the degree of acidity is not sufficient to check the normal tryptic digestion, which in some instances seems to be favored by a reaction on the acid side of neutrality. The reaction found must vary with the state of digestive activity and is simply an equilibrium condition between the chyme and the alkaline juices poured into the duodenum. Any reaction near neutrality may obtain.

In the case of a dog the intestinal contents secured during active digestion was slightly acid with $[H] = 1.6 \times 10^{-7}$, and this after much of the carbon dioxide had escaped.

In working with other animals notable variations in the reaction were found, at different times and in different parts of the small intestine, which for convenience in observation was tied so as to make three loups in each case. No simple relation was found, but for hogs, lambs and calves the reaction was found to be more often acid than alkaline, the measurements in all cases being made by concentration cells. In most cases the upper third of the intestine was found to be the most strongly acid, while the lower third might be alkaline. However, this relation was sometimes found to be reversed. In the case of the hogs some food remains were always found in the middle and lower thirds of the intestine, and the amount would vary with the time which had elapsed since feeding. Digestion would be in active progress, therefore, sometimes under acid and sometimes under an alkaline condition.

In working with the hogs we found the variations in the reaction to be between $[H] = 3.3 \times 10^{-7}$ and 8.9×10^{-9}. The slight degree of alkalinity is more marked than the acidity reached. The range for the other animals is included within these limits, but for man the acidity reached was sometimes lower. But in this case, it must be remembered, we have but little more than the duodenum for comparison.

CHICAGO, ILL.

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, MASSACHUSETTS AGRICULTURAL COLLEGE.]

THE PLANT FOOD MATERIALS IN THE LEAVES OF FOREST TREES.

BY PAUL SEREX, JR.

Received March 27, 1917.

Introduction.

This work was undertaken for the purpose of investigating the plant food constituents of the leaves of three typical New England forest trees at the beginning of their activity in the spring and practically at the end of their growth in the fall; to observe the difference in content of these materials in the leaves taken from the branches nearest the soil and those from the very top of the tree; to observe the varying content in the leaves of the same species of tree grown upon different soil type; also to estimate the manurial value of leaves.

Experimental Results of the Investigations.

Collection and Preparation of Samples.—The leaves of three common New England trees, the chestnut (*Castanea Dentata*), the sugar maple (*Acer saccharum*), and the white oak (*Quercus alba*)—were gathered in the fall, slightly previous to the time of changing color, from the highest branches of the tree and also from the lowest branches. Samples were selected from the above-mentioned species which were growing upon three very different soil types, namely, Suffield clay, Holyoke stony loam (Mt. Pleasant near college orchard), and Wethersfield loam[1] (Sugar Loaf). In each case leaves were taken only from trees which appeared healthy, showed good growth, and were in such a situation as to enable the various organs to carry on their normal functions of life. Trees of about the same age and height as nearly as could be estimated were selected for this investigation. The leaves were picked from the branches, dried in the air, and then in a hot-air oven at a temperature of about 70°, after which they were finely ground, mixed thoroughly, and stored in sealed bottles.

Methods of Analysis.[2]

The phosphoric acid (P_2O_5) was determined gravimetrically as magnesium pyrophosphate; the potash (K_2O) was determined gravimetrically as potassium chloroplatinate, and the nitrogen content of the leaves was determined by the Kjeldahl method modified to include the nitrogen of nitrates.

Characteristics of the Soil Types.[3]

Suffield clay consists of from four to eight inches of heavy dark-drab clay loam resting on a heavy, tenacious gray-drab clay, which extends to a depth of twenty, and in some instances seventy-five feet. It is an unimportant agricultural soil of small extent. It is of deep lake origin, and while appearing very heavy and tenacious, it is largely composed of silt, probably of the finer grades. The type is cold and wet and is difficult to cultivate. The subsoil is very resistent to the development of plant roots, and all crops make meager growth. It is best utilized in the production of grass. The area upon which the trees under investigation grew occurred about a mile west of Amherst.

