, as does water oak on Dundee soils in Arkansas, even a small hunting lease, WRP payment, or easement purchase would provide a sufficient supplemental income to tip the scale in favor of reforestation.*

**Finding 3:** *In addition to providing the framework for an assessment of the economic feasibility of reforestation at the individual landowner level, the simulation model provides information useful in identifying which lands to target with any reforestation “promotional efforts.”*

The simulated forestry returns identify which rotations are most likely to prove economically feasible. Regardless of the opportunity cost of reforestation, the reforestation scenarios yielding the highest possible forestry returns, such as cottonwood, Nuttall oak, and cottonwood-oak intercrop on Dundee soils, will always yield the greatest positive (or

smallest negative) economic returns. Additionally, sensitivity analyses of the results to the Base Case simulation isolate the effects of site characteristics on the economic returns to reforestation and indicate which combinations of site characteristics create conditions that are most conducive to reforestation.

***Implication 3:** Information on the contribution of physical site features and geographic location on computed returns can be used in conjunction with aerial surveys and any available GIS databases to*

*identify where such combinations of site characteristics occur. This information would be useful for targeting landowners for technical and financial reforestation assistance.*

Economic feasibility, however, is not the only consideration that factors into a landowner's decision to reforest. Questions of future price expectations, financial feasibility, feelings of social responsibility, risk aversion, and lifestyle preferences all play a role in a landowner's decision to reforest.

**Table II-A. Estimates of site index for selected species on ten soil series in the Mississippi Alluvial Plain.  
(Height of dominant and co-dominant trees at age 50 years)**

<i>Soil Series</i>	<i>Species</i>	<i>Soil Survey Avg.</i>	<i>Broadfoot 1976 range</i>	<i>Baker and Broadfoot (1979) estimate for former soybean land</i>	<i>% diff. Baker and Broadfoot and Soil Survey</i>
Alligator	cottonwood	90	80-100	76	-16
	green ash	70	70-90	74	+6
	sweetgum	80	75-95	78	-3
	water oak	90	75-95	72	-20
Amagon	cottonwood	100	na	89	-11
	green ash	80	na	76	-5
	Nuttall oak	100	na	83	-17
	sweetgum	100	na	82	-18
	water oak	100	na	77	-23
Bowdre	cottonwood	110	na	73	-34
	sweetgum	95	na	78	-18
	water oak	95	na	71	-25
Dundee	cottonwood	100	90-110	91	-9
	sweetgum	100	90-110	88	-12
	water oak	95	85-105	80	-16
Forestdale	cottonwood	100	85-105	79	-21
	green ash	78	70-90	71	-9
	Nuttall oak	95	80-100	76	-20
	sweetgum	95	85-105	71	-25
	water oak	90	80-100	65	-28
Mhoon	cottonwood	110	na	92	-16
	green ash	90	na	78	-13
	sweetgum	100	na	76	-24
Newellton	cottonwood	100	105-125	80	-20
	green ash	75	70-90	77	+3
	Nuttall oak	85	90-110	81	-5
	sweetgum	95	90-110	81	-15
	water oak	90	80-100	72	-20
Sharkey	sweetgum	90	80-100	75	-17
	water oak	90	80-100	70	-22
Tensas	sweetgum	100	90-110	76	-24
	water oak	95	85-105	72	-24
Tunica	cottonwood	90	90-110	75	-17
	sweetgum	90	85-105	73	-19

**Table II - B. NPV of the Returns to Forestry, Mississippi**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	\$20.44	-\$46.54	\$20.44	\$400.46	N/A	-\$92.74	\$124.37
Amagon	\$258.64	-\$46.54	\$258.64	\$450.60	\$171.59	N/A	N/A
Bowdre	-\$13.05	-\$46.54	\$20.44	\$171.59	\$107.87	N/A	N/A
Dundee	\$258.64	-\$46.54	\$258.64	\$450.60	\$350.31	\$347.14	\$443.54
Forestdale	N/A	-\$46.54	N/A	\$171.59	N/A	N/A	N/A
Mhoon	-\$13.05	-\$46.54	-\$13.05	\$400.46	N/A	N/A	N/A
Newellton	\$20.44	-\$46.54	\$258.64	\$400.46	\$107.87	N/A	N/A
Sharkey	-\$13.05	-\$80.03	-\$13.05	\$171.59	\$107.87	\$88.32	\$162.80
Tensas	-\$13.05	-\$46.54	-\$13.05	\$203.45	\$107.87	N/A	N/A
Tunica	N/A	-\$80.03	N/A	\$171.59	N/A	\$52.42	\$139.16

**Table II - C. Mississippi Forestry Returns in Annual Equivalent Values**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	\$1.08	-\$2.46	\$1.08	\$21.16	N/A	-\$4.90	\$6.57
Amagon	\$13.66	-\$2.46	\$13.66	\$23.80	\$9.06	N/A	N/A
Bowdre	-\$0.69	-\$2.46	\$1.08	\$9.06	\$5.70	N/A	N/A
Dundee	\$13.66	-\$2.46	\$13.66	\$23.80	\$18.51	\$18.34	\$23.43
Forestdale	N/A	-\$2.46	N/A	\$9.06	N/A	N/A	N/A
Mhoon	-\$0.69	-\$2.46	-\$0.69	\$21.16	N/A	N/A	N/A
Newellton	\$1.08	-\$2.46	\$13.66	\$21.16	\$5.70	N/A	N/A
Sharkey	-\$0.69	-\$4.23	-\$0.69	\$9.06	\$5.70	\$4.67	\$8.60
Tensas	-\$0.69	-\$2.46	-\$0.69	\$10.75	\$5.70	N/A	N/A
Tunica	N/A	-\$4.23	N/A	\$9.06	N/A	\$2.77	\$7.35

**Table II - D. NPV of the Returns to Forestry, Louisiana**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$38.76	-\$91.71	-\$38.76	\$365.12	N/A	-\$137.75	\$92.92
Amagon	\$145.08	-\$91.71	\$145.08	\$414.36	\$141.62	N/A	N/A
Bowdre	-\$65.24	-\$91.71	-\$38.76	\$141.62	\$79.06	N/A	N/A
Dundee	\$145.08	-\$91.71	\$145.08	\$414.36	\$315.89	\$284.35	\$398.96
Forestdale	N/A	-\$91.71	N/A	\$141.62	N/A	N/A	N/A
Mhoon	-\$65.24	-\$91.71	-\$65.24	\$365.12	N/A	N/A	N/A
Newellton	-\$38.76	-\$91.71	\$145.08	\$365.12	\$79.06	N/A	N/A
Sharkey	-\$65.24	-\$118.19	-\$65.24	\$141.62	\$79.06	\$35.99	\$128.10
Tensas	-\$65.24	-\$91.71	-\$65.24	\$172.89	\$79.06	N/A	N/A
Tunica	N/A	-\$118.19	N/A	\$141.62	N/A	\$1.54	\$105.42

**Table II - E. Louisiana Forestry Returns in Annual Equivalent Values**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$2.05	-\$4.85	-\$2.05	\$19.29	N/A	-\$7.28	\$4.87
Amagon	\$7.66	-\$4.85	\$7.66	\$21.89	\$7.48	N/A	N/A
Bowdre	-\$3.45	-\$4.85	-\$2.05	\$7.48	\$4.18	N/A	N/A
Dundee	\$7.66	-\$4.85	\$7.66	\$21.89	\$16.69	\$15.02	\$21.08
Forestdale	N/A	-\$4.85	N/A	\$7.48	N/A	N/A	N/A
Mhoon	-\$3.45	-\$4.85	-\$3.45	\$19.29	N/A	N/A	N/A
Newellton	-\$2.05	-\$4.85	\$7.66	\$19.29	\$4.18	N/A	N/A
Sharkey	-\$3.45	-\$6.24	-\$3.45	\$7.48	\$4.18	\$1.90	\$6.77
Tensas	-\$3.45	-\$4.85	-\$3.45	\$9.13	\$4.18	N/A	N/A
Tunica	N/A	-\$6.24	N/A	\$7.48	N/A	\$0.08	\$5.57

**Table II - F. NPV of the Returns to Forestry, Arkansas**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$86.72	-\$141.00	-\$86.72	\$329.69	N/A	-\$210.87	\$31.02
Amagon	\$105.73	-\$141.00	\$105.73	\$380.34	\$98.86	N/A	N/A
Bowdre	-\$113.86	-\$141.00	-\$86.72	\$98.86	\$34.60	N/A	N/A
Dundee	\$105.73	-\$141.00	\$105.73	\$380.34	\$279.04	\$112.10	\$271.26
Forestdale	N/A	-\$141.00	N/A	\$98.86	N/A	N/A	N/A
Mhoon	-\$113.86	-\$141.00	-\$113.86	\$329.69	N/A	N/A	N/A
Newellton	-\$86.72	-\$141.00	\$105.73	\$329.69	\$34.60	N/A	N/A
Sharkey	-\$113.86	-\$168.15	-\$113.86	\$98.86	\$34.60	-\$77.93	\$37.36
Tensas	-\$113.86	-\$141.00	-\$113.86	\$130.99	\$34.60	N/A	N/A
Tunica	N/A	-\$168.15	N/A	\$98.86	N/A	-\$104.29	\$20.01

**Table II - G. Arkansas Forestry Returns in Annual Equivalent Values**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$4.58	-\$7.45	-\$4.58	\$17.42	N/A	-\$11.14	\$1.64
Amagon	\$5.59	-\$7.45	\$5.59	\$20.09	\$5.22	N/A	N/A
Bowdre	-\$6.02	-\$7.45	-\$4.58	\$5.22	\$1.83	N/A	N/A
Dundee	\$5.59	-\$7.45	\$5.59	\$20.09	\$14.74	\$5.92	\$14.33
Forestdale	N/A	-\$7.45	N/A	\$5.22	N/A	N/A	N/A
Mhoon	-\$6.02	-\$7.45	-\$6.02	\$17.42	N/A	N/A	N/A
Newellton	-\$4.58	-\$7.45	\$5.59	\$17.42	\$1.83	N/A	N/A
Sharkey	-\$6.02	-\$8.88	-\$6.02	\$5.22	\$1.83	-\$4.12	\$1.97
Tensas	-\$6.02	-\$7.45	-\$6.02	\$6.92	\$1.83	N/A	N/A
Tunica	N/A	-\$8.88	N/A	\$5.22	N/A	-\$5.51	\$1.06

**II - H. NPV of Economic Returns (NPV<sub>Ref</sub>), Mississippi**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$283.66	-\$350.64	-\$283.66	\$96.35	N/A	-\$396.84	-\$179.73
Amagon	-\$45.46	-\$350.64	-\$45.46	\$146.50	-\$132.52	N/A	N/A
Bowdre	-\$317.15	-\$350.64	-\$283.66	-\$132.52	-\$196.24	N/A	N/A
Dundee	-\$45.46	-\$350.64	-\$45.46	\$146.50	\$46.21	\$43.04	\$139.44
Forestdale	N/A	-\$350.64	N/A	-\$132.52	N/A	N/A	N/A
Mhoon	-\$317.15	-\$350.64	-\$317.15	\$96.35	N/A	N/A	N/A
Newellton	-\$283.66	-\$350.64	-\$45.46	\$96.35	-\$196.24	N/A	N/A
Sharkey	-\$317.15	-\$384.13	-\$317.15	-\$132.52	-\$196.24	-\$215.78	-\$141.30
Tensas	-\$317.15	-\$350.64	-\$317.15	-\$100.66	-\$196.24	N/A	N/A
Tunica	N/A	-\$384.13	N/A	-\$132.52	N/A	-\$251.69	-\$164.94

**II - I. Mississippi NPV<sub>Ref</sub> in Annual Equivalent Values**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$14.99	-\$18.52	-\$14.99	\$5.09	N/A	-\$20.96	-\$9.49
Amagon	-\$2.40	-\$18.52	-\$2.40	\$7.74	-\$7.00	N/A	N/A
Bowdre	-\$16.75	-\$18.52	-\$14.99	-\$7.00	-\$10.37	N/A	N/A
Dundee	-\$2.40	-\$18.52	-\$2.40	\$7.74	\$2.44	\$2.27	\$7.37
Forestdale	N/A	-\$18.52	N/A	-\$7.00	N/A	N/A	N/A
Mhoon	-\$16.75	-\$18.52	-\$16.75	\$5.09	N/A	N/A	N/A
Newellton	-\$14.99	-\$18.52	-\$2.40	\$5.09	-\$10.37	N/A	N/A
Sharkey	-\$16.75	-\$20.29	-\$16.75	-\$7.00	-\$10.37	-\$11.40	-\$7.46
Tensas	-\$16.75	-\$18.52	-\$16.75	-\$5.32	-\$10.37	N/A	N/A
Tunica	N/A	-\$20.29	N/A	-\$7.00	N/A	-\$13.30	-\$8.71

**II - J. NPV of Economic Returns (NPV<sub>Ref</sub>), Louisiana**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$342.87	-\$395.82	-\$342.87	\$61.02	N/A	-\$441.85	-\$211.88
Amagon	-\$159.02	-\$395.82	-\$159.02	\$110.26	-\$162.49	N/A	N/A
Bowdre	-\$369.34	-\$395.82	-\$342.87	-\$162.49	-\$225.04	N/A	N/A
Dundee	-\$159.02	-\$395.82	-\$159.02	\$110.26	\$11.79	-\$19.75	\$94.86
Forestdale	N/A	-\$395.82	N/A	-\$162.49	N/A	N/A	N/A
Mhoon	-\$369.34	-\$395.82	-\$369.34	\$61.02	N/A	N/A	N/A
Newellton	-\$342.87	-\$395.82	-\$159.02	\$61.02	-\$225.04	N/A	N/A
Sharkey	-\$369.34	-\$422.29	-\$369.34	-\$162.49	-\$225.04	-\$268.11	-\$176.00
Tensas	-\$369.34	-\$395.82	-\$369.34	-\$131.21	-\$225.04	N/A	N/A
Tunica	N/A	-\$422.29	N/A	-\$162.49	N/A	-\$302.56	-\$198.69

**II - K. Louisiana NPV<sub>Ref</sub> in Annual Equivalent Values**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$18.11	-\$20.91	-\$18.11	\$3.22	N/A	-\$23.34	-\$11.19
Amagon	-\$8.40	-\$20.91	-\$8.40	\$5.82	-\$8.58	N/A	N/A
Bowdre	-\$19.51	-\$20.91	-\$18.11	-\$8.58	-\$11.89	N/A	N/A
Dundee	-\$8.40	-\$20.91	-\$8.40	\$5.82	\$0.62	-\$1.04	\$5.01
Forestdale	N/A	-\$20.91	N/A	-\$8.58	N/A	N/A	N/A
Mhoon	-\$19.51	-\$20.91	-\$19.51	\$3.22	N/A	N/A	N/A
Newellton	-\$18.11	-\$20.91	-\$8.40	\$3.22	-\$11.89	N/A	N/A
Sharkey	-\$19.51	-\$22.31	-\$19.51	-\$8.58	-\$11.89	-\$14.16	-\$9.30
Tensas	-\$19.51	-\$20.91	-\$19.51	-\$6.93	-\$11.89	N/A	N/A
Tunica	N/A	-\$22.31	N/A	-\$8.58	N/A	-\$15.98	-\$10.50

**II - L. NPV of Economic Returns (NPV<sub>Ref</sub>), Arkansas**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$390.82	-\$445.11	-\$390.82	\$25.59	N/A	-\$514.97	-\$273.08
Amagon	-\$198.37	-\$445.11	-\$198.37	\$76.24	-\$205.24	N/A	N/A
Bowdre	-\$417.96	-\$445.11	-\$390.82	-\$205.24	-\$269.50	N/A	N/A
Dundee	-\$198.37	-\$445.11	-\$198.37	\$76.24	-\$25.06	-\$192.00	-\$32.84
Forestdale	N/A	-\$445.11	N/A	-\$205.24	N/A	N/A	N/A
Mhoon	-\$417.96	-\$445.11	-\$417.96	\$25.59	N/A	N/A	N/A
Newellton	-\$390.82	-\$445.11	-\$198.37	\$25.59	-\$269.50	N/A	N/A
Sharkey	-\$417.96	-\$472.25	-\$417.96	-\$205.24	-\$269.50	-\$382.03	-\$266.74
Tensas	-\$417.96	-\$445.11	-\$417.96	-\$173.11	-\$269.50	N/A	N/A
Tunica	N/A	-\$472.25	N/A	-\$205.24	N/A	-\$408.39	-\$284.09

**II - M. Arkansas NPV<sub>Ref</sub> in Annual Equivalent Values**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$20.65	-\$23.51	-\$20.65	\$1.35	N/A	-\$27.20	-\$14.43
Amagon	-\$10.48	-\$23.51	-\$10.48	\$4.03	-\$10.84	N/A	N/A
Bowdre	-\$22.08	-\$23.51	-\$20.65	-\$10.84	-\$14.24	N/A	N/A
Dundee	-\$10.48	-\$23.51	-\$10.48	\$4.03	-\$1.32	-\$10.14	-\$1.73
Forestdale	N/A	-\$23.51	N/A	-\$10.84	N/A	N/A	N/A
Mhoon	-\$22.08	-\$23.51	-\$22.08	\$1.35	N/A	N/A	N/A
Newellton	-\$20.65	-\$23.51	-\$10.48	\$1.35	-\$14.24	N/A	N/A
Sharkey	-\$22.08	-\$24.95	-\$22.08	-\$10.84	-\$14.24	-\$20.18	-\$14.09
Tensas	-\$22.08	-\$23.51	-\$22.08	-\$9.15	-\$14.24	N/A	N/A
Tunica	N/A	-\$24.95	N/A	-\$10.84	N/A	-\$21.57	-\$15.01

