NET PRIMARY PRODUCTIVITY AND PHYTOMASS OF FORESTS OF THE TENNESSEE VALLEY

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Net primary productivity and standing crop of phytomass were calculated for 464 plots in the Tennessee Valley using a general allometric equation and continuous forest inventory plot records of the Tennessee Valley Authority. Adjustments were made for the productivity and phytomass of minor vegetation on the basis of regional averages; roots were assumed to contribute 25 percent in each case. These were then aggregated to assess differences between physiographic provinces and forest types within the region. Values for the Blue Ridge Province were compared with quantities previously reported by R. H. Whittaker for the Great Smoky Mountain National Park.

Average net primary productivity for the Tennessee Valley is 10.0 t (metric) ha^{-1} yr^{-1} and phytomass is 148 t ha^{-1}. Variability, both between forest types and physiographic provinces, is masked by the variability within these categories. However, net primary productivity and standing crop are significantly higher for some forest types within the Great Smoky Mountain National Park than for the Blue Ridge Province as a whole. These differences are attributed to the higher phytomass of forests in the National Park and to a relation of increased productivity with increasing phytomass for forests of the region.

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INTRODUCTION

Information about the net primary production and phytomass of forests of a region has been obtained primarily by extrapolating quantities laboriously obtained at a few sites (Rodin and Bazilevich 1967; Lieth and Whittaker 1975). This contrasts with the basis for much information about the merchantable characteristics of forests which comes from networks of forest inventory plots. Often these are permanently located and resurveyed at regular intervals--the continuous forest inventory (CFI) systems of various public agencies. This study brings CFI data for the Tennessee Valley to bear on the issue of region-wide forest net primary production and phytomass.

The Tennessee Valley is a region of 89 million hectares including parts of seven states (Fig 1). Five physiographic provinces occur within

its boundaries (Fenneman 1938): Blue Ridge (with the Great Smoky Mountain National Park centrally located), Ridge and Valley, Cumberland Plateau, Highland Rim and Nashville Basin sections of the Interior Low Plateau, and the Gulf Coastal Plain.

The vegetation is correspondingly diverse, as 28 forest types are recognized (Tennessee Valley Authority 1967). Yet, information about the biological productivity of this region, as distinct from merchantable productivity, is available for only a few locations in and adjacent to the Tennessee Valley. The studies by Whittaker (1966) in the Great Smoky Mountain National Park are the most exhaustive and the most often cited. Are his findings representative of overall net primary production and phytomass of the Blue Ridge Province? Could these values be extrapolated to other physiographic provinces of the Tennessee Valley?

The intent of this paper is to present the results of calculations of net primary production and phytomass for CFI plots in the Tennessee Valley. These plots have been aggregated by forest type and physiographic region to assess the geographic variability in forest productivity and phytomass within the Tennessee Valley.

