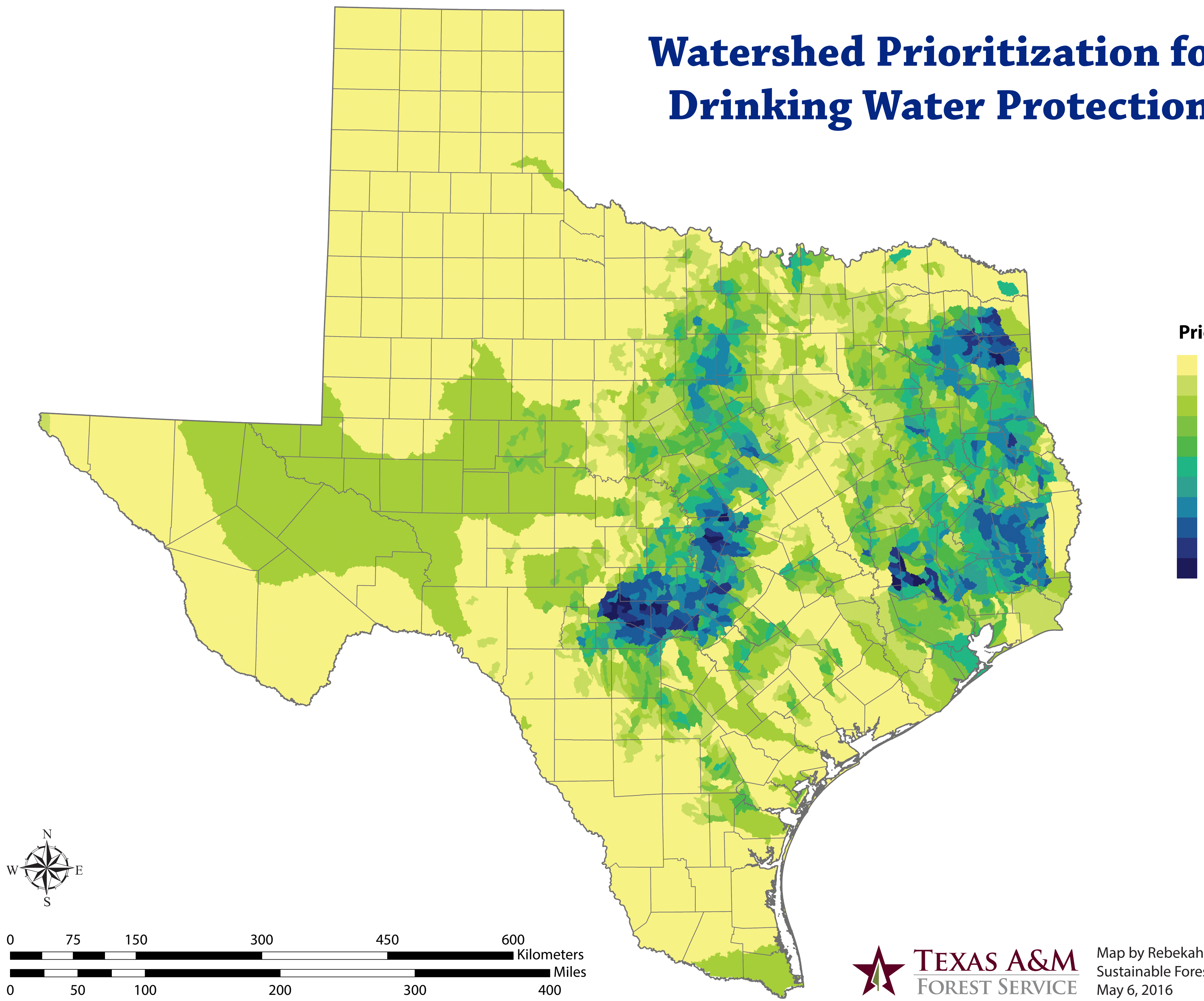
Watershed Prioritization for Drinking Water Protection



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Watershed Prioritization for Drinking Water Protection

water

Watershed Importance for Surface Drinking Water

Surface water and groundwater under the influence of surface water intakes were used with annual water supply to determine each watershed's importance for surface drinking water.

