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## DWARF CONIFERS FROM WITCHES'-BROOMS

THE English term *witches'-broom* translates directly from the German word *Hexenbesen*. Both parts of the German compound word are found in English as *hex*, meaning to bewitch, and *besom*, a bundle of twigs (usually of birch) bound together to form the age-old do-it-yourself sweeping implement still used by people in rural Europe. Plate VII shows a witches'-broom development commonly found on highbush blueberry in New England. It bears a strong resemblance to a broom. In this instance the thread-like mycelium of a rust fungus has invaded the stem and stimulated mass development of latent buds.

It seems only natural that medieval Europeans would call these peculiar growths witches'-brooms, for they were accustomed to brooms made from bundles of twigs and were inclined to relate anything mysterious and unexplainable to witchcraft.

Many superstitions were associated with witches'-brooms and they played an important part in medieval folklore. A library search by the author for information in English folklore proved fruitless, but Dr. Richard S. Meriam, Professor Emeritus in the Harvard Business School, kindly volunteered to search the German literature at Harvard's Widener Library and found the following. The German word *Hexenbesen* is now used to define only witches'-brooms and mistletoe, but in the past it was applied to other woody growths as well. It was once one of several words used to describe such abnormalities—they were also called witches'-nests (*Hexennester*) mares'-nests (*Mahnester*), and thunderbrooms (*Donnerbesen*). Witches not only caused these formations—they also used them as nests and resting places during their travels. They were also used by elves, hobgoblins and other evil and oppressive spirits. Among them were the mares (*Mahre*), who were thought to sit on the chests of sleeping persons and bring on bad dreams—the origin of our word *nightmare*. We cannot be sure that all the tales apply solely to witches'-brooms as we know them, for some other unusual growths may have been involved. A special use of the witches'-broom, of course, was for the witch to mount it and ride through the air. The ancient belief in

witches'-brooms and thunderbrooms ascribed magical protective and healing powers to them. They protected against sickness and lightning and, curiously enough, against witchcraft itself. In Silesia, a witches'-broom of birch hung in a pigpen protected the animals from the work of witches and disease.

Modern scientific literature abounds with references concerning the investigation of witches'-brooms. They have been found on many species of woody and non-woody plants, and have been shown to result from the stimuli of feeding mites and insects and parasites such as fungi, bacteria, viruses, and one of the higher plants—dwarf mistletoe (*Arceuthobium pusillum*).

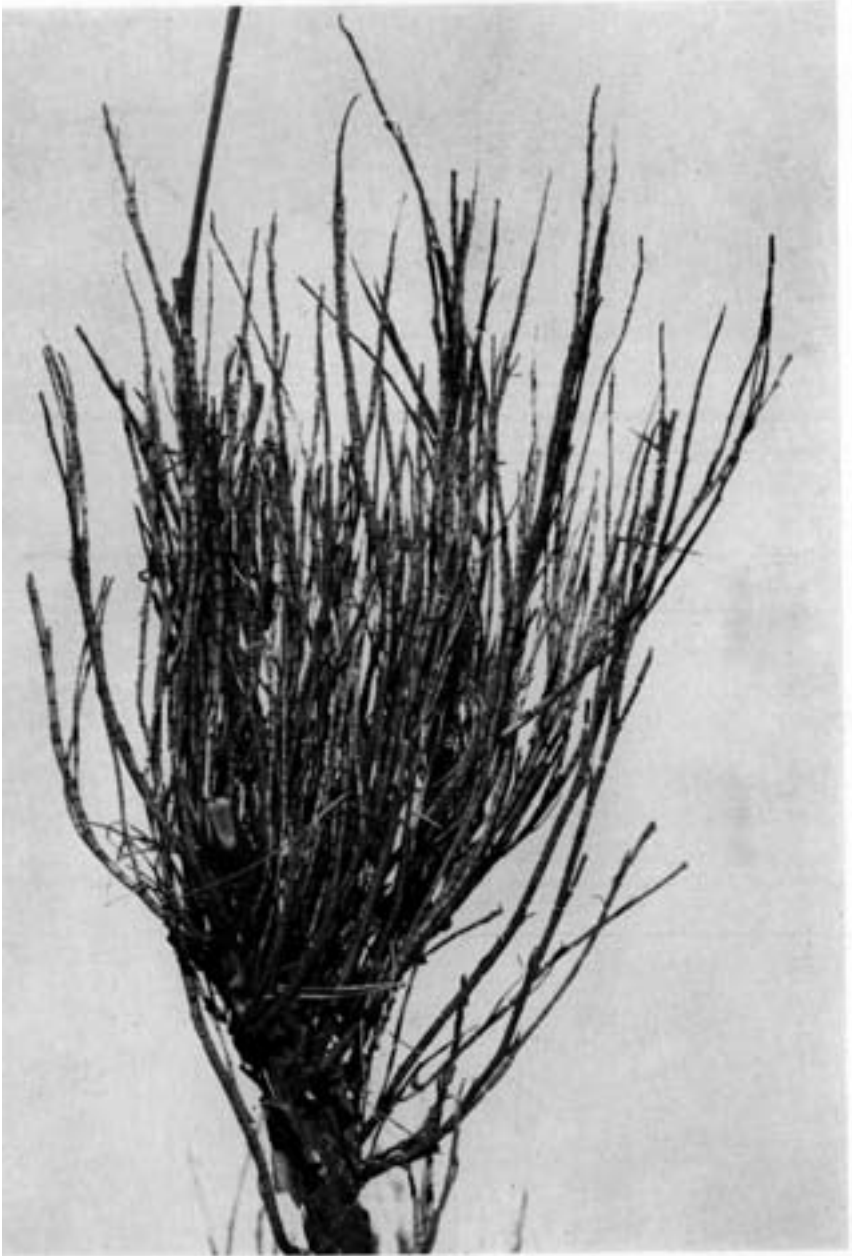
Plate VIII shows a spruce tree with numerous witches'-brooms—in this case they are symptoms of infection. In some areas all trees of a given species bear such developments, and some stunted specimens are comprised entirely of brooms. Many people are familiar with the brooms that appear so commonly on trees of hackberry (*Celtis occidentalis*). These are thought to be induced by mites in association with a fungus.

