

EDUCATOR'S TOOLKIT FOR RAIN GARDEN PROGRAMS

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The purpose of this toolkit is to provide guidance for educators on how to incorporate props, visual demonstrations and water facts into educational sessions related to home stormwater runoff management and rain gardens. The overarching goal is to increase audience understanding and to make rain garden implementation attractive and attainable for homeowners. This publication contains a list of materials and suggestions on how to use them during a session at a rain garden demonstration site or in a classroom setting. This material is generally targeted for adult audiences but may be adapted for middle school, high school or college students. It is assumed that educators have a fundamental understanding of rain garden function. For information on rain garden design and applications, please consult your local municipal stormwater department.

Quick Numbers!

- 1 cubic foot = 7.48 gallons water
- About 60 gallons of runoff is generated from every 100 square feet of impervious surface (rooftop, driveway, etc.) with a 1-inch rain.
- To find how many rain barrel gallons will be filled from a half-inch rain, multiply the contributing rooftop square footage by 0.3125.

Tennessee Rain Facts

- On average, a rooftop in Tennessee intercepts about 50 inches of rainfall a year. That's over 10,000 gallons of rooftop runoff every year coming from a single downspout (assuming it drains about 300 square feet)!
 - Calculate the runoff volume (aka free irrigation water) coming from the rooftop of the venue location and use it to discuss the possibility of using rain barrels to capture and store runoff for irrigation water later. To do this: 1) Use the dimensions of the building to calculate the flat footprint of the rooftop area using units of square feet; 2) Multiply by the feet of annual rainfall depth (i.e., 1 foot = 12 inches, 50 inches = 50/12 feet, or 4.17 feet); and 3) Multiply by 7.48 gallons per cubic foot to return a total gallons of rooftop runoff annually. See the Formula box for a quick reference for all calculations. We experience intense rainfall in parts of the state — sometimes up to 4 inches per hour! The runoff from the rooftops and driveways of a neighborhood of just 100 homes would fill an entire Olympic-size pool from that rainwater runoff (assuming the average roof/driveway area is about 2,400 square feet)!

Gallons of Rainwater Runoff per Contributing Rooftop Drainage Area (sq. feet)

Rainfall (inches)	300	600	900	1,200
0.25	40	75	110	150
0.5	75	150	225	300
0.75	115	230	335	460
1	150	300	450	600
2	300	600	900	1,200

- Tennessee has immense water resources — over 60,000 miles of rivers and streams — driven by its above average rainfall. On the Plateau, annual rainfall reaches 70 inches in some years, as compared to some areas in the southwest United States that get less than 10 inches annually or the national annual rainfall average of 32 inches. Take advantage of this resource to reduce your need for irrigation in your yard.

- A 1-inch rainfall on a typical house (1,400 square feet of roof area) will produce about 850 gallons of rainwater runoff.
 - Demonstrate how little rain it takes to fill a typical rain barrel (50 gallons of storage). Provide an example of a 1,400-square-foot roof with four downspouts that evenly drain the roof. Determine the downspout runoff area, which is 350 square feet. Divide rain barrel storage (50 gallons) by 7.48 to return cubic feet of storage. Then divide that number by the downspout runoff area (350 square feet) and multiply by 12 to convert to inches. It will only take 0.23 inches of rain to fill a 50-gallon rain barrel. This calculation may be used as an introduction activity using the workshop venue: 1) Take the group outside and ask them to count the number of downspouts; 2) Estimate the rooftop area by pacing, or have this information available; and 3) Complete the calculation.

Formula:

All Conversion factors indicated in [blue](#).