**II - N. NPV of Forestry Returns with a 20 percent Increase in Sawtimber Prices, Mississippi**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	\$52.22	-\$27.47	\$52.22	\$509.46	N/A	\$-92.74	\$170.84
Amagon	\$339.16	-\$27.47	\$339.16	\$569.51	\$234.17	N/A	N/A
Bowdre	\$12.37	-\$27.47	\$52.22	\$234.17	\$157.93	N/A	N/A
Dundee	\$339.16	-\$27.47	\$339.16	\$569.51	\$449.40	\$347.14	\$494.24
Forestdale	N/A	-\$27.47	N/A	\$234.17	N/A	N/A	N/A
Mhoon	\$12.37	-\$27.47	\$12.37	\$509.46	N/A	N/A	N/A
Newellton	\$52.22	-\$27.47	\$339.16	\$509.46	\$157.93	N/A	N/A
Sharkey	\$12.37	-\$67.32	\$12.37	\$234.17	\$157.93	\$88.32	\$192.53
Tensas	\$12.37	-\$27.47	\$12.37	\$272.28	\$157.93	N/A	N/A
Tunica	N/A	-\$67.32	N/A	\$234.17	N/A	\$52.42	\$168.89

**II - O. NPV of Economic Returns (NPV<sub>Ref</sub>) with a 20 percent Increase in Sawtimber Prices, Mississippi**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$251.88	-\$331.57	-\$251.88	\$205.35	N/A	-\$396.84	-\$133.26
Amagon	\$35.06	-\$331.57	\$35.06	\$265.41	-\$69.94	N/A	N/A
Bowdre	-\$291.73	-\$331.57	-\$251.88	-\$69.94	-\$146.17	N/A	N/A
Dundee	\$35.06	-\$331.57	\$35.06	\$265.41	\$145.30	\$43.04	\$190.14
Forestdale	N/A	-\$331.57	N/A	-\$69.94	N/A	N/A	N/A
Mhoon	-\$291.73	-\$331.57	-\$291.73	\$205.35	N/A	N/A	N/A
Newellton	-\$251.88	-\$331.57	\$35.06	\$205.35	-\$146.17	N/A	N/A
Sharkey	-\$291.73	-\$371.42	-\$291.73	-\$69.94	-\$146.17	-\$215.78	-\$111.57
Tensas	-\$291.73	-\$331.57	-\$291.73	-\$31.82	-\$146.17	N/A	N/A
Tunica	N/A	-\$371.42	N/A	-\$69.94	N/A	-\$251.69	-\$135.21

**II - P. NPV of Forestry Returns with a 20 percent Increase in Sawtimber Prices, Louisiana**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$13.93	-\$76.81	-\$13.93	\$472.17	N/A	-\$137.75	\$137.86
Amagon	\$208.00	-\$76.81	\$208.00	\$531.13	\$203.07	N/A	N/A
Bowdre	-\$45.37	-\$76.81	-\$13.93	\$203.07	\$128.23	N/A	N/A
Dundee	\$208.00	-\$76.81	\$208.00	\$531.13	\$413.20	\$284.35	\$448.75
Forestdale	N/A	-\$76.81	N/A	\$203.07	N/A	N/A	N/A
Mhoon	-\$45.37	-\$76.81	-\$45.37	\$472.17	N/A	N/A	N/A
Newellton	-\$13.93	-\$76.81	\$208.00	\$472.17	\$128.23	N/A	N/A
Sharkey	-\$45.37	-\$108.25	-\$45.37	\$203.07	\$128.23	\$35.99	\$157.29
Tensas	-\$45.37	-\$76.81	-\$45.37	\$240.49	\$128.23	N/A	N/A
Tunica	N/A	-\$108.25	N/A	\$203.07	N/A	\$1.54	\$134.61

**II - Q. NPV of Economic Returns (NPV<sub>Ref</sub>) with a 20 percent Increase in Sawtimber Prices, Louisiana**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$318.03	-\$380.91	-\$318.03	\$168.07	N/A	-\$441.85	-\$166.24
Amagon	-\$96.10	-\$380.91	-\$96.10	\$227.03	-\$101.03	N/A	N/A
Bowdre	-\$349.47	-\$380.91	-\$318.03	-\$101.03	-\$175.87	N/A	N/A
Dundee	-\$96.10	-\$380.91	-\$96.10	\$227.03	\$109.10	-\$19.75	\$144.65
Forestdale	N/A	-\$380.91	N/A	-\$101.03	N/A	N/A	N/A
Mhoon	-\$349.47	-\$380.91	-\$349.47	\$168.07	N/A	N/A	N/A
Newellton	-\$318.03	-\$380.91	-\$96.10	\$168.07	-\$175.87	N/A	N/A
Sharkey	-\$349.47	-\$412.36	-\$349.47	-\$101.03	-\$175.87	-\$268.11	-\$146.81
Tensas	-\$349.47	-\$380.91	-\$349.47	-\$63.61	-\$175.87	N/A	N/A
Tunica	N/A	-\$412.36	N/A	-\$101.03	N/A	-\$302.56	-\$169.49

**II - R. NPV of Forestry Returns with a 20 percent Increase in Sawtimber Prices, Arkansas**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$60.83	-\$125.47	-\$60.83	\$440.16	N/A	-\$210.87	\$78.12
Amagon	\$171.32	-\$125.47	\$171.32	\$500.85	\$162.28	N/A	N/A
Bowdre	-\$93.15	-\$125.47	-\$60.83	\$162.28	\$85.34	N/A	N/A
Dundee	\$171.32	-\$125.47	\$171.32	\$500.85	\$379.46	\$112.10	\$322.65
Forestdale	N/A	-\$125.47	N/A	\$162.28	N/A	N/A	N/A
Mhoon	-\$93.15	-\$125.47	-\$93.15	\$440.16	N/A	N/A	N/A
Newellton	-\$60.83	-\$125.47	\$171.32	\$440.16	\$85.34	N/A	N/A
Sharkey	-\$93.15	-\$157.79	-\$93.15	\$162.28	\$85.34	-\$77.93	\$67.49
Tensas	-\$93.15	-\$125.47	-\$93.15	\$200.75	\$85.34	N/A	N/A
Tunica	N/A	-\$157.79	N/A	\$162.28	N/A	-\$104.29	\$50.13

**II - S. NPV of Economic Returns (NPV<sub>Ref</sub>) with a 20 percent Increase in Sawtimber Prices, Arkansas**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$364.93	-\$429.57	-\$364.93	\$136.06	N/A	-\$514.97	-\$225.98
Amagon	-\$132.78	-\$429.57	-\$132.78	\$196.75	-\$141.82	N/A	N/A
Bowdre	-\$397.25	-\$429.57	-\$364.93	-\$141.82	-\$218.76	N/A	N/A
Dundee	-\$132.78	-\$429.57	-\$132.78	\$196.75	\$75.36	-\$192.00	\$18.54
Forestdale	N/A	-\$429.57	N/A	-\$141.82	N/A	N/A	N/A
Mhoon	-\$397.25	-\$429.57	-\$397.25	\$136.06	N/A	N/A	N/A
Newellton	-\$364.93	-\$429.57	-\$132.78	\$136.06	-\$218.76	N/A	N/A
Sharkey	-\$397.25	-\$461.89	-\$397.25	-\$141.82	-\$218.76	-\$382.03	-\$236.61
Tensas	-\$397.25	-\$429.57	-\$397.25	-\$103.35	-\$218.76	N/A	N/A
Tunica	N/A	-\$461.89	N/A	-\$141.82	N/A	-\$408.39	-\$253.97

**II - T. NPV of Forestry Returns at Current Sawtimber Prices, Mississippi**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$17.17	-\$69.10	-\$17.17	\$271.49	N/A	-\$92.74	\$69.38
Amagon	\$163.37	-\$69.10	\$163.37	\$309.91	\$97.54	N/A	N/A
Bowdre	-\$43.14	-\$69.10	-\$17.17	\$97.54	\$48.63	N/A	N/A
Dundee	\$163.37	-\$69.10	\$163.37	\$309.91	\$233.06	\$347.14	\$383.55
Forestdale	N/A	-\$69.10	N/A	\$97.54	N/A	N/A	N/A
Mhoon	-\$43.14	-\$69.10	-\$43.14	\$271.49	N/A	N/A	N/A
Newellton	-\$17.17	-\$69.10	\$163.37	\$271.49	\$48.63	N/A	N/A
Sharkey	-\$43.14	-\$95.07	-\$43.14	\$97.54	\$48.63	\$88.32	\$127.63
Tensas	-\$43.14	-\$69.10	-\$43.14	\$121.99	\$48.63	N/A	N/A
Tunica	N/A	-\$95.07	N/A	\$97.54	N/A	\$52.42	\$103.99

**II - U. NPV of Economic Returns (NPV<sub>ref</sub>) at Current Sawtimber Prices, Mississippi**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$321.27	-\$373.21	-\$321.27	-\$32.61	N/A	-\$396.84	-\$234.72
Amagon	-\$140.73	-\$373.21	-\$140.73	\$5.81	-\$206.56	N/A	N/A
Bowdre	-\$347.24	-\$373.21	-\$321.27	-\$206.56	-\$255.47	N/A	N/A
Dundee	-\$140.73	-\$373.21	-\$140.73	\$5.81	-\$71.04	\$43.04	\$79.45
Forestdale	N/A	-\$373.21	N/A	-\$206.56	N/A	N/A	N/A
Mhoon	-\$347.24	-\$373.21	-\$347.24	-\$32.61	N/A	N/A	N/A
Newellton	-\$321.27	-\$373.21	-\$140.73	-\$32.61	-\$255.47	N/A	N/A
Sharkey	-\$347.24	-\$399.17	-\$347.24	-\$206.56	-\$255.47	-\$215.78	-\$176.47
Tensas	-\$347.24	-\$373.21	-\$347.24	-\$182.11	-\$255.47	N/A	N/A
Tunica	N/A	-\$399.17	N/A	-\$206.56	N/A	-\$251.69	-\$200.11

**II - V. NPV of Forestry Returns at Current Sawtimber Prices, Louisiana**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$68.15	-\$109.35	-\$68.15	\$238.47	N/A	-\$137.75	\$38.22
Amagon	\$70.63	-\$109.35	\$70.63	\$276.19	\$68.90	N/A	N/A
Bowdre	-\$88.75	-\$109.35	-\$68.15	\$68.90	\$20.89	N/A	N/A
Dundee	\$70.63	-\$109.35	\$70.63	\$276.19	\$200.75	\$284.35	\$340.05
Forestdale	N/A	-\$109.35	N/A	\$68.90	N/A	N/A	N/A
Mhoon	-\$88.75	-\$109.35	-\$88.75	\$238.47	N/A	N/A	N/A
Newellton	-\$68.15	-\$109.35	\$70.63	\$238.47	\$20.89	N/A	N/A
Sharkey	-\$88.75	-\$129.94	-\$88.75	\$68.90	\$20.89	\$35.99	\$93.56
Tensas	-\$88.75	-\$109.35	-\$88.75	\$92.90	\$20.89	N/A	N/A
Tunica	N/A	-\$129.94	N/A	\$68.90	N/A	\$1.54	\$70.88

**II - W. NPV of Economic Returns (NPV<sub>Ref</sub>) at Current Sawtimber Prices, Louisiana**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$372.25	-\$413.45	-\$372.25	-\$65.63	N/A	-\$441.85	-\$265.88
Amagon	-\$233.47	-\$413.45	-\$233.47	-\$27.92	-\$235.20	N/A	N/A
Bowdre	-\$392.85	-\$413.45	-\$372.25	-\$235.20	-\$283.21	N/A	N/A
Dundee	-\$233.47	-\$413.45	-\$233.47	-\$27.92	-\$103.35	-\$19.75	\$35.95
Forestdale	N/A	-\$413.45	N/A	-\$235.20	N/A	N/A	N/A
Mhoon	-\$392.85	-\$413.45	-\$392.85	-\$65.63	N/A	N/A	N/A
Newellton	-\$372.25	-\$413.45	-\$233.47	-\$65.63	-\$283.21	N/A	N/A
Sharkey	-\$392.85	-\$434.04	-\$392.85	-\$235.20	-\$283.21	-\$268.11	-\$210.54
Tensas	-\$392.85	-\$413.45	-\$392.85	-\$211.20	-\$283.21	N/A	N/A
Tunica	N/A	-\$434.04	N/A	-\$235.20	N/A	-\$302.56	-\$233.23

**II - X. NPV of Forestry Returns at Current Sawtimber Prices, Arkansas**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$117.35	-\$159.38	-\$117.35	\$198.99	N/A	-\$210.87	-\$24.71
Amagon	\$28.13	-\$159.38	\$28.13	\$237.76	\$23.82	N/A	N/A
Bowdre	-\$138.37	-\$159.38	-\$117.35	\$23.82	-\$25.43	N/A	N/A
Dundee	\$28.13	-\$159.38	\$28.13	\$237.76	\$160.22	\$112.10	\$210.47
Forestdale	N/A	-\$159.38	N/A	\$23.82	N/A	N/A	N/A
Mhoon	-\$138.37	-\$159.38	-\$138.37	\$198.99	N/A	N/A	N/A
Newellton	-\$117.35	-\$159.38	\$28.13	\$198.99	-\$25.43	N/A	N/A
Sharkey	-\$138.37	-\$180.40	-\$138.37	\$23.82	-\$25.43	-\$77.93	\$1.72
Tensas	-\$138.37	-\$159.38	-\$138.37	\$48.44	-\$25.43	N/A	N/A
Tunica	N/A	-\$180.40	N/A	\$23.82	N/A	-\$104.29	-\$15.64

**II - Y. NPV of Economic Returns (NPV<sub>Ref</sub>) at Current Sawtimber Prices, Arkansas**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$421.45	-\$463.48	-\$421.45	-\$105.11	N/A	-\$514.97	-\$328.81
Amagon	-\$275.97	-\$463.48	-\$275.97	-\$66.34	-\$280.28	N/A	N/A
Bowdre	-\$442.47	-\$463.48	-\$421.45	-\$280.28	-\$329.53	N/A	N/A
Dundee	-\$275.97	-\$463.48	-\$275.97	-\$66.34	-\$143.89	-\$192.00	-\$93.63
Forestdale	N/A	-\$463.48	N/A	-\$280.28	N/A	N/A	N/A
Mhoon	-\$442.47	-\$463.48	-\$442.47	-\$105.11	N/A	N/A	N/A
Newellton	-\$421.45	-\$463.48	-\$275.97	-\$105.11	-\$329.53	N/A	N/A
Sharkey	-\$442.47	-\$484.50	-\$442.47	-\$280.28	-\$329.53	-\$382.03	-\$302.38
Tensas	-\$442.47	-\$463.48	-\$442.47	-\$255.66	-\$329.53	N/A	N/A
Tunica	N/A	-\$484.50	N/A	-\$280.28	N/A	-\$408.39	-\$319.74

**II - Z. IRR of Net Economic Returns (NPV<sub>Ref</sub>), Mississippi**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	2.83%	2.00%	2.83%	5.51%	N/A	----	3.59%
Amagon	4.72%	2.00%	4.72%	5.73%	4.26%	N/A	N/A
Bowdre	2.31%	2.00%	2.83%	4.26%	3.77%	N/A	N/A
Dundee	4.72%	2.00%	4.72%	5.73%	5.26%	5.86%	6.43%
Forestdale	N/A	2.00%	N/A	4.26%	N/A	N/A	N/A
Mhoon	2.31%	2.00%	2.31%	5.51%	N/A	N/A	N/A
Newellton	2.83%	2.00%	4.72%	5.51%	3.77%	N/A	N/A
Sharkey	2.31%	1.00%	2.31%	4.26%	3.77%	---	3.64%
Tensas	2.31%	2.00%	2.31%	4.46%	3.77%	N/A	N/A
Tunica	N/A	1.00%	N/A	4.26%	N/A	---	3.46%

\*IRR was incalculable for cottonwood scenarios on certain soil types.

**II - AA. IRR of Forestry Returns, Mississippi**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	5.25%	4.27%	5.25%	8.03%	N/A	---	6.49%
Amagon	7.34%	4.27%	7.34%	8.23%	6.47%	N/A	N/A
Bowdre	4.82%	4.27%	5.25%	6.47%	6.05%	N/A	N/A
Dundee	7.34%	4.27%	7.34%	8.23%	7.81%	15.56%	13.30%
Forestdale	N/A	4.27%	N/A	6.47%	N/A	N/A	N/A
Mhoon	4.82%	4.27%	4.82%	8.03%	N/A	N/A	N/A
Newellton	5.25%	4.27%	7.34%	8.03%	6.05%	N/A	N/A
Sharkey	4.82%	3.49%	4.82%	6.47%	6.05%	8.60%	8.00%
Tensas	4.82%	4.27%	4.82%	6.65%	6.05%	N/A	N/A
Tunica	N/A	3.49%	N/A	6.47%	N/A	7.26%	7.38%

**II - BB. IRR of Net Economic Returns (NPV<sub>Ref</sub>), Louisiana**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	2.21%	1.00%	2.21%	5.31%	N/A	---	3.40%
Amagon	3.92%	1.00%	3.92%	5.54%	4.12%	N/A	N/A
Bowdre	2.00%	1.00%	2.21%	4.12%	3.64%	N/A	N/A
Dundee	3.92%	1.00%	3.92%	5.54%	5.06%	4.63%	5.90%
Forestdale	N/A	1.00%	N/A	4.12%	N/A	N/A	N/A
Mhoon	2.00%	1.00%	2.00%	5.31%	N/A	N/A	N/A
Newellton	2.21%	1.00%	3.92%	5.31%	3.64%	N/A	N/A
Sharkey	2.00%	0.00%	2.00%	4.12%	3.64%	---	3.41%
Tensas	2.00%	1.00%	2.00%	4.32%	3.64%	N/A	N/A
Tunica	N/A	0.00%	N/A	4.12%	N/A	---	3.25%

\* IRR was incalculable for cottonwood scenarios on certain soil types.

