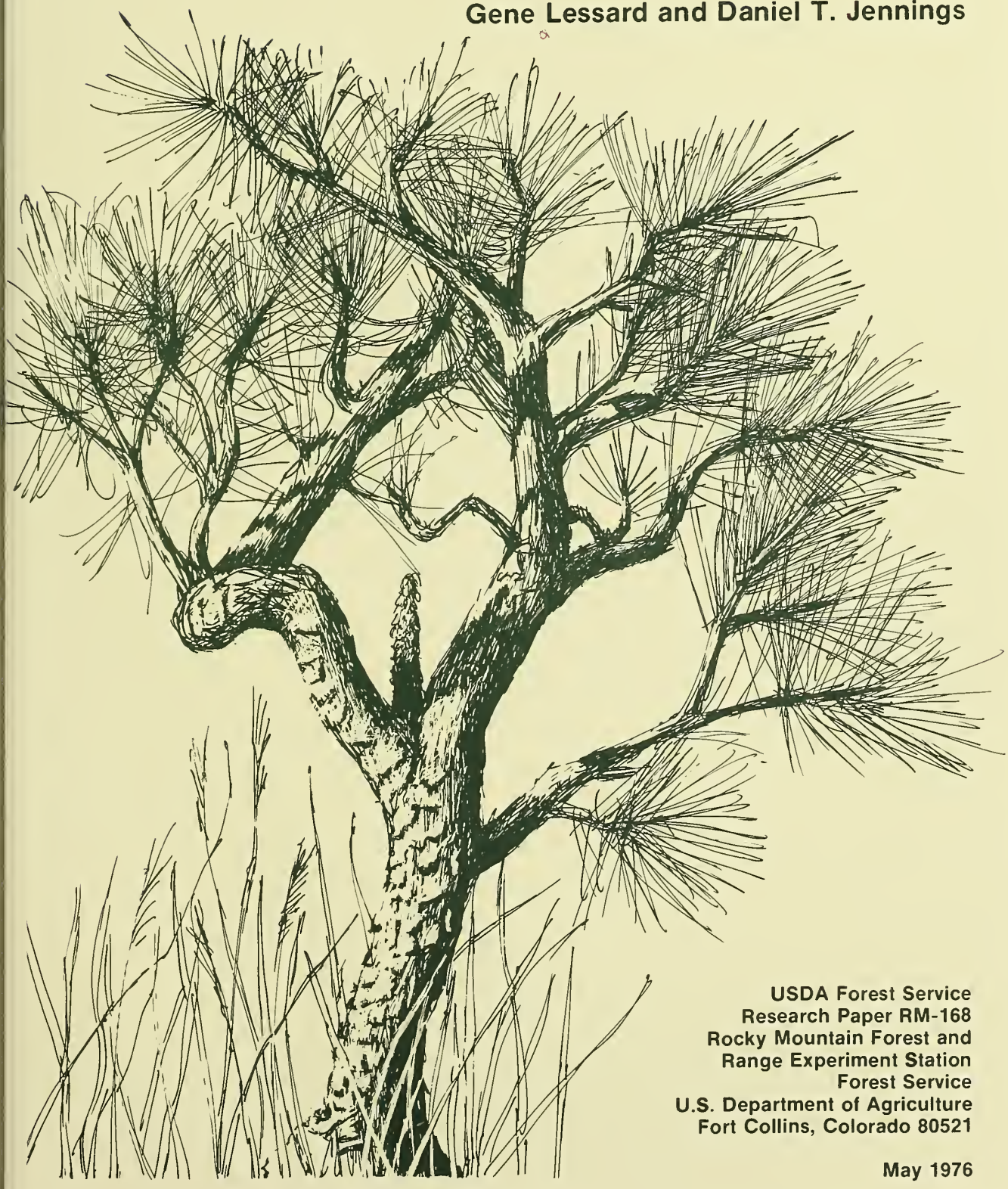
Southwestern Pine Tip Moth Damage to Ponderosa Pine Reproduction

Gene Lessard and Daniel T. Jennings



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Abstract

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As tree height increases, tip moth damage decreases. Deformities causing the greatest reduction in height growth also occur most frequently. Only 7 percent of the 5,012 whorls examined escaped tip moth damage; 89 percent had a significant height growth loss of from 13 to 40 percent.

Keywords: *Pinus ponderosa, Rhyacionia neomexicana,* insect damage.