Annual Rooftop Runoff (gallons) = Rooftop Area (ft²) x Annual Rainfall (inches) x [0.62](#)

Downspout Runoff Area (ft²) = Rooftop Area (ft²) / # Downspouts

Needed Rainfall to Fill Rain Barrel (inches) = Rain Barrel Volume (gallons) / Downspout Runoff Area (ft²) x [1.6](#)

Props and Visual Aids for Presentation Materials

- Two clear plastic bottles with a 3-inch layer of cobble/gravel/clean sand (use relevant substrate that mimics the bottom of a local stream) filled with water. Add fine sediment (i.e., clay, silt) to one bottle. You may need to rinse the “clean” bottle until the water is clear.
- Construction flags, hanging bubble level, wooden stakes, rubber mallet, thin rope or twine, measuring tape, yard stick and (if indoors) a large bed sheet and chair.
- Hand spade shovel, bucket, soil sample box and sample soil test report.

- Three clear plastic cups, water pitcher, blue food coloring, sponge (preferably tan color).
- Six wooden rectangular blocks, roughly 4 inches by 4 inches by 2 inches painted blue.
- Clear container with the following layers (oversized mason jar, at least 12 inches tall):
 - Bottom layer, clay (or native soil), 1 inch.
 - Washed sand or gravel, 2 to 3 inches.
 - Fluffed topsoil, 4 to 6 inches.
 - Top layer, triple-shredded hardwood mulch, 3 inches.
 - Plants (optional) or fake.



FIGURE 1: Two prepared bottles show comparison between a healthy stream (left) and a stream impacted by sediment pollution (right).

How to Implement Props

Visualizing urban runoff impacts on water quality and aquatic habitat with water bottles (Figure 1): Explain that sediment is one of the most common pollutants across the state and country, and streambank erosion is a large source of sediment. Explain that when it rains in developed watersheds, runoff from impervious surfaces flows quickly to streams, compounding in volume and increasing in velocity as it moves downhill. This energy causes channel incision and erosion. Point out that sediment creates turbid water that holds less oxygen and more heat, carries attached toxins and excessive nutrients that degrade water quality, and

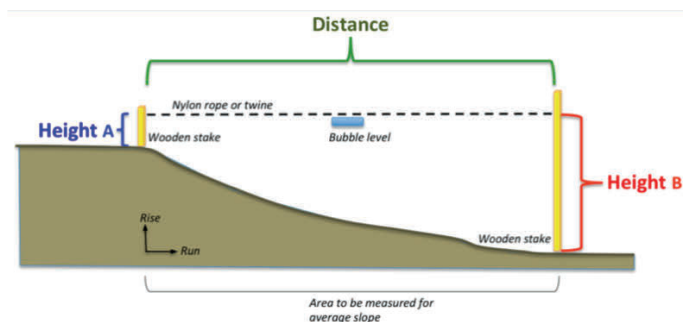


FIGURE 2: Measure land slope using a bubble level, two wood stakes and nylon rope. Slope is calculated as the rise in elevation (Height B—Height A) divided by the run distance.

settles to the bottom and fills benthic habitat, which is the ecologically important zone at the bottom of a water body. Invert the two bottles several times and pass them around the audience. Measuring land slope with bubble level: Pick out a location with a gentle slope and outline a hypothetical rain garden footprint with colored construction flags. Explain that rain gardens are best implemented in flat areas, preferably less than 15 percent slope, or used as terraced applications in greater slopes. Use the mallet to drive in a stake at the top end and another at the bottom end of the selected location. Measure this distance between the stakes. Run the rope between the two stakes and use the bubble level to ensure it is level. Measure from the ground up to the height of the rope on both stakes and take the difference. Calculate slope by taking rise over run and multiply by 100 to get percent slope (Figure 2). You may want to pre-measure a distance of 20 feet for easy math.

