INTRODUCTION

Importance of small game in Arizona, specifically Abert squirrel and cottontail, is evidenced by the increasing numbers of hunters attempting to harvest these animals. For example, Abert squirrel hunters increased approximately 80 percent in the 1960's (Patton and Green 1970). With this expanded use, it is important that knowledge become available to assess small game activities in on-going and proposed land management systems.

Some information relating to Abert squirrel activities in ponderosa pine forests is available. Keith (1965), in describing food and cover requirements of the Abert squirrel in a virgin forest near Flagstaff, found that the animal depends solely on ponderosa pine trees for food and cover. Larson and Schubert (1970) reported on the potentially detrimental influence of the seed-eating and twig-clipping activities of Abert squirrel in the same virgin forest. A segment of Abert squirrel habitat has been identified by Patton and Green (1970), who indicated that the animal preferred mature ponderosa pine trees, 11 to 30 inches in diameter, as feed trees in east-central Arizona.

Recently, work relative to Abert squirrel activities has been carried out in the vicinity of the Beaver Creek Watershed. With the winter diet of Abert squirrel consisting mostly of the inner bark of ponderosa pine twigs (Keith 1965), Patton (1974) found that squirrels actually consume less than 10 percent of the weight of twigs clipped. Stephenson (1974) reported the Abert squirrel to have a diet of seven major foods throughout a year, with fungi, apical buds and inner bark of ponderosa pine, and Gambel oak acorns the most important. In determining the number of nests and size of home ranges, Patton (1975a) discovered that Abert squirrel often have and use more than one nest in their home range; for example, three squirrels used 2, 5 and 6 nests in areas of 30, 10, and 85 acres, respectively. In another study, Patton (1975b) characterized ponderosa pine trees and stands selected by Abert squirrel for cover in terms of tree density and size, dominance and age class, and nest location and nest tree density. Finally, Ffolliott and Patton (1975) developed production-rating functions for Abert squirrel feed and nest trees and tree volume, which allow identification of conflicts between the use of ponderosa pine for squirrel feed and nest trees and for timber production.

Knowledge of cottontail activities in the ponderosa pine forests in the Southwest is essentially non-existent, although cottontail use of the adjacent pinyon-juniper woodlands has been described (Kundaeli and Reynolds 1972).

The responses of small game to land management practices being evaluated on the Beaver Creek Watershed need to be identified and, if possible, quantified to meet the objectives of the project (Brown et al. 1974). To this end, responses of Abert squirrel and cottontail to specific land management practices under evaluation have been investigated.

DESCRIPTION OF INVESTIGATION

Research on small game in Beaver Creek was designed to satisfy the following objectives:

1. Determine relative habitat use of Abert squirrel and cottontail in selected Beaver Creek Watersheds; and

2. Provide information as to how and to what degree Abert squirrel and cottontail habitat is affected by various land management practices.

Field methods used to satisfy the objectives involved the collection of data necessary to identify Abert squirrel and cottontail activities, vis-a-vis the collection of information required to document life histories. Primarily, these data were obtained from 1/100-acre plots established on each study area, with the sample points comprising the timber overstory sampling design as the plot centers. These plots represented a range of habitat parameters (i.e., vegetation, physiography, etc.) common to each study area. Furthermore, the existing timber overstory and site descriptions were then available to empirically relate Abert squirrel and cottontail activities to habitat characteristics.

The sampling design on each study area consisted of a systematic sample with multiple random starts (Shiue 1960), which allowed appropriate statistical inferences within a framework of extended coverage of each study area. However, the number of random starts varied among study areas, as did the interval among starts and between sample points.

METHODS

Study Areas. -- Beaver Creek Watersheds 8, 10, 12, 13, 14, and 17, located on the Coconino National Forest, were selected as the study areas. Study areas and corresponding land management practices investigated within the framework of the study objectives were:

Watershed 8. -- Prior to 1974, the forest overstory on this 1,802-acre watershed represented a condition of being cut by group selection to remove approximately 50 percent of the then (1950-55) merchantable volume. Then, the forest overstory was cut to enhance timber production in 1974, following a silvicultural prescription that will allow the residual stands to be managed according to a shelterwood plan.

Watershed 10. -- Prior to 1974, the forest overstory on this 571-acre watershed represented a condition of being cut by group selection to remove approximately 50 percent of the then (1950-55) merchantable volume. Then, the forest overstory was cut by creating irregular openings to benefit wildlife, and the forest overstory in the leave areas was thinned in a manner similar to that carried out on Watershed 8.

Watershed 12. -- The forest overstory on this 455-acre watershed was totally cleared in 1966-67, with slash windrowed and Gambel oak sprouts partially controlled with chemicals.

Watershed 13. -- The forest overstory on this 867-acre watershed has been cut by group selection to remove approximately 50 percent of the then (1950-55) merchantable volume. This study area is considered a "control" area for evaluation purposes.

Watershed 14. -- The forest overstory on this 1,349-acre watershed was cleared in irregular strips averaging 60 feet wide in 1971-72, with intervening leave strips averaging 120 feet wide. Furthermore, the intervening leave strips were thinned to 80 square feet of basal area by a silvicultural cut.

Watershed 17. -- The forest overstory on this 299-acre watershed was thinned by group selection in 1969, with 75 percent of the initial basal area removed, leaving residual stands in evenaged groups averaging 30 square feet of basal area per acre.

Additional characterizations of these study areas, i.e., physiographic features, climatic patterns, etc., have been presented by Brown et al. (1974).

The sample size, i.e., the number of sample points, on each study area was:

Watershed 8. -- 189 points.

Watershed 10. -- 143 points.

Watershed 12. -- 195 points.

Watershed 13. -- 184 points.

Watershed 14. -- 193 points.

Watershed 17. -- 182 points.

The following attributes were assessed on each 1/100-acre circular plot to index the seasonal activities of Abert squirrel and cottontail:

Abert squirrel

(1) Twig clippings, both needled and peeled, were recorded in spring, summer, fall, and winter, with plot clearing in spring and fall.

(2) Mushroom digs were recorded in summer.

(3) Track counts were recorded along transect lines between plots in winter, depending upon snow cover.

Cottontail

(1) Pellets were recorded and cleared in spring and fall.

(2) Track counts were recorded along transect lines between plots in winter, depending upon snow cover.

In addition, Abert squirrel feed and nest trees were counted in the spring, with the tree tallies made in the timber overstory inventory as the basis. This inventory employed point sampling techniques, using an angle gage corresponding to a basal area factor (BAF) of 25. The advantage of using this tree tally was that the permanently marked trees had already been quantified in terms of diameter, height, crown position, etc. To allow for interpretation of the intensity of feed tree use, the number of twigs found beneath trees were classified as: less than 10, 10 to 50, more than 50, and none.

As the data obtained represented a four-year (1972-76) evaluation period, an attempt was made to describe time-space differences in Abert squirrel and cottontial activities on each study area. These assessments were made in terms of a land management practice as implemented on a study area as an entity (a macro-analysis), and in terms of discrete forest stand-site elements delineated within a land management practice (a micro-analysis).

RESULTS AND DISCUSSION

Macro-Analyses

Macro-analyses primarily involved the determination of significant differences among the observed means of the attributes measured on the study areas. Analyses of variance were made, with differences evaluated by multiple range comparisons at the 10 percent level of significance.[1/]

In addition, estimates of population densities were developed when possible, and changes in relative densities throughout the study period were noted.

Abert squirrel. Evaluations of Abert squirrel activities were not made on Watershed 12, as the timber cleared on this study area essentially removed it from habitat consideration.

Twig cutting by Abert squirrel generally occurs from late fall through early spring (Keith 1965). Therefore, the twig counts made in the spring are perhaps the most important with respect to squirrel activities, as indexed by this attribute. To distinguish Abert squirrel twig cutting from

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[1/] Analyses of variance and multiple range comparisons are presented in Appendix A.

the possibility of red squirrel twig cutting, both needled and peeled twig counts were made. Peeled twig counts are definitely a characteristic of Abert squirrel activity, while needled twigs are common to the feeding activities of both Abert squirrel and red squirrel (Rasmussen et al. 1975).

The only difference in the spring peeled twig counts was observed in 1973, when the count on Watershed 8 was higher than on Watersheds 10, 14, and 17 (but not Watershed 13). Little inference can be made in terms of land management practices, however, as this difference occurred prior to implementation of the silvicultural improvement treatment on Watershed 8 in 1974.

Spring needled twig count differences were recorded in 1973, when the count on Watershed 8 was again higher than on Watershed 17 (but not Watersheds 10, 13, and 14), and in 1974, when the count on Watershed 14 was lower than on Watershed 13 (but not Watersheds 8, 10, and 17). This latter difference suggests that an irregular strip-shelterwood cut, at least as imposed on Watershed 14, may decrease squirrel habitat. However, the inconsistency of the difference among years precludes interpretations regarding management implications.

Generally, the results of the spring twig counts (both peeled and needled) were too inconclusive to draw meaningful conclusions with respect to relating Abert squirrel activities to the land management practices being tested on the Beaver Creek Watershed. It appeared that, with the exception of a timber clearing, the land management practices evaluated did not affect squirrel habitat use, at least when the practices were assessed as entities. However, activity patterns within an area may have been altered, with existing squirrel populations shifting to preferred feeding and nesting sites.

Few differences were also observed in the twig counts made in summer, fall, and winter, and the differences that did occur were inconsistent among the years of record.

The number of Abert squirrel mushroom digs recorded on the study areas did not differ in the three years of measurement. But, mushroom digs may be of little value as an index of squirrel activity because the dry micro-environments commonly associated with the sample plots on Beaver Creek were not conducive to mushroom development.

The only differences in the number of Abert squirrel track counts in snow occurred in the winter of 1972-73, when the count on Watershed 8 was higher than on any of the other study areas, and in the winter of 1973-74, when the count on Watershed 17 was higher than on Watersheds 8 and 10 (no data were available from Watersheds 13 and 14). However, small game activities indexed by track counts in snow may also be of little direct value, as the date of measurement varied among the study areas for each year in the study. It was not possible to record track counts on all study areas within a single measurement period due to the extensive sampling designs. Furthermore, lack of sufficient snow cover over a period of time necessary to index small game activities often prevented measurement of this attribute.