Despite the abundance of literature on witches'-brooms in general, few references relate to those that have arisen in the absence of causal organisms, presumably through "bud sports" or mutations. This paper, however, deals with these brooms that appear to be of genetic origin. Such witches'-brooms are relatively common when one has developed an eye for spotting them. During a recent trip to Cape Cod to collect scions of one broom, three other isolated specimens were found. The following Sunday a tour through southeastern Massachusetts led to the discovery of six more. When seeking brooms, a wide and careful search has always been made in the area where one was found, to see if others might be present. In these searches, two brooms have never been found on a single pine tree, and in only one instance has a second been seen within 100 feet of the first. Usually they are many miles apart. This, and the fact that they are free of excessive dead parts would tend to support the belief that they are not caused by organisms. A large number of dictionaries, encyclopedias, and technical publications checked by the author have defined witches'-brooms as developments arising through the action of causal organisms. In the event that brooms such as those discussed in this paper prove to be free of such agents, a new term to define them may well be needed.

To bring superstitions up to date it should be noted that witches'-brooms were found in eleven cemeteries and correspondents have mentioned brooms as occurring in seven others.

#### Development of Witches'-brooms from Single Buds

Plate IX shows a witches'-broom collected from a local eastern white pine (*Pinus strobus*). How it came about can best be explained by describing how pine trees of this type grow. With the advent of spring, the cluster of buds located at the tips of the previous year's growth become active and develop into new



**PLATE VII**

Witches'-broom development commonly found on highbush blueberry.



**PLATE VIII**

A spruce tree with numerous witches'-brooms — in this case they are symptoms of infection.



**PLATE IX**

Witches'-broom of white pine illustrating how this particular development is traceable to growth changes that took place within the growing point of a single bud (see text).

shoots. During their elongation period such new growths are commonly termed "candles". The time of this activity depends upon location and season—last year in the Boston area it commenced about May 1 and in a scant three weeks the new set of buds had formed.

Plate X (inset) shows a terminal shoot of Scots pine (*Pinus sylvestris*) with a cluster of winter buds. When growth takes place the central bud will develop into a terminal or leading shoot, while those surrounding it will develop into lateral or side shoots. In preparation for the next annual growth cycle, each "candle" will again terminate in a cluster of buds.

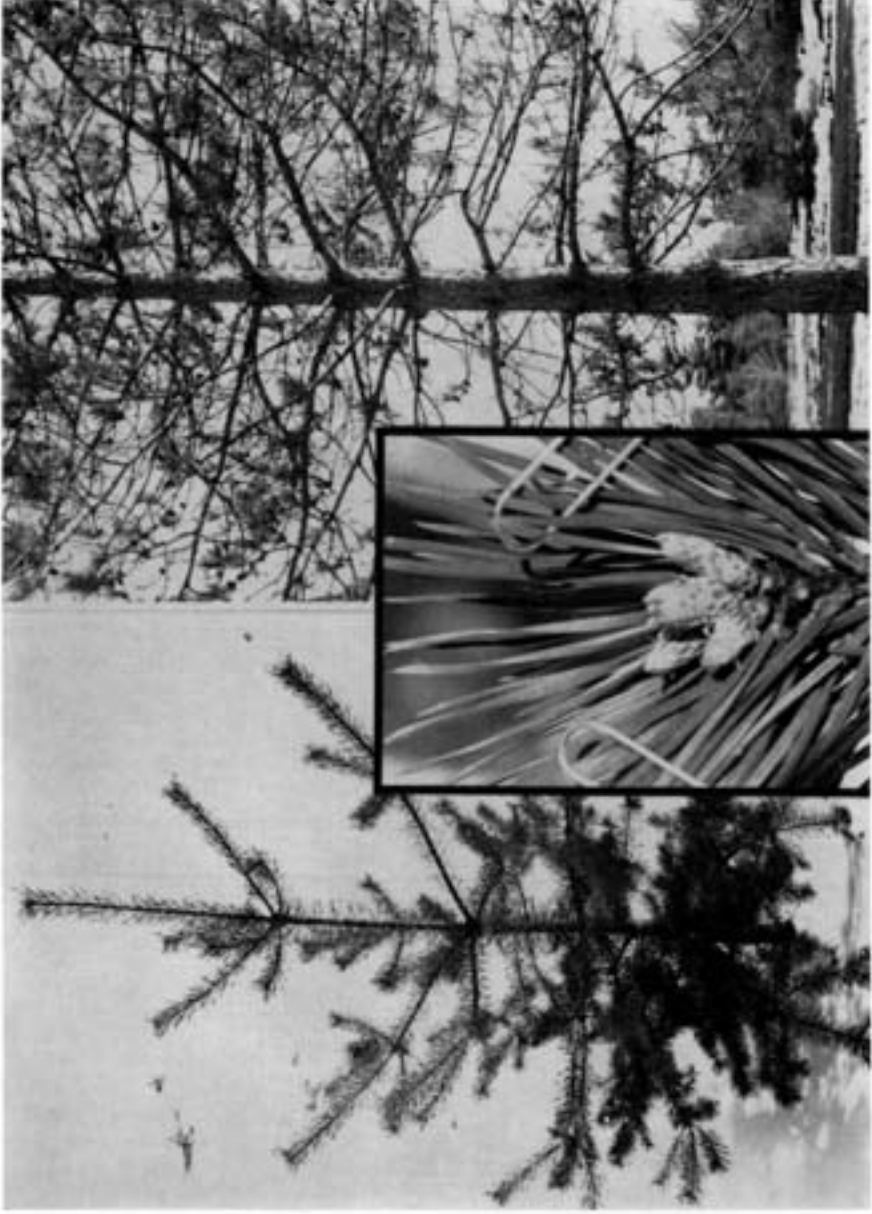
Plate X (left) illustrates how successive terminal growths of a young Scots pine have led to elongation of the trunk and side branches while lateral growths have formed branches in whorls. Thus each year's growth adds to the framework of the tree, leading to an increase in height, breadth and density. The result of such development is shown in the structure of an ailing and partly defoliated roadside pine (Plate X, right).

