The “Thin Wood” Method of Pruning Bearing Apple Trees
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SUMMARY

Review of available literature shows that pruning has long been a controversial subject. As little experimental work has been done with bearing apple trees, recommendations have been and are being made principally on the basis of observation and opinion rather than established fact.

In this investigation, it was found that:

In the average bearing tree, 49 per cent of the crop is produced by the "top," 36 per cent by the "outside," and 15 per cent by the "inside".

The predominating grades produced by the various divisions of the tree are as follows: top, U. S. Fancy; outside, U. S. No. 1; inside, U. S. Commercial.

The size of a given apple tends to be directly proportional to the diameter of the branch upon which it is borne.

The number of apples borne by a given branch tends to be directly proportional to the diameter of that branch.

The amount and shade or intensity of color present on the apples produced by a given branch tends to be directly proportional to the diameter of that branch.

More than 60 per cent of the total returns are derived from apples produced by the top, 33 per cent from apples produced by the outside, and 7 per cent from apples produced by the inside.

These related facts have been made the basis of a series of pruning trials which included conventional pruning methods, and they have resulted in the development of the "Thin Wood" method of pruning.

"Thin Wood" pruning consists in removing from the tree the "thin," relatively unproductive branches.

"Thin" wood has the following characteristics: (1) the four-year-old wood of these branches is less than two-eighths inches in diameter; (2) it makes comparatively short terminal growth; (3) it tends to grow in a downward direction; (4) most of it is found in the lower and inner part of the tree.

The amount and character of wood to be removed can be determined by observing the amount and distribution of inferior fruit produced.

"Thin Wood" pruning results in a substantial:

(1) Decrease in yield of inferior fruit, (2) increase in the average size of fruit, (3) improvement of the color grade, (4) increase in monetary returns. It: (5) requires less time and is less costly than the more conventional methods in common use, (6) makes spraying easier and more effective, (7) makes thinning easier and cheaper, (8) makes harvesting easier and less expensive, (9) reduces the sun scald hazard as compared to conventional methods, (10) results in fewer water sprouts and consequently less fire blight, (11) does not throw young trees out of beairng as may other methods, (12) is adapted to bearing trees of all ages, (13) makes several pickings less necessary, (14) minimizes frost hazards.

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INTRODUCTION

The growth and fruiting habits of bearing apple trees are probably influenced as much by pruning as by any other orchard practice. If the cost of doing the work is taken into account, as well as its influence upon the tree, it becomes apparent that pruning is one of the most important factors in successful orchard management. Mistaken pruning can cut orchard profits more rapidly than defective orchard practices of any other sort, with the possible exception of spraying. Tragically, the more industrious the ill-advised pruner, the more work he does and the more the profits suffer.

Despite its importance, there is probably no orchard practice concerning which there is, in the minds of both fruit growers and professional horticulturists, greater uncertainty as to just how to proceed. Presumably, this is because comparatively little experimental work has been done on the pruning of bearing trees. Recommendations have been based largely on observations and theoretical considerations. Not only have recommendations from different sources been conflicting, but often they have been stated in such indefinite terms that they were, and are, misinterpreted.

Furthermore, recommendations have been frequently changed and it is little wonder that fruit growers have become confused and suspicious of all pruning recommendations. There is a deceptive beguilement in tree response to pruning and in the vigorous growth and large fruits it produces, that obscures the real facts, and deceives experienced growers. Specifically, a grower might be cited who bemoaned his inability to prune more than half of his 20-acre block of 16-year-old McIntosh trees.

This grower found after harvest that the pruned trees yielded 2,512 bushels of which 98 per cent, or 2,462 bushels were of U. S. No. 1 grade or better. When packed, these were sold at an average price of $1.30. The total returns from the pruned block were $3,200.60.

The unpruned block yielded 4,220 bushels of which 90 per cent were of U. S. No. 1 grade or better. This fruit when packed was sold at an average price of $1.15. The total returns from the unpruned trees were $4,623.00.

The apples from the pruned trees were larger, of higher grade, and brought more per bushel. However, pruning had reduced the yield of the one block so materially that the total return from the pruned trees was $1,422.40 less than from an equal number of unpruned trees. When the cost of doing the work was taken into account, the direct loss to the grower exceeded $150 per acre.

There are hundreds of other growers who, because the vigor of trees appears to be improved by pruning or because of the actual improvement in grade, prune their orchards regularly with the firm conviction that their

trees are being benefited and their own profits increased. Doubtless, a careful check would, as in the case just cited, prove that the pruning done by many of these men is cutting off a large percentage of their best fruit.

There is an obvious need for a pruning method which will facilitate orchard operations and will increase size and color without at the same time reducing the yield of the better grades of fruit. Such a system has been devised and is here designated as the "Thin Wood" method of pruning. It is not only easier and less costly than methods now commonly employed, but substantially increases the monetary returns of those growers who adopt it.

For those who are interested in knowing about the origins of present pruning practices and ideas, the Review of Literature which follows is presented. Those who are interested only in the methods here recommended and the results obtained with these methods should turn at once to page 14.

REVIEW OF LITERATURE

Fruit trees have been cultivated almost since the dawn of history and there exists a considerable body of literature dealing with the cultural practices employed at different periods. Review of early writings leads to the conclusion that the pruning of apple trees for the purpose of influencing the amount and character of the fruit borne was not consciously practiced by the ancients. Pruning by the Romans was largely confined to the removal of dead wood and to the lopping-off of wayward branches; in some instances "dehorning" for the purpose of rejuvenation was employed.

European Writers—Pruning of apple trees does not appear to have been regarded as an important practice until comparatively recent times. Discussion of the subject did not take definite form until the introduction, early in the seventeenth century, of dwarfing stocks. Pruning as now understood may be said to have had its inception with the appearance, in 1652, of the book entitled "La Maniere de Cultiver les Arbres Fruitiers" (How to Grow Fruit Trees), reputedly by Le Gendre, a curate at Henouville, in Normandy.

Dwarfing stocks brought fruit trees into vogue as semi-ornamental adjuncts of the gentleman's garden. Careful examination of the available European literature indicates that for the most part, discussions of pruning concerned trees trained against walls and to forms otherwise very unlike those natural to them. These trees were prized not because of the amount of fruit borne, but rather on account of their ornamental value and because of the superior character of the few fruits which were produced. Though the horticultural writers of the time devoted considerable space to pruning, it is notable that throughout this period the chief advantages claimed for the methods employed were the appearance of the tree and the beauty, rather than the quantity, of fruit borne.

The emphasis which pruning received at this period can easily be explained by calling attention to the fact that, in order to keep the trees small and to train them to the unnatural forms in vogue, it was necessary to prune each

one with great care at frequent intervals. Some writers say that to obtain the best results it is necessary, during the active growing season, to remove wayward shoots from each tree two or three times a week. During certain seasons, under this system of management, the gardener often spent a considerable portion of his day in pruning. Although the gardeners of this period spent a great deal of time in the practice of the pruning art, they appear to have been well aware of the fact that the methods employed could not be used to advantage by commercial fruit growers. This is well illustrated by the writings of the English gardener, Meager, whose "English Gardener" was published in 1670. In discussing the pruning of standard trees, Meager[15] says,

> "Your best way is not to prune them much or often, if you love fruit more than a tree to thrive in wood, and therefore I would advise you whilst your tree is young, to endeavor to bring it into a handsome shape and order, and when it comes to bear fruit, forbear pruning, unless in case of broken, or such boughs as grow cross, and lye galling or fretting others; . . ."

He goes on to say,

> "Take notice, that many a good bearing tree, both apple and pear, have been much hindered by much and often pruning."

That other authors of that period thought as did Meager is made clear by the writings of the Frenchman, La Quintinie, who was so outstanding a man that he became "Chief Director of all the gardens of the French King". In introducing the subject of "Pruning of Fruit Trees" in his book "The Complete Gardener" La Quintinie[16] says,

> "The custom of pruning does not commonly extend to all forms of fruit trees, only to such as are known in gardens by the names Espaliers, or wall-Fruit-Trees . . . and Dwarfs. As for those that are called tall-standards, they are seldom prun'd unless it be once or twice in their first years, either to give them the first turn of a round figure . . . . or to take away some irregular branches which in progress of time might entangle or disfigure that head; . . . a kind of pruning is also practiced upon very old tall-standards by cutting off the dead or languishing branches both large and small; but this is rather called cleansing, or disincumbering than pruning."

Although "The Complete Gardener" contains some 39 chapters on the subject of pruning, the discussion is largely confined to dwarf-trees, and the directions for the "pruning of high-standards, or tall bodied trees" are contained in one short paragraph in which the author says,

> ". . . . I only desire, as I have said in the beginning of this treatis that they (tall-standards) should be touched once or twice in the beginning, that is in the three or four first years . . ."

The foregoing statements and similar discussions by contemporaries make it quite clear that the English and French gardeners were well aware of the limited application of their art, and both Meager and La Quintinie took particular pains to make this very clear.

American Writers Who Recommend the Methods Now Commonly Employed—American pioneers had little time for horticultural pursuits and it was not until the early part of the 19th century that fruit growing in America began to be seriously practiced and written about.

Most American horticultural writers who have discussed the subject of pruning fall naturally into two fairly distinct classes. One of these groups consists of those who believe pruning to be an indispensable orchard practice and have, generally speaking, recommended comparatively heavy pruning. The other group is made up of those who question the value of conventional methods and, generally speaking, recommend relatively little pruning. In order to make it easy for the reader to see to just what extent opinions have differed, the two groups of writers will be considered separately.

Attention will be given first to those who, generally speaking, recommend that, besides removing dead wood and low limbs, the bearing tree be thoroughly thinned out, especially in the top, so that the sunlight may reach all parts of the tree. Some of the advantages usually claimed for this type of pruning are (1) the grade of the fruit is improved, (2) production in the lower and inner portion of the tree is stimulated, (3) the tree is kept within bounds and the crops are easier to thin, spray, and harvest.

Robert Manning's "New England Fruit Book", which appeared in 1844, was one of the first works on horticulture to obtain a considerable circulation in America. Under the heading of *Pruning,* Manning[13] makes this statement,

> ". . . . The great principle to be attended to in pruning apple trees is cutting out all dead, diseased or useless branches, at their base, and thinning those that are healthy and vigorous so that the sun and air may penetrate to [not through], every part of the tree. Few people have confidence enough to do this effectively; but they may be assured that they would have more and better fruit were they to retain one-half the number of branches which, in general, at present exist in most orchards."

It is obvious that Manning favored rather heavy pruning and, though he was perhaps best known as a systematic pomologist, his writings no doubt greatly influenced the practices of fruit growers of his time.

J. J. Thomas[19], another of the early writers, makes it clear that he held views similar to those of Manning when he says,

> ". . . . The chief requisites to keep steadily in view, during the operation, are . . . to admit light equally into all parts of the tree by thinning out the branches . . . to do the work gradually, or in successive years, and commencing by preference at the top or center, which will favor an open top."

Patrick Barry[3] made it quite clear that he favored rather heavy pruning, when he wrote,

> "The idea that our bright American sun and clear atmosphere renders pruning an almost unnecessary operation, has not only been inculcated by horticultural writers, but has been acted upon in practice to such an extent, that more than two-thirds of all the bearing fruit trees in the country are at this moment either lean, misshaped skeletons, or the heads are perfect masses of wood, unable to yield more than one bushel in ten of fruit, well matured, colored and ripened."

Barry's "Fruit Garden" obtained a wide circulation, going through several editions, and many of the fruit growers of his time put his recommendations into practice.

Though many writers, both past and contemporary, have placed emphasis on the importance of considerable pruning, Bailey has probably been more widely read than any of the others. His "Principles of Fruit Growing" was extensively used as a textbook, and his "Pruning Book"[2] which appeared in 1898 was the first important American work devoted entirely to the subject of pruning. Not only has he been a prolific writer, but his books have

gone through many editions. When the recommendations of 20th century writers are compared with those of Bailey, it becomes apparent that his influence has been extended by contemporary authors as well as fruit growers. His position is made clear by such statements as ". . . I am convinced that pruning, even when somewhat heroic, is not a devitalizing practice . . . ." Under the heading of *Recommendations on Given Plants—Apple,* he states,

> "The apple tree is a vigorous plant and should be pruned every year . . . .When the general form of the top has been established, ... the subsequent pruning consists mainly in removing all superfluous branches in the center of the top, that is, those which run crosswise the top, which rub other limbs, or which tend to make the center portion of the top too thick . . . ."

Modern Pruning Bulletins—Prior to 1900, most horticultural writers expressed their ideas in periodicals or in books. Since that time, college and experiment station bulletins have become the most important sources of horticultural information. The number of bulletins on the subject of pruning alone is considerable, but it is unnecessary to review any considerable number of these. The task of reviewing modern pruning bulletins is made comparatively easy by the fact that the fundamental ideas upon which, with one or two notable exceptions, all are based, are essentially the same. A few examples, chosen more or less at random from the large number available, will make it clear that the recommendations of practically all of the professional horticulturists of our day who have given clear, understandable directions are similar to those made by Manning, Thomas, Bailey, and others who have advocated considerable pruning. It will be recalled that all of the early American writers so far cited have stressed the importance of "opening up the top".

Allison[1] made the following statement in 1918 regarding "Pruning Mature Apple Trees",

> "In pruning mature apple trees, it is well to keep in mind the conditions under which the greatest number of large, well colored fruits will be produced. When the top of the tree is opened up enough to admit sufficient sunlight to keep the central part of the tree in good, healthy growing condition, just as large and as well colored fruit will be found there as out on the very topmost branches. Keep this in mind while pruning, in order not to make the common mistake of cutting the short, crooked fruiting wood out of the tree."

The very title of Roberts'[18] bulletin, "Prune the Bearing Apple Tree", indicates that he believes that the practice is a very important one. In a paragraph entitled *Heading Back is Needed,* these statements appear,

> "Heading back is a greatly neglected pruning operation. While it seems desirable to the grower to reduce the height of the tree to aid spraying and harvesting, the fact that the best apples are borne in the top of over-tall trees generally causes the top to be left. As a matter of fact, good apples are borne all over the trees if the top is removed. With strong tops in the trees, the best growth is in the top; with the tops removed, good growth occurs throughout the trees."

