Tennessee River Basin Report Card

Methods report on data sources, calculation, and additional discussion

December 4, 2017

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Goals and objectives of the Tennessee River Basin Report Card

The Tennessee River Basin Report Card was developed as a tool for prioritization and restoration decisions made in the Tennessee River Basin. The report card document is also meant to serve as an outreach tool for use by managers to highlight particular issues of importance when communicating conservation and restoration with the public.

To achieve a report card that is relevant to the goals and objectives of the wider Tennessee River Basin management, conservation, and restoration community, the project team solicited feedback from participants at the Tennessee River Basin Planning Network annual meeting in Chattanooga, Tennessee in August 2017. These participants identified Biodiversity, Recreation, Sense of Place, Water Quality, and Habitat as the most important values to consider for assessing environmental condition, and Urbanization and Population Growth, Habitat Fragmentation, Pollution and Contaminants, and Climate Change as the most important stressors. Additionally, there are particular management activities tracked by local and regional groups such as the Appalachian Landscape Conservation Cooperative (AppLCC) that relate to protecting these values and reducing stressor impacts.

The report card was designed to reflect on each of these components of the Tennessee River Basin to provide a holistic assessment of environmental stressors, condition and management. The results of the report card reflect these three groups of indicators. Overall region and basin condition ultimately is the goal of stressor reduction and management, and so is portrayed as a more central to the report card results and is the element that provides the grades for each region.

The Tennessee River Basin Report Card is meant to serve as an initial assessment of environmental stressors, condition, and management response in the Basin. The report card team at the University of Maryland Center for Environmental Science recognizes that there are many improvements that can be made to the report card, indicators, data sources, and methods.

Process for developing the report card

Following the Tennessee River Basin Planning Meeting in August 2017, the UMCES report card team worked closely with AppLCC and Tennessee River Basin Planning Network staff to identify data providers and regional experts for each potential value, stressor, and management indicator. UMCES provided data analysis for each of the indicators once data was identified and obtained from providers.

In October 2017, the UMCES report card team presented the draft report card results to members of the AppLCC Steering Committee in a virtual meeting and received extensive and constructive feedback to improve the utility and value of the report card and the accompanying methods report. The report card and this methods document are in large part a reflection of the feedback and direction received at that meeting.

Potential Improvements to the report card process

The UMCES report card team recognizes that the current Tennessee River Basin report card process was imperfect. The initial project plan included a scoping process to develop a report card for the whole of the AppLCC geography. The project was redirected to achieve a preliminary report card for the Tennessee River Basin, essentially beginning with the evaluation of values and stressors at the Tennessee River Basin Planning Network meeting in August 2017. These project direction changes are mentioned solely to suggest that a future process can be improved to produce a report card that includes some elements that were seen to be important, but which were not able to be included in this report card without additional analysis, time, and deliberation.

The UMCES team envisions a process that more closely adheres to the report card process that has successfully created report cards in numerous locations worldwide. This process includes co-design and co-development of the report card product with stakeholders and end-users of the product from the initial discussions about the process goals and objectives. These steps were not achievable with the limited time and resources available for the current project, but would greatly enhance engagement with stakeholders and end-users to create a report card that is widely accepted by the Tennessee River Basin environmental conservation and protection community, and is seen as a valuable tool for environmental decision making by regional and local managers and outreach to their communities. The current report card presents a first step in creating this outcome.

How are the grades calculated?

This report documents the data sources, calculations for each indicator, interpretation, calculation and assignment of scores for indicators in the Tennessee River Basin. It also enumerates data identified for indicators not included in the report card.

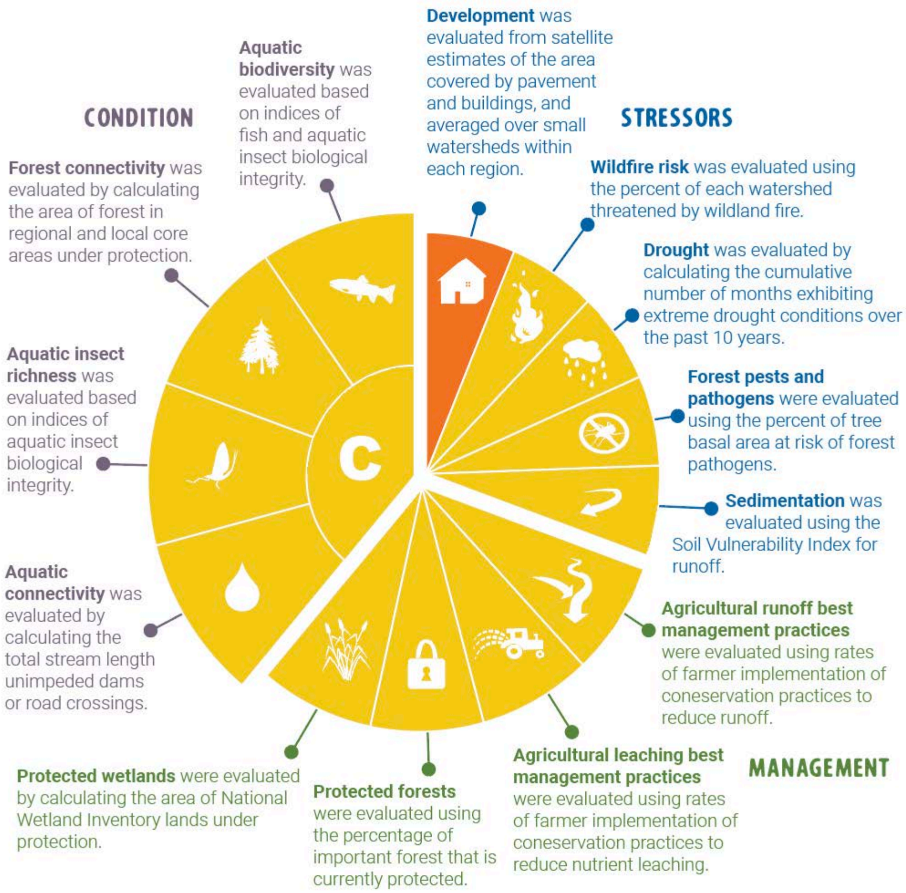

Figure 1: Preliminary results for the Tennessee River Basin Report Card. See Table 1 for indicator definitions.