Returning to Plate IX, we find a clear-cut illustration of how this particular development is traceable to growth changes that have taken place within the growing point of a single bud. At (A) is a whorl of six normal lateral branches together with a normal leading shoot that terminated its growth and set buds at (B). Leaves on these normal branches measured from  $2\frac{1}{2}$  to  $3\frac{3}{4}$  inches in length. The following year a new set of six branches arose at (B), together with a terminal shoot. One of the lateral buds underwent changes that gave rise to the broom. The other five lateral branches were positioned beneath the broom where through the years they were too deeply shaded to survive, and their scars are just discernible at (B). The terminal shoot (C), normal in character, had enough light to continue as a spindling growth. It has developed to about pencil thickness while in the same period the broom has become a dense, multibranched, globose mass, 26 inches wide and 23 inches tall, with a basal stem  $1\frac{7}{8}$  inches thick. Its leaves, borne on short, thicker-than-normal shoots, measure  $\frac{7}{8}$  to 1 inch in length.

#### Examples of Witches'-brooms Arising from Single Buds

The broom on red pine (*Pinus resinosa*) shown in Plate XI (top) is the lone survivor in a branch whorl that came into being many years ago. Its leaves are darker in color than those of normal branches on the tree on which it is borne, and it presents an appearance of thrift. Although all other members of the whorl have perished, the broom has managed to survive and prosper.

Plate XI (bottom) shows a broom on pitch pine (*Pinus rigida*). It is positioned about four feet above ground in the remains of a whorl of branches. Although its host and other trees in the area reflect the impoverished, sandy Cape Cod soil in which they grow, the broom is darker green in color and appears healthy and vigorous. It has been under observation for six years and during the past growing season produced a few pistillate conelets for the first time.



**PLATE X**

(Inset) Scots pine terminal shoot showing a cluster of winter buds. (Left) Terminal growths of a young Scots pine have led to an elongation of the trunk and side branches while lateral growths have formed branches in whorls. (Right) The result of these developments is shown in the structure of an ailing and partly defoliated roadside pine.



**PLATE XI**

(Top) Broom on red pine is the lone survivor in a branch whorl that came into being many years ago. (Bottom) Broom on pitch pine positioned in the remains of a whorl of branches.





**PLATE XII**

A broom situated about  $\frac{2}{3}$  of the way up the trunk of a 60 foot white pine tree. This, and some others so positioned resemble independent trees attached to the host plants.

A broom situated about  $\frac{2}{3}$  of the way up the trunk of a sixty foot white pine tree is shown in Plate XII. It is clear that this, too, originated from a lateral bud, for it is located in the remains of a whorl of branches. This and some others so positioned resemble independent trees attached to the host plants.

Plate XIII shows a massive witches'-broom comprising the entire crown of a white pine approximately 50 feet tall. Although witches'-brooms may be found on any part of a plant (where parasites invade or where growth changes take place within a bud), terminal brooms are more prominent and therefore more readily discovered. Because of this crowning position they can sometimes be spotted against the far distant skyline. Others, located on lower parts of trees, can be found more easily in winter when deciduous trees are bare than in summer when they may be obscured by woodland foliage.

#### Dwarf Seedlings in Nature from a Pine Witches'-broom

Plate XIV shows a terminal witches'-broom on eastern white pine (*Pinus strobus*) located in the Berkshire Hills of Western Massachusetts. What appears to be two trees is actually one that divides into two parts four feet above the ground. The broom, terminating one leader, is about 10 feet tall and 10 feet wide. Its clean growth shows no evidence of causal agents. It is of special interest because it has borne viable seeds that have given rise to numerous dwarf plants. The tree is situated at the edge of a clearance fifty yards wide cut through woods to accommodate high-tension electric lines. As a result of the unnatural opening in the woods, seeds shed from the broom have had a better chance of developing into plants than would have been the case in undisturbed woodland where slow-growing plants are at a serious competitive disadvantage.