Though many writers suggest that the top be "thinned", the fact that Roberts speaks of "removing" the top, indicates that in his opinion letting light into the tree for the purpose of promoting fruit production in the lower and inward portions is very important. The figures taken from photographs which accompany his written recommendations show clearly that the thinning out and heading back which he recommends is comparatively severe.

Burkholder and McCown[6] in 1929 made the following statements in a discussion relating to "Pruning the Top",

> "The best conditions for growth are in the top portion of mature trees. The first consideration in pruning such trees is to make sure that the tops are kept open and not allowed to grow too high."

In discussing the "Influence of Light on Fruit Spurs" the same authors say,

> "When the center and lower parts of the tree begin to show a lack of light, as shown by poor spur growth and lack of fruitfulness, a general thinning out of the center, top, and outer portions of the tree is needed."

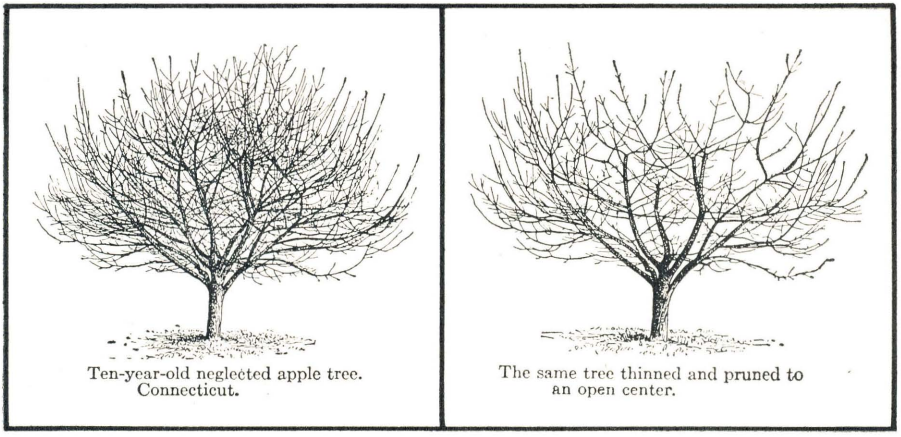
In the most recent edition (1934) of a well written bulletin on "Pruning Fruit Trees", Beach[4] states under the heading of *Fundamental Principles of Pruning,*

> "Light exposure is very important, as sunlight is the energy used by green leaves in the manufacture of food for growth. Sufficient branch spacing should be done by pruning to allow a relatively uniform distribution of sunlight on the leaves throughout the tree. The amount of branch spacing by pruning away large limbs and the amount of pruning by distributed small cuts should be coordinated to leave the tree well filled with sufficient fruiting wood."

Although only four of the older books and an equal number of modern bulletins have been cited, the quotations are characteristic of many more which are available, and these few make it clear that in many respects the recommendations of modern investigators are similar to those of some of the early American horticultural writers.

All of the writers so far quoted, from Manning in 1844 to Beach in 1934, have had something to say about thinning out the top so that light might reach and promote fruitfulness in the lower parts of the tree. A means of accomplishing this end is illustrated by the two figures* from Bailey's "Principles of Fruit Growing", which are here reproduced. In referring to these Bailey says:

"The illustrations show different commendable ideas in pruning."



Ten-year-old neglected apple tree. Connecticut.

The same tree thinned and pruned to an open center.

Fig. 1. "Commendable ideas in pruning" as illustrated by one of the writers who recommends the methods now commonly employed. These figures indicate what this particular author meant by "thinning out the top".

*Figs 80 and 81, L. H. Bailey, "Bailey's Principles of Fruit Growing". 20th Edition, 1915. Reproduced by Courtesy of the Macmillan Co.

Though other authors might not agree that trees should be pruned as shown in the accompanying illustrations, the words of the earlier writers and the figures found in most of the modern bulletins make it clear that most of them do recommend some form of "thinning out the top".

It cannot be denied that a rather severe thinning out of the branches of bearing apple trees, especially those in the top of the tree, will facilitate light penetration and result in the production of larger and better colored apples in the lower and inner part of the tree. The growth of the branches adjacent to those which are removed is stimulated and the percentage of high quality fruit is usually increased. When such men as Manning, Bailey, and a host of modern writers recommend pruning of this type, on the basis of such irrefutable facts, it may seem strange that anyone would question the recommendations. The fact remains, however, that a number of the early writers and at least a few of the modern ones have questioned the value of the methods advocated by these men. As some of the authors holding contrary views seem quite as able as those already quoted, it may be well to compare their ideas.

American Writers Who Question the Value of the Methods Now in Common Use—William Coxe[8] wrote in 1817 the first truly American work on fruit growing. In discussing the "Pruning of Orchards" he states,

> "There is no branch of the management of orchards less understood, or more unskillfully performed, than the operation of pruning: a belief of its necessity is so general, that even the most careless will seldom omit it—such, however, is the want of skill in many of the operators, that total neglect would be less prejudicial than their performance of it . . . Nothing has contributed more to the imperfect knowledge of this operation than the wordy and unintelligible systems which have been published respecting it . . . . Our great heat and dry atmosphere render close pruning less necessary here than in England, whence we derive most of our instructions on this point. A good general rule is never to shorten the branches unless to improve the figure of the tree . . . ."

The foregoing statement by Coxe makes it plain that in his opinion total neglect would in many cases have been preferable to the methods then commonly employed.

William Kenrick[12], another one of the early American writers, has this to say on the subject of pruning,

> "The complicated systems of the English for pruning the apple, pear, peach, and the plum are not in all respects so necessary for us; they are in fact adapted exclusively to a cold climate. It is not necessary with us to lay open and expose every part of the tree to the direct rays of the sun; the atmosphere being, in our climate, generally of itself sufficient to ripen the fruit."

It will be observed that his statement that, "It is not necessary . . . . to lay open and expose every part of the tree to the direct rays of the sun; . . . .", is diametrically opposed to the opinions of some of his contemporaries already quoted.

A. J. Downing was unquestionably one of the greatest horticulturists of his time. In speaking of his book, "Fruits and Fruit Trees of America", Barry later wrote,

> ". . . . It became at once the textbook of every man who sought for pomological information or felt interested in fruits or fruit trees; . . ."

In a discussion of pruning Downing[9] wrote,

> "Every fruit tree grown in the open orchard or garden as a common standard should be allowed to take its natural form, the whole effort of the pruner going no further than to take out all weak and crowded branches; those which are filling uselessly the interior of the tree where the leaves cannot be duly exposed to the light and sun, or those which interfere with the growth of others. All pruning of large branches in healthy trees should be avoided by examining them every season and taking out superfluous shoots while small."

Under the same heading he continued,

> "When pruning is not required to renovate the vigor of an enfeebled tree or to regulate its shape—in other words—in the case of a healthy tree which we wish to retain in a state of greatest luxuriance, health, and vigor, it may be considered worse than useless."

It should be remarked that though the writers of the group previously discussed recommend that the *top* be thinned out so that the light might reach the inner part of the tree, Downing recommends that we "take out all weak and crowding branches; those which are filling uselessly the *interior* of the tree where the leaves cannot be duly exposed to the light and the sun."

In the foregoing statement, Downing suggests a fundamentally different pruning system. Instead of thinning the top so that the light may reach the branches in the lower and inner part of the tree, he, in effect, recommends that the vigorous fruitful top be left and that the weak wood which uselessly fills the interior of the bearing tree be removed. Although this idea must seem radical to those who favor thinning out the tops, Downing's standing among horticulturists makes it worthy of serious consideration.

W. G. Waring[20] was another of the early writers who recommended that bearing trees be lightly pruned. In discussing "Pruning and Training", he states,

> "In Europe the greatest attention is given to this branch of culture, but in this sunnier climate we are fortunately exempt from the necessity of laboring through intricate rules, or even in the most cases from interfering at all with Nature."

It is notable that none of the writers cited up to this time have supported their statements by experimental evidence. The statements of those quoted so far have then been merely opinions. Their opinions were, no doubt, based on numerous observations, but observations are sometimes very misleading, and the opinions of very able men are sometimes proved erroneous. It is, in fact, obvious from the contrasting views so far expressed that at least one of the two groups must be in error.

In 1919, the Duke of Bedford and Spencer Pickering[5] reported the results of the first extensive experiments designed for the purpose of determining the value of different pruning methods. They report that "moderate" and "hard" pruning reduced the weight of apple trees as compared to trees receiving very little or no pruning in the following relative proportions:

None or very little pruning	120
Moderate pruning	100
Hard pruning	84

The reduction in size and weight which the pruning treatments caused was very considerable, and the authors make the following statement regarding the effect of pruning on growth,

> "That pruning encourages growth is, except under certain special conditions, one of the fallacies prevalent in horticulture, a fallacy which can readily be exposed . . ."

Pruning not only reduced the size and weight of the trees with which Bedford and Pickering worked, but it materially reduced the value of the crops borne. The relative values of the crops from trees receiving "no pruning", "moderate", and "hard pruning" were as follows:

Relative value of crops during 10-year period.

No pruning	158
Moderate pruning	100
Hard pruning	49

In discussing the results of their experiments, the investigators said,

> "The simple conclusion, therefore, is that pruning should be reduced so far as is consistent with the formation of a well shaped tree, carrying such a crop as it is likely to produce."

The results obtained in these carefully conducted experiments were so contrary to the opinions of most of the centemporary horticulturists that they refused to place much credence in the work. The fact that the workers who conducted these experiments were even criticized for publishing the results of the trials is made clear by the following statement by the authors:

> "When scientific investigation can be brought to bear on it [pruning], the teachings of the artists have not always been confirmed. Amongst the dreadful accusations brought against the Woburn Farm, one is that the work there has led to the recommendation that pruning should be abandoned."

The work of Bedford and Pickering is of peculiar interest not only because the results were so contrary to the opinions of most present day writers, but because they conducted the first extensive scientific pruning trials.

Not long after the publication of the results obtained at the Woburn experiment station, American horticulturists began to collect experimental evidence on the question of pruning, and in 1923 Chandler[7] published the results of some extensive pruning trials. Although his findings were obtained by means of experiments with comparatively young trees, they help to substantiate and in a measure explain the results obtained with older trees, and they are for this reason included in this report which has to do primarily with the performance of older trees.

In discussing the effect of pruning on the growth of the tree Chandler wrote,

> "It can be said with certainty that in young orchards any kind of pruning tends to be a dwarfing process."

When it came to the fruiting of young trees, he found that pruning reduced the total weight of the crops borne over a period of years as follows: apples, 28 per cent; pears, 38 per cent; plums, 20 per cent; cherries, 2 per cent. In discussing the thinning out of tops to let in light, Chandler said,

> "While leaving the heads rather dense reduced the percentage of well-colored fruit, yet because of the much larger yield there apparently was considerably more well-colored fruit than if much thinning-out had been done, and in addition much salable fruit of a lower grade."

In summarizing, this investigator said,

> "At least while the tree is young the pruning necessary to secure any form different from that to which the tree would naturally grow reduces both its growth and the amount of fruit that it will bear early in its life."
>
> "It seems wise to permit the tree to assume its natural form except where plainly injurious conditions such as weak crotches develop."

Chandler's work, which included trees up to 12 years of age, indicated that pruning dwarfs the young tree, materially reduces the amount of fruit borne, and that, for the most part, it seems wise to permit the tree to assume its natural form.

Although Kains[11] did not conduct any extensive apple pruning experiments the fact that he favored little if any pruning of the bearing apple tree is made clear by the following statement from his "Principle and Practice of Pruning",

> "From the time they [apple trees] come into bearing the pruner should expend his energy for sawing, hacking, and whittling upon some friendly wood pile, where he will do no harm to his fruit crop prospects and the well-being of his trees."

The opinions of the early American writers were pretty well divided between the advocates of what may be called the conventional method and those who believed that this type of cutting was detrimental. There is less evidence of such difference among the writers of recent pruning bulletins. Although there are a few exceptions such as the publication by Chandler referred to above, the authors of most publications of this type are either somewhat indefinite and contradictory or they recommend some form of conventional pruning, which usually consists of removing dead wood, low branches, and the thinning out of the entire tree with special emphasis on thinning out the top. Though many present day writers have mentioned the stunting and crop reducing effect of pruning, they have usually stated or implied either that these effects were to be expected only under special conditions or that they did not constitute sufficient grounds for adopting other methods.

It remained for Marshall[14] to obtain a considerable amount of experimental evidence on the question of the dollars and cents value of conventional pruning methods with mature apple trees, to correctly interpret the evidence, and to make recommendations on the basis of the data presented. He did this in spite of the fact that these recommendations were contrary to those being made by practically all of his contemporaries. Marshall found that:

> Conventional pruning reduced the yields of fertilized Ben Davis trees 26 per cent and the average annual net return per tree by $1.11.
>
> Conventional pruning reduced the yield of Baldwin trees 32 per cent and the average annual net return per tree by $3.77.
>
> Conventional pruning reduced the yield in another Baldwin orchard 36 per cent and the average annual net return per tree by $1.99.
>
> Conventional pruning reduced the average yield of Northern Spy trees by 39 per cent and the average annual net return per tree by $3.40.

Although Marshall concluded that because of certain secondary objectives, the pruning of a bearing apple orchard should not be entirely ignored, he says,

> "The data show, however, that it [pruning] is relatively ineffective in accomplishing what is generally regarded as its primary object and furthermore that this object is usually attained at the expense of reduced yields and reduced profits.

> "Annual, biennial, or even triannual pruning, however, is unnecessary for most bearing apple orchards and if practiced, may lead to decreased returns. Any pruning of old trees must be very light and must be done with the idea of removing dead and weak wood and possibly to facilitate or cheapen some orchard management operation. In other words, the pruning should be done with some one or more of the so-called secondary objects in view. A grower should not prune just because his neighbors are pruning. In general, don't prune the old apple tree unless there is dead or weak wood to remove or it is becoming expensive and difficult to manage."

