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Cone Crop Fluctuations in Scots Pine and Norway Spruce

An investigation based on the cone counts carried out by the National Forest Survey in the years 1954—1962 and on the reports submitted by Forest Service rangers on the cone setting in the years 1909—1961.

Om kottsättningens fluktuationer hos tall och gran

En utredning grundad på riksskogstaxeringens kotträkningar åren 1954—1962 och på kronojägarnas rapportering över kottsättningen åren 1909—1961.

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Cone Crop Fluctuations in Scots Pine and Norway Spruce

The annual flowering and fertilization of forest trees has long been observed by the Forest Service rangers. Since 1954 the cone setting of Scots pine (*Pinus silvestris L.*) and Norway spruce (*Picea abies L.*)[1] is also observed by binocular at the annual National Forest Survey. The latter registration is superior to that carried out by the State rangers in the respect that it provides an idea of the real values of the differences between the cone crops in various years and in various parts of the country. The estimations carried out by the State rangers only consist in a subjective estimation of the cone supply in relation to that which is normal for the district.

In spite of its limitations as well as other deficiencies, the long series of State ranger observations contains valuable information. This paper is intended to deal with comparisons between the two series of observations concerning the cone setting of Scots pine and Norway spruce in Sweden and to attempt on the basis of the comparisons to elucidate the fluctuations of the cone setting with particular attention to the pattern of cone setting in respect of time in various parts of the country. At the planning of the collection and storage of forest tree seeds it is of great value to know the basic conditions.

1. The cone counts of the National Forest Survey

The main object of the Swedish National Forest Survey after 10-year cycles is to present reports with about equal degree of exactness for various parts of the country. Since the extent of forest land decreases from north to south, the country has been divided into so-called regions (cf. fig. 1) with different intensities of survey.

The principles of the survey may be described as follows: On the basis of map material available the positions of a number of survey tracts have been determined indoors according to a pattern designed in advance. A certain quotient of these survey tracts are surveyed annually. The tracts are then chosen so that they are always spaced

[1] These two species generally slied their seed in late winter or in the spring. Reports on the cone-production published in the autumn will therefore be of value for the planning of seed-collections.

throughout the country. This procedure provides a uniform sampling and the results of measurements in one year are (exc. statistical variations) directly comparable with those in the following year. Every survey tract has the form of a square. The survey teams proceed along the tract sides and the measurements are mainly made within sample plots laid out at even intervals.

Ever since 1954 observations on the cone supply are made by the National Forest Survey in various parts of the country. The observations pertain to 2-summer old cones of Scots pine and one-summer-old cones of Norway spruce and they are obtained by binocular observations of trees selected randomly with restriction to trees larger than 10 cm at breast height and older than 40 years. The cones are counted on the most easily surveyed half of the tree crown at the time of observation.

Depending on the result of the cone count the trees observed are recorded in some of the following classes:

Cone class	1	2	3	4	5
No. cones	0 — 9	10 — 49	50 — 99	100 — 199	200 +

The compilation of the cone counts is briefly carried out so that the regional values are calculated for the number of cones on dominant and codominant trees distributed by seven diameter classes. The mean value of these cone numbers approximately corresponds to the yield of cones on trees with DBH = 25 cm. A report on the procedure of the calculations has previously been presented by HAGNER (1957). The numbers of cones have been adjusted to pertain to the entire crown of the tree. Investigations of the relationship between the number of cones observed by binocular and the total number of cones per tree have been reported by HAGNER (1955 and 1957).

The growing experience of the National Forest Survey sampling of the cone setting and its dependability has led to a current reporting for a large number of smaller part areas (cf. fig. 1). So doing, it has been endevoured to obtain as many areas as possible, but no more than that which usually gives a sufficient number of observations to support the number of cones calculated. Guiding the choice of area size have been the experiences concerning the accuracy of cone observations reported by HAGNER (1965).

The advantage of the small area values is that these values facilitate a detail study of the fluctuations of the cone yield. The intensive piec-

