Estimated mean annual contribution to water supply from units of the National Forest System (NFS) of the U.S. Forest Service

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In the two tables below we provide estimates of annual contribution to water supply from units of the NFS in the 48 contiguous states. These estimates were computed by overlaying ALP (Automated Lands Project) boundaries for the NFS units obtained in July 2009[1] onto the spatially distributed estimates of water supply that were produced for a 2008 publication by Brown et al. about the source of the U.S. water supply.[2] The total contribution from the NFS administrative units (based on the proclamation boundaries) reported here (329,525 million cubic meters per year) differs from that reported in Brown et al. (325,691 Mm^3/yr) because of recent changes (both additions and corrections) to the ALP NFS boundary layer.[3]

Brown et al. (2008) provided estimates of the contribution to water supply for states and major river basins. Estimates for smaller geographical units such as national forests were not released by Brown et al. because of concerns about the accuracy of the model at smaller spatial scales, especially in portions of the western U.S. These concerns arose because of two types of data limitations, as described below. Although the concerns remain, we nevertheless are providing the estimates because they may be the best that are currently available and may be useful for large-scale planning purposes.

Table 1 provides estimates of mean annual contribution to water supply and surface area for 116 NFS units in the coterminous U.S. Table 2 summarizes the estimates for the eight NFS regions to which the units belong. In both tables, estimates are provided for administrative (proclamation) boundaries and for NFS ownership boundaries. In all but four cases the administrative area is larger than the ownership area, which is expected because the administrative area includes non-NFS private in-holdings. The four exceptions occur because the administrative boundaries for those units have not yet been fully updated in the ALP database to reflect recent changes.

[1] The ALP is an ongoing project of the Forest Service to, among other things, update GIS coverages of land boundaries.
[2] Brown, Thomas C., Michael T. Hobbins, and Jorge A. Ramirez. 2008. Spatial distribution of water supply in the coterminous United States. *Journal of the American Water Resources Association* 44(6):1474-1487, available at: www.fs.fed.us/rm/value/research_cpl.html.
[3] For the analysis we converted both the ALP polygons and the 5 km water supply grid to congruent 250 m grids.

A full explanation of the methodology used to estimate mean annual water supply is included in Brown et al. (2008). Here we briefly summarize some of the key points and qualifications:

- These estimates of mean annual contribution to water supply are based on data for 1953-94, which may not represent current or future hydrologic conditions.
- There is considerable year-to-year variation about the means reported here, variation that is not at all evident in the means.
- "Water supply" as used here was computed as precipitation minus natural evapotranspiration. (Evaporation occurs as water evaporates from soil and vegetation surfaces. Transpiration occurs as vegetation gives up water vapor to the atmosphere through small openings called stomata, principally in the process of photosynthesis.) Estimating water supply in this way makes the assumption that water entering the soil that is not evaporated or transpired eventually becomes available for use either by naturally returning to the surface at some point downstream or by being pumped to the surface.
- Evapotranspiration was estimated using computer models that rely on data from weather stations (for variables such as solar radiation, wind speed, and humidity). Values of weather variables for areas between stations were estimated by spatial interpolation. In addition, precipitation for areas between weather stations was estimated. Weather stations are particularly sparse in mountainous areas of the West. This estimation between stations introduces errors in the estimates of water supply. Such errors are more likely when applying the model to small areas, which may contain few or no weather stations within the boundary.
- In selected watersheds—relatively pristine watersheds that have stream gages at the outlet—the models were tested for accuracy and were further refined by comparing predicted water supply to measured streamflow. Natural discharge data were lacking for some areas of the U.S., especially in drier portions of the West, which hampered testing and refinement.
- The estimates of water supply for NFS units could not be tested for accuracy because of the lack of strategically located stream gages.

Because of these limitations, the estimates of water supply originating in NFS units are indeed "estimates", most appropriately used for large scale planning.

To provide some perspective for these estimates of water volume, please consult the tables in the Appendix of the Brown et al. (2008) publication (see footnote 2), where it is seen, for example, that the NFS units in Montana and Colorado are estimated to provide 61% and 68%, respectively, of the water supply originating in those states in an average year. Across the 11 contiguous western states the NFS provides 51% of the water supply, with other federal lands yielding another 15%.