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Introduction

Tip- and shoot-feeding insects damage trees by injuring or destroying the apical meristems or new growth centers. One such insect, the southwestern pine tip moth (*Rhyacionia neomexicana* (Dyar)), attacks and damages ponderosa pine (*Pinus ponderosa* Laws.) in the central and southern Rockies, midwestern Plains, and the Southwest. This tip moth and related species are important pests threatening the establishment and growth of pine reproduction.

Larvae of *R. neomexicana* pass through five instars and have three distinctive feeding stages: (1) a needle-mining stage before new shoots are attacked, (2) a pitch-tent stage when new needles on expanding shoots are severed and mined, and (3) a shoot-mining stage that often destroys the entire new shoot (Jennings 1975). Both terminal and lateral shoots in upper and midcrowns of young pines are susceptible to attack. Destruction of these shoots not only reduces height growth, but also deforms subsequent tree growth form.

Damage is generally greater on young ponderosa pines less than 6 to 8 feet tall. Seedlings less than 1 foot in height may be attacked the same year they are planted (Jennings 1975). Large, open areas with numerous small trees, such as naturally seeded or planted burns, seem most vulnerable to persistent infestations.

Working with the related European pine shoot moth, *R. buoliana* (Schiff.), Heikkenen (1960) grouped tree damage into the following categories: pruning, crook, fork, posthorn, bush, and spiketop. Descriptions of these damage categories on red pine, *Pinus resinosa* Ait., are given by Heikkenen (1960), Talerico and Heikkenen (1962), Miller and Schallau (1963), and Miller (1967). Similar types of damage are found on ponderosa pine due to feeding by *R. neomexicana.*

In 1956, a devastating forest fire, the Dudley Fire, burned 21,000 acres of ponderosa pine on the Chevelon Ranger District, Apache-Sitgreaves National Forest, about 45 miles south of Winslow, Arizona. Most of the Dudley Burn reseeded naturally with ponderosa pine, but large open areas were subsequently planted with ponderosa planting stock. The young seedlings, both natural and planted, soon became infested with tip moths. Surveys conducted by entomologists with the Forest Insect and Disease Management Branch, Southwestern Region, USDA Forest Service, showed that few seedlings escaped damage. In 1966, 38 percent of the seedlings examined were damaged by tip moths.[3] By 1969, this percentage had increased to 82.[4]

Although tip moths are continuing (1975) to damage young pines at Chevelon, there is some indication that thinning naturally seeded areas allows the remaining trees to grow beyond the height susceptible to tip moth attack. The smaller plantation trees, including those under heavy grass competition, are still being heavily damaged.

In 1975, studies were initiated to obtain information on how the tip moth affects ponderosa pine regeneration in the Southwest. These studies were designed to determine the nature and extent of damage and resultant deformities to ponderosa pine reproduction at Chevelon. This paper summarizes (1) the types of tree deformities found, (2) how frequently each type occurs, and (3) their possible effects on tree growth rates.

Methods

In 1968, fifteen 100-acre study plots were established on the Dudley Burn.[5] Most of the plots were located in naturally seeded areas, and were originally established to determine the effectiveness of chemical treatments for controlling tip moths. Additional study plots were established the same year in planted areas of the George, Loop, and Hatchery Burns, on the Chevelon Ranger District. Within each study plot on the Dudley Burn, 25 subplots of variable size (only 10 subplots on the George, Loop, and Hatchery Burns) were systematically established. The 10 trees nearest subplot center were then chosen and permanently tagged.

[3] *Tip moth survey, 1966, Chevelon Ranger District, Sitgreaves National Forest. 15 p. (Unpubl. rep. on file at Southwest. Reg., USDA For. Serv., Albuquerque, N.M.)*

[4] *Buffam, Paul E. 1969. Results of the 1969 evaluation of the southwestern pine tip moth trend study plots. Sitgreaves National Forest, Chevelon Ranger District, Region 3. 4 p. (Off. Rep., on file at Southwest. Reg., USDA For. Serv., Albuquerque, N.M.)*

[5] *Buffam, P. E., and C. J. Germain. 1968. Helicopter application of Cygon (dimethoate) for control of the southwestern pine tip moth,* Rhyacionia neomexicana *(Dyar). Results-Pilot Control Study, Sitgreaves National Forest, Chevelon District, Region 3. 8 p. (Off. Rep., on file at Southwest. Reg., USDA For. Serv., Albuquerque, N.M.)*

Since 1968, Forest Insect and Disease Management entomologists have measured height growth and determined tip moth infestation trends on the George, Loop, Hatchery, and nine of the Dudley Burn plots (fig. 1). Because these observations and measurements provide infestation and tree-growth histories for individually tagged trees, these same trees were examined for tip moth-caused deformities.