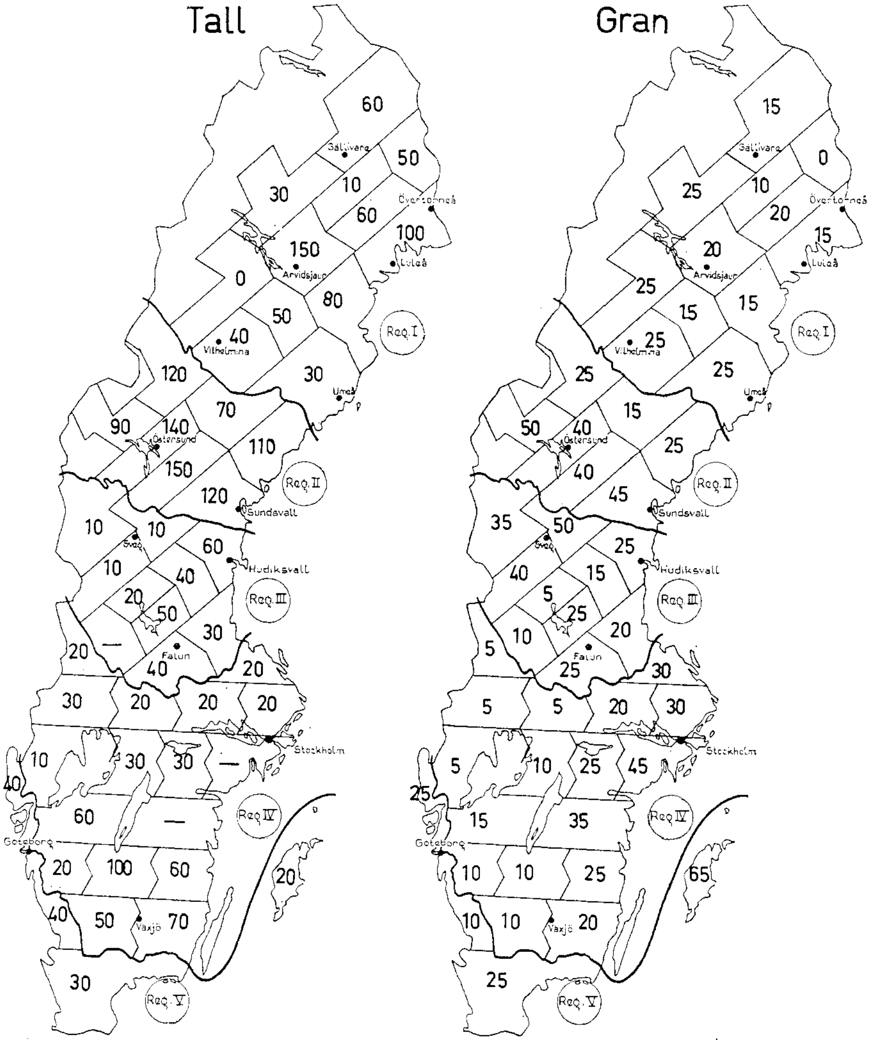

Fig. 1 Division into regions and small areas applied at the grouping of the cone observations made by the National Forest Survey and the number of cones per tree within the small areas in 1960.
Tall = Scots pine Gran = Norway spruce
Region- och småområdesindelning vid grupperingen av riksskogstaxeringens kottobservationer samt kottantalet per träd inom småområden år 1960.

ing up of the country naturally means that the individual area values are affected by greater standard errors than the regional values. Neither do they reflect, as do the latter, the number of cones on dominant and codominant trees but consist of gross mean values that are influenced by the current compositition of tree-sizes within the area

Table 1 Average number of cones per tree according to the National Forest Survey. Dominant and codominant trees, about 25 cm DBH.

Det genomsnittliga kottantalet per träd enligt riksskogstaxeringens mätningar uttryckt i antal kottar. Härskande och medhärskande träd, ca 25 cm DBH.

Year År	Scots pine Tall					Year År	Norway spruce Gran				
	Region						Region				
	I	II	III	IV	V		I	II	III	IV	V
1954	22	22	27	72	53	1954	66	78	85	127	104
1955	27	93	109	146	96	1955	0	0	0	0	0
1956	35	44	88	38	40	1956	36	48	46	60	35
1957	59	130	121	59	77	1957	0	0	9	13	20
1958	36	26	28	127	65	1958	40	41	13	42	49
1959	97	58	129	123	196	1959	0	20	37	25	15
1960	62	118	40	55	36	1960	29	40	32	21	27
1961	128	70	200	100	90	1961	9	9	0	0	0
1962	78	50	64	80	110	1962	0	10	29	35	27

concerned, the occurrence of trees belonging to various crown storeys a. s. o.

The regional values obtained so far concerning the cone setting are shown in table 1. At a judgement of the general level in each region and at comparisons between seed crops of various years it is suitable to use this series as a basis for reasons discussed above.

2. Cone setting as estimated by the State rangers

The rangers of the Forest Service have observed flowering and seed setting of Scots pine, Norway spruce, birch, oak and beech ever since 1895 when the first instruction for estimation was written. For reasons mentioned by TIRÉN (1935), however, the results of estimation were difficult to interprete up to 1908. After that year the instruction was written in the form that has been maintained without alterations up to 1961 when this kind of reporting ceased.

According to the instruction the State rangers were to estimate the relative intensity of flowering and cone setting within their districts in agreement with the following scale: 0 = none, 1 = poor, 2 = fair, 3 = rich and 4 = abundant.

Ever since 1909 the cone setting indices of the State rangers have been reported in the form of rounded management averages (e. g. vide fig. 2). Further mean value calculations lead to values for large districts. TIRÉN (1935) stressed that the individual data from State rangers or from management units could be very independable. It may be possible e. g. that neighbour State rangers have influenced each other at the estimation. By means of the cone counts of the National

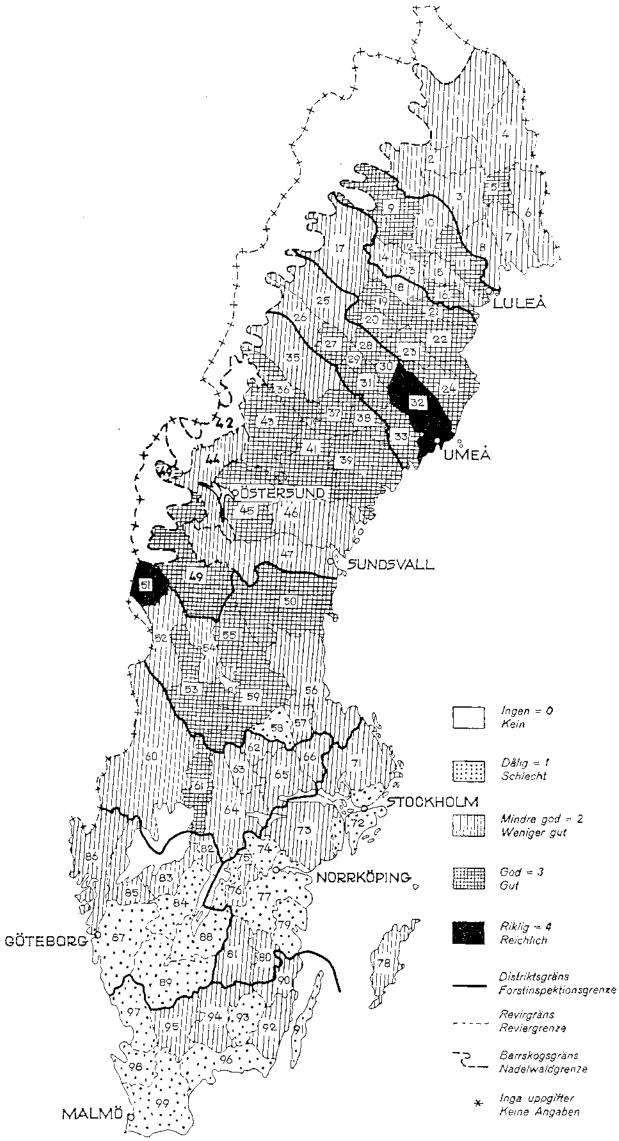

Fig. 2 Supply of 2-year old cones of Scots pine in the autumn of 1957 according to estimations made by State rangers. 0 = None, 1 = Poor, 2 = Fair, 3 = Rich, 4 = Abundant.
Tillgången på 2-årig tallkott hösten 1957 enligt kronojägarnas bedömning.

