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UTAH SCIENCE

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The white-winged pheasant posing on this month's cover is a native of Afghanistan.

Distinguishing marks of the male are greenish neck feathers and chestnut red feathers bordering the white wing coverts. The flesh is similar to a ring-neck and its habits and sporting characteristics are similar. The females are similar in appearance to ring-necked females though somewhat lighter. Both sexes are somewhat smaller than their American counterpart.

Workers of the Foreign Game Investigation Program (FGIP) located this bird and obtained specimens in the valley of the upper Amu Daria River which drains into Lake Aral of Russia. It required a 1,300-mile trip under primitive conditions in 1956 and again in 1959 to obtain eggs and breeding stock.

White-wings retain their wildness under domestication. This characteristic tends to assure their survival when released in new areas. At the present this pheasant has been introduced into several western states with arid or semi-arid habitats.

If successful, this introduced species will serve to extend pheasant ranges. More information about this interesting new game bird and the work of the FGIP is found in "The Art and Science of Relocating Birds — Ecology in Action."

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UTAH SCIENCE

A quarterly devoted to research in agriculture, land and water resources, home and community life, human nutrition and development, and published by the Agricultural Experiment Station, Utah State University, Logan, Utah.

The magazine will be sent free on request.

To avoid overuse of technical terms, trade names of products or equipment sometimes are used. No endorsement of specific products or firms named is intended, nor is criticism implied of those not mentioned.

NEW USU PRESIDENT TAKES OFFICE

Dr. Glen L. Taggart, 11th President of Utah State University, has had a distinguished career in education, government service, and foreign relations.

No stranger to Utah and the University, he is a Cache Valley native, having been born in Lewiston on January 16, 1914. He was a 1940 graduate of USU with a B.S. degree in sociology. In 1946, he received a Ph. D. degree in sociology from the University of Wisconsin.

His government service extended for a period of 10 years, beginning in 1943 when he was named rural sociologist for the Bureau of Agricultural Economics, U. S. Department of Agriculture. From 1944 to 1953 he was with the Foreign Agricultural Service of the USDA serving as social scientist (1944-49) and assistant chief (1950-53) in the Technical Collaboration Division.

He joined the staff of Michigan State University in 1953 as Professor of Sociology. In 1956, he was named Michigan State's Dean of International Studies and programs and it was from that position that he left to become president of Utah State University on July 1, 1968. From 1964 to 1966, he was on leave of absence from Michigan State to serve as Vice-Chancellor (President) of the University of Nigeria.

President Glen L. Taggart

As Michigan State's Dean of International Studies and Programs, he served as a consultant to a number of universities, foundations, and foreign governments.

President Taggart's wife is the former Phyllis Paulsen, of Logan. Mrs. Taggart holds a degree from Utah State University in art education. The Taggarts are parents of two sons and a daughter. Stephen, 26, is a graduate student at Cornell University. Edward, 22, is a junior at Utah State, majoring in geology. Elaine, 18, will enter USU this fall as a freshman.

Dr. Taggart is the author of articles and reports on social relations and international programs. He holds memberships in the American Association for the advancement of Science, the American Sociological Association, the Rural Sociological Society, the American Academy of Political and Social Science, and the Society of International Development.

Food retail price differences

ROICE H. ANDERSON

Are food prices significantly different in various areas or in various stores in the same market area? The answer to this question is important not only to aid shoppers in selecting lowest cost sources of food but gives evidence of how well food markets are performing to meet consumer demands.

At first glance, the answer to the question of comparative prices seems simple. We all have relatives and friends who live and shop in different places and we make frequent visits to different areas and to different stores within an area. Food prices among areas and stores is a frequent topic of conversation among most people and each has at least some evidence for his conviction.

When we realize, however, that retail food stores stock 3,000 to 5,000 items and that brands and qualities of products vary from store to store and area to area, the measurement is not so simple. It is possible that our convictions as to highest or lowest priced sources for food are based on skimpy evidence.

As part of a regional study on retail pricing and advertising practices, researchers collected and analyzed retail prices to make comparisons between areas and stores. A sample list of items was priced each week on alternate months for the year 1966 in food stores of the three university towns of Logan, Utah, Laramie, Wyoming and Ft. Collins, Colorado. The analysis presented here include only food stores in Logan and Laramie for area comparison and in Logan for the stores comparison. About 100 food items were included in the sample and these were grouped

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ROICE H. ANDERSON is a Professor in the Department of Agricultural Economics.

The green belt amendment and its probable impact on assessed values, taxes and mill levies in Salt Lake County

RONDO A. CHRISTENSEN and FRED DEGIORGIO

The Utah electorate will vote this autumn whether or not to permit land used for agricultural purposes to be assessed according to its value for agricultural use without regard to the value it may have for other purposes. This proposed constitutional amendment will appear on the 1968 election ballot in November as proposition number 4. It is commonly referred to as the "green belt" amendment because it presumably would help preserve and make economically feasible, continued farming of the open land surrounding cities and developed areas.

Some of the background of this proposed amendment was given in the June 1968 issue of *Utah Science*. The probable impact of the amendment on assessed values, property taxes, and mill levies in Salt Lake County, if passed and implemented by the Utah Legislature, is presented in this article. The study was made to help the electorate make a considered and informed decision as to whether they will vote for or against the proposed amendment.

This article is based on the premise that the assessed values of all taxable property in the state will be raised first to 20 percent of value if they are presently lower, and finally raised to and equalized at 30 percent of value. Present Utah law states that property shall be assessed at 30 percent of value and that market value, or "fair cash value" shall be the basis of that value. Procedures to equalize and

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HIGHLIGHTS

1. Not all of the land presently classified as agricultural land in Salt Lake County would qualify for differential assessment — assessment according to agricultural value rather than market value — as proposed by the amendment. Probably not more than 70 percent would qualify.
2. If the assessed values of all classes of taxable property in Salt Lake County were increased to at least 20 percent of value, differential assessment were permitted on "qualifying" agricultural land, and total property tax revenues were held at their 1967 level:
   a. The assessed value of agricultural land would increase from $7.8 million in 1967 to $10.2 million or 30.8 percent, compared with an average increase in assessed value of all property of 13.0 percent. Without differential assessment the assessed value of agricultural land would increase 307.7 percent compared with an average increase of 15.8 percent on all property.
   b. Property taxes on agricultural land would increase from $652,000 in 1967 to $741,000 or 13.6 percent, compared with $2,263,000 or 247.1 percent without differential assessment.
   c. The average mill levy on all taxable property would be 1.7 mills higher than it would be without differential assessment on "qualifying" agricultural land.
3. If the assessed values of all classes of taxable property in Salt Lake County were raised to and equalized at 30 percent of value, differential assessment were permitted on "qualifying" agricultural land, and property tax revenues were held at their 1967 level:
   a. The assessed value of agricultural land would increase from $7.8 million in 1967 to $15.2 million or 94.9 percent, compared with an average increase of 51.5 percent on all property. Without differential assessment, the assessed value of agricultural land would increase 511.5 percent, compared with an average increase of 55.7 percent on all property.
   b. Property taxes would increase from $652,000 in 1967 to $798,000 or 22.4 percent, compared with $2,432,000 or 273.0 percent without differential assessment.
   c. The average mill levy on all taxable property would be 1.4 mills higher than if there were no differential assessment on "qualifying" agricultural land.

bring assessed values into compliance with the law are currently underway by the State Tax Commission and county assessors.

AGRICULTURE VS. MARKET VALUES

The average market value is about 8 times the average agricultural value of the land in Salt Lake County currently classified as "agricultural" by the County Assessor's Office — $724 compared with $88 per acre (table 1). These figures are based on a sample of agricultural parcels in that county. Market values exceed agricultural values by an average of 20 times in the highly urbanized Big Cottonwood area and even as much as 3 times in the more rural Jordan area.

Only about 70 percent of the land currently classified as agricultural would probably qualify for differential assessment under the amendment, even if liberal criteria were used by the Legislature in implementing the amendment if passed.[1] The average market value of the "qualifying" land would be $809 compared with an agricultural value of $112 per acre.

Most of the other land presently classified as agricultural on the tax rolls in Salt Lake County is currently lying idle or is being used for purposes other than agricultural production. It is assumed that this land would not qualify for differential assessment under the amendment. It has an average agricultural value of only $30 per acre compared with a market value of $518. While much of this "nonqualifying" land is of low agricultural value because of inadequate drainage, poor soil, or excessive slope, it has considerable market value because of potential industrial, commercial, or residential use.

ASSESSED VALUES

Agricultural land in Salt Lake County is currently assessed at an average of about $36 per acre (table 2). This is about 5 percent of market value and about 41 percent of agricultural value. The average assessed value of "qualifying" land is $41 per acre compared with $23 for "nonqualifying" agricultural land.

Current assessments vary from an average of about 9 percent of market value in the Big Cottonwood area to about 2.6 percent in the Magna area.

The assessed value of agricultural land would increase to an average of $41 per acre if "qualifying" land were assessed at 20 percent of agricultural value and "nonqualifying" land were assessed at 20 percent of market value. "Qualifying" agricultural land would decrease, however, from $41 to $22 per acre, while "nonqualifying" land would increase from $23 to $104 per acre. The average assessed value of agricultural land would rise to $69 per acre if it were assessed at 30 percent of value and differential assessment were allowed on "qualifying" land.