In summarizing, he makes this statement,

> "Pruned trees of mature age that were in a moderately vigorous to vigorous condition produced fewer apples, smaller yields and lower net returns per tree or per acre than unpruned ones, and the differences were proportional to the severity of the pruning treatment."

This statement by Marshall is strikingly similar to the one made by Meager[15] more than 250 years before. Meager's statement reads,

> "Take notice that many a good tree, both apple and pear, have been much hindered by much and often pruning."

The results of Marshall's work were so contrary to popular and professional opinion that many of his contemporaries found it difficult to believe that his results were typical. A few have gone so far as to say that even though they were true, such information should never be made available to fruit growers.

Discussion of Literature—If the authors of pruning bulletins are included, the number of writers, both past and present, who have recommended conventional pruning far exceeds the number of those who have been skeptical of its value. However, the experimental evidence appears to be on the side of the skeptics, and the weight of this evidence is perhaps sufficient to balance the scales. Marshall's work has caused some observers to doubt the value of any pruning at all. It is certainly true that, since the publication of his findings, comparatively few pruning bulletins have appeared, and the recommendations contained in them appear to have been worded very guardedly. With the recent experimental evidence so contrary to both popular and professional opinion, it would seem that there now exists in the minds of writers considerable doubt as to the recommendations which should be made.

The situation regarding available pruning information at the present moment, 118 years after the appearance of the first American work on horticulture, might then be described in the identical words used by the author of that work. These words, the reader will recall, are,

> "There is no branch of the management of orchards less understood, or more unskillfully performed, than the operation of pruning."

STUDIES WHICH LED TO THE DEVELOPMENT OF THE "THIN WOOD" METHOD OF PRUNING

The Amount and Character of Fruit Borne in Different Parts of the Tree—It has long been known that differences exist in growth habits and in the general character and amount of fruit produced in different parts of the tree. It occurred to the writers that if the production habits of the several parts of the tree were carefully studied, it might be possible to devise pruning treatments better suited not only to these several parts, but to the tree as a whole.

With this purpose in mind each of a number of trees selected for the purpose was arbitrarily divided into three sections: "inside", "outside", and "top". The divisions were made in this way because it is in these sections that the most marked differences in the character of wood growth and fruit production were observed. Figure 2 shows diagrammatically just what, in this case, is meant by the terms inside, outside, and top.

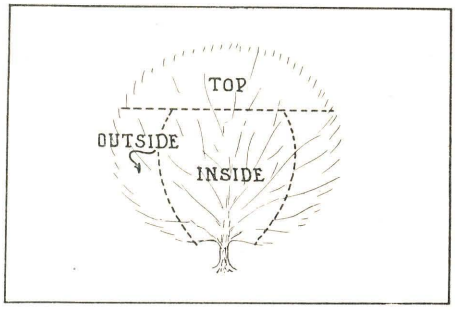


Fig. 2. The apple tree was divided, for purposes of study, into "inside," "outside," and "top". The character of the wood as well as the amount and grade of fruit produced by the different sections of the tree is very different.

In harvesting the fruit from the trees studied, the apples from each of the three sections were picked separately. After a given tree had been finished, a record of the amount of fruit from each division was made and half of the apples, selected at random from each section, were sorted on the basis of size into six grades. As the apples were sorted, a record of three color grades was also made. In practice, two or more trees, selected because of their representative character, were usually harvested at the same time, the fruit from the several trees being measured and sorted as one lot. This increased volume tended to eliminate errors in sampling as well as in measuring fractions of bushels. Table 1 showing the harvest records for the five Jonathan trees studied in Orchard 16 follows.

Table 1. Harvest record of five Jonathan trees picked by sections.

Division of tree	Bushels of respective size grades						Total bu.	Color grades expressed in per cent		
	Less than 2″	2″ to 2¼″	2¼″ to 2½″	2½″ to 2¾″	2¾″ to 3″	3″ or more		U. S. Fancy	U. S. No. 1	U. S. Com'l
Inside	2.75	*3.50*	2.50	1.50	.50	—	*10.75*	24	44	32
Outside	2.75	6.00	*10.25*	. 5	1.75	—	*28.00*	57	30	13
Top	1.25	9.00	*13.25*	*8.50*	3.25	1.00	*36.25*	92	6	2

In choosing trees for study, the authors were careful to select only those which were typical of the particular orchard in which they grew. The owners had in all cases practiced some form of conventional pruning, and, in most cases, a definite effort had been made to open up the top and the outside so that fruit of good quality would be borne throughout the tree. In most cases, records obtained in several different orchards were combined in compiling Tables for a given variety. Furthermore, records were obtained in each of the years 1932, 1933, and 1934. By including in this way data obtained in different years as well as those obtained from different orchards, the final result was a Table showing the harvest records of trees grown under different climatic as well as cultural conditions. Seven varieties of commercial importance were included in the studies. There is then, good reason to believe that Table 2, in which these data are summarized, is

Table 2. Harvest records of trees of 11 varieties picked by sections.

Variety	No. of trees	Division of tree	Bushels of respective size grades						Total bu.	Color grades expressed in per cent		
			Less than 2″	2″ to 2¼″	2¼″ to 2½″	2½″ to 2¾″	2¾″ to 3″	3″ or more		U. S. Fancy	U. S. No. 1	U. S. Com'l
Jonathan..	12	Inside	6.00	*8.00*	5.25	3.50	1.25	—	24.00	25	44	31
	12	Outside	5.75	15.00	*22.75*	16.00	4.00	—	63.50	59	29	12
	12	Top	2.75	19.75	*29.25*	*19.75*	7.50	2.00	81.00	93	5	2
Duchess..	11	Inside	.75	1.50	4.75	*10.75*	3.25	—	21.00	13	43	44
	11	Outside	.25	1.00	4.50	*22.50*	19.75	4.00	52.00	33	40	27
	11	Top	—	.75	4.00	22.75	*29.75*	6.75	64.00	40	35	25
Wealthy..	11	Inside	.75	2.75	*6.50*	*7.75*	4.75	.50	23.00	4	32	64
	11	Outside	.25	1.25	7.25	21.00	*25.75*	12.50	68.00	22	41	37
	11	Top	—	.75	5.50	26.25	*36.00*	*23.50*	92.00	43	40	17
Baldwin..	5	Inside	6.00	9.50	*17.25*	*26.50*	4.75	—	64.00	25	38	37
	5	Outside	1.25	5.00	26.50	*50.25*	13.00	—	96.00	47	38	15
	5	Top	—	1.25	17.25	*66.50*	*42.50*	6.50	134.00	73	22	5
Delicious..	5	Inside	1.75	*7.75*	4.75	.75	—	—	15.00	—	29	71
	5	Outside	—	.75	*13.50*	*15.00*	5.75	—	35.00	63	36	1
	5	Top	—	.25	10.00	*17.50*	*17.50*	—	45.25	78	21	1
McIntosh.	4	Inside	.75	3.25	*6.75*	3.25	—	—	14.00	7	32	61
	4	Outside	—	2.25	8.50	*11.50*	3.75	—	26.00	63	28	9
	4	Top	—	1.75	6.50	20.75	*27.00*	—	56.00	87	9	4
N. Spy...	3	Inside	.75	1.75	3.75	*5.00*	2.25	.50	14.00	11	35	54
	3	Outside	.25	.75	3.50	*9.25*	8.75	2.50	25.00	21	43	36
	3	Top	.25	.50	3.00	10.00	*16.00*	*14.25*	44.00	66	29	5
Steele Red	2	Inside	.50	2.00	*3.00*	.50	—	—	6.00	48	23	29
	2	Outside	—	.75	6.00	*6.25*	2.00	—	15.00	84	13	3
	2	Top	—	.75	5.75	*10.00*	4.25	1.25	22.00	94	5	1
Grimes...	25	Inside	6.50	*14.75*	*19.75*	7.25	.25	—	48.50	—	—	—
	25	Outside	3.00	22.00	*70.25*	44.00	4.00	—	143.25	—	—	—
	25	Top	3.50	22.25	*82.25*	*63.00*	11.25	—	182.25	—	—	—
W. Banana	4	Inside	1.50	2.00	*2.75*	2.75	1.00	—	10.00	—	—	—
	4	Outside	.25	2.50	7.50	*11.25*	9.50	6.00	37.00	—	—	—
	4	Top	—	2.00	5.75	12.25	*13.75*	7.25	41.00	—	—	—
Trans-parent.	2	Inside	*5.50*	.50	—	—	—	—	6.00	—	—	—
	2	Outside	*12.50*	6.75	.75	—	—	—	20.00	—	—	—
	2	Top	8.25	*12.50*	3.25	—	—	—	24.00	—	—	—
Totals all Varieties	84	Inside	30.75	53.75	*74.50*	68.00	17.50	1.00	*245.50*	14	37	49
	84	Outside	23.50	58.50	171.00	*207.00*	96.25	25.00	*580.75*	44	36	20
	84	Top	14.75	62.50	172.50	*268.75*	*205.50*	61.50	*785.50*	67	23	10

representative of conditions which at present exist in typical, well-cared-for Michigan orchards of standard varieties.

It will be observed that of the total bushels of fruit harvested from all trees, only about 15 per cent grew in the lower inside part of the tree. Approximately 36 per cent grew in the lower outside portion, while the top produced 49 per cent, or almost one-half of the total. Figure 3 shows diagrammatically these differences in productivity.

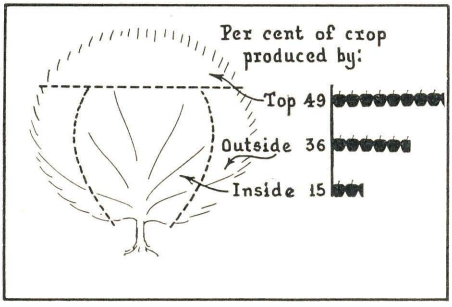


Fig. 3. Differences in the productivity of different sections of the tree are considerable. The top and outside are much more productive than the inside.

Only 35 per cent of the fruit produced in the inner portion of the tree was 2½-inch or more in diameter. The apples which grew on the outside were of medium size. Of those grown in the top of the tree, 68 per cent were 2½-inch or more in diameter. There was also a corresponding difference in the color of the fruit produced in the different sections. The combined effect of the size and color differences meant that the predominating grade of fruit produced in the top was U. S. Fancy. The predominating grade of that produced by the outside was U. S. No. 1, while most of that which came from the inside was U. S. Commercial grade, see Figure 4.

In the final analysis, it is the return in dollars and cents from a production unit which determines its value. In order to make it possible to express the value of the "inside", "outside", and "top" in these terms, the number of bushels of each grade, on the basis of size, was multiplied by the average net price of that grade as supplied by one of the cooperative fruit exchanges operating in the district in which the experimental work was conducted. The figures are shown in Table 3.

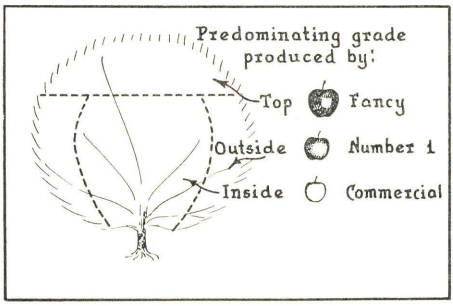


Fig. 4. The predominating grade of fruit produced by different sections of the tree. The grade of fruit produced by the top and outside is superior to that produced by the inside.

It will be observed that only 12 per cent of the total monetary returns from the trees studied came from apples grown on the "inside" of the trees, while 35 per cent of the returns were derived from fruit grown on the "outside" and 53 per cent from the sale of fruit grown in the "top". These theoretical returns were figured on the basis of size grades alone. In addition to being relatively small, the apples grown on the inside were of poor color. As a matter of fact, only 14 per cent of the fruit produced on the inside met the color requirements of the Fancy grade. On the other hand, 67 per cent of the apples grown in the tops were of Fancy color grade. The fruit exchange manager who supplied the price data said that had color been taken into account, as it would have been in making actual

Table 3. Monetary returns from different divisions of 84 trees, picked by sections.

Number of trees	Division of tree	Monetary return, figures on basis of apple size						Total returns
		Less than 2″	2″ to 2¼″	2¼″ to 2½″	2½″ to 2¾″	2¾″ to 3″	3″ or more	
84.....	Inside.....	$2.46	$12.36	$40.23	$46.92	$15.05	$1.01	*$118.03*
84.....	Outside.....	1.88	13.46	92.34	142.83	82.77	25.25	*358.53*
84.....	Top.....	1.18	14.38	93.15	185.44	176.73	62.11	*532.99*

sales, the monetary returns from the crops borne by the several parts of the tree would have been approximately those shown graphically in Figure 5.

These differences in the value of the three producing areas of the tree are so striking as at first to seem almost unbelievable, but the figures were verified not only by production records in a number of orchards, but in a few cases by actual sales. The differences in productivity are particularly striking when it is remembered that all of the trees had been pruned and that in most cases a definite effort had been made to improve the grade and increase the amount of fruit produced on the inside of the tree. The data indicate that efforts in this direction are rather futile.

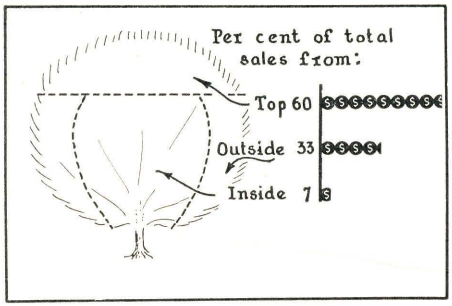


Fig. 5. Monetary returns from fruit borne by different sections of the tree. The fruit produced by the top is almost ten times as valuable as that produced by the inside.

Although a rather simple study, the facts brought out by the data just presented not only explain why currently practiced methods of pruning are so unsatisfactory, but they suggest a clue to better pruning methods. Conventional pruning, which has "thinned out" the top and outside of the trees in order that light might reach the inside, has removed a considerable portion of that part of the tree which accounts for over 90 per cent of the total monetary returns. This has been done in order that sunlight might reach a part of the tree which accounts for less than 10 per cent of the total monetary returns. Practically, this has amounted to discarding the best apples for the purpose of obtaining a limited improvement in the quantity and grade of the poorest apples. Pruning of this type is worse than useless.

