Conservation Success Index: Brook Trout

SALVELINUS FONTINALIS

Rev. 1.5 - 8/2007

SPECIES SUMMARY

The native range of brook trout (*Salvelinus fontinalis*) covers much of North America, from the headwaters of the Chattahoochee River in northern Georgia well into the northeastern provinces of Canada. Its vast historic range includes cold water streams, rivers, lakes, ponds and estuaries. In the United States brook trout have largely been replaced by non-native brown trout and rainbow trout, particularly throughout the southern Appalachians. Widespread introductions of brook trout throughout the American West pose threats to rare native cutthroat trout and bull trout.

Historic Range Relief Map

A recent assessment by the Eastern Brook Trout Joint Venture examined conditions from Ohio to Maine to Georgia and determined that brook trout populations in streams and rivers remain undisturbed in less than 5% of their historic subwatersheds. Brook trout are extirpated from 21% of subwatersheds. Population data are needed for 32% of subwatersheds across the range, particularly in New York, Pennsylvania and New England. Like other salmonids in the char genus, brook trout are intolerant of water pollution and non-native fish, and are classic indicators of water quality and ecosystem integrity.

Key CSI Findings

- 62% of subwatersheds in the historic range are currently occupied (3,282 out of 5,278)
- 1.5% of subwatersheds with brook trout had a Total CSI score > 75 (out of a possible 90)

- Median Range-wide Condition score = 15/25 for extant populations only (range 9-24)
- Median Population Integrity score = 7/15 for extant populations only (range 6-15)
- Median Habitat Integrity score = 13/25 (range 5-24)
- Median Future Security score: 18/24 (range 10-24)
- 8% of subwatersheds priority for protection
- 12% of subwatersheds high priority for reintroduction
- 62% of subwatersheds priority for restoration

Compared to other trout, the Eastern Brook Trout received relatively low CSI scores for range-wide condition, habitat integrity and especially population integrity. Aside from Maine and a few river systems in upstate New York and northern New England, brook trout populations are highly fragmented and relegated to headwater streams. Brook trout habitat across the Eastern range is highly fragmented. While large blocks of public land do protect habitat, median land stewardship score across the range is only 1.7. A dense road network on private and public land and an abundance of dams have isolated populations, reducing the median connectivity score to 1.2. Lake and pond populations remain intact in 14% of historic subwatersheds. Almost all of these populations are located in Maine, and are mostly impacted by non-native fish, specifically bass and sunfish species.

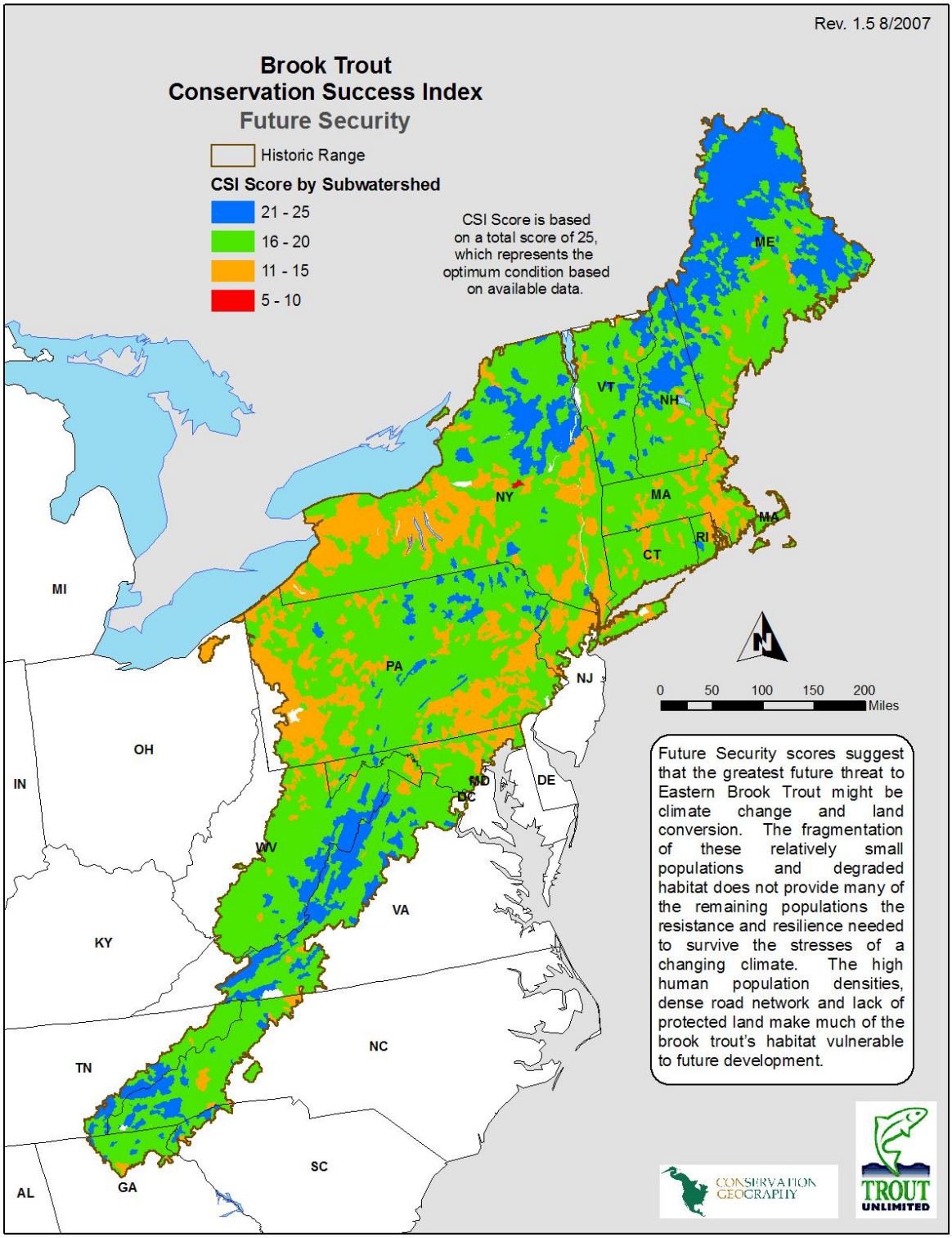
Virginia contains a concentration of protection priorities at existing population strongholds, particularly in portions of the headwaters of the Potomac, Rappahannock and James Rivers. In much of Cherokee, Pisgah and Nantahela National Forests and Great Smoky National Park, brook trout have been eliminated by a combination of past land use and exotic species establishment. In the Shenandoah Valley region, brook trout have been lost through centuries of poor land use and water quality impacts. Reconnection of isolated populations and reintroduction are priorities where water quality and habitat on private land can be restored.