Collecting a soil sample and conducting a perc test: A percolation or “perc” test may take up to three days to complete, so plan accordingly. If possible, visit the site one to two days before the session to dig the hole and conduct the test. The steps for performing a perc test are as follows: 1) Dig a 12-by-12-inch hole, placing the soil from near the bottom of the hole in a bucket; 2) Scrape the sides of the hole with a shovel to break up any slicking from the digging; 3) Fill the hole to the top with water and allow it drain — this will “prime” the hole to simulate saturated conditions; and 4) Within the same day, refill the hole with water and monitor water levels every couple hours. This will provide an estimate of the saturated soil infiltration rate. A rate of 0.25 inches per hour or greater is acceptable for a standard rain garden (empties in 48 hours or less). If a slower infiltration rate is measured, then either test a new rain garden location or consider a backyard wetland instead. Another alternative option would be the addition of a perforated pipe as an “underdrain.”

The use of an underdrain will require an outfall point downhill from the rain garden and likely quite a bit more excavation work. Discuss other potential rain garden citing concerns, such as staying away from buried utilities, shallow bedrock or areas that have a high water table (within a couple feet of the surface). Homogenize or mix the soil from the perc test hole, fill two soil sample boxes (Figure 3), and send it to the soil testing lab for particle size analysis. Rain gardens will be most effective in areas with soils that have less than 40 percent clay content. While investigating soils, collect a topsoil sample to be analyzed for pH, organic matter and fertilizer recommendations. Bring in a sample soil test analysis report. Discuss possible soil amendments to address soil health challenges, such as neutralizing pH and improving organic matter content with leaf litter compost. Manure-based or food waste-based composts are not suggested because of their high nutrient contents. Comparing water movement through compacted clay soils and porous, amended soils (Figure 4a): Fill the water pitcher with water and add blue food



FIGURE 3: A soil sample box provided at UT Extension offices and used to submit samples to the University of Tennessee Soil, Plant and Pest Center in Nashville, Tennessee.

coloring for easy viewing. Punch five to eight holes in the bottom of one cup and place a circular sponge cutout at the bottom of each cup. After discussing how to obtain perc test results, emphasize the importance of knowing that your soils will infiltrate the ponded volume within 48 hours. Fill the cup with no holes about halfway and explain that compacted, clay soils will result in a bathtub situation where water will just stand and create potential mosquito habitat. Then pour water into the cup with holes. The water will run out the bottom (if you're indoors, use a catch pan). Explain how porous soils will allow the water to drain into the subsoil and eventually recharge the water table. A cup could also be used to demonstrate the function of an outlet structure and freeboard. Cut a shallow notch in the rim of the cup

(Figure 4b). Fill the cup with water until it pours out of the "outlet." Show how this outlet elevation dictates the high water level in the rain garden. Discuss the importance of planning for this outlet to guide overflow to existing drainage infrastructure without impacting adjacent property or causing erosion.



FIGURE 4A: A cup with holes punched in the bottom represents porous soils that allow water to drain through while a cup with no holes represents compacted soils that don't allow water to drain.

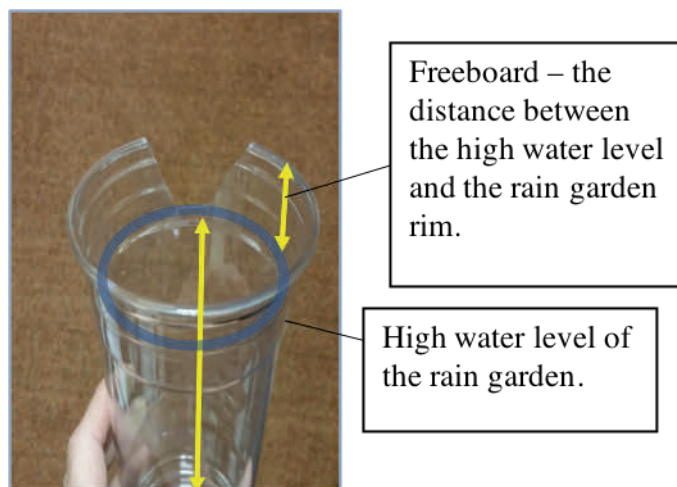


FIGURE 4B: Cut a notch in the cup to represent the rain garden outlet; pour water into the cup until it overflows out of the notch, showing the importance of the outlet and freeboard in directing rain garden overflow in the desired direction.