The soil of the Holyoke stony loam is a dark yellow or brown silty loam, from seven to twelve inches deep. The subsoil ranges from a moderately heavy yellow sandy loam to a heavy loam, with the sandier phase more

[1] "Classification of Soils According to Field Operations of the Bureau of Soils, 1903," U. S. Dept. Agr., *Massachusetts Amherst Sheet.*

[2] "Methods of Analysis, Association of Official Agricultural Chemists," U. S. Dept. Agr., *Bull.* 107 (revised). Reprint Jan. 18, 1912.

[3] "Field Operations of the Bur. of Soils, 1903," U. S. Dept. Agr., *Advance Sheets.*

abundant. The type is very stony throughout and contains pebbles and boulders of angular shape. The soil in general is of moderate fertility. Grain and grass crops give good returns, and it is also suitable for grazing. This soil is very well adapted to the growth of apples, grapes and other fruits. The trees under observation grew on an area of this soil just west of the Massachusetts Agricultural College orchard.

The Wethersfield loam (formerly called Triassic stony loam) is a reddish to red-brown silty loam, with a depth of fourteen inches, resting on a medium heavy sandy loam of reddish color three feet in depth. The material ranges from a sandy loam to a heavy silty loam which has a darker red color. Both soil and subsoil contain large numbers of angular boulders of all sizes up to several feet in diameter, and the greater portion of these consist of the red and brown sandstone of the Triassic period. The prevailing red color is due to the presence of compounds of iron. This soil is best adapted to the growth of grains and small fruits, and is also well adapted to pasture lands. The trees under observation grew on an area on the east side of Mt. Sugar Loaf.

Variations in Spring and Fall Leaves.

TABLE I.

Species of leaves.	Date of collection.	% nitrogen (dry basis).	% P_2O_5 (dry basis).	% K_2O (dry basis).	Remarks.
Maple	9–20–13	2.126	1.031	1.014	Bottom portion of tree
Maple	9–20–13	2.110	1.123	1.193	Top portion of tree
Maple	5–22–14	3.201	0.9303	1.614	Bottom portion of tree
Maple	5–22–14	3.483	1.079	1.834	Top portion of tree
Chestnut	9–24–13	2.438	1.162	0.9917	Bottom portion of tree
Chestnut	6–1–14	2.959	1.024	1.450	Bottom portion of tree
Chestnut	9–24–13	2.106	0.9428	1.017	Top portion of tree
Chestnut	6–1–14	2.660	0.9530	1.747	Top portion of tree
Oak	9–26–13	2.475	0.9634	1.007	Bottom portion of tree
Oak	6–5–14	3.175	1.048	1.581	Bottom portion of tree
Oak	9–26–13	2.453	1.091	0.9687	Top portion of tree
Oak	6–5–14	3.460	0.9399	1.519	Top portion of tree

Summary of Table I.

The nitrogen content of the leaves removed in the spring from the chestnut, oak, and maple shows a marked increase over the results obtained from the leaves removed from the same trees the preceding fall. The higher amount in the spring leaves occurs in both portions of the tree, although the leaves taken from the upper part of the tree show a greater increase. Since the leaves at the top of the tree are subject to a greater loss of water by evaporation and are attached to a younger growth of wood than the leaves at the bottom of the tree, undoubtedly the demands upon the tree sap are much greater at the top, thereby resulting in the migration of a greater supply of mineral matter from the soil to the higher portions of the tree. The leaves of the maple show the greatest variations, while the chestnut leaves show the least increase in the spring leaves as compared with those of the fall.

The potash content shows the same characteristic variations as that of nitrogen, with the exception that the oak leaves show the least increase in the spring.

The phosphoric acid content does not show the same variations as that of nitrogen and potash, but seems to vary with the species of tree and also the section of the tree from which the leaves were obtained. The leaves removed from the maple, the lower portion of the chestnut and the top portion of the oak, have an increased phosphoric acid content in the fall leaves over those collected in the spring. The greater percentage content in the spring leaves collected from the top portion of the chestnut and the lower portion of the oak is so small that undoubtedly the spring leaves show a lower amount of phosphoric acid than the leaves of the preceding fall. The variations, however, are very small in all cases and the demands of the seeds and flowers of these trees for phosphoric acid probably causes, to a very great extent, these differences.