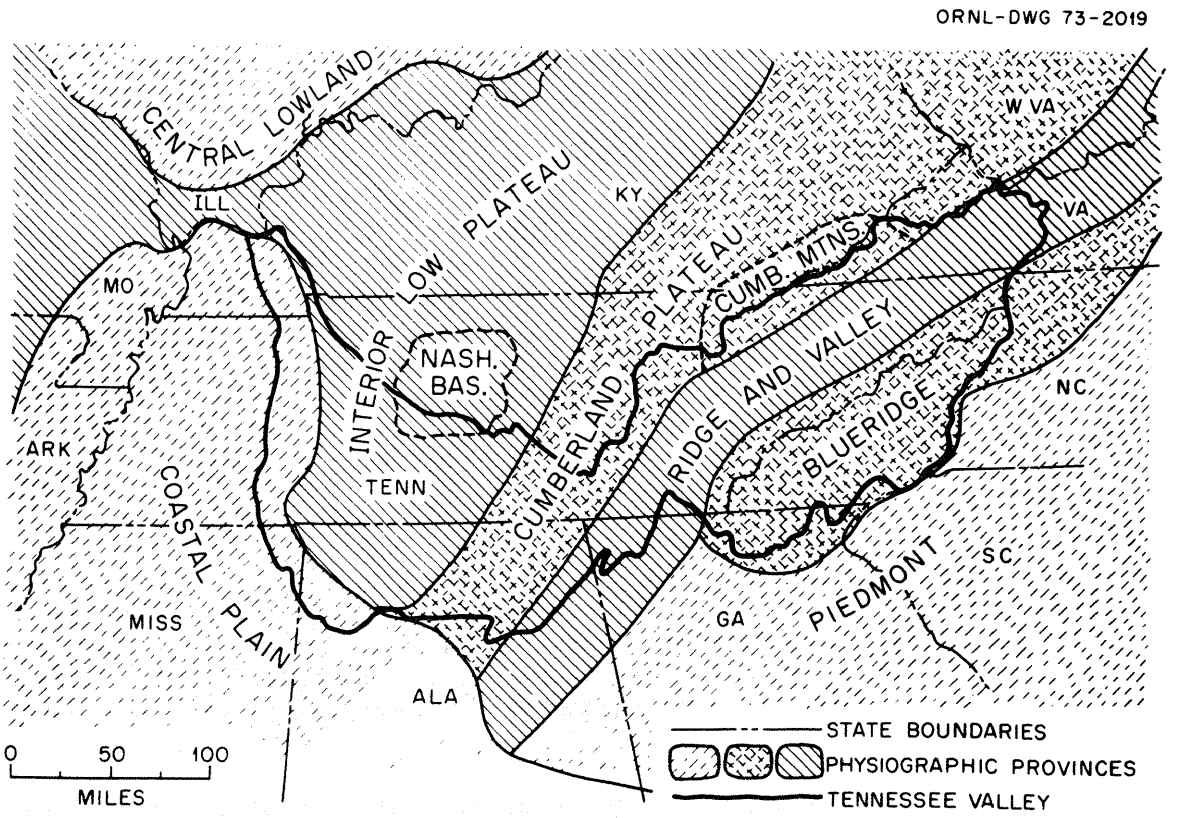

Figure 1. Physiographic provinces of the Tennessee Valley.

THE DATA BASE

The Tennessee Valley Authority maintains CFI plots at 13.6 KM (8.5 mile) intervals on a grid system that overlays the Tennessee Valley. These plots, of which there were 464 in commercial forest in 1970, are resurveyed at five-year intervals. This study utilized data collected in 1965 and 1970.

Each plot has an area of 0.08 ha (0.2 acre) with a nested 0.02 ha (0.05 acre) subplot and five 0.04 ha (0.01 acre) subplots, one at the plot center, the others on the outer perimeter (Tennessee Valley Authority 1967). Sawtimber trees (27.6 cm dbh or greater) are surveyed in the largest plot, poletimber (12.6 cm to 27.5 cm dbh) in the nested subplot, and a sapling count is taken in the five smallest plots for trees 2.5 - 12.5 cm dbh. Diameters and species are tallied for all poletimber and sawtimber-sized trees (in addition to information on merchantable quality). Saplings are tallied in the 5 cm and 10 cm size classes as conifers or hardwoods; this was done for the first time in 1970.

Computation of Phytomass and Productivity

The phytomass for the years 1965 and 1970 and the average annual net primary production for the intervening five years were computed for pole- and sawtimber trees using allometric equations for above-ground woody phytomass of bole and branches, and foliage (Sharpe 1975). The allometric equations were developed (Harris *et al.* 1973) from stem analyses of conifers and hardwoods in Georgia, North Carolina and Tennessee compiled by Sollins and Anderson (1971). The same allometric equations were used for all species. One equation relates branch and bole phytomass to tree dbh, the other relates foliage phytomass to dbh. The phytomass of roots was assumed to be 25 percent of the sum of woody and foliage phytomass (Ovington 1962; Bray 1963; Rodin and Bazilevich 1967). The phytomass of saplings was accounted as the sapling tally in the 5.0 and 10.0 cm dbh classes multipled by the phytomass of trees of these two diameters. No data on herbs and shrubs on TVA plots was available. The phytomass of these undergrowth components was assumed to be 1500 kg/ha on the basis of work reported by DeSelm *et al.* (1971).