If it were true, as some advocates of conventional pruning seem to believe, that thinning of the top and outside enables the inner portion of the tree to produce abundant crops of fancy fruit, the system would have some merit. This, however, is not the case. During the course of the experiment, the authors had an opportunity to observe the results obtained by conventional pruning of different degrees of severity. Though the grade of fruit produced was, in many cases, somewhat improved, any considerable improvement was invariably attended by material reductions not only in total yields but in the yields of the better grades. Figure 6 shows an extreme case in which very

heavy cutting had been done. The tops of the trees were, in fact, almost entirely removed. Improvement in grade was, in this case, attended by more than a 50 per cent reduction in the yield of marketable apples, and it was estimated that returns had been diminished by at least 40 per cent. Even after this extreme treatment, the apples which grew in the inner part of the tree, although of better grade than they would otherwise have been, were still inferior to those produced in what remained of the top and outside.

Fig. 6. Removing the tops for the purpose of improving the grade of fruit produced by the inside. Though this type of pruning improves the grade, it reduces the yield, and total returns are often diminished by as much as 50 per cent.

Branch Performance Studies—It occurred to the writers early in the investigation that very considerable differences might exist in the productiveness of the different types of wood which exist in bearing apple trees. With this thought in mind, the branch performance studies about to be described were undertaken. After considerable preliminary study, it was finally decided to classify the several types of branches on the basis of the diameter of the four-year-old wood. All fruit bearing branches were accordingly classified as follows:

"Thin" branches, whose four-year-old wood was less than 2/8-inch in diameter.

"Intermediate" branches, whose four-year-old wood was from 2/8-inch to 3/8-inch in diameter.

"Thick" branches, whose four-year-old wood was more than 3/8-inch in diameter.

In selecting material for study, a number of representative trees of a given variety were chosen in each of several orchards. At some time during the growing season, each of the marked trees was visited and from 12 to 24

branches, including an equal number of each class, were selected at random and tagged. By including a number of trees in each of several orchards, the investigators were assured of a representative sample for the season. To eliminate variations due to conditions existing in a given year, the work was repeated in each of the years 1932, 1933, and 1934. As eight standard varieties were included in the study, there is reason to believe that the material was truly representative.

The trees were visited at picking time and the apples from each of the previously marked branches harvested. As the fruit from each branch was picked, the size and color of each specimen was recorded, together with the total number of fruits and their aggregate weight in ounces. In addition to

Table 4. Performance of Wealthy branches less than 2/8 inch in diameter, 1933.

Branch No.	Number of apples in respective size groups						Number of apples per branch	Total weight in ounces	Number of apples in respective color grades			Age	Length in inches	Average annual growth in inches
	Less than 2″	2″ to 2¼″	2¼″ to 2½″	2½″ to 2¾″	2¾″ to 3″	More than 3″			U. S. Fancy	U.S.No.1	U.S.Com'l			
1	..	1	2	..	..	..	3	9	..	1	2	7	64	9.1
2	..	..	3	..	..	..	3	9	2	1	..	6	26	4.3
3	..	1	2	..	..	..	3	9	..	2	1	10	35	3.5
4	..	..	2	1	..	..	3	10	..	..	3	6	31	5.2
5	..	1	3	..	..	..	4	12	..	..	4	9	43	4.8
6	..	1	..	3	..	..	4	15	..	1	3	6	45	7.5
7	..	1	2	1	..	..	4	13	1	2	1	7	41	5.9
8	..	..	..	3	..	..	3	12	..	2	1	6	42	7.0
9	..	1	1	1	..	..	3	10	2	1	..	8	44	5.5
10	..	..	1	2	..	..	3	11	..	..	3	6	43	7.2
11	..	..	3	..	..	..	3	9	..	..	3	9	57	6.3
12	..	1	2	1	..	..	4	13	..	2	2	6	32	5.3
13	..	1	2	..	..	..	3	9	1	2	..	6	32	5.3
14	..	..	1	..	1	..	2	8	..	1	1	8	57	7.1
15	1	..	2	1	..	..	4	12	..	2	2	5	70	14.0
16	..	..	..	1	1	..	2	9	..	..	2	5	48	9.6
17	..	4	..	..	..	..	4	9	4	..	..	8	42	5.2
18	..	..	..	1	1	..	2	9	..	..	2	7	43	6.1
19	..	..	2	1	..	..	3	10	..	1	2	4	34	8.5
20	..	..	1	1	..	..	2	7	..	..	2	6	33	5.5
21	..	..	1	3	..	..	4	15	1	3	..	8	32	4.0
22	..	..	1	..	1	..	2	8	..	..	2	6	31	5.2
23	..	1	3	1	..	..	5	15	..	..	5	8	57	7.1
24	..	..	2	..	..	..	2	6	1	1	..	6	29	4.8
25	..	..	1	1	..	..	2	7	1	1	..	8	41	5.1
26	..	..	2	..	..	..	2	6	..	2	..	5	43	8.6
27	..	..	2	..	..	..	2	6	..	2	..	3	31	10.3
28	..	..	..	2	..	..	2	8	1	1	..	8	46	5.7
29	..	..	..	2	..	..	2	8	..	2	..	10	29	2.9
30	..	..	..	2	..	..	2	8	..	..	2	11	39	3.5
31	..	..	1	..	1	..	2	8	..	..	2	5	24	4.8
32	..	..	..	1	1	..	2	9	1	1	..	6	53	8.8
33	..	..	..	..	2	..	2	10	..	..	2	9	26	2.9
34	..	1	1	..	..	..	2	5	..	1	1	8	44	5.5
35	..	..	..	1	1	..	2	9	..	..	2	8	66	8.3
36	1	1	..	..	..	..	2	3	..	1	1	9	32	3.6
Mean	.05	.42	1.2	.83	.25	..	2.75	9.33	.42	.92	1.4	7.0	41.2	6.2
Per cent	2.0	15	44	30	9	..	..	..	15	33	52	..	..	..
Probable error	..	..	..	..	..	..	.10	.31	..	..	..	.20	1.32	.26

the information concerning the fruit, data were recorded showing the class, age, and length in inches of each branch. A typical set of records for Wealthy shoots of one size class obtained in 1933 is presented in Table 4.

The probable errors of the mean values indicate that this comparatively small sample was representative. However, data for Wealthy shoots obtained in this orchard in 1933 were supplemented by records made on 108 branches in another orchard the same year, by 258 branches located in three orchards in 1932, and on an additional 150 branches in 1934. Table 5 presents the mean values for Wealthy shoot records obtained in six different orchards, three of which were studied in 1932, two in 1933, and one in 1934. Comparable data for seven other varieties are summarized in Table 6.

Though, as would be expected, the records show considerable variation in performance from orchard to orchard and from year to year, they indicate in a general way marked uniformity within each of the size groups and striking differences between them.

The three significant facts brought out by these branch performance studies will now be stated and discussed.

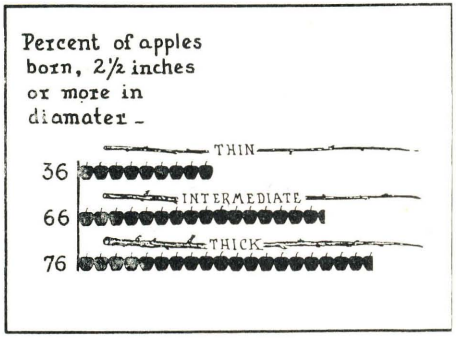


Fig. 7. A large percentage of the apples borne by thick branches are 2½ or more inches in diameter. The size of the fruit borne tends to be directly proportional to the diameter of the branch upon which it grows.

(1) *The size of the individual apples tends to be directly proportionate to the diameter of the branches upon which they are borne.* In other words, "thin" branches tend to bear small apples; "intermediate" branches tend to bear apples of medium size, while "thick" branches tend to bear large apples. For example, only 36 per cent of the apples borne on the "thin" branches were 2½-inch or more in diameter (Table 5). The performance of most branches of this diameter was obviously unsatisfactory. Sixty-six per cent of the apples produced by the "intermediate" branches were 2½-inch or more in diameter, while the corresponding percentage for the "thick" branches was 76 per cent. Figure 7 shows graphically the three types of wood and the average percentages of fruit borne which was 2½-inch or more in diameter.

Table 5. Performance records of Wealthy branches in six orchards.

Orchard No.	Year	Number of Branches	Diameter	Percentage distribution of apples in size groups						No. of apples per branch	Total weight in ounces	Per cent of apples in respective color grades			Age	Length in inches	Average annual growth in inches
				Less than 2″	2″ to 2¼″	2¼″ to 2½″	2½″ to 2¾″	2¾″ to 3″	More than 3″			U. S. Fancy	U. S. No. 1	U. S. Com'l			
7	1932	33	Less than 2/8″	14	18	28	31	9	—	3.3	10.5	17	35	48	3.9	22.4	5.7
16	1932	18		9	14	43	30	4	—	3.1	9.5	18	37	45	5.2	27.5	5.3
27	1932	35		11	21	35	17	12	4	3.9	13.1	19	41	40	2.9	18.9	6.5
18	1933	36		2	15	44	30	9	—	2.7	9.3	15	33	52	7.0	41.0	5.9
31	1933	36		9	19	40	28	4	—	3.4	10.0	17	32	51	10.9	37.7	3.5
20	1934	50		7	16	41	31	5	—	3.2	10.5	20	40	40	5.1	26.6	5.2
Total or average		208		8	17	39	28	7	1	*3.4*	*10.6*	18	37	45	5.9	29.4	*5.3*
7	1932	33	Between 2/8″ and 3/8″	6	11	31	40	10	2	7.6	27.3	20	49	31	3.4	31.7	9.3
16	1932	18		3	11	26	52	8	—	6.3	22.8	22	50	28	4.7	41.3	8.8
27	1932	35		6	23	33	23	10	5	7.3	24.4	26	52	22	2.9	29.1	10.0
18	1933	36		—	9	15	48	27	1	4.2	16.9	19	46	35	6.5	61.0	9.4
31	1933	36		—	5	17	38	35	5	4.2	19.7	14	31	55	7.6	63.4	8.3
20	1934	50		—	4	17	38	32	9	5.7	24.5	21	47	32	2.9	35.3	12.2
Total or average		208		2	10	22	39	23	4	*5.8*	*22.6*	20	46	34	4.6	43.5	*9.9*
7	1932	33	More than 3/8″	3	14	30	37	13	3	14.8	53.7	54	31	15	4.0	71.8	17.9
16	1932	18		3	17	31	35	13	1	10.5	37.1	48	33	19	5.2	77.8	15.0
27	1932	35		8	13	37	24	11	7	11.0	39.0	55	32	13	3.4	56.0	16.5
18	1933	36		—	—	6	36	45	13	8.2	39.4	59	29	12	4.8	75.0	15.6
31	1933	36		—	—	3	18	50	29	7.0	42.5	48	36	16	5.1	70.6	13.8
20	1934	50		—	1	5	24	47	23	11.7	59.1	45	37	18	5.1	72.3	14.2
Total or average		208		2	6	16	28	33	15	*10.6*	*46.7*	51	33	16	4.6	70.1	*15.4*

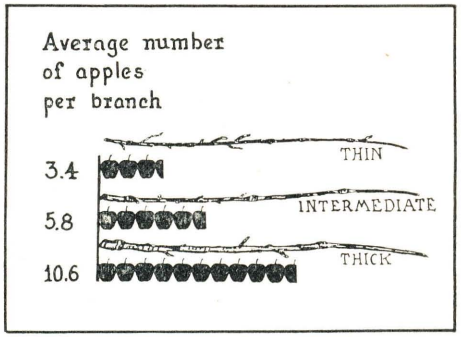


Fig. 8. The number of apples borne by a given branch depends to a considerable extent upon the diameter of that branch. Thick branches are, from the standpoint of number of apples borne, superior to those of smaller diameter.

(2) *The number of apples borne by a given branch tends to be directly proportional to its diameter.* That is, "thin" branches tend to bear few apples, "intermediate" branches tend to bear a moderate number, and "thick" branches tend to bear a comparatively large number of fruits. Thus, in the case of the Wealthy branches under consideration, those of small diameter bore, on the average, only 3.4 apples, those of intermediate diameter averaged 5.8 apples, and those of large diameter averaged 10.6 apples. These differences are shown graphically in Figure 8.

(3) *The amount and shade of color present on the apples produced by a given branch tends to be directly proportional to the diameter of that branch.* Thus, in the case of the Wealthy branches studied (Table 5), thin branches produced more apples of U. S. Commercial grade color than of U. S. Fancy or of U. S. No. 1 grade. Branches of intermediate diameter produced more apples of U. S. No. 1 color grade than of Fancy or Commercial grade, while the branches of large diameter produced fruit which was predominantly of Fancy color grade. This is brought out in Figure 9, showing graphically the three types of branches and the color of the apples most commonly produced by each.

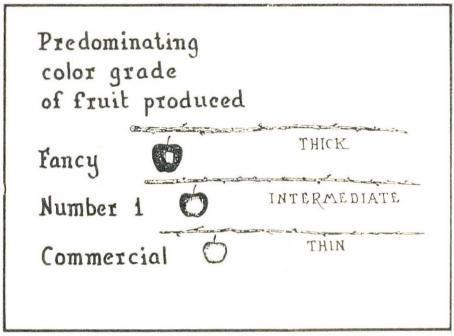


Fig. 9. The color of an apple depends upon the diameter of the branch upon which it is borne. Thick, vigorous branches produce apples of good color.

Photographs of typical "thin", "intermediate", and "thick" branches, each with its load of fruit (Figure 10), will enable the reader to visualize the combined effects of these differences existing in the character of fruit borne, as well as in the productivity of the three types of wood.

The differences in the amount and grade of fruit produced by branches of different types for the varieties included in this study are so great that it would probably be safe to say that, on the basis of fruit sales, the value of the average branch of large diameter is at least ten times that of a branch of the same age of small diameter. Branches of all types are commonly found on the same scaffold limb. Conventional methods call for the removal of a considerable number of the most vigorous branches. Only when it is realized that this has often meant the removal of several good apples for the sake of one poor one, does the full significance of these branch performance studies become apparent.