These results also indicate that a loss of mineral matter occurs with the advance of the season, regardless of the age of the tree.

Variations as Affected by Different Soil Types.

In view of the fact that various types of soil have an influence upon the composition of plants, leaves were removed from trees growing upon three typical Connecticut Valley soils already described. In Table II are the results of the analyses of the leaves of the maple, chestnut, and oak grown upon these three soil types.

TABLE II.

Species of leaves.	Soil type.	% nitrogen (dry basis).	% P_2O_5 (dry basis).	% K_2O (dry basis).	Remarks.
Maple	Suffield clay	1.379	0.4948	0.8555	Bottom portion of tree
Maple	Suffield clay	1.446	0.6305	0.8837	Top portion of tree
Maple	Holyoke stony loam	2.126	1.031	1.014	Bottom portion of tree
Maple	Holyoke stony loam	2.110	1.123	1.193	Top portion of tree
Maple	Wethersfield loam	1.907	..	0.7249	Bottom portion of tree
Maple	Wethersfield loam	1.420	1.056	1.007	Top portion of tree
Chestnut	Suffield clay	1.954	0.6992	1.489	Bottom portion of tree
Chestnut	Suffield clay	1.930	0.6852	1.221	Top portion of tree
Chestnut	Holyoke stony loam	2.438	1.162	0.9917	Bottom portion of tree
Chestnut	Holyoke stony loam	2.106	0.9428	1.017	Top portion of tree
Chestnut	Wethersfield loam	2.798	1.233	1.460	Bottom portion of tree
Chestnut	Wethersfield loam	2.991	1.405	1.343	Top portion of tree
Oak	Suffield clay	2.079	0.5182	1.022	Bottom portion of tree
Oak	Suffield clay	2.097	0.6479	1.325	Top portion of tree
Oak	Holyoke stony loam	2.475	0.9634	1.007	Bottom portion of tree
Oak	Holyoke stony loam	2.453	1.091	0.9687	Top portion of tree
Oak	Wethersfield loam	2.044	0.7295	1.182	Bottom portion of tree
Oak	Wethersfield loam	2.255	0.9389	1.280	Top portion of tree

From the above table it is evident that the highest content of nitrogen, phosphoric acid and potash in the case of the maple leaves occur in those collected from trees growing upon the Holyoke stony loam.

The same is true of the oak leaves except that the potash content was highest in the leaves taken from trees grown upon Wethersfield loam.

The leaves of the chestnut show their highest amount in those removed from trees growing upon Wethersfield loam.

The lowest amounts of nitrogen and phosphoric acid occur in the leaves of all three trees grown upon the Suffield clay. The potash content was lowest in the case of the maple leaves from the Wethersfield loam and with the chestnut and oak from trees grown upon Holyoke stony loam. A summary of the highest and lowest contents of these elements may be brought out clearer by a table. The legend as used by the United States Department of Agriculture, Bureau of Soils, will represent the soil types, and they are as follows: Suffield clay, Sc; Holyoke stony loam, Hs; and Wethersfield loam, Ts.

Variation in Nitrogen, Phosphoric Acid and Potash Content with the Soil Types.

TABLE III.

Species of leaves.	Highest am't of nitrogen.	Lowest am't of nitrogen.	Highest am't of P_2O_5.	Lowest am't of P_2O_5.	Highest am't of K_2O.	Lowest am't of K_2O.
Chestnut.....	Hs	Sc	Ts	Sc	Ts	Hs
Oak.........	Ts	Sc	Hs	Sc	Ts	Hs
Maple.......	Hs	Sc	Hs	Sc	Hs	Ts

Variations in the Composition of the Leaves Taken from the Upper and Lower Branches of the Maple, Chestnut and Oak Trees.

For the purpose of determining the effect of the relative distances of the leaves from the soil on their composition, leaves were removed from the upper and lower branches of the trees.

The highest content of nitrogen, phosphoric acid and potash in the respective leaves will be inserted under the appropriate heading with the legend of the soil type upon which the trees grew. For example, the highest content of nitrogen in the leaves removed from the maple tree growing upon Suffield clay occurred in those leaves taken from the upper branches. All results are upon leaves collected in the fall of the year.