**II - CC. IRR of Forestry Returns, Louisiana**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	4.52%	3.57%	4.52%	7.58%	N/A	---	6.01%
Amagon	6.39%	3.57%	6.39%	7.77%	6.12%	N/A	N/A
Bowdre	4.10%	3.57%	4.52%	6.12%	5.71%	N/A	N/A
Dundee	6.39%	3.57%	6.39%	7.77%	7.36%	12.66%	11.33%
Forestdale	N/A	3.57%	N/A	6.12%	N/A	N/A	N/A
Mhoon	4.10%	3.57%	4.10%	7.58%	N/A	N/A	N/A
Newellton	4.52%	3.57%	6.39%	7.58%	5.71%	N/A	N/A
Sharkey	4.10%	2.80%	4.10%	6.12%	5.71%	6.27%	6.97%
Tensas	4.10%	3.57%	4.10%	6.30%	5.71%	N/A	N/A
Tunica	N/A	2.80%	N/A	6.12%	N/A	5.06%	6.55%

**II - DD. IRR of Net Economic Returns (NPV<sub>Ref</sub>), Arkansas**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	1.95%	1.00%	1.95%	5.13%	N/A	---	3.04%
Amagon	3.71%	1.00%	3.71%	5.36%	3.93%	N/A	N/A
Bowdre	1.00%	1.00%	1.95%	3.93%	3.44%	N/A	N/A
Dundee	3.71%	1.00%	3.71%	5.36%	4.87%	0.86%	4.73%
Forestdale	N/A	1.00%	N/A	3.93%	N/A	N/A	N/A
Mhoon	1.00%	1.00%	1.00%	5.13%	N/A	N/A	N/A
Newellton	1.95%	1.00%	3.71%	5.13%	3.44%	N/A	N/A
Sharkey	1.00%	0.00%	1.00%	3.93%	3.44%	---	2.81%
Tensas	1.00%	1.00%	1.00%	4.14%	3.44%	N/A	N/A
Tunica	N/A	0.00%	N/A	3.93%	N/A	---	2.72%

\* IRR was in calculable for cottonwood scenarios on certain soil types.

**II - EE. IRR of Forestry Returns, Arkansas**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	4.01%	2.95%	4.01%	7.19%	N/A	---	5.31%
Amagon	5.95%	2.95%	5.95%	7.40%	5.73%	N/A	N/A
Bowdre	3.55%	2.95%	4.01%	5.73%	5.29%	N/A	N/A
Dundee	5.95%	2.95%	5.95%	7.40%	6.96%	8.45%	8.62%
Forestdale	N/A	2.95%	N/A	5.73%	N/A	N/A	N/A
Mhoon	3.55%	2.95%	3.55%	7.19%	N/A	N/A	N/A
Newellton	4.01%	2.95%	5.95%	7.19%	5.29%	N/A	N/A
Sharkey	3.55%	2.08%	3.55%	5.73%	5.29%	1.85%	5.48%
Tensas	3.55%	2.95%	3.55%	5.92%	5.29%	N/A	N/A
Tunica	N/A	2.08%	N/A	5.73%	N/A	0.55%	5.25%

\* IRR was in calculable for cottonwood scenarios on certain soil types

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### III. BEYOND COMPUTED NET PRESENT VALUE: UNDERSTANDING LANDOWNER MOTIVATIONS

It is likely that farm landowners will behave like “non-industrial forest landowners.” The literature shows that these landowners have concerns about forest production including the long term nature of forest earnings, the risks associated with forest production, and the problem of securing loans for reforestation. The literature also shows that these landowners have multiple objectives for the use of their land. This suggests that several dimensions of a landowner’s decision to reforest are ignored when only the computation of NPV is used to assess interest in reforestation. Factors that might adversely affect the interest in reforestation include attitudes toward and perceptions about income risk, immediate cash flow needs, and the “fit” of the forestry enterprise into the rest of the farm business. On the other hand, personal hunting or fishing interest or altruistic motives may motivate reforestation, despite a low prospective NPV. In this case, a landowner may be interested in non-timber services of their forests.

#### Risk

Forest and agricultural production involve very different sets of risks since timber-related revenues are obtained in the future while forest investments are made at the beginning of the rotation. Landowners may not have incentives to remove land from agricultural production and invest in long term forestry production if they have short time horizons or are adverse to taking income risks. The value to the landowner of future non-timber benefits such as hunting lease revenues is also uncertain, since the level of non-timber benefits can change dramatically throughout the rotation (Swallow et al. 1990).

Forest production is subject to long term production risks not generally associated with growing agricultural crops. Fire and pests are constant dangers, and flooding early in the rotation can reduce the survivability of some plantations, particularly cottonwood. Insect infestations are also serious when they occur.<sup>1</sup>

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<sup>1</sup> Insecticide spraying was not included in the site preparation costs presented in section II. Unlike agricultural production, insecticides are not sprayed regularly in forest stands as a preventative measure unless an insect problem is either occurring or expected to occur. Insecticide treatments are generally expensive and are not financially feasible for

Since these risks are present throughout the entire rotation, the risks associated with forest production are greater than the risks in growing short term agricultural crops. Furthermore, while insurance is available to cover the loss of agricultural crops due to acts of God, the casualty insurance available for forestry losses is practically non-existent. Most of the current opportunities to declare casualty losses on tax returns exist for pine plantations only (Siegal et al. 1995).

When landowners face increased risk, the return they must earn in forestry increases (Gregory 1986). One way to examine the effect of increased risk is by estimating how the NPV results change when a higher interest rate is used for discounting. The higher rate is a simple way to represent risk aversion by the landowner. Tables III-A through III-F (found at the end of Section III) present net present values of forest returns and net economic returns to reforestation assuming that the forestry returns are discounted at a 7 percent interest rate, rather than the 5 percent rate used in the Base Case.

Comparing these results with the Base Case forestry returns and  $NPV_{Ref}$  presented in Section II, it is clear that increased risk associated with forestry greatly reduces the present values of forest returns. The net present values with a two percentage point increase in interest rates are less than one-third as high as the net present values computed under the assumption of a 5 percent interest rate. These differences are most dramatic for the longer rotation oak regimes. For cottonwood plantations, the impact of increased risk on the forest landowner is lessened. Cottonwood plantations are less sensitive to increased risk because they provide cash flows more quickly and more often than pure oak plantations. Finally, the results suggest that differences in risk are most important for poorer quality sites where revenues at harvest age are already low due to the higher proportion of pulpwood produced and the longer rotation ages.

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application over several years given the lack of yearly income associated with forest management.

## Financial Constraints

Even when the NPV for reforestation is favorable, the landowner may not have the readily available cash necessary for early land preparation and tree establishment. For example, total reforestation costs in the Delta range from \$150 to \$250 per acre depending on the tree species. Much of this cost is due to the relatively high level of weed control required to establish a plantation. If a large number of acres are reforested, the total costs of reforestation can be substantial. Faced with meeting these immediate cash needs, landowners may be discouraged from undertaking reforestation. Perhaps the best reforestation regimes for the landowner who cannot wait for a cash flow are the mixed cottonwood-oak and cottonwood plantations. In these rotations, the landowner receives periodic income earlier in the rotation when cottonwood is harvested and sold as pulpwood. Also, loans and cost sharing have been considered as alternative means of overcoming this “cash flow” barrier.

Current cost sharing programs typically have total cost maximums that may limit the payments to landowners. Therefore, these programs have a limited cash flow effect and landowners may need additional funds to successfully establish forests on their lands. Borrowing the necessary capital is one solution for owners of small land parcels who may not have the internal capital to finance reforestation. Currently, a loan program for reforestation does not exist in the Delta for landowners needing to borrow funds to reforest.

However, the financial reality is that forest returns are not collected until the end of the rotation which, for the bottomland hardwoods, can be as long as 60 years from the time of planting. This limits the ability to repay the loan from timber income and also requires that the landowner be willing to wait a significant time before any cash returns are realized. This will not be acceptable to a landowner facing a current cash flow

constraint. The long term cycle of forest production also makes it difficult for landowners to secure loans early in the rotation.

In the Base Case simulation of forestry returns, it was assumed that the landowner did not need to borrow to establish each regeneration regime. If the landowner must borrow, then the net present value of the computed returns to forest production will be reduced by the cost of carrying the loan. Borrowing costs will vary according to the extent by which the loan rate exceeds the discount rate.

Table III-1 presents the borrowing costs landowners would face for a five-year loan at an 8 percent loan rate to cover the establishment costs of the silvicultural regimes included in this study. The  $NPV_{Ref}$  realized by a landowner who borrows to cover establishment costs will be lower than the Base Case  $NPV_{Ref}$  by the amount of the borrowing costs incurred.

Therefore, when the landowner must borrow at a loan rate that exceeds the discount rate to finance reforestation costs, the profitability of forest production is reduced. This result illustrates the importance of cost sharing programs for relaxing the borrowing constraints landowners face.

## Tax Concerns

If landowners reforest, their income is subject to different taxes than those paid under agricultural production. Under agricultural production landowners are required to pay property taxes to state governments and both federal and state income taxes. These taxes can be paid from current farm income earned on the land. However, a landowner who switches to forest production is subject to property taxes for forest land. If forest tax credits and special tax treatments can be used to reduce the landowner’s tax burden relative to the tax burden with agricultural production, then there is some compensation for the increased risk of forest production.

**Table III-1. Borrowing costs of selected reforestation regimes at an 8 percent loan rate**

<i>Silvicultural Regime</i>	<i>Amount needed to cover establishment costs (\$/acre)</i>	<i>Annual Payment if financed over 5 years (\$/acre/yr) (8 percent loan rate)</i>	<i>NPV of Total Loan Payments over 5 years</i>	<i>Borrowing Costs</i>
Nuttall oak	204.34	51.00	\$220.78	\$16.44
Cottonwood	199.54	49.80	\$215.60	\$16.06
Cottonwood-oak	234.24	58.46	\$253.09	\$18.85

In addition, forest landowners face state harvest taxes, and special types of federal income taxes. The Base Case simulation results account for differences in harvest and property taxes between agricultural and forest uses. However, the results ignore three types of policies that will affect the forestry returns of a specific landowner: reforestation tax credits, capital gains taxes, and estate taxes.

### Reforestation Tax Credits

Reforestation tax credits, which are applied against federal income tax liability for regeneration expenses incurred by the landowner, can encourage reforestation.<sup>2</sup> Because this is a tax credit, the extent of landowner benefits depends on the landowner's income. Generally speaking, a landowner who has substantial income (or who is in a high tax bracket), or one who has recently harvested a large timber sale and then re-established the forest, will benefit the most from the program.

In most cases, the reforestation expenses can be credited against federal income tax in the year the expenses are incurred. Generally, no more than 10 percent of the regeneration expense (\$10,000 total) is eligible to be credited. However, the landowner has a choice of when to take the credit. It can be taken immediately in the year reforestation costs are incurred, or it can be amortized and credited up to eight years after reforestation. Taking the credit immediately will improve the net present values for forest production the most. This would be the recommended strategy for a landowner who is risk averse.

The landowner's eligibility for the reforestation tax credit also depends on whether the landowner has received cost sharing payments for reforestation, and how cost sharing payments are declared on the landowner's federal tax return. The landowner has the option of either reporting cost sharing payments as income, or not reporting the payments. If the landowner reports cost share payments, then the reforestation expenses can be deducted against the landowner's income tax in the year of reforestation, but only to an amount equal to the cost share payment.

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<sup>2</sup> A detailed discussion of forest taxes and incentives and their effect on the forest landowner's reforestation decision is beyond the scope of this study. An excellent current reference for these issues is Siegel et al. (1995).

These expenses can also be amortized and deducted later. However, if the landowner does not report cost share payments as income, then they can take as a deduction only the amount that they paid out of their own pocket beyond what they received in cost share payments. Like reforestation expenses, yearly management expenses can also be deducted from federal pre-tax income.

### Capital Gains Taxes

A landowner who holds forest for profit is subject to capital gains taxation at harvest. A capital gains tax is levied on the appreciation in value of the timber using the value of the bare land as a basis in determining appreciation.<sup>3</sup> However, whether the landowner is better or worse off with a capital gains tax than with agricultural taxation depends on several factors. In general, if a forest landowner reports income from harvests as ordinary income on their federal return, then their total tax bill will be higher than if they declare the timber sale as a capital gain. This is because, as of 1995, capital gains tax rates are lower than those applied to ordinary business income. Thus, there may be tax advantages for the agricultural producer who converts to forest production.<sup>4</sup> Generally, the benefits for conversion will depend on the income of the agricultural producer and the scale of their operation.<sup>5</sup>

### Estate Taxes

Many farmers who establish forest production in a long lived species like Nuttall oak may choose to bequeath the timber to their heirs. In this case, there may be estate taxes applied to the value of bequests that are different from inheritance taxes that would apply if the landowner continued with agricultural production and then willed the family farm over to his/her heirs.

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<sup>3</sup> Details of these computations can be found in Klemperer (1996).

<sup>4</sup> In addition conservation easements, where available, may be used by the landowner to lessen the capital gains tax burden.

<sup>5</sup> In the literature on forest taxation, preferential capital gains treatment is introduced as a reduction in the interest rate facing the forest landowner. Using this assumption, Tables V-A-F indicate the impacts on landowner profitability switching from ordinary income taxation to capital gains taxation (at a lower rate) can be substantial.

Conservation easements may help reduce the tax burden of landowners. Under Internal Revenue Code Section 170(h), donors of conservation easements on both existing bottomland hardwood forests and reforested farmland are eligible for both federal income and estate tax breaks. State law in all three states provides for a state income tax deduction for easement donations.<sup>6</sup>

### **Non-Financial Objectives**

Landowners may not need to realize a positive NPV or even a significant cash flow for reforestation to be of interest. This possibility is suggested by the results from a recent survey of private landowners selected randomly from state lists of landowners involved in wetlands restoration under the Wetland Reserve Program or the Fish and Wildlife Service's

Partners for Wildlife program. The study found that only 10 percent of the 305 respondents that participated in the in-depth phone interviews, reported “financial profitability” as an important reason for their choice to participate in the wetlands restoration program. Approximately 50 percent of the same group, however, did indicate that financial assistance was “extremely important” to them (Whitaker 1996).

However, landowners who have limited interest in forestry and who are committed to farm production may not shift a land parcel out of soybean production even if the NPV of doing so is significant and there are strong cash and tax advantages. If the landowner has soybean equipment and is farming a large tract, only a share of which is flood prone, the management time needed to reorient a small part of the whole business may be more than is deemed warranted.

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<sup>6</sup> Information from personal correspondence with T. Logan Russell, Delta Land Trust.

