

be the ultimate aim. *P. radiata* at present the main species, and likely to continue so; in frost subject localities replaced by *P. ponderosa*; information meagre as to timber qualities of species other than *P. radiata*; such species require longer rotations, so timber must be markedly superior to render their growing attractive. The tending to be given to stands may influence re-establishment methods; present high proportion of low grade material might be reduced by thinning, wider spacing or pruning; possibilities and difficulties are briefly outlined.

REGENERATION OF CLEAR FELLED INSIGNIS PINE AT WHAKAREWAREWA STATE FOREST, ROTORUA.

By J. F. LYSAGHT.

Introduction.

Insignis pine (*Pinus radiata*) has been established in New Zealand for many years. It grows extremely fast, bears cones freely and regenerates on to open land near standing trees where conditions are suitable. In many parts of New Zealand and in the Rotorua District in particular, many thousands of acres have been planted in this species. Harvesting of the crop is now commencing in earnest with the clear felling of hundreds of acres annually. Most of this land is unsuitable for other purposes and will continue to be used for forest purposes so that re-establishment now becomes a problem of importance.

Previously felling was almost entirely from farm shelterbelts or small isolated areas which in most cases were not re-forested but reverted to grazing. At other times burning of the slash and replanting was practised, while in a few places exclusion of stock after felling resulted in abundant natural regeneration. In Whakarewarewa State Forest clear felling of *Pinus radiata* has been carried out over the last four years at a rate of more than 80 acres a year, and it is here that this study of regeneration has been made.

Description of Area.

Most of the area clear felled has been in Compartment 22 which is divided into two parts; 22/1 is of 236 acres, sloping down from 2,400' in the extreme south to rolling country at about 1,400' occupying one-third of the area in the north; 22/2 is of 284 acres and slopes fairly steeply from 2,400' on the east to 1,200' on the west. The higher slopes of both sub-compartments, particularly 22/1, represent a somewhat poorer site quality and are more exposed to the wind. The soil consists of from 4" to 6" of dark loam over loose gravelly pumice with occasional outcrops of rhyolite rock.

Meteorological returns show that Rotorua has an average annual rainfall of 50 inches falling on 125 days. The maximum temperature is 90°F. and the minimum 23°F. with ground frosts on 55 days during the months of May to August. Light falls of snow occasionally occur at elevations above 1,800' but do not lie for any length of time. The prevailing wind from the south and south-west exceeds force 4 on the Beaufort scale only on some 20 days during the year and rarely exceeds force 5.

Sub-compartment 22/1 was planted with *Pinus radiata* in 1915 at a spacing of 8' by 4' (1,360 trees per acre) and sub-compartment 22/2 was planted in 1914 at a spacing of 6' by 3' (2,420 trees per acre). The whole compartment was originally covered with a heavy growth of bracken (*Pteridium aquilinum*), tutu (*Coriaria arborea*) and other indigenous shrubs and small trees. No thinning had been carried out prior to clear felling; there had been almost complete natural selection with many dead suppressed standing trees on the area.

An assessment survey carried out in 1940 on the linear plot system gave the following figures:—

Sub-compartment	...	22/1	.....	22/2
Living trees per acre	...	238	.....	280
Standing dead trees per acre	...	525	.....	444
Minimum D.B.H.	... ..	6"	.....	5"
Maximum D.B.H.	... ..	20"	.....	22"
Average D.B.H.	... ..	13.2"	.....	12.6"
Volume per acre I.B. to 6" top.		6715 cu. ft.		7732 cu. ft.

By the end of March, 1944, the whole of sub-compartment 22/2 had been clear felled, yielding an average of 7,790 cu. ft. per acre. By the same date 57 acres of sub-compartment 22/1 had also been felled; this was mainly the better timber on the lower slopes in the north and was yielding an average of 8,300 cu. ft. per acre.