Summary of Table IV.

The highest content of nitrogen, phosphoric acid and potash occurs in the leaves taken from the upper branches of the maple tree grown upon all three soil types, with one exception. The highest content of nitrogen in the maple leaves from the Holyoke stony loam occurs in those samples removed from the lower branches.

The leaves taken from the chestnut tree grown upon Suffield clay show their highest content of nitrogen, phosphoric acid and potash in the leaves removed from the lower branches. The nitrogen and phosphoric acid is highest in the leaves from the lower branches, while potash is the highest in the upper leaves on the chestnut tree grown upon Holyoke stony loam. The leaves removed from the upper branches of the chestnut tree grown upon the Wethersfield loam exhibit the highest content of nitrogen and phosphoric acid, while potash is highest in the lower leaves of the same tree.

TABLE IV.

Species of leaves.	Highest content of nitrogen in the leaves taken from		Highest content of P_2O_5 in leaves taken from		Highest content of K_2O in leaves taken from	
	upper branches.	lower branches.	upper.	lower.	upper.	lower.
Maple.......	Sc	...	Sc	...	Sc	...
Maple.......	...	Hs	Hs	...	Hs	...
Maple.......	Ts	...	...	...	Ts	...
Chestnut.....	...	Sc	...	Sc	...	Sc
Chestnut.....	...	Hs	...	Hs	Hs	...
Chestnut.....	Ts	...	Ts	...	...	Ts
Oak.........	Sc	...	Sc	...	Sc	...
Oak.........	...	Hs	Hs	...	...	Hs
Oak.........	Ts	...	Ts	...	Ts	...

The upper leaves in the case of the oak show the highest content of nitrogen, phosphoric acid and potash in those leaves removed from trees grown upon Suffield clay and Wethersfield loam. The nitrogen and potash are highest in the leaves removed from the lower branches of the oak tree growing upon the Holyoke stony loam, while the phosphoric acid shows the highest content in the upper leaves of the same tree.

The highest content of nitrogen, phosphoric acid and potash occurs in the majority of cases in the leaves removed from the upper branches of the tree. The exceptions may be due to rainfall, sunlight, temperature, flow of sap in tree, and physiological functions going on within the leaves at this time of the year when the fruit and seeds are maturing which results in a drain upon the constituents of the leaf.

Variations in the Composition of Leaves Removed from the Upper and Lower Branches of the Same Tree in the Fall and Spring of the Year.

In view of the fact that the time of the year may have an influence upon the composition of the leaves removed from the upper and lower branches of trees, analyses were undertaken to show such variations as may occur. In Table V the highest content of nitrogen, phosphoric acid and potash are indicated by inserting the soil legend (in this case Hs) in the proper column.

Summary of Table V.

The maple leaves collected from the same tree in the fall and spring show their highest content of nitrogen, phosphoric acid and potash when taken from the upper branches, with one exception, which is so small that it may be considered as due to some error in collecting or preparing that particular sample.

TABLE V.

Species of leaves.	Highest content of nitrogen in the leaves taken from the upper branches.	Highest content of nitrogen in the leaves taken from the lower branches.	Highest content of phosphoric acid in leaves taken from the upper branches.	Highest content of phosphoric acid in leaves taken from the lower branches.	Highest content of potash in the leaves taken from the upper branches.	Highest content of potash in the leaves taken from the lower branches.
Maple (Fall)	...	Hs[1]	Hs	...	Hs	...
Maple (Spring)	Hs	...	Hs	...	Hs	...
Chestnut (Fall)	...	Hs	...	Hs	Hs	...
Chestnut (Spring)	...	Hs	...	Hs	Hs	...
Oak (Fall)	...	Hs[1]	Hs	...	...	Hs
Oak (Spring)	Hs	...	Hs	...	...	Hs

The leaves of the lower branches of the chestnut tree show the highest content of nitrogen and phosphoric acid in both fall and spring, while the potash is highest in the leaves removed from the upper branches.

