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Characteristics of ruffed grouse drumming sites in western Washington and their relevance to management[1]

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Drumming sites of the Pacific ruffed grouse, *Bonasa umbellus sabini*, were studied in 1974 — 1977 at three locations in western Washington, and a total of 112 logs were inspected. Forest vegetation at the sites and log characteristics are described.

The mean number of logs per territory was 1.83. The mean coverage of forest crown was 62 %, that of the understorey 52 % and of the shrub stratum 46 %. The dominant species were: *Alnus rubra* and *Tsuga heterophylla* in the forest crown, *Acer circinatum* and *T. heterophylla* in the understorey, and *Polystichum munitum* and *Rubus spectabilis* in the shrub stratum.

The means of main log and site characteristics were: diameter 69.5 cm, stage height 63 cm, length 10.5 m, height of overhead cover 94 cm and visibility radius 15.5 m.

The mean distance to the nearest log within a territory was 24 m and to the nearest opening or edge about 27 m. The distance to *Populus trichocarpa* varied from 5 to about 150 m (mean 46 m).

The grouse seem to aggregate in mixed stands 40—50 years old. The sites differed in several respects. These differences mainly indicate that the Pacific ruffed grouse can exploit a wide spectrum of habitats. Grouse habitats can easily be managed in connection with modern forestry practices without significant losses to the industries involved.

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1. Introduction

The ruffed grouse, *Bonasa umbellus*, is widely distributed over the North American continent, from the interior of Alaska to northern California and to the southern parts of Labrador, with southward range extensions along the Rocky Mountains and the Appalachians. Twelve subspecies have been described. This racial differentiation correlates with the major habitat types in this wide region (ALDRICH 1963).

The ruffed grouse is a bird of second-growth deciduous and mixed forests (e.g. JUDD 1905). Clearing for agriculture has reduced its former range in the Midwest, but forest fires and intensifying forestry have produced interspersion of successional stands favoured by the grouse (HAMERSTROM & HAMERSTROM 1961).

Being the most important forest game bird in North America the ruffed grouse has been studied intensively (KING 1937, HAMERSTROM & HAMERSTROM 1961), mainly in the north central United States from Wisconsin to Maine and south to Virginia (cf. MOULTON & VANDERSCHAEGEN 1964). In New York, BUMP *et al.* (1947) produced an exhaustive monograph on this species. Another long-term study by GRANGE (1948) deals with the ruffed grouse in Wisconsin. A notable centre of ruffed grouse studies is Minnesota (e.g. ARCHIBALD 1974, 1975, 1976, GULLION 1966, 1967, 1970, 1976, GULLION *et al.* 1962, GULLION & MARSHALL 1968), and recently this species has received increasing attention in Alberta, Canada (e.g. BOAG & SUMANIK 1969, BOAG 1976a, 1976b, AUBIN 1970, 1972, DOERR *et al.* 1970, 1974).

[1] A joint contribution from the Washington Department of Game and the Department of Applied Zoology, University of Helsinki.

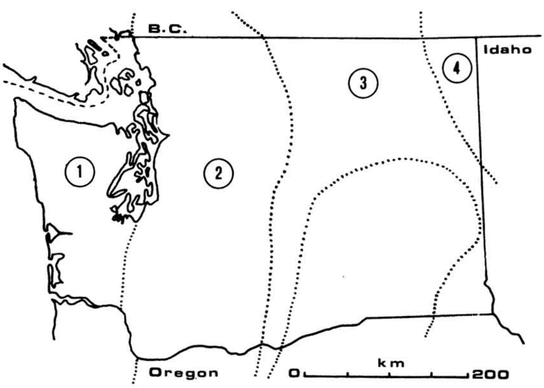

Fig. 1. Distribution of the ruffed grouse subspecies in Washington according to Aldrich (1963): 1 = Olympic (*castanea*), 2 = Pacific (*sabini*), 3 = Columbian (*affinis*), 4 = Idaho (*phaia*).

Little information is available on the ruffed grouse in the Pacific Northwest. HUNGERFORD (1951, 1953a, 1953b, 1957, 1969) and ERICKSON (1961) studied the Idaho subspecies, *B. u. phaia*. BENT (1932:174—177) compiled older information concerning the Pacific subspecies, *B. u. sabini*. There are also observations from Vancouver Island on *B. u. brunnescens*, but these are side products of a study on the blue grouse, *Dendragapus obscurus* (KING 1969). In addition, the Washington Department of Game has been collecting information on the ruffed grouse, and recently initiated a study on the population ecology and habitat requirements of the species (BREWER 1977, unpubl.) The distribution of the western subspecies in the state of Washington is shown in Fig. 1.

The purpose of this study was to obtain basic information on the drumming sites of the Pacific ruffed grouse, *B. u. sabini*, in the forest types on the western foothills of the Cascades in Washington. This type of information is considered useful in formulating the management of the ruffed grouse in the area, where forestry is intensive and wildlife management cannot be considered separately, but only in relation to modern silviculture.

2. Study areas

Field investigations were carried out at three locations in western Washington (Fig. 2). The climate is maritime, and typical of the foothill region. The forest vegetation represents successional communities of the *Tsuga heterophylla* zone (FRANKLIN & DYRNESS 1969), where the climax forests are dominated by western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*). Logging and fire have produced second-growth forests characterized by Douglas fir (*Pseudotsuga menziesii*) and red alder (*Alnus rubra*) with salal (*Gaultheria shallon*) and sword fern (*Polystichum munitum*) as undergrowth. Salmonberry (*Rubus spectabilis*) is common in stream bottoms and moist depressions, especially under deciduous cover (BECKING 1954, LONG 1973).

The Snoqualmie area (Fig. 3) consists of intensively utilized forest land owned by the Weyerhaeuser Company. The study area is roughly 1300 ha, of which about a third has recently been logged or reforested. The virgin forest was removed and the stands now maturing were established before the 1940s. Second growth timber has been harvested since 1971 (Crotts, pers. comm.). Many forest roads transect the mosaic of successional stands characterized by red alder, Douglas fir and western hemlock, clear-cut areas and Douglas fir plantations. The topography is gentle, except along the Tolt River and its forks. Elevations within the study area are from 150 m to 240 m.

The Cedar River Watershed, where the orientation stage of this study was conducted (SALO 1976), has been administered since 1920 by the City of Seattle Water Department. The watershed area is closed to the public and thus a *de facto* wildlife sanctuary. The field investigations were concentrated in an area of some 500 ha south and southeast of the Chester Morse Lake.

Thorough ecological information has been accumulated from this area (e.g. COLE & GESSEL 1968, MILLER *et al.* 1972, SCOTT & LONG 1972, LONG 1973). The area is below 600 m in elevation and lies in the *Tsuga heterophylla* zone (FRANKLIN & DYRNESS 1969). Virgin timber was removed during the first three decades of

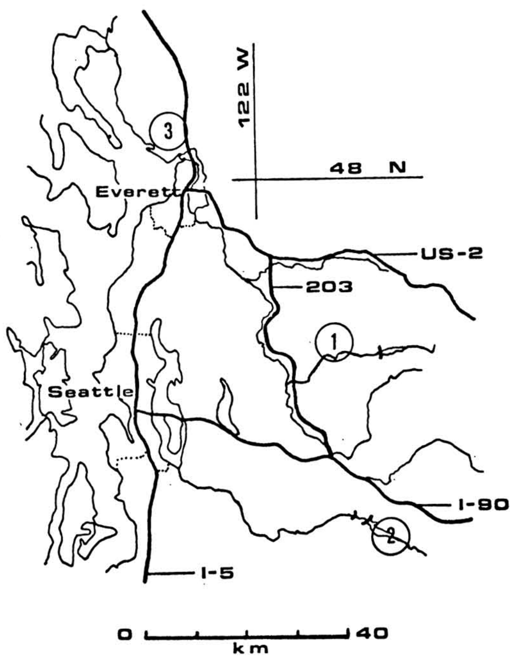

Fig. 2. Locations of the study areas in western Washington: 1 = Snoqualmie, 2 = Cedar River, and 3 = Tulalip.