Incidentally, it may be pointed out that there is a marked difference in the character of growth made by branches of different diameter. One of the most obvious and easily measured differences is in length of terminal growth. In the case of the Wealthy branches studied, see Table 5, the "intermediate" branches grew almost twice as fast as did the "thin" ones and those of large diameter grew practically three times as fast. This characteristic is of importance because it affords a means of quick and positive identification of the different classes of wood.

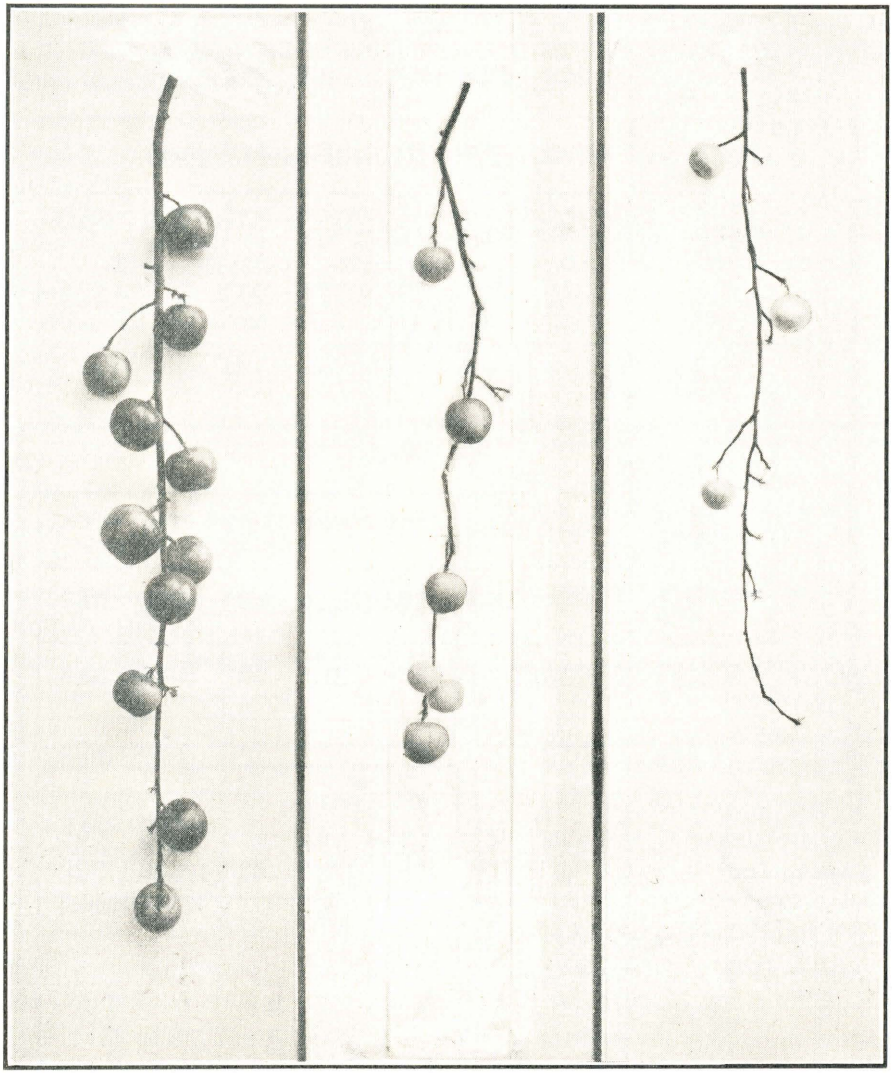


Fig. 10. The value of the average branch of large diameter is at least 10 times that of a "thin" branch. The fruit grower should, in pruning his trees, leave the thick, productive branches and remove only the thin, less productive ones.

Table 6. Branch performance records of seven standard varieties.

Number of branches studied	Diameter	Per cent of apples in respective size groups						No. of apples per branch	Total weight in ounces	Per cent of apples in respective color grades			Age	Length in inches	Average annual growth in inches
		Less than 2″	2″ to 2¼″	2¼″ to 2½″	2½″ to 2¾″	2¾″ to 3″	More than 3″			U. S. Fancy	U. S. No. 1	U. S. Com'l			
JONATHAN:															
104	2/8″ −	22	33	33	10	2	—	*4.1*	*12.6*	21	38	41	5.3	31.9	6.3
104	2-3/8″	6	34	40	17	3	—	*7.9*	*26.8*	61	19	20	4.5	59.8	14.3
104	3/8″ +	2	27	37	26	7	1	*12.1*	*41.7*	76	19	5	5.0	103.7	22.4
McINTOSH:															
64	2/8″ −	8	21	44	25	2	—	*3.4*	*10.5*	1	10	89	5.3	38.9	7.5
64	2-3/8″	—	5	38	40	15	2	*5.9*	*22.1*	9	16	75	4.2	54.2	12.8
64	3/8″ +	—	1	16	48	29	6	*10.3*	*44.1*	41	35	24	3.9	82.1	21.4
DUCHESS:															
57	2/8″ −	22	30	29	18	1	—	*3.2*	*8.6*	—	11	89	8.2	30.3	3.7
57	2-3/8″	7	10	26	45	12	—	*6.1*	*21.8*	5	36	59	7.3	49.3	6.8
57	3/8″ +	2	3	14	45	36	—	*9.3*	*41.9*	23	44	33	4.8	65.0	13.6
BALDWIN:															
51	2/8″ −	33	35	23	8	1	—	*3.9*	*8.9*	7	20	73	10.5	31.6	3.0
51	2-3/8″	5	17	38	35	4	1	*6.5*	*21.4*	18	22	60	7.2	49.7	6.9
51	3/8″ +	2	6	29	49	12	2	*12.0*	*46.1*	61	29	10	4.9	55.7	11.9
NORTHERN SPY:															
21	2/8″ −	8	47	35	9	1	—	*4.7*	*12.8*	8	24	68	8.2	40.4	4.9
21	2-3/8″	6	19	32	31	11	1	*7.9*	*26.9*	5	20	75	6.6	67.0	10.2
21	3/8″ +	—	1	12	40	37	10	*11.8*	*53.8*	42	31	27	5.3	92.0	17.4
GRIMES:															
115	2/8″ −	29	43	23	5	—	—	*3.7*	*8.5*	—	—	—	8.3	37.7	4.6
115	2-3/8″	9	34	46	11	—	—	*6.1*	*17.0*	—	—	—	7.7	58.2	7.6
115	3/8″ +	1	18	52	27	2	—	*11.8*	*35.9*	—	—	—	5.8	63.8	11.2
TRANSPARENT:															
70	2/8″ −	61	27	12	—	—	—	*3.0*	*4.3*	—	—	—	8.0	33.6	4.2
70	2-3/8″	39	32	26	3	—	—	*6.0*	*12.5*	—	—	—	7.5	55.7	7.6
70	3/8″ +	14	34	44	8	—	—	*10.8*	*28.6*	—	—	—	5.6	68.7	12.5

Comparable data for seven other varieties are summarized in Table 6.

Plainly, two inferences may be drawn from the data that have been presented: (1) if only the weak or "thin", unproductive wood is removed in pruning bearing apple trees, the reduction in total yield will be much less than that which follows the conventional type of pruning that removed relatively large amounts of thick, productive wood; (2) removal of the "thin" wood will mean that the average grade of fruit produced will be improved by eliminating in this way the smaller and poorer colored fruits. It seemed desirable to put to an experimental test these inferences or hypotheses. The method of pruning employed in this connection can be both designated and described by the term "Thin Wood" pruning.

Before presenting the results obtained from such pruning treatments, it seems desirable to explain in some detail the method developed.

THE "THIN WOOD" METHOD OF PRUNING

Reduced to its simplest terms, "Thin Wood" pruning consists in removing from the tree the "thin" or slender, relatively unproductive branches. The four most outstanding characteristics of thin wood are illustrated in Figure 11.

Although the same results may be accomplished in any one of several different ways, the authors usually divide the work of pruning a given tree by the "Thin Wood" method into three steps.

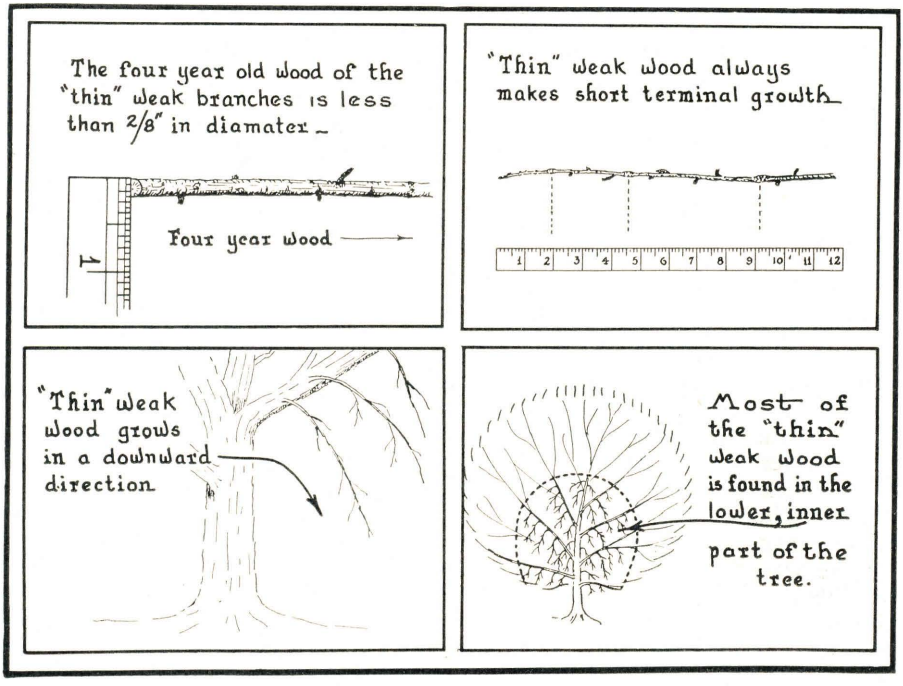


Fig. 11. The outstanding characteristics of "thin" wood. The illustrated characteristics make the identification of "thin" wood easy.

The First Step—There is in almost every bearing tree which has not been previously pruned by the "Thin Wood" method a number of comparatively large limbs which give rise to a number of smaller branches, practically all of which are of the "thin" wood type. Though some of these branches may grow more or less upright, most of them are usually found growing in a horizontal or even downward direction. The weight of a crop of fruit pulls the extremities of such branches toward or even to the ground where the fruit may be damaged. As a first step the large branches, most of whose laterals fall into this class, are removed. This is done with a saw. The first cut is made at the most convenient point, after which the worker proceeds around the tree, making all the necessary cuts of this type. The removal of these branches makes the subsequent work easier. Sketches showing the tree in cross section before and after the saw cuts have been made will help the reader better to visualize the first step.

Fig. 12. The tree in cross section before and after the first step. In this step large branches, all or most of whose laterals fall into the "thin" wood class, are removed with a saw.

The Second Step—After having made the saw cuts just described, the writers prefer to discard the saw and do the work which remains with lopping shears, though some may prefer to use hand shears or to continue with a saw. With the lopping shears, the worker moves once more around the trunk of the tree, this time removing the "thin" wood which still remains in the lower center. Sketches showing the tree before and after the ground lopper work are shown in Figure 13.

The Third Step—Most of the work is done in what is here described as the first and second steps, and in the case of younger trees it only remains for the worker to step up on the lower branches of the tree and remove any "thin" wood which could not be reached from the ground. In the case of older and larger trees, some climbing and the use of a ladder may be necessary. When the "thin" wood has been removed from the upper, interior part of the tree, the job is finished. Sketches of the tree before and after the "third step" are shown in Figure 14 and will enable the reader to visualize how the completed tree looks in cross section.

Fig. 13. The tree in cross section before and after the second step. In this step the "thin" wood is removed from the lower and inner part of the tree.

Photographs of a typical 22-year-old Northern Spy tree before and after pruning by the "Thin Wood" method are reproduced in Figure 15.

Although it is not essential in pruning a tree to follow the exact procedure just described, it is important to have and to follow some system. The writers have often observed that when the conventional method is employed, workers often walk around the tree a number of times before the job is completed. When a systematic "Thin Wood" method is employed, much time is saved by going over the tree once and then proceeding to the next tree. Of course, dead or broken branches are removed whenever encountered during the progress of the work.

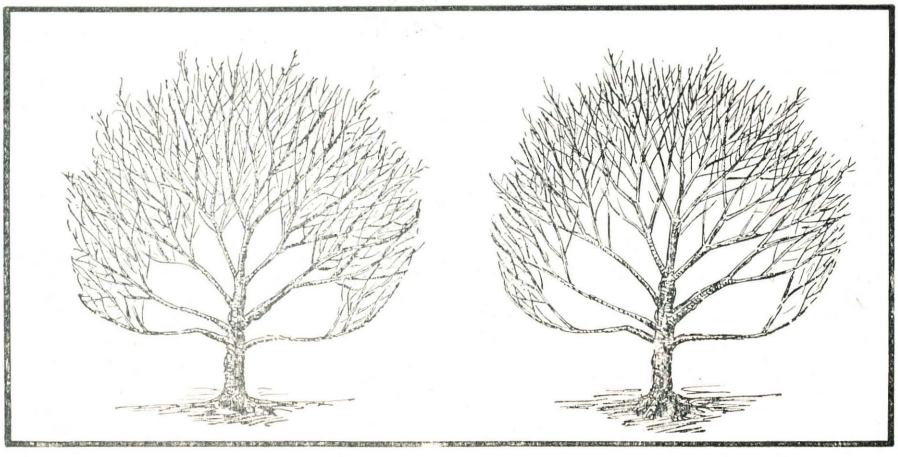


Fig. 14. The tree in cross section before and after the third step. In this step "thin" wood which could not be reached from the ground is removed.

Fig. 15. A typical 22-year-old Northern Spy tree before and after pruning by the "Thin Wood" method. Although the branches around the outside of the tree make it difficult to see just what wood was removed from the inside, a study of Figures 12, 13, and 14 will help the reader to visualize just what was done to this tree.