**Table III-A. NPV of Forestry Returns at a 7 percent Discount Rate, Mississippi**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$81.46	-\$103.05	-\$81.46	\$73.35	N/A	-\$94.27	-\$27.07
Amagon	\$19.18	-\$103.05	\$19.18	\$92.50	-\$32.73	N/A	N/A
Bowdre	-\$92.25	-\$103.05	-\$81.46	-\$32.73	-\$53.27	N/A	N/A
Dundee	\$19.18	-\$103.05	\$19.18	\$92.50	\$54.20	\$202.73	\$208.50
Forestdale	N/A	-\$103.05	N/A	-\$32.73	N/A	N/A	N/A
Mhoon	-\$92.25	-\$103.05	-\$92.25	\$73.35	N/A	N/A	N/A
Newellton	-\$81.46	-\$103.05	\$19.18	\$73.35	-\$53.27	N/A	N/A
Sharkey	-\$92.25	-\$113.84	-\$92.25	-\$32.73	-\$53.27	\$27.98	\$30.71
Tensas	-\$92.25	-\$103.05	-\$92.25	-\$22.46	-\$53.27	N/A	N/A
Tunica	N/A	-\$113.84	N/A	-\$32.73	N/A	\$3.74	\$12.42

**Table III-B. NPV of Economic Returns ( $NPV_{ret}$ ) (Forestry Returns Discounted at 7 percent), Mississippi**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$385.56	-\$407.15	-\$385.56	-\$230.75	N/A	-\$398.37	-\$331.17
Amagon	-\$284.92	-\$407.15	-\$284.92	-\$211.60	-\$336.83	N/A	N/A
Bowdre	-\$396.35	-\$407.15	-\$385.56	-\$336.83	-\$357.37	N/A	N/A
Dundee	-\$284.92	-\$407.15	-\$284.92	-\$211.60	-\$249.91	-\$101.38	-\$95.60
Forestdale	N/A	-\$407.15	N/A	-\$336.83	N/A	N/A	N/A
Mhoon	-\$396.35	-\$407.15	-\$396.35	-\$230.75	N/A	N/A	N/A
Newellton	-\$385.56	-\$407.15	-\$284.92	-\$230.75	-\$357.37	N/A	N/A
Sharkey	-\$396.35	-\$417.94	-\$396.35	-\$336.83	-\$357.37	-\$276.12	-\$273.39
Tensas	-\$396.35	-\$407.15	-\$396.35	-\$326.56	-\$357.37	N/A	N/A
Tunica	N/A	-\$417.94	N/A	-\$336.83	N/A	-\$300.37	-\$291.68

**Table III-C. NPV of Forestry Returns at a 7 percent Discount Rate, Louisiana**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$118.80	-\$135.87	-\$118.80	\$42.93	N/A	-\$133.61	-\$57.28
Amagon	-\$41.11	-\$135.87	-\$41.11	\$61.74	-\$60.65	N/A	N/A
Bowdre	-\$127.33	-\$135.87	-\$118.80	-\$60.65	-\$80.81	N/A	N/A
Dundee	-\$41.11	-\$135.87	-\$41.11	\$61.74	\$24.13	\$151.38	\$168.94
Forestdale	N/A	-\$135.87	N/A	-\$60.65	N/A	N/A	N/A
Mhoon	-\$127.33	-\$135.87	-\$127.33	\$42.93	N/A	N/A	N/A
Newellton	-\$118.80	-\$135.87	-\$41.11	\$42.93	-\$80.81	N/A	N/A
Sharkey	-\$127.33	-\$144.40	-\$127.33	-\$60.65	-\$80.81	-\$16.30	-\$2.26
Tensas	-\$127.33	-\$135.87	-\$127.33	-\$50.57	-\$80.81	N/A	N/A
Tunica	N/A	-\$144.40	N/A	-\$60.65	N/A	-\$39.57	-\$19.81

**Table III-D. NPV of Economic Returns (NPV<sub>Ref</sub>) (Forestry Discounted at 7 percent), Louisiana**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$422.90	-\$439.97	-\$422.90	-\$261.17	N/A	-\$437.71	-\$361.38
Amagon	-\$345.21	-\$439.97	-\$345.21	-\$242.36	-\$364.75	N/A	N/A
Bowdre	-\$431.43	-\$439.97	-\$422.90	-\$364.75	-\$384.92	N/A	N/A
Dundee	-\$345.21	-\$439.97	-\$345.21	-\$242.36	-\$279.97	-\$152.72	-\$135.16
Forestdale	N/A	-\$439.97	N/A	-\$364.75	N/A	N/A	N/A
Mhoon	-\$431.43	-\$439.97	-\$431.43	-\$261.17	N/A	N/A	N/A
Newellton	-\$422.90	-\$439.97	-\$345.21	-\$261.17	-\$384.92	N/A	N/A
Sharkey	-\$431.43	-\$448.50	-\$431.43	-\$364.75	-\$384.92	-\$320.41	-\$306.36
Tensas	-\$431.43	-\$439.97	-\$431.43	-\$354.67	-\$384.92	N/A	N/A
Tunica	N/A	-\$448.50	N/A	-\$364.75	N/A	-\$343.67	-\$323.91

**Table III-E. NPV of Forestry Returns at a 7 percent Discount Rate, Arkansas**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$154.05	-\$171.55	-\$154.05	\$12.68	N/A	-\$184.84	-\$103.84
Amagon	-\$72.85	-\$171.55	-\$72.85	\$32.03	-\$94.23	N/A	N/A
Bowdre	-\$162.80	-\$171.55	-\$154.05	-\$94.23	-\$114.94	N/A	N/A
Dundee	-\$72.85	-\$171.55	-\$72.85	\$32.03	-\$6.66	\$33.22	\$71.26
Forestdale	N/A	-\$171.55	N/A	-\$94.23	N/A	N/A	N/A
Mhoon	-\$162.80	-\$171.55	-\$162.80	\$12.68	N/A	N/A	N/A
Newellton	-\$154.05	-\$171.55	-\$72.85	\$12.68	-\$114.94	N/A	N/A
Sharkey	-\$162.80	-\$180.30	-\$162.80	-\$94.23	-\$114.94	-\$95.09	-\$70.94
Tensas	-\$162.80	-\$171.55	-\$162.80	-\$83.87	-\$114.94	N/A	N/A
Tunica	N/A	-\$180.30	N/A	-\$94.23	N/A	-\$112.89	-\$84.37

**Table III-F. NPV of Economic Returns (NPV<sub>Ref</sub>) (Forestry Returns Discounted at 7 percent), Arkansas**

<i>Soil Type</i>	<i>Sycamore</i>	<i>Green Ash</i>	<i>Sweet Gum</i>	<i>Nuttall Oak</i>	<i>Water Oak</i>	<i>Cottonwood Plantation</i>	<i>Cottonwood-Oak Intercrop</i>
Alligator	-\$458.15	-\$475.65	-\$458.15	-\$291.42	N/A	-\$488.95	-\$407.94
Amagon	-\$376.96	-\$475.65	-\$376.96	-\$272.07	-\$398.33	N/A	N/A
Bowdre	-\$466.90	-\$475.65	-\$458.15	-\$398.33	-\$419.04	N/A	N/A
Dundee	-\$376.96	-\$475.65	-\$376.96	-\$272.07	-\$310.77	-\$270.88	-\$232.84
Forestdale	N/A	-\$475.65	N/A	-\$398.33	N/A	N/A	N/A
Mhoon	-\$466.90	-\$475.65	-\$466.90	-\$291.42	N/A	N/A	N/A
Newellton	-\$458.15	-\$475.65	-\$376.96	-\$291.42	-\$419.04	N/A	N/A
Sharkey	-\$466.90	-\$484.40	-\$466.90	-\$398.33	-\$419.04	-\$399.19	-\$375.04
Tensas	-\$466.90	-\$475.65	-\$466.90	-\$387.97	-\$419.04	N/A	N/A
Tunica	N/A	-\$484.40	N/A	-\$398.33	N/A	-\$416.99	-\$388.47

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## IV. POLICIES AND PROGRAMS TO ENCOURAGE REFORESTATION

The significant potential benefits from reforestation to the surrounding environment were described in Section I. The results reported in Section II indicated that there were circumstances where the net present value of landowners' income from reforestation was close to being competitive with continued soybean production. However, soybean production does not offer the same environmental services as a forested site. Therefore, in those cases where landowners might be close to indifferent between land uses, public policies to encourage reforestation may be warranted. The effectiveness of these policies in encouraging reforestation need to be assessed both in terms of their effect on NPV and in terms of non NPV considerations. Possible policies and their likely effect on landowners' reforestation decisions are discussed in this section.

### Systems for Improved Cash Flow

Even when positive  $NPV_{Ref}$  is possible, the landowner may not be willing to spend current income for an uncertain future cash flow. One way for landowners to mesh the need for up front reforestation expenditures with cash flow realities is to have a third party provide the up front costs in return for a share of the future timber sales revenues. The landowner provides the land and some modest contribution to annual costs.

In the Delta, some forest companies are willing to share in the costs of reforestation if they are given the "right of first bid-refusal" when the timber is sold at rotation age. Right of first refusal means that the company has the right to submit for consideration the first bid. One example of such a program is Crown Vantage's landowner assistance program. In this case, Crown Vantage will provide free seedlings and advice for site preparation, a savings of \$20-40 per acre for most regimes (personal communication, J. Portwood, Fidler Managed Forest, Crown Vantage). The expansion of such programs would likely make a contribution to landowner interest in reforestation.

A more creative alternative may be the encouragement of a type of "private futures market." Some businesses are less concerned with current liquidity and are willing, for tax and long term investment purposes, to secure some assets having a long term payoff. An example would be a life

insurance company. These businesses might be willing to enter a contractual agreement with the landowner. The landowner might sell all future rights to timber harvest, and perhaps other associated but speculative returns from the forest. In return the landowner might receive an immediate payment that would offset the costs of establishing the forest and that eliminates all future uncertainty about the timber returns. That payment would be based on the expected NPV for the timber adjusted for risk. There are reasons to believe that if this market were well established and the timber industry was secure, then this risk adjustment would be minimal.

### Hunting Leases as an Income Source

Hunting lease income can be realized from soybean fields and from reforested land. When considering reforestation a landowner might believe that the potential return from hunting leases will be higher from a forested tract than a soybean field. If this is the case, hunting lease income might provide an annual cash flow that would increase the  $NPV_{Ref}$ . However, the market value of hunting leases is site specific, depending upon the forest species established and how neighboring landowners manage their land. Section I reported that bottomland hardwoods, or mixed cottonwood-oak forests provide the greatest potential for huntable wildlife production. Landowners who are nearer to urban centers have a greater potential for sale of hunting leases. Also, for the landowner to be successful leasing land, a substantial amount of acreage needs to be reforested, especially for deer habitat. If neighboring landowners also reforest, then there is an increased chance of securing a high price for hunting leases. However, if these same landowners also sell hunting leases, then the price may be depressed.

Hunting leases for all lands, both forested and soybean fields, generally average \$3-5 per acre per year for deer habitat throughout the U.S. Hunting leases for deer habitat in the Delta can be as much as \$20-30 per acre annually and substantially more for duck habitat when duck holes are present near established forest. Leases for duck hunting average \$9 per acre annually and can be as high as \$5,000 per duck blind annually on sites with high quality habitat. Other evidence suggests that these are high prices for the region.

Tables II-I, II-K and II-M can be used to determine the annual hunting lease payment, net of prospective lease income from the soybean field, that would make  $NPV_{Ref}$  zero. The amount of the net lease income needed equals the amount of income that would be required to bridge the gap between soybean and forestry returns on an annual basis (i.e., any negative values reported in Tables II-I, II-K and II-M).

A landowner would need to receive \$5-15 per acre per year from hunting leases for bottomland oak reforestation, over and above lease income from soybean fields, to make reforestation as profitable as soybean production. Interplanted oak and cottonwood only requires \$2-14 per acre in net annual hunting lease income on better sites. Referring to Tables III-A through III-F, when forest land is associated with increased risk for the landowner, the annual income from nonforest on-site opportunities must be substantially larger (as much as \$25 per acre per year) to make forestry more profitable than continued soybean production. Of course, if the landowner hires a brokerage firm to locate hunters and sell the rights to hunt, then the landowner would need to be paid slightly more to compensate for the brokerage fees.

The net present value figures assume that the landowner manages the forest to maximize timber profits. One possible market barrier to the development of extensive hunting markets for deer is a possible incompatibility of hunting potential and timber production. Wildlife management, while consistent with timber harvesting, may require different types of harvesting than managing the forest for profits. For example, deer require small openings within mature hardwood forests. Yet harvest prices are typically highest as the size of the tract increases. Other recommendations for wildlife include seeding of log decks and logging roads after harvesting. This is an additional cost incurred by the landowner and it may reduce access to the land in the future, thus decreasing harvest prices for the next rotation. If a landowner seeks to maximize hunting potential on the land, then the net returns to forest production may be reduced. On the other hand, the fact that the owner may have a personal interest in hunting and the fact that lease income provides an annual cash flow may offset landowner concerns about reduced NPV.

Opportunities to expand hunting lease sales warrant additional consideration as a means of encouraging reforestation. While there are market limits to the price of leases, limits that may be

lowered if lease supply expands, the cash flow possibilities and the mesh of lease sales with personal goals of some landowners make policies to expand hunting lease sales an attractive reforestation incentive.

### **Government Conservation Programs Encouraging Reforestation**

Two conservation programs administered by the US Department of Agriculture (USDA), the Wetlands Reserve Program (WRP) and Conservation Reserve Program (CRP), offer landowners compensation for substituting conservation practices for agricultural production on environmentally sensitive lands.

#### Conservation Reserve Program

By participating in the Conservation Reserve Program, landowners receive annual rental payments from the government in return for placing their environmentally sensitive sites into conservation practices for 10-15 years. The required conservation practices include establishment of a cover crop, which can include forest cover. The landowner also receives cost-share payments to assist in covering the costs of re-establishing land cover.

While historically the Conservation Reserve Program tended to target primarily highly erodible lands, under the Federal Agricultural Improvement and Reform Act of 1996 (commonly referred to as the 1996 Farm Bill) CRP eligibility requirements and ranking criteria were adjusted to ensure that farmed wetlands and cropland associated with non-cultivated wetlands would also be candidates for CRP enrollment.<sup>1</sup> Sites may also be eligible for the CRP if

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<sup>1</sup> After meeting the base CRP eligibility criteria, applicants are ranked using an "Environmental Benefits Index" (EBI). The EBI ranks a site according to the extent it contributes to particular measures of environmental quality. Some of the water quality benefits included in these measures can be associated with the restoration of Delta forested wetlands, including the reduction of erosion and runoff. Another factor considered in the EBI is the potential for "long-term" environmental benefits extending beyond the life of the initial contract due to the establishment of a more permanent form of land cover, such as trees. Depending upon the intended definition of "long-term," it's possible that a landowner establishing a sixty year rotation may earn points under the EBI for the long-term benefits incurred during the course of the sixty year rotation.

they fall within a National or State Conservation Priority Area. Although, to date no National Conservation Priority Areas are designated in the Delta, the Farm Service Agency has the authority to recommend that up to 10 percent of a state's cropland be designated as a State Conservation Priority Area, rendering it eligible for the CRP (NRCS 2/97).

An established formula is used to calculate the appropriate CRP rental rate for a site. Rental rates are not to exceed local market values, although additional amounts (not to exceed \$5/acre/year) may be offered in return for certain maintenance activities (NRCS 2/97). Rates are calculated using an established formula that utilizes the county average dryland cash or cash rent equivalent rental rates adjusted for site specific characteristics affecting soil productivity. For lands designated as "cropped wetlands", landowners may receive a one-time incentive payment above and beyond the established rental rate in return for restoring the hydrology of the site (NRCS 2/97).

#### Wetlands Reserve Program

Following reauthorization under the 1996 Farm Bill, the Wetlands Reserve Program offers eligible landowners three alternative means of acquiring compensation for ceasing agricultural production and restoring croplands to their original state as wetlands. Landowners may receive compensation through permanent or 30-year easements. Alternatively, they have the option of entering into a restoration cost share agreement (USDA 1996).

Under a permanent easement, agricultural production is restricted in perpetuity, required conservation practices are implemented and the landowner receives an easement payment equal to the lesser of: (1) the estimated agricultural value of the land, (2) an established payment cap, or (3) the amount offered by the landowner. The government also pays one hundred percent of all restoration costs under a permanent easement. The 30-year easement alternative provides landowners with seventy five percent of the amount they would have received under a permanent easement as well as seventy five percent of the cost of restoration (NRCS 1997).

Landowners opting to enter into a restoration cost share agreement do not receive an easement payment as reimbursement for the restoration site provided. Instead, in return for agreeing to restore degraded wetland habitat for a minimum of ten years, the

landowner receives a cost share payment equivalent to seventy five percent of the cost of the restoration measures taken (NRCS 1997).

#### Conservation Program Payments Required to Equate Forestry and Soybean Returns

The returns to reforestation computed in Section II can be used to determine what the landowner would have to receive in order for reforestation to become profitable under circumstances where soybean returns are greater than forestry returns. Tables II-H, II-J and II-L report the NPV of economic returns ( $NPV_{Ref}$ ) for all combinations of tree species and soil types examined in each state. Any negative  $NPV_{Ref}$  reported can be interpreted as the amount of income a landowner would need to receive as a one-time, up-front conservation program payment, such as might be received for the sale of a permanent easement under WRP, in order for reforestation to be as profitable as soybean production.

If, instead, the landowner received conservation program payments annually, say in the form of CRP rental payments (or WRP installments), any of the negative annual equivalent values recorded in tables II-I, II-K and II-M describe the size of the annual payments a landowner would need to earn in each of the sixty years for reforestation to be as profitable as soybean production.

Tables II-20, II-21 and II-22 present the reforestation regimes that produce the *least negative* per acre  $NPV_{Ref}$  in each state. The corresponding annual equivalent values are in parentheses beside each  $NPV_{Ref}$  reported. These are the forestry regimes that require the smallest annual or up-front payments in order to bridge the gap between forestry and soybean returns.

The majority of the reported  $NPV_{Ref}$  are negative since soybean returns are higher than forest production returns. Exceptions are cottonwood-oak in Mississippi and Arkansas, which have higher returns compared to soybean production on the better soils. Some Nuttall oak plantations on better sites in Mississippi also have positive  $NPV_{Ref}$ . This is due to the higher prices and cost sharing payments in Mississippi. Also, note that forestry returns were computed including cost sharing payments from applicable landowner assistance state and federal programs. However, these programs are similar to the cost share arrangement present with

WRP enrollment and maintenance so that no adjustment is needed.

Amagon, Alligator, and Dundee soils support the most profitable forest production. Nuttall oak, interplanted cottonwood/oak, and pure cottonwood reforestation regimes are the most profitable across states for these soil types. For Nuttall oak reforestation, roughly \$130 - 205 are required per acre in WRP payments when the easement is sold for the  $NPV_{Ref}$  to be zero. Required payments are highest in Arkansas and lowest in Mississippi, reflecting differences in prices, taxes and cost sharing provisions between the two states. On an annual basis, a landowner would need to receive approximately \$7 - 11 per acre per year in CRP rental payments or WRP installments for  $NPV_{Ref}$  to be zero. These amounts are certainly possible at existing prices and WRP payments in the Delta.