Net primary production in woody phytomass of pole- and sawtimber trees was computed as the difference between computed phytomass for the 1965 and 1970 surveys divided by the five-year survey interval. This provides a conservative value of the above-ground woody component of net primary production since the growth and sloughing of branches is not accounted for.

The foliage component of net primary production for pole- and sawtimber was computed as the average foliage phytomass divided by foliage persistence, one year for deciduous species and three years for evergreens. Average foliage phytomass was the mean of the computed foliage phytomass for 1965 and 1970. Only the foliage component of the net primary production of saplings was computed, since no sapling tally was made in 1965.

The net primary production attributed to roots was assumed to be 25 percent of above-ground net primary production (Bray 1963; Whittaker and Woodwell 1969; Olson 1968). Growth by herbs, shrubs and trees less than 2.5 cm dbh was assumed to contribute 300 kg/ha-hr. to the total community net primary production, again on the basis of several past studies in Tennessee (DeSelm et al. 1971).

No direct comparisons of computed and measured net primary production and phytomass for specific TVA plots are available. Nevertheless, the allometric equations have been used in studies of productivity of a watershed in East Tennessee with good results (Harris et al. 1973). Stem analysis of black oak sawtimber gave measured values within a few percent of values computed from the equations used in this study (Tennessee Valley Authority 1972). Computed foliage phytomass has been compared to litter trap figures (Henderson et al. 1972; Harris et al. 1973). While litter fall for individual plots differed significantly from computed values they agreed within 0.5 percent for the watershed as a whole when computed values were adjusted for pre-abscission weight loss. The foliage phytomass and production for hardwoods is probably accurate; subsequent studies have shown that conifer foliage phytomass is underestimated when a single allometric equation is used (Sollins et al. 1973). Total phytomass would be only slightly affected, since foliage is a minor proportion of the total.

RESULTS

Plots have been grouped by forest type, physiographic region and categories of phytomass. Plots were assigned to forest types on the basis of species dominance (Tennessee Valley Authority 1967). I have combined some forest types. For example, I combined beech-yellow birch-hard maple, yellow poplar, and northern red oak-basswood-ash as northern hardwoods. Moreover, the topographic position of TVA plots was used to make further distinctions in forest type. Thus, a cove hardwoods type occupying moist uplands was separated from the northern hardwoods type occupying dry uplands to facilitate comparison with the cove hardwood and beech gap forests investigated by Whittaker (1966).

Forests of the Blue Ridge Province

The values for TVA plots in commercial forest outside the Great Smoky Mountain National Park (GSMNP) are listed in table 1, together with Whittaker's (1966) figures for comparable forest types inside the GSMNP. Above-ground data are presented because Whittaker did not consider roots. Standard errors are included for those forest types represented by more than four plots and values for TVA plots that differ significantly from Whittaker are denoted by an asterisk.

Above-ground net primary production for TVA plots in the Blue Ridge Province varies from 5.9 mt ha^{-1} yr^{-1} for pitch and Table Mountain pines to 13.5 mt ha^{-1} yr^{-1} for hemlock-white pine. The average for the Blue Ridge Province is 9.4 mt ha^{-1} yr^{-1} (based on 107 plots). The values computed by Whittaker (1966) are similar to TVA plots for most forest types. The greatest disparity is between cove hardwoods outside the National Park, which are significantly less productive than the cove hardwoods studied

by Whittaker (11.6 mt ha^{-1} yr^{-1} vs. 16.6 mt^{-1} ha^{-1} yr^{-1}). The average productivity is higher on GSMNP than in the surrounding commercial forest (10.4 or 9.4 mt ha^{-1} yr).

Table 1. Above-ground net primary production and phytomass by forest type in the Blue Ridge Province (excluding Great Smoky Mountain National Park, GSMNP), and for selected stands in GSMNP (Whittaker 1966). Number of TVA plots is in parentheses next to forest type names. Values shown are mean ± one standard error. (* = TVA plots differ from Whittaker (1966) at 5% level).