Unfortunately, estimates of Abert squirrel population densities on the Beaver Creek Watershed cannot be made at this time. It is not possible, for instance, to link the observed twig counts, considered the best measure of squirrel activity, to actual squirrel numbers. While clipped twigs are indicative of squirrel feeding, the number of twigs clipped per day by a squirrel is variable (Patton 1974). Therefore, twig counts are only a measure of relative squirrel activity.

Using twig counts and numbers of active feed trees as indices of changes in relative abundance, differences in squirrel densities apparently occurred during the study period. High densities extending into the winter of 1972-73 were indicated by measurements obtained in the spring of 1973. However, densities then declined in 1973 and 1974, presumably a delayed result of the severe winter in 1972-73 (Barnes et al. 1974). By the spring of 1975, densities had rebounded to levels similar to those initially observed in 1972-73.

Cottontail. The deposition of fecal pellets was used as the primary measure of cottontail response to the land management practices evaluated. Pellet tallies made in the spring and fall allowed for assessments of relative activity at different points in time.

Differences existed in cottontail pellet counts for all sampling periods with the exception of fall 1975, when only Watersheds 8, 10, and 13 were measured. The observed differences, which were consistent during the study peirod, indicated that the counts on Watershed 12, the study area on which the timber was cleared, were higher than on all of the other study areas. Furthermore, no differences occurred in the counts on these latter study areas, suggesting that a silvicultural improvement cut (Watershed 8), a big game habitat improvement cut (Watershed 10), an irregular stripcut-thinning (Watershed 14), a severe thinning (Watershed 17), and a near natural area (Watershed 13) had no effect on cottontail use.

The study area on which timber had been cleared was unique among the land management practices evaluated in that it contained an abundance of slash and small, scattered thickets of Gambel oak sprouts. Previous investigators have stated that slash and brushpiles often provide important protective cover for cottontail (Bowers 1956, Kundaeli and Reynolds 1972, Webb 1949). Others have concluded that woody sprouts and coppice growth also provide cover (Haugen 1942, Redd 1956, Perkins 1974).

Apparently, the favorable cottontail response to the timber clearing treatment was due to an increase in yearlong protective cover furnished by the slash and Gambel oak thickets. Although necessary in winter months when weather could be a decimating factor, cover is also important for survival during the reproductive season. In addition to cover, the improved herbage production created by the timber clearing cannot be overlooked (Brown et al. 1974). This herbage, which increased approximately 500 pounds per acre after treatment, has provided a yearlong food supply.

Estimates of cottontail population densities on the Beaver Creek Watershed have been derived from knowledge of pellet accumulations and an average defecation rate of 475 pellets, determined from cottontails penned on an area of natural vegetation near Beaver Creek. Generally, densities were less than 1 per section on all of the study areas with the exception of Watershed 12, the area on which timber was cleared, where densities averaged 14 per section throughout the study period.

Relative cottontail densities were higher in the initial stages of the study (1973) than in the later years (1974 and 1975). Within a given year, densities were generally higher in the fall than the preceding spring. Apparently, populations increased throughout the reproductive seasons and subsequently died off during winter months.

Micro-Analyses

Micro-analyses were carried out to define relationships between the attributes used to index Abert squirrel and cottontail activities and the associated forest and physiographic features. In addition, Abert squirrel feed and nest trees were identified by size classes and classified by surrounding levels of forest density to determine whether differences existed in selection among the study areas. Individual feed trees were also classified in terms of their intensity of use over time to provide a dynamic framework in which ponderosa pine forests may be described in relation to squirrel habitat.

Abert squirrel. Using basal area as the expression of forest density, the general trend assumed by relationships between twig counts (both needled and peeled) and ponderosa pine forest density was: increasing twig counts between 25 and 100 square feet of basal area per acre, then decreasing twig counts to 300 square feet. While this trend occurred on all study areas, the numbers of twigs differed by basal area levels among the study areas in the three years of measurement, reflecting dissimilar (and inconsistent) intensities of use in time and space.

The relationships between Abert squirrel twig counts and ponderosa pine forest density suggest that land management practices which reduce forest densities to 100 square feet of basal area per acre may exert a positive effect in terms of squirrel habitat use, while reductions below 100 square feet may be detrimental. However, forest density-tree size interactions play as important a role in defining habitat as simple basal area levels. For example, forest stands that were predominately large pole-small sawtimber exhibited higher twig counts than stands comprised of either smaller or larger tree size classes.

No relationships were found between Abert squirrel mushroom digs or track counts in snow and ponderosa pine forest density levels.

Little meaningful association was observed between Abert squirrel twig counts, mushroom digs, or track counts in snow and physiographic features, such as slope-aspect combinations, position on slope, or degree of surface rock.

Identification of feed trees by size classes showed that, while Abert squirrel fed in trees 8 to 34 inches dbh on the Beaver Creek Watershed, they apparently preferred 14- to 22-inch trees for this purpose, as reported elsewhere (Patton and Green 1970, Ffolliott and Patton 1975). The preferred size classes were consistent with respect to the study areas, suggesting that land management practices evaluated had little effect on feed tree selection. However, the numbers of active feed trees did fluctuate among the study areas in the three years of measurement, indicating to some extent the same patterns of relative activities as indexed by twig cuttings.

In classifying feed tree sites in terms of surrounding forest density, approximately 85 percent of the sites were characterized by basal area levels between 75 and 175 square feet per acre. The highest percentage of sites were in the 100- to 150-square-foot class. No differences existed in frequency distributions of feed tree sites by basal area among the land management practices evaluated on Beaver Creek throughout the measurement period. Generally, tree sizes corresponding with those preferred by Abert squirrel as feed trees comprised most of the basal area.

Tree sizes selected for nest trees by Abert squirrels were similar to those preferred for feed trees, with most nests found in 14- to 22-inch trees. The selected size classes, which were essentially the same on all study areas, coincided with those described by Patton (1975b) in a detailed study of Abert squirrel cover requirements on Watershed 8 prior to implementation of the silvicultural improvement treatment. Nest trees were not tallied in sufficient enough numbers on the individual study areas to draw inferences in terms of management implications.

Forest density levels associated with the selected nest tree sites were generally the same as reported by Patton (1975b), as basal area levels ranging from 75 to 200 square feet per acre were most common.

To assess the use of Abert squirrel feed trees over time, individual ponderosa pine trees were classified in terms of twigs (both needled and peeled) found beneath the trees each spring of measurement. No consistent differences were observed among the land management practices evaluated. Therefore, the data were grouped for analysis.

Of 1,435 trees (7 inches dbh and larger) examined, 867 were used as feed trees at sometime during a three-year measurement period. Sixty-four percent of the feed trees were used in only one year in three, while 30 percent were used two years in three and 6 percent were used in all three years.[2/]

In general, it appeared that Abert squirrel selected feed trees at random on Beaver Creek, and they did not necessarily return to the same feed tree each year. This observation is contrary to the pattern described by Larson and Schubert (1970), who reported that repeated twig cutting of the same tree year after year was the rule on the Fort Valley Experimental Forest near Flagstaff.

Under feed trees used only one year in three, less than 10 twigs were found beneath 78 percent (425 trees), 10 to 50 twigs were found beneath 18 percent (97 trees), and more than 50 twigs were found beneath 4 percent (26 trees). Similar trends in annual twig counts were noted under feed trees used two and three years.

Most of the twig cutting activities on the Beaver Creek Watershed followed the pattern described by Pearson (1950), with Abert squirrel preferring the upper portions of tree crowns, especially terminals and upper laterials. In particular, loss of upper crown foliage was frequently

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[2/] A three-year (1972-1975) measurement period is described herein. However, an analysis based on the four-year (1972-1976) evaluation period will be presented in a subsequent manuscript.

observed in trees under which large numbers of twigs (more than 50) were found in two or more consecutive years. No tree mortality directly attributed to Abert squirrel feeding activities occurred.

Cottontail. The greatest numbers of cottontail pellets were consistently recorded on Watershed 12, an area representing 9 square feet of basal area per acre. Pooling data from the other study areas (which exhibited no differences in mean pellet counts), and considering only sample plots on which pellets were counted, resulted in an inverse relationship between cottontail pellet counts and ponderosa pine density, with decreasing counts as basal area increases. However, this trend reflects low pellet counts even at low basal area levels.

No relationships were identified between cottontail pellet counts and physiographic features on any of the study areas.

MANAGEMENT IMPLICATIONS

Using Abert squirrel twig counts and cottontail pellet counts as the assessment basis, most of the land management practices tested on the Beaver Creek Watershed, when viewed as entities, had little effect on habitat use by these small game species. The exception to this was the timber clearing treatment imposed on Watershed 12, which essentially removed the area from consideration as Abert squirrel habitat but enhanced cottontail habitat through an increase in protective cover and herbage production.

While overall habitat use was not affected by most of the land management practices tested, changes in use patterns did occur within treatment areas. For example, as land management practices altered overstory spatial arrangements and tree size distributions, Abert squirrel frequently shifted their feeding activities to preferred sites. Regardless of the specifics of a given treatment prescription, it was always possible to find preferred sites on the study areas. Furthermore, the numbers of preferred sites found were apparently sufficient enough to maintain the existing Abert squirrel densities on Beaver Creek, as these densities remained unchanged after treatment. If Abert squirrel densities increased to high levels approaching those reported on the Fort Valley Experimental Forest in 1940 to 1945 (Pearson 1950, Keith 1967), more preferred sites may be required, however. Quite possibly, the land management practices evaluated in this study may not provide the required "optimum" numbers in this case.

Similar changes in use patterns within treatment areas were also observed with respect to Abert squirrel nesting activities and to some extent by cottontail habitat use as indexed by pellet counts. Again, these internal shifts in activities within a study area did not affect general population densities.