Overall, the cottonwood/oak interplanting regime requires the least amount of up front and annual payments to make  $NPV_{Ref}$  zero. In Louisiana and Arkansas, roughly \$32 - 176 per acre for an easement sale, or \$1.73 - 9.30 per acre in annual rental income is required. Pure cottonwood forests generate high returns relative to the other regimes. In Louisiana and Mississippi, this regime is more profitable than soybean production on Dundee soils, even without WRP payments. However, a pure cottonwood stand is not compatible with the current requirement of WRP participation concerning mast producing tree species. In many cases, especially in Mississippi, Nuttall oak on good soils is more profitable than agriculture at current costs and forecasted prices.

Perhaps most significantly, the WRP has the benefit of addressing the cash flow concerns associated with reforestation. By making a significant cash payment to the landowner upon enrollment, the concerns over uncertain timber yields and prices are alleviated. When it is recognized that current WRP payments are far in excess of the amount calculated to make  $NPV_{Ref}$  zero, the attractiveness of the program to an individual landowner is clear. While these high payments may be seen as desirable for a single landowner, they are made from a limited WRP budget and so reduce the number of acres that can be enrolled.

The WRP and CRP can offer landowners a significant inducement to reforest; but, there are unresolved issues that must be addressed if either program is to encourage reforestation. The potential of

these two programs as supplemental income sources may be limited by the conservation requirements included in a WRP easement or CRP contract. For example, landowners deciding to enroll land into WRP must agree to establish some proportion of the land designated with mast-bearing (oak) species.<sup>2</sup> This requirement means that pure cottonwood stands are not a feasible alternative, yet they are the most profitable. Although the cottonwood-oak interplanted regime is compatible with the mast requirement later in the rotation, it is not when the site is regenerated. Thus, the WRP payment required to make  $NPV_{Ref}$  equal to zero will rise if cottonwood is not an eligible species.

Furthermore, it is not always clear what types of commercial activities will be allowed under a WRP easement or CRP contract. For example, although WRP landowners are clearly permitted to sell leases to recreational activities that are compatible with the program's restoration objectives, such as hunting or fishing, it is not clear what types of timber harvesting (or frequencies) are allowed under the current WRP definition. While landowners may receive permission to engage in timber harvests, any such commercial activities must be "...fully consistent with the protection and enhancement of the wetland" (NRCS 1997). Allowable practices appear to vary by state. This uncertainty must be addressed because the necessary payment that was computed for this study assumes that standard harvest practices are used.

Confusion over tax treatment of land enrolled in the WRP must also be eliminated. Landowners who enroll will certainly face lower tax burdens under the WRP if income is declared as capital gains income. However, there is much debate about how WRP revenues are taxed. Currently there are two opinions--first, income from the initial sale of land is subject to capital gains tax and then the capital gains tax is applied at harvest. The basis for the capital gain is related to the purchase price of land at WRP enrollment and some measure of the purchase price of land. The second opinion is that yearly rental income is taxed at capital gains rates. Tax implications are also different for 30 year and permanent easements.

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<sup>2</sup> In Mississippi the requirement is that 2/3 of the site must be established in mast-bearing species, but this requirement is subject to change.

Finally, the WRP enrollment process is competitive. Both WRP and CRP have base eligibility requirements that must be met before a site will be considered for enrollment. For example, to be considered eligible for CRP enrollment, a site must have been planted to an agricultural commodity in at least two of the most recent five years. A site must also meet at least one of the designated descriptions of environmentally sensitive sites eligible for CRP enrollment. Lands designated as cropped wetland or cropland associated with non-cropped wetland are included in the list of eligible sites. Similar eligibility criteria for WRP require that a site must be considered both restorable and likely to provide wildlife benefits (NRCS 1997). Additionally, former wetlands converted after December 23, 1985 are ineligible for WRP, as are lands on which timber has been established under CRP (NRCS 1997).

Even if deemed eligible, landowners are not guaranteed enrollment upon applying. Rather, eligible applicant sites are further evaluated according to a set of criteria that includes both the environmental benefits and the costs of acquiring the WRP easement or CRP contract. Applicant sites are ranked according to these factors and only the highest ranked are enrolled. Because landowners are not guaranteed enrollment upon applying, they may view applying as a cost, particularly if they think there is a lower probability of acceptance. Under the old Farm Bill, this was particularly true of landowners seeking 30 year easements. However, given the additional risk present for forest investments, 30 year easements may be more attractive than permanent set asides.

### **Create New Market Opportunities**

In recent years, there has been significant interest in creating markets to financially reward producers of environmental services. For example, people downstream of a reforestation site may benefit from the service of reduced river channel sedimentation. If those beneficiaries pay a landowner who reforests, then a market for sediment reduction exists. Such markets could replace or supplement general government cash transfers or tax subsidies as the way to offer a financial reward for reforestation activity.

The creation of markets for environmental services requires significant public initiative and oversight. Such requirements include the need for the public to: 1) define the product that will be bought and sold, often called an environmental "credit," 2) create the

demand for the credits, and 3) create and manage a system of exchange of credits for money between buyers and sellers. Consider again the example of sediment reduction from reforestation. First, there needs to be a certification of the amount of sediment reduction that occurs from any scale and practice of reforestation -- the "credit." Such certification offers both buyers and sellers an independent judgment on the credits available to be traded.

Once the credit is defined, public policy must create an effective demand for that credit. Creating effective demand means assuring that cash payments will be offered for the credits provided. For example, if the public instituted a rule that required anyone who creates a new sediment source to buy sediment reduction elsewhere, then public policy has created an effective demand for the sediment reduction credits of reforestation.

Last, the public may need to manage a system of exchange that can help willing buyers and willing sellers come together. For example, there may need to be a clearinghouse where people can get their sediment reduction credits certified, registered, and then listed for sale. Prospective buyers of credits could use this listing rather than seeking out individual landowners who might be willing to reforest for sediment reduction.

There are three market concepts that are currently under consideration and that might be relevant to reforestation: payments for carbon sequestration credits, wetlands mitigation credit sales, and water pollution control credit sales. The possibility for these markets to emerge and result in positive prices for reforestation credits are considered next.

### Payments for Carbon Sequestration

As discussed previously, trees -- and hence reforestation -- act as a sink for atmospheric carbon. Suppose that an area has 10,000 acres of soybean land and that land might be planted to cottonwood. Further, suppose that each year 1,000 acres of the forested land is harvested for wood pulp that is used in the manufacture of paper. The paper once used might be disposed of, releasing the sequestered carbon into the atmosphere. The acres are then replanted the following year. As a result, 90 percent of the land always has trees that are sequestering carbon in some stage of their maturity.

Under this scenario, the net carbon sequestration for the 10,000 acres over a ten-year period, versus having the land in soybeans for the same period, could be calculated. The result would be an estimate of the “permanently” sequestered tons of carbon for the 10,000 acres. Each forested acre could be ascribed a permanent carbon sequestration credit, even if that acre is harvested once every 10 to 15 years.

The concern over global warming and the recognition that carbon dioxide is a greenhouse gas has led to international agreements to limit CO<sub>2</sub> emissions from each nation. However, as economies grow and energy consumption rises, CO<sub>2</sub> emissions will rise. This rise could be offset by reforestation to sequester atmospheric carbon. In a market for carbon sequestration, emitters of new CO<sub>2</sub> could offset such increases by paying landowners who reforest and creating carbon sequestration credits. The amount buyers would be willing to pay for a sequestration credit would depend upon the value of the products associated with the increased CO<sub>2</sub> emissions in relation to the cost of a reforestation payment and in relation to the cost of alternative ways available to offset the CO<sub>2</sub> increase. The willingness to reforest to create credits for sale would depend upon landowners’ reforestation costs, returns from other compatible uses of the trees (e.g., harvest for pulp) and their financial objectives. In fact, the management of a tract for carbon storage may require special attention. Moulton and Richards (1990) and Richards et al. (1993) compared costs of various tree planting regimes designed to maximize carbon uptake.

In an operating market, the price of a carbon sequestration credit would be set by the aggregate demand and supply for credits. This price would be available to any landowner who might consider reforestation credit development in lieu of continued agricultural production. While the carbon payments alone might not be adequate to compensate a landowner for reforestation, these carbon payments, when combined with other possible sources of income, might tip the balance toward reforestation over continued farming.

The carbon sequestration credit market requires three features, none of which are yet present. First, there needs to be some public agency that defines and certifies carbon sequestration credits from different reforestation approaches at the individual land parcel level. The science is sound for the individual tree species and adjustments can be made for harvest

activity and release of sequestered carbon. However, there is no public authority in place that is presently certifying credits. Also, as the scenario described above illustrates, the credits need to be defined as part of a general region with a specific harvest rotation. Therefore, the landowner who reforests for the carbon sequestration market must have control over significant acreage or there will need to be some institutional means developed to assemble many smaller tracts into a larger seller of credits.

The second requirement is the most problematic. There is no enforcement associated with the achievement of a no net increase goal. Unless government acts to buy credits on behalf of the whole economy, no single CO<sub>2</sub> producer has an incentive to buy sequestration credits to offset new emissions because there is no effective limitation on CO<sub>2</sub> emissions at any source. The best that can be hoped for at this time is that there will be some voluntary purchase made by large scale emitters, perhaps in an effort to head off regulatory action. However, there is no evidence of large scale voluntary purchases at this time.<sup>3</sup> The possibility of selling “carbon credits” may increase as future carbon storage policies are implemented at the domestic and international level (Calloway et al. 1993).

An emerging carbon sequestration credit market may need to be facilitated to help buyers and sellers locate each other and to assure that large areas of reforestation occur so that the credits are defined as part of a large watershed area. The market may need to be organized around landowner cooperatives to get large scale assurance of permanent credits while harvest occurs.

#### Pollution Allowance Credit Sales

Recent concerns for hypoxia in the Gulf of Mexico have been associated with nutrient enrichment. At the same time, heavy sediment loads are common in many streams in the Delta. Forested wetlands, when compared with farmed wetlands, have lower sediment and nutrient loading factors. Therefore, reforestation of currently farmed lands may be one means to improve water quality parameters downstream of the reforested site.

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<sup>3</sup> As an exception to this statement, Norway recently purchased 200,000 tons worth of carbon bonds from Costa Rica for an estimated 1 million dollars (Tico Times 1997). However, trading on a large scale has yet to occur.

Recently the USEPA has encouraged effluent allowance trading as a means to achieve water quality improvement at the lowest possible cost. This market based strategy is designed to encourage pollution sources with high control costs to pay those with lower control costs to provide required pollution control. If there are no concerns over location effects, a unit of sediment or phosphorus reduction from one site, say from an urban best management practice, would be equivalent to a unit of reduction at another site from, say reforestation. Therefore, the quantification of the product to be traded for this market is less complicated than would be quantification of credits in a carbon market. Nonetheless, it would be necessary for there to be some quantification of the sediment or nutrient reduction from an acre of reforestation for a market in these services to emerge.

However, there is no policy in the region or the nation that requires pollution sources to reduce sediment or nutrient discharges. These are not criteria pollutants under the Clean Water Act. Therefore, even if the units of reduction could be established, there is no reason for a polluter in one location to make payments to a landowner for reforestation that would offset that discharge. The presence of such a “cap” on discharge is a limit on the “allowances” for discharging the target pollutant. Sources with different control costs exchange allowances so that those with the higher costs purchase allowances and continue to discharge while those with lower costs assume pollution control responsibility in return for a cash payment for selling their allowances. A variation on this approach is for a polluter to simply purchase reductions from any willing seller and those reductions are then used to allow increased discharges at their location. While there is much encouragement of effluent allowance trading, the opportunity to tap into such a market in the near future seems limited.

#### Wetlands Mitigation Credit Sales

The national goal for wetlands is to achieve no net loss and then a net gain in area and function over time. The “net” refers to the need to secure wetlands restoration whenever a current wetland is degraded by an economic activity. Under Section 404 of the Clean Water Act, compensatory mitigation required for permitted wetlands fills has been subject to priorities, where the first priority is to make the wetlands replacement on-site (i.e., as close as possible to the permitted activity). However, some permit recipients have been allowed to develop a single off-site

restoration or creation project to offset wetland losses caused by one or more of their own development projects. This is the general understanding of a *single user mitigation bank*. More recently, private (or government) entities have restored or created wetland credits (as measured by acres or some index of wetland function) for sale to permit recipients. Some permit recipients have been allowed to satisfy their compensatory mitigation requirements by paying these credit suppliers who provide the required compensation. The shift from single user banks to private credit sales encourages technical specialists to establish wetland credits and directs replacement wetlands to the most ecologically beneficial locations. Guidelines published in the *Federal Register* on November 28, 1995, are intended to further encourage private firms to create wetlands credits for sale to recipients of fill permits.

The 1996 farm bill authorized the USDA to expend funds on a pilot program to assist landowners in creating mitigation credits. This provision, which is currently restricted to the Prairie Pothole region, remains under review and has drawn concern that if implemented it might provide a federal subsidy to landowners who create credits that they would then sell in competition with the newly emerging private sales ventures.

Reforestation of farmed wetland soils with bottomland hardwood species may be viewed as wetlands restoration. Such restoration might be done in order to develop wetlands credits for sale to those who might need to purchase such credits to satisfy the Section 404 or swampbuster requirements. These sales would provide a source of income that might increase the computed NPV of reforestation.

For this market option to be practical, the landowner who seeks to sell credits must get their credits certified by a wetlands regulatory agency. Certification is based on the landowner documenting and measuring the additional wetlands characteristics that are established by the reforestation. Based on such information a regulatory agency certifies some number of wetlands credits for sale. The cost of gaining certification can be high and the delays are numerous. However, new federal guidance is intended to shorten this time to approval.

Once credits are certified, the price received may be quite high. Most of the demand for credits comes from residential and commercial developers who are

willing to pay significant premiums in order to retain land at their site for development rather than for mitigation and to shorten the time of the fill permitting process. If bottomland hardwoods are filled, then the regulatory agencies may require that each wetlands lost be compensated by purchase of three or four replacement credits. This is often required when there is a long time to full functional maturity of the wetlands as would be the case for bottomland hardwood restoration. Thus, when there is a fill permitted, the recipient of the permit will pay a high price and will demand credits that are several times the losses they create. It appears, at first consideration, that the demand for such credits might be a significant contributor to long term economic returns from reforestation.

The unit price that may be offered may be high and the number of units demanded from any permit recipient may be high, but the overall market is limited. The demand for credits is a function of the development pressure and the option to do mitigation on-site. In the Delta, the development pressure is such that in any year the number of credits demanded may be few.

In addition, the emergence of a true market for credits (many competing sellers) may be limited by “demand side” constraints rooted in wetlands permitting policy. The market demand for mitigation credits arises when an issued wetland permit requires compensatory mitigation. Without regulation of wetland filling, there is no demand for wetland credits. Therefore, the future scope and practice of wetland fill regulation has direct and predictable implications for the economic viability of private credit sales ventures.

- ecological concerns might support a preference for mitigation on or near the site of the fill. This will limit the demand for venture credits which are necessarily at off-site locations. This preference remains strong in permit review.
- environmental concerns about “out of watershed” compensation might limit the geographic service (sales) area of credit ventures. Limitations of market sales area will reduce the demand for credits but such limits are common.
- landowner’s concerns might limit the area defined as wetlands subject to fill placement regulation and/or might limit the requirement for wetland compensation to only certain “categories” of

wetlands. These limitations will sharply reduce the demand for credits, the economic viability of investing in commercial mitigation sales ventures, and the private sectors’ interest in wetland restoration for making mitigation credit sales.

In summary, the continuing debate over the future scope and structure of wetlands regulation may create a significant barrier to the expansion of wetland credit markets.

### **Research for Targeting Technical and Financial Assistance**

In addition to providing the framework for an assessment of the economic feasibility of reforestation at the individual landowner level, the simulation model provides information useful in identifying which lands to target with any reforestation “promotional efforts.” The simulated forestry returns identify which rotations are most likely to prove economically feasible. Regardless of the opportunity cost, the reforestation scenarios yielding the highest possible forestry returns, such as Cottonwood and Nuttall oak on Dundee and Amagon soils, will always yield the greatest positive (or smallest negative) economic returns. Additionally, sensitivity analyses of the results to the Base Case simulation isolate the effects of site characteristics on the economic returns to reforestation and indicate which combinations of site characteristics create conditions that are most conducive to reforestation. This information can be used in conjunction with COE aerial surveys and any available GIS databases to identify where such combinations of site characteristics occur in order to target landowners for technical and financial reforestation assistance.

Targeting also requires information about the landowners themselves. The importance of NPV<sub>Ref</sub>, cash flow, financing, or other issues raised and discussed in Section V to the landowner's reforestation decision depend, in large part, upon who the landowner is. Such information may only be available from specialized surveys. If the limited funds to provide incentives and advice to encourage reforestation are to be best spent, there needs to be improved understanding about who the landowners are and about their motivations and goals for the land they own. A survey study needs to be carefully designed and administered that will determine not only the characteristics of the landowner (farm owner - operators or absentee landowners) but also will elicit

the following: 1) how much land they own, 2) what proportion is comprised of these flood prone clay soils, 3) other forms of income beside the returns off their land, 4) financial feasibility and cash flow returns, 5) non-economic concerns such as, perceptions of social responsibility to improve the environment or personal interest in hunting, 6) willingness to take the risk of an alternative source of income, 7) attitudes toward government programs, and 8) interest in participating in new markets such as carbon sequestration. Other dimensions of the landowners goals and attitudes would also need to be explored.