Cones from the broom showed a diversity of subnormal sizes, when compared with normal white pine cones (Plate XV). Those from the normal tree (left) measured from  $4\frac{3}{4}$  to  $5\frac{1}{2}$  inches in length, while the ones produced on the witches'-broom (right) varied from  $1\frac{3}{4}$  to  $3\frac{5}{8}$  inches, most being less than  $2\frac{1}{2}$  inches long. White pine cones have five clearly defined sets of spirally arranged cone-scales fixed to a central axis. Though not always clearly defined, this same arrangement was found in cones from the witches'-brooms. However, the number of scales present varied enormously. Scales on 25 witches'-broom cones were counted and the number ranged from 20 to 50, while normal cones bore between 68 and 80. In the witches'-broom cones, there was no relationship between cone length and scale number — the shortest had 25 scales, while the longest had only 21. However, seed size did vary, the small cones containing proportionately small seeds.

Through the years, more than 250 pines exhibiting genetic dwarfism have arisen in the vicinity of the broom-bearing tree, some as far distant as one-quarter mile. Seeds collected from this broom were germinated at the Arnold Arboretum and 48% of the seedlings showed dwarfism (1198-63, Table I).



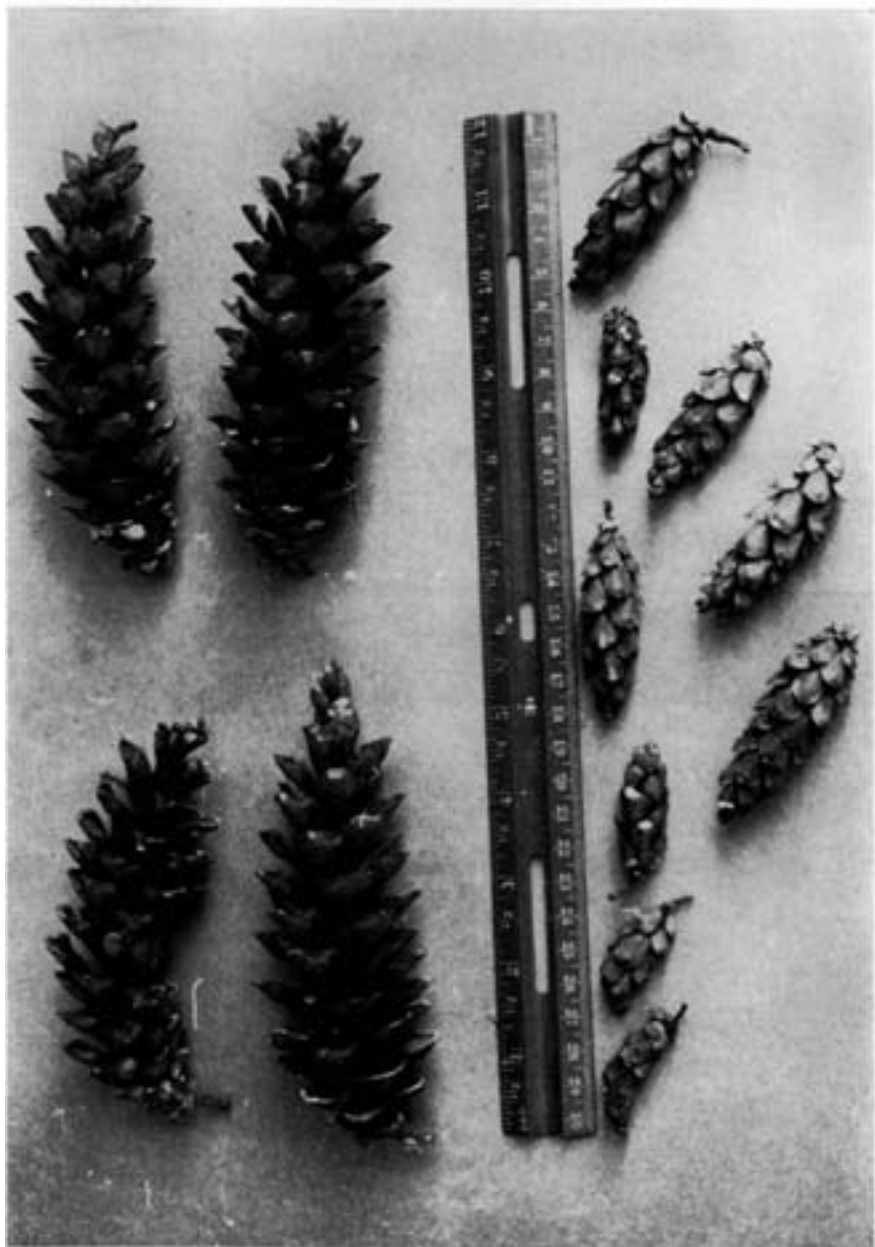
**PLATE XIII**

A massive witches'-broom comprising the entire crown of a white pine tree approximately 50 feet tall.



**PLATE XIV**

A terminal witches'-broom on eastern white pine. Its seeds have given rise to numerous dwarf plants.