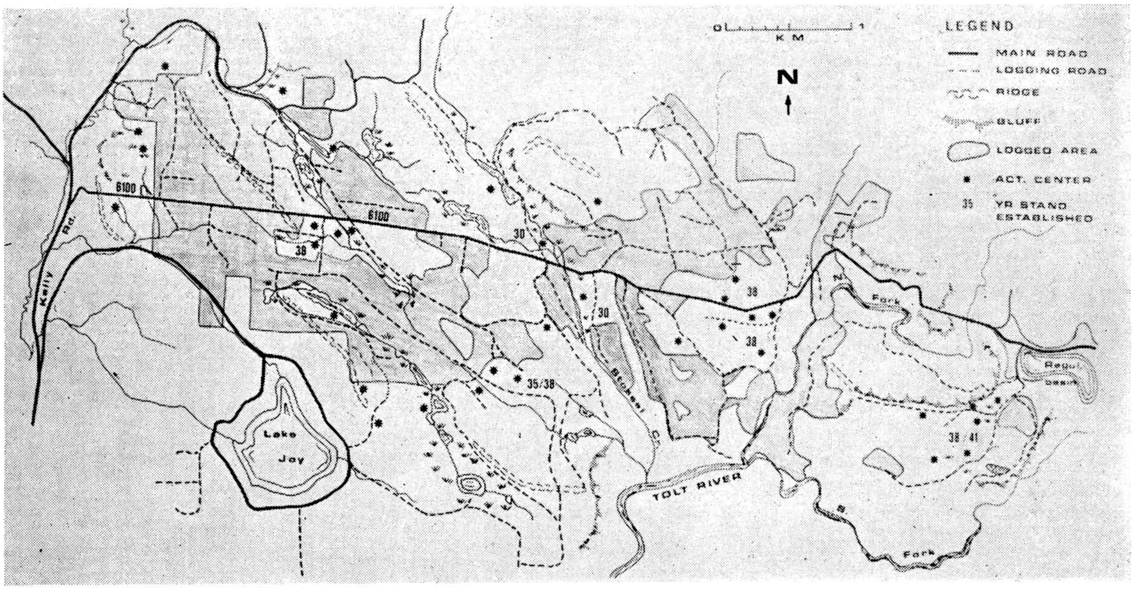

Fig. 3. Major habitat features of the Snoqualmie study area.

this century, except from some higher elevations (GREEN *et al.* 1944). Drier sites are now dominated by second growth Douglas fir stands. Level lowlands, especially stream bottoms, are dominated by red alder with vine maple (*Acer circinatum*) forming the understorey. The lowlands also have the richest grass and herb stratum of all the communities in the area (SCOTT & LONG 1972). In the study area the forest vegetation is primarily composed of western hemlock and red alder with vine maple in the understorey.

The Tulalip area is situated just north of the city of Everett. Here the Washington Department of Game is conducting an intensive population study on a plot of about 400 ha. This site has the lowest elevation of all three, from 15 m to about 125 m. The general aspect is eastern and the slope is gentle. The continuous, mostly deciduous second-growth forest grew up after loggings during the 1920s and 30s (Williams, pers. comm.[1]). The forest canopy is dominated by red alder and black cottonwood (*Populus trichocarpa*), the understorey by vine maple, western red cedar and red elderberry (*Sambucus racemosa*), and the shrub stratum by salmonberry and red elderberry.

At present the area is controlled by the Boeing Company and is closed to the public.

3. Material and methods

Observations were made at 61 ruffed grouse territories. All information was recorded by the author, although several people reported locations where grouse had been seen or heard drumming. The drumming sites in the Tulalip study area were those where the male birds had already been trapped for the population study mentioned earlier. About 870 h were spent in the field, some 130 h with an assistant. The field work was concentrated on the Snoqualmie study area, primarily because of its general suitability with gentle topography, mosaic pattern of forest and logged areas, and a good road system.

The orientation stage of the study was conducted in the Cedar River area from 4 April to 8 May 1974 (SALO 1976). The main objective was to gain experience in locating drumming grouse. In spring 1975, the field work was shifted to the Snoqualmie study area. Daily field work began at about 09.00 and continued until 19.00 or 20.00. As the ruffed grouse may drum at any time of day (BUMP *et al.* 1947:278, also GULLION 1966) the field hours were adjusted to between 08.00 and 21.00. This provided ample time for locating the logs of grouse heard drumming in the morning and to be ready for the evening peak of drumming activity (cf. PETRABORG *et al.* 1953).

In spring 1976, field work was continued in the Snoqualmie study area from 20 April to 4 June. The Cedar River sites were checked on 30 April and 10 May. The search for new logs, however, was limited to the vicinity of the old sites. The drumming logs already located in the Tulalip area were inspected on 10 June.

In 1977, the field work in the Snoqualmie study area started on 30 March and ended on 3 June. The Tulalip area was visited on 18 June.

The search for grouse territories was based on sightings and drumming observations, or was systematic in potential grouse habitats (cf. GULLION 1967). When this study began in spring 1974, only very general

[1] Wayne Williams, Business manager, Tulalip Indian Tribe.

information was available about the distribution of grouse from the Cedar River area. The first step was to reconnoitre the area through the forest road system, looking for habitats suitable for ruffed grouse (see SALO 1976).

The Snoqualmie study area is heavily patrolled by the wildlife agents of the Washington Department of Game, and they provided a good portion of sightings and drumming observations, which I then carefully checked. By the end of the 1977 spring display season practically all the forest within 1—1.5 km from the main road (6100) had been searched. In several cases one sighting or drumming observation resulted in the location of more than one territory in that general area.

In the Tulalip area, the Washington Department of Game biologists had marked transects through the forest and located drumming birds from these lines. This was a systematic effort and the results were made available for this study.

The composition of vegetation at each drumming site was recorded from a circular plot within a 10 m radius from the log (cf. WEBB 1942, BORMANN 1953). For three strata (forest crown, understorey, and shrubs, including *Polystichum munitum*) the coverage was estimated to the nearest 10 % (cf. POORE 1955, DAUBENMIRE 1959). Early in each field season a simple tube about 5 cm in diameter was used for estimating the crown coverage at several points within a plot (cf. SARVAS 1953). This was done to gain familiarity with relative differences in the crown cover in order to avoid a systematic personal error (cf. DAUBENMIRE 1959). In the understorey and the shrub stratum the coverage was estimated visually at 4—5 points within a plot.

The aspect of the terrain at each drumming site was recorded. The distances to the nearest opening or edge, to the nearest drumming log within the same territory, and to the nearest black cottonwood were either paced or estimated. The visibility radius was in most cases paced.

Of the log the following characteristics were measured: diameter, length, stage height, and width of the stage (in some cases the section used for strutting). The moss cover was estimated on a scale of 0 = 0—30 %, 1 = 30—70 % and 2 = 70—100 %. The occurrence of other vegetation on the log was recorded using a 10 % coverage as the minimum. The firmness of the log surface 3 m on either side of the stage was recorded as 0 = 0—50 % (decayed) or 1 = 50—100 % (firm). The numbers of droppings and feathers on the log and in its immediate vicinity were counted.

Information concerning the forest of the Snoqualmie study area was provided by the land use staff of the Snoqualmie Tree Farm (Weyerhaeuser Company).

In addition to these data, relascope measurements of the basal area (see p. 265) were taken at ten drumming sites and ten sites not observed to be occupied by grouse during the study.

In 1977, the height of sword fern rosettes was determined from six samples of ten measurements taken on 15 and 20 May. At the same time the average stem density of salmonberry was obtained from a sample of 25 1 m^2 plots.

Standard computer programs were used in processing the information separately for each study area and for the overall results. The characteristics of sites used during at least two seasons were compared with those of sites occupied only once during the study. This comparison concerned 93 sites in the Snoqualmie and Cedar River areas checked at least twice.

4. Results

A total of 61 activity centres (cf. GULLION *et al.* 1962) were found and 112 drumming logs described. Of these logs, 45 (40.2 %) were found by systematic searching at potential habitats; in 9 cases (8.0 %), the bird was flushed in the vicinity of his log, which was subsequently located; in 26 cases (23.2 %) drumming was heard and the log found after a search; and in 32 cases (28.6 %) the drumming bird was either flushed from the stage or trapped on his log. The Tulalip material (14 logs) belongs to this category.

The results are presented in Tables 1—20. In Tables 1, 2 and 3 the composition of the vegetation is presented separately for each stratum. The lists include only the species which reached a mean coverage of 1 % or higher in at least one of the study areas. In these tables "Mean 1" is the true mean computed from the sum of the coverage estimates for each species divided by the total number of sites (N) in the area. "Mean 2" is an 'aggregate mean' computed from the same sum divided by the number of observations (n) in which the species was actually recorded. "Mean 2" can be interpreted as an indicator of the 'abundance when present'.