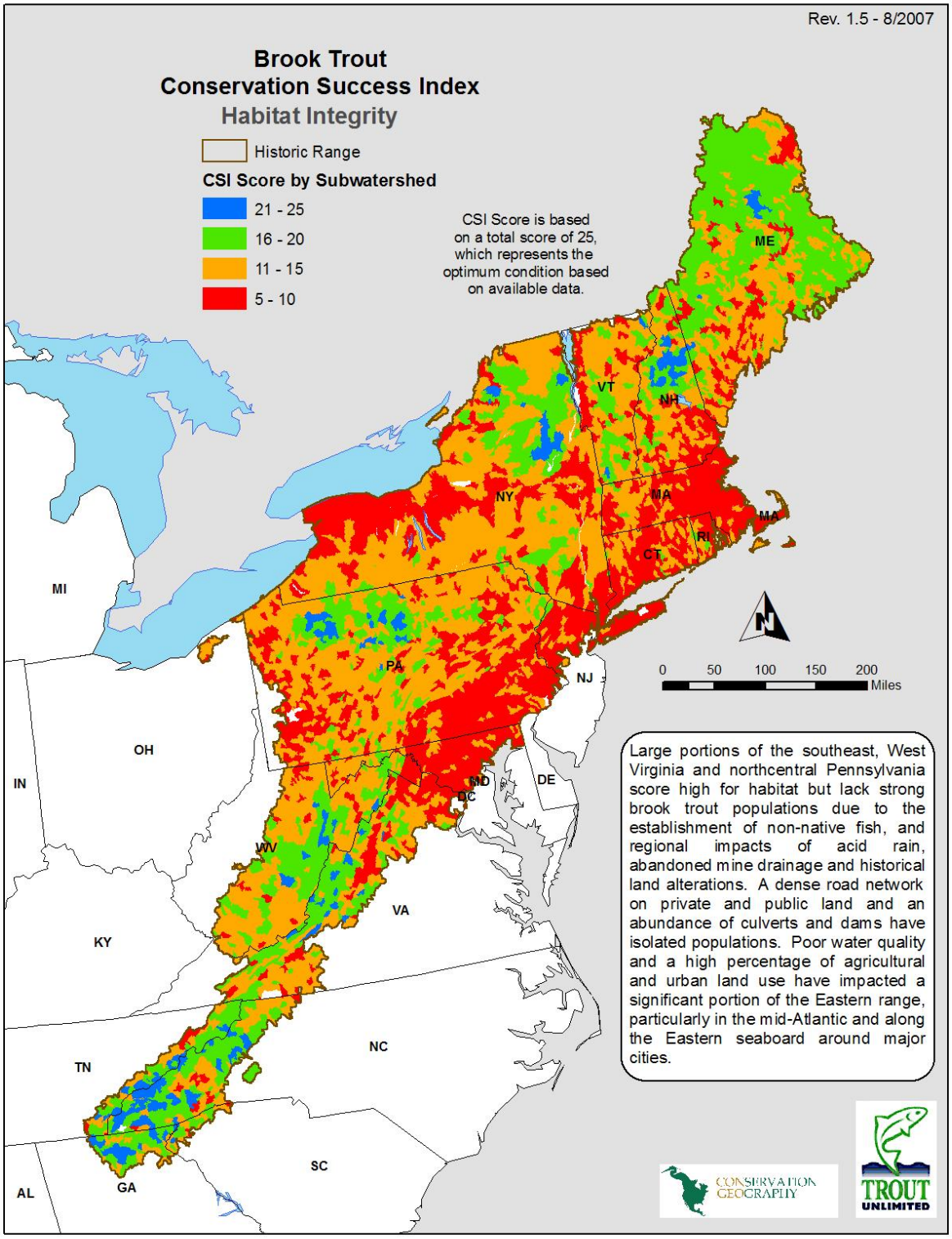
West Virginia, Maryland and Pennsylvania have large opportunities for restoring subwatersheds impacted by abandoned mine drainage, acid deposition and outdated agricultural and grazing practices. Population strongholds are located in western Maryland and the headwaters of the West Branch Susquehanna. A large percentage of the historical range in this region is prioritized for restoration. Potentially, brook trout may be reintroduced in valley regions impacted by human land use and mitigated abandoned mineland habitats.

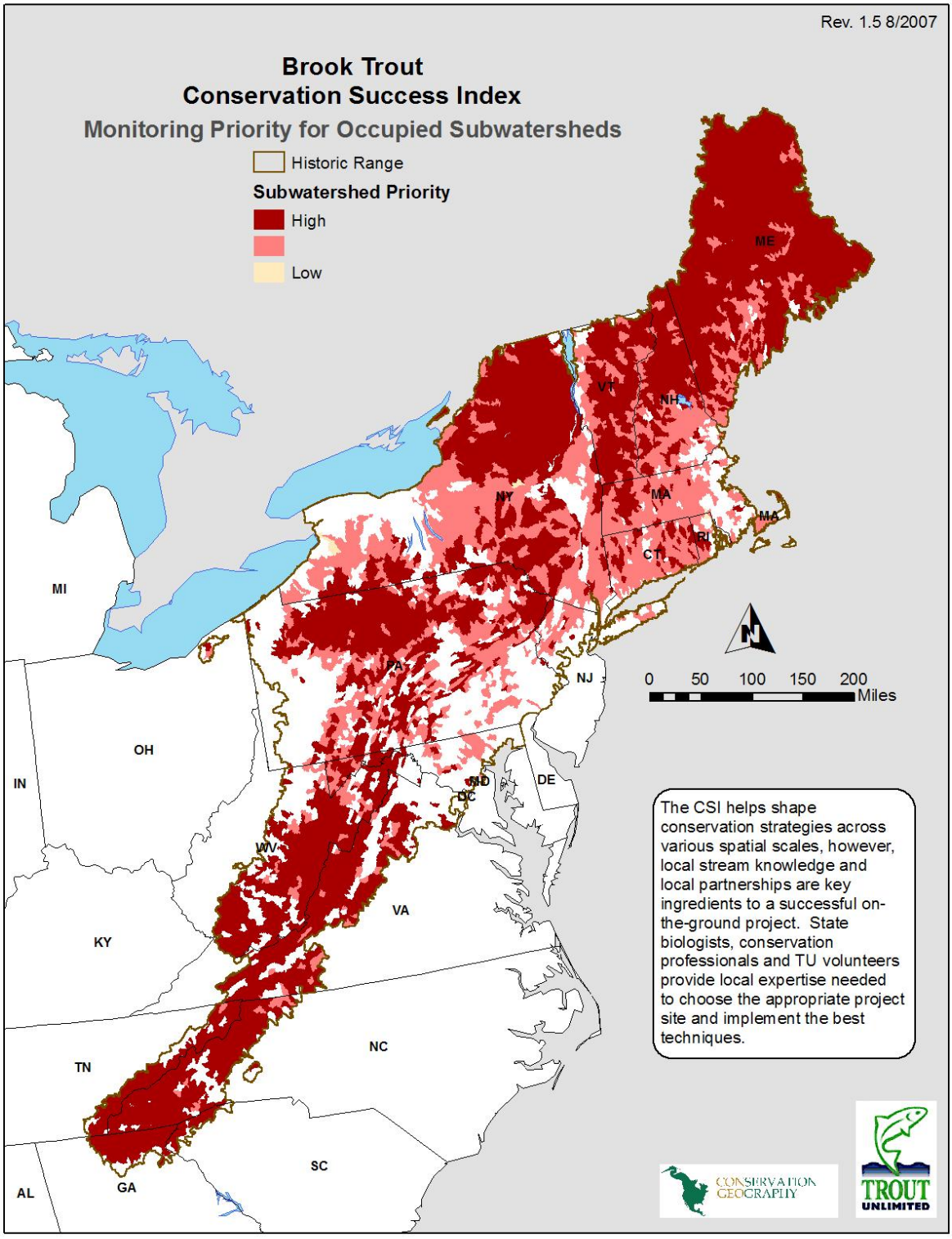
Road culverts, aging dams and non-native species fragment brook trout habitat across much of southern New York, New Jersey, Connecticut and Massachusetts. Expansion of habitat through habitat restoration, improved dam operations, and reconnection of fragmented populations constitute restoration activities in priority areas. Protection and restoration of the relatively rare brook trout strongholds are prioritized for tributary systems to the Delaware River in New Jersey and Pennsylvania, the Catskills in New York, and the Batten Kill watershed in Vermont/New York.