The clear felling of the stands was commenced in 1939, on the lower slopes to the west of sub-compartment 22/2 gradually extending to the upper slopes. A small area was taken from the upper slopes of sub-compartment 22/1; then operations were shifted to the lower slopes in the north early in 1944. The rate of felling has been as follows:—

Sub-compartment	22/1	22/2
1939-40	—	2 acres
1940-41	—	79 acres.
1941-42	—	86 acres.
1942-43	16 acres	68 acres.
1943-44	41 acres	49 acres.
	—	—
	57 acres	284 acres.

Logging was entirely by tractor until June, 1941, when a diesel hauler was used to work some of the steeper slopes. Since then both hauler and tractors have been used.

Records of Investigation by Sample Plots.

Immediately felling commenced, the possibilities of natural regeneration were considered and tested by the establishment at intervals of plots of a square chain (one tenth acre) each. Over the greater part of the period these have been located in positions considered to give a reasonable representation of different parts of the compartment. At a later date more attention was paid to dates of felling and, more recently still, a plot has been established every month immediately after felling. To date, 36 plots have been established but some of the most recent of these have no regeneration as yet and a further number have some seedlings but will probably have more at later counts, so are not yet fully stocked. These plots are recounted at intervals of about six months and the results tabulated. The following is a list of the plots showing the number of trees at the last count, the month of felling and the month of the last count.

No. of Plot	No. of Trees at Last Count	Date of Clear Felling	Date of Last Count
1	497	Feb. 1940	June 1943
2	241	Sept. 1940	June 1943
3	106	Apr. 1940	Jan. 1944
4	19	Mar. 1940	Jan. 1944
5	617	Sep. 1940	Jan. 1944
6	541	Nov. 1940	Jan. 1944
7	128	July 1941	Jan. 1944
8	96	Sept. 1941	Jan. 1944
9	505	June 1942	Jan. 1944
10	124	Apr. 1942	Jan. 1944
11	138	Mar. 1942	Jan. 1944
12	81	Dec. 1941	Mar. 1944
13	401	June 1941	Sept. 1943
14	861	Feb. 1941	Sept. 1943
15	12	Apr. 1941	Jan. 1944
18	671	Apr. 1942	Mar. 1944
19	938	Apr. 1943	Mar. 1944
20	324	Apr. 1942	Mar. 1944
21	61	July 1942	Mar. 1944
22	124	Aug. 1942	Mar. 1944
23	407	Oct. 1942	Mar. 1944
24	139	Jan. 1943	Mar. 1944
25	271	May 1943	Mar. 1944
26	92	Sept. 1943	Aug. 1944
27	44	Oct. 1943	Aug. 1944

28	124	Nov. 1943	Aug. 1944
29	192	Dec. 1943	Aug. 1944
30	44	Jan. 1944	Aug. 1944
31	34	Feb. 1944	Aug. 1944
32	2	Mar. 1944	Aug. 1944
33	—	Apl. 1944	Aug. 1944
34	—	May 1944	Aug. 1944
35	—	June 1944	Aug. 1944
36	—	July 1944	Aug. 1944

An attempt has been made to correlate climatic factors with the numbers of trees on plots, but the results are not very conclusive, partly owing to the influence of other factors and partly to the fact that regeneration continues to appear up to two years after felling. From the figures of the plots so far established and counted, it seems that plots in fellings of the months of February, April, May, June, September, October, and November have produced the best regeneration, while fellings in July, August, December, January and March are not so good.

In an attempt to discover whether any climatic factors had a deleterious effect on regeneration a study of the ten least successful plots was made. These are listed below together with a record of the weather during the month of felling and the subsequent month :—

Plot	No. of Trees	Date Felled	Month of Felling			Month after Felling		
			Rain	Max. Temp.	No. of Frosts	Rain	Max. Temp.	No. of Frosts
15	12	April 1941	1.26"	68°	5	.98"	70°	7
4	19	Mar. 1940	.55"	78°	1	2.30"	73°	7
21	61	July 1942	6.77"	64°	13	7.98"	63°	10
12	81	Dec. 1941	3.62"	—	Nil	7.99"	—	Nil
8	96	Sept. 1941	2.70"	72°	Nil	7.83"	68°	Nil
3	106	April 1940	2.30"	73°	7	4.26"	65°	7
22	124	Aug. 1942	7.98"	63°	10	11.50"	68°	2
7	128	July 1941	4.62"	62°	17	7.24"	62°	15
11	138	Mar. 1942	4.71"	—	1	2.38"	76°	4
24	139	Jan. 1943	2.22"	91°	Nil	2.36"	82°	1

