significant ($F = 14.18^{***}$) as was storage time ($F = 3.87^{***}$).

The viscometer readings were made to the nearest half digit. The data indicate that samples held at the higher temperatures (41°C) began losing viscosity 2 to 3 hours after the experiment was initiated, those at room temperature began deteriorating at the 5th hour, while the refrigerated samples seemed to hold up throughout the experiment. Although the data were not calculated to determine the difference between lots, it did appear that the testing temperature had a slight effect upon the viscosity reading.

Storage temperature was extremely critical in its effect upon viscosity. The higher the storage temperature, the more rapidly sample viscosity is destroyed. At the other extreme, freezing was equally destructive as was the addition of potassium dichromate. Refrigeration of the milk sample gave consistently good results within a 24-hour time period, as measured by Rolling Ball Viscometer and CMT.

The precision of all gel viscosity tests, such as CMT and Wisconsin Mastitis Tests, are affected by time × temperature. Estimation of cell content of milk by gel viscosity methods without complete knowledge of how each milk sample was collected and stored, and without compensatory adjustment in interpretation, are subject to considerable error and are unsatisfactory for milk quality control.

The Ruakura Rolling Ball Viscometer lends itself to less subjective readings than CMT methods presently in use in California, resulting in greater agreement between readers testing the same sample. A relatively low C.V. 16 to 21 percent within sample variability was noted and could be lowered if reading procedure was altered to the nearest full digit reading, rather than the nearest estimated half digit. Further work is required to determine the full value of the Rolling Ball Viscometer in the future administration of cell count determinations.

Robert O. Leonard is Farm Advisor (Dairy), Monterey, San Benito, Santa Clara, and Santa Cruz counties. Gale Gurtle is Farm Advisor (Dairy), Tulare County. John Bruhn, Agriculturist with Cooperative Extension, *reviewed and edited the manuscript. Dairymen's Cooperative Creamery Association, Tulare, California, donated the use of their laboratory and their Coulter Counter. W. G. Whittlestone, Ruakura Research Station, New Zealand, donated the Ruakura Rolling Ball Viscometer for use in California.*

ALFALFA DAMAGE BY JACKRABBITS IN THE SOUTHERN CALIFORNIA DESERTS

Jackrabbits are significant threats to alfalfa production only when their population density is high, usually in drought periods preceded by years of plentiful rainfall. Jackrabbits living near alfalfa fields do not usually depend solely on alfalfa for nutrition, but individuals may consume up to 65 lbs dry alfalfa per year when desert forage is unsuitable. Observations indicate that hares may travel over two miles at night to reach fields. Fencing fields with poultry wire offers complete control.

PHILIP E. BICKLER

V. H. SHOEMAKER

ALFALFA PRODUCTION contributes significantly to arid-land agriculture in southern California. During 1973, San Bernardino County alone produced alfalfa valued at over $5,000,000. Jackrabbits (*Lepus*) are conspicuous crop depredators in this area, periodically reaching epidemic proportions, and causing loss of entire cotton and alfalfa crops and destruction of range forage. Despite this economic loss, little work has been done to quantify crop damage due to jackrabbits.

To measure jackrabbit impact on alfalfa, detailed knowledge of the structure and behavior of the jackrabbit population must be obtained. It is important to know that jackrabbits infest alfalfa fields only at night, traveling some distance from the surrounding desert to consume alfalfa. Population density and the distance traveled by jackrabbits for food are important, as is the seasonal variation in impact arising from the changing nutritional needs of the jackrabbit population. As desert grasses and wildflowers dehydrate in late spring, the jackrabbit population is forced to rely more on the alfalfa fields for water and nutrition. During drought years jackrabbits may accumulate around fields.

To measure seasonal differences in nutrient supplementation and hare population density, jackrabbit use of agricultural areas near Barstow, California, was observed from winter through summer 1974. Succulent sources of vegetation apart from irrigated areas are not available from June through January at the study sites, where precipitation averages 2½ inches per year.

The Lenwood-Hinkley agricultural area and the Sun and Sky Golf Course, both about seven miles west of Barstow, were visited periodically at about 10 p.m., to monitor the total number of hares consuming grass or alfalfa. Jackrabbit use of the numerous ranches in the Lenwood-Hinkley area never exceeded three animals per night, but visibility was a problem when the alfalfa was tall. The golf course observation site afforded unimpeded visibility, and here jackrabbit presence reflected the abundance of succulent desert vegetation. Spring annuals were in full bloom from mid-April to early May, during which time no hares were seen at either the alfalfa fields or the golf course (graph 1).