Forest Survey we shall here add another aspect to the independability of the individual estimations. Since the two series of observations have proceeded parallel to each other for eight years, there are certain possibilities to make comparisons.

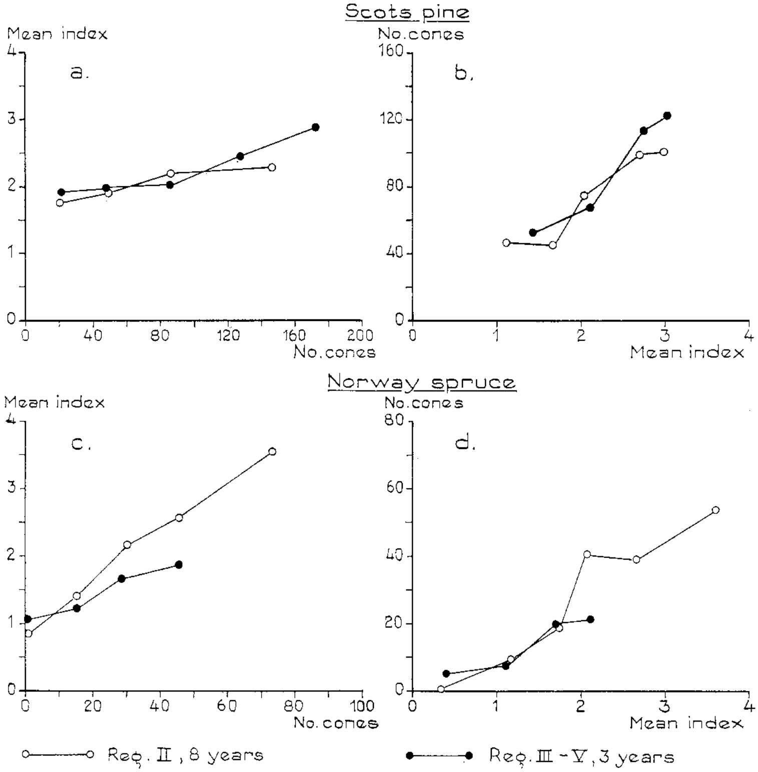

Fig. 3 Relationship between the number of cones per tree according to the observations of the National Forest Survey in small areas and the corresponding number according to the State ranger reports. In figs. 3 a and 3 c the State ranger observations have been grouped by the number of cones according to survey and in figs. 3 b and 3 d the survey data have been grouped by State ranger indices in the area concerned. Cf. text.

Sambandet mellan kottantalet per träd enligt riksskogstaxeringen inom småområden och motsvarande enligt kronojägarnas bedömning. I fig. 3 a och 3 c har kronojägarobservationerna grupperats beroende på kottantalet enligt taxeringen och i fig. 3 b och 3 d har taxeringsuppgifterna grupperats beroende på kronojägarindex inom resp. område. Jfr text.

3. Special scrutiny of the State ranger observations

3. 1 Grouping

Since the cone data collected by the National Forest Survey are currently referred to small areas, the values concerning cone supply can be compared with the corresponding State ranger reports. In each small area of the kind there is then only a small number of State ranger observations supporting the corresponding average index.

By compiling the cone counts recorded by the National Forest Survey into groups in reference to the average index of the State rangers in these small areas, it should be possible to get an average concept of the number of cones that corresponds to the indices of the State ranger reports. However, we must then assume that all the State rangers have applied equal standards of estimation, which must be considered unrealistic at a closer thought.

In practice the population of observers is expected to be composed of persons who have consistently estimated high and others who have estimated low. If we study all the occasions when a good cone supply has been reported and all the occasions when supply is estimated as poor, it is probable that the average observers in the groups have had different standards of estimation. In the group with high average indices, the cone crop, taking into account an average rather 'optimistic' estimation, should be correspondingly lower and in the group with low indices, on account of a more 'pessimistic' view, correspondingly higher than that estimated had each group been uniformly composed in respect of observers.

A desirable composition of that kind can be obtained e. g. by grouping instead the mean index of the State rangers in the small areas over the nearly true numbers of cones recorded by the National Forest Survey. If a sufficient number of comparisons of the kind can be made at various levels of cone yield, the population of observers on each level can be considered similarly composed.

The justifications of the assumptions outlined above is shown by comparisons the results of which are presented graphically in fig. 3. The comparisons have been made for two areas, for both Scots pine and Norway spruce. First scrutinizing the relationship where the average indices of the State rangers have been put in relation to the number of cones according to the National Forest Survey, a procedure considered the most correct one according to reasons mentioned above, we find that great real differences in respect of Scots pine cone yield only correspond to slight differences in respect of the mean index. This statement must be interpreted to mean that the average inconsistency has been great at the ocular estimation of the current cone crop. Great real differences have only caused a slight change in the concept of the average observer. The corresponding graph for Norway spuce shows a relationship with steeper slope to the effect that a low supply of cones in reality corresponds to low indices, and a good supply of cones corresponds to high indices. Apparently, it has been considerably easier for the average observer to express a differentiated concept of the cone setting in Norway spruce than of that in Scots pine. Considering the differences between the species in respect of fertilization, this finding is hardly any surprise.

We now proceed to compare the results of the opposite method of grouping, i. e. the one where the number of cones per tree in the small areas have been grouped by the extent of cone setting reported by the State rangers. Fig. 3 b then shows e. g. that small groups of observers that recorded a Scots pine cone index 1.5 on an average were found in areas where the National Forest Survey recorded about 50 cones per tree. A group of observers of average composition (fig. 3 a) would instead have produced an estimation of »about 2» for this cone crop. In a corresponding manner observers recording good supply of Scots pine cones (= 3) have occurred in areas with an average of 100—120 cones per tree. Fig. 3 shows that a group of observers of a more average composition would have estimated similarly only at the very highest yield of cones. For Norway spruce, fig. 3 d can be compared with fig. 3 c in a corresponding way. The risk of relying on observations made by individual persons or by small groups of State rangers apparently applies to Norway spruce cone setting as well, though the discrepancies are not so great as those with Scots pine. Fig. 3 c further shows that a lower amount of spruce cones is required in region II than farther south to result in a high index. Knowing that the cone yield of Norway spruce decreases strongly toward the north (vide HAGNER 1957), we may accept this indication as a confirmation that the scale of estimations applied by the State rangers is really adapted to the locally prevailing variations in respect of the cone setting ability of the trees.