### **Diminish the Implicit Crop Insurance Subsidy to Soybean Agriculture**

There is a common perception that the federal crop insurance program is a significant subsidy to continued soybean agriculture on flood prone soils. In turn, policy reforms might be proposed that will reduce the possible incentive of crop insurance on continued agriculture. For the validity of this assertion to be evaluated and for policy reforms to be described, requires a detailed understanding of the federal crop insurance program design.

To the extent that federally subsidized crop insurance coverage contributes to the net returns to soybean production, it reduces the economic returns to reforestation. Crop insurance coverage can increase or reduce the soybean returns, depending upon whether the level of compensation received (the “indemnity”) exceeds or falls short of the premium paid for the policy.

#### Catastrophic Coverage

Indemnities received under a Catastrophic (CAT) policy are calculated based on the lowest available level of coverage; a 50 percent yield guarantee at 60 percent of the FCIC-estimated market price (hereafter abbreviated as 50/60)<sup>4</sup>. The premium for a CAT policy is fully subsidized by the federal government. Therefore, catastrophic coverage increases the net returns to soybean production by the amount of the expected value of the indemnity. Expected crop insurance indemnities are affected by site characteristics such as the frequency and timing of flooding, the productive potential of the soils on the site that affect soybean yields, APH, and the timing of planting (see summary of effects in Table IV-15).

This means that the magnitude of the contribution of CAT coverage to soybean returns may differ dramatically from location to location, according to changes in these site specific characteristics.

In the Base Case simulation (Section II), the soybean crop insured by a CAT policy yields an annual expected indemnity of \$5.17. Removing the contribution of this expected indemnity results in a decline in the NPV of soybean returns from the Base Case value of \$304.10/ac to \$206.27/ac. Thus, a \$97.83 dollar increase in the NPV of soybean returns can be attributed to the CAT crop insurance coverage.

The sensitivity analysis provides additional insight into the role of CAT on flood prone soils. Of the fifteen probability set / best possible yield variations made for the sensitivity analysis (Table II-25), the five largest annual expected indemnities (ranging from \$5.68/ac to \$6.34/ac) were earned for the five variations tested at a 40 bu/ac “best possible” yield. Conversely, the five lowest annual expected indemnities (ranging from \$4.26 to \$4.76) were earned by the five variations tested at the lowest “best possible” yield of 30 bu/ac. Therefore, for the specific flooding scenarios defined in the Base Case, a site with high potential productivity will benefit more from crop insurance coverage than will a site with lower potential productivity.

#### Additional Crop Insurance Coverage

A farmer might choose to purchase Additional or “buy-up” crop insurance coverage to realize higher levels of coverage than are provided under a CAT policy. Specifically, when purchasing buy-up coverage the farmer can select a 50 percent, 55 percent, 60 percent, 65 percent, 70 percent or 75 percent yield guarantee at a price election ranging anywhere from 50 percent to 100 percent of the established market price. Additionally, with buy-up coverage the farmer is eligible for partial indemnification for the costs of one replanting if a replanting is required.

The producer pays only a share of the total premium for buy-up coverage, with the rest being subsidized. Because the premium payments are not based on actuarial costs, a buy-up policy can either increase or decrease expected annual soybean returns, depending upon whether the premium paid by the farmer is greater or less than the expected indemnity.

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<sup>4</sup> See Section II, Landowner Perspectives on Reforestation

The ratio of indemnities earned to premiums paid, also called the “loss ratio”, is one measure of the net contribution of a buy-up policy to expected net returns. A loss ratio greater than one means that the expected indemnity exceeds the premium paid. In this case, soybean net returns are higher than they would be without the crop insurance coverage. A loss ratio of less than one means that the policy premium exceeds the expected indemnity and the net returns for soybean production are lowered by the purchase of buy-up insurance. The simulation model can be used to compute loss ratios if a buy-up policy is purchased in lieu of CAT.

If a buy-up policy providing a 65 percent yield guarantee at 100 percent price election (hereafter referred to as 65/100 coverage) is acquired for land designated as high risk under the Base Case, the expected annual premium (\$21.64) exceeds the expected indemnity (\$16.42) resulting in a loss ratio of .76. Thus, acquiring a 65/100 buy-up policy actually results in a net decrease of \$98.78 in the NPV of soybean returns, from the \$206.27 that would be earned without crop insurance coverage, to the \$107.49 earned under the 65/100 policy.

The loss ratio will differ from site to site, according to changes in site specific characteristics of frequency and timing of flooding and soil productivity. For CAT coverage, the effects of changes in site specific characteristics affect only the expected indemnities. Under a buy-up level of coverage, both expected indemnities and expected premiums are affected by site characteristics. Understanding how site characteristics affect the loss ratio requires understanding how crop insurance premiums are calculated.

### *Calculating Crop Insurance Premiums*

The annual premium paid by the producer for a buy-up level of coverage is calculated in two steps. In the first step, the total premium for the policy acquired is determined. Then the percentage of the total premium that is to be paid by the producer after the subsidy is subtracted is calculated. The total premium is calculated as a percentage of the producer's total liability, which is the maximum amount a producer could potentially receive as an annual indemnity, given the level of coverage purchased. For example, the total liability for a producer with an Average Production History (APH) of 35 bushels per acre, who has acquired a policy with a 65 percent yield guarantee

level (ygl) at a price election (pe) of 100 percent of the established market price of \$5.80, equals  $35\text{bu} * 65\text{ percent} * 100\text{ percent} * \$5.80/\text{bu}$ , or \$131.95<sup>5</sup>.

The percentage of the total liability that a farmer is expected to pay as a premium is called the “base premium rate.” The base premium rate times total liability is the dollar amount of the required crop insurance premium for the coverage selected. The base premium rate used in calculating a farmer's premium depends upon (1) the yield guarantee selected by the farmer, and (2) the rate class into which his land is categorized. The higher the yield guarantee selected by the farmer, the greater the base premium rate used in determining his premium.

For purposes of calculating the crop insurance premium, a producer's land is categorized into rate classes. The lower the land's APH, the lower its rate classification. The lower the rate class designation received by the site, the higher the base premium rate used to calculate the premium (and hence the higher the percentage of total liability paid as a premium). The base premium rates are specified by rate class and yield guarantee in actuarial tables prepared by the FCIC for each county (FCI-35 1996). Both the rate classes and base premium rates differ from county to county.

Land which FCIC underwriters deem to be at high risk of flooding is designated as “high risk” and is delineated on county actuarial maps (FCI-33 Actuarial Map)<sup>6</sup>. For each county in which high risk lands are insured, a set of risk adjustment factors are specified in the county actuarial tables (FCI-35 1996). A risk adjustment factor is a percentage by which the premium (calculated as the liability times the base premium rate) is increased to account for the higher risk incurred by insuring the frequently flooded land. Like the base premium rate, the risk adjustment factors differ across rate class designations. Unlike the base premium rates, however, the risk adjustment factor decreases the lower the rate class designation of the site.

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<sup>5</sup> See Section II for a definition of these crop insurance determinants.

<sup>6</sup> The acre of land represented in the Base Case is assumed to be designated as “high risk” land, therefore, the appropriate high risk factor is used to calculate a policy premium.

After the total premium has been calculated and adjusted for a high risk designation, the proportion of the total premium for which the farmer is responsible (i.e., the “producer percentage”), is determined. Producer percentages are listed in the FCIC Producer Premium Percentage Tables for every available price election - yield guarantee combination (CFSA 1996). The total premium is multiplied by the appropriate percentage to calculate the premium paid by the farmer.

The various calculations made in determining the premium are affected by the physical characteristics of a site. For example, the soil fertility and flooding incidences on a site affect the amount of premium paid through their effects on the site's annual yields and hence its APH. The APH, in turn, factors into almost every step of the premium calculation process. APH also determines the rate class under which the site will be categorized. And, the rate class determines which base premium rate and high risk factor are applicable. However, the net effect of an increase in APH on expected premiums is indeterminate. As APH increases, the land is classified at increasingly higher rate classes. A higher rate classification results in a lower base premium rate but increases the high risk adjustment factor. Additionally, it is the likelihood of flooding on a site that distinguishes “high risk” lands for which the high risk factors are used in calculating the premium. Finally, premiums are affected by the geographic location of a site. Because the actuarial tables, which specify the base premium rates and high risk factors, differ from county to county, very different premiums might be paid from county to county for the same level of coverage on comparable sites. These multiple interactions in the determination of rates for a site have been represented in the simulation model.

#### *Effects of Buy-up Coverage on Computed Net Returns*

Based on calculations from the simulation model, it appears that a high risk designation can dramatically reduce the contribution of crop insurance to the profitability of soybean production. For example, *without* a high risk designation, 65/100 coverage under the Base Case produces a loss ratio of 2.04, reflecting an expected indemnity (\$16.42) well in excess of the expected premium (\$8.04). If, however, the acre of land is designated as high risk, the producer pays a risk adjusted expected premium of \$21.64 for the same \$16.42 expected indemnity. Given a high risk designation, the loss ratio declines to .76 indicating a

net reduction in soybean returns due to the purchase of the 65/100 crop insurance coverage.

For the same level of coverage, both crop insurance premiums and indemnities will vary from location to location according to changes in site specific characteristics that affect the frequency and severity of losses due to flooding, as well as determine the site's APH, and determine which county actuarial tables are used to calculate premiums. To examine the change in loss ratio from site to site, the results of the simulation model were used to calculate both the loss ratio and net returns to soybean production, under a 65/100 level of coverage for the same fifteen probability set / best possible yield combinations considered for the sensitivity analysis in Section IV. The land is likely to be high risk, and incorporating high risk into the premium calculation results in loss ratios of less than one for all fifteen scenarios (see above.) Therefore, to isolate the effects of changes to the probability sets and best possible yields of the buy-up coverage, the premiums calculated are not adjusted by high risk factors. The results of the fifteen scenarios are reported in Table IV-1 in ascending order of the size of the loss ratios.

The loss ratio is greater than one for all fifteen scenarios; meaning that expected indemnities are greater than expected premiums in all cases. The five highest loss ratios reported, ranging from 2.3 to 2.52, are produced by the five scenarios in which the highest best possible yield tested (40 bu/ac) is used. These scenarios also produce some of the highest APH's (or expected yields) recorded, ranging from 26.11 to 29.15. This result suggests that sites with higher productive potential (as is measured by the best possible yield estimate), and thus higher APHs, benefit more from a buy-up level of coverage than do sites with lower productive potential<sup>7</sup>.

#### Policy Implications

Acquiring CAT crop insurance coverage will increase the net returns to soybean production if the farmer has any expected loss. The net effect of a buy-up policy on soybean returns depends upon the size of the expected indemnity received, relative to the size of the expected premium paid by the producer. For both CAT and buy-up policies, the extent to which crop

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<sup>7</sup> The loss ratio, however, will also differ with changes in the flooding scenarios. Alternative flooding scenarios that may affect these conclusions were not examined.

**IV-1. Loss Ratios and Net Returns with 65/100 Buy-up Coverage for Lands *Not* Designated High Risk**

<i>Probability Set Variation</i>	<i>Best Possible Yield</i>	<i>Loss Ratio for 65/100 Coverage</i>	<i>NPV Returns with 65/100 Coverage</i>	<i>NPV Returns Without Crop Insurance</i>	<i>Expected Yield (APH)</i>	<i>Expected Indemnity</i>	<i>Expected Premium</i>
Variation I	30	1.68	-\$20.59	-\$129.34	20.37	\$14.21	\$8.46
Variation IV	30	1.68	-\$102.31	-\$206.87	19.58	\$13.66	\$8.14
Variation III	35	1.69	\$552.20	\$438.69	25.51	\$14.63	\$8.63
Variation III	30	1.73	\$180.20	\$78.44	21.86	\$12.78	\$7.40
Variation II	35	2.01	\$503.93	\$341.95	25.14	\$17.07	\$8.51
Variation I	35	2.04	\$364.80	\$206.27	23.76	\$16.42	\$8.04
Variation II	30	2.06	\$133.37	-\$13.03	21.54	\$15.03	\$7.29
Variation IV	35	2.06	\$271.06	\$115.81	22.85	\$15.94	\$7.73
Variation V	35	2.22	\$475.73	\$281.34	24.93	\$18.71	\$8.44
Variation V	30	2.28	\$104.98	-\$70.69	21.37	\$16.51	\$7.23
Variation III	40	2.30	\$973.76	\$798.93	29.15	\$16.35	\$7.11
Variation II	40	2.30	\$897.82	\$696.93	28.73	\$18.76	\$8.14
Variation I	40	2.34	\$737.18	\$541.87	27.16	\$18.02	\$7.70
Variation IV	40	2.37	\$630.09	\$438.49	26.11	\$17.53	\$7.40
Variation V	40	2.52	\$866.34	\$633.37	28.49	\$20.38	\$8.08

insurance contributes to soybean returns varies according to level of coverage selected and particular site characteristics, including the flooding regime on the site, the inherent productive potential of the land, and the geographic location of the site. In the simulation analysis, using 65/100 to represent buy-up coverage reduces net returns if the land is designated high risk. If the land is not high risk, buy-up coverage adds to net returns.

Because the federal crop insurance program has undergone many dramatic reforms during the course of the past decade, it is difficult to draw conclusions about the current and potential future contribution of crop insurance to the profitability of soybean production on frequently flooded Delta agricultural lands, based on records of historical insurance experiences. Since the 1980s, it has been acknowledged that the federal crop insurance program, in many cases, was not an actuarially sound program. As of 1990, program losses for soybean coverage incurred by the Delta states all exceeded the national loss ratio of .84, including a state-wide loss ratio of 1.60 for Mississippi, 1.76 for Louisiana, and 1.42 for Arkansas (Skees 1992). Additionally, prior to 1994, participation in the crop insurance program was, in many cases, quite low as farmers chose to rely on ad-hoc federal disaster assistance payments to off-set any catastrophic losses.

During the course of the 1990s, however, a series of program reforms were implemented in an effort to

both encourage participation in the crop insurance program and to minimize the extent to which indemnities paid out under the program exceeded the total premiums received. In the Omnibus Budget Reconciliation Act of 1993, Congress required that a national average loss ratio of 1.10 (considered "91 percent adequacy") be achieved by October 1995 (GAO 1995). This congressional mandate provided the impetus for the 1994 Crop Insurance Reform Act under which ad-hoc disaster assistance payments were consolidated with the federal Crop Insurance Program, creating a single "on-budget" source of compensation for producers in the event of a crop loss (GAO 1995). Catastrophic coverage was made available, in effect as a substitute for the disaster assistance payments and efforts were made to strongly encourage producers to obtain Catastrophic coverage for all insurable crops.<sup>8</sup> For example, the U.S. Code currently requires that any producer intending to acquire CAT coverage for any one crop in a county, must obtain coverage for all of his crops in the same county. Furthermore, under the 1994 Farm Bill, eligibility for most federal farm support programs required participation in the crop insurance program. Although this requirement was subsequently removed under the most recent Farm Bill, any producer choosing to forgo crop insurance

<sup>8</sup> Even with the availability of Catastrophic coverage, periodic ad hoc disaster assistance is still sometimes provided under presidential disaster declarations following occurrences of greater than normal flooding.

coverage, waives his right to any emergency crop loss assistance.

Recent reforms made to improve the actuarial soundness of the program include:

- the designation of high risk producers and the use of high risk factors to adjust the buy-up premiums paid for coverage of lands designated as high risk (GAO 1995).
- the use of actual production histories in calculating yield guarantees, instead of estimates based on county average yields. Prior to 1994, farmers could choose to calculate their yield guarantee levels at either their own historical production levels (APH) or at a modified county average level of production. By using the modified county average to calculate the yield guarantee for a site with historical yields lower than the modified county average, a farmer would receive a higher coverage base for a production level that is higher than the level he is likely to achieve under normal circumstances. As for the 1994 Crop Insurance Reforms Act, farmers are required to purchase insurance at their actual production levels or on the basis of reduced actual production levels to

prevent them from purchasing insurance for production levels higher than they are actually likely to achieve (GAO 1995).

- the deadline for purchasing crop insurance was moved 30 days earlier in the year to reduce a farmer's ability to predict whether or not insurance will be needed as he gets closer to the planting season (GAO 1995).

These changes in the crop insurance program have significantly altered the policy environment under which producers are making their decisions concerning the levels of coverage they acquire. Furthermore, fine tuning of the reform implementation is ongoing. For example, high risk designations and the high risk adjustment factors are frequently adjusted in response to producer appeals.

With such significant reforms occurring as late as the 1995 crop year and the possibility of further reforms in the future, the simulation results may not hold for future conditions. Given the intent of recent modifications made to the program, crop insurance may play a diminishing role in contributing to soybean returns on frequently flooded agricultural lands.

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## V. REGIONAL ECONOMIC IMPACTS OF REFORESTATION

### Introduction

Just as individual landowners require credible evidence of the potential profitability of reforestation before they are willing to replace soybeans with timber production, policy makers will be slow to invest significant financial or political capital in a restoration effort without first understanding its potential impacts on the regional economy. Individual landowner decisions to reforest, when combined across the entire Delta region, may result in substantive regional economic consequences in terms of regional industry production, income, and employment. These regional economic consequences may arise from three sources: 1) changes in farmer purchasing patterns associated with the switch from crops to trees, 2) changes in income-generated spending by farm households as the profitability of their efforts change, and 3) changes in the activity of regional soybean and timber processing industries. These initial changes in the farming and processing sectors will then cause industries that supply inputs to farmers and processors to change their own purchases necessary to meet new levels of demand. The next level of input-supplying industries will then respond to their new levels of demand, and so on, until all of the initial change has “leaked out” of the economy through the purchase of goods and services from outside the region. In this way, the impacts will spread across the regional economy through subsequent rounds of activity that occur as a result of the initial changes in farming and processing activity. It is these combined “multiplier” effects of landowner purchasing and additional processing in the region, as a consequence of reforesting the Mississippi River Delta, that are addressed in this portion of the report.