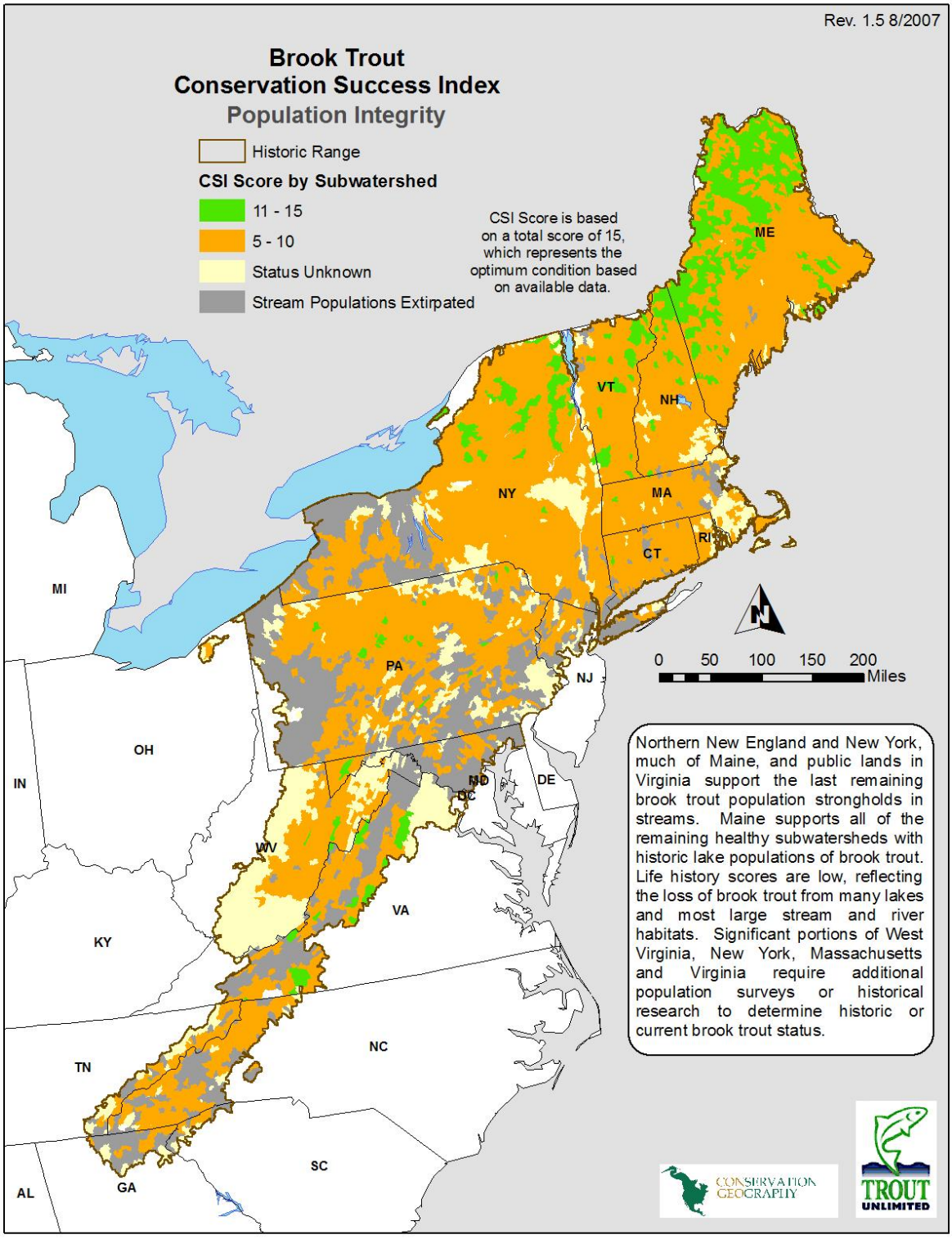
Nearly all of the range's highest scoring subwatersheds (Total CSI scores > 70) are in Maine, northern New Hampshire and Vermont and New York's Adirondacks. Those areas with high Future Security scores represent multiple protection priorities across this region, particularly against the introduction of non-native fish. Numerous protection opportunities exist in the portions of the Grass, Hudson, Upper Connecticut and Upper Androscoggin rivers and throughout western and northern Maine.

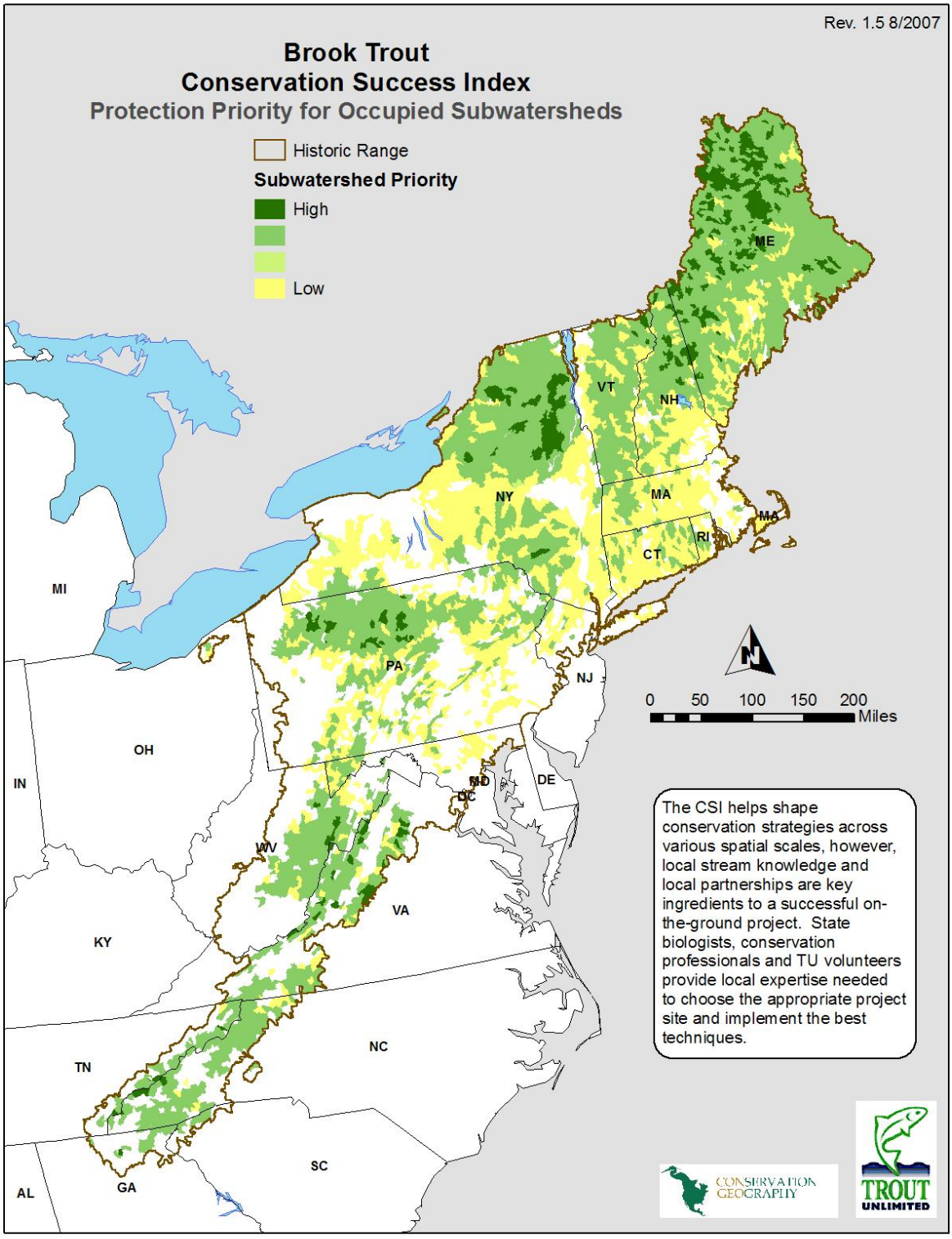
Prepared by Nathaniel Gillespie, TU, 8/15/07