Tagged natural and planted trees were measured and examined for deformities in September-October 1975. By this time, *R. neomexicana* larvae had completed their shoot feeding. Tree heights were measured with telescoping 12-foot poles. Heights were measured to the nearest inch from the uppermost shoot, regardless of intrawhorl position, to ground level. For example, if the terminal shoot was destroyed by tip moth feeding, a lateral shoot generally assumed dominance. Height of this uppermost shoot aboveground determined tree height.

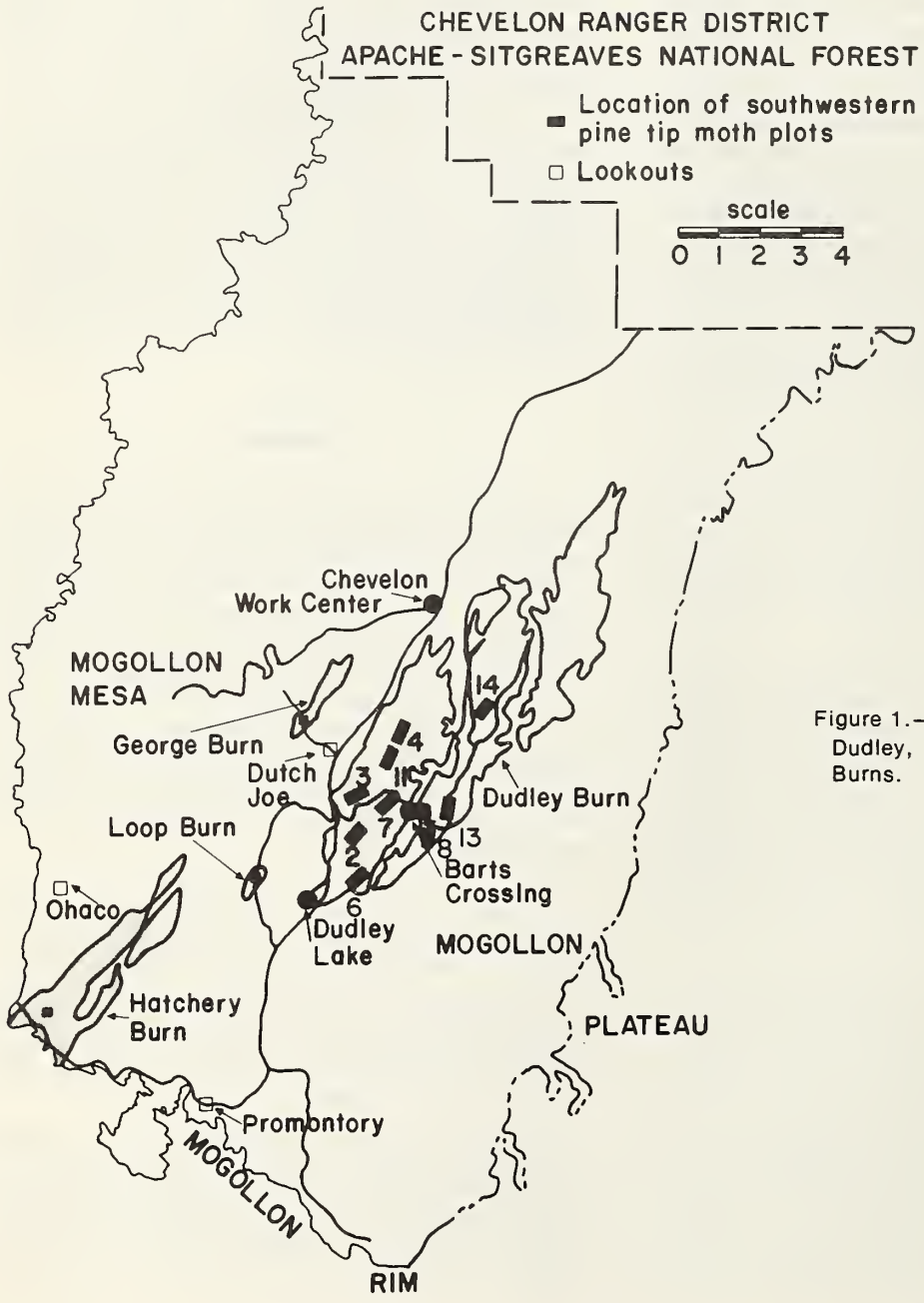


Figure 1.—Location of study plots on the Dudley, Loop, George, and Hatchery Burns.