Scoring and Letter Grades

All measurements were standardized to a 0-100 scale to enable aggregation of individual indicator results to the goal score. Scores were distributed in even increments to enable ease of aggregation. It is important to note that the scoring scheme is not a reflection of a "curve" or a lenient grading system; the goal teams and expert advisors determined through data analysis what data values represented good and bad grades, and those were translated to the final scoring scheme distributed into the 0-100 scale in 20-point increments. Final scores were given a grade based on the simple grading scheme as below:

Score	Grade
80-100	A
60-80	B
40-60	C
20-40	D
0-20	F

Figure 2: Scoring scheme for the Tennessee River Basin Report Card.

There were several potential scoring methods that were applied for report card indicators, including:

1. Pre-determined scoring. For some indicators, the data provider had already provided a rating of observations or results. These may have been measured against a regionally specific desired condition, or some other method. We use this method when the assessment methods were from an accepted source, using generally accepted practices.
2. Comparison to geographic range of data. For several indicators, data were compared to the regional range of data. The most desirable (for example, lowest percent of forest threatened by wildfire) was the top score, and the least desirable value became the lowest possible score.

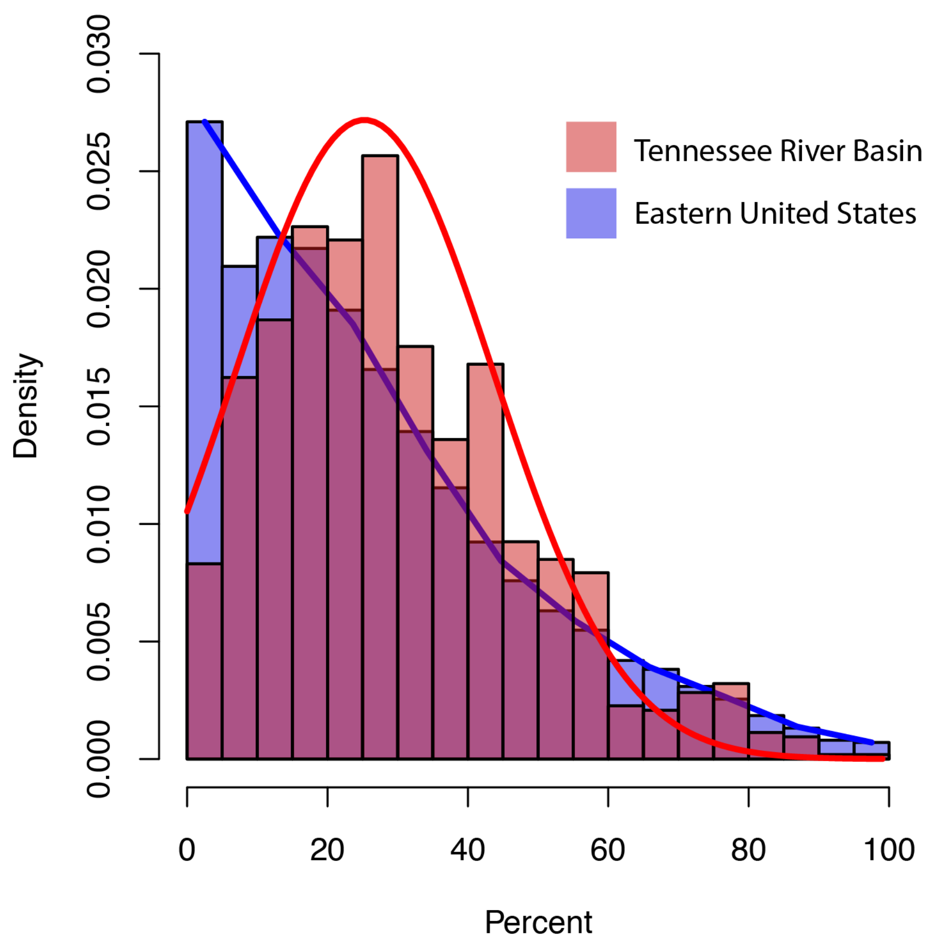

Figure 3. Example comparison of an indicator across two different geographic ranges. The data presented are the percent of each sub-watershed expected to experience an increase in housing density in forested areas between 2000 and 2030.

3. Comparison to national average. Where established goals and thresholds had not been previously defined, data were normalized by the average and standard deviation of each indicator calculated over a larger representative geography (e.g., nationally, or over the TRB itself). The resulting Z-Score, was divided into 5 levels bounded by the standard deviation of the data from the mean over the larger representative geography. If the basin average was within one standard deviation of the US average, the resulting score was a "C", for example. This technique assumes that the most desired condition exists somewhere in the reference geography.

Description	Standard Deviation	Grade
substantially above national average	1.5 - 2.5	A
above national average	0.5 - 1.5	B
near national average	-0.5 - 0.5	C
below national average	-1.5 - -0.5	D
substantially below national average	-2.5 - -1.5	F

Figure 4. Example scheme for comparison to the national average.

Table 1: Indicator data sources and scoring schemes.