The characteristics of the drumming sites other than vegetation are presented in Tables 4—20. The bearings were grouped into four sectors: northern, 315—044°; eastern, 045—134°; southern, 135—214°; and western, 225—314°. The same division is used in other tables where the data are divided similarly.

More than half of the sites were level. The averages for the slopes measured varied from 3.6 to 6.3°. The areal and total means were less than 3° for all sites. The differences between the means and the distribution of bearings are not significant. The Tulalip area lies completely on an eastern slope and the lower half is practically level. Both the Snoqualmie and the Cedar River sites provided examples of drumming logs with a terrace location, where the bird had a panoramic view down the slope. In most cases clearly denser vegetation on the level ground behind the log provided protective cover (cf. e.g. BOAG 1976a, BOAG & SUMANIK 1969). Accumulation of droppings indicated that in such cases the grouse sat on the log facing down the slope (cf. ARCHIBALD 1964, PORATH & VOHS 1972).

The direct overhead cover (Table 11)

consists of branches hanging over the stage and slender stems closing above it (cf. PALMER 1963). In some cases this type of cover was replaced by the understorey canopy of vine maple and western hemlock forming an almost completely closed cover 3 to 4 m above the log.

Forest density was estimated in terms of basal area (the sum of the cross-sectional areas of the tree-trunks at breast height in relation to the ground area). The basal area measurements at ten drumming sites in the Snoqualmie area gave a mean of 39 m^2 /ha (SD 8.1), with extremes of 28 and 50 m^2 / ha. Another sample taken at ten sites where no grouse had been observed during the study gave 70.4 m^2 / ha (SD 11.1), and extremes of 57 and 92 m^2 / ha. The difference between these means is significant: $t = 22.9$ (18 df), $P < 0.001$.

The average height of sword fern rosettes in 1977 was 76 cm (SD 15.5) on 15 May and 1 m (SD 15.5 cm) on 20 May.

The mean stem density of salmonberry measured on 20 May 1977 was 28.6 (SD 5.2) old stems and 5.8 (SD 3.8) new stems per m^2. Thick stems were about 2 cm in diameter and the growth reached over 2.5 m.

The plant associations typical of the region (cf. SCOTT & LONG 1972) are indicated by the correlations between some habitat and log characteristics (Table 21). The conifers of the forest crown are in negative correlation with the deciduous component, with the understorey, and with several dominant shrub species. Under the deciduous crown the understorey and shrub stratum are well developed. This is reflected in the positive correlations of red alder, cottonwood and big-leaf maple (*Acer macrophylla*) with several typical understorey species and shrubs. Correlations also indicate that Douglas fir, a subclimax species, is to some extent able to reproduce under its own sparse crown, but not under a denser canopy cover including other species.

The species which thrive under a deciduous crown occur together and the respective correlations are positive. Vine maple, with its shading, may limit the occurrence of some species such as red elderberry.

Of shrubs, salal (*Gaultheria shallon*) has a positive correlation with western hemlock in the forest crown. Also the distinct non-overlapping occurrence of salmonberry and sword fern is reflected in the negative correlation of their coverage values.

The height of the stage is naturally correlated with the size of the log. But it is also correlated with the coverage of sword fern in the shrub stratum. Overhead cover at the stage is provided by western red cedar saplings and salmonberry. The species providing most important side cover but at the same time obstructing visibility from the stage is salmonberry. Several other correlations in Table 21 indicate the location of the drumming log in relation to openings, the nearest cottonwood tree or trees, or another log within the same territory.

The material included 17 "perennial" sites (cf. GULLION 1967) occupied during at least two seasons. The vegetation and the log characteristics of these sites were compared with those of the "transient" sites observed to be occupied only once during the study. Only two differences were found. The total understorey cover was denser at the perennial sites: 30 (SD 5.1) vs. 24.6 (SD 4.8) %; $t = 2.07$ (91 df), $P < 0.05$. Salal had a greater coverage at the perennial sites: 5.3 (SD 4.1) vs. 0.4 (SD 1.4) % ; $t = 2.49$, $P < 0.02$. Salal was recorded only at 10 sites in the Snoqualmie area (see Table 3).

5. Discussion

As mentioned in the introduction, ruffed grouse drumming sites have been studied intensively. In this respect, however, the Pacific Northwest is practically an unwritten page. BOAG & SUMANIK (1969) justified their comparative study in Alberta: "No one to our knowledge has investigated the characteristics which make the sites initially attractive to male ruffed grouse...». A similar justification is valid for this study. For lack of comparable information, the discussion can, of course, only be of a general nature.

A. General features of sites

Altogether 112 drumming logs were located at 61 activity centres. There were thus 1.83 logs per male grouse or 2.0 logs per bird when the Tulalip material is excluded. These ratios correspond to the 1.9 logs per male reported by PORATH & VOHS (1972) but are clearly higher than the average of 1.33 logs per male given by BUMP *et al.* (1947). Of the activity centres

22, or 55 %, consisted of more than one log (range 2 — 7). In Alberta, SUMANIK (1966) found that 70 % of the activity centres had 2—4 logs, and BOAG (1976b) reports a range of 1 — 6 logs per territory (cf. also AUBIN 1972). In the Pacific Northwest earlier wasteful logging practices have furnished the ruffed grouse with an ample supply of drumming logs, quite a few of them western red cedar, which is very resistant to decay.

BUMP *et al.* (1947:280) state that the number of logs used varies with the competition. If the life-time territory of the Pacific ruffed grouse were about 50 ha (cf. PALMER 1956) and 2—4 ha during the spring display (cf. MARSHALL 1965, ARCHIBALD 1975), there would certainly be several suitable logs within this area in otherwise acceptable habitats.

The mean distance to the adjacent drumming log within the same territory was about 25 m. This easily allows the maximum observed number of logs, 7, to be within 1 ha (cf. ARCHIBALD 1975). Also, of 49 secondary logs only 6 were more than 30 m from the primary site. AUBIN (1970) reports the mean distance between activity centres as 85 m in a high-density habitat in Alberta. In one case of the present study such a short distance was observed, and it was not confirmed whether the occupant of the adjacent log was actually controlling a territory or was a 'silent male' (cf. GULLION 1966, 1967, RUSCH & KEITH 1971). The observation was made early in the display season and seems to represent what ARCHIBALD (1976) describes as an unstable stage of spatial distribution. Other short distances between the activity centres were cases where there were ecotone-type or man-made boundaries (cf. ARCHIBALD 1975, GULLION 1976).

Sixty-one, or 54.5 %, of the sites were on level ground. When the slope was measurable, it was in most cases slight, averaging from 3.6 to 6.3° in the three study areas. One site in the Cedar River area was on a 20° slope. The occupant had adjusted himself to the situation, sitting parallel with the log axis on the lower end of the log, which lay perpendicular to the slope (cf. MCGOWAN 1966). In addition, the stage was worn to the extent that the incline was reduced to about 5°. BOAG & SUMANIK (1969) and PORATH & VOHS (1972) have observed that the ruffed grouse avoids slopes exceeding 20°. No incompatible observations were made in the present study.

As mentioned above and in several other cases, in terrace and slope situations the grouse sat facing down the slope. This was indicated by the accumulation of droppings and the wear of the stage (cf. BOAG & SUMANIK 1969). In two cases this observation was utilized in locating the adjacent activity centre on the opposite slope (cf. HJORT 1970, ARCHIBALD 1974). When flushed, the bird left the log flying downhill.

B. Vegetation

In the forest crown, which at the drumming sites in western Washington is about one-third open, deciduous and coniferous species are represented about equally. With a mean coverage of 28.5 %, red alder is clearly the dominant species. Thus the general cover conditions are surprisingly similar to those reported for Minnesota, where the stand is mixed if the forest crown coverage at a drumming site is over 60 % (GULLION *et al.* 1962).