The experiences made must lead to the conclusion that work with the State ranger reports must be carried out by establishing large or uniformly composed groups of observers in order to produce comparable values. Naturally, grouping must not result in all too large areas being lumped together as the mean index then certainly becomes more dependable but, too, increasingly uninteresting. The purpose of reporting has been to facilitate the localizing of areas where cone setting occurs. Precision in this work is certainly impaired when the area treated as unity increases. It has been considered fairly suitable in the following work to compile the State ranger reports into annual mean indices computed for each one of the five regions treated previously and used by the National Forest Survey. The values then obtained for the years 1909—1961 are presented in table 2.

Table 2 Annual mean indices for various regions according to the State ranger reports on cone setting.

Årsvisa medelindex för olika regioner enligt kronojägarens bedömning av kottsättningen.

Year År	Scots pine Tall Region I	II	III	IV	V	Year År	Norway spruce Gran Region I	II	III	IV	V
1909	0,97	1,11	1,00	1,38	1,33	1909	1,21	1,33	1,00	1,74	1,67
1910	2,33	2,22	2,50	1,91	1,50	1910	1,79	2,44	2,60	2,26	0,83
1911	1,94	1,36	1,27	1,63	1,50	1911	1,58	1,00	1,45	1,95	2,17
1912	2,33	2,36	2,36	2,32	2,00	1912	1,27	1,55	1,55	0,84	0,50
1913	2,67	2,09	2,82	2,24	1,83	1913	3,21	3,82	3,64	2,54	1,67
1914	2,55	1,91	2,00	1,89	1,83	1914	1,48	1,00	1,18	1,13	0,83
1915	2,15	1,82	1,92	2,08	2,00	1915	2,76	2,36	2,62	3,56	3,62
1916	2,15	1,91	2,27	2,00	2,00	1916	1,32	0,82	0,73	0,50	0,88
1917	1,77	1,82	2,27	1,85	1,62	1917	2,55	2,45	2,13	0,32	0,62
1918	2,04	1,73	2,20	2,00	1,88	1918	0,62	0,36	1,47	3,55	3,25
1919	3,38	3,00	2,13	1,85	1,88	1919	1,68	1,45	0,33	0,30	0,25
1920	2,07	1,64	2,00	1,86	2,12	1920	1,31	0,93	0,88	0,26	0,38
1921	1,91	1,71	2,00	1,91	1,88	1921	3,36	3,71	3,12	3,28	2,75
1922	2,11	1,71	1,94	2,09	2,00	1922	0,96	0,29	1,00	0,88	1,88
1923	2,19	2,43	2,67	3,07	2,75	1923	1,09	1,43	0,67	0,26	0,38
1924	2,15	2,07	2,00	2,07	2,12	1924	1,44	2,64	2,80	3,65	3,50
1925	1,72	1,79	1,93	2,00	2,00	1925	3,43	2,57	1,33	0,12	0,25
1926	2,49	2,14	2,27	2,10	1,88	1926	1,30	1,29	1,40	0,93	0,88
1927	2,12	1,71	2,13	2,07	1,86	1927	1,10	1,64	2,47	2,73	2,29
1928	2,10	1,64	1,73	2,17	1,57	1928	2,70	3,00	2,47	3,12	3,00
1929	1,78	1,21	1,73	2,05	1,57	1929	0,38	0,57	0,40	0,15	0,43
1930	1,35	1,14	1,80	2,28	2,14	1930	0,71	1,00	1,53	0,97	0,29
1931	1,63	1,71	2,07	2,62	2,00	1931	3,82	3,93	3,93	3,67	3,14
1932	3,40	2,71	2,87	2,08	1,86	1932	0,60	0,36	0,20	0,13	0,00
1933	1,43	1,57	1,67	1,97	1,71	1933	1,44	0,50	1,93	2,51	2,00
1934	1,97	1,78	2,50	3,00	2,43	1934	2,54	2,89	2,83	2,83	2,71
1935	1,78	1,56	2,25	1,97	1,71	1935	0,57	0,22	0,17	0,38	0,43
1936	2,59	3,00	2,25	2,07	2,00	1936	0,86	1,57	2,44	2,90	2,17
1937	1,27	1,43	1,58	2,00	2,14	1937	1,24	2,29	1,55	2,10	2,71
1938	2,03	1,86	1,67	1,90	1,86	1938	1,38	0,43	0,27	0,31	0,43
1939	3,27	3,43	2,67	1,83	2,00	1939	0,65	0,43	0,27	0,69	0,29
1940	2,00	1,71	2,08	2,31	2,00	1940	0,65	0,71	0,83	2,28	1,86
1941	1,84	1,71	1,67	2,17	1,71	1941	0,65	0,29	1,25	2,66	2,14
1942	1,94	1,29	1,67	1,79	1,29	1942	2,86	3,71	3,33	3,10	3,14
1943	1,78	1,71	2,08	1,76	1,57	1943	0,84	0,14	0,33	0,41	0,00
1944	2,03	2,29	2,67	2,21	2,29	1944	1,30	1,29	2,00	1,83	1,14
1945	3,14	2,43	3,00	2,31	2,00	1945	1,97	2,57	2,75	2,66	2,43
1946	1,68	1,83	2,00	1,45	1,57	1946	2,57	2,00	1,83	0,69	0,43
1947	2,16	1,83	2,08	2,07	2,14	1947	1,08	1,17	1,00	0,66	0,43
1948	2,22	1,86	2,25	2,34	2,43	1948	1,35	1,50	1,08	2,34	2.57
1949	2,70	3,29	3,00	1,97	2,00	1949	1,19	1,17	1,00	0,55	0,29
1950	2,11	1,86	2,17	2,38	2,00	1950	1,61	1,57	1,33	1,31	0,57
1951	1,89	2,14	1,92	2,14	2,00	1951	1,30	1,43	1,25	1,41	1,57
1952	3,11	3,00	2,50	2,38	1,86	1952	1,35	2,00	1,67	1,10	0,71
1953	2,14	1,78	1,92	2,21	1,71	1953	1,19	1,22	1,42	1,69	1,43
1954	1,59	1,56	1,67	1,90	1,86	1954	3,57	3,75	3,67	3,87	3,71
1955	2,30	2,33	2,50	2,43	2,57	1955	0,72	0,33	0,50	0,24	0,29
1956	1,89	2,00	2,00	1,67	1,71	1956	1,95	2,00	2,25	2,10	2,00
1957	2,59	2,33	2,50	1,67	1,29	1957	1,14	1,00	0,67	0,60	0,29
1958	1,81	1,56	1,67	2,38	1,57	1958	2,17	1,56	1,00	1,90	2,43
1959	2,51	1,89	1,92	2,76	2,29	1959	1,65	1,33	1,55	1,21	1,29
1960	2,59	2,22	2,00	2,00	1,57	1960	2,03	2,22	2,17	1,62	1,00
1961	3,00	2,56	2,83	2,31	1,71	1961	1,46	1,38	0,91	0,93	0,71