Indicator	Data Source	Scoring Scheme
Stressor Indicators		
Development	USDA Forest Service	Z-score compared to the Tennessee River Basin
Drought	NOAA Palmer Drought Severity Index	Z-score compared to the national average
Wildfire	USDA Forest Service	Z-score compared to the national average
Forest pests and pathogens	USDA Forest Service	Z-score compared to the national average
Sedimentation vulnerability	NRCS's Soil Vulnerability Index	Z-score compared to the Tennessee River Basin
Condition Indicators		
Forest connectivity	AppLCC Natureserve	Z-score compared to the Tennessee River Basin
Aquatic connectivity	National Hydrography Data and Tiger Roads	Z-score compared to the Tennessee River Basin
Aquatic biodiversity	Tennessee Valley Authority	Scaled TVA health classifications from 0-100
Benthic Macroinvertebrate Condition	Tennessee Valley Authority	Scaled TVA health classifications from 0-100
Management Response Indicators		
Agricultural best management practices for runoff	NRCS's Soil Vulnerability Index	Z-score compared to the Tennessee River Basin
Agricultural best management practices for leaching	NRCS's Soil Vulnerability Index	Z-score compared to the Tennessee River Basin
Protected connected forest	US Protected Areas Database, National Land Cover Dataset	Z-score compared to the Tennessee River Basin
Wetland protection	US Protected Areas Database, US National Wetlands Inventory	Z-score compared to the Tennessee River Basin

Stressor Indicators

Indicator: Development

Data source: Weidner, E. & Todd, A. (2011) From the Forest to the Faucet: Drinking Water and Forests in the US. USDA Forest Service. Available on the web: http://www.fs.fed.us/ecosystemservices/FS_Efforts/forests2faucets.shtml

Calculation method: The Forest to the Faucet dataset provides a projection of the threat of development to forests, summarized by HUC12 watershed. This projection is derived from David Theobald's Spatially Explicit Regional Growth Model (SERGoM v3), which takes into account land protection status, census block population and change over time, road density, and travel time along major roads to population centers to map housing density in 2000 and project it to 2030. The model results were validated by hindcasting housing density for 2000 using data from 1980 and 1990 and comparing with observed housing density patterns for 2000. Theobald's work classified housing density into 12 classes spanning Urban to Undeveloped private land. Later, Stein et al. 2009 collapsed these into three categories: Rural 1 (> 40 acres per housing unit), Rural 2 (10-40 acres per housing unit), and Exurban Rural (less than 10 acres per housing unit). For this report card, the difference in housing density between 2000 and 2030 was used to identify areas projected to change categories (e.g., from Rural 2 to Rural 1, or from Exurban Rural to Rural 2). As was implemented for the Forest to Faucets analysis, all forests projected to change categories were classified as highly threatened by development. When expressed as a percent of all forests in each HUC12 watershed nationally, the national mean was calculated as 14.6% and the national standard deviation as 22.6%.

For each HUC12 watershed in the TRB, we calculated a Z-score for forests threatened by development using the national average and standard deviation:

$Development_{Zscore}$ = (Development% - 14.6)/22.6

The Development Z-score was then scaled from 0 to 100 representing a Z-score of 2.5 (highly threatened) to -2.5 (not threatened).

Citations:

Stein, S. R. McRoberts, L. Mahal, M. Carr, R. Alig, S. Comas, D. Theobald, and A. Cundiff. 2009. Private Forests, Public Benefits: Increased Housing Density and Other Pressures on Private Forest Contributions. USDA Forest Service, Pacific Northwest Research Station, PNW-GTR-795. December 2009.

Theobald, D. 2005. Landscape patterns of exurban growth in the USA from 1980 to 2020. Ecology and Society. 10(1):32.

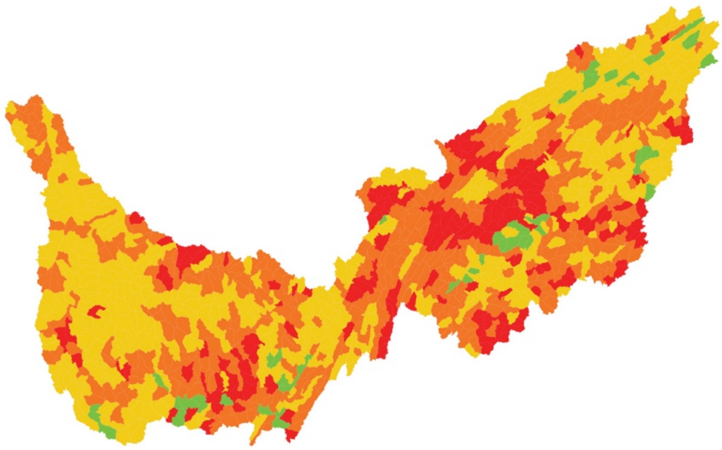

Figure 1: Development threat in forests throughout the TRB.

Indicator: Drought

Data source: https://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers/

Calculation method: The Palmer Drought Severity Index (PDSI) is based on a physical water-balance model, uses both precipitation and surface air temperature as input, and takes the precedent condition into account. It is generally considered superior to other statistically based drought indices, that are often based purely on past statistics of limited climate variables. While the PDSI is not without criticisms, it is reliably used in the context needed for this report card. The PDSI is a continuous value but is often classified monthly to describe drought conditions as moderate, severe, or extreme.

We downloaded monthly PDSI values by climate division for the lower 48 US states. We then calculated the number of months of extreme drought (i.e., months with PDSI values < -4) over the past 10 years for each climate division. For the lower 48 states, the mean number of months of extreme drought was 9.2 with a standard deviation of 9.4. We then identified the 19 climate divisions that overlapped the TRB. We intersected the TRB with the climate divisions to assign data to each HUC12 watershed. The number of months of extreme drought ranged from 1 to 20 across HUC12 watersheds. We used the national statistics to calculate an extreme drought Z-score, which was scaled from 0 to 100 using -2.5 and 2.5 as endpoints.

Citations:

Dai, A., 2011b: Drought under global warming: A review. Wiley Interdisciplinary Reviews: Climate Change, 2, 45-65

Figure 2: Months of extreme drought, evaluated via the Palmer Drought Severity Index, over the past 10 years.