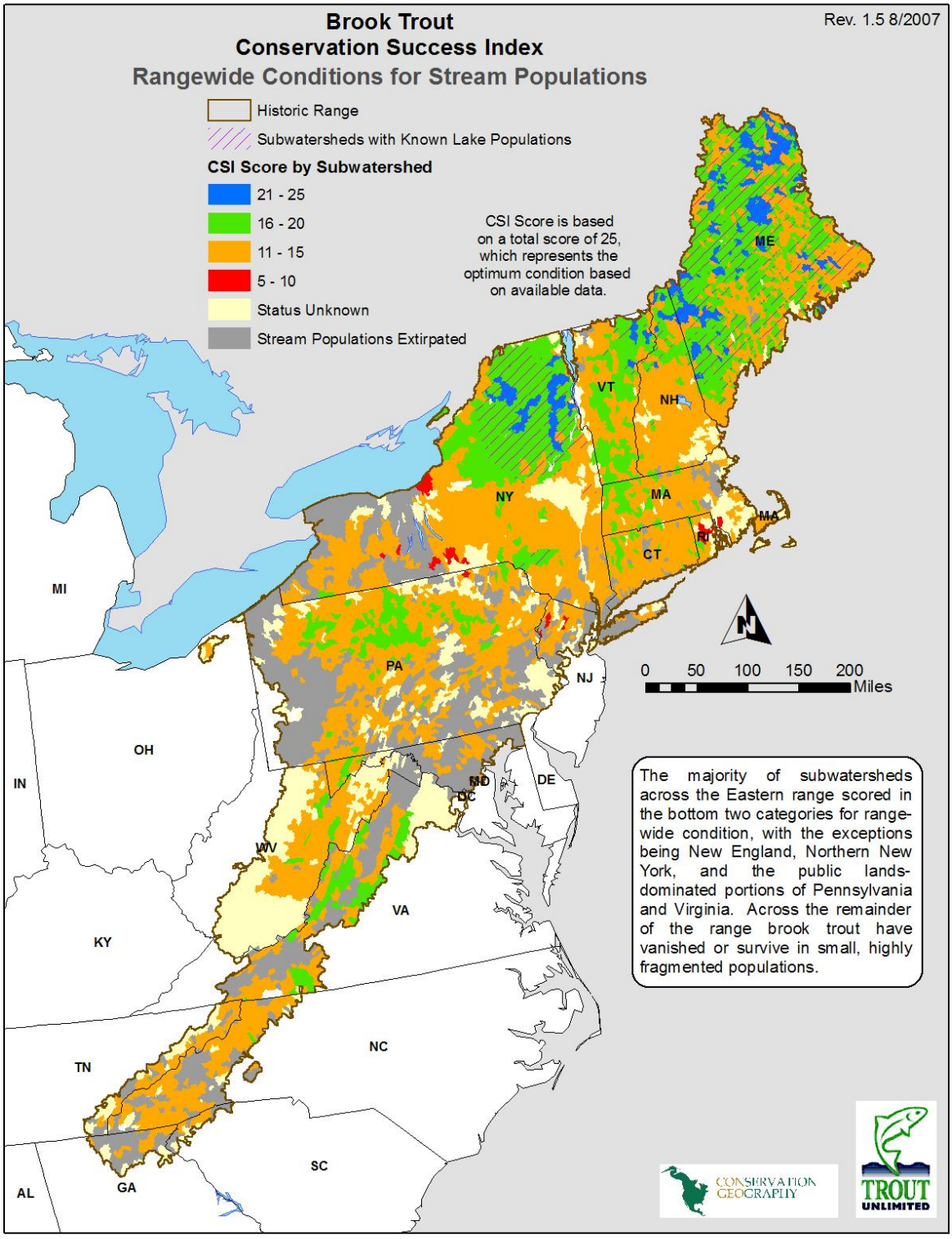

Rev. 1.5 8/2007
Brook Trout
Conservation Success Index
Future Security
Historic Range
CSI Score by Subwatershed
21 - 25
16 - 20
11 - 15
5 - 10
CSI Score is based on a total score of 25, which represents the optimum condition based on available data.
ME
VT
NH
NY
MA
RI
CT
MI
PA
NJ
OH
IN
MD
DE
DC
WV
VA
KY
NC
TN
SC
GA
AL
0 50 100 150 200
Miles
Future Security scores suggest that the greatest future threat to Eastern Brook Trout might be climate change and land conversion. The fragmentation of these relatively small populations and degraded habitat does not provide many of the remaining populations the resistance and resilience needed to survive the stresses of a changing climate. The high human population densities, dense road network and lack of protected land make much of the brook trout's habitat vulnerable to future development.
CONSERVATION GEOGRAPHY
TROUT UNLIMITED