The lower leaves of the oak are highest in potash in both fall and spring, while phosphoric acid is highest in the upper leaves for both seasons of the year. In the case of nitrogen the fall leaves taken from the lower branches of the oak are highest in this constituent, while in the spring the leaves from the upper branches exhibit the highest amount of nitrogen.

These variations in the composition of the leaves from the upper and lower branches, especially in the case of the spring and fall leaves, may be due to a large extent to the relative amount of sap flowing from the roots to the other organs of the tree and also the return of matter from the assimilative organs to the branches, trunk and roots of the tree. O. M. Shedd,[2] in an investigation upon the mineral composition of sap in the sugar maple found that the composition of the sap varied considerably when collected at the same point on the tree during two successive years just after the sap flow had commenced.

In view of this fact, the variations which are noted in Tables IV and V may be influenced to a large extent by the upward sap flow in the spring and to a backflow of sap in the fall of the year. Another factor which may influence this variable composition is the demand of the fruit and seeds for these constituents for their proper development.

Estimation of the Value of Tree Leaves as a Fertilizer.

As the function of tree leaves is primarily the elaboration of crude inorganic materials taken from the air and soil into the various compounds

[1] The increased content of nitrogen in the lower leaves of the oak and maple collected in the fall over the content in the upper leaves is so small that the results may change as the various factors enter into the processes of the leaf.

[2] O. M. Shedd, "Variations in Mineral Composition of Sap, Leaves, and Stems of the Wild Grape Vine and Sugar-Maple Tree," *J. Agr. Res.*, 5, 529–542 (1915).

for the nutrition and support of the tree and its different organs, it is natural that these specific organs would contain much of the chief plant food materials. Their use as a source of organic matter and as plant food has long been recognized, and in the early agricultural history of Europe leaves and other forms of litter were used to a large extent for their fertilizer value. An early practice in Europe was the complete raking of all woodlands for the fallen leaves which were used on the farms as a manure. The practice became so extensive that the foresters in many of the large forests in Germany and Austria forbade the raking of their woodlands, because of the loss of this valuable material as a fertilizer for the trees grown upon the land. The foresters assigned the decreasing rate of growth of the forests to this constant raking by the farmers.

Some fifty years ago, here in New England many farmers gathered all the available leaves and used them as bedding for their animals and as an absorbent in barns, after which they were composted and then spread upon the farm. On many of the farms in the Connecticut Valley the same practice is still in use. Many of the leaves about the college grounds are gathered in the fall, used as bedding for horses, composted with other manures for a period of two years or so, and then applied to the soils in the greenhouses.

As the cost of labor for collecting and handling the leaves would be large, it would be inadvisable for the farmer to spend his time in this way. As an aid in promoting the growth of trees in woodlands, the leaves have a distinct value and should be allowed to remain where they fall.

The value of leaves as a source of organic matter can hardly be estimated by any cash value. The humus added to the soil in this way undoubtedly amounts to a great deal, and aids in the improvement of the physical condition of the soil, *i. e.*, improves texture, aeration, water holding capacity, and capillarity. This organic matter in all probability serves as favorable food for the various microörganisms in the soil, and as such should be considered as a valuable asset. It is probable, however, that the usual cost of collection and preparation would exceed their physical and chemical value.

There is one disadvantage in the use of freshly fallen leaves upon the soil, and that is the production of acid. Crops which are acid tolerant will not be injured by this condition. On the other hand, crops which require an alkaline or neutral soil will be adversely affected if a heavy application of freshly fallen leaves has been incorporated into the soil. All favorable microörganism action in the soil ceases upon soils with an excess of acid, and unless plenty of lime has been added to produce an alkaline condition, ammonification and nitrification does not take place. As an example of the acidity of freshly fallen leaves, the following table will show the amount in tons of ground limestone required per acre to neutralize a compact layer of leaves six inches in depth estimated to weigh when dry 500,000 pounds:

TABLE VI.[1]

Acidity of Freshly Fallen Leaves in Terms of Lime Requirement per Acre.