Generally, but not invariably, it seems that poor regeneration has resulted when the month of felling and the subsequent month have been drier than average or when these two months have had a number of frosts. This agrees with a previous finding wherein July and August, two of the coldest, and December, January and March, three of the hottest months, show poor regeneration.

Referring to the previous statement that regeneration continues to appear up to two years after felling, the following is the record of some plots counted at 12 months and 24 months after felling.

Plot No.	Number of Trees	
	At 12 months	At 24 months
2	155	228
5	313	621
6	158	520
7	77	144
8	55	96
10	66	124
13	369	426
18	548	671
20	266	324
Average	223	350

Other plots exhibit the same tendency though they have not been counted at the same intervals.

Other Operations of Interest.

Planting was carried out over an area of 12 acres in 1941, some six months after felling. The planted trees are doing quite well, but are now surrounded and mostly surpassed in height growth by natural regeneration which started about the same time.

Tops and debris over an area of about six acres were burned in June, 1942, with the object of opening the cones and by destroying the slash to give the regeneration a good start. In practice it was found that the fire destroyed the seed in the cones and on the ground and that regeneration was poor or absent.

This burned area was planted in August, 1943, with 2/0 *Pinus radiata*. The planted trees are not doing as well as natural regeneration on neighbouring areas.

In July, 1943, a grid survey was made over that part of sub-compartment 22/2 felled previous to August, 1941, and in this it was found that almost the whole of the area had regenerated quite well. There was at that time no regeneration on a steep fern slope in the centre of the area that may not originally have been planted, on the experimental burned area nor on various log skid sites where the soil had been bulldozed down to the bare pumice. There was poor regeneration on two small areas in the bottom of gullies.

In August, 1944, some 2,400 *P. radiata* trees were planted, principally on open firebreaks to the north-west of sub-compartment 22/2, but a proportion of these was also used in blanking up some of the more sparsely stocked areas on the lower slopes on the west side of the compartment.

A further experiment that is of interest in its bearing on the seed supply for regeneration was the testing of stem cones for viable seed. Cones were collected from points on the stems of dominant, intermediate and suppressed trees in sub-compartment 22/2 and the age of each whorl determined by ring counts and the position of whorls of branches. Cones were opened and the seed extracted and tested. From the results of these tests it was found that cones which had been on the tree up to 20 years (i.e. when the tree was 18 years old) still had a small amount of viable seed; whereas stem cones up to eight years old contained a considerable proportion of viable seed.

Factors Affecting Regeneration.

Slash was present in large quantities from the tops of felled trees and from the large number of standing dead trees. The method of working leaves some parts of the area almost clear and other with just a scattering of branches; these present no obstacle to regeneration. In other places tops have been heaped to a depth of three to four feet; here regeneration may be delayed for a year until the needles have fallen. Only in comparatively few places, such as the bottoms of small depressions, is there a sufficient accumulation of slash to prevent re-establishment entirely.

Similarly logs, where washed down into heaps in the bottoms of gullies, have prevented regeneration over small areas. Slash also makes difficult the planting up of any areas which have not regenerated successfully.

The only animals present in considerable numbers are deer, which feed mainly on five-finger (*Nothopanax spp.*). They do not appear to eat the leaves or shoots of the pines but occasionally trees about 6 ft. high are killed by barking.

In the spring in some places the wings of seeds have been found from which the seed has been taken. This may be done by either field mice or birds but the loss has not had any serious effect on the quantity of regeneration.