With preferred small game habitat components existing within all of the land management practices tested on Beaver Creek, it may be helpful to identify and resolve, if possible, potential conflicts in the use of these sites as Abert squirrel or cottontail habitat and for timber production. Such information, which can be gleaned from simple decision-making models synthesized from production-rating functions, would allow land managers to coordinate wildlife needs with timber harvesting.

Production-Rating Functions

By definition, a production function specifies how much output can be expected for different levels of input. These functions, based on quantitative input-output relationships between two or more uses, enable estimates of production to be made in physical terms.

Unfortunately, many production functions may be too complex to be described, in which case they cannot be used to estimate production in physical quantities. Generally, these latter functions only indicate trends of output associated with different levels of input, not necessarily the magnitudes of change. Such functions, which are often generated when quantitative data are lacking, may be considered qualitative production functions, or production-rating functions (Worley and Gill 1969).

Worley and Gill (1969) conceptualized production-rating functions for different wildlife species and timber production in the Northeast. These functions were plotted as graphs that illustrated the potential of a forest tract for production of each wildlife species and timber under alternative land management options. By combining the graphs, land managers could identify potential conflicts between competing uses of a forest, and more efficiently coordinate wildlife use with timber production.

In a recent study, the general procedures given by Worley and Gill (1969) were used by Ffolliott and Patton (1975) to develop production-rating functions for two Abert squirrel habitat components--feed and nest trees--and ponderosa pine tree volume. These production-rating functions were then combined to identify conflicts between the use of ponderosa pine as squirrel feed or nest trees and for timber.

Using the results reported herein, production-rating functions may be generated to produce more holistic decision-making models than described by Ffolliott and Patton (1975) to assess potential conflicts between wildlife use and timber production in ponderosa pine forests. Specifically, potential conflicts in the use of a forest as Abert squirrel or cottontail habitat and for timber production can be analyzed.

Abert squirrel. The development of a production-rating function for Abert squirrel required knowledge of the relationship between ponderosa pine basal area levels (the input) and squirrel preference for different basal area levels as feeding and nesting sites (the output). The specified relationship was developed as a composite of the basal area levels selected as feeding and as nesting sites on Beaver Creek. (Tree sizes corresponding with those preferred by Abert squirrel as feed and nest trees comprised most of the basal area.) This information indicated that, while Abert squirrel feed and nest on sites representing 75 and 175 square feet of basal area per acre, they prefer sites representing 100 to 150 square feet per acre. A general curve drawn between these critical values defined the production-rating function.

In developing the Abert squirrel production-rating function (fig. 1), it was assumed that the ponderosa pine basal area level most preferred by squirrels represented the highest level of output. A potential rating value of 5 was arbitrarily assigned to this maximum level.

Cottontail. A production-rating function for cottontail was synthesized from the general relationship between ponderosa pine basal area levels (the input) and cottontail preference for sites representing different basal area levels, as indexed by pellet counts on Beaver Creek (the output). The highest preference, which occurred at 0 square feet of basal area per acre, was assigned a potential rating value of 5 (fig. 2).

Timber production. A timber production-rating function was developed from a relationship between ponderosa pine basal area levels (the input) and estimated yield of sawtimber volume per acre at different basal area levels (the output). Data required to define this relationship was approximated from information presented by Schubert (1974) to estimate yield of

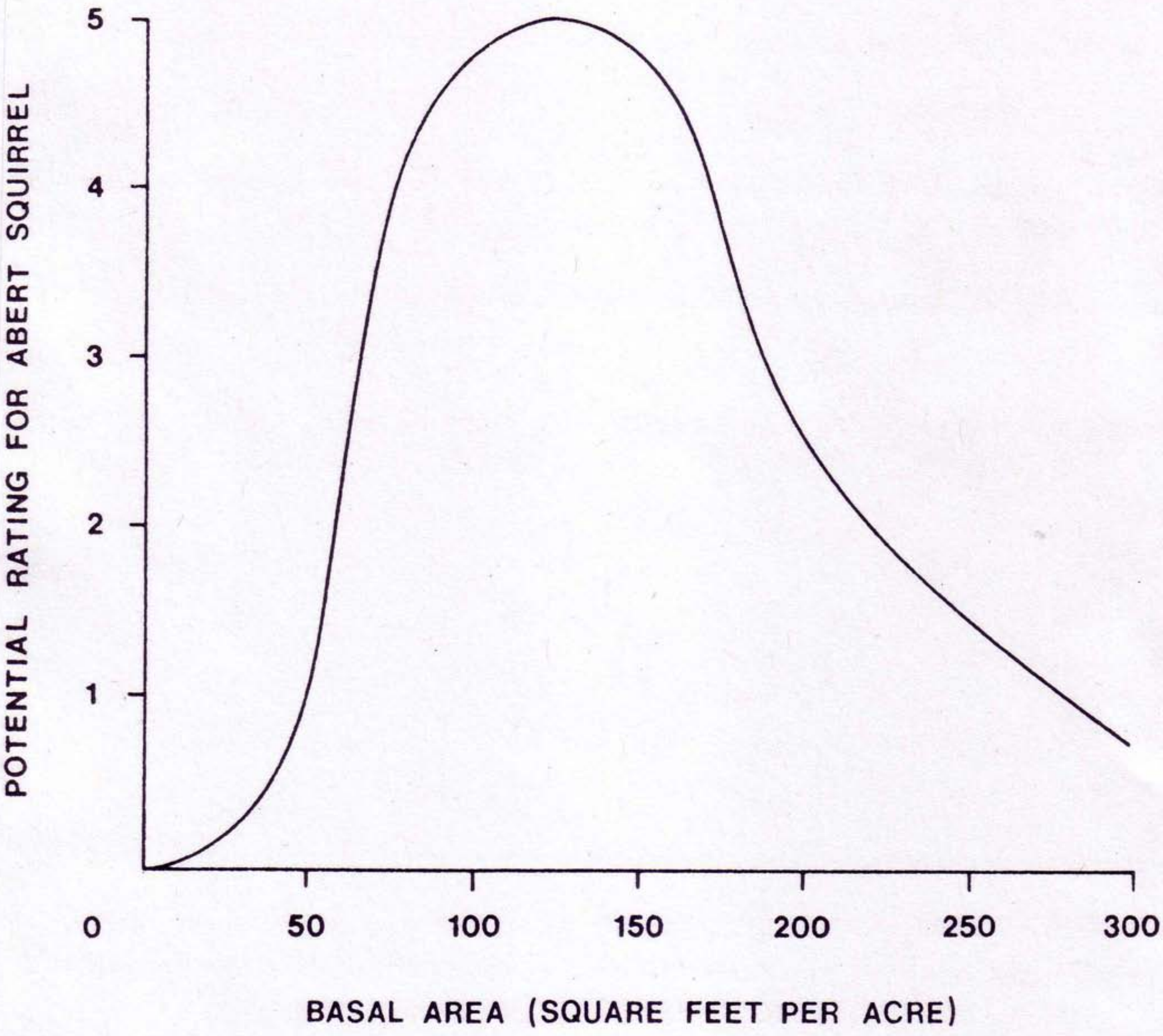

Figure 1. Production-rating function of Abert squirrel habitat in relation to ponderosa pine basal area levels.

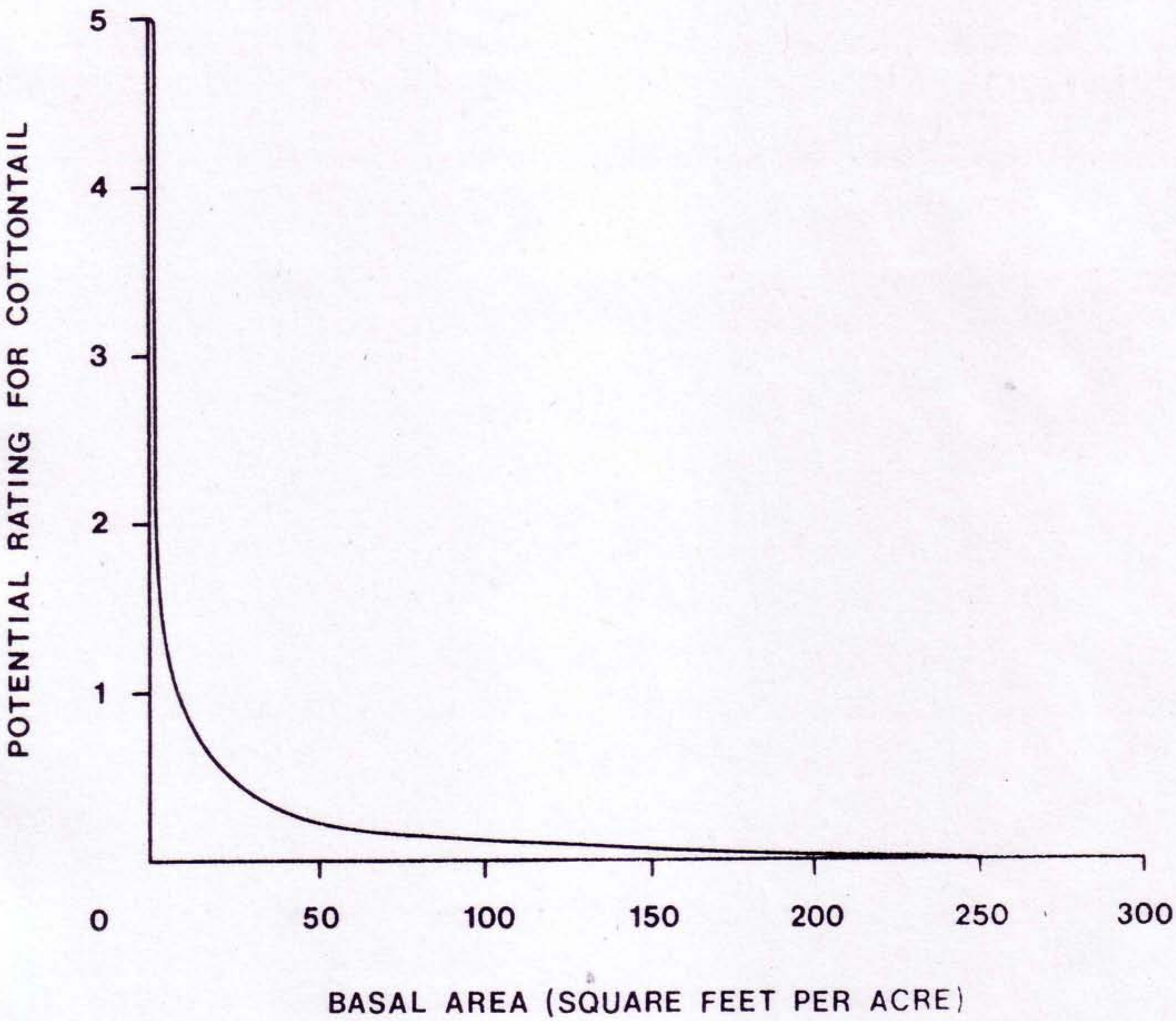

Figure 2. Production-rating function of cottontail habitat in relation to ponderosa pine basal area levels.

southwestern ponderosa pine sawtimber per acre in terms of growing stock levels,[3/] assuming a rotation period of 120 years. The maximum sawtimber volume per acre within the range of basal area levels inventoried was assigned a potential rating value of 5 (fig. 3).

