Longleaf Pine and Payments for Watershed Services

Research supported by Longleaf Stewardship Fund of the National Fish and Wildlife Foundation
Fig. 1. Longleaf pine habitat (USFWS 2019).
Research Methods

Interviews
18 public and private sector experts in forest and watershed science, policy and management.

Literature Review
Almost 60 publications, including journal articles, grey literature, and book chapters and technical reports.
Research Findings

Feasible

PWS may serve as a market-based tool to incentivize the cultivation, retention and management of southern pine – *including longleaf* – by private forest landowners.

Fig. 2. Historic range of the longleaf pine ecosystem (USDA NRCS 2014).
Significance

Benefits of Forested Watersheds

• Water supply, purification and flow regulation
• Erosion control
• Habitat and biodiversity
• Carbon sequestration
• Forest products
• Recreational, cultural and aesthetic

Fig. 3. Pony Ranch Pond, De Soto National Forest, MS (USDA 2017).
Significance

Trends

In the Southeast, *forest* and *water* resource management challenges are driven by changing:

• Climate
• Land use
• Population

Fig. 4. *Outlook for Coastal Plain Forests* (Klepzig et al. 2014).
Significance

Climate

• Less water availability and lower water quality

• Greater intensity, frequency and duration of forest disturbance
  o Droughts and cyclones
  o Insects, pathogens and invasives
  o Wildfires

Fig. 5. Water supply stress in 2050 under four climate, land use, forest products markets and bioenergy scenarios (Wear and Greis 2012).

Source:
Klepzig et al. 2014, Wear and Greis 2012
Significance

Land Use and Population

By 2060

• 60% population growth
• Loss of 11-23M acres forest
• 10% increase in water stress and worsening water quality
• More planted pine?

Fig. 6. Water supply stress in 2050 due to population growth and land use change (Klepzig et al. 2014).

Sources:
Klepzig et al. 2014, Wear and Greis 2012
Significance

Private Forests

- Unstable ownership
- Vulnerable to land use change
- Private/state forests account for 44% of surface drinking water supply in Southeast

Fig. 7. Land use change threatens drinking water supply (Mockrin et al. 2014).

Source:
Liu et al. 2020
Longleaf Pine and Water

**Tree Level**

- Efficient in use of water
- Low drought mortality
- Better adapted to drier conditions than slash and loblolly pine

*Fig. 8. Illustration of longleaf pine (University of Maryland Center for Environmental Science 2020)*

Sources:
Samuelson et al. 2012 and 2019
Longleaf Pine and Water

Stand and Plot Level

Fire-maintained longleaf pine ecosystem uses

- 15% less water than fire-excluded mixed pine-hardwoods
- 30% less water than intensive slash and loblolly plantations

<table>
<thead>
<tr>
<th>Vegetation type</th>
<th>Transpiration (mm yr⁻¹)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longleaf pine savanna</td>
<td>244</td>
<td>Ford and others 2008</td>
</tr>
<tr>
<td>Old field</td>
<td>250</td>
<td>Sty and others 2006</td>
</tr>
<tr>
<td>Oak-pine-hickory forest</td>
<td>278</td>
<td>Oren and Pataki 2001</td>
</tr>
<tr>
<td>Upland oak forest</td>
<td>313</td>
<td>Wullschleger and others 2001</td>
</tr>
<tr>
<td>Mixed pine hardwood</td>
<td>355</td>
<td>Philips and Oren 2001</td>
</tr>
<tr>
<td>Mixed pine hardwood</td>
<td>442</td>
<td>Sty and others 2006</td>
</tr>
<tr>
<td>Planted loblolly pine</td>
<td>490</td>
<td>Sty and others 2006</td>
</tr>
<tr>
<td>Mixed pine hardwood</td>
<td>523</td>
<td>Schaefer and others 2002</td>
</tr>
<tr>
<td>Slash pine flatwoods</td>
<td>563</td>
<td>Powell and others 2005</td>
</tr>
<tr>
<td>Eucalyptus hybrid plantation</td>
<td>882</td>
<td>Estimated for Baker County, southwestern GA in 2006 for an average climate and rainfall year.</td>
</tr>
<tr>
<td>Planted loblolly pine (early rotation)</td>
<td>328</td>
<td>Domec and others 2012; Sun and others 2010</td>
</tr>
<tr>
<td>Planted loblolly pine (mid-rotation)</td>
<td>777</td>
<td>Domec and others 2012; Sun and others 2010</td>
</tr>
</tbody>
</table>

*Derived from a model that used data collected in 2006 by the Joseph W. Jones Ecological Research Center, 3988 Jones Center Drive, Newton, GA 39870. Model assumed no soil water limitation; all trees at age 5; 1,111 trees ha⁻¹; and a leaf area index of 6 m² m⁻² (Mielke and others 1999).

Fig. 9. Mean annual transpiration (mm yr⁻¹) for forest cover types in the Southeast (Lockaby et al. 2013).