BOAG & SUMANIK (1969) mention the role of aspen, *Populus tremuloides*, in the forest crown at the sites accepted by the ruffed grouse in Alberta. GULLION'S (1976) statement on the matter is practically: no aspen, no grouse, not even during the peak populations. Although the ruffed grouse – black cottonwood (*P. trichocarpa*) relation in the Pacific Northwest has not been studied, it is perhaps worth mentioning that 70 % of the logs in the present study were within 50 m of a cottonwood tree or trees. Cottonwood is an indicator of an open forest crown and well-developed understorey and shrub stratum. The correlations presented in Table 21 also indicate the relation of cottonwood to openings and edges, which apparently play an important role in making sites attractive to the grouse (cf. PALMER 1963, DORATH & VOHS 1972:795, SCHEMNITZ 1976).

In Wisconsin mixed forests are used by the ruffed grouse more than either deciduous or coniferous forests alone (DORNEY 1959). A similar pattern is observable in western Washington. Dense stands of Douglas fir or western hemlock and the *Alnus rubra* — *Polystichum munitum* association (see SCOTT & LONG 1972) are marginal habitats for the ruffed grouse. Some interspersion of tree species immediately improves the suitability.

The presence of deciduous trees seems to become decisive when the basal area exceeds

40 m^2/ha. For example, in the Snoqualmie study area the ruffed grouse aggregated into 40 to 45-year-old mixed stands (see Fig. 3). The largest basal area measured at occupied sites by the author was 50 m^2/ha and the largest stand average reported was 52.3 m^2/ha (Crotts & Saasen, pers.comm.). Within these stands, however, were sites indicating basal areas of 60—90 m^2/ha, which were invariably observed to be unacceptable to the grouse.

The important species-pair in the understorey is vine maple with western hemlock. The mean total understorey coverage at the drumming sites was 52 %, of which about half is attributed to vine maple. Boag (1976 a, b) observed that the understorey canopy was denser at used than at unused sites. The growth form of a well-developed vine maple understorey gives excellent overhead protection and by its shading also reduces the growth of the shrub stratum, so improving horizontal visibility from the stage (cf. Gullion *et al.* 1962, Palmer 1963, Rusch & Keith 1971). Regarding cover by vine maple, the upper limit that the grouse will tolerate is hard to define, but probably one erect cluster of 20—40 stems per 100 m^2 would provide enough canopy cover, allow a well-developed shrub stratum and an acceptable visibility radius from the stage. In Alberta an apparently comparable association exists between used sites and small spruce trees (Boag & Sumanik 1969).

The importance of the shrub stratum at an acceptable drumming site is well documented (e.g. Dorney 1959, Gullion *et al.* 1962, Palmer 1963, Berner & Gysel 1969, Boag & Sumanik 1969, Rusch & Keith 1971, Gullion 1972, Boag 1976a). The forest crown and understory coverages apparently acquire their importance from their effect on the development and species composition of the shrub stratum. In western Washington the two dominant species of the ground vegetation at the drumming sites of ruffed grouse are sword fern and salmonberry. Their occurrence overlaps, but in general the abundance of one correlates with the scarcity of the other (Table 21). Together they seem to play an important role in making a site acceptable to the grouse.

Under primarily deciduous crown cover sword fern may completely cover the forest floor, with occasional patches of mahonia (*Berberis nervosa*), salmonberry and red huckleberry (*Vaccinium parvifolium*). The understorey is well developed, consisting mostly of vine maple and saplings of the overstorey species. In this type of habitat Pacific ruffed grouse seem to select logs which are higher than the surrounding growth of sword fern. The correlation ($r = 0.229$, $P < 0.05$) is at least indicative. At the start of the drumming season the fern rosettes of the previous year are flattened by winter rains or snow, but the new leaves grow fast, reaching 1 m by about mid-May. The average stage height measured in this study was 63 cm (SD 4.7). During normal phenological conditions drumming activity diminishes toward the end of April. Thus it seems obvious that drumming grouse have enough time before visibility is obstructed by the new growth of sword fern.

An interesting comparison can be made concerning salmonberry. Gullion *et al.* (1962) and Boag (1976a) stress the importance of a visibility radius of 20 m from the stage. Gullion (1972) also writes that there may be 80—200 stems over 1 m high within 3—4 m of the log. But Boag (1976a) considers this excessive, at least in the conditions of Alberta. In western Washington, the shrub stratum may become extremely well developed when the forest crown is sparse and the understorey forms a low canopy. Salmonberry may then grow more than 2.5 m high, forming dense thickets. A drumming log can be completely hidden in such a thicket, with branches closing above and also providing good side cover. The mean visibility radius in this study was established as 16 m (SD 2.5), with 59 % of the logs in the 11—20 m range. The visibility radius was inversely correlated with the coverage of salmonberry in the shrub stratum, but during most of the drumming season, salmonberry has no leaves and the visibility through these high thickets apparently remains acceptable.

Some 30 salmonberry stems per 1 m^2, as observed in this study, would, within 3—4 m from the log, as Guillion (1972) mentions, result in over 1,000 stems within a 6 × 6 m area. Thus, 80—200 stems within 36 m^2 is nothing exceptional at sites where salmonberry provides the principal cover.

Red huckleberry had the second highest frequency of occurrence, even higher than salmonberry. It is characteristic of sites where either a forest crown cover is lacking or there are sizable openings. Bushes may then be more than 2.5 m high, and with the low hanging branches of understorey conifers they provide the stage with side cover (cf. PALMER 1963). Tender leaves of this species may also be a part of the "early greens" in the diet of the grouse (cf. HUNGERFORD 1953a, KING 1969).

C. Drumming log

The drumming log is generally described as: "some old, more or less moss-covered relic — mouldering on the forest floor" (BUMP *et al.* 1947:279). The logs inspected in the present study were slightly on the solid side, 60 % vs 40 %. Eighty logs, 71 %, had 70 to 100 % moss cover (Table 13). Yet only about 11 % of the logs had other vegetation covering more than 10 % of the surface (Table 14). Later in spring some herbaceous species such as *Maianthemum dilatatum* and *Dicentra formosa* grew on some logs practically to the stage. However, these species are not tall and they do not usually grow until the drumming activity is slowing down in late April and early May.

The drumming logs studied had diameters ranging from 25 cm to 1.60 m, the means for the three areas being 56, 61 and 73 cm. The mean of all 112 logs measured was 69.5 cm (SD 5.5). PALMER (1963) gives 33 cm as the mean width of 40 logs he studied. The 80 logs in the study by BOAG & SUMANIK (1969) were from 13 cm to 61 cm in diameter with a mean of about 30 cm, and the 29 logs studied by McGOWAN (1966) were from 25 to 63.5 cm with a mean of about 41 cm. In the present study about 74 % of the logs were in the 25—80 cm group. The ruffed grouse in the Pacific Northwest drum mainly on fallen or cut conifers, which in every respect are larger than the conifers of the boreal forest region. A trunk of a deciduous species used as a drumming log was observed only four times in this study, and in one case the tree, black cottonwood, was a still living windfall (cf. BUMP *et al.* 1947: 279, PALMER 1963). A 25-cm log is used primarily if the vegetation provides acceptable visibility or if the log is elevated and the actual stage is higher (cf. PALMER 1963, McGOWAN 1966, BOAG & SUMANIK 1969). As mentioned earlier, there may be some selection for logs of large diameter, but the chi-square test failed to show any significant difference in the size distribution between used and unused logs. Similarly the 98 unused logs measured by BOAG & SUMANIK (1969) averaged 26.5 cm in diameter and ranged from 18 to 46 cm. PALMER (1963) had indicated earlier that there is no correlation between the diameter of a log and its use. The possibility that the Pacific ruffed grouse selects larger logs and higher stages agrees with the conclusion by GULLION *et al.* (1962) that an important factor is the visibility from the stage.

The mean length of 40 logs measured by PALMER (1963) was 6 m with a range from 1.7 to about 13. He also observed that the length and the log use were not correlated. McGOWAN (1966) reports the mean length of 29 logs as 7.6 m with a range from 3.5 to about 17 m. In the present study the length varied from 1 m to about 30m, and some 85 % of the logs were 6 m or longer. As with diameter, the difference from the Midwest results is due to the clearly different sizes of the trees in the Pacific Northwest. Although there is a difference between the lengths of the drumming logs and the control sample of unused logs ($P < 0.025$), it is questionable whether this really indicates anything. The doubt is justified because on two occasions the grouse used sections of one log as if they were separate logs.