If differential assessments were not allowed, the average assessed value of agricultural land in Salt Lake County would increase from $36 in 1967 to $145 per acre if assessed at 20 percent of value, and to $217 per acre if assessed at 30 percent of value. "Qualifying" land would increase from $41 currently to $162 if assessed at 20 percent of value, and to $243 if assessed at 30 percent of value.

One of the reasons there would be such a large increase in the assessed value of agricultural land per acre is because it has been assessed in the past more in relation to its agricultural value rather than its market value. While full market values are not yet being recognized in assessing agricultural land in Salt Lake County, it is obvious from current assessments that values are being used which exceed agricultural values, particularly in and around the populated areas.

The total assessed value of all agricultural land in Salt Lake County

Table 1. Number of parcels, acres per parcel and agricultural and market values per acre, by area and qualification, 168 parcels of agricultural land, Salt Lake County, 1967

Area and Qualification for Differential Assessment	Number of parcels	Acres per parcel	Average value per acre: Agricultural	Average value per acre: Market
Big Cottonwood	13	13.8	$169	$3,555
Qualifying	9	8.1	369	5,583
Nonqualifying	4	26.7	33	2,167
Little Cottonwood	24	11.3	134	2,536
Qualifying	17	12.6	145	2,553
Nonqualifying	7	8.3	95	2,474
Magna	17	93.2	16	228
Qualifying	8	62.4	14	377
Nonqualifying	9	120.7	17	160
Draper	24	15.7	126	1,031
Qualifying	15	10.2	260	1,563
Nonqualifying	9	24.9	34	666
Valley	38	15.0	222	1,730
Qualifying	33	16.0	230	1,669
Nonqualifying	5	8.8	121	2,459
Jordan	52	48.9	87	368
Qualifying	46	53.1	87	369
Nonqualifying	6	17.2	90	337
Total	168	32.9	88	724
Qualifying	128	30.5	112	809
Nonqualifying	40	40.6	30	518

[1]It was assumed that land would qualify for differential assessment under the proposed amendment if it were being used currently to produce crops, forest, products, livestock or livestock products and had been so used during the previous 3 years.

Table 2. Alternative assessed values per acre, by area and qualification, 168 parcels of agricultural land, Salt Lake County, 1967

Area and qualification for differential assessment	Number of parcels	Actual in 1967	With differential assessment on "qualifyiing" agricultural land: Assessment at at least 20% of value	With differential assessment: Assessment at 30% of value	Without differential assessment on "qualifying" agricultural land: Assessment at at least 20% of value	Without differential assessment: Assessment at 30% of value
Big Cottonwood	13	$307	$287	$444	$ 711	$1,067
Qualifying	9	555	74	111	1,117	1,675
Nonqualifying	4	137	433	650	433	650
Little Cottonwood	24	82	129	193	507	761
Qualifying	17	73	29	43	511	766
Nonqualifying	7	115	495	742	495	742
Magna	17	6	23	34	46	68
Qualifying	8	7	33	4	75	113
Nonqualifying	9	5	32	48	32	48
Draper	24	47	100	150	206	309
Qualifying	15	81	52	98	313	469
Nonqualifying	9	25	133	191	133	191
Valley	38	65	80	120	346	519
Qualifying	33	63	46	69	334	501
Nonqualifying	5	94	492	738	492	738
Jordan	52	22	19	29	74	110
Qualifying	46	22	17	26	74	111
Nonqualifying	6	15	67	101	67	101
Total	168	36	41	69	145	217
Qualifying	128	41	22	34	162	243
Nonqualifying	40	23	104	155	104	155

Table 3. Alternative assessed values of taxable property in Salt Lake County, by class of property, 1967

Class of property	Actual in 1967	With differential assessment on "qualifying" agricultural land: Assessment at at least 20% of value	With differential assessment: Assessment at 30% of value	Without diifferential assessment on "qualifying" agricultural land: Assessment at at least 20% of value	Without differential assessment: Assessment at 30% of value
		Millions of dollars			
Agricultural land	7.8	10.2	15.2	31.8	47.7
Qualifying	6.2	3.5	5.2	25.1	37.7
Nonqualifying	1.6	6.7	10.0	6.7	10.0
Utilities, mines, gas & oil	228.7	228.7	245.0	228.7	245.0
Improved real estate	318.8	366.5	549.7	366.5	549.7
Unimproved real estate	98.5	149.5	244.2	149.5	224.2
Personal property	121.3	121.3	140.0	121.3	140.0
Total	775.1	876.2	1,174.1	897.8	1,206.6

would increase from $7.8 million in 1967 to $10.2 million or 30.8 percent, if assessed at 20 percent of value and differential assessment were used on "qualifying" land (table 3). The increase would all come from the "nonqualifying" land, however. The assessed value of it would increase from $1.6 million in 1967 to $6.7 million, while the assessed value of "qualifying" agricultural land would decrease from $6.2 million to $3.5 million.

If the assessed value of all other classes of property were raised to 20 percent of market value, the total assessed value of improved real estate would increase 15.0 percent and unimproved real estate would increase 51.8 percent. There would be no change in utilities, mines, gas, oil and personal property since these are already assessed at more than 20 percent of market value. The increase in total assessed value in the county would be 13.0 percent.

If differential assessment were not allowed on "qualifying" agricultural land, the total assessed value of agricultural land would increase to $31.8 million, an increase of 307.7 percent, and the total assessed value of all taxable property would increase to $897.8 million — an increase of 15.8 percent.

If property were assessed at 30 percent of value and differential assessments were allowed on "qualifying" agricultural land, the assessed value of all agricultural land would increase 94.9 percent from 1967; utilities, mines, gas and oil, 7.1 percent; improved real estate 72.4 percent; unimproved real estate, 147.9 percent; and personal property, 15.4 percent. The increase in assessed value of all property would be 51.5 percent. If differential assessment were not allowed the total assessed value of agricultural property would increase 511.5 percent and the total assessed value of all property would increase 55.7 percent.

TAXES

Property taxes on agricultural land in Salt Lake County would increase from $652,000 in 1967 to $741,000 if all taxable property were assessed at at least 20 percent of value, differential assessment were allowed on "qualifying" agricultural land, and total property tax revenues were maintained at their 1967 level. This would amount to an increase of 13.6 percent. The increase would be 1.6 percent for improved real estate and 34.4 percent for unimproved real estate. Taxes charged against utilities, mines, and gas and oil properties would decrease 13.3 percent and taxes charged on personal property would decrease 11.4 percent.

If differential assessment were not allowed on "qualifying" agricultural land, taxes charged on agricultural land would increase to $2,263,000, an increase of 247.1 percent over taxes charged in 1967.

If assessed values on all property were raised to 30 percent of value and total tax revenues were held at their 1967 level, property taxes charged against agricultural land would increase to $798,000 if "qualifying" land were assessed in relation to agricultural value, and to $2,432,000 if in relation to market value. Assessing at 30 percent of value instead of 20 percent would shift more of the tax burden to agricultural as well as to improved and unimproved real estate, and would lighten the tax burden on utilities, mines, gas, oil, and personal property.

Table 4. Property taxes under alternative assessment levels and methods, by class of property, Salt Lake County, 1967*

Class of property	Actual in 1967	With differential assessment on "qualifying" agricultural land: At least 20% of value	With differential assessment on "qualifying" agricultural land: At 30% of value	Without differential assessment on "qualifying" agricultural land: At least 20% of value	Without differential assessment on "qualifying" agricultural land: At 30% of value
	Thousands of dollars				
Agricultural land	652	741	798	2,263	2,432
Qualifying	526	254	273	1,776	1,907
Nonqualifying	126	487	525	487	525
Utilities, mines, gas and oil	18,310	15,875	11,976	15,473	11,630
Improved real estate	29,321	29,802	33,409	29,157	32,634
Unimproved real estate	9,178	12,334	13,896	12,072	13,580
Personal property	11,369	10,078	8,751	9,865	8,554
Total	68,830	68,830	68,830	68,830	68,830
	Percent of total				
Agricultural land	1.0	1.1	1.2	3.3	3.6
Qualifying	0.8	0.4	0.4	2.6	2.8
Nonqualifying	0.2	0.7	0.8	0.7	0.8
Utilities, mines, gas and oil	26.6	23.1	17.4	22.5	16.9
Improved real estate	42.6	43.3	48.5	42.4	47.4
Unimproved real estate	13.3	17.9	20.2	17.5	19.7
Personal property	16.5	14.6	12.7	14.3	12.4
Total	100.0	100.0	100.0	100.0	100.0

*Assuming a constant total property tax revenue of $68,830,000.

Table 5. Alternative average property tax mill levies, by class of property, Salt Lake County, 1967*

Class of property	Actual in 1967	Average mill levy per dollar of assessed value, with assessments: At least 20% of value: With differential assess. on "qualifying" agr. land	At least 20% of value: Without differential assess. on "qualifying" agr. land	At 30% of value: With differential assess. on "qualifying" agr. land	At 30% of value: Without differential assess. on "qualifying" agr. land
Agricultural land	83.6	72.9	71.2	52.4	51.0
Qualifying	83.6	72.9	71.2	52.4	51.0
Nonqualifying	83.6	72.9	71.2	52.4	51.0
Utilities, mines, gas and oil	80.1	69.4	67.7	48.9	47.5
Improved real estate	92.0	81.3	79.6	60.8	59.4
Unimproved real estate	93.2	82.5	80.8	62.0	60.6
Personal property	93.7	83.1	81.3	62.5	61.1

* Assuming a constant total property tax revenue of $68,830,000.