		Net Primary Production mt ha^{-1} yr^{-1}		Biomass mt ha^{-1}	
		TVA	GSMNP	TVA	GSMNP
Coniferous Types					
Va., Shtlf. Pine	(10)	8.2 ± 0.9	8.8	135 ± 24	181
Loblolly Pine	(1)	6.9	-	189	-
Pitch, Ta. Mtn Pine	(4)	5.9	6.6	126	94
Hemlock, Wh. Pine	(3)	13.5	10.2	296	511
Hardwood Types					
Bottomland[1/]	(1)	10.8	-	138	-
Oak-Hickory[2/]	(55)	9.5 ± 0.9	10.7	152 ± 7*	286
Pers., Sass., Locust	(2)	8.9	-	82	-
No., Cove Hdwds.[3/]	(15)	11.6 ± 1.6*	16.6	149 ± 31*	348
No., Hdwds-Upland[4/]	(5)	7.5 ± 1.8	7.4	144 ± 20	131
Mixed Types					
Hemlock, Wh. Pine, Hd	(2)	8.9	12.6	108	402
Yellow Pine, Hdwds.[5/]	(9)	8.5 ± 1.1	-	133 ± 20	-
Average	(107)	9.4 ± 0.5*	10.4	149 ± 6*	260

[1/] Oak-gum-cypress and elm-ash-soft maple

[2/] Red oak-white oak-hickories and blackjack oak-post oak

[3/] Beech-yellow birch-sugar maple, yellow poplar, and northern red oak-basswood-ash forest types on moist upland sites

[4/] Same species composition as footnote 3 on dry uplands and upland flats

[5/] Yellow pines include Virginia, shortleaf, table mountain and loblolly pines

A more striking difference between the GSMNP and the surrounding region is in phytomass, especially for the more impressive forest types for which the Smokies are noted. The hemlock-white pine, oak-hickory, northern and cove-hardwoods, and hemlock-white pine-hardwoods maintain a far greater standing crop in the GSMNP than outside its boundaries. Average above-ground phytomass for the Blue Ridge Province outside the GSMNP is 149 mt ha^{-1} and 70 percent of the TVA plots support less than 200 mt ha^{-1}.

Would the productivity of the forests outside the GSMNP be higher if their average phytomass were higher? Studies by Kira and Shidei (1967) and Loucks (1970), among others, suggest that productivity increases with phytomass to a point, after which it levels off or decreases somewhat. Average net primary production (shoots and roots) was plotted against total stand phytomass in 1970 by 50 mt/ha classes for the TVA plots in the Blue Ridge Province (Fig 2). Average net primary production for the region (as shown by the heavy line) increases from a calculated low of 4 mt ha^{-1} yr^{-1} when phytomass is under 50 mt ha^{-1} to about 19 mt ha^{-1} yr^{-1} for stands with 250-300 mt ha^{-1} of phytomass. The few old growth plots suggest a decline in productivity as phytomass exceeds 300 mt ha^{-1}. The trend of each of the four forest types with more than ten plots is consistent with the average. There appears to be little difference in productivity between forest types below a phytomass of 200 mt ha^{-1}. The productivity of Virginia-shortleaf pine stabilizes, or may decline, above this phytomass.

This trend suggests that the productivity of the forests of this region will, in fact, increase as their phytomass increases. Phytomass is now increasing by about 3.8 mt ha^{-1} yr^{-1} (from 130 mt ha^{-1} in 1965 to 149 mt ha^{-1} in 1970). It is likely to stabilize more quickly for Virginia-shortleaf pine, whereas the productivity of the northern hardwoods, and to a lesser extent the oak-hickory, could continue to rise for several decades. Disturbance patterns in the region, especially timber harvesting, will have a great affect. If harvest rates were to remain at current levels, average phytomass would continue to rise for nearly a century, to 300 mt ha^{-1} (Sharpe and Johnson 1973). Steadily increased harvest rates in the future would reduce the maximum average phytomass that is ultimately achieved, and perhaps cause subsequent reductions. But in either case, net primary productivity is likely to rise for a number of years.