Source:
Brantley et al. 2018
Longleaf Pine and Water

Stand and Plot Level
In multi-year study across 36 plots of southern pine in Florida:

• Tree species not significant predictor of water yield
• Strong associations between leaf area index and evapotranspiration
• Long-term fire effects (e.g., forest structure) on water yield were significant
• High water quality across all forest types

Source:
Cohen et al. 2017
Longleaf Pine and Water

Watershed Scale

• Long-term, empirical paired watershed study underway at Santee Experimental Forest

• Models show longleaf restoration would increase water availability in:
  o ACF River Basin
  o Altamaha River watershed

Sources:
Brantley and Gollady 2020, Hallema et al. 2019, Trettin et al. 2019

Fig. 10. Water yield response to 50% reduction in leaf area index (Vose et al. 2019).
Net Benefits & Tradeoffs: Water

**Low Tree Density**

**Supply**
- More water yield

**Quality**
- High baseline water quality
- Lower risk of severe wildfire impacts

**Flow Regulation**
- Mitigates floods
- Higher baseflows

**High Tree Density**

**Supply**
- Less water yield

**Quality**
- High baseline water quality
- Higher risk of severe wildfire impacts

**Flow Regulation**
- Mitigates floods
- Lower baseflows
## Net Benefits & Tradeoffs: Resilience

**Low Tree Density**

**Drought**
More water available for fewer trees

**Insects and Pathogens**
Lower risk of insects and pathogens, including as secondary effect of drought

**Wildfire**
Lower risks of severe wildfire due to lower fuel loads, including from tree mortality from drought, insects and pathogens

**High Tree Density**

**Drought**
Less water available for more trees

**Insects and Pathogens**
Higher risk of insects and pathogens, including as secondary effect of drought

**Wildfire**
Higher risks of severe wildfire due to higher fuel loads, including from tree mortality from drought, insects and pathogens
# Net Benefits & Tradeoffs: Other

<table>
<thead>
<tr>
<th>Low Tree Density</th>
<th>High Tree Density</th>
</tr>
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<tbody>
<tr>
<td><strong>Habitat and Biodiversity</strong></td>
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</tr>
<tr>
<td>Higher quality aquatic and terrestrial habitat and biodiversity values</td>
<td>Lower quality aquatic and terrestrial habitat and biodiversity values</td>
</tr>
<tr>
<td><strong>Carbon</strong></td>
<td><strong>Carbon</strong></td>
</tr>
<tr>
<td>Less carbon sequestration with lower risk of release due to severe wildfire</td>
<td>More carbon sequestration with higher risk of release due to severe wildfire</td>
</tr>
<tr>
<td><strong>Forest Products</strong></td>
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</tr>
<tr>
<td>Less fiber and timber production</td>
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Payments for Watershed Services

Overview

• Market-based tool to align interests

• Clear linkage between upstream management practices and downstream water conditions

• 380+ programs, 60+ countries, $25B

Source: Salzman et al. 2018

Fig. 11. Payments for watershed services transaction (Forest Trends Ecosystem Marketplace 2013)
Payments for Watershed Services

Program Types

- Source water protection programs
- Fire risk mitigation programs
- Voluntary customer offsets
- Point source pollution offsets
- Hydropower mitigation initiatives

Source:
Bennet et al. 2014
Payments for Watershed Services

Funding Mechanisms
• Ratepayer surcharge (City of Raleigh)
• Municipal bonds (City of Austin)
• Sales tax (City of San Antonio)
• Donated water conservation savings (City of Tucson)
• Voluntary ratepayer contributions (Oregon)
• Revolving impact funds (City of Wilmington, DE; SW Colorado)

Source:
Bennet et al. 2014
Payments for Watershed Services

Regional Success Stories
• Upper Neuse Clean Water Initiative
• Savannah River Clean Water Fund
• Northwest and Central Arkansas
• Central Texas
Longleaf Pine and PWS

Opportunities

• Support for forested watershed protection and landowner assistance among general public in Southeast
• Growing interest in watershed conservation among utilities and municipalities
• Growing interest in PES among landowners
• Institutional buy-in and momentum for longleaf restoration
• PWS models from which to borrow and adapt
• Bundle with other PES schemes (biodiversity, wildfire risk reduction, etc.)

Source:
Kang et al. 2019, Kreye et al. 2019
Challenges

• Economies of scale
• Valuation and forecasts
• Sustainability
• Institutional, financial and technical capacity
Longleaf Pine and PWS

Thought Experiment 1: Low Tree Density, Fixed Rate

Transaction Design
PWS program pays landowners a per-acre rate to manage for low tree density and implement regular prescribed fire and silviculture BMPs for watershed protection.

Forest Outcomes
Ecological restoration with longleaf and/or slash canopy

Benefits
• Water supply and quality
• Climate resilience and risk reduction
• Habitat and biodiversity

Tradeoffs
• Forest products
• Carbon storage
Longleaf Pine and PWS

**Thought Experiment 2:**
**Flexible Tree Density, Fixed Rate**

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<thead>
<tr>
<th><strong>Transaction Design</strong></th>
<th><strong>Benefits</strong></th>
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<td>PWS program pays landowners a fixed per-acre rate to implement silviculture BMPs for watershed protection.</td>
<td>This approach would likely skew towards the benefits provided by high-density forests.</td>
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<th><strong>Forest Outcomes</strong></th>
<th><strong>Tradeoffs</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial silviculture is most likely outcome, though restoration/conservation forestry would also benefit.</td>
<td>This approach would likely skew towards the tradeoffs provided by high-density forests.</td>
</tr>
</tbody>
</table>
Thought Experiment 3: Flexible Tree Density, Tiered Rate

Transaction Design
PWS program and possibly other partners pay landowners a per-acre base rate to implement silviculture BMPs for watershed protection plus higher rates for additional benefits as applicable (water supply, resilience/risk reduction, habitat/biodiversity, etc.).

Forest Outcomes
Allows for flexible management over time and space.

Benefits
Programs could attempt to balance incentives to achieve a wide range of local objectives.

Tradeoffs
Program transaction costs may increase as a result of greater complexity. Additional payors may need to be identified for non-water benefits (e.g., biodiversity/habitat).
References


References