MILL LEVIES

The average mill levy on agricultural real estate in Salt Lake County was 83.6 mills in 1967 (table 5). It was 80.1 mills on utilities, mines, gas and oil property, 92.0 mills on improved real estate, 93.2 mills on unimproved real estate, and 93.7 mills on personal property. The average mill levy on each class of property varies depending on the location of the property and the various taxing districts. The average mill levy charged on agricultural land is a little lower than most other classes of property because much of it lies outside of the incorporated limits of towns and cities and is consequently not taxed by them.

If the assessed value of all taxable property in Salt Lake County were raised to at least 20 percent of market value, the average mill levy could be dropped 12.4 mills, providing total property tax revenues were maintained at their 1967 level. To raise the same revenue the average mill levy would have to be 1.7 mills higher if differential assessment were allowed and "qualifying" agricultural property were assessed at 20 percent of agricultural value rather than market value. With assessed values equalized at 30 percent of value, the average mill levy on each class of property would have to be 1.4 mills higher than would otherwise be necessary to raise the same revenue if "qualifying" agricultural land were assessed in relation to agricultural value rather than market value.

SOURCE OF DATA

These estimates are based on a recent study of a sample of 168 parcels of land classified as "agricultural" in the county assessor's office in 1967. For each parcel, information on present and previous use was obtained from the owner, 1967 assessed values, and mill levies. Acres and location were obtained from the Assessor's Office, and agricultural and market values were obtained from current appraisals made by the State Tax Commission. Agricultural values were based on a schedule of values including $500 per acre for Class I irrigable land, $400 for Class II, $300 for Class III, and $200 for Class IV; $60 for dryland Class III and $30 for Class IV; $15 for grazing land Class II and $10 for Class III. Market values were based on sales values of comparable parcels of land.

Total assessed values of different classes of property in the county in 1967 were obtained from the State Tax Commission. In adjusting these to what they would be if all property were assessed at at least 20 percent and at 30 percent of value, it was assumed that improved real estate was assessed in 1967 at an average of 17.4 percent of market value, unimproved real estate at 13.2 percent, personal property at 26 percent, utilities, mines, gas and oil properties at 28 percent, and agricultural land at 5 percent. All but the latter were based on State Tax Commission estimates which were derived from studies of assessed values and sales prices of parcels of land bought and sold in the county in recent years.

(*continued on page* 83)

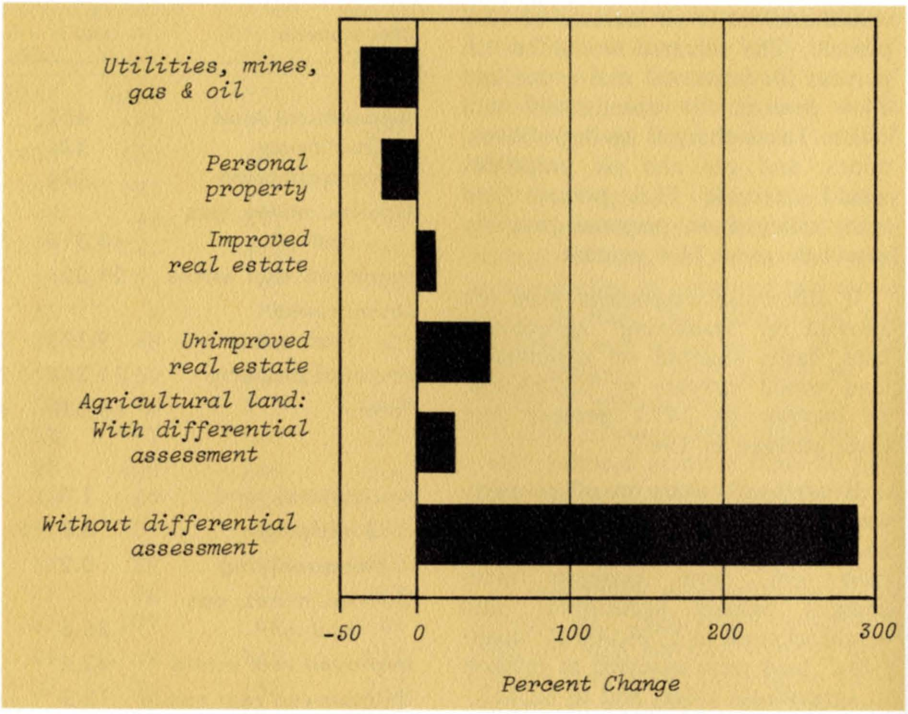

Figure 1. Changes in assessed values from 1967 to estimated levels if all taxable property were assessed at 30 percent of value, by class of property, Salt Lake County.

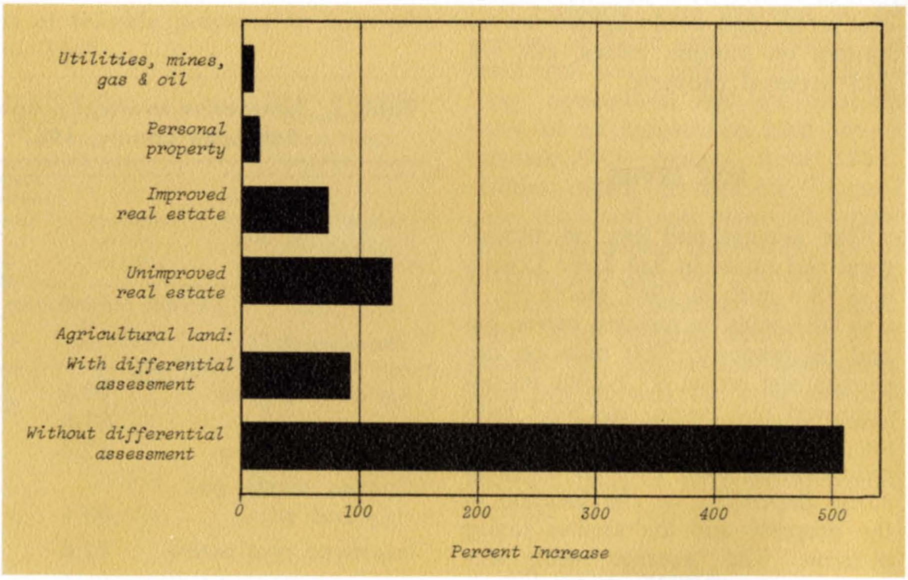

Figure 2. Changes in property taxes from 1967 to estimated levels if all taxable property were assessed at 30 percent of value and total property taxes charged were held constant, by class of property, Salt Lake County.

BIOCLIMATOLOGY A PRACTICAL SCIENCE...

NEW RULES FOR AN OLD GAME

Illustrated by
BERNARD THURSTON

LOIS M. COX, GAYLEN L. ASHCROFT and E. ARLO RICHARDSON

The name of the game is "Pursuit of Energy." It began when the world began. It is played by every member of the bioclimatological universe.

Over the centuries, man's evolving intelligence made him the most proficient player. With proficiency came power. And power made us forget what early man knew instinctively — nature's rules can neither be wished nor forced out of existence. We remain subject to the involuntary interdependence that unites all of nature.

Unfortunately, most modern Americans have been taught to be more solicitous of their own comfort and convenience than of nature's energy equilibriums. The idea of working *with* nature to maintain a worldwide balance in the energy budget is alien to our experience. It is easier and more comfortable to turn our backs on the natural world in favor of a self-seeking version.

The product of this shortsightedness has been an egocentric ecosystem that can persist only if artificially nurtured. And even the precocious offspring of our prolific science and technology may not be able to sustain such a costly system indefinitely.

Our increasingly frantic pursuit of energy (whether as food, fuels, water, or air) could be slackened if we'd revise our rule book to give wisdom precedence over expediency. A logical first step in the revision would be the application of bioclimatological principles at individual, local and national levels.