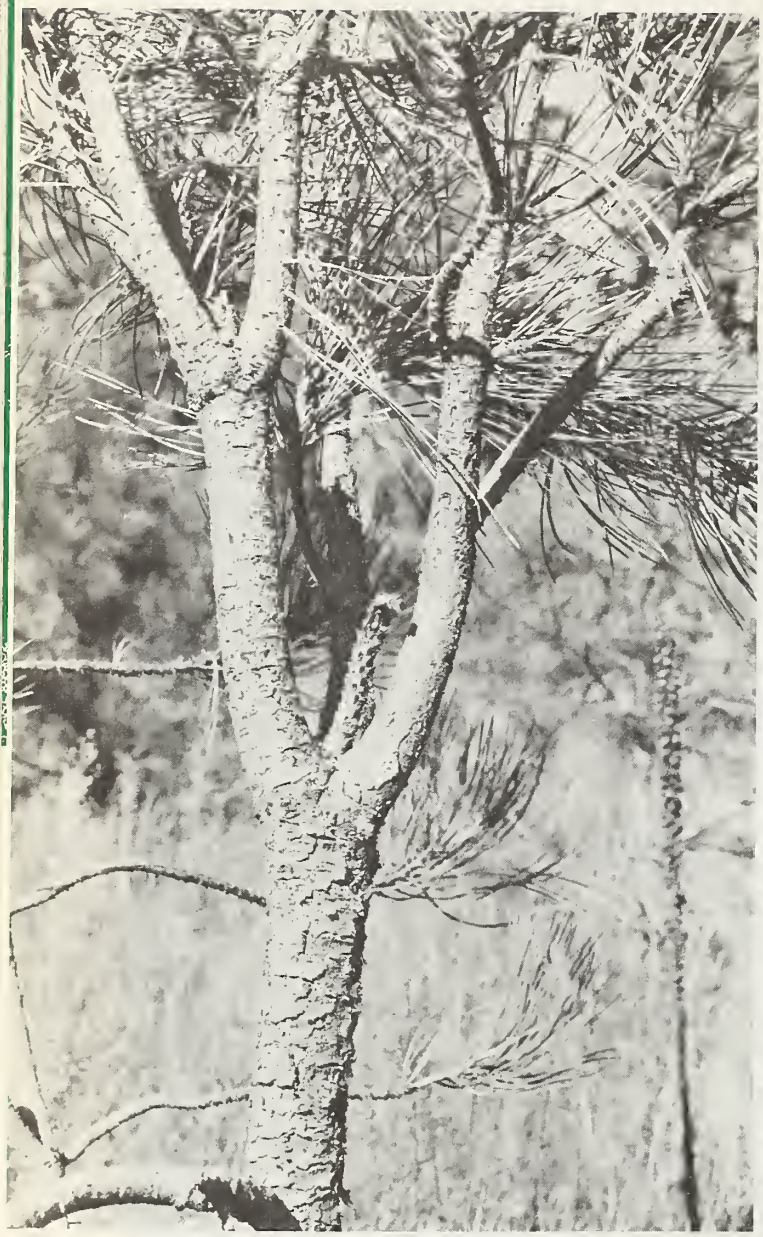
Individual whorls within trees were examined for deformities and measured for internodal growth, starting at the crown apex and working downward toward the base of the tree. Small trees were examined for three or four whorls; larger trees for five or six and occasionally seven whorls. For analysis, the type and percentage of each deformity was determined for each 10 inches of tree height. Mean height growth following each type of deformity was then determined from the internodal measurements.

Results and Discussion

Types of Deformities

The deformities found on ponderosa pine due to feeding by *R. neomexicana* are summarized as follows:

Prune: one or more lateral buds killed, resulting in fewer branches per whorl; no crook in main stem (fig. 2).