We can conclude that the slightly higher productivity of forests in the GSMNP is due to their higher phytomass. The differences are no greater than observed because the forests of the surrounding regions are approaching a phytomass where net primary production stabilizes. The small difference that remains for some forest types, e.g., Virginia-shortleaf pine and oak-hickory, should disappear as their phytomass increases. The upland northern hardwoods and hemlock-white pine may already have more phytomass than sustains maximum productivity. Cove hardwoods have the capacity for significantly increased productivity, but will probably be maintained at an ecologically suboptimal phytomass because of their commercial value.

These results suggest that selected old-growth stands reflect the maximum net primary production and phytomass for a particular forest type in a region. These selected plots will be more representative of regional productivity for a forest type as its average phytomass increases, but there is a broad range of phytomass over which the difference is negligible.

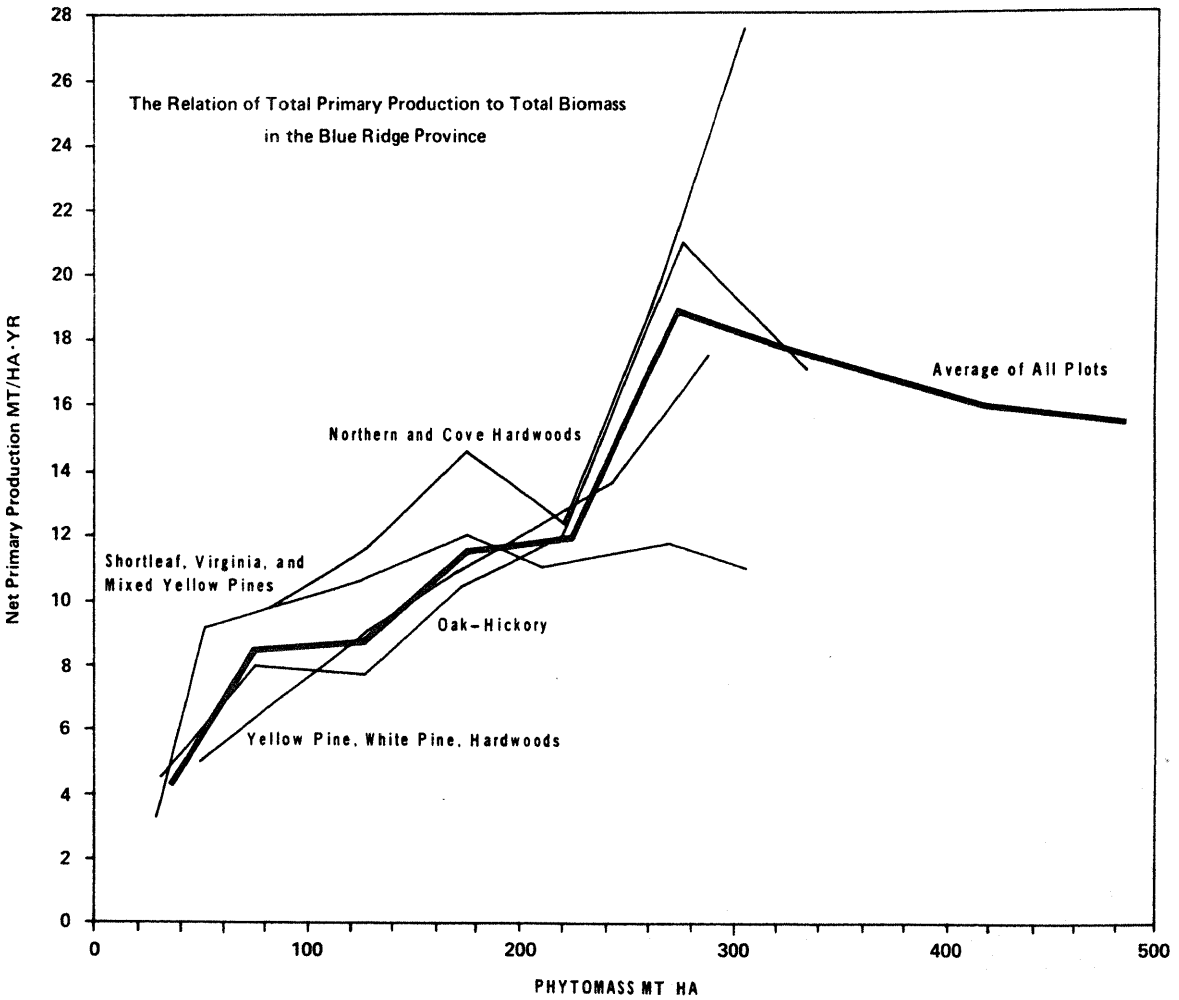

Figure 2. The relation of total net primary production to total phytomass in the Blue Ridge Province for Virginia-shortleaf pine; oak-hickory; northern hardwoods (cove and upland); yellow pine-white pine-hardwoods; and average for all plots (avg). (See footnotes on table 1 for species composition of forest types).

Trends in the Tennessee Valley

The TVA plots were also grouped by forest type and physiographic province. Net primary production (above-ground and roots) for forest types with more than five plots varies from 8.6 mt ha^{-1} yr^{-1} for the northern hardwoods and pine-hardwoods in the Cumberland Plateau to 13.2 mt ha^{-1} yr^{-1} for the northern hardwoods (the combined cove and upland hardwoods) in the Blue Ridge Province (Table 2). The average for the Tennessee Valley is 10.0 mt ha^{-1} yr^{-1}. The average for physiographic provinces varies from 8.9 mt ha^{-1} yr^{-1} in the Cumberland Plateau to 11.8 mt ha^{-1} yr^{-1} in the Blue Ridge Province. In an east-west transect across the Tennessee Valley, net primary production generally declines from the Blue Ridge Province to the Cumberland Plateau, then increases through the Highland Rim and Nashville Basin to the Coastal Plain in West Tennessee. The average net primary production of the Blue Ridge is 33 percent greater than that of the Cumberland Plateau, and that of the Coastal Plain is 14 percent greater. However, there is no significant difference (at the 5 percent confidence level) between either regional averages or within forest types across regional boundaries because of the large variation in productivity within forest types and regions.