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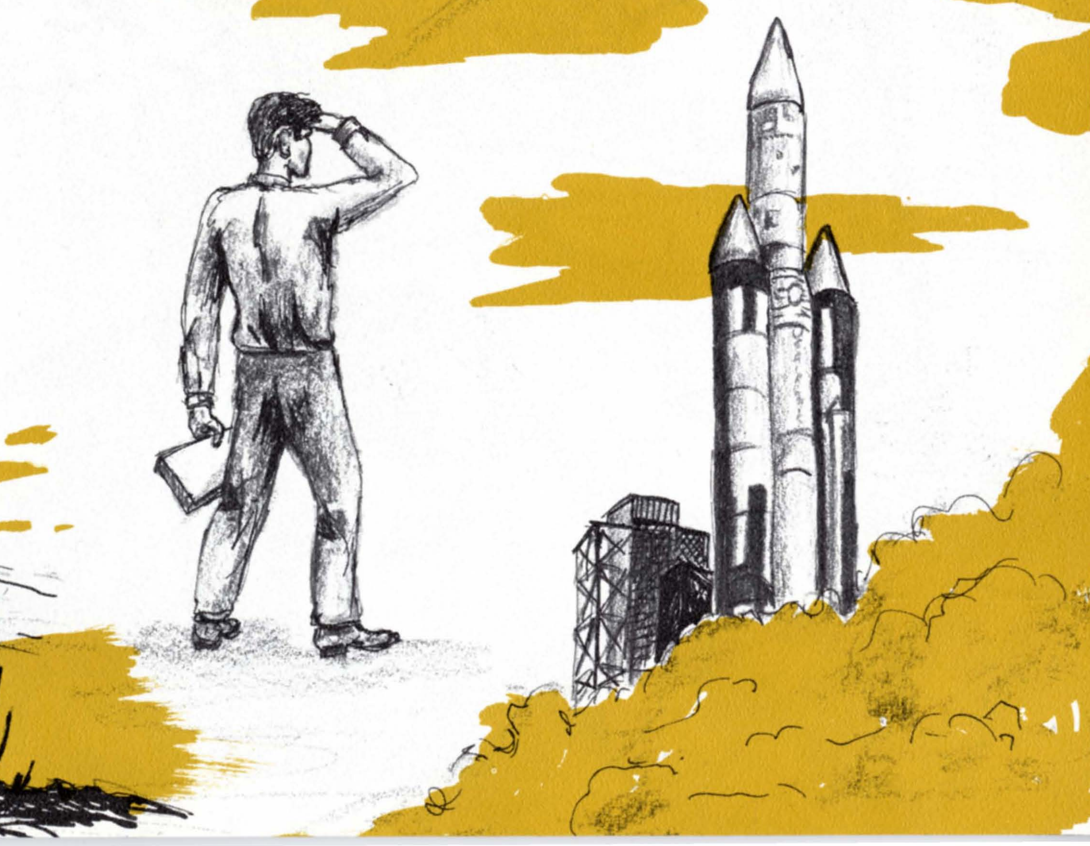


THE SIMPLIFIED GENERAL CYCLE – SANS MAN

Plants utilize the sun's energy directly, by converting it into carbohydrates through photosynthesis. Different plants require different energy environments. Thus, the climate and micro-climates of an area define which plants will be able to thrive there.

The energy stored in plants often becomes the food of herbivorous (plant-eating) animals, with certain animals being particularly efficient users of certain types of vegetation. The vegetation of a region therefore helps determine its animal populations.

Herbivorous animals extract only a portion of the energy in a plant and eliminate the remainder as waste. In turn, the herbivores that are eaten by carnivores (meat-eaters) provide them with energy. Again, however, considerable amounts of what is eaten become waste products. The bear shown in the picture will actually "use" only a small percentage of his just-caught fish.

Wastes eliminated by herbivores and carnivores, dead plant materials, and dead animals are gradually converted by soil organisms into basic elements such as nitrogen, oxygen, and carbon dioxide. When these decomposer organisms die, they release further energy back to the atmosphere.

The result is a dynamic energy balance, which requires that all the populations (plant, animal, soil organisms, insects, etc.) within the ecosystem participate in its mutually dependent fluctuating relationships.

AGRICULTURE

In prehistoric times, man saw himself as part of such a unit. Even the first farmers, making their feeble but deliberate attempts to modify the natural habitat, tried to work *with* nature. But in the seventh century A.D., man's relation to nature as a whole, and the soil in particular, underwent a drastic change.

A new plow, one that required eight oxen to pull it and attacked the earth ruthlessly, spawned a new philosophy. As their mechanical powers flourished, our ancestors saw less and less need to respect nature's integrity. Indifferent exploitation replaced reverent use. And then in the 19th century, the fusion of science and technology gave the process an unprecedented efficiency.

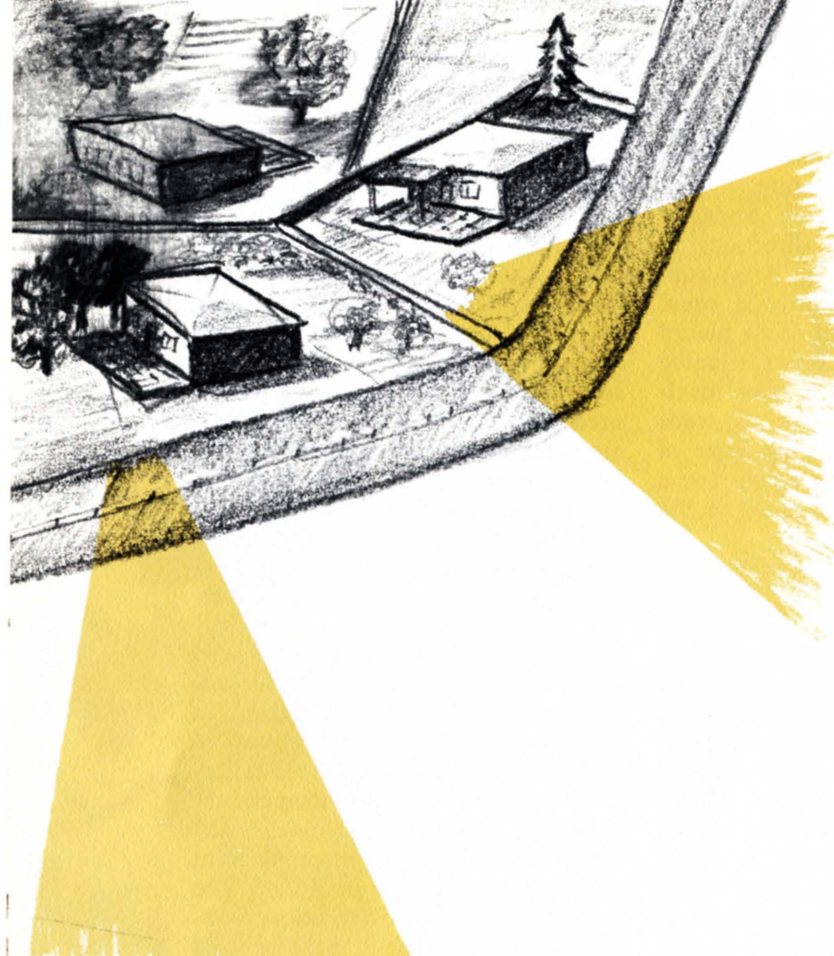
Only recently, catalyzed by existing or predicted problems, have agriculturists begun thinking again in terms of a partnership rather than a master-slave relationship with nature.

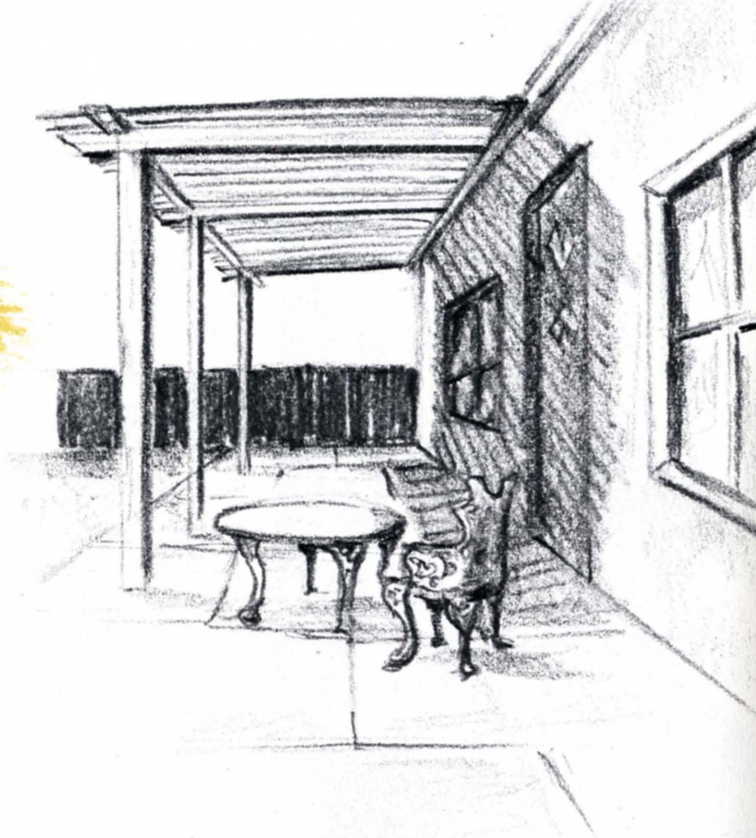
For example, they are orienting furrows with compass directions to promote crop production. Rows running north and south provide equal exposure to the sun for seeds placed anywhere in a row. Rows running east and west, however, give maximum sun exposure only to seeds planted on the south-facing slope of the furrow. The same principle (on a large scale) applies to planting on the sides of a hill.