The actual drumming stage is a precise spot on the log, fanned clean of debris if not worn and void of all vegetation, and marked with droppings (e.g. BUMP *et al.* 1947, HJORT 1970). In the present study about 70 % of the stages were from 0.5 to 1 m wide. The wear of the log surface or moss cover may lead the grouse to use a narrower section than if the log surface were solid with little moss cover. It is obvious that on a sloping log the grouse uses the stage, which is worn level (cf. BOAG & SUMANIK 1969).

The bearings of the log axis showed a practically even distribution in the 90° sectors defined for the purpose. There was no evidence of preferential use of logs in any sector. Nor was there any evidence of an effect of any specific direction of wind (cf. BOAG & SUMANIK 1969).

Of the logs examined 84 (75 %) were horizontal. The mean slope of the 28 logs used was 7.3° (SD 4.3). This is comparable with the observations of BOAG & SUMANIK (1969). One log, as mentioned earlier, was perpendicular to the 20° slope (cf. McGOWAN 1966). The surface, however, was so worn that the stage sloped only about 5°.

The intensity of use of a log has been assessed from the number of droppings on the log and in its immediate vicinity (e.g. BUMP *et al.* 1947: 280, GULLION 1967:98—99). According to GULLION (1966), the ruffed grouse deposits about 4 droppings an hour. PORATH & VOHS (1972) counted from 7 to 278 droppings at a site, and obtained an average of 85 droppings per log.

There is no reason to suppose that the Pacific ruffed grouse defecates at a different rate from the other subspecies. However, the maximum number of droppings counted during the present study was 65 and at another site 38 (see also Table 16). In both cases the texture indicated that the droppings had been deposited in early spring. Droppings of this type may remain observable through the wet winter and early spring of western Washington, especially if the sites have a coniferous cover. When the soft "early-green diet" droppings appear, these are washed away by rain or devoured by slugs. In Alberta BOAG & SUMANIK (1969) observed chipmunks feeding on grouse droppings. Depending on the weather, soft droppings may remain visible for about 2 weeks. The usefulness of dropping counts for determining the level of activity at a drumming site should therefore be tested for western Washington conditions.

Feathers, in contrast, seem to remain observable in spite of wet weather, especially at sites under conifers. As they tend to be few, however, they only indicate whether the log is used for drumming.

D. Differences between study areas

The three study areas differed in several respects. But as the observations were not evenly distributed and no population density data are available, the differences are considered to be only indicative. They show that the Pacific ruffed grouse is present in a broad spectrum of habitats produced by forest succession, and can probably be managed successfully in most of them. Comparisons and setting of criteria for the optimal habitat or habitats must await the results of large-scale population studies or at least expanded comparative censusing.

E. Ruffed grouse habitat management and silviculture

The essentials of a good game habitat were defined by LEOPOLD (1931) as the proper interspersion of the basic requirements: food, water and cover. EDMINSTER (1934) and KING (1937) described the practical aspects of habitat management for the ruffed grouse. MORTON & SEDAM (1938) experimented with forestry practices equally usable in forest management, harvesting of timber and creation of habitat for the ruffed grouse and the white-tailed deer, *Odocoileus virginianus*. In their view, timber sales and habitat could be improved simultaneously.

The male ruffed grouse is known to be strongly attached to his territory, which is about 16 ha in winter and about 4 ha during the drumming season (MARSHALL 1965). Broods also stay within relatively small home-ranges. In a Minnesota study this was about 13 ha (GODFREY 1974). Dispersal movements of juvenile birds are in general from 1 to 12 km, occasionally more (CHAMBERS & SHARP 1958, HALE & DORNEY 1963, GODFREY & MARSHALL 1969).

The ample information about the habitat requirements and preferences of the ruffed grouse has been applied in recommendations concerning the size of grouse management areas and practices for improving and maintaining the habitat. The consensus is that numerous small blocks creating a habitat mosaic are better than a few large but widely scattered areas (e.g. KING 1937, HUNGERFORD 1953b, GULLION *et al.* 1962, SHARP 1963, 1970, GULLION 1977).

Forests in western Washington represent various stages of secondary succession. Vast areas are covered by primarily deciduous stands, dominated by red alder. Naturally regenerated stands of Douglas fir already yield timber and wood of smaller size-classes. In general, clear-cut areas are reforested without delay and managed for maximum production (see e.g. CAMPBELL & EVANS 1975).

The topography of western Washington provides two basic situations for the management of ruffed grouse habitat. In valley systems with steep slopes only level bottomlands and ridgetops can be considered. Where features are gentle, ruffed grouse habitat can be established practically anywhere and, with some adjustments, managed within the framework of forestry.

To create the all-important brood habitat, thinning and opening the continuous forest canopy by clear-cutting small areas about 500 m apart have been recommended (MORTON & SEDAM 1938, SHARP 1963). In Idaho, the effects of 25—30 % thinning of pole-size Douglas fir stands lasted for 30—40 years (HUNGERFORD 1969); small clear-cuts were usable by the ruffed grouse but discouraged deer and mice, an important point where reforestation is intensive (cf. also BLACK 1969, 1974, BERG 1970). KING (1938:526) stated that in heavily wooded areas small clear-cuts do not sacrifice valuable timber (cf. STAEBLER 1976). In the present study, ruffed grouse were observed to prefer openings smaller than 50 by 50 m. In large-scale timber harvesting small blocks are obviously unpractical. A clear-cut strip with irregular boundaries provides more edge and thus makes parts of the surrounding dense forest acceptable to the grouse. The present study indicates that stands with a basal area exceeding 50 m^2/ha are unacceptable.

Where a road system is available logging could be planned in cycles. For instance, adjacent 10—20 ha blocks could be cut every 10 years. A 40-year rotation would include commercial thinnings and keep the stands open enough for the ruffed grouse. Suitable brood habitat would then always be available. As stressed by GULLION (1975) and CAMPBELL & EVANS (1975), it is important to know the local key food plants, which can then be saved in logging operations. In western Washington one question mark is the role of black cottonwood in the winter and early spring diet of the ruffed grouse (cf. SVOBODA & GULLION 1972).

Burning of logging slash greatly helps the development of a good grouse habitat by removing the litter, rejuvenating food plants and controlling their diseases (SHARP 1970). In western Washington, the elimination of slash piles would also help to control damage by the mountain beaver, *Aplodontia rufa*, in Douglas fir plantations. Considering the spring weather pattern in western Washington, the danger of air pollution has probably been exaggerated.

Alder forests, which to some extent are marginal as a ruffed grouse habitat, may well be utilized in the near future (cf. BOYD *et al.* 1977). The solutions would call for various commercial uses of alder, e.g. as pulpwood, for wood products and as firewood. Thinning off the log-size alder would also allow the growth of the western hemlock saplings generally present and make these stands suitable for the ruffed grouse for several years.

Stream floodplains of valley systems are the areas which for many reasons call for less intensive use (cf. e.g. NELSON 1975). In western Washington these bottomlands have supported stands of western red cedar. In many such areas red cedar at present reproduces well under a primarily deciduous crown cover. Deeper in the mountainous terrain practically the only suitable ruffed grouse habitats are found along streams. When adjacent slopes are clear-cut there should always be a shelter zone against the floodplain. For the territorial needs of a male grouse, 100 m on both sides would be enough. In narrow valleys a shelter zone extending across the valley and up the slopes for some distance is also needed for protection of the stream. When necessary, individual trees of desired species or size class could be removed selectively without major difficulty or disturbance.

The problems of managing the habitat for forest wildlife while producing raw material for the wood industries have been acceptably solved within the well-established principle of multiple use (e.g. CHASE 1949, NELSON 1975). Although foresters and wildlife managers may have some differences of approach, they are at least able to communicate with each other (POOLE 1974). More serious problems seem to be met within the scope of forestry itself. POOLE (1974) and STAEBLER (1975) both comment on the slow transfer of research findings and the tardy process of applying what is already known. Harvesting technology has advanced slowly due to inadequate research and development, as revealed by the increased demand for wood products and the restrictions of operations (BOYD *et al.* 1977). In decision-making the representatives of technology and economics have a disproportionately stronger voice than resource managers, who after all have the all-important knowledge of how the ecosystem functions (POOLE 1974, also HALLS 1975). STAEBLER (1976) writes that responsible management goes beyond exploitation of the growth capability of the forest, and that minor sacrifices in timber production result in tremendous gains in other uses (cf. also KIM 1973).