Decision-Making Models

Since the production-rating functions for Abert squirrel habitat, cottontail habitat, and timber production have a common base (ponderosa pine basal area levels), their respective potential rating values can be plotted against one another. The resulting graphs, which are essentially product-product functions (output-output relationships), form simple decision-making models to identify conflicts between the use of ponderosa pine forest sites as small game habitat or for sawtimber production.

Abert squirrel. The product-product model for Abert squirrel habitat and timber production indicates a complementary stage, where the values of a ponderosa pine forest site as squirrel habitat and for sawtimber production both improve, exists through basal area levels approaching 50 square feet per acre (fig. 4). Therefore, land managers concerned with Abert squirrel habitat and timber production would allow basal area to increase to at least 50 square feet per acre.

A supplementary stage, where the value of one use improves while the other remains unchanged, is approximated by basal area levels between 50 and 100 square feet per acre. In this range, values for Abert squirrel habitat increase while the value for sawtimber production remains essentially

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[3/] Numerical designation of growing stock level assigned is basal area per acre that will remain after thinning when average diameter of the forest stand is 10 inch dbh or more.

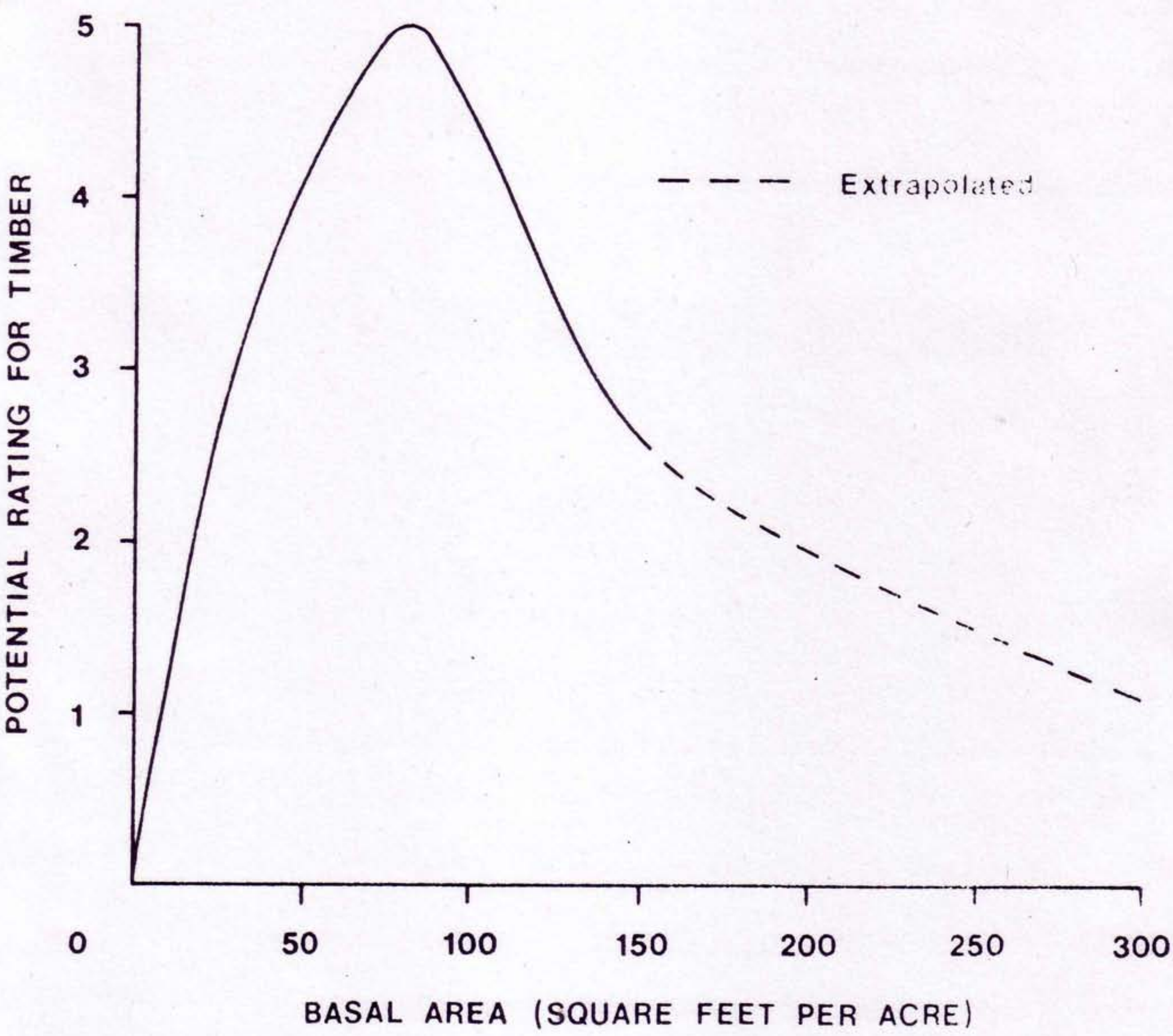

Figure 3. Production-rating function of ponderosa pine sawtimber volume in relation to ponderosa pine basal area levels.

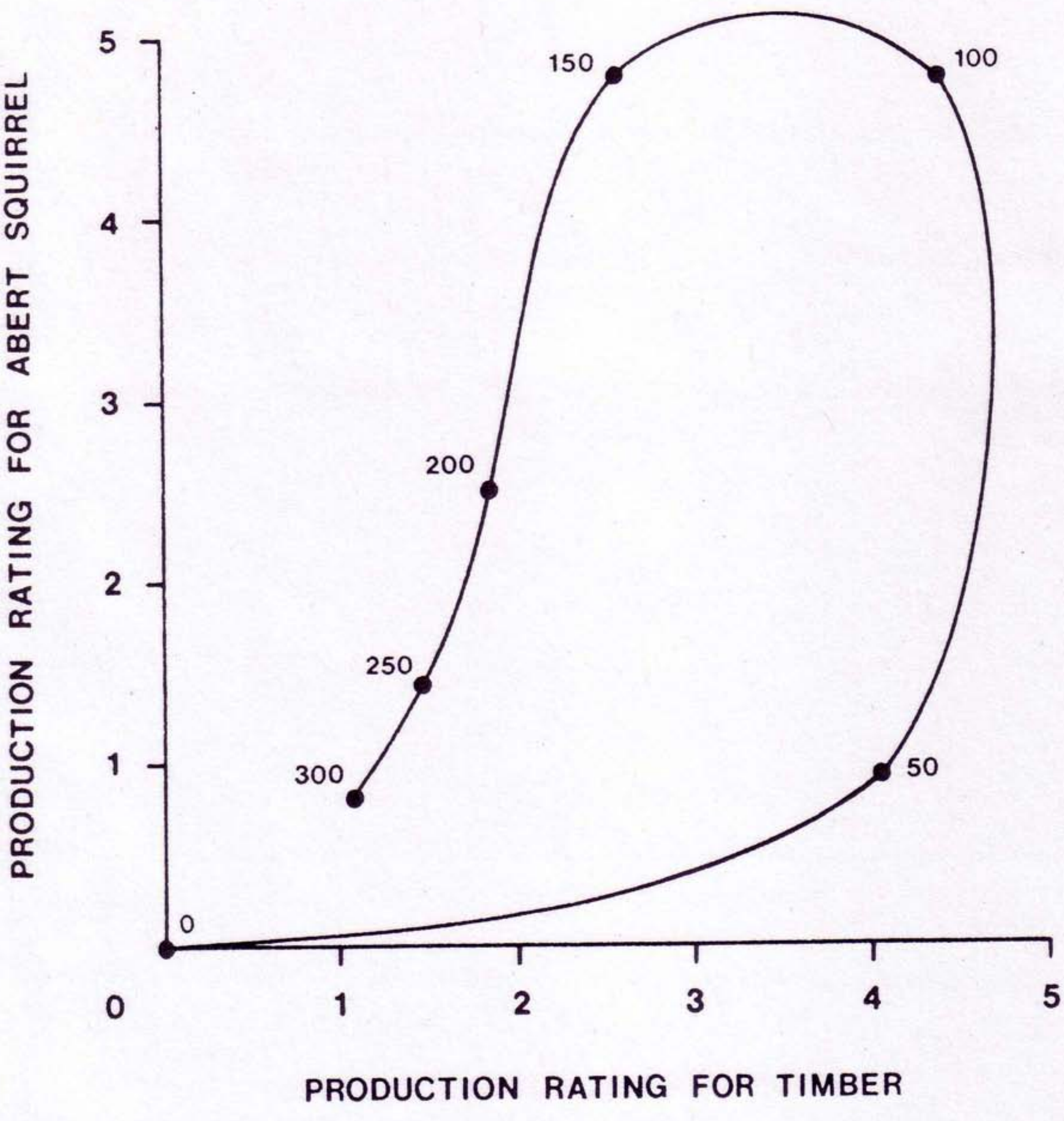

Figure 4. Abert squirrel habitat vs. ponderosa pine sawtimber volume per acre ratings.

unchanged. Depending upon the objectives of land management, basal area can be allowed to increase to 100 square feet per acre, as such a decision is valid under the Pareto criterion. This criterion states that any action which is adverse to no one and is beneficial to someone is an improvement (Bethune and Fortson 1969).