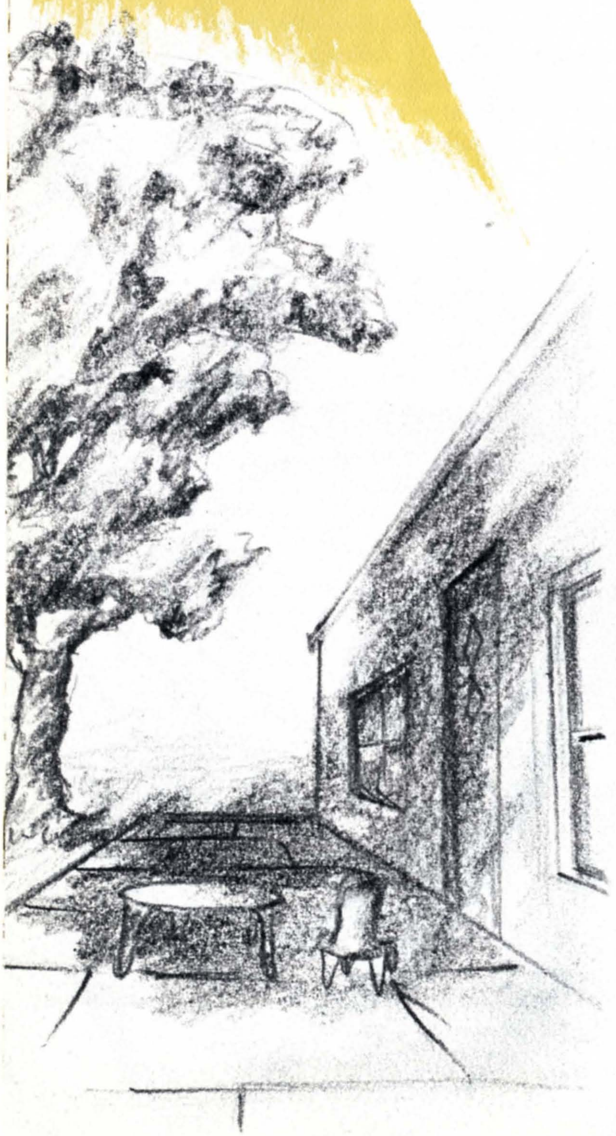
Range and forest managers have decided that a seed's microclimate environment warrants considerable attention in attempts to rehabilitate both rangelands and clean-cut or burnt-over forestlands. Full exposure to the sun can mean a soil temperature that will prohibit seed germination of some range grasses. Windrowed brush can sometimes modify the microclimate enough to allow seedlings to become established. The specific soil temperature requirements of seeds from certain trees largely determine the order in which different species succeed one another. Forest managers can alter this normal succession only if they are able to create the microclimate required by the species they want to encourage.

Recent work at Utah State University has demonstrated an especially significant interaction of animal physiology and environment. Sheep can maintain themselves through Utah's winters if they are watered every day, or if they have access to soft snow. In the heat of summer, however, they want and apparently need considerably more water. If they are grazing over the range during the hot hours of the day, their desire for water is increased even more. Rest in the shade during the peak heat period of each day can be expected to lessen this need for large quantities of water.

The individual farmer can also make bioclimatology work to his advantage when he designs or renovates his farmstead. Preplanting in terms of prevailing and/or seasonal winds, exposure to sun, expected temperature extremes, and microclimates can make his family's life more pleasant and his business more profitable. The principles he uses to minimize problems of drifting snow, heat or cold stress for people and livestock, windborne malodors, flooding, blown-off roofs, and blown-out windows are equally applicable in suburbs or city. Only the specific hazards and benefits vary.







AT HOME

A homeowner who understands bioclimatological principles has considerable flexibility in his home-based energy game. If he is in the pre-blueprint stage he can decide early what sort of things are most important to him and his family in the context of the area's general climate. Do they want to live on a hill or in a valley? Will beautiful landscaping be a "must"? (Such items as wind direction and velocity, growing season potentials, and vegetative water needs are determined by the over-all site choice.) Do they want to bring the out-doors indoors by means of large windows? (In most of Utah, large expanses of glass are impractical for many months of the year.) Is minimum upkeep on house and grounds a consideration?

When buying a ready-made home, the bioclimatology buff will check things the more casual buyer would probably not see. He'll want to know: Are trees or overhangs arranged to provide maximum protection from summer sun while promoting warmth in the winter? Will the roof color reflect the summer sun, or absorb it? Are the windows located so as to minimize wind and storm effects but provide good light and views? Is the garage, or are closets, placed to buffer the house against summer heat and winter cold? Will existing trees or walls create microclimates detrimental to plants that he wants to raise? Is the overall location (on a bench, in the valley, or on a steep hillside) favorable to his microclimate requirements? (The growing season averages 30 to 60 days longer on the benchlands than in the valley along the Wasatch front.)

No two people will evaluate the answers to such questions in the same way. But the shape of the individual's decision is secondary to his having been able to consciously consider the alternatives; a capacity that equates with an awareness of what bioclimatology and nature's energy game really mean.

IN THE CITY

City life tends to deaden such awareness. The hearts of most big cities have been completely divorced from nature. They throb to the rhythm of expendables—the "throw-away" philosophy dominates the modern city.

But even though a city requires its energy in far different forms than does a forest, a prairie, or a lake, it is not immune to nature's inexorable laws. Wind, temperature, radiation, precipitation, these and other climatic factors are still relevant.

As on a farm, odors and air borne pollutants can be controlled by making certain that the sources are downwind from residential areas. Streets placed at right angles to the prevailing wind flow, however, effectively trap the city's polluted air. On the other hand, streets that parallel the prevailing winds can magnify them to hurricane velocities. The ferocious "breezes" that prowl the asphalt canyons of Chicago are a prime example.

In addition to their potentials as wind tunnels, the masses of concrete and asphalt in large cities tend to become "heat islands." Average temperatures in a city such as New York often are 6 to 8 degrees above those in the surrounding areas. The higher temperatures, combined with the city's air pollutants, promote increased shower and thunderstorm activity over the city proper during the summer months. This, in turn, frequently over-taxes drains and storm sewers.

New cities, or cities that are just beginning to grow rapidly, can design their streets and structures to take advantage of the area's climate. Phoenix, Arizona has been blessed with such foresighted planning. That city is busily annexing much of the surrounding land in order to plan intelligently for future expansion.

But what of cities with inflexible boundaries? Must they (and their inhabitants) resign themselves to a declining bioclimatic health? No, not unless they are so irrevocably wedded to past patterns that they reject other possibilities.

By razing several blocks of slum dwellings simultaneously, a city gives itself the ability to put bioclimatology to work. By deliberately interspersing park and recreation areas with dwelling units, the city improves the psychological and physiological health of its residents. These open spaces, with their minimal amounts of concrete help reduce the heat island effect. They also absorb considerable moisture from storms. But, perhaps, most important, such green "oases" have been proved to be exceptionally "good medicine" for modern man.

Even the dingiest, most depressing city can become a pleasant place if rejuvenation projects are designed to produce a people-oriented blend of natural and man-made resources.

AMALGAMATING NATURE AND TECHNOLOGY

Whether farmer, suburbanite, or city dweller, the individual remains part of the bioclimatological world and subject to its energy concepts. Sometimes involuntarily — as when a dreary day makes him edgy or depressed, or when a severe storm coincides with a locally upped birthrate. Sometimes more deliberately — as when he plants a garden, pulls a fish from a stream, or helps launch a space probe.

Over time, our participation in the energy game has become more sophisticated. Atomic is replacing electric energy, scientific expertise substitutes for individual "horse sense," and we seed clouds instead of praying for rain. As a result, the score now must be reckoned in terms such as oil reserves, desalinization plants, extinct species, burned-out neighborhoods, air pollution indices, automobiles per capita, production per acre, and sewage disposal plants. And all of these items seem far beyond the influence of any one person.

More and more, it seems that the individual has only two alternatives. He can either work to slow the depletion of his rapidly dwindling natural heritage, or he can hail the world built by science and technology. But these needn't be mutually exclusive possibilities. We don't have to reject the one to enjoy the other.

We can learn to "use" natural phenomena to achieve what we want (deciduous trees to provide summer shade and winter sun; boundary walls to create microclimates favorable to plants we like; orientation of our homes to reap summer breezes but turn back winter storms; cities deliberately designed to produce pleasant meso-climates; etc.), without abandoning modern conveniences.

The energy concepts of bioclimatology provide an effective bridge between our natural and man-made worlds. The dichotomy that we've created between these worlds can be diminished, if not erased. But only as more and more of us try to recognize and respect the interrelationships that are basic to both.

GROWTH RATES FOR DAIRY HERD REPLACEMENTS

ROBERT C. LAMB and LAMON L. PERKES

A relatively new and rapidly growing trend in the dairy industry is the development of heifer raising enterprises. In some cases the heifers are purchased at an age ranging from newborn to yearlings and grown out to springing 2-year-olds when they are resold to the original owner or on the open market. Another plan is to raise heifers for some specified period between birth and first freshening on contract with dairymen.

RAISING HEIFERS

Since newborn calves cannot stand the stresses from shipping long distances, calf raising operations should be located within 100 miles of where the calves are born. The main feed for the first 2 or 3 weeks is milk or milk replacer, so calves of this age must be kept close to where they are born. Heifer raising is often divided into two phases. The calf raising specialist, either the dairyman or someone in the same general locality, raises the calves for the first 2 to 6 months. The next 18 to 24 months are taken over by a heifer-raising specialist. There are some distinct advantages for this type of specialization. It frees the dairyman to utilize his labor, capital, and management with his milking herd which allow increased herd size and production level. If the dairy farm is located in or near a heavily populated area, it is possible that a heifer raising specialist located where land and feed are less expensive can raise the heifers cheaper than the dairyman can. This makes it profitable for both.

Raising heifers provides a good market for feed, labor, buildings, and management for former dairymen who no longer milk cows. It also is a possibility on many farms which are located some distance from the market place. It is cheaper to truck the heifers to the feed than to ship the feed to the heifers. This program also helps alleviate the problem of manure disposal in the heavier populated area, and at the same time keeps some of the fertilizer on the farm producing the feed.