Re-evaluation of priorities will evidently justify the economic feasibility of the alternative uses of forest resources to an extent acceptable to the public and without any significant loss to the wood industries (see KIM 1973).

Many forestry practices are basically beneficial to wildlife, and the growing environmental concern of the public and subsequent restrictions may "soften" the impact of modern forestry upon the ecosystem. The present trend towards a shorter rotation can be applied in the management of the wildlife habitat, including that of the ruffed grouse, without any major obstacles. Cooperation is needed in planning harvesting and subsequent reforestation and management to create a habitat mosaic both favourable to the wildlife and pleasant to the human eye.

6. Conclusions

1. The Pacific ruffed grouse occupies a wide range of habitats in western Washington and its management is feasible within the framework of modern forestry.

2. Population densities of 5—7 males/km^2 are not uncommon in suitable habitats.

3. Dense conifer stands are the least attractive to the grouse and should thus be of limited size. Large continuous forests should be opened by clear-cutting small tracts whenever feasible.

4. In areas which have good road systems, cyclic logging of adjacent 10—20 ha blocks every 10 years or so would provide habitat for the ruffed grouse within its relatively small home-range. The size, shape and location of these clear-cuts should be planned to create a habitat mosaic. This type of habitat management would fit into the 40-year rotation of Douglas fir stands.

5. In valley systems west of the Cascades, the valley floors or floodplains are practically the only habitats suitable for the ruffed grouse. These areas should be protected with a shelter zone across the valley or for at least 100 m on the both sides of the stream. Desired tree species or size classes could be removed selectively without major difficulty.

6. Manipulation of alder-dominated areas would make them more attractive to the grouse and release the growth of the young western hemlock generally present. At present the main obstacle is the limited commercial use of alder.

7. Increasing environmental concern and changing needs of the people will evidently be reflected in more compatible uses and management of forest resources, including wildlife.

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Table 1. Composition of forest crown at ruffed grouse drumming sites in western Washington.

Species	Mean 1	SD %	Mean 2	SD	Freq – %	n
Snoqualmie, N = 85						
Total coverage	62.7	4.6			100.0	85
Alnus rubra	28.2	5.1	36.4	4.9	77.7	66
Tsuga heterophylla	16.8	4.6	31.8	4.4	52.9	45
Pseudotsuga menziesii	8.5	3.5	16.6	3.6	51.8	44
Thuja plicata	2.6	2.7	16.9	3.1	15.3	13
Acer macrophylla	1.9	2.2	10.7	2.6	17.7	15
Salix spp. (*S. lasiandra*, *S. scouleriana*)	1.8	2.7	21.4	4.0	8.2	7
Populus trichocarpa	1.3	2.0	10.0	2.5	12.9	11
Cedar River, N = 13						
Total coverage	61.5	4.1			100.0	13
Tsuga heterophylla	20.8	4.5	33.8	3.9	61.5	8
Alnus rubra	15.4	4.1	25.0	3.9	61.5	8
Acer circinatum	6.9	4.1	45.0	2.7	15.4	2
Thuja plicata	5.4	3.5	23.3	3.9	23.1	3
Pseudotsuga menziesii	4.6	3.4	30.0	0	15.4	2
Acer macrophylla	2.3	2.4	15.0	2.7	15.4	2
Picea sitchensis	2.3	2.4	15.0	2.7	15.4	2
Abies grandis	2.3	2.9	30.0	0	7.7	1
Populus trichocarpa	1.5	2.3	20.0	0	7.7	1
Tulalip, N = 14						
Total coverage	60.0	4.0			100.0	14
Alnus rubra	42.1	4.7	45.4	4.4	92.9	13
Populus trichocarpa	12.1	3.6	18.9	3.4	64.3	9
Acer macrophylla	2.9	2.5	13.3	2.4	21.4	3
Pseudotsuga menziesii	1.4	1.9	10.0	0	14.3	2
Thuja plicata	1.4	1.9	10.0	0	14.3	2
All areas combined, N = 112						
Total coverage	62.2	4.5			100.0	112
Alnus rubra	28.5	5.0	36.7	4.8	77.7	87
Tsuga heterophylla	15.2	4.5	32.1	4.4	47.3	53
Pseudotsuga menziesii	7.2	3.4	16.8	3.5	42.8	48
Thuja plicata	2.8	2.7	17.2	3.2	16.1	18
Populus trichocarpa	2.7	2.6	14.3	3.1	18.7	21
Acer macrophylla	2.1	2.3	11.5	2.6	17.8	20
Salix spp. (*S. lasiandra*, *S. scouleriana*)	1.3	2.5	21.4	4.0	6.2	7

No significant differences in total crown coverage between the study areas.
Alnus rubra: Tulalip – Cedar River; $t = 3.52$, $P < 0.002$.
Pseudotsuga menziesii: Snoqualmie – Tulalip; $t = 2.14$, $P < 0.05$.
Populus trichocarpa: Tulalip – Snoqualmie; $t = 6.18$, $P < 0.001$; Tulalip – Cedar River; $t = 2.70$, $P < 0.02$.

Degrees of freedom: Snoqualmie – Tulalip 97, Snoqualmie – Cedar River 96, Cedar River – Tulalip 25.

Table 2. Composition of forest understorey at ruffed grouse drumming sites in western Washington.

Species	Mean 1	SD %	Mean 2	SD	Freq – %	n
Snoqualmie, N = 85						
Total coverage	49.9	4.7			100.0	85
Acer circinatum	27.2	4.8	31.2	4.6	87.1	74
Tsuga heterophylla	14.9	3.9	20.2	3.9	74.1	63
Thuja plicata	1.6	2.1	10.0	2.6	16.5	14
Rhamnus purshiana	1.5	2.0	9.3	2.5	16.5	14
Alnus rubra	1.1	1.9	8.2	2.4	12.9	11
Cedar River, N = 13						
Total coverage	44.6	5.7			100.0	13
Acer circinatum	17.7	5.0	38.3	4.8	46.6	6
Tsuga heterophylla	12.3	5.0	26.4	4.9	46.6	6
Pyrus fusca	6.9	4.1	45.0	2.7	15.4	2
Alnus rubra	4.6	3.1	20.0	3.2	23.1	3
Pseudotsuga menziesii	1.5	1.9	10.0	0	15.4	2
Tulalip, N = 14						
Total coverage	72.1	4.5			100.0	14
Acer circinatum	26.4	5.7	46.2	5.4	57.1	8
Sambucus racemosa	11.7	4.6	22.9	5.1	50.0	7
Thuja plicata	10.7	4.2	25.0	4.3	42.9	6
Tsuga heterophylla	7.1	3.4	16.7	3.5	42.9	6
Acer macrophylla	7.1	4.9	50.0	7.5	14.3	2
Osmaronia cerasiformis	5.7	3.5	26.7	3.4	21.4	3
Alnus rubra	2.1	2.1	10.0	0	21.4	3
Rubus spectabilis (> 2.5 m)	1.4	1.9	10.0	0	14.3	2
All areas combined, N = 112						
Total coverage	52.1	4.9			100.0	112
Acer circinatum	26.0	4.9	33.1	4.7	78.6	88
Tsuga heterophylla	13.7	4.0	20.4	3.9	67.0	75
Thuja plicata	2.7	2.8	14.3	3.6	18.7	21
Alnus rubra	2.0	2.4	13.8	3.1	14.3	16
Sambucus racemosa	2.0	2.9	14.7	4.3	13.4	15
Rhamus purshiana	1.2	1.9	8.7	2.5	13.4	15
Pseudotsuga menziesii	1.0	1.8	8.5	2.3	11.6	13
Acer macrophylla	1.0	2.9	36.7	6.8	2.7	3

Total understorey coverage: Tulalip – Snoqualmie; $t = 3.58$, $P < 0.001$; Tulalip – Cedar River; $t = 2.63$, $P < 0.02$.
Thuja plicata: Tulalip – Snoqualmie; $t = 4.11$, $P < 0.001$.
Sambucus racemosa: Tulalip – Snoqualmie; $t = 4.60$, $P < 0.001$.
Acer macrophylla: Tulalip – Snoqualmie; $t = 2.75$, $P < 0.01$.

Table 3. Composition of shrub stratum at ruffed grouse drumming sites in western Washington.