Total phytomass (shoots and roots) varies from 114 mt ha^{-1} for Virginia-shortleaf pine in the Gulf Coastal Plain to 190 mt ha^{-1} for oak-hickory in the Blue Ridge Province (Table 3). The Blue Ridge has the highest average phytomass standing crop (186 mt ha^{-1}), while the adjacent Ridge and Valley Province has the lowest (132 mt ha^{-1}). The average for the Tennessee Valley is 148 mt ha^{-1}. Again, the variation in phytomass within forest types and regions makes it impossible to note any significant difference between regions or differences for each forest type from one region to another.

One reason for the variability in both productivity and phytomass of the forests of the Tennessee Valley is the variability in stocking levels of the stands. Only 282 of the 464 plots were well-stocked in 1970, the remainder having fair or poor stocking. Total phytomass in well-stocked oak-hickory, the dominant forest type in the Tennessee Valley, averages 172 mt ha^{-1} in contrast to 119 mt ha^{-1} for poorly stocked oak-hickory. The average phytomass for well and poorly stocked stands in all forest types in the Tennessee Valley is 173 and 108 mt ha^{-1}, respectively. The mean net primary production for well stocked oak-hickory is 11.4 mt ha^{-1} yr^{-1} in contrast to 8.1 mt ha^{-1} yr^{-1} for stands with fair or poor stocking. The average for all forests in the Tennessee Valley is 11.3 mt ha^{-1} yr^{-1} and 8.0 mt ha^{-1} yr^{-1} for well and poorly stocked forests, respectively.

A second factor is the relation between phytomass and productivity. Average productivity correlates well with average phytomass in the Tennessee Valley ($r = 0.8$; Table 2 vs Table 3). Finally, local site variations will play a role, but there is little evidence that broad environmental gradients are reflected in the productivity of forests in the Tennessee Valley.

Table 2. Total net primary production for selected forest types in the six physiographic provinces of the Tennessee Valley. Values shown are mean ± one standard error (Metric Tons per Hectare per Year) and sample size.