Indicator: Wildfire

Data source: Weidner, E. & Todd, A. (2011) From the Forest to the Faucet: Drinking Water and Forests in the US. USDA Forest Service. Assessable via the web: http://www.fs.fed.us/ecosystemservices/FS_Efforts/forests2faucets.shtml

Calculation method: We used wildfire risk assessments summarized in the Forests to the Faucet dataset, which were based on the wildfire hazard potential (WHP) map produced by the USDA Forest Service, Fire Modeling Institute. These data are used to help inform evaluations of wildfire risk or prioritization of fuels management needs across very large landscapes (millions of acres). Areas of high wildfire potential are described as having fuels and recurring weather conditions conducive to fire conditions, particularly those difficult for suppression resources to contain. The map is intended to be paired with spatial data depicting highly valued resources and assets such as communities, structures, and powerlines. As in the Forests to the Faucet analysis, areas categorized as threatened by wildfire potential were ranked as having high or very high wildland fire potential in the WHP map. These areas were summarized by sub-watershed (HUC12-level) across the TRB to arrive at the percent of forests threatened by wildfire. Across the entire US, the mean wildfire potential was 25.0% with a standard deviation of 38.8% at the HUC12 level. We used these statistics to calculate a Z-score and scaled the Z-score from 100 to 0 using -2.5 (low wildfire potential) to 2.5 (high wildfire potential) endpoints.

Citations:

Dillon, Gregory K.; Menakis, James; Fay, Frank. 2015. Wildland fire potential: A tool for assessing wildfire risk and fuels management needs. In: Keane, Robert E.; Jolly, Matt; Parsons, Russell; Riley, Karin. Proceedings of the large wildland fires conference; May 19-23, 2014; Missoula, MT. Proc. RMRS-P-73. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. p. 60-76.

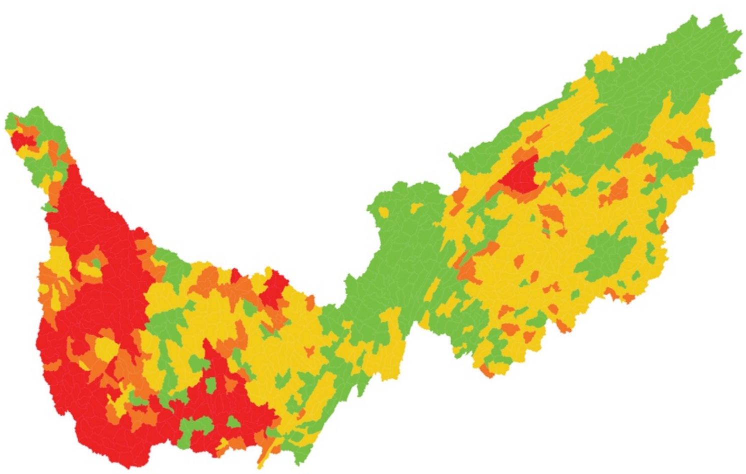

Figure 3: Wildfire potential

Indicator: Forest Insects and Disease

Data source: Weidner, E. & Todd, A. (2011) From the Forest to the Faucet: Drinking Water and Forests in the US. USDA Forest Service.
http://www.fs.fed.us/ecosystemservices/FS_Efforts/forests2faucets.shtml

Calculation method: The Forest to the Faucet dataset provides a summary of the National Insect and Disease Risk Map (NIDRM) created by the Forest Health Technology Enterprise Team (FHTET). We used these data to summarize the risk of forest insect and disease across the TRB. The NIDRM defines insect and disease risk as forests that "without remediation, 25 percent or more of the standing live basal area (BA) of trees greater than 1 inch in diameter will die over the next 15 years (starting in 2005) due to insects and diseases"(Krist, et al, 2006). The Forest to the Faucet dataset summarized these data as the percent of forests in each HUC12 watershed highly threatened by insect and disease. We calculated a national average score of 4.0% and standard deviation of 11.3%, which were used to calculate a Z-score. We scaled the Z-score from 100 to 0 using -2.5 (low threat level) to 2.5 (highly threatened).

Citations:

Krist, F., F. Sapio, B. Tkacz. 2006. Mapping Risk from Forest Insects and Diseases. Forest Health Technology Enterprise Team, USDA Forest Service. FHTET 2007-06.

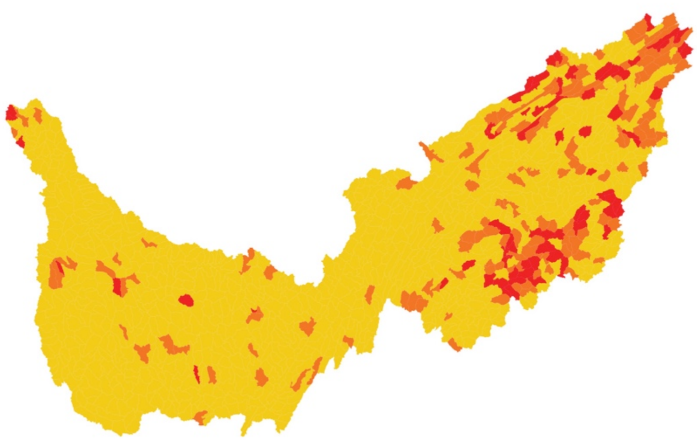

Figure 4: Threat of forest insects and disease.

Indicator: Sediment Sources

Data source: The Soil Vulnerability Index (SVI) is not a published data set. The data represent geospatial layers representing soil vulnerability and treatment needs on cultivate cropland currently under development by the RAD GIS Lab and CEAP modeling Team. The results are based on findings from the CEAP Cropland Reports.

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Calculation method: The USDA provided the Soil Vulnerability Index for cultivated cropland (SVI-cc) at the HUC12 level for the entire TRB. These data use soil and topographic characteristics for cultivated cropland to estimate soil vulnerability to sediment generation during runoff. Vulnerability to runoff is provided in 4 classes, with classes 3 and 4 considered priority 1 lands (highly vulnerable). Priority 1 lands are targeted for treatment and management progress is assessed against the fraction of priority lands that have been treated for runoff (e.g., via agricultural best practices such as winter cover crop implementation and riparian buffer placement.) Therefore, the SVI-cc was evaluated by calculating the percent of each HUC12 watershed that was reported as priority 1 cropland for runoff. This value ranged from 0 to 46.2% across the TRB with a mean of 4.3% and a standard deviation of 6.2%. We used these statistics to calculate a Z-score that rescaled the percent priority 1 data between 0 and 100 based on the Z-score range of 2.5 to -2.5.