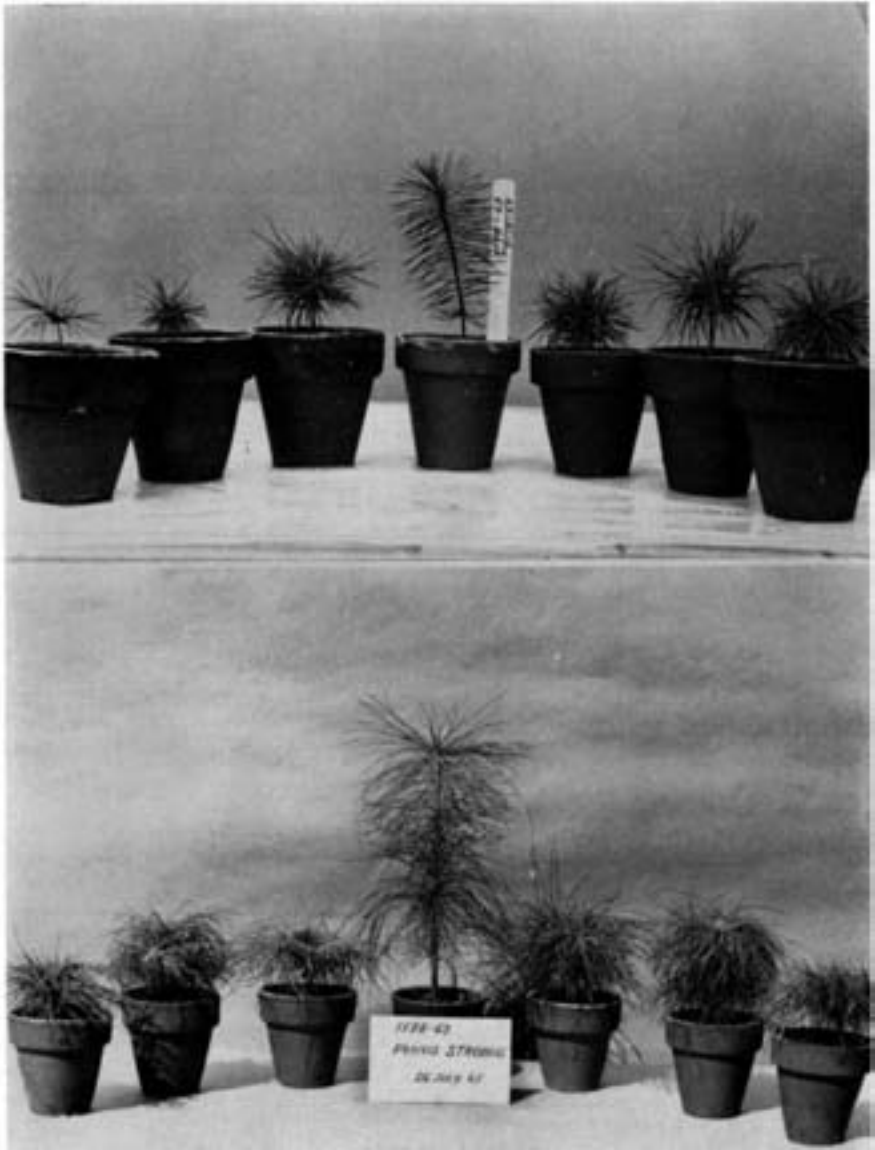


**PLATE XV**

Cones from a witches'-broom (right) showing the diversity of subnormal sizes as compared with normal white pine cones (left).

TABLE I  
OBSERVATIONS — SEEDS AND SEEDLINGS FROM WITCHES'-BROOMS

Species	Arnold Arboretum Accession No.	Percentage of Germination	Percentage of Abnormal Segregates	Observations
<i>Pinus banksiana</i>	200-64	67	48	Abnormal seedlings have central trunks. Internodes are short, leading to midget plants with crowded branches. In some, side branch growth exceeds leader growth, resulting in plants that are broader than tall.
<i>Pinus banksiana</i>	1025-65	96	52	Dwarf form.
	1026-65	98	12	Normal form.
				Second generation witches'-broom seedlings (see text).
<i>Pinus rigida</i>	158-64	11	36	All have central trunks. Growth rates vary widely. Some plants are prostrate.
<i>Pinus strobus</i>	1198-63	59	48	Abnormal seedlings lack central leaders. Lateral branches have developed in cotyledon area of young seedlings, leading to multibranching, globe-shaped plants. Growth rates are variable.
	119-64	98	54	
	159-64	49	48	
	1143-64	Seeds not counted	57	
	1145-64	67	58	
<i>Pinus strobus</i>	1144-64	Seeds not counted	65	Smallest cones separated from lot 1143-64 and processed independently. This lot produced a higher ratio of dwarf seedlings than any other observed.
<i>Pinus virginiana</i>	1122-64	42	35	All seedlings had central trunks and showed no abnormality until they were about four inches tall. At this stage some leading shoots grew horizontally and later became pendulous. Still others bent over at ground level and became prostrate.



**PLATE XVI**

(Top) A selected sampling of white pine witches'-broom seedlings (1198-63, Table I).  
(Bottom) Seedlings from the same lot one year later.

A professional plant collector discovered the broom and the abnormal seedlings in October 1962. Some seedlings bore leaves about normal in size while others had leaves less than one inch long. The discovery of these abnormal pines illustrates one method by which dwarf conifers may originate spontaneously under natural conditions.