Beginning in May 1974, daytime counts were made of hares living next to alfalfa fields at the Lockhart Ranch. These 3000-acre alfalfa fields are 23 miles northwest of Barstow near Harper dry lake. Early in the morning, two observers walked through the study area and noted the total number of hares seen. Flushing distance averaged 50 yards. The number of jackrabbits spotted was converted to density on a per acre basis. During May through August, a total distance of 33 miles was traversed. Data collected at Lockhart reveal population accumulations were dependent upon distance to fields and the vegetation type in the area. Within one mile west of Lockhart, in a dense saltbush shrub community, hare population as measured by 14 census passes indicated an average density of .13 hares per acre. This density corresponds to a 40–50 acre home range (with no overlap) and is similar to population density reported in the literature for desert regions. Density to the north of Lockhart fields was .17 hares per acre, based on minimal data. In two separate creosote-saltbush associations 2.2 miles to the west of the ranch area, census values of .03 and 0 hares per acre were obtained. A sharp gradient in hare density and distance to fields thus existed.

Alfalfa use

To characterize the extent of alfalfa use by jackrabbits, fecal pellets and stomach contents of hares at the study sites were examined. Jackrabbits housed in the laboratory were fed pure alfalfa so that the microscopic characteristics of this plant could be used to recognize alfalfa in samples from the field population. Fecal pellets of jackrabbits were collected at varying distances from the fields.

The feces were ground and examined microscopically to determine the relative density of plant species present and the percentage dry weight of alfalfa consumed. Several hares from the field population were shot to obtain stomach contents. Stomachs were removed in the field and kept frozen until analyzed. Contents were washed in water, mixed to achieve even particle distribution, and treated in an alcohol bath series before mounting in balsam.

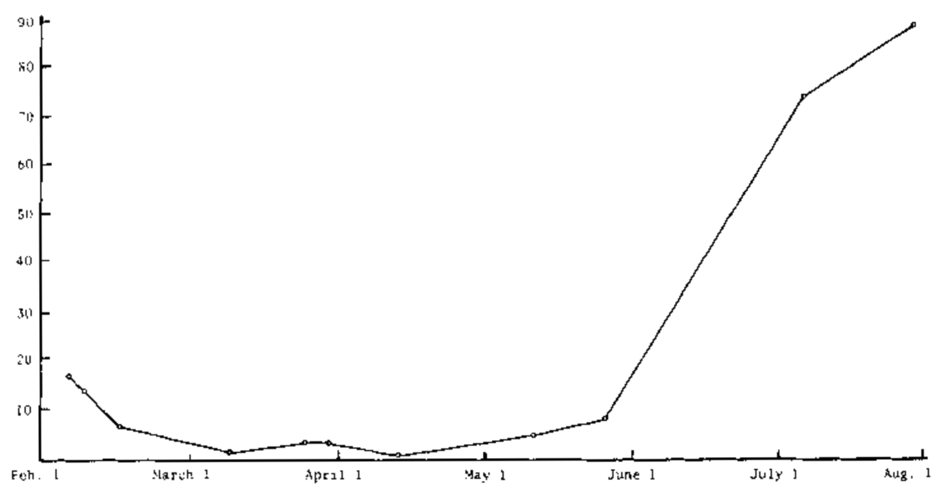
Fecal pellet and stomach content analysis indicates only partial use of alfalfa resources by hares in the study populations during summer 1974. Fresh pellets collected within one mile of fields in June varied in alfalfa content from 0 to 100%. Generally, as the summer went on, stomach contents and fecal pellets showed alfalfa as an increasing part of the diet. By August, all fresh fecal material contained 100% alfalfa. An animal taken from the golf course in early July had 63% grass and 37% desert plants in its stomach. These results support, as do the nocturnal observations, the prediction that jackrabbits must supplement their diets with succulent sources as the desert plants dehydrate in the summer through winter seasons.

Fecal pellet composition, coupled with census measurements, sets nightly distances traveled for food at less than 2.2 miles. Using this figure and the number of hares seen at the golf course in the summer, a good correlation was found between jackrabbit density for areas surrounding the golf course and adjacent to alfalfa fields. No alfalfa was found in fecal material collected further than 1.9 miles from fields.