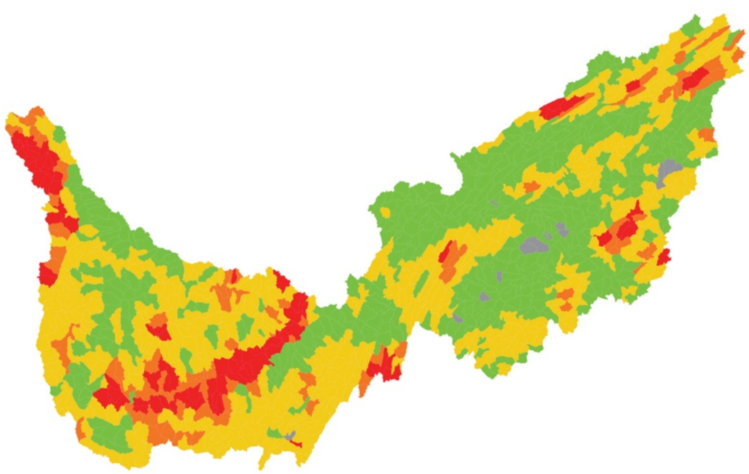

Figure 5: The area of croplands in priority 1 risk for runoff, as assessed by the Soil Vulnerability Index.

Condition Indicators

Indicator: Forest Connectivity

Data source: AppLCC Natureserve aka Landscape Conservation Design (LCD2)

Calculation method: The Landscape Conservation Design (LCD2) project used conservation planning software to identify areas of the landscape important for landscape connectivity. These were labeled local and regional cores and linkages, covering 22770 km^2 of the TRB, or about 21.5% of the basin area. The land cover type (e.g., agriculture, urban, forest) in these areas is a useful measure of the connectivity of forests in the region. HUC12 watersheds with no connected forests contribute to regional forest fragmentation, impeding the dispersal of plants and animals to new habitat and movement across landscapes in response to changes in climate. Areas of high forest cover in watersheds designated as important for regional and local forest connectivity have the highest desired condition. Therefore, we calculated the area of forest in regions designated as local or regional cores and linkages in the Landscape Conservation Design results. This connected forest layer included all forests, private and public, regardless of protection level, and was based on the 2011 National Land Cover Dataset. Across HUC12 watersheds in the TRB, mean local and regional core and linkage forest area was 21.2 km^2 and the standard deviation was 32.3 km^2. We used these statistics to calculate a Z-score that scaled the connected forest layer between 0 (no connected forest) to 100 (a high area of connected forest) using -2.5 and 2.5 as the Z-score endpoints.

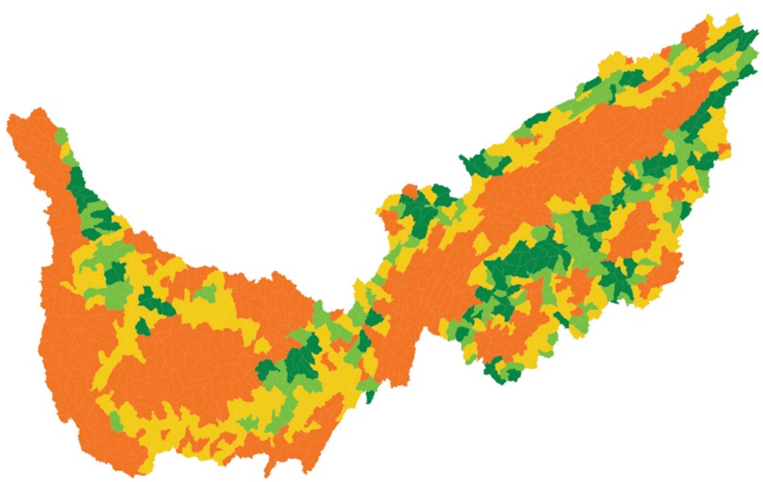

Figure 6: Connected forest area.

Indicator: Aquatic connectivity

Data source: National Hydrography Data and Tiger roads

Calculation method: Aquatic connectivity is degraded by dams, primarily, but also by road crossings. Both types of man-made features impede the dispersal of aquatic organisms along streams and rivers. We assumed aquatic connectivity was high for all streams without these features and low for streams with them. The National Hydrography Dataset includes the point locations of all dams in the basin, including both large hydroelectric generation facilities and small "mill pond" dams. For each HUC12 watershed, we calculated the number of dams per km of stream length. Across the TRB there were an average of 8.7 dams/ 1000km of stream length with a standard deviation of 18.8 dams/1000km of stream length. We used these statistics to calculate a Z-score that scaled the dams/km stream length between 0 and 100 using 2.5 (a high number of dams) and -2.5 a low number of dams as the Z-score endpoints.

Road crossings also degrade aquatic connectivity. Using data on roads provided by the Tiger roads database, we calculated the number of road-stream intersections for each HUC12 watershed and divided by the total stream length in each HUC12. There were between 0 and 5.2 road crossings per km of stream, with a mean of 0.946 and a standard deviation of 0.589 crossings per km. We used these statistics to calculate a Z-score that scaled the data between 0 and 100 using Z-scores of 2.5 and -2.5 as endpoints.

After scaling each of these sub-indicators between 0 and 100 we calculated an average aquatic connectivity score for each HUC12 watershed. Therefore, in the final aquatic connectivity indicator, the weighted scores for dam density and road crossing density are weighted equally.

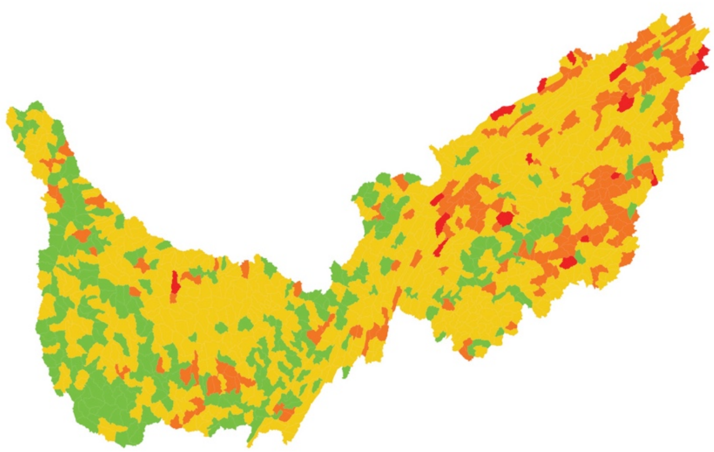

Figure 7: Aquatic connectivity scores that reflect data on both dam and road crossing density.