Decisions regarding the improvement of both Abert squirrel habitat and sawtimber production values beyond 100 square feet of basal area per acre are considered irrational, as values for either one or both uses decline.

Cottontail. A competitive stage, where the value of one use improves while the other declines, occurs from 0 to 100 square feet of basal area per acre in the product-product model for cottontail habitat and sawtimber production (fig. 5). This competitive stage identifies areas of conflict between the use of a ponderosa pine forest site as cottontail habitat and for sawtimber production.

Decisions must be made whether to maintain a site for cottontail habitat or to harvest it for timber production. In a sense, the rates of trade-offs between cottontail habitat and timber production are defined within the competitive stage. For example, equating cottontail habitat ratings to sawtimber production ratings suggests 0.5 to 2.0 cottontail rating units equals 1 timber production rating unit. If the value scales are the same (for instance, if a monetary value could be placed on both uses), economic analysis could be employed to identify the basal area level within the competitive stage where the value of a ponderosa pine forest site as cottontail habitat and for sawtimber production can be optimized. Unfortunately, such value scales are not available at this time. Therefore, land managers concerned with cottontail and sawtimber in a given locale must use subjective

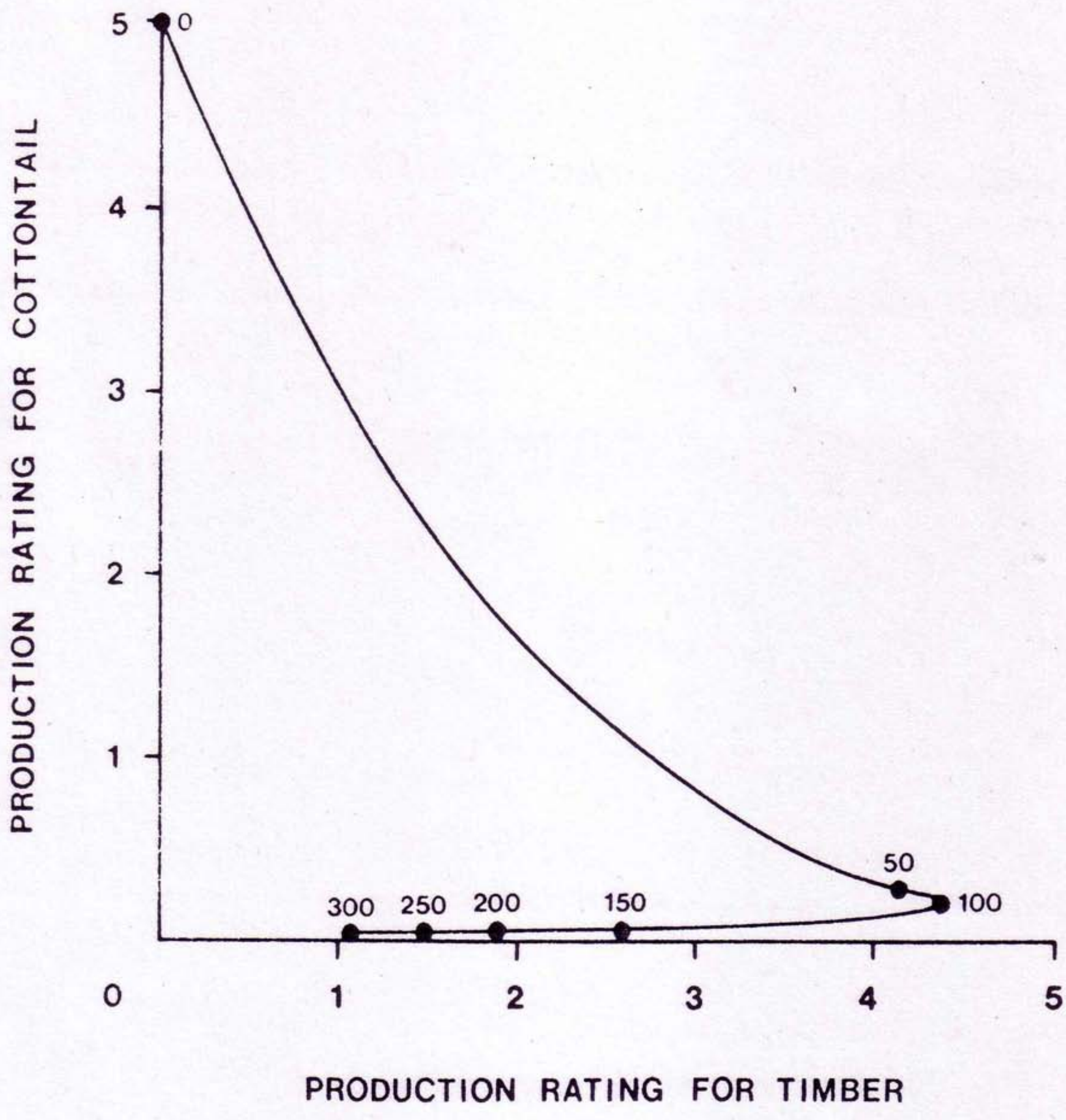

Figure 5. Cottontail habitat vs. ponderosa pine sawtimber volume per acre ratings.

value judgments in deciding the optimum basal area level for both.

Decisions with respect to improving both cottontail habitat and sawtimber production beyond 100 square feet of basal area per acre are irrational.

CONCLUSIONS

1. With the exception of a timber clearing treatment, the land management practices tested on the Beaver Creek Watershed did not affect habitat use by Abert squirrel or cottontail. Timber clearing removed an area from consideration as Abert squirrel habitat, while cottontail habitat was enhanced.

2. Although small game population densities were not altered by land management re-direction (again, with the exception of timber clearing), changes in activities within study areas did occur. Generally, these species shifted activities to sites representing preferred habitats after treatment implementation. Particular basal area levels were preferred by Abert squirrel as feeding and nesting sites, while little or no basal area was associated with highest cottontail activities.

3. The development of production-rating functions, and the synthesis of simple decision-making models from these functions, provides an approach to identifying and possibly resolving potential conflicts between the use of a ponderosa pine forest site as Abert squirrel or cottontail habitat and for timber production. These techniques have been used by economists in examining land management alternatives (Worley and Gill 1969). However, it should be remembered that only small game habitat and sawtimber production were assessed in the above examples. Other forest-based products and uses (forage for domestic livestock, water for on-site and downstream use, etc.) must be included in land management plans for the entire multiple use mix.

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TABLE A1. Abert Squirrel; Needled: Winter 72-73

Watershed	1	2	3	4	X_i	n_i
8	1.1489	1.9149	.2857	.6047	3.9542	4
10	.4516	1.0435	1.1667	--	2.6618	3
13	2.7742	2.5313	1.5833	--	6.8888	3
14	.7143	.2642	5.3043	.9787	7.2615	4
17	.0517	.7273	.1000	--	.8790	3
a = 5					Ex_i = 21.6453	n = 17

C = 27.5599

Total = 54.9138 - 27.5599 = 27.3539

Watersheds = 35.5290 - 27.5599 = 7.9691

Variation	DF	SS	MS
Total	16	27.3539	
WS	4	7.9691	1.9923
WS/T	12	19.3848	1.6154

F = 1.9923/1.6154 = 1.2333 $F^{0.10}$ = 3.26

TABLE A2. Abert Squirrel; Peeled: Winter 72-73

Watershed	1	2	3	4	X_i	n_i
8	.5319	.5745	0	0	1.1064	4
10	.0968	.2174	.6250	--	.9392	3
13	.8548	.9063	.4833	--	2.2417	3
14	.5102	0	.3261	.4681	1.3044	4
17	0	0	0	--	0	3

$a = 5$ $\Sigma x_i = 5.5917$ $n = 17$

$C = 1.8392$

Total = 3.4210 - 1.8392 = 1.5818

Watersheds = 2.7005 - 1.8392 = .8613

Variation	DF	SS	MS
Total	16	1.5818	
WS	4	.8613	.2153
WS/T	12	.7205	.0600

$F = .2153/.0600 = 3.5883$ $F^{0.10} = 3.26$

$W = .10(5,12).2449$
$= 3.92(.2449)$
$= .9600$

17	8	10	14	13
0	.2712	.3118	.3260	.7481

13-17	=	.7481	>	.5515	S
13-8	=	.4769	<	.5170	
13-10	=	.4363	<	.4800	

TABLE A3. Abert Squirrel; Needled: Spring 1973

Watershed	1	2	3	4	X_i	n_i
8	6.9783	8.5532	12.3571	6.3721	34.2607	4
10	4.3778	4.8958	3.0238	--	12.2974	3
13	7.1017	6.5574	10.0167	--	23.6758	3
14	2.0208	.9020	8.7273	3.5745	15.2246	4
17	.5254	3.8030	3.1167	--	7.4451	3

a = 5 $\quad$ $\Sigma x_i = 92.9036$ $\quad$ n = 17

$C = (92.9036)^2/17 = 507.7105$

Total $\Sigma x_i^2 - C = 679.4935 - 507.7105 = 171.7830$

Watersheds = $293.4489 + 50.4087 + 186.8478 + 57.9471 + 18.4765 = 607.1290 - 507.7105 = 99.4185$

Variation	DF	SS	MS
Total	16	171.7830	
WS	4	99.4185	24.8546
WS/T	12	72.3645	6.0304