### Seedlings from Witches'-broom Seeds

In 1933, two discussions of seedlings from fruiting witches'-brooms appeared in the German scientific literature. In the first, von Tubeuf<sup>1</sup> reported on his experiments in 1907 and 1930 with seeds from witches'-brooms of Norway Spruce (*Picea abies*). Two seedling lots in 1930 led to populations in which 27.7% and 38.5% of the seedlings showed the "bush-like" growth of witches'-brooms. In the second paper, Liese<sup>2</sup> discussed witches'-broom seedlings of pines and believed that the brooms originated from bud mutations. A number of seedling populations presently under observation at the Arnold Arboretum (Table I) tend to support this conclusion, for in a portion of each, abnormal characteristics are transmitted to the progeny.

A number of fruiting white pine witches'-brooms have been observed by the author during the past five years. Each had only female conelets, but bore them heavily every year, in contrast to the usual fruiting habit of white pine, in which lean and lush years occur. In years when cones have been scarce on trees in an area, weevils have concentrated on the more abundant cones of the brooms and have destroyed many seeds. Cones from these brooms did not open as white pine cones normally do, and each scale had to be pried open separately to extract the seeds. Such tedious procedure is compensated for by the increased latitude in time when seeds can be collected—in the Boston area, cones of white pine open and disperse their seeds in late August, but some witches'-broom cones still contained seeds when collected many weeks later.

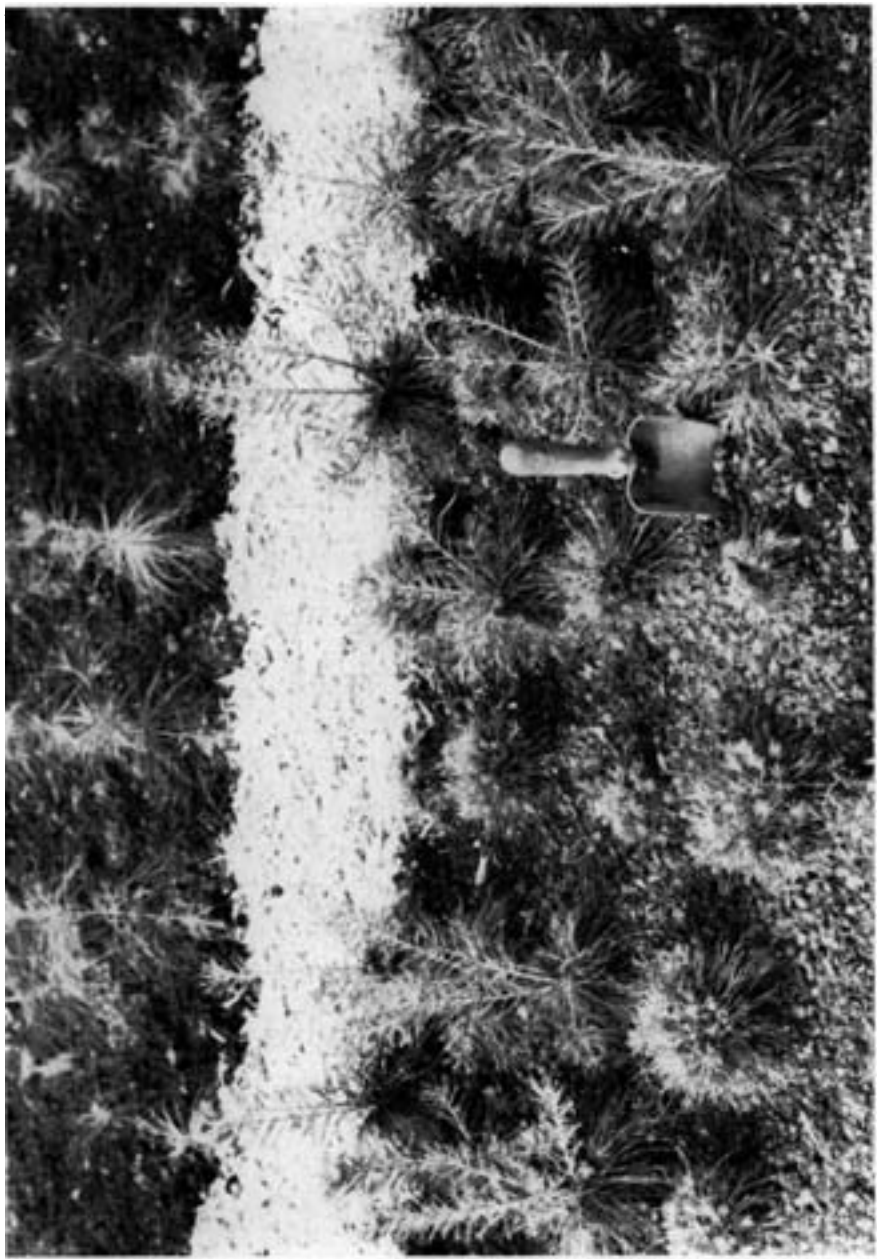
Plate XVI (top) shows a selected sampling of white pine witches'-broom seedlings (1198-63, Table I). The seeds were collected on September 20, 1963, placed in cold stratification for 3 months, sown on December 20, and had germinated by January 3, 1964. Differences in the seedlings became readily apparent as soon as they had passed the cotyledon stage. Those considered normal (52%) developed central stems, while the other 48% produced lateral branches in the cotyledon area, were slow growing, and lacked central leaders. Adult leaf bundles had appeared on the dwarfs when this picture was made in July 1964, while the normal seedlings (center plant) still bore juvenile foliage. Plate XVI (bottom) pictures seedlings from the same lot one year later. At this stage the normal

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<sup>1</sup>K. von Tubeuf, "Das Problem der Hexenbesen," *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz* (1933).