Some possible disadvantages to specialization also should be recognized. Calf raising is much more difficult with large numbers of calves, primarily because of disease. However, strict sanitation and careful management can overcome this problem as evidenced by some operations successfully raising as many as 1,200 calves per year. Another problem is continuity of a breeding program, which is impossible unless female calves are permanently identified before leaving the farm where they are born and this identification maintained throughout the growing period. If a breeding program is being followed, the original owner must make provisions to get his own heifers back at freshening and perhaps even to specify the breeding program for the heifers. Under loosely managed conditions there is also the possibility of introducing diseases into a herd if

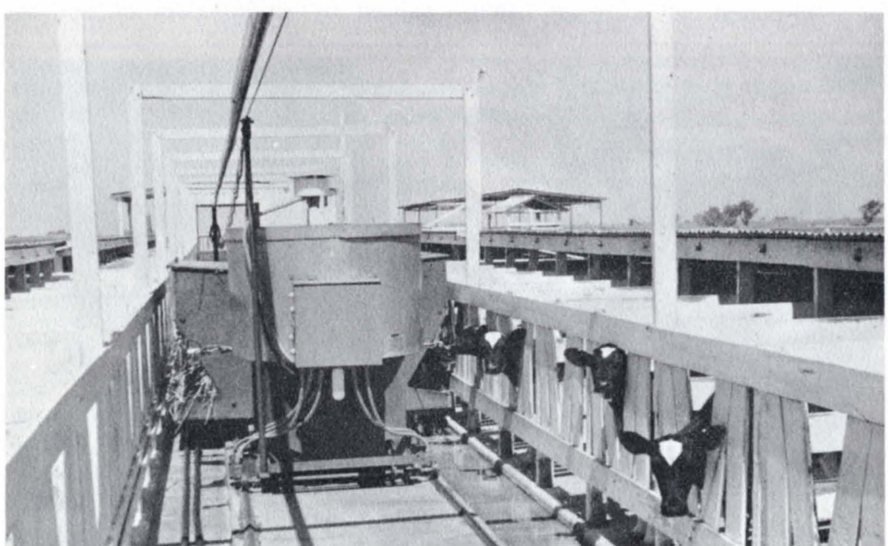


Figure 1. Large calf raising operations use mechanization for feeding calves in individual pens. This automatic feeder passes each pen once every six hours and allows each calf one minute to drink reconstituted milk replacer, one minute to eat grain and two minutes to eat hay each feeding.

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sound herd health practices are not followed by those raising heifers.

INFORMATION REQUESTS

Recently many requests have been received for information regarding this type of venture. Dairymen want to know what to expect if others raise their heifers. If they are currently raising their own replacements they are looking for a guide or measuring stick to judge their operations. They may be wondering if specialists do better or do as well at cheaper prices?

Potential heifer raising specialists want to know how fast heifers should gain, how large should they be by freshening age, what size or age should they be bred, and how much and what type of feed is required. The purpose of this article and one to follow is to try to answer some of these questions.

Records of birth weights of newborn calves at the Utah State University experimental farm show that the average birth weight of 506 Holstein heifer calves born alive during the last 7 years was 90 pounds. The average for 62 Jersey calves during the same period was 53 pounds. Table 1 shows the number of months required for a 90-pound calf to reach 1,000, 1,200, or 1,400 pounds or a 50-pound calf to reach 800 pounds at different rates of daily gain ranging from 1.0 to 2.0 pounds per day. If one of the three variables in the table is known then the other two can be obtained from the table. For example, if it is desired to have heifers calve at 24 months of age then the table shows that Jerseys would take an average daily gain of 1.0 pound per day to reach 800 pounds. Holsteins would take a gain of 1.25 pounds per day to reach 1,000 pounds, 1.5 pounds per day to reach 1,200 pounds, or 1.8 pounds per day to reach 1,400 pounds by this age.

If two of the factors are known then the third one can be pinpointed more specifically. For example, the table shows that with a gain rate of 1.4 pounds per day and a goal of 1,200 pounds it would take heifers 26 months to reach the desired weight.

GROWTH AND FRESHENING

All heifers will not grow at the same rate even if kept under the same management. Part of this difference is caused by breed differences and part by inherited differences within breeds. Some differences may be caused by environment outside the control of management. For example, a calf born on an extremely cold or stormy night might be more susceptible to early calfhood diseases and thus get a poorer start than another calf born under more favorable conditions.

It is recommended that Holsteins freshen at approximately 24 months of age and weigh approximately 1,200 to 1,300 pounds. Guernseys should freshen at the same age but weigh about 950 pounds. Jerseys should freshen at 22 to 24 months and weigh about 850 pounds. Using this as a general guide and allowing for some differences in growth and varying preferences of dairymen, the blocked-in portion of table 1 contains the most desirable data to work with from the standpoint of both the dairyman and the heifer raising specialist.

Owners of Holstein and Brown Swiss cattle should use the two right-hand columns of table 1. The lighter breeds of dairy cattle — Guernseys, Ayrshires, and Jerseys — have lower rates of gain and lighter weights at freshening. The column for 1,000 pounds will serve as a rough guide for Guernseys and Ayrshires. Jersey owners should use the column for 800 pounds.

There are several reasons for expecting that the intermediate growth rates in the blocked area of table 1 are the most desirable. First, it is fundamentally important to get calves off to a sound start and sustain a good growth rate. This enables each heifer to express her real genetic ability to produce. If growing heifers get too fat at any stage in the growing period, however, it can be detrimental because fatty tissue tends to deposit in the developing udder in place of secreting tissue. On the other hand, slow rates of gain are much too costly for the raiser since it takes a much higher proportion of the feed for body maintenance at slower rates of gain. For example, 2 pounds gain per day does not require twice as much feed as 1 pound per day and it only takes half as long to reach the required weight.

How realistic is it to expect to achieve the average daily gains shown

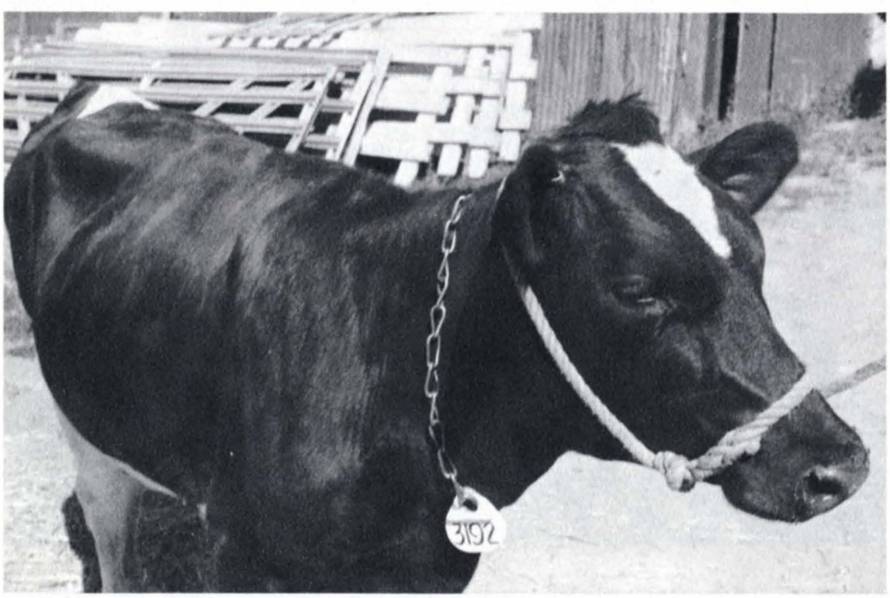

Figure 2. Identification is essential for selecting the best heifers genetically. A metal ear tag as shown in the right ear provides permanent identification while the neck tag gives a temporary but easier means of identification.

in the colored portion of table 1? Table 2 shows the results of two growth studies of Holstein heifers. The first study was made of the U. S. Department of Agriculture herd at Beltsville, Maryland. It was published as United States Department of Agriculture Technical Bulletin 1099. The other study was made from data collected at the USU Dairy Experimental farm over the past 7 years. During this time the heifer raising program has been rather typical for the intermountain area and should represent what can be achieved on most farms in this area with good average management. Estimated heart girth measurements for the various weights were taken from Research Bulletin 194 (1960) published by the Nebraska Agricultural Experiment Station.

PATTERN OF GROWTH

The overall average rate of growth for the first 20 months was very similar for the two studies — 1.45 pounds per day at Logan and 1.46 pounds per day at Beltsville. The average daily gain for 24 months in the USU study was 1.48 pounds. However, the rate of gain was not the same for all periods throughout the study. This indicates some differences in management practices at the two localities. It should also be pointed out that the average birth weight was 96 pounds at Beltsville compared to 90 pounds at Logan, accounting for part of the difference in weights at the end of each 2-week period.

The most important conclusion to be drawn from table 2 is that the rate of growth is not constant from birth to first freshening. Growth is slowest early in life, being less than 1 pound per day for the first few weeks. The rate of growth increases rapidly, however, reaching its highest rate of over 2 pounds per day at about 4 months. This high rate of gain continues for the next 2 months and then starts to decrease. Nutrition is probably the biggest factor in this change. Generally calves are taken off calf starter and start a simpler and less expensive grain mix at about 6 months of age.

A very marked drop in growth rate occurred in the Utah data at 10 months of age. Again nutrition seems responsible as grain feeding was stopped at this time. A similar though not as drastic drop occurred with the Maryland heifers between 10 and 14 months of age. Although limited grain feeding (3 pounds per heifer per day) was continued throughout the growing period at Beltsville, other management changes were made at this age. Heifers either went onto pasture or had corn silage added to their ration at this time and they also were put in larger groups.