How to Check the Work—The "Thin Wood" method of pruning, although simple, is so different from the conventional one that the grower may wish to check his work when he first begins to employ it. Although he will have little difficulty in identifying the weakest wood, he may find it somewhat puzzling to decide just how far to go in the matter of removing wood of the intermediate type.

The grower who wants to decide ahead of time on the wood to be removed should go over his trees just before the preceding harvest. He will see, more especially in the lower part of the tree, a number of small, green apples. The wood upon which these apples are growing is that which should be removed during the following dormant season. If the grower is not sure, he can bear in mind the characteristics of the wood to be removed, he should "summer prune" at least one tree at harvest time. With the apples to guide him, and by noting carefully the wood removed and the appearance of the pruned tree, he can hardly fail to do an excellent job. This tree may then be used as a guide when the dormant season pruning is done. Trees which have received "Thin Wood" pruning during the domant season should be observed carefully just before the succeeding harvest. The worker can, in this way, identify weak branches which may have been missed by simply noting those branches upon which small, poorly-colored apples are growing. Mistakes made the first year may be readily corrected when the trees are next gone over.

Though relation of the following observations and experience possibly more properly belongs later in this account, it is placed here because it bears rather directly on the question of identifying wood to be removed in "Thin Wood" pruning. The writers have found that the late "summer pruning" of a typical tree by the conventional method and one by the "Thin Wood" method is an excellent way in which to convince even the most skeptical critic of the superiority of the latter system. In one such trial, the writers marked with white string, during the dormant season, the branches which, according to the "Thin Wood" system, they believed should be removed. A skeptical grower marked with red string those branches which, according to the ordinary method, he believed should be removed. Just before harvest the writers actually removed those branches which they had previously marked. From these limbs were picked slightly more than two bushels of small, poorly-colored apples. When the grower saw the quality and quantity of fruit growing on the branches he had marked for removal, he decided not to make the cuts. The apples growing on these limbs were, however, picked and graded separately. When the grower found that by making the contemplated cuts he would have, in effect, cut off more than six bushels of apples, most of which were of large size and good color, he became thoroughly "sold" on the "Thin Wood" method. The two crates of apples actually removed by the "Thin Wood" method, the six crates picked from the branches which would have been removed had the conventional method been used, and the small pile picked from those branches which would have been removed regardless of the method used are shown in Figure 16. The size of this third pile indicates that in the matter of wood removed there is little overlapping of the two methods.

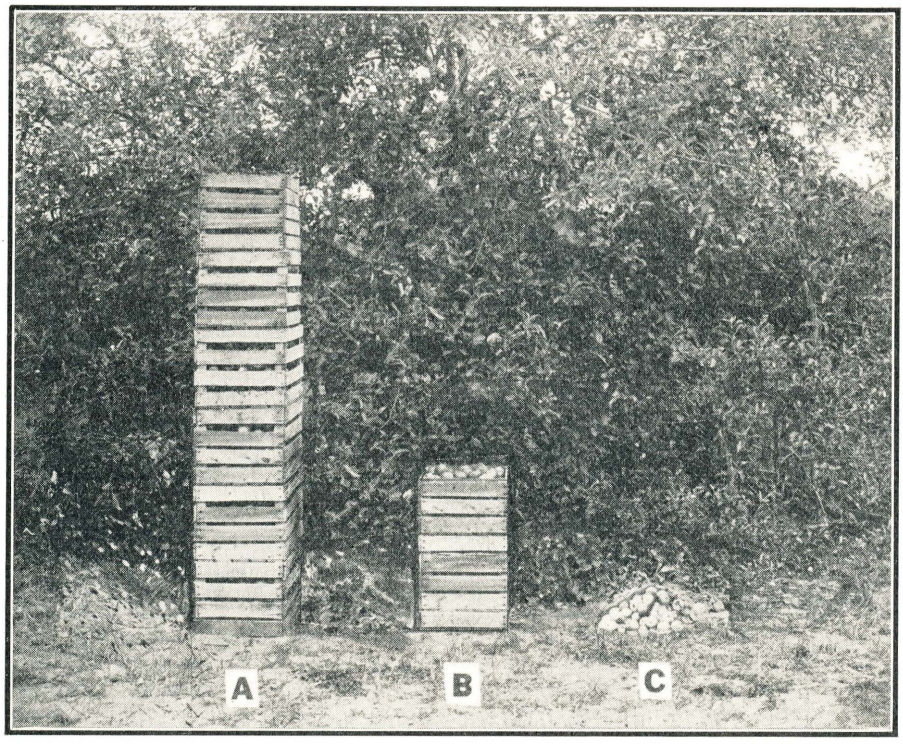


Fig. 16. Fruit harvested from branches marked for removal by the conventional, and by the "Thin Wood" method of pruning. The six crates of apples (A) were harvested from branches marked for removal by the conventional method. The two crates (B) were picked from branches marked for removal by the "Thin Wood" method. The small pile (C) was harvested from branches marked by both methods.

DETERMINING THE VALUE OF THE "THIN WOOD" METHOD OF PRUNING

Field Plot Technique—In selecting the trees for the pruning trials about to be described, every effort was made to secure trees which were truly representative of Michigan conditions. Their ages varied between 13 and 43 years. Soil borings were made in each orchard under consideration and in making final selections orchards were included growing on all the principal soil types devoted to fruit growing in Michigan. Only trees that needed pruning were employed. All trees which recently had been subjected to severe or unusual pruning treatments were eliminated. Most of the trees finally chosen had received no pruning during the two years preceding the time when the trials were commenced, and none had received more than relatively light conventional pruning for a number of years. Having found a reasonably uniform block of trees which were suitable with respect to present condition and previous treatment, individual trees were selected from the standpoint of uniformity in respect to soil, site, and freedom from disease and injuries of various kinds. Trees which did not have both an

ample number and good distribution of fruit buds were also eliminated. They were then scored on the basis of trunk circumference, height, spread, and the average treminal growth. When possible, a record of the yields produced in former years was obtained from growers. Different pruning treatments were applied to adjacent trees having approximately the same score.

Treatments—The treatments included "Thin Wood" pruning, light conventional pruning (in most orchards), and trees which received no pruning.

Harvest Records—A record was made of the total number of bushels harvested from each tree. One-half of the apples selected at random were then sorted into six size grades and the number of bushels of each grade recorded. As the fruit was sorted, a record was made of the color grade of each specimen. In practice, all of the trees in a particular orchard having received a given treatment were usually gone over at the same time. In this way errors in sampling and in the measurements of fractions of bushels were largely eliminated.

RESULTS OBTAINED BY THE "THIN WOOD" METHOD OF PRUNING

Yield data obtained in 1934 from 40 Jonathan trees in four different orchards and pruned in different ways are presented in Table 7.

Though the results obtained in a single orchard could hardly be regarded as conclusive, there is reason to believe that the totals for the four orchards are truly representative. Similar data for six other varieties are summarized in Table 8, and the combined data for all seven varieties are presented in Table 9.

Table 7. How conventional and "Thin Wood" pruning affected the yield and grade of fruit borne by Jonathan trees in four orchards in 1934.

Orch-No.	Treatment*	No. of trees	Bushels of respective size grades						Bu. less than 2¼"	Bu. 2¼" or more	Total bu.
			Less than 2"	2" to 2¼"	2¼" to 2½"	2½" to 2¾"	2¾" to 3"	More than 3"			
16.....	Conv..	5	1.50	10.00	37.25	47.00	8.75	2.25	11.50	95.25	106.75
16.....	No. P.	5	1.75	15.00	56.50	45.25	8.75	—	16.75	110.50	127.25
16.....	T.W.P.	5	—	4.75	40.25	55.00	14.00	2.25	4.75	111.50	116.25
23.....	Conv..	5	.25	2.00	22.25	35.00	9.25	1.25	2.25	67.75	70.00
23.....	No. P.	5	1.00	12.25	55.25	36.00	.75	—	13.25	92.00	105.25
23.....	T.W.P.	5	.50	5.25	51.25	43.25	1.75	—	5.75	96.25	102.00
31.....	No. P.	3	.25	5.00	34.25	34.00	7.75	—	5.25	76.00	81.25
31.....	T.W.P.	3	—	1.50	16.75	39.50	16.75	4.00	1.50	77.00	78.50
19.....	No. P.	2	.50	5.75	19.00	14.75	2.25	—	6.25	36.00	42.25
19.....	T.W.P.	2	.25	3.00	16.75	21.00	1.25	—	3.25	39.00	42.25
Totals..	Conv..	10†	2.62	18.00	89.25	123.00	27.00	5.25	20.62	*244.50*	265.12
	No. P.	15	3.50	38.00	165.00	130.00	19.50	—	41.50	*314.50*	356.00
	T.W.P.	15	.75	14.50	125.00	158.75	33.75	6.25	15.25	*323.75*	339.00

*Under the heading "Treatment", Conv. refers to trees which received conventional pruning; No P. to unpruned trees; and T.W.P. to those pruned by the "Thin Wood" method.

†Weighted so as to compare with the 15 trees which received the other treatments.

Table 8. How "Thin Wood" pruning affected the yield and grade of fruit borne by Grimes, Transparent and Duchess in 1933, and McIntosh, Rome Beauty and Winter Banana in 1934.

Variety	Treatment*	No. of trees	Bushels of respective size grades						Bu. less than 2¼"	Bu. 2¼" or more	Total bu.
			Less than 2"	2" to 2¼"	2¼" to 2½"	2½" to 2¾"	2¾" to 3"	More than 3"			
Grimes	Reg.	10†	6.37	27.75	90.00	85.87	18.37	—	34.12	194.25	228.37
	No P.	15	10.25	41.00	108.00	78.25	5.50	—	51.25	191.75	243.00
	T.W.P.	15	3.00	22.00	86.50	97.00	33.25	—	25.00	216.75	241.75
McIntosh	No P.	5	1.75	12.25	47.50	65.75	22.00	—	14.00	135.25	149.25
	T.W.P.	5	.25	.75	10.50	54.00	62.50	19.00	1.00	146.00	147.00
Transparent	No P.	2	5.75	16.00	17.00	3.50	—	—	21.75	20.50	42.25
	T.W.P.	2	2.75	12.50	17.25	7.50	—	—	15.25	24.75	40.00
Duchess	No P.	3	1.50	1.50	4.25	15.25	18.25	4.50	3.00	42.25	45.25
	T.W.P.	3	.50	.75	3.50	15.75	19.25	5.50	1.25	44.00	45.25
Rome Beauty	No P.	5	5.50	13.50	22.50	21.00	5.00	—	19.00	48.50	67.50
	T.W.P.	5	3.75	10.50	21.75	21.25	7.00	—	14.25	50.00	64.25
Winter Banana	No P.	1	.75	4.50	8.00	3.25	.75	—	5.25	12.00	17.25
	T.W.P.	1	—	.50	2.50	7.50	4.00	.75	.50	14.75	15.25

*Under the heading "Treatment", Conv. refers to trees which received conventional pruning; No P. to unpruned trees; and T.W.P. to those pruned by the "Thin Wood" method.
†Weighted so as to compare with the 15 trees which received the other treatments.

Table 9. A comparison of the yield and grade of fruit produced by trees having received conventional, "Thin Wood," and no pruning.

Treatment*	No. of trees	Bushels of respective size grades						Bu. less than 2¼"	Bu. 2¼" or more	Total bu.
		Less than 2"	2" to 2¼"	2¼" to 2½"	2½" to 2¾"	2¾" to 3"	More than 3"			
Conv.	20†	13.75	70.25	274.75	320.25	69.50	8.25	84.00	*672.75*	756.75
No P.	46	29.00	126.75	372.25	317.00	71.00	4.50	155.75	*764.75*	920.50
T.W.P.	46	11.00	61.50	267.00	361.75	159.75	31.50	72.50	*820.00*	892.50

*Under the heading "Treatment" Conv. refers to trees which received conventional pruning; No P. to unpruned trees; and T.W.P. to those pruned by the "Thin Wood" method.
†Weighted so as to compare with the 46 trees which received the other treatments.

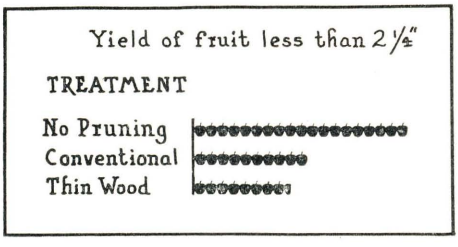


Fig. 17. "Thin Wood" pruning materially reduces the number of small apples produced. Unpruned trees produce almost twice as many small apples as do those pruned by the "Thin Wood" method.

"Thin Wood" Pruning Materially Reduces the Yield of Small Apples—The data presented in Tables 8 and 9 clearly show that "Thin Wood" pruning reduces by about a half the small, unsalable apples (less than 2¼ inches in diameter), as compared with no pruning, and that it effects a substantially greater reduction in apples of this type than is brought about by moderate or light pruning of the conventional type. This is well brought out in Figure 17.

For convenience, that part of Table 9 which deals with apples less than 2¼ inches in diameter is here reproduced.

Treatment	Bushels of fruit in respective size grades		Total bushels less than 2¼"
	Less than 2"	2" to 2¼"	
No pruning	29.00	126.75	*155.75*
Conventional	13.75	70.25	*84.00*
"Thin Wood"	11.00	61.50	*72.50*

In view of the fact that studies by Gaston[10] show that in Michigan, (1) 43 per cent of total crop from the commercial orchards of the state fail to meet the requirements for the Michigan "A" grade, (2) that 15 per cent grade out as culls, (3) that a third of the culling is done because of failure to meet the size specifications of the "A" and the "B" grades, respectively, (4) that the "B" grade seldom nets the growers a profit, and (5) that the cull grade is produced and handled at an actual loss, the importance of reducing the quantity of small-sized fruits becomes apparent.