Table 1. Mean annual contributions to water supply from units of the NFS, arranged by region

NFS unit	NFS unit code	State	Water volume (Mm^3/yr)		Area (1000 acres)	
			Admin bdy	Own bdy	Admin bdy	Own bdy
Beaverhead-Deerlodge NF	102	MT	3165	3008	3567	3338
Bitterroot NF	103	MT	2650	2611	1664	1595
Clearwater NF	105	ID	7330	7028	1951	1827
Custer NF	108	MT	1006	980	1281	1188
Dakota Prairie Grasslands	118	ND/SD	100	45	2747	1257
Flathead NF	110	MT	7358	6998	2631	2348
Gallatin NF	111	MT	3078	2652	2157	1812
Helena NF	112	MT	1000	879	1163	975
Idaho Panhandle NF	104	ID	8025	7043	2895	2445
Kootenai NF	114	MT	4952	4547	2566	2200
Lewis and Clark NF	115	MT	2804	2706	2001	1864
Lolo NF	116	MT	5000	4364	2622	2111
Nez Perce NF	117	ID	5305	5259	2252	2224
Arapaho-Roosevelt NF	208	CO	1276	1474	1717	1728
Bighorn NF	202	WY	1244	1237	1112	1105
Black Hills NF	203	SD	150	123	1536	1243
Cimmaron NG	218	KS	0	0	342	108
Comanche NG	219	KS	21	5	1117	444
Grand Mesa-Uncompahgre-Gunnison NF	201	CO	2954	3454	3154	3526
Medicine Bow-Routt NF	206	WY/CO	2701	2389	2697	2104
Nebraska NF	207	NE	65	45	2062	1052
Pawnee NG	222	CO	55	12	768	192
Pike-San Isabel NF	212	CO	1600	1493	2505	2224
Rio Grande NF	209	CO	2021	2043	1946	1708
San Juan NF	213	CO	2372	1565	2094	1553
Shoshone NF	214	WY	2920	2901	2469	2438
Thunder Basin NG	224	WY	13	7	1820	551
White River NF	215	CO	3070	2267	2482	1812
Apache-Sitgreaves NF	301	AZ	693	672	2110	2016
Carson NF	302	NM	736	712	1588	1487
Cibola NF	303	NM	119	102	3215	1841
Coconino NF	304	AZ	465	440	2011	1824
Coronado NF	305	AZ	469	445	1776	1663
Gila NF	306	NM	486	475	3387	3269
Kaibab NF	307	AZ	263	253	1601	1549
Lincoln NF	308	NM	276	237	1262	1095
Prescott NF	309	AZ	182	146	1411	985
Santa Fe NF	310	NM	923	877	1807	1643
Tonto NF	312	AZ	464	452	2968	2867
Ashley NF	401	UT	1189	1185	1401	1378
Boise NF	402	ID	4811	4412	2599	2262
Bridger-Teton NF	403	WY	5460	5413	3467	3420
Caribou-Targhee NF	415	ID	4442	4287	3071	2900