Rain garden runoff volume visualized using wooden blocks (Figure 5): Explain that a rain garden is sized to catch a designated amount (or volume) of rainwater runoff. The size (i.e., footprint) is related to soil perc test results (how fast water will infiltrate into the soil) and how much rainfall is collected from the contributing drainage area (generally 1 inch of rain). Assemble the six blocks in a flat square with two rows of three blocks. Explain that this model represents an inch of rain falling on a portion of a rooftop, and a downspout is draining to the rain garden off of one corner. Explain that if the

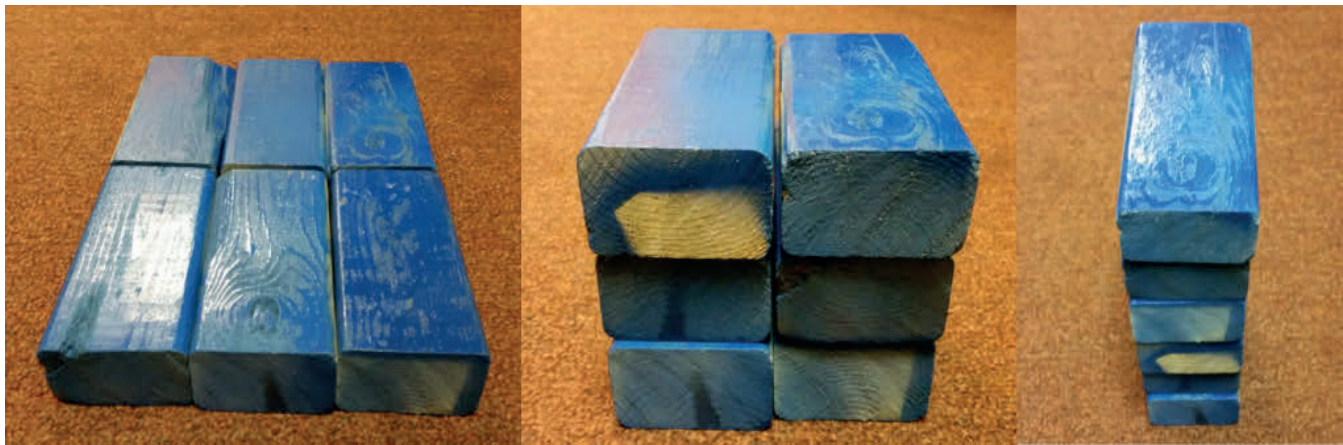


FIGURE 5: Wooden blocks painted blue represent the volume of water running off a rooftop (1-inch deep) and then stacking into a rain garden (3–6 inches deep) where the depth is dependent on soil texture and infiltration capacity. As infiltration capacity increases, stack can get higher and rain garden footprint gets smaller.

perc test showed slow-draining soils, then you can “stack” that water up in the rain garden to about 3 inches and be confident that it will infiltrate (or empty) within two days. Stack the blocks three deep and show that the rain garden footprint is two blocks in footprint size. Explain that if the soils are fast-draining, you can stack the water up to 6 inches or more. Stake all of the blocks on top of each other, six blocks high. Then compare the footprint that is now one block in size — half of the size of the slow-draining size, but the same volume of water. Emphasize that slow-draining soils need a larger rain garden footprint to spread out the water, and fast-draining soils need only a small footprint where you can stack the water up higher. Refer to the table below for general sizing guidelines.