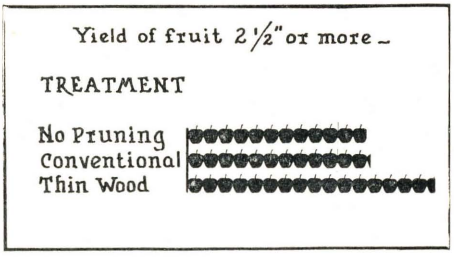


Fig. 18. "Thin Wood" pruning results in the production of larger apples. The grower who wishes to produce more large apples should use the "Thin Wood" method of pruning.

"Thin Wood" Pruning Materially Increases the Yield of Fancy Fruit—More important, however, than the reduction of the quantity of small fruits by "Thin Wood" pruning is its effect in increasing the quantity of large fruits. This influence is brought out clearly in Tables 8 and 9 and is shown graphically in Figure 18.

For convenience, that part of Table 9 dealing with apples 2½ inches or more in diameter is here reproduced.

Treatment	Bushels of fruit in respective size grades			Total bushels more than 2½"
	2½" to 2¾"	2¾" to 3"	3" or more	
No pruning	317.00	71.00	4.50	*392.50*
Conventional	320.25	69.50	8.25	*398.00*
"Thin Wood"	361.75	159.75	31.50	*553.00*

Evidently, the removal of the "thin" wood and of that which otherwise would have matured into small, unsalable apples materially increases the capacity of the tree to develop into still larger specimens the fruits that

remain. Though this is an influence comparable to that produced by fruit thinning, it must not be regarded as a substitute for that practice.

It may be well to remark at this point that, judged on the basis of thinning experiments, the amount of potential fruit removed by "Thin Wood" pruning is hardly sufficient to account for the increase in the amount and size of that which remains. It, therefore, seems likely that there is another contributing factor. Though the authors have no experimental evidence on the point, one plausible explanation is that the so-called "thin" wood consumes in respiration and manufacture of wood, more carbohydrates than it manufactures and might, therefore, be said to be parasitic on the tree. This does not seem unreasonable when it is remembered that thin, weak branches are equipped with small and comparatively light-colored leaves, and that the total number is relatively small. Though at the present time only conjecture, this hypothesis seems reasonable and would, if true, help to explain the superior performance of trees pruned by the "Thin Wood" method.

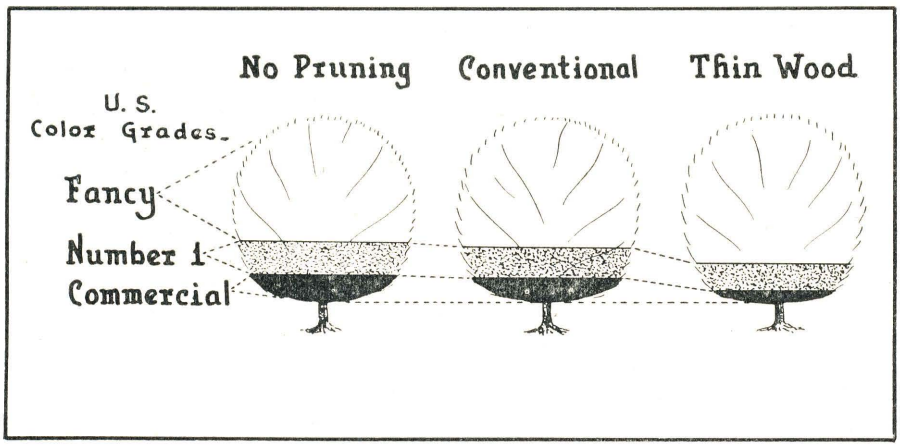


Fig. 19. "Thin Wood" pruning improves the color grade. Growers who wish to improve the color grade of the fruit should adopt the "Thin Wood" method of pruning.

Note: It should be observed that this figure refers to color grades only, and it should be borne in mind that some of the fruits which met color requirements were thrown out because of other defects.

"Thin Wood" Pruning Improves the Color Grade—This is accomplished by removing the wood upon which the relatively under-colored apples would grow and leaving that which normally bears well-colored specimens. The result is brought out in Table 10 which shows the color grade of the apples of the four varieties on which color records were made. See also Figure 19. The size and yield data obtained from the trees included in this study have already been presented (Tables 7 and 8).

The investigators were somewhat surprised to find that conventional pruning failed almost completely to effect a significant improvement in color. This, however, can be explained by pointing out that, though thinning out of the top undoubtedly results in improving the color of some of the apples

Table 10. Percentages of fruit produced by trees under different pruning treatments meeting the color requirements of the respective grades.

Variety	U. S. color grade	Treatment		
		No pruning (per cent)	Conventional (per cent)	"Thin Wood" (per cent)
Jonathan	Fancy	69	72	81
Jonathan	Number 1	18	16	15
Jonathan	Commercial	13	12	4
McIntosh	Fancy	68	69	74
McIntosh	Number 1	18	16	17
McIntosh	Commercial	14	15	9
Rome Beauty	Fancy	79	80	85
Rome Beauty	Number 1	12	11	10
Rome Beauty	Commercial	9	9	5
Duchess	Fancy	33	33	42
Duchess	Number 1	40	39	36
Duchess	Commercial	27	28	22

produced on the inside of the tree, this effect is almost completely offset by the removal from the top of wood that otherwise would have produced apples of high color. If well-colored apples are removed in order that the color of inferior ones be improved, the percentage of the various color grades remains practically unchanged.

Monetary Returns from "Thin Wood" Pruning—The returns derived from the trees which received "Thin Wood" pruning exceeded those from the unpruned trees by 11 per cent, and they are 21 per cent greater than returns from the trees pruned by the conventional method. Total returns from the trees included in the study are presented in Table 11 and are shown graphically in Figure 20.

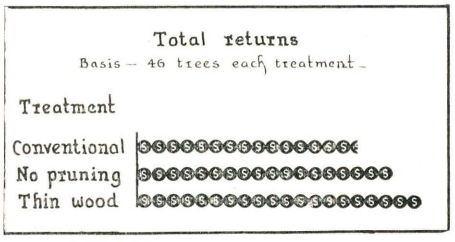


Fig. 20. "Thin Wood" pruning increases total monetary returns. The grower who wishes to increase monetary returns should adopt the "Thin Wood" method of pruning.

Judged from the standpoint of monetary returns alone, it would seem that, if the cost of doing the work were taken into account, the unpruned trees might be the most profitable. Any doubt which may exhist is eliminated by the fact that "Thin Wood" pruning materially facilitates such orchard operations as thinning, spraying, and harvesting. The more important of these advantages will be briefly discussed at this time.

Table 11. A comparison of the monetary returns from trees receiving conventional, "Thin Wood" and no pruning.

Treatment	No. of trees	Returns derived from respective size grades						Returns from bushels less than 2¼"	Returns from bushels 2¼" or more	Total returns
		Less than 2"	2" to 2¼"	2¼" to 2½"	2½" to 2¾"	2¾" to 3"	More than 3"			
Conventional...	20*	$1.10	$16.15	$148.37	$220.97	$59.77	$8.33	$17.25	$437.44	*$454.69*
No pruning....	46	2.32	29.15	201.02	218.73	61.06	4.54	31.47	485.35	*516.82*
T.W.P.....	46	.88	14.15	144.18	249.61	137.38	31.81	15.03	562.98	*578.01*

*Weighted so as to compare with the 46 trees which received the other treatments.

SECONDARY RESULTS FROM "THIN WOOD" PRUNING

"Thin Wood" Pruning is Less Costly Than the Conventional Method—Careful records of the time required to prune the trees included in the experimental blocks were kept, and it was found that to prune by the conventional method required, on the average, from 25 to 35 per cent more time than did the "Thin Wood" method. This may not mean much to the man whose orchard consists of only a couple of hundred trees, but for large acreages it becomes a matter of considerable importance.

Although different growers do not always agree upon the living branches which should be removed in pruning, they do concur in the opinion that dead wood should be removed. In this connection, it should be remembered that the wood removed by "Thin Wood" pruning, if allowed to remain, would in a few years die. The cost of this type of pruning is, for this reason, probably little if any greater than would be the cost of later removing the dead wood. One grower who acquired a block of trees which had not been pruned for a number of years found that the cost of removing the dead wood from these trees was very near the total cost of the several prunings received by a comparable block of trees which had been regularly pruned.

"Thin Wood" Pruning Makes Spraying Easier and More Effective—Ricks and Toenjes[17] found that 80 per cent of the codling moth larvae which entered apples gained access from the inner side of the apple. In other words, most of the worms enter from that side which, because of the difficulty of covering it, is most often left without a protective coating of spray material. From the standpoint of codling moth control it is then very important to cover the side of the apple which faces toward the tree trunk. In pruning a tree by the "Thin Wood" method, most of the cutting is done in the lower central portion of the tree. It is much easier to cover the towards-the-trunk side of the apple in a hollow-centered, "Thin Wood" pruned tree than in a thick-centered, conventionally-pruned one. A better idea of just how pruning facilitates spraying may be gained by a study of Figure 21 which represents the two types of trees in cross section.

"Thin Wood" Pruning Makes Thinning and Harvesting Easier—It is obvious that a method of pruning which removes a considerable percentage of the undergrade apples and which materially reduces the total number

reduces the cost of thinning. The authors wish to make it clear, however, that "Thin Wood" pruning is by no means a substitute for thinning.

Other things being equal, the larger the apples the more quickly they may be harvested. As "Thin Wood" pruning not only reduces the total number of apples but increases the average size of those which remain, it is most certainly a distinct aid in harvesting. In Orchard No. 17, the owner assigned two of his pickers to the job of harvesting the trees pruned by the "Thin Wood" method. These men were paid by the bushel and, because they were afraid they might not be able to pick as fast on the experimental trees, accepted the assignment reluctantly. When they discovered, as they soon did, that they could pick more bushels and make more money on the "Thin Wood"-pruned trees, they asked to be allowed to pick the same block in succeeding years.

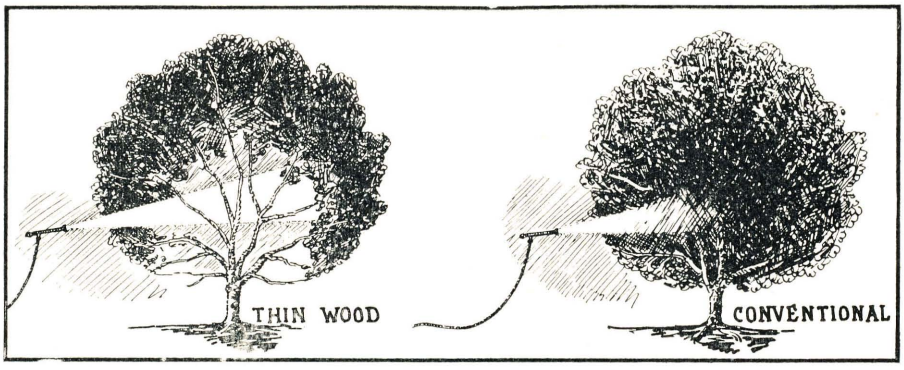


Fig. 21. "Thin Wood" pruning facilitates spraying. It is much easier to drive spray material through an open-centered tree than to make it penetrate one with a relatively dense interior.

"Thin Wood" Pruning Reduces Sun Scald Hazard as Compared to the Conventional Method—Conventional pruning sometimes exposes wood in the tops of trees, which has formerly been partially shaded, to the direct rays of the sun. Drastic pruning such as is illustrated in Figure 6 is sure to do so. Serious sun scald and other forms of injury often follow. As "Thin Wood" pruning is largely confined to the lower and inner portions of the tree, there is little danger of exposing wood to the danger of sun scald.

"Thin Wood" Pruning Results in Fewer Water Sprouts and Less Fire Blight—The severe conventional pruning practiced by many growers often results in a considerable amount of tender, succulent growth. The removal of a large, vigorous branch is almost certain to mean that one or more water sprouts will arise close to the cut. This tender, rapidly-growing wood is very subject to the ravages of fire blight. When this disease breaks out in an orchard, the grower is usually told to refrain from pruning and to do all he can to prevent water sprout growth until the disease can be brought under control. "Thin Wood" pruning is seldom followed by any considerable amount of tender, succulent growth. The method is for this reason especially desirable in sections where outbreaks of fire blight are likely to occur.

It should be borne in mind that while "Thin Wood" pruning reduces, it

does not entirely eliminate the fire blight hazard. Should a serious outbreak occur, the orchard should receive no pruning at all, other than that necessitated by removal of blighted tissues, until the disease is brought under control.

"Thin Wood" Pruning Does Not Throw Young Trees Out of Bearing as May Other Methods—It often happens that a rather severe conventional pruning will throw young trees almost entirely out of bearing for several years. The grower need not fear that "Thin Wood" pruning will have this effect.

"Thin Wood" Pruning Reduces the Number of Pickings Necessary—If not removed, the comparatively small, green apples found in the lower part of the tree usually mature at a later date than those which grow in the top. This undesirable characteristic is sometimes dealt with by making several pickings. "Thin Wood" pruning may not enable the tree to mature all of its fruit at exactly the same time. It does, however, by eliminating much of the fruit which would be late in maturing, make it possible in many cases to reduce the number of pickings.

"Thin Wood" Pruning Minimizes Frost Hazard as Compared to Conventional Methods—All of the trees in one experimental block were severely damaged by frost in the spring of 1934. Though it was first feared that the results would, insofar as pruning methods were concerned, be of no value, they were in the end turned to good account.

The frost practically wiped out all of those apples which would normally have been borne in the lower third of the trees. When the crop was harvested, it was found that the average yield of the unpruned trees was 16 bushels. The trees which had received "Thin Wood" pruning bore on the average a like amount of fruit while the conventionally-pruned trees bore only 12½ bushels. In the "Thin Wood"-pruned trees the cuts had, of course, been confined to the lower parts, and when the frost came they were just as well off as were the unpruned checks. Not so with the conventionally-pruned trees. This pruning method had reduced the bearing capacity of the tops, and when the frost killed the buds in the lower part of the trees it was impossible for them to bear as heavily as either the checks or the "Thin Wood"-pruned trees whose tops remained untouched.