Assessment of the regional economic impacts of reforestation was accomplished using the IMPLAN input-output model (Taylor et al. 1993), combined with a detailed accounting of landowner expenses and revenues. The input-output model, which is based on the transactions occurring between agents (industries, households, governments, and the rest of the world) at a point in time in the regional economy, can be used to track the impact (or multiplier effect) of a policy or program across 528 industries in a region. IMPLAN data for 1993 were used to estimate the regional impacts. The economic region considered in the analysis was comprised of the states of Arkansas,

Louisiana, and Mississippi, combined with Tennessee counties of Fayette, Hardeman, Haywood, Lauderdale, Shelby, and Tipton. This region was chosen on the basis of Rand-McNally, Major Trading Areas in the region. We did not analyze reforestation across the entire region, but considered the regional economic impacts across that entire region that are expected to occur as a result of reforestation in the Delta.

### Assumptions

1. Fixed production technology - Input-output models like the one used to estimate the regional economic impacts of reforestation are constructed using an assumption of fixed production technologies. That is, regardless of the magnitude of change in the output level of an industry, the same proportions of all production inputs (labor, capital, and all other commodities) are assumed to be used. Thus the projections imply that production activity expands or contracts linearly with wood and soybean yields. Further, no changes in production processes over time are incorporated.
2. Fixed prices - The fixed production technology assumption leads directly to an additional assumption that prices do not change as a result of changes in raw material (soybeans and timber) supply. We do incorporate long-term future price projections for soybeans and timber when calculating farm profits, and hence, farm household spending in the region. However, price changes that could potentially result from shifts in raw material supply in the Delta are not incorporated. In trade theory, this is known as the “small country” assumption. This assumption is based on the notion that changes in production in the small country (in our case, the Delta region) are not significant enough to influence prices that are established by overall markets in the rest of the world, with which trade adjusts to keep prices in the small country (region) at fixed levels.
3. Raw material processing - The effects of reforestation on raw material processing (e.g., in soybean oil mills, sawmills, and pulp and paper mills) are uncertain. Hence two assumptions regarding the processing industry response to soybeans and timber production changes are considered, as follows: 1) changes in raw material supply do not change soybean or timber processing activity in the region, and 2) changes in raw material supply change soybean or

timber processing activity proportionally to the regional yields of those commodities.

The first of these processing assumptions implies that processing levels are established by market forces or factors other than the level of raw material supply in the region. Additional quantities of soybeans or timber produced under this assumption would not generate additional processing, but would be exported from the region to the rest of the nation or world in their raw form. The second processing assumption implies that regional soybean and wood processing industries are limited in their production levels only by the level of raw material produced in the region, and the industry would expand to absorb all increases in the regional production of raw material. Increases (decreases) in the production of these raw materials would proportionally increase (decrease) output of the processing industries, as these industries consume any amount of soybeans or wood available at the current price.

4. Time - The regional impacts are represented on an annual basis, with the impact estimates being developed as though reforestation has progressed to a point that there is an approximately equal distribution of reforested land of each species in each annual age class of timber. The precise time at which the reported impacts would appear is indefinite, however, due to uncertainty about the rate at which reforestation practices would be adopted by landowners.

5. Non-timber economic activity - The estimated regional impacts of reforestation reflect only the effects of commercial timber production activities and foregone agricultural production. Reforestation, however, can introduce economic activity into the regional economy apart from commercial agricultural and timber production, including the sale of hunting leases or credits for environmental services, as well as government transfer payments through programs designed to encourage environmental restoration, such as WRP and CRP. The information needed to model the effects of these alternative income sources includes estimates of the level of payments received and the specific land cover required to create suitable wildlife habitat for hunting or to meet CRP / WRP land use restrictions. Because, in many cases, the information needed to estimate the effects of non-timber income sources is not readily available, these activities have been excluded from the initial analysis of the regional economic impacts of reforestation. The impacts of non-timber enterprises will be considered in the

subsequent section, "Impacts of Non-timber Economic Activities."

## Impact Calculations

The initial or "direct" impacts of reforestation were estimated using the costs, revenues, and yields generated in the individual landowner analysis, and the Base Case flood regime and crop insurance program. Prices, property taxes, and reforestation cost share payments were averaged across the region, because the location of land that would actually be reforested is unknown. To estimate the subsequent economic activity that could occur across industries of the regional economy, or "multiplier" effects, direct costs paid by landowners to produce timber or soybeans were allocated to the appropriate IMPLAN industries, while net revenues to landowners were assumed to be spent in the same proportions as middle income household purchasing that is recorded for the region in IMPLAN. All direct costs and revenues were deflated to the 1993 base year of the IMPLAN model. The links between the individual landowner data and IMPLAN are outlined in Tables V-1 and V-2.

Soybean revenues and costs are incurred annually, and direct impacts were calculated using the expected value of those annual net revenues and costs, based on the hypothesized flood regime of the individual landowner analysis. Reforestation costs and revenues occur over an entire rotation period. Calculation of annual impacts involved dividing reforestation expenditures by the rotation length for the species and site under consideration. Again, implicit in this calculation is the assumption that reforestation of marginal farmlands would occur gradually over time, creating something akin to a regulated forest condition, with an approximately equal area in each age class of a given species of timber. The landowner revenues used in calculating the income-generated impacts of reforestation scenarios were the annualized net present values of revenue over the rotation period, or "annual land rents."<sup>1</sup> The portion of total harvest value "lost" to the present value calculation was assumed to go toward the payment of interest on reforestation expenses, and subsequently lost from immediate use in the region. These present values include state cost share payments associated with reforestation expenses.

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<sup>1</sup> Annual land rents were derived from analyses in which herbicide applications were not part of the cottonwood or cottonwood-oak silvicultural regimes.

**TABLE V-1. Soybean Production Direct Impacts and Link to IMPLAN**

<i>Activity</i>	<i>Dollars/Acre</i>	<i>IMPLAN Industry</i>	<i>Notes</i>
Fuel Cost	\$3.94	210 Petrol. Refining	Use IMPLAN trade & transp. margins
Repair and Maint. Cost	\$15.51	482 Misc. Repair	
Herbicide Cost	\$39.31	204 Ag. Chemicals	Use IMPLAN trade & transp. margins
Insecticide Cost	\$3.51	204 Ag. Chemicals	Use IMPLAN trade & transp. margins
Seed Cost	\$8.64	21 Oil Bearing Crops	
Hauling Cost	\$4.90	435 Motor Freight Transport	
Air Applic. Cost	\$1.25	26 Ag., For. and Fish. Services	
Fixed Cost	\$30.98	309 Farm Mach. & Equipment	Use Bureau of Econ Analysis-Commodity Composition of Producer Expend. trade and transp. margins
Property Tax	\$2.59	State and Local Govt	Average rate for AR, LA, and MS
Landowner Revenue	\$124.68	Mid. Income Households (use net revenue)	Use \$5.03 future price for expected soybean yield of 23.76 bu/ac and expected flood insurance payment of \$5.17/ac
Soybean Processing	\$265.26	87 Soybean Oil Mills	Based on direct forward link from IMPLAN Industry 21 Oil Bearing Crops (with backward link to soybean farms removed to avoid double counting)

To account for imports of goods that are purchased by landowners, and the subsequent loss of that income to the region, all direct purchases were reduced by the proportion of each good that is imported from outside the region (i.e., using IMPLAN local purchase coefficients).

Direct impacts resulting from processing of soybeans were calculated by determining the level of production in the processing industry that would be allowed by a given soybean yield using the production coefficient for soybeans by the Soybean Oil industry in IMPLAN, combined with the input-output assumption of fixed-proportion production functions.

The multiplier effects were then calculated by applying this direct change in processing to the IMPLAN Soybean Oil Mills industry output level. Similarly, the impacts of timber processing were calculated by determining the production that would be allowed by a given harvest level in the following IMPLAN industries: Logging Camps and Contractors, Sawmills and Planing Mills, Pulp Mills, and Paper Mills. Total harvest volume was allocated between sawtimber and pulpwood, and hence among the solid wood and paper industries, using the percentages determined in the landowner analysis by reforestation scenarios.

**TABLE V-2. Reforestation Direct Impacts and Link to IMPLAN**

<i>Activity</i>	<i>Dollars/Acre</i>	<i>IMPLAN Industry</i>	<i>Notes</i>
Site Preparation	\$56.77	26 Agric, Forestry, and Fisheries Services	
Oak Planting	\$147.63	26 Agric, Forestry, and Fisheries Services	
Cottonwood Planting	\$125.99	26 Agric, Forestry, and Fisheries Services	
Cultivation	\$6.84	26 Agric, Forestry, and Fisheries Services	Used only in cottonwood scenarios
Disking	\$17.12	26 Agric, Forestry, and Fisheries Services	Used only in cottonwood scenarios
Property Tax	\$2.59	State and Local Govt	Average rate for AR, LA, and MS
Landowner Revenue	varies by soil type and species	Mid. Income Households (use net revenue)	Use annualized net present value of revenues to account for interest paid (i.e., opportunity cost) on reforestation expenses. Use long-term projected prices
Logging	varies by soil type and species	133 Logging Camps and Contractors	Based on backward link from IMPLAN processing industries
Lumber Production	varies by soil type and species	134 Sawmills and Planing Mills	Based on direct forward link from IMPLAN Logging industry
Pulp Production	varies by soil type and species	161 Pulp Mills	Based on direct forward link from IMPLAN Logging industry
Paper Production	varies by soil type and species	162 Paper Mills	Based on direct forward link from IMPLAN Logging industry

### **Soybean Farming Impacts**

The regional economic activity that is estimated to be lost from the region as a result of reduced soybean production is presented in Table V-3 for soybean production only, and when soybean processing is included. These impacts include the direct economic activity generated by soybean production (i.e., production expenses and landowner income earned), as well as the multiplier effects that would be expected to occur as that direct spending works its way through

the regional economy. Impacts are shown in terms of industry output, employee income, proprietary income, value added, and employment. Industry output is simply the dollar value of the output produced by an industry. Employee income is the income earned in the form of wages and salaries, while proprietary income is that earned by business owners. Value added is the increase in product value that is created in processing, above the cost of inputs (i.e., sum of employee compensation, proprietary income, taxes, and imports).

**TABLE V-3. Regional Economic Impacts per Acre of Soybean Production Lost**

<i>Industry</i>	<i>Industry Output</i> (\$/acre)	<i>Employee Compens.</i> (\$/acre)	<i>Proprietary Income</i> (\$/acre)	<i>Total Income</i> (\$/acre)	<i>Value Added</i> (\$/acre)	<i>Employment</i> (jobs/1000 ac)
Soybean Production Only	-191.30	-63.18	-41.26	-104.44	-118.68	-3.12
Soybean Prod. & Processing	-582.47	-108.10	-81.64	-189.73	-213.31	-5.38

Another potentially important aspect of the regional economic impacts of reforestation is the distribution of changes that is anticipated across regional industries. The distribution of soybean impacts across regional industries are presented in Tables V-4 and V-5 for soybean production-only, and when soybean processing is included, respectively. IMPLAN estimates the impacts by 528 separate industries, which were aggregated to the 1-digit Standard Industrial Classification (SIC) level for presentation. From the perspective of the value of total industry output, the greatest impact occurs in the agriculture, forestry, and fisheries industry when only soybean production is considered (Table V-4), while the manufacturing industry receives the greatest impact when reductions in soybean processing occur (Table V-5). The ranking of impacts across industries shifts, depending upon the measure of impact, however.

### Timber Production-Only Impacts

Estimated regional economic impacts of timber production across all industries of the lower Mississippi River Delta region per acre of reforestation are presented in Table V-6 for each of the soil types when only timber production activities on marginal lands are included. When calculating the impacts on each soil type, it was assumed that only the highest net present value treatment would be applied. For the Alligator, Amagon, Bowdre, Mhoon, Forestdale, Newellton, and Tensas soils, the highest present values were obtained for Nuttall oak grown on a 50 to 60- year rotation. For the Dundee, Sharkey, and Tunica soil types, the mixed cottonwood-oak regime achieved the highest present values. In addition, a pure cottonwood regime on Dundee soils was considered to examine the consequences of that

short rotation regime. Differences between the per acre timber production-only impacts for each treatment are due to estimated differences in yield and rotation length, and hence, annual income-earning potential on each of the sites. Reforestation costs are constant across all soil types for a given treatment.

The soybean production-only impacts (Table V-3) are somewhat larger than the timber production-only impacts for all measures of impact (Table V-6) due to the greater frequency of activity on the land. Even though the cottonwood regime on Dundee soils entails more frequent activity than the other forestry regimes, the activities are not frequent enough, nor the pulpwood valuable enough to offset the impacts of the annual soybean production activities. However, the timber production impacts do not incorporate any wetland reserve program (WRP) payments, recreational leases, or carbon payments that could narrow the gap between soybean and timber production impacts, or even reverse their relative magnitudes.

Table V-7 presents the distributed impacts by industry for the timber production-only scenarios on Alligator soils, one of the more prevalent soil types in the region. Again, the Nuttall oak regime was assumed to be applied on this soil type because of its higher net present value. Table V-8 presents the same information for the Dundee soil, on which the mixed cottonwood-oak regime yields the highest net present value. For timber production-only, the impacts are concentrated primarily in the agric/forestry/fisheries, trade, and service industries. Again, these distributed impacts are somewhat lower than the soybean production-only impacts (Table V-4) due to the annual activity of soybean farms.

**TABLE V-4. Impacts per Acre of Soybean Production Lost by Regional Industry--Soybean Production Only**

<i>Industry</i>	<i>Industry Output</i> (\$/acre)	<i>Employee Compens.</i> (\$/acre)	<i>Proprietary Income</i> (\$/acre)	<i>Total Income</i> (\$/acre)	<i>Value Added</i> (\$/acre)	<i>Employment</i> (jobs/1000 ac)
Ag, Forestry & Fisheries	-92.79	-32.88	-20.81	-53.69	-61.46	-1.57
Mining	-1.16	-0.12	-0.45	-0.58	-0.63	-0.00
Construction	-5.84	-1.28	-0.92	-2.20	-2.26	-0.06
Manufacturing	-17.50	-3.29	-2.14	-5.44	-5.82	-0.11
Transp, Comm & Utilities	-10.21	-2.91	-2.29	-5.20	-5.72	-0.09
Wholesale & Retail Trade	-17.87	-8.40	-2.73	-11.13	-14.02	-0.53
Finance, Insur, Real Est	-17.22	-2.38	-5.82	-8.20	-10.36	-0.11
Services	-27.06	-11.22	-5.66	-16.89	-17.29	-0.62
Government	-1.66	-0.70	-0.43	-1.12	-1.13	-0.02
<b>Total</b>	<b>-191.30</b>	<b>-63.18</b>	<b>-41.26</b>	<b>-104.44</b>	<b>-118.68</b>	<b>-3.12</b>

**TABLE V-5. Distributed Impacts per Acre of Soybean Production Lost by Regional Industry, Soybean Production and Processing Combined**

<i>Industry</i>	<i>Industry Output</i> (\$/acre)	<i>Employee Compens.</i> (\$/acre)	<i>Proprietary Income</i> (\$/acre)	<i>Total Income</i> (\$/acre)	<i>Value Added</i> (\$/acre)	<i>Employment</i> (jobs/1000 ac)
Ag, Forestry & Fisheries	-112.67	-34.42	-34.75	-69.18	-77.46	-2.02
Mining	-2.70	-0.32	-1.07	-1.39	-1.52	-0.01
Construction	-11.38	-2.51	-1.78	-4.30	-4.41	-0.12
Manufacturing	-295.87	-12.99	-9.58	-22.57	-23.84	-0.42
Transp, Comm & Utilities	-31.26	-9.55	-6.24	-15.79	-17.17	-0.28
Wholesale & Retail Trade	-44.62	-22.31	-6.80	-29.11	-36.84	-1.18
Finance, Insur, Real Est	-32.77	-4.78	-10.45	-15.23	-19.17	-0.21
Services	-47.98	-19.90	-10.07	-29.98	-30.71	-1.11
Government	-3.23	-1.31	-0.88	-2.19	-2.19	-0.04
<b>Total</b>	<b>-582.47</b>	<b>-108.10</b>	<b>-81.64</b>	<b>-189.73</b>	<b>-213.31</b>	<b>-5.38</b>