Species	Mean 1	SD %	Mean 2	SD	Freq − %	n
Snoqualmie, N = 85						
Total coverage	46.6	5.0			100.0	85
Polystichum munitum	20.7	4.3	23.5	4.3	88.2	75
Rubus spectabilis	8.7	4.5	30.8	5.3	28.2	24
Vaccinium parvifolium	5.2	2.8	7.9	2.9	65.9	56
Berberis nervosa	3.6	3.2	11.9	3.9	30.6	26
Gaultheria shallon	1.8	2.9	15.0	4.6	11.8	10
Cedar River, N = 13						
Total coverage	28.5	4.8			100.0	13
Rubus spectabilis	14.6	4.8	31.7	5.1	46.6	6
Polystichum munitum	8.5	3.5	18.3	3.4	46.6	6
Berberis nervosa	3.8	2.8	16.7	2.4	23.1	3
Vaccinium parvifolium	1.5	1.9	10.0	0	15.4	2
Tulalip, N = 14						
Total coverage	57.9	5.3			100.0	14
Rubus spectabilis	35.0	5.4	37.7	5.4	92.9	13
Sambucus racemosa	12.9	4.5	25.7	4.7	50.0	7
Polystichum munitum	5.7	2.5	7.3	2.5	78.6	11
Vaccinium parvifolium	1.4	2.3	20.0	0	7.1	1
All areas combined, N = 112						
Total coverage	45.9	5.1			100.0	112
Polystichum munitum	17.4	4.2	21.8	4.2	82.1	92
Rubus spectabilis	12.7	4.8	33.0	5.2	38.4	43
Vaccinium parvifolium	4.3	2.7	8.1	2.9	52.7	59
Berberis nervosa	3.3	3.0	12.3	3.8	26.8	30
Sambucus racemosa	2.3	2.9	11.8	4.0	19.6	22
Gaultheria shallon	1.3	2.7	15.0	4.6	8.9	10

Total coverage of shrub stratum: Snoqualmie — Cedar River; $t = 2.43$, $P < 0.02$; Tulalip — Cedar River; $t = 2.94$, $P < 0.01$.
Polystichum munitum: Snoqualmie — Tulalip; $t = 2.94$, $P < 0.01$; Snoqualmie — Cedar River; $t = 2.27$, $P < 0.05$.
Rubus spectabilis: Variation of occurrence significant; $F = 8.76$, $P < 0.01$ (df 2, 109); Snoqualmie — Tulalip; $t = 4.21$, $P < 0.001$.
Vaccinium parvifolium: Note the low overall coverage but high frequency.
Sambucus racemosa: Snoqualmie — Tulalip; $t = 5.25$, $P < 0.001$.

Table 6. Heights of ruffed grouse drumming stages in western Washington.

Areas		Mean	SD	Number of stages < 40	41 − 80	81 − 120	> 120 cm
Snoqualmie	N = 85	64.2	4.8	13	59	12	1
Cedar River	N = 13	60.8	4.9	1	10	2	—
Tulalip	N = 14	58.6	4.5	4	8	2	—
All combined	N = 112	63.1	4.7	18	77	16	1
Percentage				16.1	68.7	14.3	0.9

Stage height 20 — 170 cm. No significant differences between the study areas.

Table 4. Aspect (bearing and slope) of the terrain at ruffed grouse drumming sites in western Washington.

Areas	Mean	SD	Sectors N	E	S	W	Level	
Snoqualmie								
n			10	7	20	5	43	50.6 %
mean bearing			356	089	195	269		
mean slope			4.5	4.1	5.8	3.6		
n = 42	4.9	3.1						
N = 85	2.3	1.8						
Cedar River								
n			1	—	2	—	10	76.9 %
mean bearing			360	—	195	—		
mean slope			5.0	—	11.5	—		
n = 3	9.3	9.3						
N = 13	2.2	2.4						
Tulalip								
n			—	6	—	—	8	57.1 %
mean bearing			—	113	—	—		
mean slope			—	6.0	—	—		
n = 6	6.0	4.5						
N = 14	2.9	2.0						
All areas combined								
n			11	13	22	5	61	54.5 %
mean bearing			356	100	195	269		
mean slope			4.5	5.0	6.3	3.6		
n = 51	5.3	3.8						
N = 112	2.3	1.9						

Table 5. Diameters of ruffed grouse drumming logs in western Washington.

Areas		Mean	SD	Number of logs < 40	41 − 80	81 − 120	> 120 cm
Snoqualmie	N = 85	73.1	5.5	40	46	20	6
Cedar River	N = 13	61.2	5.3	3	8	2	—
Tulalip	N = 14	56.1	4.6	4	9	1	—
All combined	N = 112	69.5	5.5	20	63	23	6
Percentage				17.9	56.3	20.5	5.4

Diameter 25 — 160 cm. The grouping into size classes was tested against a random sample of 112 logs not used by the grouse. There was no significant difference between the two samples (20 — 63 — 23 — 6 vs. 28 — 56 — 23 — 5): $\chi^2 = 3.15$ (3 df), $P > 0.1$.
Snoqualmie — Tulalip, narrowly significant difference; $t = 1.99$, $P < 0.05$.

Table 7. Lengths of ruffed grouse drumming logs in western Washington.

Areas		Mean	SD	Number of logs < 2	2–5	6–10	> 10 m
Snoqualmie	N = 85	10.9	2.5	2	9	45	29
Cedar River	N = 13	8.0	2.0	–	4	6	3
Tulalip	N = 14	9.9	2.4	–	2	7	7
All combined	N = 112	10.5	2.4	2	15	58	37
Percentage				1.8	13.4	51.8	33.0

Length 1 – 30 m. The grouping into size classes differs from the result obtained from a random sample of 112 logs not used by the grouse (2–15–58–37 vs. 3–24–42–43): χ^2 = 10.83 (3 df), P < 0.025

Table 8. Lengths of the portion of logs used for drumming and strutting by ruffed grouse in western Washington.

Areas		Mean	SD	Number of logs 0.5	1.0	1–3	> 3 m
Snoqualmie	N = 85	1.6	1.2	26	34	14	11
Cedar River	N = 13	1.6	0.9	6	5	2	–
Tulalip	N = 14	2.3	1.4	3	5	2	4
All combined	N = 112	1.6	1.2	35	44	18	15
Percentage				31.2	39.3	16.2	13.4

Cedar River – Tulalip: t = 2.16, P < 0.05.

Table 9. Aspect (bearing and slope) of ruffed grouse drumming logs in western Washington.

Areas	Mean	SD	Sectors N	E	S	W	Level	
Snoqualmie								
n			4	4	6	9	62	72.9 %
mean bearing			348	064	178	275		
mean slope			5.8	6.3	8.0	5.8		
n = 23	6.4	3.3						
N = 85	1.7	1.8						
Cedar River								
n			–	–	–	1	12	92.3 %
mean bearing			–	–	–	230		
mean slope			–	–	–	20.0		
n = 1	20.0	0						
N = 13	1.5	2.4						
Tulalip								
n			–	3	1	–	10	71.4 %
mean bearing			–	102	150	–		
mean slope			–	10.0	5.0	–		
n = 4	8.8	4.8						
N = 14	2.5	2.2						
All combined								
n			4	7	7	10	84	75.0 %
mean bearing			348	080	174	271		
mean slope			5.8	7.9	7.6	7.2		
n = 28	7.3	4.3						
N = 112	1.8	1.9						

Slope 2–20°. In many cases, however, the stage was worn or situated in such a way that the slope was either greatly reduced or eliminated completely.
No significant differences between the study areas.

Table 10. Bearings of ruffed grouse drumming logs in western Washington.

Areas		Number in sectors N	E	S	W
Snoqualmie,	N = 85	28	22	17	18
Cedar River,	N = 13	2	3	2	6
Tulalip,	N = 14	4	6	3	1
All combined,	N = 112	34	31	22	25
Percentage		30.4	27.7	19.6	22.3
Mean bearing		355	067	185	268
SD		26	21	26	25

The distribution of logs among the sectors does not differ from an even distribution: χ^2 = 4.60 (3 df), P > 0.1.

Table 11. Height of direct overhead cover at ruffed grouse drumming sites in western Washington.

Areas		Mean	SD	Number of sites < 0.5	0.5–1.0	> 1.0 m	n
Snoqualmie,	N = 85	95.5	7.2	10	26	15	51
Cedar River	N = 13	60.0	0	–	1	–	1
Tulalip,	N = 14	113.6	7.7	1	6	4	11
All combined	N = 112	93.6	6.4	11	33	19	63
Percentage (none, n = 49, 43.8%)				9.8	29.5	16.9	56.2

Height 20 cm – 2.5 m. The means are not significantly different.