Indicator: Aquatic biodiversity

Data source: Tennessee Valley Authority

Calculation method: The TVA sampled 499 streams (spanning 386 different HUC12 watersheds) between 2010 and 2014. Fish sampling followed TVA's Index of Biotic Integrity protocol (modified from Karr (1981)), using multiple gears and techniques to obtain representative samples of the fish community from all discernible habitat types within riffle, run, and pool areas. Fish captured were identified, counted, checked for apparent disease and released. Some voucher specimens were kept to document new occurrences or to confirm identification. Samples were analyzed with TVA's Stream Survey computer program to produce IBI scores for each station. The IBI analysis rated sampling results against reference conditions based on fish communities occurring under pristine conditions within the same ecoregion and similar drainage area. This analysis uses 12 metrics or measures of community attributes such as species richness and composition, trophic structure, fish abundance, fish condition, and hybridization. IBI scores, ranging from 12 to 60, and classifications were used to indicate the level of ecological condition reflected by fish communities.

For this report card, we rescaled the IBI scores between 0 and 100 in such a way that the classifications defined by the TVA (Excellent, Good, Fair, Poor, Very Poor, and No Fish) were preserved as grades of A, B, C, D, and F in the report card.

Citations:

Karr, J. R., K. D. Fausch, P. L. Angermier, P. R. Yant, and I. J. Schlosser. 1986. Assessing biological integrity in running waters, a method and its rationale. Illinois Natural History Survey. Special Publication 5. 28 pp.

Karr, J. R. 1981. Assessment of biotic integrity using fish communities. Fisheries 6:21-27.

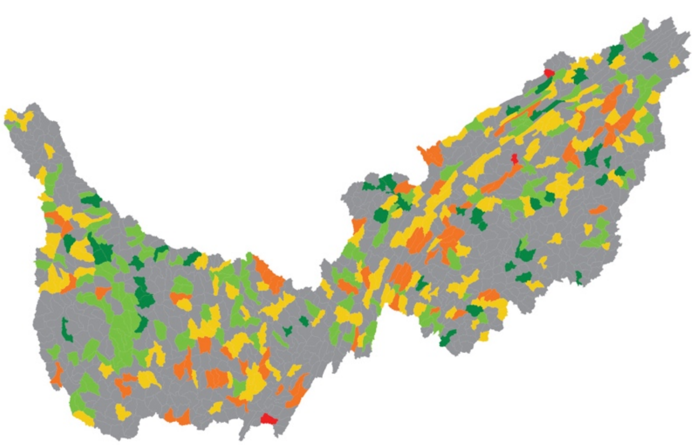

Figure 8: The Index of Biotic Integrity (IBI) based on TVA sampling campaigns between 2010 and 2014.

Indicator: Benthic Macroinvertebrate Condition

Data source: Tennessee Valley Authority

Calculation method: The TVA sampled 499 streams (spanning 386 different HUC12 watersheds) between 2010 and 2014. This effort included a Benthic Macroinvertebrate Community Sampling program that used a qualitative approach and provided an ecological classification based on diversity among three pollution intolerant taxonomic orders (mayflies (*Ephemeroptera*), stoneflies (*Plecoptera*) and caddisflies (*Trichoptera*) , aka EPT) and the density of tolerant organisms. The primary output is a "good", "good/fair", "fair", "fair/poor", or "poor" rating based upon the number of EPT families sampled and ecoregion classification. General interpretation of observed relative abundance of tolerant organisms and other taxa can be used to help determine the nature of environmental problems affecting the community. We rescaled the EPT scores from 0 to 100 in a way that preserved the classifications provided by the TVA.

Citations:

Kerans, B. L. and J. R. Karr. 1994. A benthic index of biotic integrity (B-IBI) for rivers of the Tennessee Valley. Ecological Applications 4(4): 768-785.

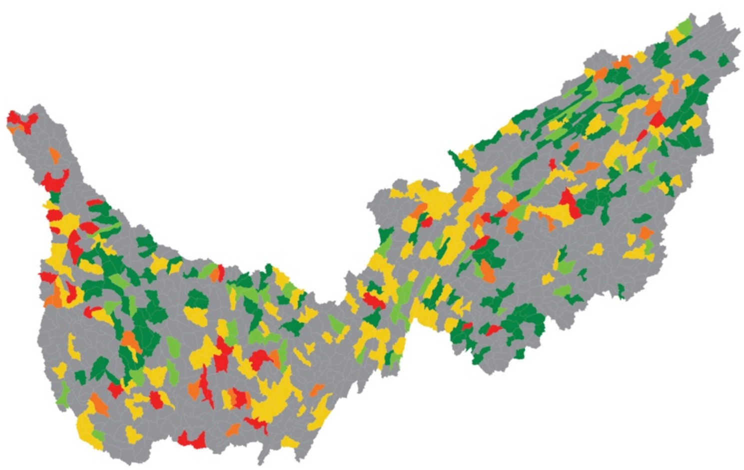

Figure 9: Ephemeroptera, Plecoptera and Trichoptera scores

Response Indicators

Indicator: Agricultural best management practices for runoff

Data source: The Conservation Effects Assessment Project (CEAP) Conservation Benefits Identifier (CCBI) are not published data, but represent geospatial layers reflecting treatment needs on cultivate cropland currently under development by the RAD GIS Lab and CEAP modeling Team. The results are based on findings from the CEAP Cropland Reports: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/ceap/na/?cid=nrcs143_014144.