**TABLE V-6. Regional Economic Impacts per Acre of Reforestation--Timber Production Only**

<i>Soil Type/ Timber Type/ Rotation Length</i>	<i>Industry Output (\$/acre)</i>	<i>Employee Compens. (\$/acre)</i>	<i>Proprietary Income (\$/acre)</i>	<i>Total Income (\$/acre)</i>	<i>Value Added (\$/acre)</i>	<i>Employment (jobs/1000 ac)</i>
Alligator/Nuttall oak/50 yrs	40.55	14.68	8.42	23.11	25.72	0.81
Amagen/Nuttall oak/50 yrs	44.34	15.89	9.24	25.13	28.01	0.87
Bowdre/Nuttall oak/60 yrs	22.20	8.83	4.42	13.25	14.57	0.49
Dundee/cottonwood-oak/50 yrs	45.06	16.08	9.38	25.45	28.41	0.88
Dundee/pure cottonwood/10 yrs	43.81	15.91	9.24	25.15	27.90	0.91
Forestdale/Nuttall oak/60 yrs	22.20	8.83	4.42	13.25	14.57	0.49
Mhoon/Nuttall oak/50 yrs	40.55	14.68	8.42	23.11	25.72	0.81
Newellton/Nuttall oak/50 yrs	40.55	14.68	8.42	23.11	25.72	0.81
Sharkey/cottonwood-oak/60 yrs	24.44	9.52	4.90	14.42	15.91	0.52
Tensas/Nuttall oak/60 yrs	24.60	9.59	4.94	14.53	16.02	0.53
Tunica/cottonwood-oak/60 yrs	22.83	9.01	4.55	13.56	14.93	0.49

**TABLE V-7. Distributed Impacts per Acre of Reforestation on Alligator Soils Under Nuttall Oak Regime by Regional Industry--Timber Production Only**

<i>Industry</i>	<i>Industry Output (\$/acre)</i>	<i>Employee Compens. (\$/acre)</i>	<i>Proprietary Income (\$/acre)</i>	<i>Total Income (\$/acre)</i>	<i>Value Added (\$/acre)</i>	<i>Employment (jobs/1000 ac)</i>
Ag, Forestry & Fisheries	17.28	7.44	3.50	10.94	11.95	0.43
Mining	0.23	0.03	0.09	0.12	0.13	0.00
Construction	1.48	0.32	0.23	0.55	0.57	0.02
Manufacturing	3.20	0.56	0.37	0.93	1.00	0.02
Transp, Comm & Utilities	2.09	0.58	0.48	1.06	1.18	0.02
Wholesale & Retail Trade	4.40	2.05	0.67	2.72	3.42	0.13
Finance, Insur, Real Est	4.58	0.65	1.56	2.21	2.78	0.03
Services	6.85	2.87	1.41	4.28	4.40	0.16
Government	0.43	0.19	0.11	0.29	0.29	0.01
Total	40.55	14.68	8.42	23.11	25.72	0.81

**TABLE V-8. Distributed Impacts per Acre of Reforestation on Dundee Soils Under Mixed Cottonwood-Oak Regime by Regional Industry--Timber Production Only**

<i>Industry</i>	<i>Industry Output (\$/acre)</i>	<i>Employee Compens. (\$/acre)</i>	<i>Proprietary Income (\$/acre)</i>	<i>Total Income (\$/acre)</i>	<i>Value Added (\$/acre)</i>	<i>Employment (jobs/1000 ac)</i>
Ag, Forestry & Fisheries	19.51	8.14	3.97	12.11	13.31	0.46
Mining	0.26	0.03	0.10	0.13	0.14	0.00
Construction	1.67	0.36	0.26	0.63	0.64	0.02
Manufacturing	3.53	0.62	0.40	1.02	1.10	0.02
Transp, Comm & Utilities	2.31	0.64	0.53	1.17	1.30	0.02
Wholesale & Retail Trade	4.78	2.23	0.73	2.96	3.72	0.15
Finance, Insur, Real Est	5.04	0.73	1.71	2.43	3.05	0.03
Services	7.49	3.14	1.55	4.69	4.81	0.17
Government	0.48	0.21	0.12	0.32	0.32	0.01
<b>Total</b>	<b>45.06</b>	<b>16.08</b>	<b>9.38</b>	<b>25.45</b>	<b>28.41</b>	<b>0.88</b>

**Combined Timber Production and Wood Processing Impacts**

Table V-9 presents the estimated impacts of reforestation in the region by soil type when increased production is assumed to expand the wood processing industries proportionally to the timber yield increase. Substantially higher impacts per acre are estimated as a result of including these potential processing impacts, and the positive reforestation impacts exceed soybean losses for many of the soil types, depending upon the impact measure considered (i.e., industry output, income, value added, or employment). Again, differences shown between soil types result primarily from differences in site productivity and rotation length. Even though it is less profitable for landowners than the mixed cottonwood oak regime, pure cottonwood grown on Dundee soils yields the highest regional impacts. The pure cottonwood regime allows greater regional processing activity because of the more frequent harvesting on each reforested acre.

The results in Table V-9 implicitly assume that wood processing is limited only by the availability of the wood resource, and that the price of wood remains constant. Thus, the results should be viewed with caution, and be considered as upper bounds on the true regional impacts of reforestation in the Delta. In

practice, processing plants face capacity constraints which would limit their ability to generate increased demand for wood in the short run. Evidence of these constraints exist throughout the Southeast in the form of quotas placed on loggers. If these constraints are important, then conversion of land to timber production could lead to a decline in wood prices and a corresponding decline in the regional impact of reforestation. Decreasing prices might not occur if new processing facilities expanded in the Delta and generated increased demand for wood, or if additional timber production could be exported from the region at current prices. In the short run new processing facilities might not be expected, since processing plants are highly capital intensive ventures. However, processing capacity could adjust in the long run time period for which the impacts are estimated.

Tables V-10 and V-11 present the distributed impacts by industry for the combined timber production-wood processing scenarios on Alligator and Dundee soils, respectively. When wood processing impacts are included, the largest impacts occur in the manufacturing industries. The positive impacts of timber production and processing compare favorably to the soybean losses, even without including WRP payments, recreational leases, or carbon payments.

**TABLE V-9. Regional Economic Impacts per Acre of Reforestation, Timber Production and Wood Processing Combined**

<i>Soil Type/ Timber Type/ Rotation Length</i>	<i>Industry Output (\$/acre)</i>	<i>Employee Compens. (\$/acre)</i>	<i>Proprietary Income (\$/acre)</i>	<i>Total Income (\$/acre)</i>	<i>Value Added (\$/acre)</i>	<i>Employment (jobs/1000 ac)</i>
Alligator/Nuttall oak/50 yrs	504.68	120.17	79.14	199.32	219.45	5.58
Amagen/Nuttall oak/50 yrs	550.69	130.97	86.39	217.37	239.37	6.08
Bowdre/Nuttall oak/60 yrs	408.84	96.95	63.68	160.63	176.57	4.43
Dundee/cottonwood-oak/50 yrs	554.74	137.58	95.04	232.62	255.37	5.44
Dundee/pure cottonwood/10 yrs	761.51	194.04	139.79	333.83	365.14	6.48
Forestdale/Nuttall oak/60 yrs	408.84	96.95	63.68	160.63	176.57	4.43
Mhoon/Nuttall oak/50 yrs	504.68	120.17	79.14	199.32	219.45	5.58
Newellton/Nuttall oak/50 yrs	504.68	120.17	79.14	199.32	219.45	5.58
Sharkey/cottonwood-oak/60 yrs	335.15	82.91	56.16	139.06	152.55	3.38
Tensas/Nuttall oak/60 yrs	449.89	106.52	70.12	176.64	194.22	4.86
Tunica/cottonwood-oak/60 yrs	317.99	78.54	52.98	131.52	144.27	3.23

**TABLE V-10. Distributed Impacts per Acre of Reforestation on Alligator Soils Under Nuttall Oak Regime by Regional Industry, Timber Production and Wood Processing Combined**

<i>Industry</i>	<i>Industry Output (\$/acre)</i>	<i>Employee Compens. (\$/acre)</i>	<i>Proprietary Income (\$/acre)</i>	<i>Total Income (\$/acre)</i>	<i>Value Added (\$/acre)</i>	<i>Employment (jobs/1000 ac)</i>
Ag, Forestry & Fisheries	19.33	7.75	4.27	12.02	13.04	0.48
Mining	2.24	0.26	0.88	1.15	1.26	0.01
Construction	18.83	4.05	2.96	7.01	7.20	0.19
Manufacturing	302.60	51.70	36.13	87.83	94.09	2.07
Transp, Comm & Utilities	32.27	9.93	6.86	16.79	18.31	0.29
Wholesale & Retail Trade	36.89	17.77	5.62	23.40	29.53	1.05
Finance, Insur, Real Est	34.50	5.27	10.70	15.97	20.06	0.22
Services	54.15	21.77	10.73	32.50	33.30	1.23
Government	3.86	1.68	0.97	2.65	2.65	0.05
Total	504.68	120.17	79.14	199.32	219.45	5.58

**TABLE V-11. Distributed Impacts per Acre of Reforestation on Dundee Soils Under Mixed Cottonwood-Oak Regime by Regional Industry, Timber Production and Wood Processing Combined**

<i>Industry</i>	<i>Industry Output (\$/acre)</i>	<i>Employee Compens. (\$/acre)</i>	<i>Proprietary Income (\$/acre)</i>	<i>Total Income (\$/acre)</i>	<i>Value Added (\$/acre)</i>	<i>Employment (jobs/1000 ac)</i>
Ag, Forestry & Fisheries	21.67	8.46	4.77	13.23	14.45	0.51
Mining	3.51	0.41	1.35	1.77	1.95	0.01
Construction	19.98	4.34	3.14	7.47	7.68	0.20
Manufacturing	335.14	63.96	49.84	113.80	121.99	1.76
Transp, Comm & Utilities	45.53	14.26	8.08	22.34	24.31	0.43
Wholesale & Retail Trade	36.45	17.60	5.56	23.16	29.24	1.03
Finance, Insur, Real Est	34.26	5.34	10.47	15.81	19.90	0.22
Services	54.16	21.50	10.77	32.27	33.09	1.21
Government	4.03	1.71	1.06	2.76	2.76	0.05
<b>Total</b>	<b>554.74</b>	<b>137.58</b>	<b>95.04</b>	<b>232.62</b>	<b>255.37</b>	<b>5.44</b>

**Impacts of Non-timber Economic Activity**

The estimated regional impacts of reforestation reflect only the effects of commercial timber and agricultural production. However, landowners may be able to capitalize on the environmental gains of reforestation through markets for recreational opportunities such as hunting and fishing or through the sale of credits for such environmental services as wetlands mitigation, water pollution reduction, and carbon sequestration. Additionally, reforestation may qualify landowners to receive transfer payments under government programs intended to encourage environmental restoration, such as the Wetlands Reserve Program or the Conservation Reserve Program. Finally, off-site environmental gains from reforestation may also create new activity within the regional economy. By reducing the runoff of sediments and water pollutants, reforestation can improve the economic productivity of downstream estuaries, lakes and bays as commercial fisheries, recreational areas, or hunting grounds for waterfowl (Siegel and Johnson 1991).

As noted previously, the estimated regional impacts of reforestation do not include additional payments that landowners could receive from non-

timber income sources, such as WRP payments, recreational lease payments, and the proposed carbon payments. At this point, the level of these payments is not clear. WRP payments may vary substantially from county to county or parish to parish, and they also interact with certain cost share payments that are incorporated in this analysis. The level of recreational lease payments is also unknown because the extent of the demand for recreational leases is uncertain. Nor is the form or timing of carbon payments to landowners well understood at this point. Finally, it is not clear what configuration of land (forest cover combined with other agriculture and the proximity to water) is required to meet the land use limitations of the WRP/CRP program, to maximize carbon sequestration capacity, or to make the land attractive for recreational leases.

Even though recreational and hunting leases and the spending of recreation seekers may have regional economic impacts, the difference between new activity and “within-region” transfers should be carefully considered. Only “new” spending brought in by recreation seekers coming from outside of the Delta region can be considered a net gain in the regional economy. Additionally, landowners may choose to provide friends or business associates access to their

land for hunting or recreational purposes under informal “quid pro quo” arrangements, rather than through the sale of a hunting lease. Although these in-kind exchanges may represent new economic activity within the region, they are difficult to capture in formal economic impact estimates (Siegel and Johnson 1991).

Additional information is also needed for evaluating the regional economic benefits of off-site environmental improvements. Assessing the value of off-site environmental improvements requires knowing the location of the reforested land and the off-site areas benefiting from increased environmental quality (Siegel and Johnson 1991).

Finally, the estimates of the regional economic impacts of all non-timber income sources are limited by the per acre basis used for the analysis. Impacts will vary, depending on the location of the reforestation, because of tax and localized market conditions that are not captured in the generic per acre analysis. However, at this point we do not have sufficient information about existing cover types or landowner behaviors to make the impact estimates more geographically specific.

It is reasonable to expect that landowners will act to maximize the returns to their land. This means that if they adopt reforestation, they will likely pursue all compatible income opportunities available to them. Although uncertainties concerning the magnitude and conditions of these payments make it difficult to determine the extent of their impact on the regional economy, including them would at least slightly increase the positive regional impacts of reforestation through increases in the present value of landowner revenues, and the subsequent farm household spending that might be induced.

### **Summary**

To summarize, it appears from this analysis that when only raw material production is considered, the

positive impacts of timber will not offset the losses associated with foregone soybean production, apart from additional subsidy payments that could boost landowner revenues, and consequently their income-induced spending in the region. The gap between timber and soybeans is closed somewhat, and for many soil types and industries reversed, when additional processing of the raw materials occurs. However, the occurrence of this additional processing is dependent upon market factors that would not likely be influenced by policies that encourage reforestation.

In addition to increased timber production, reforestation may also result in new, “non-timber” economic activities in the Delta region. Household income may be supplemented through transfer payments from government conservation programs (e.g., WRP or CRP), or by the sale of recreational leases or credits for environmental services such as pollution reduction, carbon sequestration, or wetlands mitigation. Additionally, the environmental gains of reforestation may enhance the productivity of off-site economic enterprises.

The net effect of these non-timber income sources on the regional economy, however, is speculative. It must be determined that spending arising from economic activities generated by reforestation is “new” to the region, rather than simply transferred from another activity within the region. Additionally, more information is needed to determine the level of payments that can be expected through conservation programs or markets for environmental and recreational services. Without further evidence of the extent of “new” spending and income generated by any “non-timber” economic activities pursued under reforestation, it cannot be determined that these additional activities will bridge the gap between the regional economic impacts of timber and foregone soybean production.

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## VI. MAKING RESTORATION HAPPEN: CONCLUSIONS FROM THE MISSISSIPPI DELTA CASE

Restoration measures taken to reclaim the original structural and functional characteristics of an ecosystem may impose economic costs on individual landowners as well as in the regional economy as a whole. Such costs can act as a disincentive to restoration, deterring private landowners from adopting restoration measures, and leaving local and regional policy makers hesitant to lend their support to the effort. Achieving restoration goals requires that the costs of restoration be recognized and, when possible, mitigated.

In the case of the Mississippi Delta, the economic consequences of pursuing alternative reforestation strategies as a means of restoring current agricultural land to its original condition as forested wetlands were assessed for both individual landowners and for the Delta regional economy. For landowners, it was found that NPV of computed returns to reforestation varied according to site characteristics and tree species. For some combinations, computed net returns to reforestation were greater than foregone soybean returns (e.g., Nuttall oak on Alligator, Amagon, Dundee, Mhoon and Newellton soils and cottonwood - oak intercrop on Dundee soils). In other cases, soybean returns were slightly more profitable (see tables II-20 through II-22). In such instances, opportunities exist to bridge the gap with non-timber income earned through markets for the environmental services generated by forested lands or transfer payments through government conservation programs such as WRP and CRP.

The computed economic returns to reforestation vary according to the physical characteristics of a site, landowners' expectations concerning future market and policy conditions, landowner type (i.e., owner-operator vs. owner-landlord), and underlying assumptions concerning product quality, as well as future forestry and soybean prices. In addition to the computed economic returns, a landowner's decision to reforest is also influenced by cash flow considerations, risk aversion, altruistic motivations, and lifestyle preferences.

From the perspective of the regional policy maker, it was found that the net positive impact of reforestation on the regional economy was not sizable enough to offset the losses of foregone agricultural production, when considering only raw material

production. If additional processing is assumed to occur, then in some cases, reforestation generated a positive net impact.

It was explained that additional, non-timber income sources such as hunting and recreation lease sales or payments through government conservation programs (e.g., WRP and CRP) may also have a positive impact on the regional economy through increased household income. However, the extent of the impact these non-timber economic activities may have is highly uncertain. Expenditures on such activities only contribute to the economy if they are new to the region; spending merely transferred from another activity within the region does not count towards the net impacts of reforestation. Determining whether non-timber spending is new to the region is difficult. Furthermore, there is much uncertainty concerning the level of payments that can be expected through conservation programs or markets for environmental services.

Both the landowner and regional analyses indicate that the potential exists for achieving restoration of bottomland forested wetlands in the Mississippi Delta. However, the computed net returns to reforestation may be low, or even negative. In such cases, a small infusion of money may be required to make restoration economically attractive to landowners.

Knowing the extent of costs expected and understanding what factors underlie these costs makes it possible to identify circumstances under which reforestation is most likely to occur and target landowners accordingly. Additionally, policies and programs can be better formulated and more effectively implemented when the causes of financial barriers to reforestation are understood. The computer simulation model used in this study to examine the costs of restoration from the perspective of a representative landowner provides the groundwork for future research addressing such policy considerations.

The simulation model could be modified to allow for re-evaluation of restoration costs under a range of alternative assumptions and future market and policy conditions, extending beyond those represented by the Base Case situation. The model, once modified, could be used to examine the economic consequences of alternative reforestation strategies from the perspective

of both the individual landowner and the regional economy. In addition to identifying the least costly restoration alternatives, the findings could be used to

suggest the policy reforms or market opportunities that would be most effective at mitigating any restoration costs.