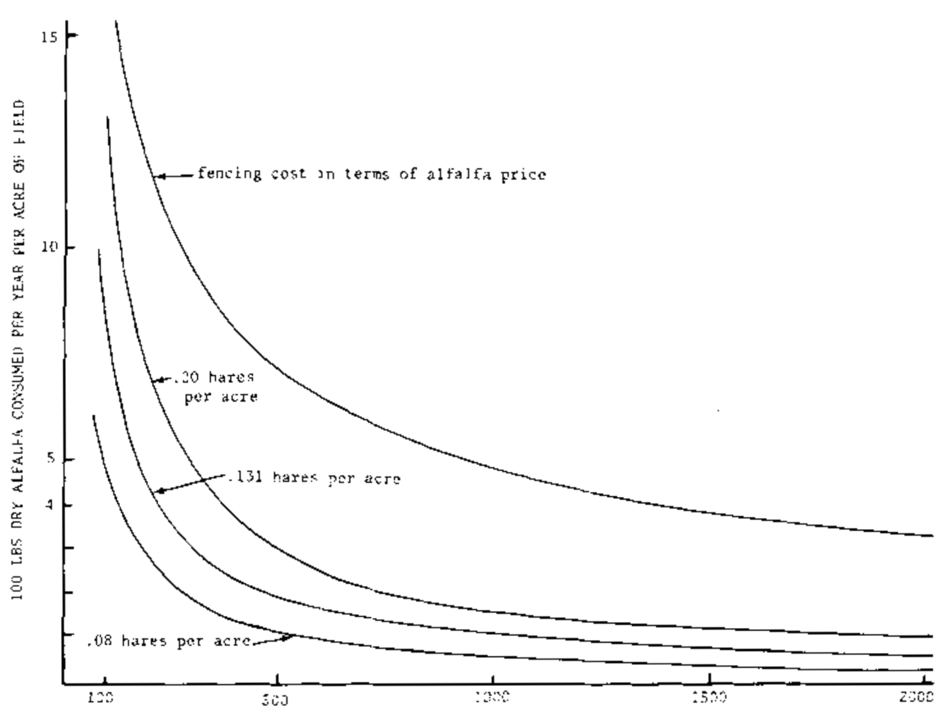
Jackrabbit nutritional requirements under various conditions can be used to predict alfalfa damage, by estimating the deficit of energy and water that a jackrabbit population would be subject to during periods of drought and then taking these figures to represent nutrition possibly obtained from alfalfa fields. Earlier studies by V. H. Shoemaker show that jackrabbits utilizing natural browse receive sufficient energy and water to achieve food and water balance during the spring months. In summer, as suitable forage dries, adult (5.5 lbs) jackrabbits in the Mohave Desert receive from desert plants energy equivalent to 23% of the 110 g dry alfalfa they would ordinarily consume per day in that season. To balance this deficit, jackrabbits need 85 g dry alfalfa daily. In winter, due to lack of palatable browse and low digestive efficiency, desert jackrabbits receive energy equivalent to only 10% of the 140 g dry alfalfa per day required in that season as determined by alfalfa consumption studies. One hundred twenty-six g dry alfalfa per day is needed by adult hares to balance these deficits.

In obtaining alfalfa to satisfy caloric

GRAPH 1. NUMBER OF JACKRABBITS OBSERVED AT NIGHT AT THE SUN AND SKY GOLF COURSE, BARSTOW, CALIF., SPRING THROUGH SUMMER 1974.



GRAPH 2. RELATIONSHIP OF SQUARE FIELD SIZE TO ALFALFA CONSUMPTION OF JACKRABBITS.



requirements, hares also receive adequate water. On a yearly basis, alfalfa loss from hares ingesting enough alfalfa to alleviate these deficits would amount to 56 lbs dry alfalfa per animal. This study measured alfalfa consumed by adult hares only, because reproductive activity occurs during the months of February through May, when the population relies exclusively on desert food sources. By June the majority of young rabbits produced during spring would be ingesting alfalfa at a rate exceeding 80% of adult intake.

Alfalfa consumed in a particular field depends not only upon the acreage of the alfalfa field, but on the total perimeter exposed to the desert. In general, relatively less perimeter is exposed by a large field and correspondingly less alfalfa loss per acre can be expected. Graph 2 shows this relationship for a population migrating up to 2.2 miles nightly from surrounding desert. Curves shown include density determined near the Lockhart Ranch (.131 hares per acre) and the .08 and .20 hare per acre levels which have been reported in the literature for yearly average density and spring density highs, respectively, for desert jackrabbits. The graph applies to square fields, but conversion to a more specific case should not be difficult. Yearly production (dry weight) for an average San Bernardino County acre of alfalfa was 13,980 lbs in 1973.

Jackrabbit control methods

Four-foot high one-inch mesh poultry wire offers complete protection from hare damage and should last five years before replacement is necessary. Cottontails may be discouraged by burying the bottom twelve inches of the fencing. Contrary to beliefs held by many producers, three-foot fencing will deter jackrabbits. At the cost of $1.00 per linear foot (including labor), fencing will be less expensive than damage by jackrabbits only at high jackrabbit population densities or in cases of small alfalfa fields. Graph 2 shows the relationship of field acreage to fencing cost assuming the 1973 price of $33.50 per ton of alfalfa. Stacks of baled alfalfa outside the fenced area are effectively protected by wraps of poultry wire or canvas. Other jackrabbit control methods include chemical repellants applied to crops or shooting and trapping, which are costly, aside from being ineffective as complete controls.