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Calculation method: The CEAP Conservation Benefits Identifier (CCBI) geospatial data layer is an attempt to translate core CEAP Cropland study findings about "conservation treatment needs" into actionable information suitable for supporting agency landscape planning and program delivery at the field level. It is intended to address the general desire within NRCS and outside the agency that scientific findings from CEAP be effectively incorporated into agency conservation implementation efforts. These data reveal the extent to which high priority croplands identified by the SVI have been treated through resource conservation strategies that *avoid* management that leads to excessive erosion or nutrient applications, *control* losses of sediment and nutrients from farm fields, and *trap* sediment and nutrients that do leave the fields before they reach surface waters.

Data from the CCBI were provided at the HUC12 scale, and represented a summary of the area of high priority cropland and the area of these croplands that have been treated for runoff. We used these results to calculate the percentage of high priority area that has been treated for runoff. At the HUC12 level, the percentage of treated high priority cropland ranged from 0 to 100%, exhibited a mean value of 62.6% and a standard deviation of 37.6%. We used these statistics to calculate a Z-score which was scaled from 0 to 100 using -2.5 and 2.5 as endpoints.

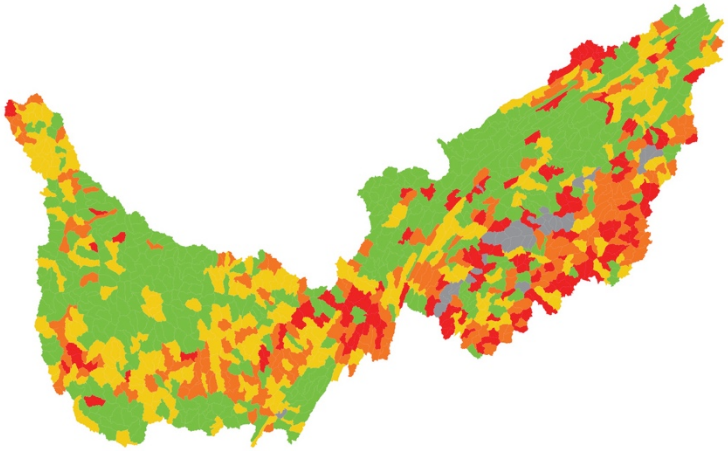

Figure 10: The percentage of treated high priority cropland.

Indicator: Agricultural best management practices for leaching

Data source: The Conservation Effects Assessment Project (CEAP) Conservation Benefits Identifier (CCBI) are not published data, but represent geospatial layers reflecting treatment needs on cultivate cropland currently under development by the RAD GIS Lab and CEAP modeling Team. The results are based on findings from the CEAP Cropland Reports: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/ceap/na/?cid=nrcs143_014144.

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Calculation method: Data from the CCBI were provided at the HUC12 scale, and represented a summary of the number of high priority acres and the area of these croplands that have been treated for leaching. We used these results to calculate the percentage of high priority area that has been treated for leaching. At the HUC12 level, the percentage of treated high priority cropland ranged from 0 to 100%, exhibited a mean value of 56.7% and a standard deviation of 41.3%. We used these statistics to calculate a Z-score, which was scaled from 0 to 100 using -2.5 and 2.5 as endpoints.

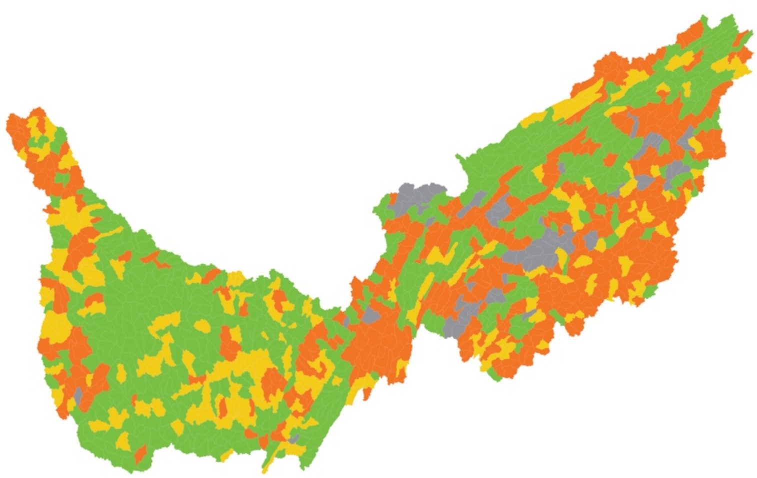

Figure 11: The percentage of high priority area that has been treated for leaching.

Indicator: Protected Connected Forest

Data source:

(1) US Protected Areas Database (https://gapanalysis.usgs.gov/padus/)
(2) AppLCC Landscape Conservation Design (LCD) layers of local and regional forest cores and linkages
(3) National Land Cover Dataset (NLCD) (https://www.mrlc.gov/)

Calculation method: Management progress towards creating and maintaining forest connectivity across the TRB was evaluated by calculating the area of connected protected forest in each HUC12. Connected forest was determined using the AppLCC (LCD) data layers as described earlier. The percent of these connected forests that are protected from development was calculated using the US Protected Areas Database (PAD) version 1.4. The PAD uses GAP Status Codes to describe the degree to which land is managed for conservation. Land in Codes 1 and 2 have the highest degree of management for conservation, while status 3 lands support multiple uses, including resource extraction (forestry, mining, etc.), but are protected from development. Status 4 lands have more ambiguous protection, but in the TRB this designation generally refers to Department of Defense land and State land trusts. Therefore, we classified all lands in codes 1-4 as "protected" for the purpose of this report card. We recognize that many activities that have the potential to influence biodiversity are permitted in these protected lands.

We calculated the percentage of connected forest that was protected from development for each HUC12. Percent connected forest ranged from 0 to 100% with a mean value of 34.7% and a standard deviation of 37.3%. We used these statistics to calculate a percent connected forest Z-score which was rescaled between 0 and 100 using -2.5 and 2.5 as endpoints.