Soil Texture / Perc Test Outcome	Size as % of Impervious Surfaces Draining to Garden
Clay loam or slow draining (24–48 hrs)	15%
All other loams or fast-draining (< 24 hrs)	10%

Visualizing rain garden footprint and finalizing

layout: Discuss how rain gardens may be integrated into existing landscaped areas or be detached, but in either circumstance, the depression footprint is sized to capture a designated volume of water based on the soil characteristics, the amount of area draining to the garden, and any local requirements targeting a specific level of treatment (e.g., 1 inch of runoff from impervious surfaces). Generally, residential rain gardens will be 100-200 square feet in size. For larger applications,

the space should be broken up into multiple pools using internal low berms. Contact your local municipal stormwater departments for sizing requirements. Use flags (Figure 6) and a measuring tape to outline the boundary for a given depression size, or work in small groups to outline several different rain garden options around the venue building. Suggest that they work with the natural contours of the space and maximize the flowpath of concentrated inflow. Then discuss how other factors might affect the final shape and placement: getting water in and out of the garden, footpaths in and around the garden for maintenance, mowing, etc. You may also use surveyors’ paint instead of the flags, but consider that the paint may take quite some time to wear away if you are not close to installation time.

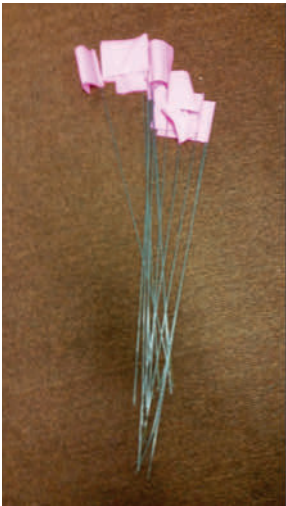


FIGURE 6: Construction flags or spray paint can be used to outline future rain garden boundaries to visualize the shape and placement in the context of the surroundings.

Mason jar demonstration of the components of a rain garden soil (Figure 7): Revisit the concept of soil texture and the results of the perc test. Use the glass container to show the ideal volumetric components of a rain garden soil or media mixture: sand, topsoil and organic amendment, such as leaf litter compost or aged woodchips, and mulch. These layers are adapted to fit your specific situation based on native soil characteristics and local availability of materials. Make note of a bowl depth (or ponded water depth) of 3-6 inches and freeboard above outlet. Additional features such as plant roots, an underdrain or a rock layer above the native soil may be added. Discuss the difference in using sand and gravel layers as internal water storage layers underneath a 4-to-6-inch planting topsoil zone in contrast to organic amendments that should be mixed into the native soil for a “native soil rain garden.” Discuss the added costs in excavation for soil replacement. Discuss potential use for the excavated soil. If the subsoil has high clay content, it can be used for a compacted berm on the lower end of the garden, which will minimize the extent of excavation. Suggest stockpiling good topsoil for return back into the rain garden after the bowl is dug.



FIGURE 7: A large mason jar is used to show volumetric components of a rain garden soil mix.

Rain Garden Classroom Planner Activity

Appended to the back of this document is a set of rain garden stencils and a planning worksheet. This activity is intended to be used by municipal government, Extension professionals or trained volunteers while working with land managers (i.e., homeowners, public works departments, property managers, etc.) interested

in building rain gardens in residential or small-scale commercial settings. The blue lines on the footprint stencils indicate contour lines to show bowl depth (e.g., ponded water depth). Soil moisture conditions and ponded water depth increase from the perimeter of the footprint to the center. Diameters on the blank plant stencils indicate approximate mature growth. White numbers on the photographic plant stencils indicate approximate mature height.

Purpose: The purpose of this activity is to:

1. Complement a training session, workshop or other form of educational program led by a professional with experience in rain garden design.
2. Teach about considerations related to plant selection using a hands-on, experiential learning approach.
3. Create a sense of empowerment leading to implementation of the planned rain garden by providing students/clientele with a planting plan and cost estimate for their project.

Resources: The following resources are included in this packet:

- Rain garden footprint stencils, scaled to 1 inch = 2 feet. The contour lines reflect the bowl topography, which relates to general soil moisture conditions where the innermost contour is the wettest area and the outer edge is the driest area.
- Plant stencils are sized to expected plant growth diameters, scaled 1 inch = 2 feet.
- Plant identification sheets, one organized by plant diameter and the other according to recommended soil moisture conditions.