3. 2 Level of index

A matter of interest as regards the possibilities to utilize the State ranger reports is whether the standards of estimation have varied between different areas or whether they have changed during the time of observation. It is a possibility e. g. that the concept of the cone setting ability of the trees was different at the beginning of the period of observation from that 50 years later. Differences in the general level of index stated for various times, however, may depend on real long-term fluctuations in respect of cone setting. Unfortunately, it appears impossible to separate one effect from the other in the material at hand. This statement also applies to differences stated between the actual regions.

The matter outlined above has been investigated by means of gliding mean indices for 20-year periods computed regionally beginning with the period 1909—1928. The main portion of the great annual variation of the cone setting index is thus eliminated. When potential differences within or between the time series are tested, however, the mean index of the individual years should be used since the periodic indices formed are naturally strongly autocorrelated.

Fig. 4 shows the series of mean indices for 20-year periods graphically. Concerning the indices for Scots pine it can be stated that the general level within one and the same region has varied slightly only with time. A trend may possibly be traced to the effect that the mean indices in the northernmost three regions have stabilized on a slightly higher level from 1930 on. A t-test of differences in average level of index between the first and the last 25 years, however, consistently gives entirely insignificant values.

The figure shows that the mean index is located on various levels in the various regions. Region II and region V differ in particular from the others by having a distinctly lower level of estimation. A testing of the 0-hypothesis »no difference» in respect of mean level in the annual ring index between the neighbouring regions I and II and between the regions IV and V also gives strong indications that a real difference exists.

	Region I-II	*Region IV-V*
Mean difference	0.187	0.203
$t =$	4.54***	5.98***

The result may either be interpreted to mean either that the State rangers have conceived differences in the mean yield between the

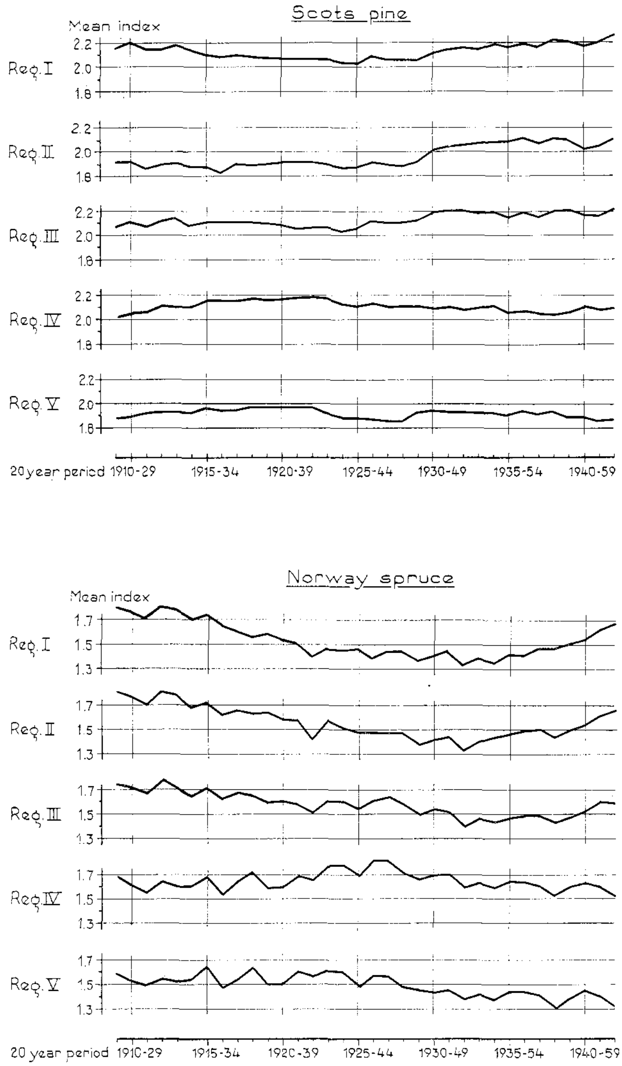

Fig. 4 Regional mean indices for gliding 20-year periods according to the State ranger reports. Cf. text.
Regionvisa medelindex för glidande 20-årsperioder enligt kronojägarnas bedömning. Jfr text.

areas concerned, or that the standards of estimation have been different. A regional treatment of this comparison between the mean index and the number of cones according to the National Forest Survey should reduce the importance of these special features.