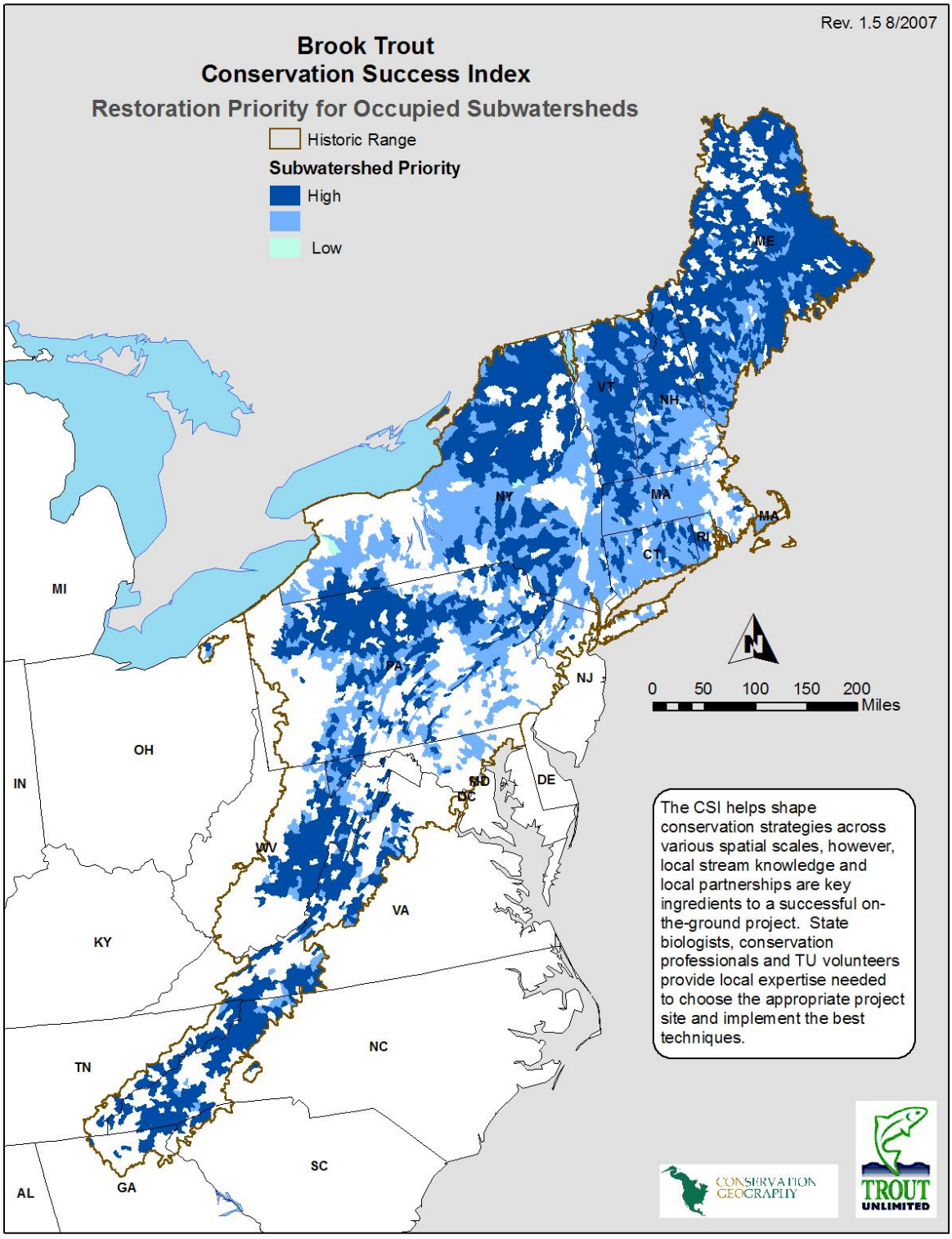

Rev. 1.5 - 8/2007
Brook Trout
Conservation Success Index
Habitat Integrity
Historic Range
CSI Score by Subwatershed
21 - 25
16 - 20
11 - 15
5 - 10
CSI Score is based on a total score of 25, which represents the optimum condition based on available data.
ME
VT
NH
NY
MA
MA
RI
CT
MI
PA
NJ
0 50 100 150 200
Miles
OH
IN
MD
DC
DE
WV
VA
KY
NC
TN
SC
GA
AL
Large portions of the southeast, West Virginia and northcentral Pennsylvania score high for habitat but lack strong brook trout populations due to the establishment of non-native fish, and regional impacts of acid rain, abandoned mine drainage and historical land alterations. A dense road network on private and public land and an abundance of culverts and dams have isolated populations. Poor water quality and a high percentage of agricultural and urban land use have impacted a significant portion of the Eastern range, particularly in the mid-Atlantic and along the Eastern seaboard around major cities.
CONSERVATION GEOGRAPHY
TROUT UNLIMITED

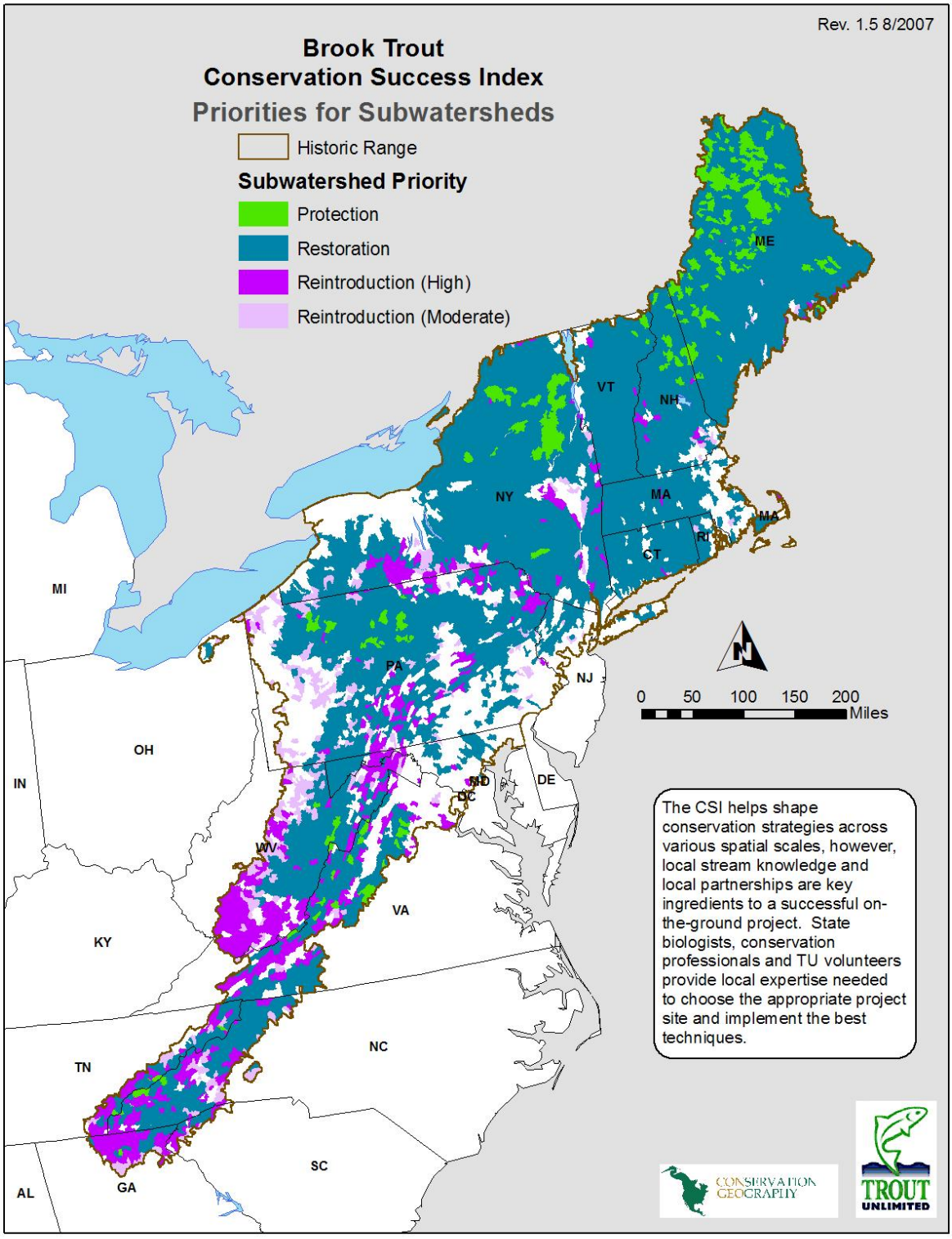

Rev. 1.5 8/2007
Brook Trout
Conservation Success Index
Monitoring Priority for Occupied Subwatersheds
Historic Range
Subwatershed Priority
High
Low
ME
VT
NH
NY
MA
MA
RI
CT
MI
PA
NJ
OH
IN
MD
DC
DE
WV
VA
KY
NC
TN
SC
GA
AL
0 50 100 150 200
Miles
The CSI helps shape conservation strategies across various spatial scales, however, local stream knowledge and local partnerships are key ingredients to a successful on-the-ground project. State biologists, conservation professionals and TU volunteers provide local expertise needed to choose the appropriate project site and implement the best techniques.
CONSERVATION GEOGRAPHY
TROUT UNLIMITED