$F = 24.8546/6.0304 = 4.1216 \qquad F^{0.10} = 3.26$

$W = .10(5,12)2.4557$
$= 3.92(2.4557)$
$= 9.6263$

17	14	10	13	8
2.4816	3.5442	4.1046	7.8919	8.0229

8-17 = 5.5413 > 5.1838 S

8-14 = 4.4787 < 4.8132

13-17 = 5.4103 < 5.5303

13-14 = 4.3477 < 5.1838

TABLE A4. Abert Squirrel; Peeled: Spring 1973

Watershed	1	2	3	4	X_i	n_i
8	6.4565	4.5957	8.5000	3.3721	22.9243	4
10	.5333	2.1250	.7619	--	3.4202	3
13	3.0847	3.2131	4.0000	--	10.2978	3
14	.4375	.1765	5.3409	2.4894	8.4443	4
17	.6780	.9545	1.6167	--	3.2492	3
a = 5					Ex_i = 48.3358	n = 17

$C = (48.3358)^2/17 = 137.4323$

Total $Ex_i - C = 226.5773 - 137.4323 = 89.1450$

Watersheds = 131.3809 + 3.8993 + 35.3482 + 17.8266 + 3.5191 =
191.9741 - 137.4323 = 54.5418

Variation	DF	SS	MS
Total	16	89.1450	
WS	4	54.5418	13.6355
WS/T	12	34.6032	2.8836

$F = 13.6355/2.8836 = 4.7286 \quad F^{0.10} = 3.26$

W = .10(5,12)1.6981
= 3.92(1.6981)
= 6.6566

10	17	14	13	8
.9828	1.0496	2.1101	3.3770	5.6586

8-10	=	4.6758	>	3.5846	S
8-17	=	4.6090	>	3.5846	S
8-14	=	3.5485	>	3.3283	S
8-13	=	2.2816	<	3.5846	
13-10	=	2.3942	<	3.8242	

TABLE A5. Abert Squirrel; Needled: Summer 1973

Watershed	1	2	3	4	X_i	n_i
8	.2979	.1489	.2857	.0698	.8023	4
10	.3556	.2083	.0952	--	.6591	3
13	.0820	.1563	.0333	--	.2716	3
14	.1458	.0392	.4250	.1739	.7839	4
17	.1017	.0455	.2333	--	.3805	3
a = 5					Ex_i = 2.8974	n = 17

$C = (2.8974)^2/17 = .4938$

Total $Ex_i - C = .7090 - .4938 = .2152$

Watersheds = .1609 + .1448 + .0246 + .1536 + .0483 =
.5322 - .4938 = .0384

Variation	DF	SS	MS
Total	16	.2152	
Watersheds	4	.0384	.0096
WS/T	12	.1768	.0147

$F = .0096/.0147 = .6531$ $F^{0.10} = 3.26$

TABLE A6. Abert Squirrel; Peeled: Summer 1973

Watershed	1	2	3	4	X_i	n_i
8	.0638	.0213	.0238	0	.1089	4
10	.0444	0	0	---	.0444	3
13	0	0	0	---	0	3
14	0	0	0	0	0	4
17	0	0	.1667	---	.1667	3
a = 5					Ex_i = .3200	n = 17

$C = (.3200)^2/17 = .0060$

Total Ex_i^2 - C = .0290

Watersheds = .0130 - .0060 = .0070

Variation	DF	SS	MS
Total	16	.0290	
Watersheds	4	.0070	.0018
WS/T	12	.0220	.0018

F = .0018/.0018 = 1.0000 $F^{0.10}$ = 3.26

TABLE A7. Abert Squirrel; Needled: Fall 1973

Watershed	1	2	3	4	X_i	n_i
8	.7021	.2766	.3902	.4186	1.7875	4
10	.6889	.7500	.1429	--	1.5818	3
13	.3226	.3281	.3333	--	.9840	3
14	0	0	0	.1277	.1277	4
17	0	.0455	.0333	--	.0788	3

a = 5 $\quad\quad$ Ex_i = 4.5598 $\quad$ n = 17

C = 1.2230

Total Ex_i^2 - C = 2.2967 - 1.2230 = 1.0737

Watersheds = 1.9618 - 1.2230 = .7388

Variation	DF	SS	MS
Total	16	1.0737	
Watersheds	4	.7388	.1847
WS/T	12	.3349	.0279

F = 6.6201 $\quad\quad$ $F^{0.10}$ = 3.26

W = .10(5,12).1670
= 3.92(.1670)
= .6546

17	14	13	8	10
.0206	.0319	.3501	.4350	.4854

10-17 = .4648 > .3761 S
10-14 = .4535 > .3525 S
8-17 = .4144 > .3525 S
8-14 = .4031 > .3273 S
13-17 = .3295 < .3761

TABLE A8. Abert Squirrel; Peeled: Fall 1973

Watershed	1	2	3	4	X_i	n_i
8	.0426	0	0	0	.0426	4
10	0	.1042	0	--	.1042	3
13	.1129	.0469	0	--	.1598	3
14	0	0	0	0	0	4
17	0	0	0	--	0	3
a = 5					Ex_i = .3066	n = 17

C = .0055

Total Ex_i^2 - C = .0276 - .0055 = .0221

Watersheds = .0126 - .0055 = .0071

Variation	DF	SS	MS
Total	16	.0221	
Watershed	4	.0071	.0018
WS/T	12	.0150	.0013

F = 1.3846 $F^{0.10}$ = 3.26

TABLE A9. Abert Squirrel; Needled: Winter 73-74

Watershed	1	2	3	4	X_i	n_i
8	.4894	.4681	.3810	.5714	1.9099	4
10	.4103	.3171	.2500	--	.9774	3
17	.0508	0	.0517	--	.1025	3
a = 3					Ex_i = 2.9898	n = 10

C = .8939

Total = 1.2670 - .8939 = .3731

Watersheds = 1.2338 - .8939 = .3399

Variation	DF	SS	MS
Total	9	.3731	
WS	2	.3399	.1700
WS/T	7	.0332	.0047

F = 36.1702 $\quad F^{0.10} = 4.74$

W = .10(3,7).0686
= 3.45(.0686)
= .2367

17	10	8
.0341	.3163	.4663

8-17 = .4322 > .1275 S

8-10 = .1500 > .1275 S

10-17 = .2822 > .1360 S

TABLE A10. Abert Squirrel; Peeled: Winter 73-74

Watershed	1	2	3	4	X_i	n_i
8	.0426	.0213	.0952	.0238	.1829	4
10	0	.0244	0	--	.0244	3
17	0	0	0	--	0	3

a = 3 Σx_i = .2073 n = 10

C = .0042973

Total = .0124930 - .0042973 = .0081957

Watersheds = .0085615 - .0042973 = .0042642

Variation	DF	SS	MS
Total	9	.0081957	
WS	2	.0042642	.0021321
WS/T	7	.0039315	.0005616

F = 3.7964743 $F^{0.10}$ = 4.74

TABLE A11. Abert Squirrel; Needled: Spring 74

Watershed	1	2	3	4	X_i	n_i
8	.0426	.1304	.0385	.1163	.3278	4
10	.0727	.1522	0	--	.2249	3
13	.3870	.2031	.8333	--	1.4234	3
14	0	0	0	0	0	4
17	.0517	.3030	.6167	--	.9714	3

a = 5 $\quad$ Σx_i = 2.9475 $\quad$ n = 17

C = .5110

Total = 1.4225 - .5110 = .9115

Watersheds = 1.0337 - .5110 = .5227

Variation	DF	SS	MS
Total	16	.9115	
WS	4	.5227	.1307
WS/T	12	.3888	.0324

F = .1307/.0324 = 4.0340 $\quad F^{0.10}$ = 3.26

W = .10(5,12).1800
= 3.92(.1800)
= .7056

14	10	8	17	13
0	.0750	.0819	.3238	.4745

13-14 = .4745 > .3740 $\quad$ S

13-10 = .3995 < .4054

17-14 = .3238 < .3740

TABLE A12. Abert Squirrel; Peeled: Spring 1974

Watershed	1	2	3	4	$X_{i.}$	n_i
8	.0426	.0435	.0385	.1163	.2409	4
10	.0545	.0652	0	--	.1197	3
13	.0323	.0625	.3833	--	.4781	3
14	0	0	0	0	0	4
17	0	0	0	--	0	3
a = 5					Σx_i = .8387	n = 17

C = .0414

Total = .1778 - .0414 = .1364

Watersheds = .0955 - .0414 = .0541

Variation	DF	SS	MS
Total	16	.1364	
WS	4	.0541	.0135
WS/T	12	.0823	.0069

F = .0135/.0069 = 1.9565 $F^{0.10}$ = 3.26

TABLE A13. Abert Squirrel; Needled: Summer 1974

Watershed	1	2	3	4	X_i	n_i
13	.3387	.2031	.3833	--	.9251	3
14	.0612	.0566	.2174	.0426	.3778	4
17	0	0	.1500	--	.1500	3
a = 3					Ex_i = 1.4529	n = 10

C = .2111

Total = .3813 - .2111 = .1702

Watersheds = .3285 - .2111 = .1174

Variation	DF	SS	MS
Total	9	.1702	
WS	2	.1174	.0587
WS/T	7	.0528	.0075

F = .0587/.0075 = 7.8267 $F^{0.10}$ = 4.74

W = .10(3,7).0866
= 3.45(.0866)
= .2988

17	14	13
.0500	.0945	.3077

13-17 = .2577 > .1717   S

13-14 = .2132 > 1609   S

TABLE A14. Abert Squirrel; Peeled: Summer 1974

Watershed	1	2	3	4	X_i	n_i
13	.0484	0	.0833	--	.1317	3
14	.0204	0	0	0	.0204	4
17	0	0	0	0	0	3
a = 3					Ex_i = .1521	n = 10