Population served by watershed, accounting for flow out of watershed ✖ Annual water supply of watershed (precipitation minus evapotranspiration)

Data used:

Public Water Systems population served and surface water and groundwater under the influence of surface water intakes (TCEQ)

Annual water supply (Brown et al 2008)

forest

Forest Importance to Surface Drinking Water

A forest index based on the prevalence of forest in the watershed weighted by landscape position and ownership was combined with watershed importance to produce forest importance to drinking water.

Watershed importance for surface drinking water (intakes and supply) ✖ Percent forest, weighted by landscape position and ownership

Data used:

Forest, separated into upland, wetland, and riparian, based on Wilson et al (2012) as adapted by Simpson et al (2013)

Public lands (internal TFS data)

threats

Threats to Forests Important for Surface Drinking Water

Threats to forests—development, wildfire, and insects and disease—were incorporated to identify those watersheds with forests important to surface drinking water at greatest risk.

Forest importance to surface drinking water (intakes, supply, forest) ✖ Threats, weighted by development, wildfire, and insects and disease

Data used:

Development level, wildfire risk, and forest health as described by Texas A&M Forest Service (2009)

partners

Partnership Potential for Watershed Protection

To prioritize watersheds for surface drinking water protection efforts, the intakes, forest, and threats results were combined with partnership potential: Watershed Protection Plans, TMDLs, and large water users.

At-risk forests important to surface drinking water (intakes, supply, forest, threats) ✚ Partnership potential (Watershed Protection Plans, TMDLs, water rights)

Data used:

Watershed Protection Plans, watersheds with Total Maximum Daily Loads (TMDLs), and permitted water rights holders (TCEQ)

Sustainable Forestry & Water Resources

http://tfsweb.tamu.edu/water

Texas A&M Forest Service

Watershed Prioritization for Drinking Water Protection

To prioritize Texas watersheds by forest importance to surface drinking water for source water protection, four main factors were considered: (1) watershed importance for surface drinking water, (2) forest importance to surface drinking water, (3) threats to forests, and (4) potential for partnership. The methods used are adapted from the US Forest Service's Forest to Faucet study. Please refer to the Forest to Faucet methods paper, "From the Forest to the Faucet: Drinking Water and Forests in the US," by Emily Weidner and Al Todd (2011) for background and technical details. The analysis was performed at the 12-digit HUC level.

(1) Watershed Importance for Surface Drinking Water

The spatial and hydrological relationship between each watershed and surface water intake, the population served by each intake, and the annual available water supply were analyzed to produce an index of watershed importance to surface drinking water.

Drinking Water Protection Model (PR)

The number of people served by each surface water (SW) and groundwater under the influence of surface water (GUI) intake was determined using information from the TCEQ online Water Utility Database. For Public Water Systems with both SW and GUI intakes, it was assumed that the SW intakes served 75% of the population while any GUI intakes served the remaining 25% (collectively). Population was divided equally among intakes of the same type. Additionally, it was assumed that intakes with an operational status of operating are online 100% of the time, those with demand status are online 35% of the time, and emergency intakes are online 5% of the time. When overlapping in online time, equal distribution was assumed between the intakes. If the PWS had both a demand and an emergency intake, it was assumed that the 5% online time of the emergency intake was concurrent with the online time of the demand intake.

A given watershed serves the population that uses the intakes within the watershed, but it also serves people using intakes located downstream in other watersheds. Or, from the perspective of the intake, an intake is influenced not only by its own watershed but also by the watersheds upstream from it. To account for this, the population served by a watershed was calculated as the sum of the watershed's intake population plus a portion of the population of intakes downstream as a function of distance. Full details of the method employed are given by Weidner and Todd (2011). The result is an index of surface drinking water protection (PR) based on population and hydrologic flow.

Index of Importance to Surface Drinking Water (IMP)

To gain a measure of the importance of each watershed to surface drinking water, the drinking water protection model (PR) is combined with annual water supply (Q). The result is an index that highlights areas important to supply, demand, and linking supply and demand. Water supply data was obtained from Brown et al (2008). The index is obtained simply by multiplying PR and Q for each watershed and dividing the nonzero results into 100 quantiles.

$$\mathbf{IMP = PR \times Q}$$

(2) Forest Importance to Surface Drinking Water

A forest index, taking into account landscape position and ownership, was combined with the outcome of the first step to create an index of forest importance to surface drinking water by watershed.

Forest Index (FOR)

The forest map used is based on the FIA forestland map produced by Wilson et al (2012), as described in "Texas Statewide Assessment of Forest Ecosystem Services" (2013).