Crook: a departure from straightness, resulting from complete or partial destruction of the terminal shoot. Miller (1967, p. 13) lists four types. Lateral generally assumes dominance over damaged terminal; loss of form depends on degree of crook and number of lateral shoots that continue height growth (fig. 3).

Fork: two or more laterals assume dominance (fig. 4). Forking may follow bushing (Talerico and Heikkenen 1962); one ultimate effect of forking may be a crook, if a competing branch becomes dominant.

Posthorn: a severe crook resulting from larval feeding on only one side of the terminal shoot; feeding stops before the shoot is killed and the injured leader bends at the point of attack (fig. 5).

Bush: an increase in the normal number of branches at a whorl; adventitious buds produce multiple shoots after destruction of terminal and lateral shoots (fig. 6).

Spiketop: insect attack kills the terminal but adventitious buds *do not* develop, resulting in a dead top (fig. 7).

Frequency of Deformities

We examined a total of 5,012 whorls for tree deformities caused by tip moths (table 1). Only 7

Table 1.--Distribution of southwestern pine tip moth tree deformities, by whorl level

Damage Category	Whorl level							Total or average
	1	2	3	4	5	6	7	
				Number				
Observations	919	919	905	828	664	488	289	5012
				Percent				
SINGLE:								
Normal	11.0	5.0	6.0	5.1	6.6	6.4	13.5	7.0
Bush	15.3	6.3	6.8	4.2	7.8	9.2	10.0	8.4
Crook	8.2	9.8	9.7	10.5	10.5	7.8	6.9	9.3
Prune	21.0	15.0	12.5	17.9	18.4	21.1	18.3	17.4
Fork	1.2	2.8	1.9	1.9	1.5	1.8	1.7	1.9
Spiketop	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Posthorn	1.0	0.0	0.2	0.0	0.3	0.2	0.0	0.4
DOUBLE:								
Prune/crook	25.4	34.7	31.7	34.3	33.3	32.6	28.0	31.6
Bush/crook	14.1	21.8	27.2	23.2	20.2	18.2	21.1	21.0
Prune/fork	0.9	2.5	2.2	1.8	1.0	1.8	0.3	1.7
Bush/fork	0.5	1.2	1.6	1.0	0.2	0.8	0.0	0.9
Posthorn/fork	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Posthorn/bush	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.2
Posthorn/prune	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.1

percent of the whorls were categorized as normal, that is, without damage and having a complement of at least three lateral branches (fig. 8). Most whorls (55 percent) had a combination of two kinds of deformity, such as crook/prune or prune/fork; 38 percent had only one kind.

The crook, bush/crook, prune, and prune/crook categories accounted for about 79 percent of the deformities. The remaining categories made up 14 percent of the total whorls examined, of which only 5 percent were forks, posthorns, and spiketops. In contrast, Talerico and Heikkenen (1962) found that most European pine shoot moth damage resulted in forking, and that most forks were an outgrowth of bushing. From 60 to 90 percent of the red pine trees they sampled had forks.

As tree height increased, especially above 61 inches, tip moth damage decreased (table 2). Distribution of damage by 10-inch height classes indicates that as tree height increases: (1) percentage of normal and bush whorls increases; (2) percentage of crook, bush/crook, prune/crook and prune/fork decreases; and (3) percentage of prune remains about the same. These percentages possibly reflect

Table 2.--Percent deformity, by tree height class and damage category

Damage Category	Tree height class (inches)									
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
	Percent									
Normal	2.4	4.7	6.5	9.0	7.1	7.3	8.0	9.7	14.9	13.9
Bush	2.7	8.0	7.6	8.3	8.2	8.3	7.4	10.1	12.9	20.3
Crook	3.9	7.4	8.7	9.4	10.8	11.3	13.0	11.2	9.8	8.9
Bush/crook	25.9	18.9	20.8	21.1	21.7	23.0	21.5	20.4	19.6	16.5
Prune	13.6	19.8	16.0	15.9	17.2	17.7	19.3	16.2	14.9	25.3
Prune/crook	44.9	37.5	34.0	32.4	29.6	27.5	25.8	25.0	24.2	11.4
Prune/fork	3.9	1.6	2.3	0.7	1.1	1.2	1.1	1.2	0.5	0.0

height preferences by ovipositing females. Fewer eggs are deposited on upper crown needles more than 6 to 8 feet aboveground; consequently, larger trees sustain less tip moth damage.