This means a greater range in ages and sizes of heifers, which puts the younger and smaller heifers at a disadvantage in competition for feed. Some or all of the above changes are normally made in raising heifers under commercial conditions.

Because the Beltsville heifers received grain longer, they maintained a faster rate of growth during the 10 to 14-month period. This indicates that heifers at this age may not be developed enough to handle a strictly forage ration and maintain desirable rates of gain. If a higher rate of gain than the 1.5 pounds per day shown in these studies is desired, it possibly can be best achieved by continuing the grain feeding for a few additional months past 10 months of age or by

Table 1. Time required to reach various body weights at different rates of average daily gains

Rate of gain	Months required to reach 800 lbs	1000 lbs	1200 lbs	1400 lbs
2.0	12.3	14.9	18.2	21.5
1.9	13.0	15.7	19.1	22.6
1.8	13.7	16.6	20.2	23.9
1.7	14.5	17.5	21.4	25.3
1.6	15.4	18.7	22.8	26.9
1.5	16.4	19.9	24.3	28.6
1.4	17.6	21.3	26.0	30.7
1.3	19.0	23.0	28.0	33.0
1.2	20.6	24.9	30.0	35.8
1.1	22.4	27.1	33.1	39.0
1.0	24.7	29.8	36.4	43.0

Table 2. Average rate of gain, body weight and heart girth measurement by 2-month intervals from birth to 24 months

	USU, Logan, Utah			USDA, Beltsville, Maryland		
		Ending			Ending	
Age (months)	Rate of gain (pounds/day)	Weight (pounds)	Heart girth (inches)	Rate of gain (pounds/day)	Weight (pounds)	Heart girth (inches)
B-2	1.02	152	35½	1.12	161	36¼
2-4	1.81	263	43½	1.84	272	44
4-6	2.08	388	49¾	2.04	396	50
6-8	1.73	494	54¾	1.93	508	55¼
8-10	1.74	599	58¾	1.64	609	59
10-12	1.10	666	61	1.41	714	64¼
12-14	1.26	743	63¼	1.18	774	64¼
14-16	1.17	813	65½	1.09	841	66
16-18	1.25	889	67½	1.12	912	68
18-20	1.33	970	69½	1.23	985	70
20-22	1.57	1066	72	—	—	—
22-24	1.70	1170	74½	—	—	—

feeding higher quality forage during this period.

At about 18 to 20 months of age the growth rate of heifers starts to increase again, continuing up to 24 months. Part of the accelerated growth rate during the last few months of this period can be attributed to increased weight from pregnancy. Also, as heifers grow and mature they may be more able to convert forages into growth than they were at the yearling stage.

Although only growth rates for Holsteins are shown in table 2, a similar study has been made of Jerseys. This was reported in USDA Technical Bulletin 1098. Essentially the Jerseys have the same pattern of growth as Holsteins, except at lower rates. The average rate of gain for the first 20 months for Jerseys was 1.1 pounds per day. Although comparable data are not available for Guernseys, it is expected that they should gain approximately 1.25 pounds per day, following the same general pattern of Holsteins.

MEASURING BODY WEIGHT

The body weights shown in table 2 for 2 month intervals can be used as a guide to determine if heifers are growing normally. In doing so it should be remembered that the weights shown are average. Individual animals may weigh so much as ± 35 pounds from the listed weight at 2 months, increasing each month to ± 120 pounds at 12 months or ± 175 pounds at 24 months and still be normal. However, if heifers are thin, too fat, or outside of this range of weights for their age then they probably have not been receiving proper feeding and management.

Since most farms do not have a set of animal scales, it is often difficult to weigh growing animals. However, it is not difficult to take a tape and measure the heart girth (the distance around the animal just back of the front legs). Either a steel or cloth tape may be used. The distance around the heart girth in inches can be converted to pounds by using the information in table 2.

With normal rates of growth shown in this report, heifers will be large enough and mature enough to freshen for the first time at 24 months. This means breeding at 15 months of age. In bovines, size appears to be as important as age in reaching puberty and size of animal at calving is important for ease of calving. Therefore, some authorities recommend breeding dairy heifers at a specific weight rather than age. The recommended weights are 750-800 pounds for Holsteins, 600-650 pounds for Guernseys, and 550-600 pounds for Jerseys. With normal growth these weights will be reached on the average by 15 months of age.

By way of summary, contract raising of dairy herd replacements is a

Figure 3. After 10 months of age heifers can be raised economically on pasture in the summer or hay and corn silage in the winter.

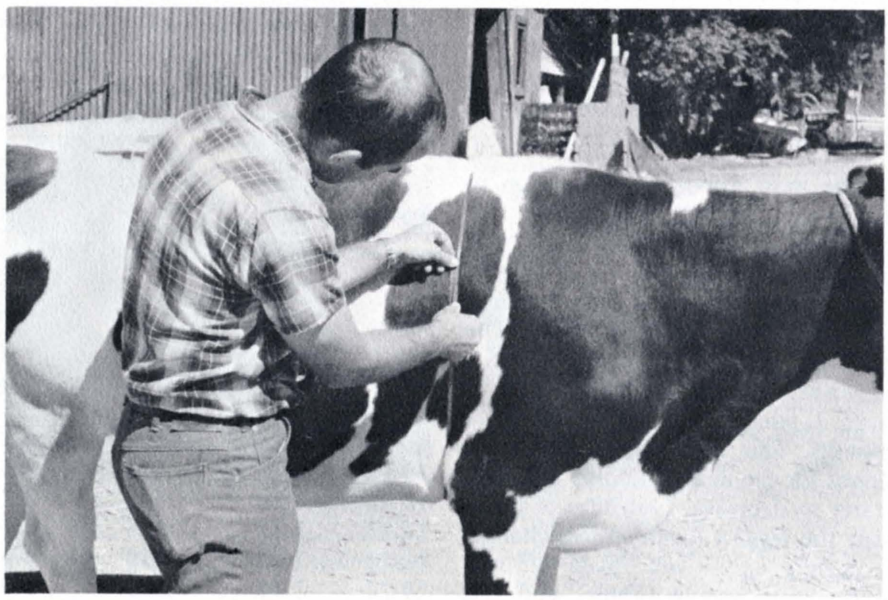

Figure 4. Utah State University herdsman Miles Geddes shows the proper method for measuring the heart girth of an animal to estimate body weight.

growing trend. In studies made in Maryland and Utah, the rate of growth for Holsteins, while not constant throughout the growing period, averaged about 1.5 pounds gain per day from birth to 24 months of age. At this rate Holstein heifers weigh about 1,200 pounds at 24 months which is the recommended age and weight for freshening. Jerseys should average about 1.1 pounds gain per day and weigh 850 pounds at 24 months. Guernseys should gain an average of 1.25 pounds per day to weigh 950 pounds at 24 months.

A second article will deal with the kinds, amounts and costs of feeds required to achieve these growth rates.

FOOD RETAIL PRICE DIFFERENCES

(*continued from page* 63)

into six categories: meat, dairy, produce, canned, frozen, and staple. National brand items were analyzed separately from store brands and regular and special prices were isolated for comparability. Only major stores in each of the markets were audited.

PRICES COMPARED

Food prices were significantly lower in Logan, Utah than in Laramie, Wyoming. On average for all items the difference was just under 4 percent. Prices of all food categories were lower in Logan except dairy products of both national and store brands and store brands of frozen foods.

The greatest price difference between the two cities was in produce — about 12 percent. The smallest difference, less than 2 percent, was found in staples. All other categories were lower in Logan by 4 to 6 percent except for the dairy products which were higher in Logan by about 4 percent. That retail prices for dairy products should be higher in Logan, a surplus producing area for dairy products, is interesting and could be related to the Great Basin Milk Marketing Order in operation in Utah.

Of the four stores audited in Laramie, the one with the lowest food prices had the same chain affiliation as the store with the highest prices in the Logan market. Prices in the two stores of this chain in the two cities were almost identical, however. This indicates that stores of the same affiliation offer a different image to shoppers depending on the competitive conditions in the particular market.

FOOD PRICES AMONG STORES

For national brand food items, two of the six food stores audited in Logan had significantly higher prices than the others. One store had significantly lower prices than the others. One store had significantly lower prices than the other five for both national and store brands. Prices of all items in three of six stores in Logan were not significantly different from each other. Using the three stores with similar prices as a base, two stores had prices averaging about 2 percent higher and one store had prices about 4 percent lower for a spread of 6 percent. The average situation doesn't tell the whole story, however. Except for one store, all had highest prices in at least one of the six categories. Likewise all of the

(*continued on page* 92)

NEW PUBLICATIONS

Bulletin 471 — Techniques of Research in Range Livestock Nutrition by L. E. Harris, G. P. Lofgreen, C. J. Kercher, R. J. Raleigh and V. R. Bohman.

Bulletin 472 — Nutritive Value of Seasonal Ranges by C. Wayne Cook and Lorin E. Harris.

Bulletin 473 — An Analysis of Protein Accounting and Pricing for Milk and its Products by Allen LeBaron and Roy Brog with the assistance of Robert Lamb.

Bulletin 474 — Tourist Vacations — Planning and Patterns by John D. Hunt.

Bingham Soil Series — Utah Benchmark Soils by John L. Swenson, Jr.

The Truth About Agriculture (special informational brochure).