Physiographic Province	Va., Shtlf. Pine	Oak-Hickory[1/]	Northern Hardwoods[2/]	Pine Hardwoods[3/]	Average
Blue Ridge	10.2 ± 1.1 (n=10)	11.8 ± 1.1 (n=55)	13.2 ± 1.6 (n=20)	10.6 ± 1.3 (n=9)	11.8 ± 0.7 (n=107)
Ridge & Valley	9.0 ± 1.0 (n=19)	9.6 ± 0.5 (n=43)	11.8 ± 1.1 (n=10)	9.0 ± 1.2 (n=11)	9.6 ± 0.4 (n=99)
Cumberland Plateau	9.0 ± 0.9 (n=11)	9.2 ± 0.6 (n=33)	8.6 ± 1.3 (n=8)	8.6 ± 0.4 (n=11)	8.9 ± 0.3 (n=99)
Highland Rim	11.1 (n=1)	9.6 ± 0.4 (n=65)	10.9 ± 1.2 (n=3)	10.3 ± 3.1 (n=2)	9.4 ± 0.4 (n=84)
Nashville Basin	-- --	11.0 ± 0.6 (n=3)	12.9 (n=1)	-- --	9.9 ± 1.2 (n=13)
Gulf Coastal Plain	8.8 ± 2.4 (n=5)	9.4 ± 0.9 (n=29)	-- --	11.9 ± 1.5 (n=6)	10.2 ± 0.7 (n=61)
Average	9.3 ± 0.6 (n=46)	10.0 ± 0.3 (n=257)	11.8 ± 0.9 (n=42)	9.8 ± 0.5 (n=39)	10.0 ± 0.2 (n=464)

1/ Red oak-white oak-hickories and blackjack oak-post oak

2/ Beech-yellow birch-sugar maple, yellow poplar, and northern red oak-basswood-ash

3/ Conifers comprise 25-50 percent of codominant and dominant trees

Table 3. Total phytomass for selected forest types in the six physiographic provinces of the Tennessee Valley. Values shown are mean ± one standard error (Metric Tons per Hectare). See Table 2 for sample sizes.

Physiographic Province	Va., Shtlf. Pine	Oak-Hickory[1/]	Northern Hardwoods[2/]	Pine-Hardwoods[3/]	Average
Blue Ridge	169 ± 30	190 ± 9	185 ± 19	166 ± 26	186 ± 8
Ridge & Valley	127 ± 18	137 ± 10	157 ± 11	123 ± 19	132 ± 7
Cumberland Plateau	120 ± 17	135 ± 9	145 ± 25	139 ± 12	134 ± 5
Highland Rim	164	142 ± 7	222 ± 32	119	138 ± 7
Nashville Basin	---	158 ± 3	293	---	170 ± 31
Gulf Coastal Plain	114 ± 37	140 ± 17	---	130 ± 16	136 ± 10
Average	134 ± 11	150 ± 4	176 ± 11	139 ± 9	148 ± 3

[1/] Red oak-white oak-hickories and blackjack oak-post oak

[2/] Beech-yellow birch-sugar maple, yellow poplar, and northern red oak-basswood-ash

[3/] Conifers comprise 25-50 percent of codominant and dominant trees

CONCLUSIONS

Conclusions that can be drawn from this analysis include:

1. The forests of the Tennessee Valley have low phytomass relative to the selected stands normally chosen for study, but phytomass is increasing by nearly 4 mt ha^{-1} yr^{-1}.

2. Productivity increases with phytomass in stands with low phytomass, (and certainly with poor stocking), but stabilizes and may decline as stands mature.

3. Low phytomass is not reflected in significantly lower average net primary production for the Tennessee Valley and its forest types than measured in selected mature stands except for forest types that have the potential to attain high phytomass, e.g., cove hardwoods.

4. There are indications that productivity varies across the Tennessee Valley, but differences in the history of forest utilization as reflected in their current phytomass appear to explain a large part of this variability.