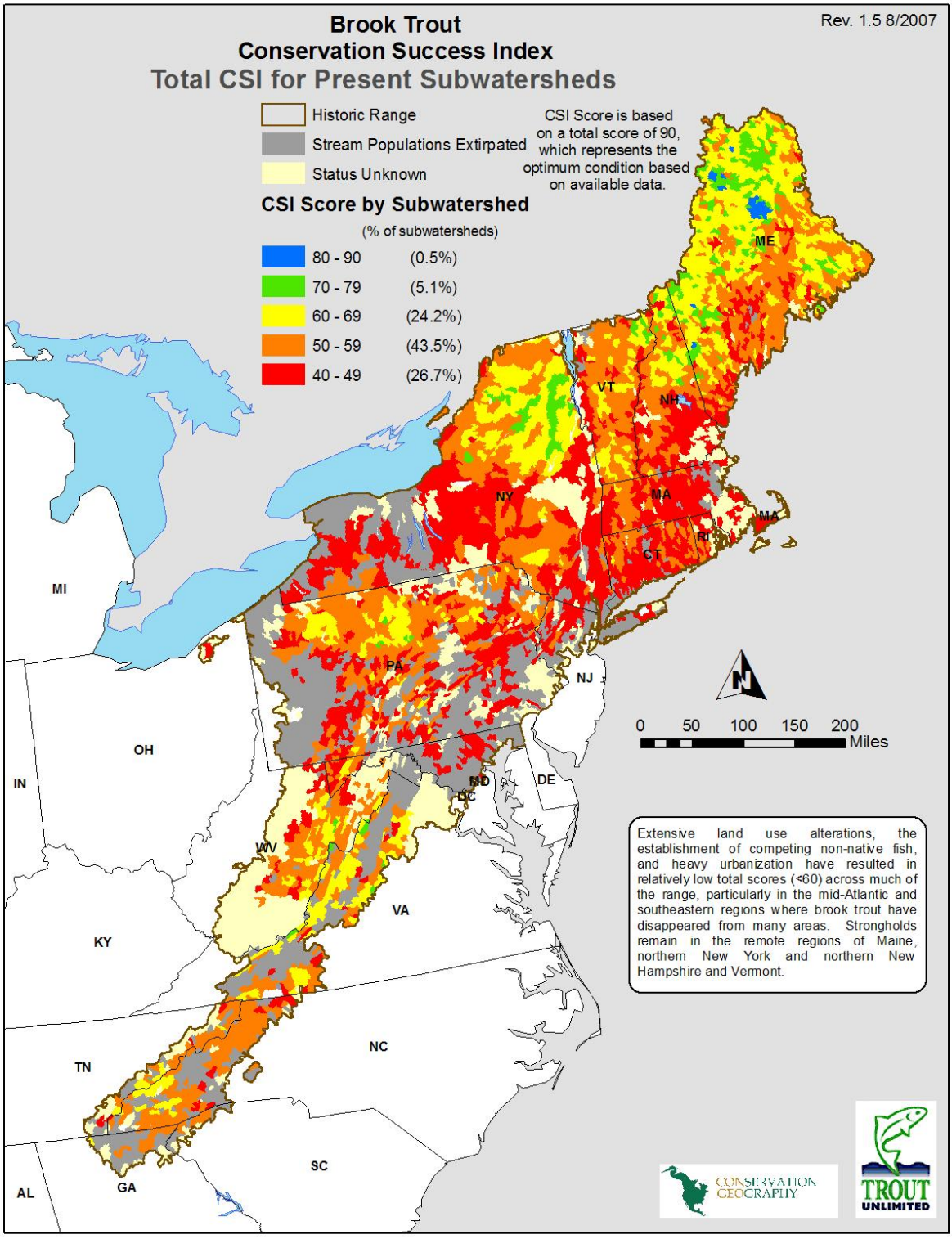

Rev. 1.5 8/2007
Brook Trout
Conservation Success Index
Population Integrity
Historic Range
CSI Score by Subwatershed
11 - 15
5 - 10
Status Unknown
Stream Populations Extirpated
CSI Score is based on a total score of 15, which represents the optimum condition based on available data.
ME
VT
NH
NY
MA
RI
CT
MI
PA
NJ
OH
IN
MD
DC
DE
WV
VA
KY
NC
TN
SC
GA
AL
N
0 50 100 150 200
Miles
Northern New England and New York, much of Maine, and public lands in Virginia support the last remaining brook trout population strongholds in streams. Maine supports all of the remaining healthy subwatersheds with historic lake populations of brook trout. Life history scores are low, reflecting the loss of brook trout from many lakes and most large stream and river habitats. Significant portions of West Virginia, New York, Massachusetts and Virginia require additional population surveys or historical research to determine historic or current brook trout status.
CONSERVATION GEOGRAPHY
TROUT UNLIMITED


Rev. 1.5 8/2007
Brook Trout
Conservation Success Index
Protection Priority for Occupied Subwatersheds
Historic Range
Subwatershed Priority
High
Low
ME
VT
NH
NY
MA
MA
RI
CT
MI
PA
NJ
0 50 100 150 200
Miles
OH
IN
MD
DE
DC
WV
VA
KY
NC
TN
SC
GA
AL
The CSI helps shape conservation strategies across various spatial scales, however, local stream knowledge and local partnerships are key ingredients to a successful on-the-ground project. State biologists, conservation professionals and TU volunteers provide local expertise needed to choose the appropriate project site and implement the best techniques.
CONSERVATION GEOGRAPHY
TROUT UNLIMITED


Brook Trout
Conservation Success Index
Rangewide Conditions for Stream Populations
Rev. 1.5 8/2007
Historic Range
Subwatersheds with Known Lake Populations
CSI Score by Subwatershed
21 - 25
16 - 20
11 - 15
5 - 10
Status Unknown
Stream Populations Extirpated
CSI Score is based on a total score of 25, which represents the optimum condition based on available data.
ME
VT
NH
NY
MA
RI
CT
MI
PA
NJ
OH
IN
MD
DC
DE
WV
VA
KY
TN
NC
SC
GA
AL
0 50 100 150 200
Miles
The majority of subwatersheds across the Eastern range scored in the bottom two categories for range-wide condition, with the exceptions being New England, Northern New York, and the public lands-dominated portions of Pennsylvania and Virginia. Across the remainder of the range brook trout have vanished or survive in small, highly fragmented populations.
CONSERVATION GEOGRAPHY
TROUT UNLIMITED


Rev. 1.5 8/2007
Brook Trout
Conservation Success Index
Restoration Priority for Occupied Subwatersheds
Historic Range
Subwatershed Priority
High
Low
ME
VT
NH
NY
MA
MA
RI
CT
MI
PA
NJ
0 50 100 150 200
Miles
OH
IN
MD
DC
DE
WV
VA
KY
NC
TN
SC
GA
AL
The CSI helps shape conservation strategies across various spatial scales, however, local stream knowledge and local partnerships are key ingredients to a successful on-the-ground project. State biologists, conservation professionals and TU volunteers provide local expertise needed to choose the appropriate project site and implement the best techniques.
CONSERVATION GEOGRAPHY
TROUT UNLIMITED


Rev. 1.5 8/2007
Brook Trout
Conservation Success Index
Priorities for Subwatersheds
Historic Range
Subwatershed Priority
Protection
Restoration
Reintroduction (High)
Reintroduction (Moderate)
ME
VT
NH
NY
MA
RI
CT
MI
PA
NJ
OH
IN
MD
DC
DE
WV
VA
KY
NC
TN
SC
GA
AL
0 50 100 150 200
Miles
The CSI helps shape conservation strategies across various spatial scales, however, local stream knowledge and local partnerships are key ingredients to a successful on-the-ground project. State biologists, conservation professionals and TU volunteers provide local expertise needed to choose the appropriate project site and implement the best techniques.
CONSERVATION GEOGRAPHY
TROUT UNLIMITED


Brook Trout
Conservation Success Index
Total CSI for Present Subwatersheds
Rev. 1.5 8/2007
Historic Range
Stream Populations Extirpated
Status Unknown
CSI Score is based on a total score of 90, which represents the optimum condition based on available data.
CSI Score by Subwatershed
(% of subwatersheds)
80 - 90 (0.5%)
70 - 79 (5.1%)
60 - 69 (24.2%)
50 - 59 (43.5%)
40 - 49 (26.7%)
ME
VT
NH
NY
MA
MA
RI
CT
MI
PA
NJ
OH
IN
MD
DC
DE
WV
VA
KY
NC
TN
SC
GA
AL
0 50 100 150 200
Miles
Extensive land use alterations, the establishment of competing non-native fish, and heavy urbanization have resulted in relatively low total scores (<60) across much of the range, particularly in the mid-Atlantic and southeastern regions where brook trout have disappeared from many areas. Strongholds remain in the remote regions of Maine, northern New York and northern New Hampshire and Vermont.
CONSERVATION GEOGRAPHY
TROUT UNLIMITED

Conservation Success Index
Brook Trout Rule Set

June 11, 2007

Range-wide Conditions
General Scoring - scored for all currently occupied stream or lake populations.