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LAND USE MAPPI

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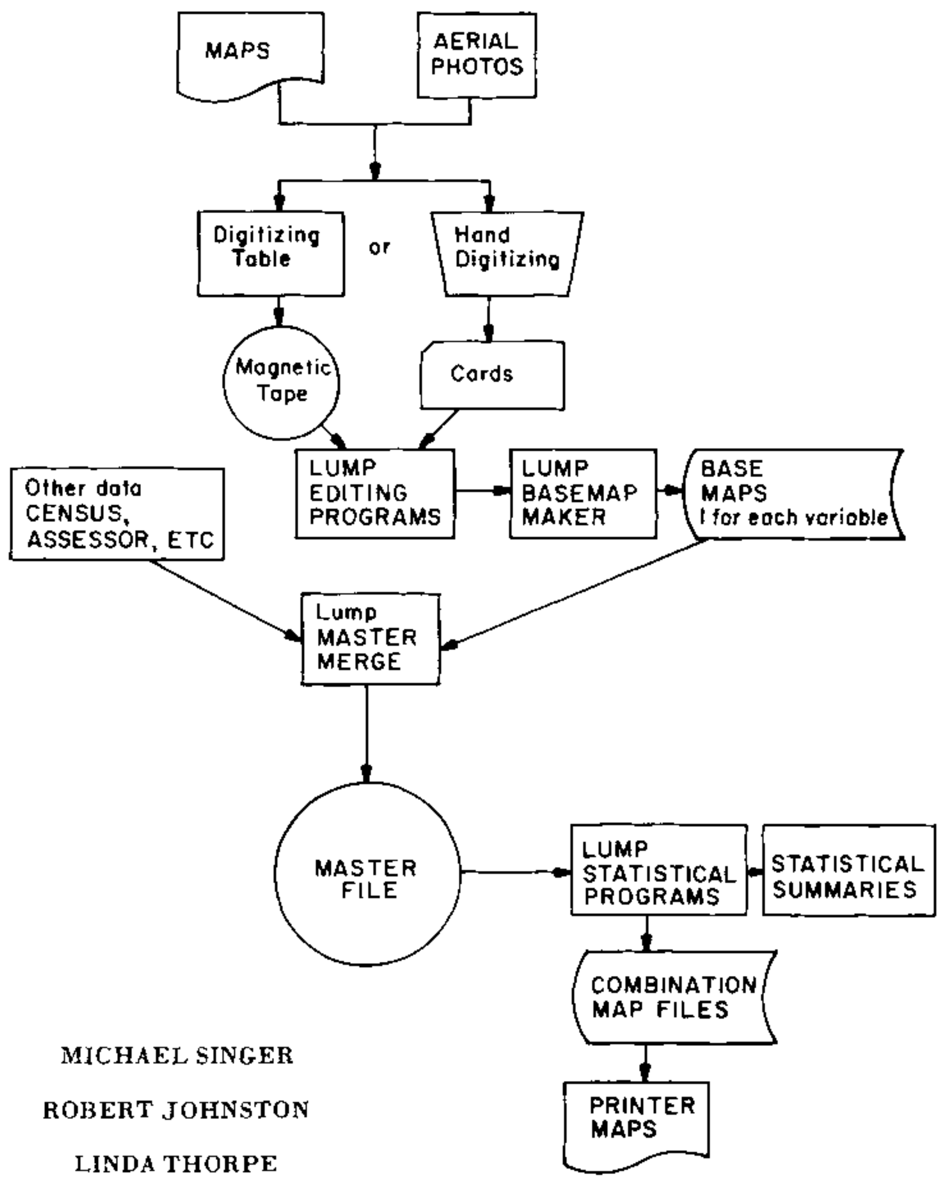

MICHAEL SINGER

ROBERT JOHNSTON

LINDA THORPE

A series of computer Land Use Mapping Programs (LUMP) is being developed to assist land use planners and decision makers in data interpretation vital to environmental planning. Forthcoming land use legislation will have important effects on individual land owners and on California agriculture. This system of programs is designed to be an inexpensive tool for the production of inventory, interpretive, combination and evaluation maps from social and physical resource data.

Recent world events have highlighted the thin margin which exists between starvation and sufficiency in the world food situation. In addition, rising food costs in the United States have stimulated renewed interest in maintaining and improving yields from agricultural land. New land, as well as land previously in agriculture but removed for various reasons, is being returned to agricultural production. Counter to these trends is the expansion of non-agricultural land uses onto agricul-