Weeds are present in considerable quantity but are not of very great consequence. Scotch thistle appears profusely the year after felling but does not seem to prevent regeneration, and may even be an advantage in providing a certain amount of shelter. *Fuchsia*, *Coprosma*, *Aristotelia*, and other indigenous shrubs become noticeable the second year after felling but the young *P. radiata* are well able to compete with them except perhaps in a few damp gully bottoms. Tutu appears in the second year, mainly along old haulings tracks,

has a fast rate of growth and is capable of suppressing young pines but is limited in its distribution. Bracken is heavy on the firebreaks on the edge of the compartment but does not appear to have spread into the interior to any extent. Blackberry (*Rubus fruticosus*) is common in the vicinity but appears in the felled area only as scattered bushes of little consequence. Larch and Douglas fir seedlings have come into the area in small numbers from Compartment 14 on the west but will probably not survive in competition with *P. radiata*. Likewise *Eucalyptus viminalis* has appeared in small numbers from Compartment 18 to the south.

The pine bark beetle (*Hylastes ater*) is breeding profusely in stumps and logs on the clear felled area and the adults have killed a number of trees by ring-barking at the root collar. This has usually been less than 5% of the trees on the plot but in one case deaths reached as high as 24% ; but here it has still left a stocking of over 1,000 trees per acre. At the end of the second year, when the young pines are over three feet high, there are no further losses from this cause.

The shoestring fungus (*Armillaria mellea*) was present to a marked extent in the stand before felling and has attacked and killed some of the regeneration, usually trees two to three years old, but in no case has this disease killed more than three per cent. of the trees in any plot.

Summary.

Plantations of *Pinus radiata* in the Rotorua district are now being clear felled to an increasing extent and in Whakarewarewa State Forest some 80 acres per annum have been felled since 1940.

The compartments now being worked were planted in 1914 and 1915, and in 1940 carried some 250 living trees per acre, averaging 13 ins. in diameter. The trees were clear felled and the logs extracted by both hauler and tractor.

Natural regeneration has occurred in considerable quantity and has been studied by periodic observations on tenth-acres ample plots.

These reveal stockings of from 100 to over 9,000 trees per acre. Climatic factors appear to have little effect on the amount of regeneration except that heavy frosts or unusually dry periods reduce the number of seedlings. Planting immediately after felling has been tried, but has proved unnecessary. Burning removes slash and weeds

but also destroys seed ; planting after burning does not appear entirely successful. In addition to the plots, a grid survey shows a very satisfactory state of re-establishment. A small amount of planting up of poorly regenerated areas has been carried out.

The presence of slash, deer, insects and fungi has had only a minor effect on regeneration, so that in spite of them, stocking is still good.

FURTHER WAR IMPRESSIONS OF SOME WOODS IN SOUTHERN ENGLAND. *

By A. L. POOLE.

Amongst the numerous woodland areas at present being worked by the New Zealand Forestry Companies in the South of England, are two of considerable historical interest in that they were once Royal Forests. These are Woolmer Forest in Hampshire, and Savernake Forest in Wiltshire.

The use of the term "Forest" in England originally implied areas annexed by a despotic monarchy for the purpose of providing him with revenue and for the preservation of animals, usually deer, for the hunt. This seizing of land commenced in Saxon times, but the practice was greatly increased under the Norman kings, and excessively stringent "Forest Laws" were passed dealing exclusively with these "Forests." Such afforested areas reached their peak in the eleventh and twelfth centuries when whole counties such as Devon, Cornwall, Essex, Leicestershire etc. came under Forest Law : estimates of their extent during these times range to as high as one-third of the total area of the Kingdom. A Forest therefore included within its bounds open land, cultivated land and woods but in some instances, such as the Forest of Dartmoor, may have possessed no woods at all. From time to time the hunting rights on parts of the areas were granted to subjects, and they were sometimes even allowed to enclose areas which became known as Parks. The chief officers of the King's Forests were men of high standing known as Keepers or Wardens and in some instances these positions were even hereditary.

* This article was received in 1942. Mr. Poole contributed "War Impressions of Some Woods in Southern England" to the last issue of the Journal while he was attached to the 15th Forestry Company, N.Z.E.—Ed.