C = .0023

Total = .0096 - .0023 = .0073

Watersheds = .0059 - .0023 - .0036

Variation	DF	SS	MS
Total	9	.0073	
WS	2	.0036	.0018
WS/T	7	.0037	.00053

F = .0018/.00053 = 3.3962 $F^{0.10}$ = 4.74

TABLE A15. Abert Squirrel; Needled: Fall 1974

Watershed	1	2	3	4	X_i	n_i
8	.0426	.0217	.0192	0	.0835	4
10	.0363	.0625	0	--	.0988	3
13	.0656	.1406	.1500	--	.3562	3
14	.0204	.0566	.0222	.0213	.1205	4
17	.0345	.1515	1.3000	--	1.4860	3
a = 5					Ex_i = 2.1450	n = 17

C = .2706

Total = 1.7733 - .2706 = 1.5027

Watersheds = .7871 - .2706 = .5165

Variation	DF	SS	MS
Total	16	1.5027	
WS	4	.5165	.1291
WS/T	12	.9862	.0822

F = .1291/.0822 = 1.5706 $F^{0.10}$ = 3.26

TABLE A16. Abert Squirrel; Peeled: Fall 1974

Watershed	1	2	3	4	X_i	n_i
8	0	0	0	0	0	4
10	0	0	0	--	0	3
13	0	.0156	0	--	.0156	3
14	0	0	0	0	0	4
17	0	0	0	0	0	3
a = 5					Ex_i = .0156	n = 17

C = .0000143

Total = .0002433 - .0000143 = .0002290

Watersheds = .0000811 - .0000143 = .0000668

Variation	DF	SS	MS
Total	16	.0002290	
WS	4	.0000668	.0000167
WS/T	12	.0001622	.0000135

F = .0000167/.0000135 = 1.2370 $F^{0.10}$ = 3.26

TABLE A17. Abert Squirrel; Needled: Spring 1975

Watershed	1	2	3	4	X_i	n_i
8	1.6170	2.0851	2.9512	2.1860	8.8393	4
10	2.0444	4.1875	.1190	--	6.3509	3
13	3.4839	2.0820	5.3500	--	10.9159	3
14	2.6458	.6154	.8444	.5319	4.6375	4
17	.3559	.5758	1.0167	--	1.9484	3
a = 5					Ex_i = 32.6920	n = 17

C = 62.8686

Total = 97.1411 - 62.8686 = 34.2725

Watersheds = 79.3389 - 62.8686 = 16.4703

Variation	DF	SS	MS
Total	16	34.2725	
WS	4	16.4703	4.1176
WS/T	12	17.8022	1.4835

F = 4.1176/1.4835 = 2.7756 $F^{0.10}$ = 3.26

TABLE A18. Abert Squirrel; Peeled: Spring 1975

Watershed	1	2	3	4	X_i	n_i
8	.5957	.0851	.0244	.1628	.8680	4
10	1.5333	1.2917	0	--	2.8250	3
13	1.3226	.5902	3.0500	--	4.9628	3
14	1.0000	0	.0417	.0851	1.1268	4
17	0	.0303	0	--	.0303	3
a = 5					Ex_i = 9.7826	n = 17

C = 5.6294

Total = 16.8186 - 5.6294 = 11.1892

Watersheds = 11.3761 - 5.6294 = 5.7467

Variation	DF	SS	FS
Total	16	11.1892	
WS	4	5.7467	1.4367
WS/T	12	5.4425	.4535

$F = 1.4367/.4535 = 3.1680 \quad F^{0.10} = 3.26$

TABLE A19. Abert Squirrel; Needled: Summer 1975

Watershed	1	2	3	4	X_i	n_i
8	0	0	0	0	0	4
10	.6364	.7500	0	-	1.3864	3
13	0	.2656	0	-	.2656	3
a = 3					Ex_i = 1.6520	n = 10

C = .2729

Total = 1.0380 - .2729 = .7651

Watersheds = .6642 - .2729 = .3913

Variation	DF	SS	FS
Total	9	.7651	
WS	2	.3913	.1956
WS/T	7	.3738	.0534

F = .1956/.0534 = 3.66 $F^{0.10}$ = 4.74

TABLE A20. Abert Squirrel; Peeled: Summer 1975

Watershed	1	2	3	4	X_i	n_i
8	0	0	0	0	0	4
10	.0182	.2500	0	-	.2682	3
13	0	.0469	0	-	.0469	3

a = 3 $\qquad$ Ex_i = .3151 $\qquad$ n = 10

C = .0099

Total = .0650 - .0099 = .0551

Watersheds = .0247 - .0099 = .0148

Variation	DF	SS	FS
Total	9	.0551	
WS	2	.0148	.0074
WS/T	7	.0403	.0058

F = .0074/.0058 = 1.2759 $\qquad$ $F^{0.10}$ = 4.74

TABLE A21. Abert Squirrel; Needled: Fall 1975

Watershed	1	2	3	4	X_i	n_i
8	0	0	0	0	0	4
10	.4727	1.125	0	-	1.5977	3
13	.2623	0	.1167	-	.3790	3
a = 3					Ex_i = 1.9767	n = 10

C = .3907

Total = 1.5578 - .3907 = 1.1671

Watersheds = .8988 - .3907 = .5081

Variation	DF	SS	FS
Total	9	1.1671	
WS	2	.5081	.2541
WS/T	7	.6590	.0941

F = .2541/.0941 = 2.7003 $F^{0.10}$ = 4.74

TABLE A22. Abert Squirrel; Peeled: Fall 1975

Watershed	1	2	3	4	X_i	n_i
8	0	0	0	0	0	4
10	0	.3125	0	-	.3125	3
13	0	0	0	-	0	3
a = 3					Ex_i = .3125	n = 10

C = .0098

Total = .0879

Watersheds = .0326 - .0098 = .0228

Variation	DF	SS	FS
Total	9	.0879	
WS	2	.0228	.0114
WS/T	7	.0651	.0093

F = .0114/.0093 = 1.2258 $F^{0.10}$ = 4.74

TABLE A23. Abert Squirrel; Needled: Spring 1976

Watershed	1	2	3	4	X_i	n_i
8	.2128	.0435	.4038	.5581	1.2182	4
10	.3273	.8478	.0476	-	1.2227	3
13	1.0323	.9531	3.0500	-	5.0354	3
a = 3					Ex_i = 7.4763	n = 10

C = 5.5895

Total = 12.6265 - 5.5895 = 7.0370

Watersheds = 9.3211 - 5.5895 = 3.7316

Variation	DF	SS	FS
Total	9	7.0370	
WS	2	3.7316	1.8658
WS/T	7	3.3054	.4722

F = 1.8658/.4722 = 3.9513 $F^{0.10}$ = 4.74

TABLE A24. Abert Squirrel; Peeled: Spring 1976

Watershed	1	2	3	4	X_i	n_i
8	.0426	.0217	.1538	.2093	.4274	4
10	.0545	.1739	0	-	.2284	3
13	.7097	.4219	.9667	-	2.0983	3
a = 3					Ex_i = 2.7541	n = 10

C = .7585

Total = 1.7192 - .7585 = .9607

Watersheds = 1.5307 - .7585 = .7722

Variation	DF	SS	FS
Total	9	.9607	
WS	2	.7722	.3861
WS/T	7	.1885	.0269

F = .3861/.0269 = 14.3532 $F^{0.10}$ = 4.74

TABLE A25. Abert Squirrel; Mushroom Digs: Summer 1973

Watershed	1	2	3	4	X_i	n_i
8	.1277	.3830	.0769	.0465	.6341	4
10	0	.0208	0	--	.0208	3
13	.0328	.0317	.0169	--	.0814	3
14	0	.0577	.0750	.1087	.2414	4
17	0	0	0	0	0	3
					Ex_i = .9777	n = 17

C = .0575

Total = .1946 - .0575 = .1371

Watersheds = .1174 - 0575 = .0599

Variation	DF	SS	MS
Total	16	.1371	
WS	4	.0599	.0150
WS/T	12	.0772	.0064

F = .0150/.0064 = 2.3438 $F^{0.10}$ = 3.26

TABLE A26. Abert Squirrel; Mushroom Digs: Summer 1974

Watershed	1	2	3	4	X_i	n_i
13	.0968	.1094	.0339	--	.2401	3
14	.2917	0	0	.0213	.3130	4
17	0	0	0	--	0	3
a = 3					Ex_i = .5531	n = 10

C = .0306

Total = .1081 - .0306 = .0775

Watersheds = .0437 - .0306 = .0131

Variation	DF	SS	MS
Total	9	.0775	
Watersheds	2	.0131	.0066
WS/T	7	.0644	.0092

F = .0066/.0092 = .7174 $F^{0.10}$ = 4.74

TABLE A27. Abert Squirrel; Track Counts (tracks/mile): Winter 72-73

Watershed	1	2	3	4	X_i	n_i
8	8.992	8.376	8.888	7.520	33.776	4
10	0	0	1.128	--	1.128	3
13	2.760	1.336	1.784	--	5.880	3
14	2.136	1.960	5.856	1.816	11.768	4
17	2.080	.920	4.048	--	7.048	3
a = 5					Ex_i = 59.600	n = 17

C = 208.9506

Total = 367.9718 - 208.9506 = 159.0212

Watersheds = 348.3330 - 208.9506 = 139.3824

Variation	DF	SS	MS
Total	16	159.0212	
Watersheds	4	139.3824	34.8456
WS/T	12	19.6388	1.6366

F = 21.2915 $F^{0.10}$ = 3.26

W = .10(5,12)1.2793
 = 3.92(1.2793)
 = 5.0149

10	13	17	14	8
.376	1.960	2.352	2.944	8.448

8-10 = 8.076 > 2.7005 S
8-13 = 6.488 > 2.7005 S
8-17 = 6.096 > 2.7005 S
8-14 = 5.504 > 2.5075 S
14-10 = 2.568 < 2.7005

TABLE A28. Abert Squirrel; Track Counts (tracks/mile): Winter 73-74

Watershed	1	2	3	4	X_i	n_i
8	.312	2.792	1.112	.680	4.896	4
10	.624	.728	0	--	1.352	3
17	15.584	12.872	9.112	--	37.568	3
a = 3					Ex_i = 43.816	n = 10