Table 12. Radius of visibility at ruffed grouse drumming sites in western Washington.

Areas		Mean	SD	Number of sites < 10	10–20	> 20 m
Snoqualmie,	N = 85	14.8	2.3	33	47	5
Cedar Rider,	N = 13	18.5	2.4	2	9	2
Tulalip,	N = 14	18.2	3.2	3	10	1
All combined,	N = 112	15.6	2.5	38	66	8
Percentage				33.9	58.9	7.1

The wide variation, from 5 to about 50 m, is reflected in the F value for the data: F = 3.43 (2, 109 df), P < 0.05. The means for the Snoqualmie and Tulalip areas do not differ significantly, although at Tulalip the understorey is about 20 % denser and the shrub stratum 10 % denser.
Snoqualmie – Cedar River: t = 2.27, P < 0.05.

Table 13. Moss cover on ruffed grouse drumming logs in western Washington.

Areas		Mean	SD	Number of logs		
			Cover:	0–30	30–70	70–100%
Snoqualmie,	N = 85	81.8	27.7	3	25	57
Cedar River,	N = 13	88.5	22.0	–	3	10
Tulalip,	N = 14	96.5	13.4	–	1	13
All combined,	N = 112	84.4	26.0	3	29	80
Percentage				2.7	25.9	71.4

The recording scale, 0–1–2, has been transformed to percentages. No significant differences between the study areas.

Table 14. Occurrence of vegetation other than mosses on the ruffed grouse drumming logs in western Washington.

Areas		Number of logs			
	Cover:	< 10%	%	> 10%	%
Snoqualmie,	N = 85	76	89.4	9	10.6
Cedar River,	N = 13	12	92.3	1	7.7
Tulalip,	N = 14	12	85.7	2	14.3
All combined,	N = 112	100	89.3	12	10.7

The recording scale, 0–1, has been transformed to percentages No significant differences between the areal means.

Table 15. Firmness of ruffed grouse drumming logs in western Washington.

Areas		Number of logs			
	Firmness:	< 50% (decayed)	%	> 50% (firm)	%
Snoqualmie,	N = 85	39	45.9	46	54.1
Cedar River,	N = 13	3	23.1	10	76.9
Tulalip,	N = 14	3	21.4	11	78.6
All combined,	N = 112	45	40.2	67	59.8

No significant differences.

Table 16. Number of droppings at ruffed grouse drumming sites in western Washington.

Areas		Mean	SD	Number of sites			
			Droppings:	< 10	10–20	> 20	n
Snoqualmie,	N = 85	12.4	3.1	45	26	10	81
Cedar River,	N = 13	5.4	1.9	12	1	–	13
All combined,	N = 98	11.4	3.0	57	27	10	94
Percentage							
(none, n = 4, 4%)				58.2	27.6	10.2	96.0

No information from the Tulalip area.
Snoqualmie – Cedar River; $t = 2.64$, $P < 0.01$.

Table 17. Number of feathers at ruffed grouse drumming sites in western Washington.

Areas		Mean	SD	Number of sites			
			Feathers:	< 5	5–10	> 10	n
Snoqualmie	N = 85	3.0	1.7	21	2	1	24
Cedar River	N = 13	1.3	0.8	3	–	–	3
All combined	N = 98	2.8	1.2	24	2	1	27
Percentage							
(none, n = 71, 72. 4%)				24.5	2.0	1.0	27.5

No information from the Tulalip area.

Table 18. Distance to the nearest drumming site within the territory of ruffed grouse in western Washington.

Areas		Mean	SD	Number of sites				
		Distance:		< 10	10–20	21–30	> 30 m	n
Snoqualmie	N = 85	24.3	3.2	8	15	20	6	49
Cedar River	N = 13	21.3	3.1	2	3	4	–	9
All combined	N = 98	23.9	2.7	10	18	24	6	58
Percentage								
(none, n = 40, 40.8%)				10.2	10.2 18.4	24.5	6.1	59.2

No information from the Tulalip area. No significant differences.

Table 19. Distance to the nearest opening from ruffed grouse drumming sites in western Washington.

Areas		Mean	SD	Number of sites			
			Distance:	< 10	10–50	> 50 m	n
Snoqualmie	N = 85	29	5	18	48	8	74
Cedar River	N = 13	17	4	6	7	–	13
All combined	N = 98	27	4	24	55	8	87
Percentage							
(none, n = 11, 11.2%)				24.5	56.1	8.2	88.8

In the Tulalip area there were no openings to be considered.

Table 20. Distance to the nearest *Populus trichocarpa* from ruffed grouse drumming sites in western Washington.

Areas		Mean	SD	Number of sites			
			Distance:	< 10	10–50	> 50 m	n
Snoqualmie	N = 85	49	5	9	51	21	81
Cedar River	N = 13	48	5	1	9	3	13
Tulalip	N = 14	20	7	9	–	1	10
All combined	N = 112	46	5	19	60	25	104
Percentage							
(none, n = 8, 7.1%)				17.0	53.6	22.3	92.9

Distance 5 – 150 m. Snoqualmie – Tulalip: $t = 3.00$, $P < 0.01$

Table 21. Correlations of some selected characters of the ruffed grouse drumming sites in western Washington. N = 112; 0.195 = P < 0.05, 0.254 = P < 0.01, 0. 321 = P < 0.001.

Forest Crown	
Total coverage:	
Tsuga heterophylla	0.327
Alnus rubra	0.424
understorey, total coverage	−0.413
Acer circinatum, u-storey	−0.375
Pseudotsuga menziesii, u-storey	−0.242
Vaccinium parvifolium, shrubs	−0.309
Tsuga heterophylla:	
Thuja plicata	0.255
Alnus rubra	−0.497
Populus trichocarpa	−0.247
understorey, total coverage	−0.320
Acer circinatum, u-storey	−0.338
Gaultheria shallon, shrubs	0.219
Thuja plicata:	
Alnus rubra	−0.293
Pseudotsuga menziesii:	
P. menziesii, u-story	0.306
Rubus spectabilis, shrubs	−0.253
Alnus rubra:	
understorey, total coverage	0.227
Sambucus racemosa, u-storey	0.220
S. racemosa, shrubs	0.235
Acer macrophylla:	
Sambucus racemosa, u-storey	0.299
Populus trichocarpa:	
Osmaronia cerasiformis, u-storey	0.333
Thuja plicata, u-storey	0.247
Rubus spectabilis, u-storey	0.531
R. spectabilis, shrubs	0.443
Understorey	
Total coverage:	
Acer circinatum	0.562
Pseudotsuga menziesii	0.259
Tsuga heterophylla	0.219
Acer circinatum:	
Sambucus racemosa, shrubs	−0.247
Thuja plicata:	
S. racemosa	0.316
Pseudotsuga menziesii:	
Rhamnus purshiana	0.275
Vaccinium parvifolium	0.232
Sambucus racemosa:	
shrubs, total coverage	0.295
S. racemosa, shrubs	0.718
Rubus spectabilis:	
R. spectabilis, shrubs	0.362
Osmaronia cerasiformis	0.274
Shrub stratum	
Total coverage:	
Rubus spectabilis	0.521
Polystichum munitum	0.351
Rubus spectabilis:	
P. munitum	−0.348
Log characteristic	
Stage height:	
understorey, total coverage	−0.250
Polystichum munitum, shrubs	0.229
log diameter	0.731
log length	0.316
Height of overhead cover:	
shrub stratum, total coverage	0.303
Rubus spectabilis, shrubs	0.260
Thuja plicata, u-storey	0.223
Visibility radius:	
Rubus spectabilis, shrubs	−0.315
Distance to opening:	
Populus trichocarpa, crown coverage	−0.258
understorey, total coverage	−0.343
distance to *P. trichocarpa*	0.414
Distance to adjacent log in same territory:	
distance to opening	0.377
Tsuga heterophylla, crown coverage	0.290
understorey, total coverage	−0.215
Acer circinatum, u-story	−0.293
Distance to *P. trichocarpa:*	
P. trichocarpa, crown coverage	−0.454
Alnus rubra, —»—	−0.421
Rubus spectabilis, shrubs	−0.250

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