Figure 4 shows for Norway spruce a trend to the effect that the average indices for the northernmost three regions have been lower in the middle of the period of observation than in the beginning and in the end. In the regions IV and V, however, the indices are more even. The strength of the tracing trend has been tested in the following way: In the case with a distinct decline as above in the annual mean index a numeric fitting by means of the curved regression line $y=a+b_1x+b_2x^2$ where $y=$ the year and $x=$ its index, should give a significantly superior fit than does the straight line $y=a+b_1x$. However, it appears that fit when using the curved regression line is improved but slightly. A test of significance with and without the curving term b_2x^2 gives for region I, F=1.09 and for region II, F=0.40 which values both are insignificant. Evidently, the trend appearing at a study of the gliding mean index can hardly be traced in the annual mean index.

The Norway spruce index, too, shows differences between various regions in respect of the average level of index, particularly concerning the neighbouring regions IV and V. A test of the 0-hypothesis »no difference» gives a mean difference of 0.172 units of index and $t=3.07^{**}$ for »difference» between the populations. The reason for this may be that the State rangers in the narrow coast region V to some extent have put the local cone setting in relation to the conditions in the neighbouring region IV where, as shown in the following presentation, the yield of Norway spruce cones is essentially higher.

4. Transformation of the mean indices of the State ranger reports to the National Forest Survey estimation scale.

As shown above there are possibilities for each of the few regions to make paired comparisons between the State ranger mean indices and the number of cones according to the National Forest Survey for the last eight years. Fig. 5 shows the result of such a grouping. At a numerical fitting of the mean index (x) as a straight line regression on the number of cones according to the National Forest Survey (y) by means of the function $y=a+bx$, the following values were obtained for the constants

Apparently, the relationships in fig. 5 are largely similar to those stated previously for small areas at a grouping of the mean index over the number of cones according to the National Forest Survey (fig. 3 a and 3 c). This finding is not surprising since the mean index in this instance should be calculated on the basis of a sufficient material from individual observers.

As shown, however, dispersion about the fitted lines is considerable in spite of consistently strong relationships. That is to say, at a certain mean index, the real cone setting has varied within rather wide limits.

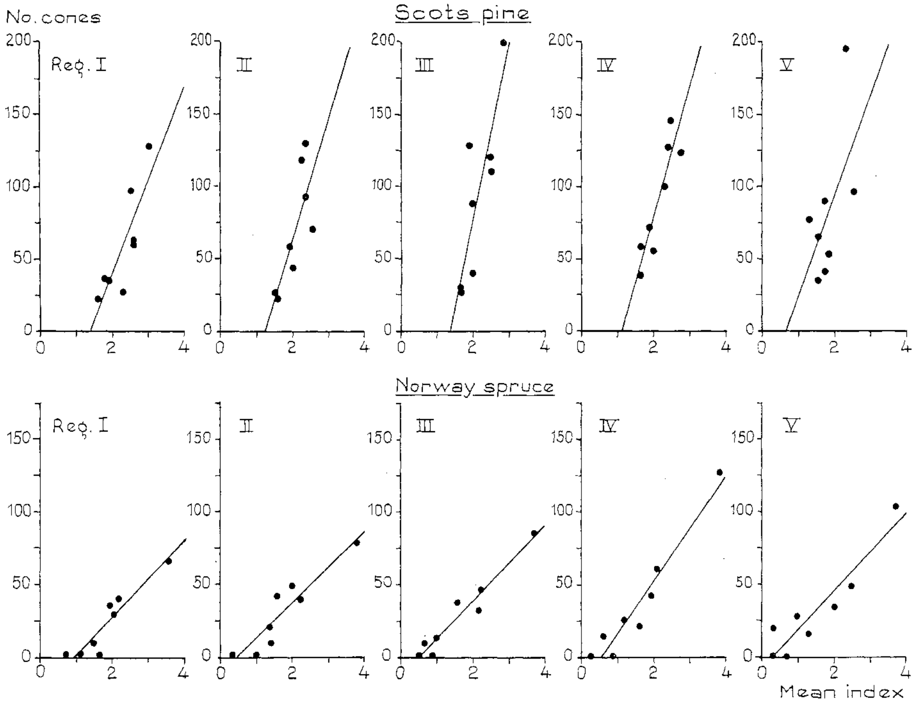

Fig. 5 Relationships between the annual mean indices of the State ranger reports on the cone setting in various regions and the number of cones according to the observations made by the National Forest Survey.
Sambandet mellan kronojägarnas årsvisa medelindex för kottsättningen i olika regioner och kottantalet enligt riksskogstaxeringens observationer.

This statement particularly applies to Scots pine for which the regression lines show a very steep slope.

Species Trädslag	Region	a	b
Scots pine Tall	I	— 89,72	64,76
	II	— 101,68	83,56
	III	— 163,06	119,75
	IV	— 100,31	88,93
	V	— 45,87	70,01
Norway spruce Gran	I	— 26,02	26,43
	II	— 12,96	25,03
	III	— 13,93	26,22
	IV	— 19,93	35,88
	V	— 7,60	26,52

The errancy stated must naturally be observed if we want to transform the mean indices in table 2 to the level of values according to the National Forest Survey by means of the functions of line fitting. The cone values of the individual years are thus rather erratic. However, the disadvantage of this condition should be counteracted by the great advantage of replacing indices with values that are transferrable into e. g. amounts of substance matter. Transformation also means another great advantage which will be exploited in this context for the calculations of frequencies of years with varying richness of cone setting. From this point of view it is less important if the number of cones in one year or the other is ascertained with moderate precision since errors occurring in various directions soon tend to balance each other at a frequency study based on a large number of observations. Against the background of the statements made above, the State ranger reports on the cone setting in various regions for the years 1909—1953 are transformed to the scale of estimation according to the National Forest Survey in table 3.

5. Fluctuations of the cone setting.

The transformations enable us to acquire a concept of how often a certain size of cone crop has occurred in various regions, at least as long as the forest conditions within the areas concerned remain about the same as those prevailing in the years 1954—1961. It should be associated with great advantages when estimating the cone setting in a certain year and in a given area to be able to judge whether the year is to be considered good, medium or poor from the point of cone setting. For many reasons the times of good cone setting are the ones that are most interesting. Fig. 6 therefore shows a regional summation graph based on the tables 1 and 3 presenting the frequency of years with a minimum degree of cone setting during the period 1909—1962. The relationships have been fitted graphically.