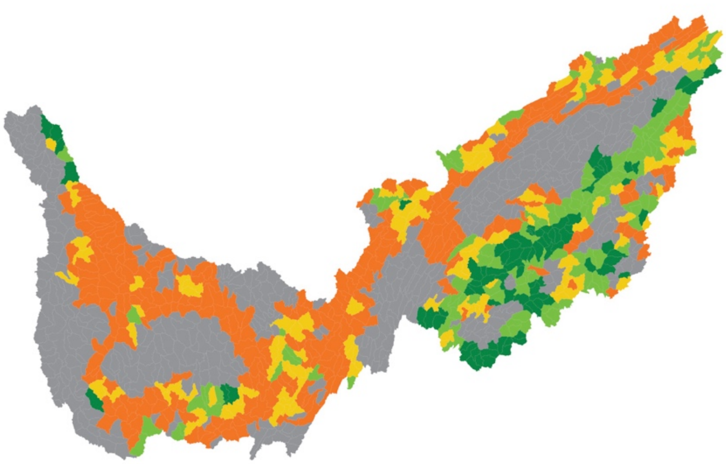

Figure 12: Evaluation of protected land status within connected forests in the TRB.

Indicator: Protected wetlands

Data source:
US Protected Areas Database
https://gapanalysis.usgs.gov/padus/

US National Wetlands Inventory
https://www.fws.gov/wetlands/

Calculation method: Wetlands provide unique ecosystem services related to habitat, carbon sequestration, and water quality. Management actions that protect wetlands from development and other forms of impairment are necessary. For this indicator, we used the National Wetlands Inventory data to define the spatial distribution of wetlands. We then intersected this layer with the protected areas data base described earlier to calculate the percentage of wetland area in each HUC12 that was protected. The resulting data on percent of wetlands protected ranged from 0 to 100 and exhibited a mean of 15.6% and a standard deviation of 24.7%. We used these statistics to generate a Z-score that was rescaled from 0 to 100 using -2.5 and 2.5 as endpoints.

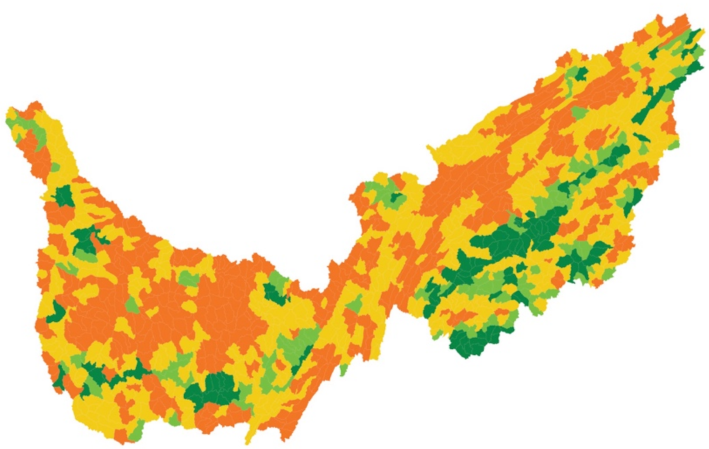

Figure 13: Percent wetlands protected from development.

Indicators and categories considered but not included

Throughout the report card process, many indicators and indicator possibilities were suggested to the report card team and considered. Many of these indicators were dropped for the final draft version of the report card that we have provided at this time. The indicators dropped were not included for various reasons, which are outlined for each indicator in the following section.

When scoping for the report card, it was brought to the report card team's attention that including social, economic and cultural indicators would be beneficial for the management parties involved in improving the health of the Tennessee River Basin. As the report card progressed, discussions lead to data that was either not relevant to a management lever, or the data was not able to be assessed throughout the basin or compared to a relevant threshold.

Some social, economic and human health indicators were identified but not included as they were not directly shown to be linked with the environmental health of the Tennessee River Basin and therefore could not be readily changed through environmental management. These indicators are as follows:

Indicator: Recreational opportunities
Sources considered: National Survey of Fishing and Hunting
National Park Service Visitation Statistics
Reason for not evaluating: Data was aggregated at the state level, and therefore could not be attached to the spatial level that was needed in this report card. The TRB includes small portions of many states.

County-level data for hunting participation could be pursued for further iterations of the report card. The Report Card Team was only able to gain state data for hunting licenses for a subset of the states in the TRB.

Indicator: Protected Cultural Areas or Change in Cultural Preservation
Sources considered: State Historic Preservation Offices
Tennessee Historical Commission GIS Database
Blue Ridge National Heritage Area Management Plan
Tennessee Civil War National Heritage Area evaluation
NPS Trail of Tears
TN Department of Tourist Development 2016 Economic Impact Report
TN Historical Commission
Reason for not evaluating: Cultural resources and data that were preliminarily evaluated did not have relevant thresholds to be assessed against, or were only for very specific states or pieces of the basin.

It was also suggested to look into how some indicators effect native people of Western North Carolina, and the Report Card Team thinks this should be pursued further if there is to be another iteration of this process.

Indicator: Food Insecurity
Sources considered: Map the Meal Gap
Reason for not evaluating: Not immediately relevant to the environmental health and management of the Tennessee River Basin.

Indicator: Access to healthy foods
Sources considered: USDA Food Environment Atlas
Reason for not evaluating: Not immediately relevant to the environmental health and management of the Tennessee River Basin.

Indicator: Obesity
Sources considered: CDC Diabetes Interactive Atlas
Reason for not evaluating: Not immediately relevant to the environmental health and management of the Tennessee River Basin.

Indicator: Life expectancy (premature death)
Sources considered: National Center for Health Statistics – mortality files
Reason for not evaluating: Not immediately relevant to the environmental health and management of the Tennessee River Basin.

Indicator: Access to exercise opportunities
Sources considered: Business Analyst, Delorme map data, ESRI, & US Census Tigerline Files
Reason for not evaluating: Not immediately relevant to the environmental health and management of the Tennessee River Basin.

Indicator: Education level- some college
Sources considered: American Community Survey
Reason for not evaluating: Not immediately relevant to the environmental health and management of the Tennessee River Basin.