General Source - for all indicators in Range-wide Conditions Group:
Hudy, Mark and Teresa M. Thieling U.S. Forest Service, Fish and Aquatic Ecology Unit, James Madison University, Nathaniel Gillespie, Trout Unlimited,Eric P.Smith Department of Statistics, Virginia Tech. 2006. Distribution, Status and Threats to Brook trout within the eastern United States.

1. Percent historic stream habitat occupied.
Scoring - Stream status defined by subwatershed status defined by Eastern Brook Trout Joint Venture data assessment

Stream Status	CSI Score
Extirpated	1
Present Qualitative	2
Greatly Reduced	3
Reduced	4
Intact	5
Unknown or Absent, Unclear History	No Data

Source: Hudy et al. 2006

2. Percent subbasins occupied, 4th Level Hydrologic Unit Code (HUC)

Scoring - Historic and current ranges defined for calculation. See Hudy et al. 2006 for stream and lake status classifications. "current" = occupied. "historic" = extirpated.

		Stream Status						
		Intact	Reduced	Greatly Reduced	Present, Qualitative	Never Occurred	Extirpated	Unknown & Absent
Lake Status	Intact	current	current	current	current	current	current	current
	Reduced	current	current	current	current	current	current	current
	Greatly Reduced	current	current	current	current	current	current	current
	Present, Qualitative	current	current	current	current	current	current	current

	Never Occurred	current	current	current	current	current	historic	No Data
	Extirpated	current	current	current	current	historic	historic	historic
	Unknown & Absent	current	current	current	current	No Data	historic	No Data

Percent subbasins occupied	CSI Score
1-49%	1
50-69%	2
70-79%	3
80-89%	4
90-100%	5
Unknown & Absent	No Data

Source – Hudy et al. 2006

3. Subwatersheds occupied within subbasin.
Scoring - Same geographic scope as used in 2 above.

Percent subwatersheds occupied by subbasin	CSI Score
1 – 20%	1
21-40%	2
41-60%	3
61-80%	4
81-100%	5
Unknown & Absent	No Data

Source – Hudy et al. 2006

4. Habitat by stream order occupied.
Scoring - Geographic scope: stream status <> 'never occurred' as defined by Hudy et al. 2006. Strahler stream order from NHD Plus 1:100,000 dataset used.

Stream Status	CSI Score
Extirpated	1
Present Qualitative	2
Greatly Reduced	3
Reduced	4
Intact	5
Unknown & Absent	No Data

Source - US Geological Survey, National Hydrography Dataset Plus, 1:100,000,

5. Historic lake habitat occupied.
Geographic scope: lake status <> ‘never occurred’

Lake Status	CSI Score
Extirpated	1
Present Qualitative	2
Greatly Reduced	3
Reduced	4
Intact	5
Unknown & Absent	No Data

Population Integrity

Scoring - Includes all current stream or lake populations as defined by the Eastern Brook Trout Joint Venture data assessment.

Source for all Population Integrity Indicators: Hudy, Mark and Teresa M. Thieling U.S. Forest Service, Fish and Aquatic Ecology Unit, James Madison University, Nathaniel Gillespie, Trout Unlimited, Eric P. Smith Department of Statistics, Virginia Tech. 2006. Distribution, Status and Threats to Brook trout within the eastern United States.

1. Density – no data exists.

2. Population Extent – based on stream and lake populations.

		Stream Status						
		Intact	Reduced	Greatly Reduced	Present, Qualitative	Never Occurred	Extirpated	Unknown & Absent
& Lake Status	Intact	5	4	4	4	5	3	3
	Reduced	4	3	2	2	3	2	2
	Greatly Reduced	4	2	1	1	1	1	1
	Present, Qualitative	4	2	1	1	1	1	1
	Never Occurred	5	3	1	1	No Data	1	No Data
	Extirpated	3	2	1	1	1	1	1
	Unknown & Absent	3	2	1	1	No Data	1	No Data

3. Genetic Purity – no data exists

4. Disease Vulnerability

All scored as 5 except as follows.

HUCs 360425 and 360129	3
Adjacent HUCs with no barrier	4

5. Life History Diversity – 2 stream forms, 1 lake form.

		Stream Status						
		Intact	Reduced	Greatly Reduced	Present, Qualitative	Never Occurred	Extirpated	Unknown & Absent
Lake	Intact	5	3	3	3	1	1	1

	Reduced	5	3	3	3	1	1	1
	Greatly Reduced	5	3	3	3	1	1	1
	Present, Qualitative	5	3	3	3	1	1	1
	Never Occurred	3	1	1	1	No Data	1	No Data
	Extirpated	3	1	1	1	1	1	1
	Unknown & Absent	3	1	1	1	No Data	1	No Data

Habitat Integrity
Scored for all subwatersheds in historic range.

1. Land Stewardship

Scoring – "Public" land includes U.S. Forest Service, State Forest land and BLM land open to resource extraction. "Protected" land includes designated wilderness, designated roadless, unique area, special designation area, National Park, National Recreation Area, or National Wildlife Refuge land.

Percent Public Acres	CSI Score
0-19%	1
20-39%	2
40-59%	3
60-79%	4
80-100%	5

Greater or Equal to (GE) 25-50% protected: +1 point
GE 50% protected: +2 points

Source - Tele Atlas/GDT, Protected areas, 1:100,000; 2004. National Atlas, Land ownership.

2. Watershed Connectivity

Scoring - 1 Barrier = 1 dam or 3 road crossings over a 1st or 2nd order stream. Scored for 5th Level HUC (watersheds) and 6th Level HUC (subwatershed)

Barriers in 5th Level HUC	Barriers in 6th Level HUC	CSI Score
GE 0	GE 4	1
GE 0	2-3	2
GE 0	1	3
GE 40	0	4
LT 40	0	5

Source - US Geological Survey, National Hydrography Dataset Plus, 1:100,000, http://mapping.usgs.gov. US Army Corps of Engineers, Dams, March 22, 2006 http://crunch.tec.army.mil/nid/webpages/nid.cfm
Tele Atlas/GDT, Road network, 1:100,000; 2002

Bisson, Peter A. 2002. USDA Forest Service Northwest Research Station, Olympia, Washington. Statement concerning scientific information concerning fish passage at road crossings in the Pacific Northwest before the Subcommittee on Interior and Related Agencies, Committee on Appropriations, United States House of Representatives.

Coffman, Joseph Seth. James Madison University. May 2005. Evaluation of a predictive model for upstream fish passage through culverts. U.S. Forest Service FEAU/PIBO Publication, Fish & Aquatic Ecology Unit.

Gibson, RJ, RL Haedrich, CM Wernerheim. 2005. Loss of fish habitat as a conse-quence of inappropriately constructed stream crossings. *Fisheries*, 30(1): 10-17.

Hudy, Mark. U.S. Forest Service, Fish & Aquatic Ecology Unit, June 2006. Personal communication.

U.S. General Accounting Office. 2001. Land management agencies: restoring fish passage through culverts on forest service and BLM lands in Oregon and Washington could take decades. GAO-02-136. Washington, DC, U.S. General Accounting Office. 35 pp.