The graphs show for Scots pine that the cone setting conditions in the long run are most favourable in region III.

The trees in region I produce the smallest cone quantities. Although the southernmost regions, IV and V, are inferior to region III in respect of the frequency of years with very high numbers of cones, they feature a low frequency (or none) of years with poor cone setting. Thus, in region I cone setting in 50 % of the years is less than 50 cones per tree, in region III the corresponding frequency is 40 %, in region III 15 %, in region IV 7 % and in region V only about 5 %. A cone setting

Table 3 Mean indices for the period 1909—1953 of the State ranger reports transformed to the National Forest Survey estimation scale. Values for the period 1954—1962 see table 1, p. 8.

Kronojägarnas, till riksskogstaxeringens värdeskala transformerade regionvisa medelindex åren 1909—1953. Värden för åren 1954—1962 återfinnas i tab. 1.

Year År	Scots pine Tall					Year År	Norway spruce Gran				
	Region						Region				
	I	II	III	IV	V		I	II	III	IV	V
1909	0	0	0	22	47	1909	6	20	12	43	37
1910	61	84	136	69	59	1910	21	48	54	61	14
1911	36	12	0	45	59	1911	16	12	24	50	50
1912	61	96	124	106	94	1912	8	26	27	10	6
1913	83	73	172	99	82	1913	59	82	81	71	37
1914	76	58	76	68	82	1914	13	12	17	21	14
1915	50	50	64	85	94	1915	47	46	55	108	88
1916	50	58	112	78	94	1916	9	8	5	0	16
1917	25	50	112	64	68	1917	41	48	42	0	9
1918	42	43	100	78	86	1918	0	0	25	108	79
1919	129	149	88	64	86	1919	18	23	0	0	0
1920	44	35	76	65	102	1920	9	10	9	0	2
1921	34	41	76	69	86	1921	63	80	68	98	65
1922	47	41	64	86	94	1922	0	0	12	12	42
1923	52	101	160	173	147	1923	3	23	4	0	2
1924	50	71	76	84	102	1924	12	53	59	111	85
1925	22	48	64	78	94	1925	65	51	21	0	0
1926	72	77	112	86	86	1926	8	19	23	13	16
1927	48	41	88	84	84	1927	3	28	51	78	53
1928	46	35	40	93	64	1928	45	62	51	92	72
1929	26	0	40	82	64	1929	0	1	0	0	4
1930	0	0	52	102	104	1930	0	12	26	15	0
1931	16	41	88	133	94	1931	75	85	89	112	76
1932	131	125	184	85	84	1932	0	0	0	0	0
1933	3	30	40	75	74	1933	12	0	37	70	45
1934	38	47	136	166	124	1934	41	59	60	82	64
1935	26	29	100	75	74	1935	0	0	0	0	4
1936	78	149	100	84	94	1936	0	26	50	84	50
1937	0	18	28	78	104	1937	7	44	27	55	64
1938	42	54	40	69	84	1938	10	0	0	0	4
1939	122	185	160	62	94	1939	0	0	0	5	0
1940	40	41	88	105	94	1940	0	5	8	62	42
1941	30	41	40	93	74	1941	0	0	19	76	49
1942	36	6	40	59	44	1942	50	80	73	91	76
1943	26	41	88	56	64	1943	0	0	0	0	0
1944	42	90	160	96	114	1944	8	19	38	46	23
1945	114	101	196	105	94	1945	26	51	58	76	57
1946	19	51	76	29	64	1946	42	37	34	5	4
1947	50	51	88	84	104	1947	3	16	12	4	4
1948	54	54	100	108	124	1948	10	24	14	64	61
1949	85	173	196	75	94	1949	5	16	12	0	0
1950	47	54	100	111	94	1950	17	26	21	27	8
1951	33	77	64	90	94	1951	8	23	19	31	34
1952	112	149	136	111	84	1952	10	37	30	20	11
1953	49	47	64	96	74	1953	5	18	23	41	30

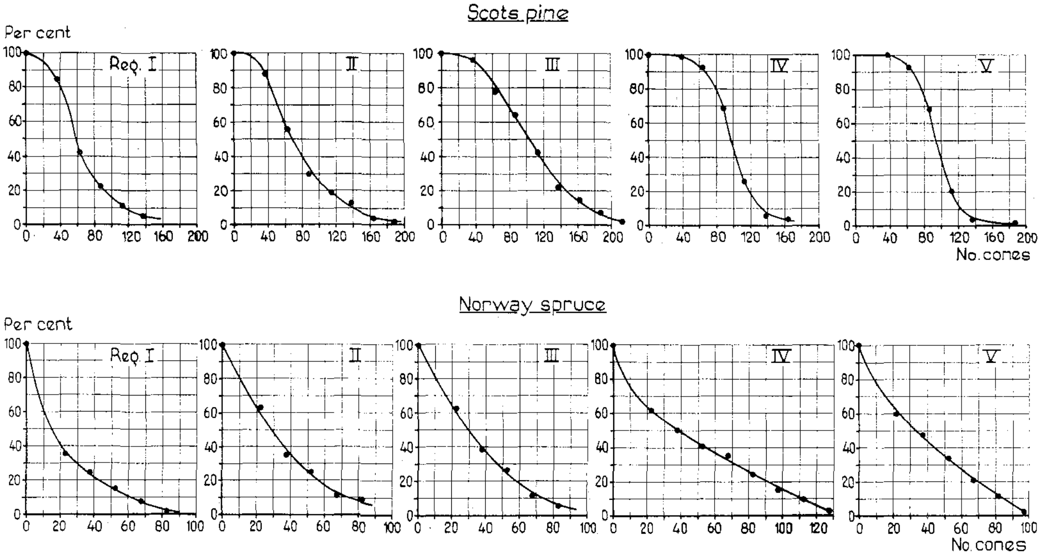

Fig. 6 Frequency of years (per cent) with at least a certain rate of cone setting in various parts of the country. The level of the National Forest Survey. Dominant and codominant trees, about 25 cm DBH.
Frekvensen år i procent med minst en viss kottsättning i olika landsdelar. Riksskogstaxeringens värdenivå. Härskande och medhärskande träd, ca 25 cm DBH.

of at least 100 cones per tree is considered as good in region I where it occurs at a frequency of about 15 % only. In region II the frequency is instead 25 % and in the regions III and IV this cone setting occurs about every other year. In region V the frequency is again slightly lower but at least 100 cones per tree are produced in 40 % of the cases. High numbers of cones, such as 200 per tree are consistently extremely rare, but they can primarily be expected in region III.