Instructions for use (Figure 8):

1. Print all resources using a color printer. Print multiple copies for large groups or workshops.
2. Laminate all stencils and plant ID sheets, cut out each stencil, and put all like-sized plants in labeled bags or containers. Optional: add Velcro to the backs of the laminated plants to be able to use on a large felt board in group demonstrations of example rain gardens.
3. Use during trainings or as an interactive activity at display tables during community events and fairs.



FIGURE 8: Example 200-square-foot rain garden layout using the stencils provided in this packet.

Tips:

1. Suggest to participants that they take a picture of the garden layout they create so they have a record to take home.
2. Create a plant price list using cost information from local nurseries in your area.
3. Add regionally specific native plant species to the offered plant options.
4. Use the green grid for plug counting when surrounding sedge or groundcover is used in edge plantings that transition to the surrounding landscape.

Concluding Remarks to Leave an Impression

Conclude with a reminder that rain gardens and other conservation landscaping practices provide function and benefits on *multiple* scales. The benefits are additive:

- To the *individual* homeowner, their property will have greater functionality, contain a greater diversity of plants and beneficial insects, and may even have greater sale value with increased aesthetic appeal;
- To the *neighborhood*, the general aesthetic appeal of the area will be heightened as more grey infrastructure is turned green and less erosion occurs; and

- To the *community*, an overall improved quality of life through cleaner water and a healthy ecosystem that supports economic enterprises in development and outdoor recreation.

From a hydrological perspective, rain garden benefits are cumulative across a watershed. Revisit the concept of rooftop runoff by restating that about 850 gallons of rainwater runoff comes from a typical home in a 1-inch rain event, which means that in a neighborhood of 40 homes, almost 35,000 gallons of water will fall just from the rooftops. Consider translating that to feet of standing water in the presentation room (about 4 feet deep in a room with dimensions 30 feet by 40 feet). That's a lot of water we can use to grow plants instead of sending it downstream!

The following table includes estimates for the total amount of impervious surface area in each Tennessee county, total land area of each county, and the imperviousness of each county, which is a ratio of impervious surface to total area (all units in square miles). Impervious surfaces are those that shed rainfall and do not soak it in (such as rooftops, pavements and decking). Pervious surfaces are any land surface that soaks in water, like lawns and gardens. Multiply the impervious surface for your county by 26.3 to determine the number of Olympic-size swimming pools that would be filled using the runoff water coming from impervious surfaces and entering local creeks during a 1-inch rainfall.

An interactive web map can be found at tiny.utk.edu/TNimpervious. This map contains a data layer that shows the percent of impervious cover on the landscape shown on a 90-by-90-foot grid. Research has shown that watersheds that are composed of more than 10 percent impervious area can result in streams that are unstable, which can cause costly damage to municipal infrastructure like roadways and utilities. Use this map to click around your locality to see which areas may be above that threshold. Ask if anyone has seen signs of this instability (stream banks falling into the channel, cut banks, mounds of soil and sediment, etc.).

Table 1. County information for impervious surface,* total area, and percent of county in impervious area. Land cover data published in 2011.