LITERATURE CITED

Bray, J. R. 1963. Root production and the estimation of net productivity. Canad. Jour., Bot 41:65-72.

DeSelm, J. R., D. Sharpe, P. Baxter, R. Sayres, M. Miller, D. Natella and R. Umber. 1971. Final Report; Tennessee Productivity Profile, 182 pp (mineogr.) US-IBP-EDFB Memo Report 71-13.

Fenneman, N. A. 1938. Physiography of the Eastern United States. New York. McGraw-Hill, 714 pp.

Harris, W. F., R. A. Goldstein and G. S. Henderson. 1973. Analysis of forest biomass pools, annual primary production and turnover of biomass for a mixed deciduous forest watershed. In IUFRO Biomass Studies. International Union of Forest Research Organizations, College of Life Sciences and Agriculture, University of Maine at Orano, pp. 41-64.

Henderson, G. S., W. F. Harris and D. E. Todd. 1972. Validation of foliage biomass prediction equations using litterfall data on Walker Branch Watershed. 8 pp. (mimeogr.). US-IBP-EDFB Memo Report 72-158.

Kira, T. and T. Shidei. 1967. Primary production and turnover of organic matter in different forest ecosystems of the western Pacific. Japanese Journal of Ecology 17:70-87.

Lieth, Helmut and R. H. Whittaker (ed). 1975. Primary productivity of the biosphere. New York. Springer-Verlag ix + 339 pp.

Loucks, Orie L. 1970. Evaluation of diversity, efficiency and community stability. American Zoologist 10: 17-25.

Olson, J. S. 1968. Distribution and radio-cesium transfers of roots in a tagged mesophytic Appalachian forest in Tennessee. In U.S.S.R. Academy of Sciences. Methods of Productivity Studies in Root Systems and Rhigosphere Organisms. pp. 133-139.

Ovington, J. D. 1962. Quantitative ecology and the woodland ecosystem concept. In J. B. Cragg (ed.), Advances in Ecological Research 1: 103-192.

Rodin, L. E. and N. I. Bazilevich. 1967. Production and mineral cycling in terrestrial vegetation. (Trans. ed. G. E. Fogg). London. Oliver and Boyd. 300 pp.

Sharpe, David M. 1975. Methods of assessing the primary production of regions. In Helmut Lieth and Robert H. Whittaker (ed.) Primary Productivity of the Biosphere. New York. Springer-Verlag, pp. 147-166.

Sharpe, David M. and W. Carter Johnson. 1973. Biomass dynamics of the commercial forests of the Tennessee Valley. IUFRO Biomass Studies. International Union of Forest Research Organizations. S. 401 Mensuration, Growth and Yield. Working Party on the Mensuration of the Forest Biomass. College of Life Sciences and Agriculture, University of Maine at Orono. pp. 145-157.

Sollins, P. and R. M. Anderson. 1971. Dry-weight and other data for trees and woody shrubs of the Southeastern United States. ORNL-IBP-71-6, 80 pp. Oak Ridge, Tennessee: Oak Ridge National Laboratory.

Sollins, P., D. E. Reichle and J. S. Olson. 1973. Organic matter budget and model for a Southern Appalachian Liriodendron forest. USAEC Rep. No. EDFB-IBP-73-2. Oak Ridge National Laboratory, Oak Ridge, Tenn. 150 pp.

Tennessee Valley Authority. 1967. TVA forest inventory field manual for county-wide units and watersheds in the Tennessee Valley, 20 pp (mimeogr.) Norris, Tennessee: Forest Survey Section, Forest Products Branch, Division of Forestry, Fisheries and Wildlife Development.

Tennessee Valley Authority. 1972. Biomass estimates of black oak tree components. Technical Report B1. Division of Forestry, Fisheries and Wildlife Development. Tennessee Valley Authority, Norris, Tenn.

Whittaker, R. H. 1966. Forest dimensions and production in the Great Smoky Mountains. Ecology 47:103-121.

Whittaker, R. H. and G. M. Woodwell. 1969. Structure, production and diversity of the oak-pine forest at Brookhaven, New York. Journal of Ecology 57:155-174.

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