Species of leaves.	Acidity. Tons.	Species of leaves.	Acidity. Tons.
White oak	25	Sugar maple	22
Red oak	16	Tulip tree	14
Silver maple	22	Virginia pine	22

In other words, it requires 25 tons of ground limestone to neutralize 250 tons of freshly fallen leaves of the white oak tree. In view of this fact, it is advisable to accumulate the various leaves and compost the entire mass of organic matter. The leaves are allowed to decompose for various periods of time, and when they have reached the alkaline stage they may be used in hot-beds, greenhouses, or on the field. During the decomposition there is undoubtedly some of the fertilizing material lost by volatilization and leaching. This slight loss is offset to some extent by the favorable alkaline condition of the leaves and also by the large amount of alkali matter added to the soil.

The manurial value as estimated in this investigation will be somewhat higher than in the case of fallen leaves, because they were picked from the branches on the different trees shortly before the coloring and before the complete return to the trunk of the tree of a certain amount of the mineral matter. The manurial units were obtained by multiplying the per cent. of N by 2.5; the per cent. potash by 1; the per cent. phosphoric acid by 1; then adding the results. The commercial value[2] estimated upon raw material like leaves was 10 cents per pound for nitrogen, 4 cents per pound for potash, and 4 cents per pound for phosphoric acid.[3] The value per ton of leaves was then obtained by multiplying the manurial units by 4 cents and that result by 20. In order to draw a comparison, the analytical results following have all been reduced to the dry basis. The results are expressed upon leaves in dry condition and also on those with a 20% moisture content.

The values given are figured simply upon the basis of the chief fertilizer constituents in the leaves and no attempt has been made to deduct the cost of handling or to determine the availability of these substances. Further investigations will be undertaken to ascertain the availability.

Summary of Table VII.

The leaves of the chestnut show the highest cash value, $6.52 per ton for leaves taken from the top branches of the tree.

[1] Table taken from U. S. Dept. Agr., *Bull.* 6, by F. V. Coville.

[2] The commercial values were figured upon materials before the war and not upon the values now existing.

[3] Cash prices of materials obtained from Henri D. Haskins, in charge of Fertilizer Section, Massachusetts Agricultural Experiment Station.

TABLE VII.
Estimated Manurial Value of Leaves.

Species of leaves.	Time of collection.	Soil type.[1]	Height of leaves from top of soil.	% nitrogen (dry basis).	% P_2O_5 (dry basis).	% K_2O (dry basis).	Manurial units.	Estimated value per ton of dry matter.	Estimated value per ton on a 20% moisture basis.
Maple	9–16–13	Sc	15 ft.	1.379	0.4948	0.8555	4.79	$3.83	$3.06
Maple	9–16–13	Sc	45 ft.	1.446	0.6305	0.8837	5.11	4.09	3.27
Chestnut	9–16–13	Sc	10 ft.	1.954	0.6992	1.489	7.07	5.65	4.52
Chestnut	9–16–13	Sc	50 ft.	1.930	0.6852	1.221	6.72	5.37	4.29
Oak	9–13–13	Sc	12 ft.	2.079	0.5182	1.022	6.71	5.35	4.29
Oak	9–13–13	Sc	40 ft.	2.097	0.6479	1.325	7.19	5.74	4.59
Maple	9–20–13	Hs	8 ft.	2.126	1.031	1.014	7.34	5.87	4.69
Maple	9–20–13	Hs	50 ft.	2.110	1.123	1.193	7.59	6.07	4.85
Chestnut	9–24–13	Hs	10 ft.	2.438	1.162	0.9917	8.25	6.60	5.28
Chestnut	9–24–13	Hs	50 ft.	2.106	0.9428	1.017	7.21	5.76	4.60
Oak	9–26–13	Hs	5 ft.	2.475	0.9634	1.007	8.13	6.50	5.20
Oak	9–26–13	Hs	50 ft.	2.453	1.091	0.9687	8.18	6.54	5.23
Maple	9–28–13	Ts	8 ft.	1.907	..	0.7249	...	...	...
Maple	9–28–13	Ts	50 ft.	1.420	1.056	1.007	5.61	4.48	3.58
Chestnut	9–28–13	Ts	8 ft.	2.798	1.333	1.460	9.66	7.72	6.17
Chestnut	9–28–13	Ts	50 ft.	2.991	1.405	1.343	10.20	8.16	6.52
Oak	9–28–13	Ts	10 ft.	2.044	0.7295	1.182	7.01	5.60	4.48
Oak	9–28–13	Ts	40 ft.	2.255	0.9389	1.280	7.84	6.27	5.01
Maple	5–22–14	Hs	8 ft.	3.201	0.9303	1.614	10.54	8.43	6.74
Maple	5–22–14	Hs	50 ft.	3.483	1.079	1.834	11.61	9.28	7.40
Chestnut	6–1–14	Hs	10 ft.	2.959	1.024	1.450	9.87	7.89	6.31
Chestnut	6–1–14	Hs	50 ft.	2.660	0.9530	1.747	9.34	7.47	5.97
Oak	6–5–14	Hs	5 ft.	3.175	1.048	1.581	10.55	8.44	6.75
Oak	6–5–14	Hs	50 ft.	3.460	0.9399	1.519	11.11	8.88	7.10