<sup>2</sup>J. Liese, "Vererbung der Hexenbesenbildung bei der Kiefer," *Zeitschrift für Forst- und Jagdwesen* (Berlin, 1933).





**PLATE XVII**

A white pine seedling lot (199-64, Table I) in a nursery bed. Normal plants and globe-shaped dwarfs of variable growth rate are present.

seedlings had continued upward growth while the dwarfs were globe-shaped. All other witches'-broom seedling lots of eastern white pine behaved similarly.

Plate XVII shows another white pine seedling lot (199-64) in a nursery bed. Normal plants and globe-shaped dwarfs of variable growth rate are present.

The characteristics of a group of jack pine (*Pinus banksiana*) witches'-broom seedlings (200-64) are described in Table I and shown in Plate XVIII (top). All have central trunks, but about half have short internodes resulting in midget plants with crowded branches. In some, lateral growth has exceeded upright growth, resulting in plants broader than tall.

A group of witches'-broom seedlings of Virginia pine (*Pinus virginiana*) (1122-64), described in Table I, is shown in Plate XVIII (bottom). All have central trunks and failed to show abnormality until about 4 inches tall. At this stage some leading shoots grew horizontally and later became pendulous. Still others bent over near ground level and became prostrate. A seedling population of *Pinus rigida* (158-64) behaved in a manner similar to *P. virginiana*—no distinct differences appeared until about a year and a half had elapsed. At that time the abnormal seedlings (36%) showed varying growth rates and some were prostrate.

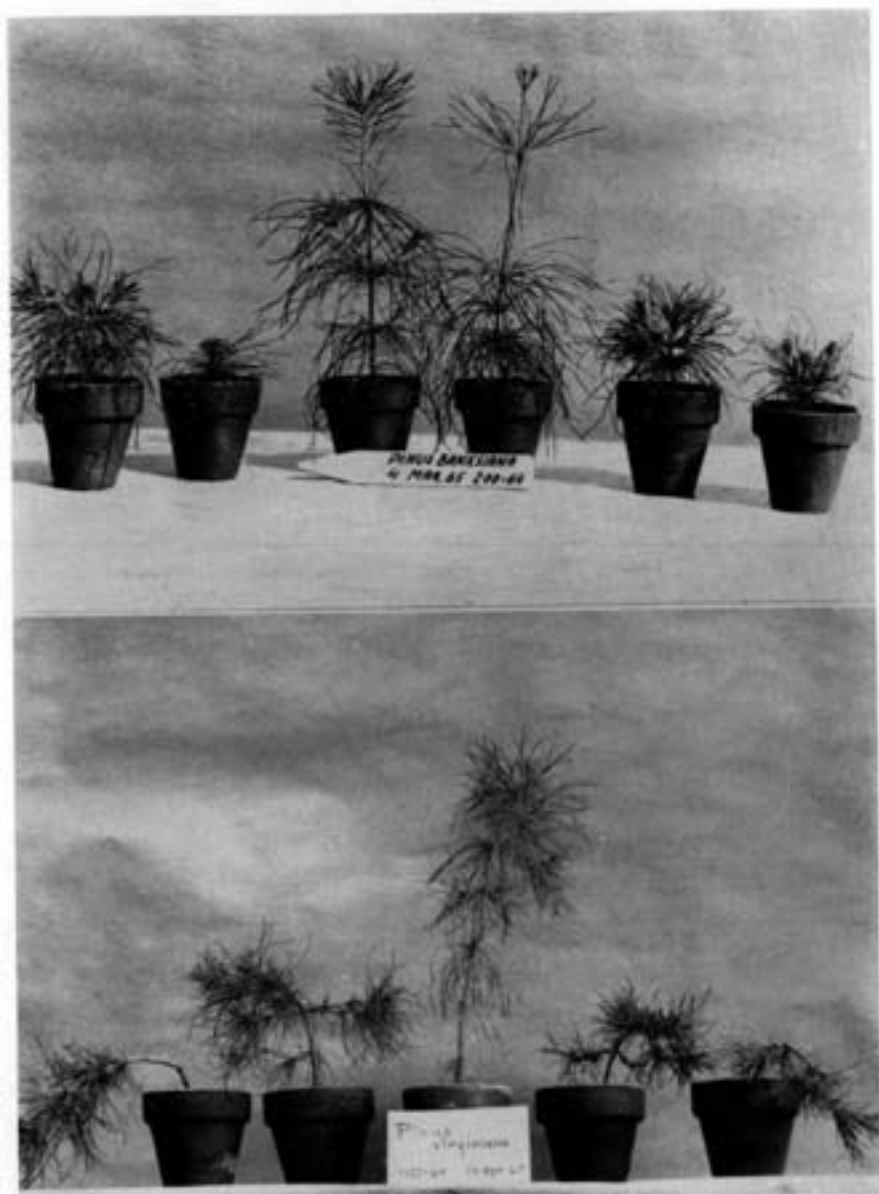
### Second Generation Witches'-broom Seedlings