Weighting of forest by landscape position

The percent of each watershed covered by wetland (w), riparian (r), and upland (u) forest was calculated. These values were then weighted according to likelihood of landowner engagement in protection strategies. The results were scaled such that the maximum value would be 100.

$$\mathbf{FOR_{LP} = ((0.55 \times u + 0.25 \times w + 0.2 \times r) \ / \ max\ value) \times 100}$$

Weighting of forest by ownership

The percent of each watershed covered by forest with a public owner was calculated, and watershed scores were assigned as follows.

percent public forest	0%	0-10%	10-25%	25-50%	>50%
FOR_{own}	0	25	50	75	100

Weighting of FOR_{LP} and FOR_{own}

The forest landscape position and ownership indices were combined using the following formula to develop an overall forest index, giving most of the weight to landscape position.

$$\mathbf{FOR = 0.9 \times FOR_{LP} + 0.1 \times FOR_{own}}$$

Forest Importance (FIMP)

The forest index was then combined with the importance to surface drinking water index to produce an index of forest importance to surface drinking water.

$$\mathbf{FIMP = IMP \times FOR \ / \ 100}$$

(3) Threats to Forests Important to Surface Drinking Water

Threats to forests—development, wildfire, and insects and disease—were incorporated to identify at-risk watersheds. The threat maps in "Texas Statewide Assessment of Forest Resources" (2009) were utilized for this purpose.

Threats (THR)

Development

The threat of development (dTHR) was calculated as the percent of forest in the watershed with a development level score of 70 or higher in the state assessment.

Wildfire

The threat of wildfire (wTHR) was calculated as the percent of forest in the watershed with a wildfire risk score of 70 or higher in the state assessment.

Insects/Disease

The threat of insects and disease (iTHR) was calculated as the percent of forest in the watershed with a forest health score of 70 or higher in the state assessment.

Weighting Threats

The three threats were weighted to give an overall threat index as follows, with development receiving the bulk of the weight, followed by wildfire and then insects and disease.

$$\mathbf{THR = 0.75 \times dTHR + 0.15 \times wTHR + 0.1 \times iTHR}$$

Threats and Forest Importance to Surface Drinking Water (TFIMP)

Combining the threats with the index of forest importance yields an index showing watersheds that are important for surface drinking water, have significant forestland, and have forestland at risk. The nonzero results were split into 10 quantiles.

$$\mathbf{TFIMP = FIMP \times THR \ / \ 100}$$

(4) Partnership Potential for Watershed Protection

Potential partners were identified based on existing watershed protection plans, TMDLs, and water rights.

Partnership Potential (PP)

Watershed Protection Plans (WPP)

Watersheds were given 0 points if they did not have a Watershed Protection Plan, 5 if they had one sponsored by a 3rd party, and 10 if they had one sponsored by a state agency.

Total Maximum Daily Loads (TMDL)

TMDL watersheds were identified by TCEQ and were given 10 points; other watersheds received 0 points.

Water Rights (WR)

Large corporate water users were identified from TCEQ permitted water rights holder information. Each watershed was given 0 points if there were no large water users in the encompassing 8-digit HUC watershed, 5 if there was 1, and 10 if there were 2 or more.

Watershed Priority

Partnership potential was combined with the threats and forest importance to surface drinking water index to produce an overall prioritization for targeting drinking water source protection efforts.

$$\mathbf{Priority = 0.75 \times TFIMP + 0.2 \times (WPP + TMDL) + 0.05 \times WR}$$

Sources

Brown, T.C., M.T. Hobbins, and J.A. Ramirez. 2008. "Spatial Distribution of Water Supply in the Coterminous United States." Journal of the American Water Resources Association 44 (6): 1474–87.

Simpson, H., E. Taylor, Y. Li, and B. Barber. 2013. "Texas Statewide Assessment of Forest Ecosystem Services." Texas A&M Forest Service.

"Texas Statewide Assessment of Forest Resources." 2009. Texas A&M Forest Service.

Texas Commission on Environmental Quality. https://www.tceq.texas.gov/.

Weidner, E., and A. Todd. 2011. "From the Forest to the Faucet." USDA Forest Service.

Wilson, B.T., A.J. Lister, and R.I. Riemann. 2012. "A Nearest-Neighbor Imputation Approach to Mapping Tree Species over Large Areas Using Forest Inventory Plots and Moderate Resolution Raster Data." Forest Ecology and Management 271 (0): 182–98.

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