C = 191.9842

Total = 502.0889 - 191.9842 = 310.1047

Watersheds = 477.0535 - 191.9842 = 285.0693

Variation	DF	SS	MS
Total	9	310.1047	
WS	2	285.0693	142.5347
WS/T	7	25.0354	3.5765

F = 39.8531 $\quad F^{0.10} = 4.74$

W = .10(3,7)1.8912
= 3.45(1.8912)
= 6.5246

10	8	17
.451	1.224	12.520

17-10 = 12.069 > 3.7484 S

17- 8 = 11.296 > 3.5135 S

TABLE A 29. Cottontail: Spring 1973

Watershed	1	2	3	4	X_i	n_i
8	8.2609	0	.0192	0	8.2801	4
10	.1818	.7083	.1429	--	1.0330	3
12	24.8750	14.9348	11.4583	16.9792	68.2473	4
13	3.3220	.8136	1.1833	--	5.3189	3
14	.2083	.1538	.0930	.0213	.4764	4
17	.1167	.0758	.4000	--	.5925	3
a = 6					Ex_i = 83.9482	n = 21

$C = (83.9482)^2/21 = 335.5857$

Total $Ex_i^2 - C = 1343.551 - 335.5857 = 1007.9654$

Watersheds = 17.1400 + .3557 + 1164.4234 + 9.4302 + .0568 + .1170 =
1191.5231 - 335.5857 = 855.9374

Variation	DF	SS	MS
Total	20	1007.9654	
Watersheds	5	855.9374	171.1875
WS/T	15	152.0280	10.1352

$F = 171.1875/10.1352 = 16.8904 \quad F^{0.10} = 2.90$

W = .10(6,15)3.1836
= 4.05 (3.1836)
= 12.8936

14	17	10	13	8	12
.1191	.1975	.3443	1.7730	2.0700	17.0618

12-14 = 16.9427 > 6.4468

12- 8 = 14.9918 > 6.4468

8-14 = 1.9509 < 6.4468

TABLE A 30. Cottontail: Fall 1973

Watershed	1	2	3	4	X_i	n_i
8	0	0	0	0	0	4
10	.4815	.2917	6.3810	--	7.1542	3
12	13.9792	9.8958	18.0213	14.6939	56.5902	4
13	.1774	.2344	.2000	--	.6118	3
14	.2041	0	0	0	.2041	4
17	0	0	.0500	--	.0500	3

a = 6 $\quad$ Ex_i = 64.6103 $\quad$ n = 21

$C = (64.6103)^2/21 = 198.7853$

Total $Ex_i^2 - C = 875.2276 - 198.7853 = 676.4423$

Watersheds = 17.0609 + 800.6127 + .1248 + .0104 + .0008 =
817.8096 - 198.7853 = 619.0243

Variation	DF	SS	MS
Total	20	676.4423	
Watersheds	5	619.0243	123.8049
WS/T	15	57.4180	3.8279

$F = 123.8049/3.8279 = 32.3428 \qquad F^{0.10} = 2.90$

W = .10(6,15)1.9565
= 7.9238

8	17	14	13	10	12
0	.0167	.0510	.2039	2.3847	14.1476

12-10 = 11.7629 > 4.2670

10-13 = 2.1808 < 4.5522

10- 8 = 2.3847 < 4.2670

TABLE A31. Cottontail: Spring 1974

Watershed	1	2	3	4	X_i	n_i
8	0	.0851	0	0	.0851	4
10	.3818	.0435	0	--	.4253	3
12	4.0417	9.2000	5.7917	10.4667	29.5001	4
13	.5385	.0645	.1897	--	.7927	3
14	.0208	.0566	1.9556	0	2.0330	4
17	.0508	.0152	0	--	.0660	3
a = 6					Ex_i = 32.9022	n = 21

$C = (32.9022)^2/21 = 51.5502$

Total $Ex_i^2 - C = 248.3868 - 51.5502 = 196.8366$

Watersheds = .0018 + .0603 + 217.5640 + .2095 + 1.0333 + .0015 =
218.8704 - 51.5502 = 167.3202

Variation	DF	SS	MS
Total	20	196.8366	
Watersheds	5	167.3202	33.4640
WS/T	15	29.5164	1.9678

$F = 33.4640/1.9678 = 17.0058 \qquad F^{0.10} = 2.90$

W = .10(6,15)1.4028
= 4.05(1.4028)
= 5.6813

8	17	10	13	14	12
.0213	.0220	.1418	.2642	.5082	7.3750

12-14 = 6.8668 > 2.8407

14-13 = .2440 < 3.0594

14- 8 = .4869 < 3.0594

TABLE A32. Cottontail: Fall 1974

Watershed	1	2	3	4	X_i	n_i
8	.0638	.0638	.0196	0	.1472	4
10	.0909	0	.0244	--	.1153	3
12	16.3125	9.4783	12.2708	12.6383	50.6999	4
13	.0192	.0312	3.0666	--	3.1170	3
14	0	0	0	.0851	.0851	4
17	.0169	.0758	.0339	--	.1266	3
					Ex_i = 54.2911	n = 21

$C = (54.2911)^2/21 = 140.3583$

Total $Ex_i^2 - C = 675.6722 - 140.3583 = 535.3139$

Watersheds = .0054 + .0044 + 642.6200 + 3.2386 + .0018 + .0053 =
645.8755 - 140.3583 = 505.5172

Variation	DF	SS	MS
Total	20	535.3139	
Watersheds	5	505.5172	101.1034
WS/T	15	29.7967	1.9864

$F = 101.1034/1.9864 = 50.8978$ $F^{0.10} = 2.90$

W = .10(6,15)1.4094
= 5.7081

14	8	10	17	13	12
.0213	.0368	.0384	.0422	1.0390	12.6750

12-13 = 11.6360 > 3.0738

13-17 = .9968 < 3.2793

13-14 = 1.0177 < 3.0738

TABLE A33. Cottontail: Spring 1975

Watershed	1	2	3	4	X_i	n_i
8	0	0	.2549	0	.2549	4
10	.2545	.2292	.3095	--	.7932	3
12	14.2553	10.0000	10.3958	8.4255	43.0766	4
13	1.6452	.2381	.0333	--	1.9166	3
14	.0204	.2500	.0222	.0426	.3352	4
17	.0169	.3333	0	--	.3502	3
a = 6					Σx_i = 46.7267	n = 21

$C = (46.7267)^2/21 = 103.9707$

Total $\Sigma x_i^2 - C = 485.4946 - 103.9707 = 381.5239$

Watersheds = .0163 + .2097 + 463.8987 + 1.2245 + .0281 + .0409 = 465.4182 - 103.9707 = 361.4475

Variation	DF	SS	MS
Total	20	381.5239	
Watersheds	5	361.4475	72.2895
WS/T	15	20.0764	1.3384

$F = 72.2895/1.3384 = 54.0119 \quad F^{0.10} = 2.90$

W = .10(6,15)1.1569
= 4.05(1.1569)
= 4.6854

8	14	17	10	13	12
.0637	.0838	.1167	.2644	.6389	10.7692

12-13 = 10.1303 > 2.5231
13- 8 = .5752 < 2.5231
13-10 = .3745 < 2.6918

TABLE A34. Cottontail: Fall 1975

Watershed	1	2	3	4	X_i	n_i
8	.1276	0	0	0	.1276	4
10	.1091	.0208	.3810	-	.5109	3
13	.2459	.0635	.1000	-	.4094	3
a = 3					Ex_i = 1.0479	n = 10

C = .1098

Total = .2483 - .1098 = .1385

Watersheds = .1470 - .1098 = .0372

Variation	DF	SS	FS
Total	9	.1385	
WS	2	.0372	.0186
WS/T	7	.1013	.0145

F = .0186/.0145 = 1.2828 $F^{0.10}$ = 4.74

TABLE A35. Cottontail: Spring 1976

Watershed	1	2	3	4	X_i	n_i
8	0	0	0	.2558	.2558	4
10	3.6727	.0217	0	-	3.6944	3
13	.3770	.2540	.2500	-	.8810	3
a = 3				Ex_i = 4.8312		n = 10

C = 2.3341

Total = 13.8237 - 2.3341 = 11.4896

Watersheds = 4.8246 - 2.3341 = 2.4905

Variation	DF	SS	FS
Total	9	11.4896	
WS	2	2.4905	1.2453
WS/T	7	8.9991	1.2856

F = 1.2453/1.2856 = .9687 $F^{0.10}$ = 4.74

TABLE A36. Cottontail; Track Counts (tracks/mile): Winter 72-73

Watershed	1	2	3	4	X_i	n_i
8	.624	2.792	.832	1.024	5.272	4
10	0	2.536	0	--	2.536	3
13	0	0	0	--	0	3
14	.352	.656	1.168	2.544	4.720	4
17	1.040	1.840	1.016	--	3.896	3
a = 5					Ex_i = 16.424	n = 17

C = 15.8675

Total = 30.2466 - 15.8675 = 14.3791

Watersheds = 19.7215 - 15.8675 = 3.8540

Variation	DF	SS	MS
Total	16	14.3791	
Watersheds	4	3.8540	.9635
WS/T	12	10.5251	.8771

F = 1.0985 $\quad F^{0.10}$ = 3.26

TABLE A 37. Cottontail; Track Counts (tracks/mile): Winter 73-74

Watershed	1	2	3	4	X_i	n_i
8	1.240	2.168	.552	.344	4.304	4
10	.624	1.456	1.736	--	3.816	3
17	8.312	7.36	4.048	--	19.720	3
a = 3					Ex_i = 27.840	n = 10

C = 77.5066

Total = 151.8290 - 77.5066 = 74.3224

Watersheds = 139.1112 = 61.6046

Variation	DF	SS	MS
Total	9	74.3224	
WS	2	61.6046	30.8023
WS/T	7	12.7178	1.8168

F = 16.9542 $F^{0.10}$ = 4.74

W = .10(3,7)1.3479
= 3.45(1.3479)
= 4.6503

8	10	17
1.080	1.272	6.720

17-8 = 5.64 > 2.5042 S

17-10 = 5.448 > 2.6716 S