The frequency curves for Norway spruce have a form that is entirely different from those for Scots pine. Poor cone setting is common irrespective of region. However, it is most common in the north. The largest amounts of cones are produced in region IV where numbers of cones exceeding 100 occur in about 15 % of the cases. So high numbers of cones are extremely rare in the other regions. The cone production conditions for Norway spruce are particularly poor in region I where e. g. a minimum of 60 cones per tree is produced in 10 % of the years as against about 35 % in region IV and 25 % in region V.

At the planning of cone collection it must be of interest also to know how often occasions with cone quantities worth picking occur

Table 4 Average time lapse in number of years (*M*) and the boundaries of variation between the cone collection occasions in various parts of the country. Yield and quality of the seed are not taken into account (cf. text).

Det genomsnittliga avståndet i tiden i antal år (*M*) liksom variationsgränserna mellan kottplockningstillfällen i olika landsdelar. Hänsyn är ej tagen till fröutbyte och frökvalitet.

Region	Scots pine ≧ 80 cones Tall, ≧ 80 kottar		Norway spruce ≧ 50 cones Gran, ≧ 50 kottar	
	M	Boundaries of variation Variationsgränser	*M*	Boundaries of variation Variationsgränser
I	5,00	1—12	7,20	3—11
II	2,85	1— 8	3,56	0— 8
III	0,82	0— 3	2,67	0— 8
IV	0,75	0— 6	1,30	0— 5
V	0,47	0— 3	2,07	0— 5

in various regions. Store keeping for example is dependent on such information. The tables 1 and 3 also provide information of value in this context. It should initially be stressed that the tables give quantities of cones produced and that the possibilities to collect cones are also determined by the yield and quality of the seed. Unfortunately, material of observation elucidating the long term fluctuations in this respect is not available, but the matter has been discussed by HAGNER (1957).

To exemplify how these conditions can be elucidated, we resort to the following reasoning: the regional mean values of 80 Scots pine cones and 50 Norway spruce cones we consider indicating that quantities worth picking exist. The choice of these levels of yield may be said to have a certain basis of reality. However, it is simple for the interested reader to carry out his own calculations on the basis of other values in the table. The average time lapse between the cone collection occasions with a minimum yield as above, and the shortest and longest time elapsed between these occasions during the period of observations are shown in table 4.

The superiority of the southern parts of the country in respect of cone setting is clear. On an average, cone collection in these parts can be carried out with short intervals and the longest time lapse between good cone crops is relatively short. More than a couple of consecutive poor cone crops is rare and more than 5—6 hardly occurs at all. This statement applies to both Scots pine and Norway spruce. In the north five poor years usually occur between the years of good cone setting in Scots pine but as many as 12 poor years have been recorded in a row. The corresponding periods for Norway spruce are

7 years and 11 years respectively. It is particularly important in this region to remember that good cone setting is not associated with good seed quality which immediately widens the ranges of variation in respect of time lapse between occasions of good cone crops worth picking. This statement applies to Norway spruce irrespective of region.

It should be stressed that the values for cone yield presented here pertain to trees with DBH = about 25 cm. This condition favours the northern regions in relation to the southern regions at a comparison since the average tree is larger in the south than in the north.

It may also be worth mention that the observations made concerning the sustained cone producing ability of the trees in various regions extremely well agrees with the experiences previously made at the processing of another, quite independent material of observation (HAGNER 1957). The latter investigation pertained to measured cone quantities from trees in various parts of the country instead of numbers of cones as in this investigation. If the numbers of cones recorded in this context are transformed to volume of cones, Norway spruce in south Sweden is gaining considerable superiority in relation to Norway spruce in north Sweden due to the fact that its cones are larger and contain more seed. The differences between north and south also increases in respect of Scots pine cone yield, but not to the same extent since the differences in cone size are smaller (cf. HAGNER 1957, table 8).

Summary

The present work reports on comparisons (figs. 3 and 5) between observations of the annual cone setting of Scots pine and Norway spruce in various parts of the country carried out by the State rangers (table 2) and observations made by the National Forest Survey (table 1). On the basis of these comparisons the long series of State ranger observations (1909—1953) has been regionally transformed to an absolute scale of values (table 3). Calculations have been made by means of these series with the purpose of elucidating how often a certain level of cone setting occurs in various parts of the country (fig. 6) and what range of variation that might occur in respect of number of years between cone crops of a size considered worthwhile to collect (table 4).

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TIRÉN, L., 1935: Granens kottsättning, dess periodicitet och samband med temperatur och nederbörd. — MSS, Band 28.
Förklaringar:
MSS: Meddelanden från statens skogsförsöksanstalt resp. skogsforskningsinstitut.
NST: Norrlands skogsvårdsförbunds tidskrift.

Sammanfattning

Om kottsättningens fluktuationer hos tall och gran

En utredning, grundad på riksskogstaxeringens kotträkningar åren 1954—1962 och på kronojägarnas rapportering över kottsättningen åren 1909—1961. I arbetet redovisas jämförelser (fig. 3 och 5) mellan observationer över den årliga kottsättningen på tall och gran i olika landsdelar utförda av landets kronojägare (tab. 2) och vid riksskogstaxeringen (tab. 1). Med ledning härav har regionvis kronojägarnas långa bedömningsserie (1909—1953) kunnat transformeras till en absolut värdeskala (tab. 3). Med hjälp av denna serie har beräkningar utförts avsedda att belysa hur ofta en viss kottsättning uppträder i olika landsdelar (fig. 6) och vilken variationsvidd som kan förekomma i fråga om antal år mellan kottskördar av ur insamlingssynpunkt önskvärd storlek (tab. 4).