U.S. General Accounting Office. "Restoring Fish Passage Through Culverts on Forest Service and BLM Lands in Oregon and Washington Could Take Decades." *GAO-02-136,* Washington, DC (2001). http://www.gao.gov/new.items/d02136.pdf Accessed June 8, 2007.

Warren, M. L. J. & M. G. Pardew. 1998. Road crossings as barriers to small-stream fish movement. Transactions of the American Fisheries Society, 127:637-644

Washington Dept. of Fish and Wildlife Habitat Program Environmental Restoration Division. 2000. Salmonid Screening, Habitat Enhancement and Restoration (SSHEAR) Section. 158 p. http://www.wdfw.wa.gov/hab/engineer/mnl2000.pdf Accessed June 8, 2007.

3. Watershed Conditions

Scoring - based on GIS modeling and analysis by EBTJV data team. CSI score is downgraded 1 point if road density is GE 4.7 mi/square mile.

Percent Forested Acres	CSI Score
0-17%	1
18-45%	2
46-67%	3
68-82%	4
83-100%	5

Source - Hudy, Mark and Teresa M. Thieling U.S. Forest Service, Fish and Aquatic Ecology Unit, James Madison University, Nathaniel Gillespie, Trout Unlimited,Eric P.Smith Department of Statistics, Virginia Tech. 2006. Distribution, Status and Threats to Brook trout within the eastern United States. Road density by subwatershed, Land cover/land use by subwatershed.

Thieling, T.M. 2006. Assessment and predictive model for brook trout (*Salvelinus fontinalis*) population status in the eastern United States. A thesis submitted to the Graduate Faculty of James Madison University in partial fulfillment of the requirements for Master of Science, Biology Department.

4. Water Quality

Scoring – See chart below. Final score is the lowest of the 3 columns. Riparian Roads are defined as any road within 45.7 meters (150 feet) of a stream from the National Hydrography Dataset 1:100,000.

303 (d) Streams		Agricultural Land		Riparian Roads	
Miles	**CSI Score**	**Percent**	**CSI Score**	**Strm mi/rd mi**	**CSI Score**
GT 0	1	58-100%	1	0.5 – 1.0	1
	2	28-57%	2	0.25 – 0.49	2
	3	16-27%	3	0.24 - 0.10	3
	4	6-15%	4	0.05 – 0.09	4
	5	0-5%	5	0 – 0.04	5

Source - US Environmental Protection Agency, 303(d) streams, 1:24,000; 2002
http://www.epa.gov/waters/data/downloads.html

US Geological Survey, National Hydrography Dataset Plus, 1:100,000
http://mapping.usgs.gov

Tele Atlas/GDT, Road network, 1:50,000; 2005.

Thieling, T.M. 2006. Assessment and predictive model for brook trout (*Salvelinus fontinalis*) population status in the eastern United States. A thesis submitted to the Graduate Faculty of James Madison University in partial fulfillment of the requirements for Master of Science, Biology Department (Ag land scoring)

5. Flow Regime
Scoring – Based on rationale that larger impoundments have more potential to alter natural flow regime in subwatershed. Scored on amount of storage in acre-feet/stream mile per subwatershed.

Storage (acre-ft)/stream mile	CSI Score
GE 151	1
86-150	2
50-85	3
20-49	4
0 - 20	5

Source - US Army Corps of Engineers, Dams, March 22, 2006
http://crunch.tec.army.mil/nid/webpages/nid.cfm

Vulnerability/ Resistance to Future Change
Scored for all subwatersheds in historic range.

1. Land Conversion – modeled based on slope, land ownership, roads, and existing urban areas.
   Scoring – Slope based on elevational change in a subwatershed.
   Land Ownership – public land not vulnerable to conversion
   Roads and existing urban areas defined by layers listed below.

Land Vulnerable to Conversion	CSI Score
83 – 100%	1
69 – 82%	2
45 - 68%	3
19 – 44%	4
0 – 18%	5

Source - Consortium for Spatial Information (CGIAR-CSI), Topography, 90 meter.
http://srtm.csi.cgiar.org/

Tele Atlas/GDT, Road network, 1:100,000; 2002

Population centers, 1:300,000; 1997, www.teleatlas.com/
National Atlas, Land ownership

2. Resource extraction – oil and gas, and coal reserves
Scoring – See table below

Oil and Gas*	Coal Field	CSI Score
yes	10.1 – 100%	1
yes	2.1-10%	2
yes	LE 2%	3
no	10.1 – 100%	3
no	2.1 - 10%	4
no	LE 2%	5

*Based on presence of oil and gas field or current operation.

Source - USGS National Assessment of Oil and Gas Oil and gas development; 0.25 mile resolution; 2002
http://certmapper.cr.usgs.gov/noga/servlet/NogaGISResultsServ?subtheme=67&page=gis&vintage=2000

US Department of Energy, EPCA, Oil and gas reserves, 2005
http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/maps/maps.htm#geodata

3. Flow Modification – based on INEL hydropower potential data set.
Scoring – See table below relating to 5th level Hydrologic Units (Watersheds) and 6th Level Hydrologic Units (Subwatersheds)

New Dams in 5th Level HUC	New Dams in 6th Level HUC	CSI Score
GE 0	GE 2	1
GE 1	1	2

GE 0	1	3
GE 1	0	4
0	0	5

Source - U.S. Department of Energy, Idaho National Laboratory Water energy resource assessment of the United States, 1995 - 1998.
http://hydro2.inel.gov/resourceassessment/

US Army Corps of Engineers Dams, March 22, 2006
http://crunch.tec.army.mil/nid/webpages/nid.cfm

4. Climate Change

Scoring - Average of:
Rangewide CSI #1 – % historic stream habitat occupied
Habitat Integrity CSI #2 – Watershed connectivity
Habitat Integrity CSI #3 – Watershed conditions
Mean Temperature Score – see charts below

Latitude LE 39°N

Mean Temp	CSI Score
GT 26°	1
25-26°	2
22-25°	3
21-22°	4
LE 21°	5

Latitude GT 39°N

Mean Temp	CSI Score
GT 24°	1
23-24°	2
21-23°	3
20-21°	4
LE 20°	5

Source - Consortium for Spatial Information (CGIAR-CSI) Topography, 90 meter.
http://srtm.csi.cgiar.org/

Flebbe, P.A., L.D. Roghair, and J.L. Bruggnik. 2006. Spatial modeling to project southern Appalachian trout distribution in a warmer climate. Transactions of the American Fisheries Society 135:1371-1382.

5. Introduced Species

Scoring – See table below. Rationale based on potential impact of introduced species on brook trout population are increased if introduced species is present and currently impacting populations in that subwatershed, and potential ease of transfer by people is increased in subwatersheds with higher road densities.

Threat	Road Density	CSI Score
High	any	1
Medium	GT 1.7	2
Low	GT 4.7	2
Medium	LT 1.7	3
Low	LT 4.7	3
None	GT 1.7	4
None	LT 1.7	5

Source - Tele Atlas/GDT, Road network, 1:50,000; 2005

Hudy, Mark and Teresa M. Thieling U.S. Forest Service, Fish and Aquatic Ecology Unit, James Madison University, Nathaniel Gillespie, Trout Unlimited,Eric P.Smith Department of Statistics, Virginia Tech. 2006. Distribution, Status and Threats to Brook trout within the eastern United States. Threats data.

Larson, G. L., and S. E. Moore. 1985. Encroachment of exotic rainbow trout into stream populations of native brook trout in the southern Appalachian Mountains. Transactions of the American Fisheries Society 114:195-203.