ANSWERS TO THE QUESTIONS MOST FREQUENTLY ASKED REGARDING THE "THIN WOOD" METHOD OF PRUNING

Though the general principles of the system of pruning that has been described find ready acceptance on the part of growers, there are points on which additional information is sometimes requested. As the writers have encouraged interested parties to ask questions, many of the requests for further information have come in the form of direct interrogations. As questions of a similar nature may arise in the minds of some of our readers, those most frequently voiced are here repeated, answered, and discussed.

(1) *Can the "Thin Wood" method be applied to trees of different ages?* The "Thin Wood" method of pruning is one which may be used with confidence in pruning bearing trees of all ages. As only that wood which

would otherwise bear inferior fruit is pruned out, the amount of wood which should be removed can be determined by observing the quantity of small, green apples produced. Practically all the fruit produced by most trees during the first few bearing years is of good size and color. So long as this habit prevails, the tree will require little or no pruning. When the tree begins to bear apples of inferior grade, the "thin" wood upon which they are produced should be removed during the subsequent dormant season. If the producer will remove the "thin" wood as it appears, the tree will continue to produce throughout its life fruit of good size and high color.

If, instead of using this method early in the life of the tree, it is applied for the first time to an older tree, the severity of the treatment will, as in the case of the young tree, depend upon the amount of wood present which produces undergrade fruit. If the volume of this inferior fruit be used as a guide, the "Thin Wood" method may be applied to trees of all ages without fear of injuring the tree or reducing the volume of the better and more profitable grades.

(2) *Does not "Thin Wood" pruning push the bearing surface to the outside and cause a hollow-centered tree?* No. It is true that the bearing surface of "Thin Wood"-pruned trees is largely confined to the outside and the centers contain little if any bearing wood. It should be remembered, however, that essentially the same thing is true of all older trees regardless of pruning treatment. This condition, therefore, is not the *result* of "Thin Wood" pruning. It is not prevented by conventional pruning methods. It is a result of the trees' growing old. As has already been pointed out, even in those orchards where a distinct effort is made to encourage production throughout the tree, only seven per cent of the monetary returns was from apples produced on the inside of the trees. It is also true that trees which remain unpruned for many years naturally assume the hollow-centered form. So it may be said that "Thin Wood" pruning results not in an undesirable form but rather that it assists nature in attaining that natural form which is inevitable regardless of pruning treatment.

(3) *Is not the top of the "Thin Wood"-pruned tree larger in proportion to its roots than it should be?* No. Conventional pruning which materially reduces the amount of top without a corresponding reduction of the root system sometimes seems an advantage in that it *appears* to promote more top growth than would have otherwise been the case. As a matter of fact, although the vigor of those branches which remain may be increased, the *total* amount of growth is less than would have otherwise been produced. Not only this, but the root system tends to adjust itself to a smaller top, and the productivity of the tree is curtailed. When this operation is repeated, as it must be if the appearance of increased vigor is to be maintained, the cumulative effect becomes considerable and productiveness is materially curtailed. Thus as "Thin Wood" pruning is pruning of a relatively light sort and as the cuts are confined to branches which, if left, would in the natural course of events die, the system does not materially affect the natural balance which exists between roots and tops.

(4) *Are not losses from breakage in "Thin Wood"-pruned trees greater than in conventionally-pruned trees whose tops are thinner?* No. It might be supposed that the "Thin Wood"-pruned tree with its thick top and concentrated load of fruit would be more subject to breakage than the conventionally-pruned tree with a thinner top and more widely distributed load.

This, however, is not the case. Although the authors found no satisfactory means of measuring this factor quantitatively, they did observe that the amount and severity of breakage was usually greater in conventionally-pruned trees.

(5) *Does "Thin Wood" pruning call for the thinning out of tops which are very thick?* No. Even very thick tops need not be thinned if the wood of which they consist is vigorous. This question may be answered, at least in part, by reminding the reader that in thinning the tops more potential apples are removed from that part of the tree than can be produced by the wood which supposedly benefits from the pruning. No matter how thick the tops may be, the vigorous branches will not only produce apples of larger size and better color, but will produce more of them than will the branches in other parts of the tree. This means that the thick tops should be encouraged rather than discouraged.

(6) *Does "Thin Wood" pruning call for the removal of parallel, crossing, or interfering branches?* Thick, productive branches should be allowed to remain even though they may cross, be parallel, or otherwise interfere. It is difficult for those who have formerly practiced conventional pruning to believe that the crossing branch should not be removed. Yet, why should a productive branch be removed just because it happens to grow in close proximity to another? The burden of proof is on the individual who would remove one or both of the crossing or parallel branches. The greater the number of vigorous branches, the greater the productiveness of the tree. Only when two branches rub or interfere to the extent that one is injured so severely that one assumes the characteristics of "thin" wood, should it then be removed, and not before.

The study of interfering branches led to the discovery that "Thin Wood"-pruned, and even unpruned, trees have comparatively few seriously interfering branches. In pruning some vigorous Northern Spy trees 25 years of age which had never before been pruned, the authors observed that on the average these trees contained not more than two or three seriously interfering branches. Conventional pruning upsets the natural course of events and often causes the tree to send out vigorous water sprouts which interfere with those branches already present. Though it may be necessary for those who employ the conventional method to devote considerable attention to the removal of interfering branches, those who practice the "Thin Wood" method need not give the matter especial attention.

(7) *Will "Thin Wood" pruning cause a tree to grow too high?* It can be said with confidence that "Thin Wood" pruning will not cause a tree to assume a more upright habit of growth or to attain a height appreciably greater than that which is natural to the tree. Fortunately, there are certain natural forces in operation which tend to check the height of trees. A discussion of one of these will enable the reader to understand why trees do not attain the height which might be expected.

In studying the growth habits of trees, the authors tagged, during the early spring, given points on a number of branches on each of several bearing apple trees typical of the varieties in question. The distances from the selected points to substantial stakes driven into the ground directly below them were measured and recorded. The distances from the marked points to the stakes were again measured just before the subsequent harvest, while the trees were loaded with fruit. It was found, as expected, that the branches

Table 12. The branches of a bearing tree are permanently lowered by a crop of fruit.

Branch number	Branch diameter in inches	Distance from marked point to stake directly below			Amount of temporary lowering	Amount of permanent lowering
		Jan. 15, 1934	Sept. 26, 1934	Nov. 25, 1934		
1	2.50	8′ 2″	6′ 7″	7′ 10″	1′ 7″	4″
2	2.50	11′ 7″	10′ 2″	11′ 2″	1′ 5″	5″
3	1.50	16′ 7″	15′ 9″	16′ 4″	10″	3″
4	1.25	11′ 0″	6′ 10″	10′ 1″	4′ 2″	11″
6	.75	11′ 3″	9′ 0″	11′ 2″	2′ 3″	1″
7	1.00	15′ 6″	14′ 3″	15′ 3″	1′ 3″	3″
8	.75	14′ 10″	13′ 1″	14′ 6″	1′ 9″	4″
9	.15	13′ 3″	3′ 2″	12′ 8″	10′ 1″	7″
10	.15	9′ 11″	1′ 8″	9′ 1″	8′ 3″	10″
11	.15	14′ 6″	7′ 3″	13′ 4″	7′ 3″	14″
12	.15	14′ 2″	6′ 10″	13′ 6″	7′ 4″	8″

had been considerably borne down by the weight of the crop. The distances were again measured during the following dormant season after the branches had had an opportunity to spring back to their former positions. Table 12 gives the diameters of the branches studied on one representative tree at the points marked, as well as the distances from these points to the corresponding stake, during the early spring, at harvest time, and 60 days later.

The interesting thing about this experiment was that, when released from the load of fruit, none of the branches assumed their original positions.

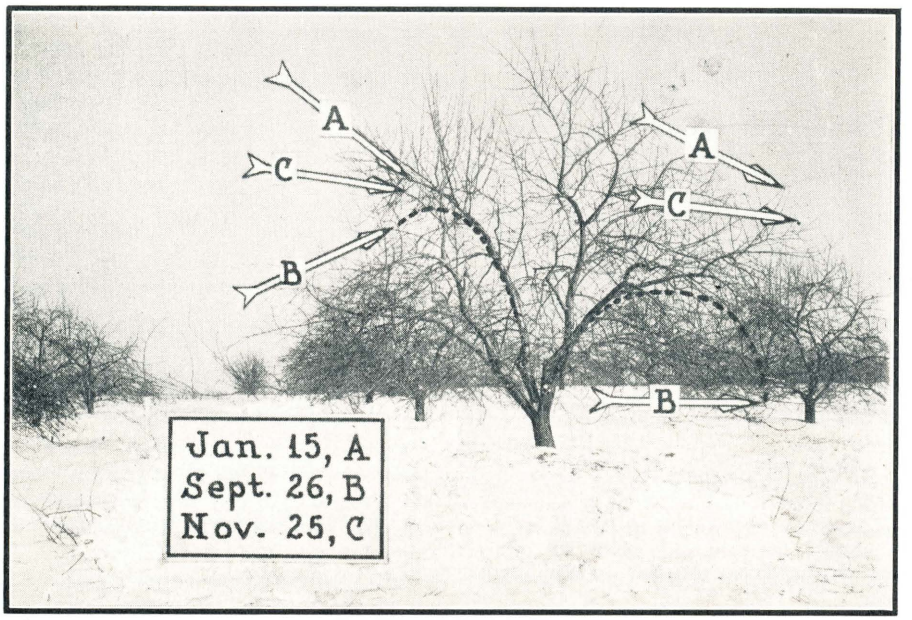


Fig. 22. The branches of trees are permanently borne down by the loads of fruit which they carry. Note that the branches spring back up when relieved of the fruit but that they do not assume their original positions.

The marked points were from one to 14 inches, depending upon the diameter, the load of fruit, and direction of growth, nearer the ground than they had been 10 months previous. A photograph (Fig. 22) of the tree from which the data just presented were obtained, showing diagrammatically how two of the branches behaved, will perhaps enable the reader better to understand just what happened.

Though some producers believe that it is good business to lower the tops of their older trees, there is good reason to think that this should be done only in extreme cases. For one thing, it should be remembered that more than 60 per cent of the total returns from a crop of apples is derived from fruit produced in the tops of the trees. The heavy cutting necessary to lower the tops materially reduces the crop, and the lowering of tops is usually attended by a material reduction in returns. Not only this, but heavy cutting in the top often forces remaining branches to make two or three times the amount of growth which would otherwise have been produced. This vegetative wood is not likely to produce and be borne down by fruit as described above. Without this natural check, the growth tends to be not only more rapid, but comparatively upright. This, of course, means that the tree will for a time increase in height more rapidly than would otherwise have been the case. So, cutting back the top not only curtails the crop, but the height of the tree is not always permanently lowered.

Fig. 23. Branches which at first grow in an upward direction may later grow horizontally or downward. Branches B, C, and D will eventually assume a downward direction of growth (a). They should not be removed until they have assumed this downward direction. Branch A should be removed when its laterals assume the characteristics of "thin" wood.

The permanent bearing down of branches by the crops which they bear has, in addition to checking tree height, another effect which should be recognized and taken into account when the trees are pruned. While the results come about slowly, the lowering effect already described means that branches which may at first grow comparatively upright gradually assume a less upright and finally a horizontal or even a downward direction of growth. As branches which originate low in the tree assume a horizontal or downward direction of growth, they usually take on the characteristics of "thin" wood. When this happens they should be removed. By this means poor wood is eliminated and that of superior quality given a better opportunity to develop and bear fruit.

A photograph (Figure 23) of a typical tree showing branches in all stages may help to make clear what goes on in the typical tree.

It may be well to explain that in a tree of the age shown most of the horizontal branches which have so far been removed arise from the trunk

of the tree. As the tree becomes older, all but a few permanent scaffold limbs are in this way removed. As these branches thicken, they bend down less and less and finally assume practically fixed positions. As this happens, the branches which should be removed arise not from the trunk but from the permanent scaffold limbs. This is but another way of saying that as the tree increases in age the places at which the cuts are made gradually shift outward and upward.

Growers need not hesitate to remove these weak branches from the lower part of their trees. If they are not removed by the pruning saw, the lower part of the tree soon becomes a tangled mass of unproductive wood. The removal of such wood enables the tree to renew itself from above or from that part in which the strongest and most productive wood originates.

(8) *What will a tree look like after 30 years of "Thin Wood" pruning?* If the space has been such that the tree could develop naturally, it will be a large, spreading tree of great productive capacity.

Fig. 24. What a McIntosh tree looks like after 20 years of "Thin Wood" pruning. Note the size, shape, and bearing capacity of this 30-year-old McIntosh tree. Observe the crop of apples which it bore. Eighty per cent of these apples were of U. S. No. 1 grade and 2½ or more inches in diameter.

Some growers seem to fear that though the "Thin Wood" method may, for a time, be satisfactory, it will eventually result in a tree of undesirable form. Such is not the case. There are in Michigan a few growers who have for many years practiced systems of pruning which, although unnamed by them, are in most respects essentially the same as the "Thin Wood"

method. By studying the results obtained by these men, it is possible to predict with certainty what can be expected of the method.

The conventional method often results in a flat-topped tree of comparatively small capacity, inherent mechanical weakness, and unnatural form; but not so with the "Thin Wood"-pruned tree. As already stated, well-spaced trees having received this treatment throughout their lives develop naturally into large, spreading trees of great capacity. The accompanying photograph shows a 30-year-old McIntosh tree which has, since beginning to bear, been pruned by what is essentially the "Thin Wood" method. This method will help the producer in growing trees which, like the one shown, is capable of yielding large crops of high grade apples. Such crops mean substantial profits.

ACKNOWLEDGMENTS

The writers wish to take this opportunity of expressing their appreciation to the fruit growers in whose orchards experimental pruning was conducted. Without their cooperation the work would have been impossible. These men not only allowed their trees to be used for experimental purposes, but in many cases helped with the record-taking and other labor involved. All of the following growers made material contributions to the success of the work: Harry T. Bigelow, R. A. Buyce, B. F. Hall, W. L. Hamilton, Geo. Herman, Bert Hills, C. C. Kniebs, John Miller, Herbert Nafziger, J. A. Richards, L. A. Royal, Scott Bros., Schemenauer Bros., Clyde Smith, Steimle Bros., Abe Teichman, Harry Wakeman, and R. Wenzel.

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