County	Total Impervious Area (mi ²)	Total Area (mi ²)	Impervious-ness	County	Total Impervious Area (mi ²)	Total Area (mi ²)	Impervious-ness
Anderson	22.83	344.96	6.6%	Lauderdale	6.40	505.28	1.3%
Bedford	11.49	474.89	2.4%	Lawrence	8.76	618.31	1.4%
Benton	3.47	436.19	0.8%	Lewis	1.65	282.40	0.6%
Bledsoe	3.76	406.61	0.9%	Lincoln	8.27	570.65	1.4%
Blount	21.41	566.53	3.8%	Loudon	13.57	246.92	5.5%
Bradley	19.93	331.52	6.0%	Macon	3.18	307.24	1.0%
Campbell	14.60	498.26	2.9%	Madison	21.92	558.79	3.9%
Cannon	2.59	265.55	1.0%	Marion	7.73	513.44	1.5%
Carroll	5.90	600.30	1.0%	Marshall	5.83	376.26	1.6%
Carter	7.47	347.68	2.1%	Maurry	15.63	615.34	2.5%
Cheatham	4.11	305.94	1.3%	McMinn	12.14	431.98	2.8%
Chester	3.28	285.96	1.1%	McNairy	6.40	563.99	1.1%
Claiborne	10.05	440.68	2.3%	Meigs	2.08	216.64	1.0%
Clay	2.49	259.24	1.0%	Monroe	8.69	653.53	1.3%
Cocke	5.94	443.30	1.3%	Montgomery	27.92	544.40	5.1%
Coffee	14.56	434.47	3.4%	Moore	1.29	130.41	1.0%
Crockett	4.21	267.00	1.6%	Morgan	7.93	522.67	1.5%
Cumberland	19.22	684.89	2.8%	Obion	8.07	555.70	1.5%
Davidson	101.22	525.62	19.3%	Overton	9.38	435.15	2.2%
Decatur	2.68	345.15	0.8%	Perry	1.27	422.88	0.3%
DeKalb	5.15	328.90	1.6%	Pickett	3.10	174.19	1.8%
Dickson	8.01	492.01	1.6%	Polk	3.26	442.26	0.7%
Dyer	9.85	530.79	1.9%	Putnam	24.22	402.06	6.0%
Fayette	11.92	706.30	1.7%	Rhea	8.25	336.67	2.5%
Fentress	7.33	499.37	1.5%	Roane	19.20	394.96	4.9%
Franklin	8.65	574.58	1.5%	Robertson	10.58	476.54	2.2%
Gibson	10.91	603.73	1.8%	Rutherford	54.95	624.43	8.8%
Giles	6.12	611.26	1.0%	Scott	7.80	532.35	1.5%
Grainger	7.31	302.56	2.4%	Sequatchie	3.07	267.39	1.1%
Greene	14.21	623.92	2.3%	Sevier	15.17	597.71	2.5%
Grundy	3.46	359.74	1.0%	Shelby	188.70	784.97	24.0%
Hamblen	11.37	175.83	6.5%	Smith	4.86	326.40	1.5%
Hamilton	67.18	575.52	11.7%	Stewart	2.06	492.41	0.4%
Hancock	3.39	224.30	1.5%	Sullivan	32.70	429.78	7.6%
Hardeman	6.25	670.03	0.9%	Sumner	23.01	543.97	4.2%
Hardin	7.20	596.00	1.2%	Tipton	10.48	469.19	2.2%
Hawkins	11.26	499.61	2.3%	Trousdale	1.12	115.84	1.0%
Haywood	9.46	532.88	1.8%	Unicoi	3.47	186.25	1.9%
Henderson	5.05	525.75	1.0%	Union	4.43	247.10	1.8%
Henry	6.11	593.01	1.0%	Van Buren	2.19	274.34	0.8%
Hickman	2.90	612.48	0.5%	Warren	10.43	434.33	2.4%
Houston	0.86	206.93	0.4%	Washington	21.67	329.97	6.6%
Humphreys	4.34	556.70	0.8%	Wayne	4.75	735.62	0.6%
Jackson	3.97	319.69	1.2%	Weakley	6.96	581.95	1.2%
Jefferson	7.06	313.79	2.2%	White	10.93	379.60	2.9%
Johnson	2.02	302.81	0.7%	Williamson	30.24	584.17	5.2%
Knox	97.40	525.92	18.5%	Wilson	26.06	582.11	4.5%
Lake	2.13	194.19	1.1%	Tennessee	1334	42140	3.2%

* Impervious surface data from the USA National Land Cover Database 2011 and analyzed in ArcGIS Pro 1.4.0 (© ESRI, 2016).



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