Effect on Tree Growth

Three distinct deformity classes were established on the basis of analysis of variance and multiple range tests (table 3). Mean internodal height growth was significantly different (P<.05) between each of the deformity classes, but no differences were found within classes: Class I, normal and bush; Class II, crook and bush/crook; and, Class III, prune, prune/crook, and prune/fork. Deformities not included in these three classes were infrequently observed.

Table 3.--Mean internodal height growth,[1] by deformity class[2]

Type of deformity, by class	Mean internodal height growth	Standard deviation	Observations
	Inches		*Number*
CLASS I:			
Normal (no damage)	7.5	3.3	194
Bush	7.6	4.2	165
CLASS II:			
Crook	6.4	3.2	314
Bush/crook	6.5	8.0	783
CLASS III:			
Prune	5.5	3.1	520
Prune/crook	5.0	2.9	1229
Prune/fork	4.5	2.0	59

[1]Internodal growth following each deformity class.
[2]Classes are significantly different at P<.05.

Mean internodal height growth following fork (6.1 inches) was significantly different from Class I deformities, but not from Class II or III deformities. Also, no differences were found following posthorn (6.8 inches) or bush/fork (6.3 inches), or between these two damage categories and all other damage categories.

Height growth following crook and bush/crook was significantly less than that following the normal internode. Pruning and combinations of prune/fork and prune/crook produced even greater departures from normal. Reduced height growth following crook is probably a function of the severity of the crook. Although pruning causes no departure from straightness, loss of height growth may be a function of reduced photosynthetic area necessary for terminal growth.

Only 7 percent of the 5,012 whorls examined escaped tip moth damage; 89 percent of the whorls had a significant height growth loss of from 13 to 40 percent. Although we have no data on long-term effects of the southwestern pine tip moth on ponderosa pine, Miller (1967) found that red pine eventually outgrows crook and bush deformities. In the Southwest, ponderosa pines taller than 6 to 8 feet are less susceptible to attack by the southwestern pine tip moth. Some deformities probably persist as the tree matures, however, and may appear later as defects in merchantable trees. Ffolliott and Barger (1967) quantified some stem features, including crook and fork, that reduce quality of southwestern ponderosa pine. Perhaps some of these defects may be attributed to earlier tip moth infestations.

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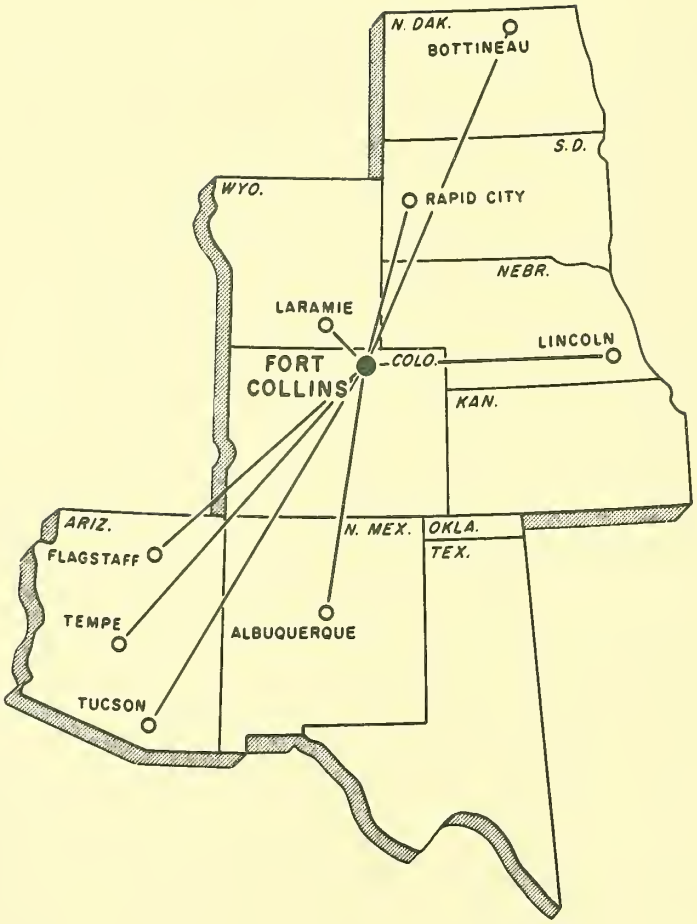
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