NFS unit	NFS unit code	State	Water volume (Mm^3/yr)		Area (1000 acres)	
			Admin bdy	Own bdy	Admin bdy	Own bdy
Dixie NF	407	UT	563	539	1965	1886
Fishlake NF	408	UT	754	707	1533	1453
Humboldt-Toiyabe NF	417	NV	3092	2875	6791	6256
Manti-La Sal NF	410	UT	840	794	1414	1340
Payette NF	412	ID	5140	4967	2433	2343
Salmon-Challis NF	413	ID	4401	4373	4332	4288
Sawtooth NF	414	ID	2582	2534	2190	2110
Uinta NF	418	UT	772	718	984	890
Wasatch-Cache NF	419	UT	2759	1819	1908	1247
Angeles NF	501	CA	99	94	701	662
Cleveland NF	502	CA	0	0	561	423
Eldorado NF	503	CA	1806	1416	793	604
Inyo NF	504	CA	671	660	2041	1984
Klamath NF	505	CA	5184	4991	1887	1691
Lake Tahoe Basin Mgt Unit	519	CA/NV	304	272	197	176
Lassen NF	506	CA	1880	1507	1487	1151
Los Padres NF	507	CA	274	255	1908	1731
Mendocino NF	508	CA	2477	2117	1073	915
Modoc NF	509	CA	68	64	2022	1679
Plumas NF	511	CA	2525	2033	1430	1202
San Bernardino NF	512	CA	268	221	808	671
Sequoia NF	513	CA	2290	2180	1162	1114
Shasta-Trinity NF	514	CA	7640	5843	2707	2132
Sierra NF	515	CA	3517	3274	1415	1320
Six Rivers NF	510	CA	6102	5614	1082	974
Stanislaus NF	516	CA	3867	3114	1090	898
Tahoe NF	517	CA	3169	2209	1179	825
Columbia River Gorge NSA	622	OR/WA	101	109	24	27
Colville NF	621	WA	1844	1459	1316	1064
Deschutes NF	601	OR	2286	2186	1869	1609
Fremont-Winema NFs	602	OR	972	874	2810	2255
Gifford Pinchot NF	603	WA	10261	9364	1506	1374
Malheur NF	604	OR	753	712	1544	1468
Mt Baker-Snoqualmie NF	605	WA	16310	14596	1958	1729
Mt Hood NF	606	OR	6610	6405	1104	1062
Ochoco NF	607	OR	183	180	1155	967
Okanogan-Wenatchee NF	617	WA	11230	10747	4192	3940
Olympic NF	609	WA	7306	6779	691	630
Rogue River-Siskiyou NF	610	OR	10617	10053	1837	1716
Siuslaw NF	612	OR	4593	3454	699	523
Umatilla NF	614	OR	2255	2143	1511	1406
Umpqua NF	615	OR	3418	3297	1030	986
Wallowa-Whitman NF	616	OR	2395	2329	2382	2253
Willamette NF	618	OR	9778	9170	1794	1683
Chattahoochee-Oconee NF	803	GA	5225	2830	1734	866

NFS unit	NFS unit code	State	Water volume (Mm^3/yr)		Area (1000 acres)	
			Admin bdy	Own bdy	Admin bdy	Own bdy
Cherokee NF	804	TN	2956	1644	1222	643
Daniel Boone NF	802	KY	4196	1447	2043	710
Francis Marion-Sumter NF	812	SC	2053	979	1377	630
George Washington-Jefferson NF	808	VA	5835	2989	3459	1781
Kisatchie NF	806	LA	1915	1135	1029	608
Land Between the Lakes NRA	860	KY/TN	314	322	167	171
NFs in Alabama	801	AL	2882	1504	1289	670
NFs In Florida	805	FL	2208	1986	1328	1186
NFs In Mississippi	807	MS	5303	2711	2343	1193
NFs In North Carolina	811	NC	8850	4026	2978	1244
NFs In Texas	813	TX	2594	891	1923	677
Ouachita NF	809	AR	4433	3354	2382	1783
Ozark-St Francis NF	810	AR	2547	1928	1522	1156
Allegheny NF	919	PA	1842	1275	741	513
Chequamegon-Nicolet NF	913	WI	2194	1681	2001	1520
Chippewa NF	903	MN	805	344	1598	673
Green Mountain-Finger Lakes NF	920	VT	2475	1219	836	400
Hiawatha NF	910	MI	1633	1158	1263	868
Hoosier NF	912	IN	1031	314	646	201
Huron-Manistee NF	904	MI	2709	1267	1989	964
Mark Twain NF	905	MO	3630	1748	3087	1514
Midewin National Tallgrass Prairie	915	IL	30	20	27	18
Monongahela NF	921	WV	4642	2583	1659	906
Ottawa NF	907	MI	2234	1370	1514	956
Shawnee NF	908	IL	1231	474	740	285
Superior NF	909	MN	2173	1366	3181	2072
Wayne NF	914	OH	1432	397	852	235
White Mountain NF	922	NH	2986	2644	922	800
Total			329525	271892	211357	169074

Table 2. Mean annual contributions to water supply by NFS region

NFS Region	Water volume (Mm^3/yr)		Area (1000 acres)	
	Admin bdy	Own bdy	Admin bdy	Own bdy
1	51,772	48,119	29,497	25,183
2	20,460	19,015	27,821	21,788
3	5,077	4,810	23,136	20,239
4	36,804	34,622	34,087	31,773
5	42,142	35,863	23,542	20,152
6	90,912	83,855	27,422	24,693
8	51,311	27,747	24,796	13,320
9	31,048	17,862	21,056	11,925
Total	329,525	271,892	211,357	169,074