The values for the spring leaves are much higher than the value of the fall leaves taken from the same tree. The results upon the spring leaves were obtained only for comparison.

Conclusions.

1. The leaves collected in the spring show a higher content of nitrogen and potash than those collected in the fall from the same trees.

2. The phosphoric acid content varies with the species of tree and also with the section of the tree from which the leaves were obtained.

3. The lowest amount of nitrogen and phosphoric acid occurred in those leaves collected from trees grown upon a clay soil. The highest content of nitrogen, phosphoric acid, and potash occurred in those leaves collected from trees grown upon the Holyoke stony loam and Wethersfield loam.

4. The leaves from the upper branches of the maple and oak have a higher content of nitrogen, phosphoric acid and potash in the majority of cases than those taken from the lower branches. In the case of the

[1] Soil types referred to are according to legend used by Bureau of Soils and are as follows: Sc, Suffield clay; Hs, Holyoke stony loam; Ts, Wethersfield loam.

chestnut the reverse appears to be true, the leaves from the lower branches having the larger amount of nitrogen, phosphoric acid and potash, with some exceptions, than those removed from the upper branches.

5. The estimated theoretical cash value of a ton of leaves calculated upon a 20% moisture basis varies from $3.00 to $6.50, depending upon the kind of leaves and upon what portion of the tree they were grown.

6. The cost of collecting and handling would probably be greater than the value of the leaves, thus making it inadvisable in most cases for farmers to spend their time in this way.

This investigation was undertaken at the suggestion of Dr. Ernest Anderson, and the author desires to express his thanks to Dr. Anderson for advice and encouragement during the work.

AMHERST, MASS.

NEW BOOKS.

A German-English Dictionary for Chemists. By AUSTIN M. PATTERSON, Ph.D., formerly Editor of "Chemical Abstracts." New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Limited, 1917. Pp. xvi + 316. Price, $2.00.

In the preface we read, "This book is not solely a dictionary of chemical terms. It includes words from related fields of science and, what is perhaps a novelty in a technical dictionary, a *general* vocabulary." This will appeal to most chemical students, whose knowledge of literary German is not apt to be large; they will appreciate not being obliged to use two dictionaries, one for technical terms and another for non-technical. By the aid of the excellent introduction they will be able to make their way, even though their knowledge of the language be meager.

No one is better equipped for preparing such a work than Dr. Patterson, with his wide experience in dealing with chemical literature, and it is sufficient to say that his work has been most thoroughly and skilfully done. The title is too modest, for while a glance at any page shows the chemical aim of the book, yet the student of physics, or mineralogy, or even of medicine, will find his needs well provided for.

Perhaps the most surprising feature is the completeness of the vocabulary of technical chemistry. After some little study the reviewer has failed to find a missing term. The book will thus be of especial value to the technical chemist, for unless his knowledge of German is exceptionally broad, he will only too frequently find in modern German technical literature an abundance of words, whose exact significance is unknown to him.

The convenient size (large pocket), clear type, good paper and flexible leather binding, further enhance the value of the book, which will be a useful addition to the library of every chemist. JAS. LEWIS HOWE.