In April 1965, two seed lots of jack pine (*Pinus banksiana*) were received from Mr. Albert G. Johnson, Associate Scientist, Department of Horticultural Science, University of Minnesota. He had collected seeds earlier from a jack pine witches'-broom at Gordon, Wisconsin, and from these had raised plants to fruiting size. Of four seedlings surviving in 1965, one was dwarfed and resembled the parent broom in form and leaf character. The other three were normal in form. Two lots of seeds sent to the Arnold Arboretum in 1965 consisted of 50 seeds (1025-65) from the dwarf form and 50 seeds (1026-65) from one of the normal trees. The character of seedlings grown from these two lots is given in Table I.

### Progeny of Witches'-brooms Propagated Vegetatively

A number of plants propagated vegetatively from witches'-brooms are under observation at the Arnold Arboretum. Table II lists them and summarizes their present condition and characteristics.

Plate XIX (top) shows a dwarf multi-branched white pine of witches'-broom origin (315-63) propagated by grafting in March 1963 and photographed in April 1967. It is now 12 inches tall and 19 inches broad. Some well known dwarf conifers that originated as vegetative propagation of witches'-brooms, and the dates when they first appeared in the literature, are: *Picea abies* 'Maxwellii' (1874), *P. nigra* 'Hornibrookiana' (1932), *P. sylvestris* 'Beauvronensis' (1891), *P. abies* 'Tabulaeformis' (1890). These have maintained their characteristics through propagation and repropagation—they have withstood the test of time. It is probable that others will soon appear in the literature, for in the last



**PLATE XVIII**

(Top) A group of jack pine witches'-broom seedlings. (Bottom) A group of Virginia pine witches'-broom seedlings.

**TABLE II**  
**PROGENY OF WITCHES'-BROOMS PROPAGATED VEGETATIVELY**

Species	Arnold Arboretum Accession No.	Method of Propagation	Observations
<i>Abies balsamea</i>	991-64	Rooted cuttings	Unhealthy in appearance, failed to survive.
<i>Abies cephalonica</i>	467-65	Grafted	Unhealthy, apparently diseased.
<i>Abies concolor</i>	908-65	Grafted	Unhealthy, apparently diseased.
<i>Cedrus libani</i>	249-65	Grafted	Grafts united and seemed healthy until understock was removed at which time they promptly failed. In 3 cases the understock was not removed and the scions have gone through several cycles of defoliation and foliation each year.
<i>Larix laricina</i>	681-63	Rooted cuttings	Failure of certain branches was continuous and plants petered out over a period of three years.
<i>Picea glauca</i> 'Conica'	1536-65	Rooted cuttings	Condition good.
<i>Picea rubens</i>	676-63	Rooted cuttings	Condition good.
<i>Pinus resinosa</i>	1205-65	Grafted	Multibranched, condition good.
<i>Pinus strobus</i>	313-63	Grafted	Multibranched, globe-shaped, condition good.
<i>Pinus strobus</i>	315-63	Grafted	Multibranched, globe-shaped, condition good,
<i>Pinus strobus</i>	380-65	Grafted	Broom had unnatural swellings, fissures, and resinous exudate on its branches. Propagations are pale in color and unthrifty.
<i>Pinus strobus</i>	487-65	Grafted	Multibranched, condition good.
<i>Pinus strobus</i>	1522-65	Grafted	Multibranched, condition good.
<i>Pinus strobus</i>	265-66	Grafted	Multibranched, condition good.
<i>Tsuga canadensis</i>	80-64	Grafted	Multibranched, condition good.



**PLATE XIX**

(Top) Dwarf multi-branched white pines of witches'-broom origin, propagated by grafting. (Bottom) Canada hemlock of witches'-broom origin propagated by grafting. Although over 150 Canada hemlock variants are present in the Arnold Arboretum this one appears to be distinct.

few years interest in witches'-broom propagation has expanded enormously.

A propagation of Canada hemlock (*Tsuga canadensis*) by grafting (80-64) is shown in Plate XIX (bottom). Although more than 150 Canada hemlock variants are present in the Arnold Arboretum, this one appears at present to be distinct from others in the collection.

### Horticultural Significance of Witches'-broom Progeny

Increasing interest in dwarf and slow-growing conifers has given added significance to dwarf plants of witches'-broom origin. Those propagated vegetatively have retained characteristics of the brooms from which they originated, thereby leading to slow-growing forms with year-round interest. They are suitable for use in dwarf conifer collections, rock gardens, foundation designs, and situations where plants requiring little or no maintenance are desired. Seedlings from fruiting witches'-brooms have produced large numbers of dwarf and abnormal plants, including forms of prostrate habit suitable for planting over rocks and walls. Still other seedlings characterized by central stems, horizontal leaders, and short internodes quickly develop into miniature plants presenting an appearance of age, making them ideal subjects for bonsai.

As time passes, this increased interest in propagating plants from witches'-brooms will doubtless add greatly to the list of dwarf and unusual plants presently available for horticultural use.

If perchance a reader has knowledge of a fruiting witches'-broom of any conifer, a contribution of its seeds would be welcomed by the Arnold Arboretum to further this study.

ALFRED J. FORDHAM