URS 39 — Chemical and Physical Properties of Soils in the Carbon-Emery Area, Utah by J. P. Thorne, LeMoyne Wilson, T. B. Hutchings, and John Swenson.

URS 40 — Pricing Practices and Marketing Margins in Utah's Egg Industry by Roice H. Anderson and Wilbur N. Sherman.

URS 41 — The Growth of Farmer Cooperatives in Utah by Rondo A. Christensen.

URS 42 — Arable Land Resources of Utah by LeMoyne Wilson, T. B. Hutchings, and Paul Shafer.

URS 43 — Estimating Profits from Sales of Pinion-Juniper Products by Allen LeBaron.

URS 44 — Chemical and Physical Properties of the Soils of the Wasatch Front Counties — Weber, Davis, Salt Lake and Utah by James P. Thorne, LeMoyne Wilson, T. B. Hutchings, and Austin Erickson.

Mimeograph Series 500 — Probability of Selected Precipitation Amounts by R. O. Gifford, G. L. Ashcroft, and M. D. Magnuson.

Mimeograph Series 504 — Chemical Analyses for Nutritional Elements and Toxic Oxalate Compounds of Sedges, Rushes, and Certain Broadleafed Plants Typifying Inter-mountain Meadowland Forage by Raga H. Abaza, J. T. Blake, and E. J. Fisher.

RESEARCH - THE SOLID BASE OF AGRICULTURE AND INDUSTRY

K. W. HILL, DIRECTOR

UTAH AGRICUTURAL EXPERIMENT STATION

In his widely read book, "The Affluent Society," Kenneth Galbraith states that there are certain ideas which are esteemed for their acceptability at any one time in history and these he calls "the conventional wisdom." It is his contention that events and circumstances, rather than ideas, precipitate change in established patterns of living. From this it follows that we can inch our way into the future only in relation to developing events. Those in positions of leadership therefore, whether in agriculture, industry or government must keep informed on broad intellectual fronts — the broader the better, for all developing frontiers are interrelated and all impinge on the welfare of mankind, the ultimate goal.

These thoughts have a special significance as related to research. Research is the primary source of all new knowledge. Public supported research is a process in which a national citizenry agree to pool their resources and put some of their number, especially prepared, to work for them. Thus research becomes closely allied with education.

Agriculture and industry are interdependent as are research and education. Shou-Nung, a Chinese emperor who lived 2,000 years before Christ, put it very well when he said, "The well-being of a people is like a tree. Agriculture is its root. Manufacturing and commerce are its branches and leaves. If the root is injured, the leaves fall, the branches break away and the tree dies."

In the "conventional wisdom" of today research holds a high place. Many people seem to think that science and technology, through research, will solve all the problems of the world.

I will not argue that research will solve *all* our current problems. I will contend, however, that *much* of what we enjoy today as compared to a generation ago is directly attributable to new knowledge resulting from research and its application in agriculture and industry. I shall not differentiate much between science and technology but shall maintain that the progress of both depends upon successful research.

Perhaps the greatest overall contribution to research (or science or technology) is that modern man, in the Western world at least, has been freed from a daily struggle with the elements to feed himself and keep his family comfortable. An American farmer now produces enough food and fiber for himself and 39 others; in 1930 he was providing only for himself and 9 others. An industrial worker, with almost unlimited power and electronic gadgetry at his finger tips, now turns out single handedly what it formerly took an army of bare hands to produce.

A LOOK AT THE PRESENT

The last 30 or 40 years have been an interesting time to live and observe. Unbelievable progress has been made. Things have been moving so rapidly that we scarcely knew how far we had come in agricultural research and so a couple of years ago we took an inventory and made a projection. This was published under the title, "A National Program for Research in Agriculture." This document has been widely quoted and highly praised as a realistic appraisal of where we are now and also what we must do in the next few years. The report showed that there are about 6,000 research scientists working in the 53 State Experiment Stations and 4,000 working in the laboratories of U. S. Department of Agriculture, a total of 10,000. There are approximately as many serving in agriculturally oriented industries. Their work is equally significant although it is usually slanted toward products, processes, and profits.

INFORMATION STORAGE AND RETRIEVAL

Some very exciting things are going on. It is a Herculean task just to keep track of all the information and avoid duplication of effort. This task is being met by a Current Research Information System — a computerized card index system.

This is how it works. A brief summary of the objectives and procedures of each of our 200 research projects at the Utah Agricultural Experiment Station has been supplied to a central office of USDA. These, together with similar summaries from 10,000 additional projects in other State Experiment Stations and USDA, are coded onto cards with special key words and cross reference. Information on any topic can be obtained in a matter of minutes. This system will be expanded to include research work in industry and ultimately that done in other countries. Scientists are now talking about a World Science Information Centre with mechanical readers, mechanical translators, and a service by which a scientist could introduce his proposed new project to the Centre via a console in his laboratory and receive back an almost instantaneous reply as to whether or not the proposed work was original or whether it had already been tried or accomplished.

ACCOMPLISHMENTS OF RESEARCH

Ten or twenty thousand agricultural scientists working on food, fiber and welfare problems for 200 million people — one scientist for every 100,000 citizens — may sound like pretty good coverage. Some may wonder about the high cost. However, it is easily shown that it has been and continues to be a wise investment. The increased production of hybrid corn has already paid for all the agricultural research which has been done in the United States. A new variety of wheat, called Gaines, was introduced about 5 years ago in the northwest. This variety consistently yields over 100 bushels per acre and yields of 200 bushels per acre have been recorded. It has been calculated that the value of the increased production of this variety in its first 5 years has paid for all the wheat research work we have ever done. Similarly, the gains from artificial insemination would pay for all the research in animal reproduction. Such examples can be multiplied almost ad infinitum.

Some recounting of accomplishments of the last year or two may be enlightening. Here are a few selected more or less at random from a recent report of USDA and State Experiment Stations:

1. A substance has been found that prevents insects from developing into adults. Future studies will determine whether the substance, called *juvabione,* can be synthesized inexpensively for large scale insect control. It is possible that insect control could be accomplished with as little as 1 gram of material per acre.

2. A tasteless, colorless fat from cottonseed oil may change the packaging of nuts, meats, and other foods. The fat is sprayed on the product in a very thin film that locks out oxygen and retards rancidity for long periods. The process is now being used on nutmeats.

3. Scientists investigating the possibility of using flour to give desired qualities to paper reported that chemically modifying flour to give it a positive charge appears to be a promising technique. The positively charged flour adheres well to negatively charged wood pulp fibers from which paper is made and adds strength to the paper.

4. In marketing research it was found that sound waves can be used to measure firmness and indicate quality in fruits and vegetables.

5. Controlled atmospheres have nearly doubled the normal storage life of fresh peaches and nectarines. After 9 weeks in storage atmospheres of 1 percent oxygen and 5 percent carbon dioxide, peaches and nectarines were juicy and had excellent flesh color and flavor. The Utah Station has had a part in this work.

In a state where most of the land resources and sources of water are in public ownership, government policy can have a profound effect on the state's economy. Our Experimental Station has made important contributions on problems and policies of public resource management.

A LOOK AT THE FUTURE

People my age, looking backward 20 or 30 years, will likely agree that much progress has been made. Most would agree that now is our best time. Will such progress continue till 2000 A.D. or will somber predictions of the "doom-prophets" be realized? What does the "conventional wisdom" of today indicate that we must do to provide adequate and enjoyable food and fiber, unpolluted air and water — not to mention space.

Our study, "A National Program for Research in Agriculture," indicates that the domestic demand for farm products will increase by one-third in the next 15 years. Population will increase by one-fourth and incomes will be higher and the wants of people more demanding. We will be eating more meat and less grain and potatoes. At present productivity levels all the available arable land in the United States would not produce our domestic needs — to say nothing of food exports. The productivity of American farms is currently increasing at a rate of a little less than 2 percent per year but even this rate of increase will not keep our food in balance with our population. The rate of increase must be stepped up and *only research can show the way to the improved technology required.*

Current "conventional wisdom" points out certain directions which research scientists can take to further increase agricultural productivity. These include new combinations of genes, improved managements, and use of hormones and chemicals with both plants and animals.

YIELD POTENTIALS OF CROPS

Corn, with an annual production of 4.7 billion bushels, is the most important single crop in America. The average annual yield during the last few years is about 72 bushels per acre but record yields of 300 bushels have been obtained. Can we narrow this discrepancy? Water, plant nutrients, perhaps even carbon dioxide can be added in optimum amounts. There is plenty of energy available from the sun but to get maximum yields *all* the leaves of a plant must have the benefit of direct solar energy. To accomplish this is going to require some drastic changes in the geometry of crop plants. The upper leaves of the present corn plant tend to shade the lower leaves. The ideal plant should be shaped like a Christmas tree with its upper leaves oriented vertically, and the lower leaves horizontal. Such challenges do not frighten today's plant breeder, and it is confidently expected that the average yield of corn will be tripled by 2000 A.D. as occurred from 1930 to 1965.

Wheat is the most important food crop in the world, rice is second. Current average yields for both crops are about 25 bushels per acre; record yields exceed 200. Outstanding recent work by plant breeders has produced new varieties of both crops that yield over 100 bushels per acre the biological limits seem to be considerably higher.

IMPROVEMENT OF MANAGEMENT PRACTICES

When adequate amounts of nutrients, water, and other environmental factors are provided, the production of plant material is then limited only by the ability of the green plant to convert the energy from the sun into carbohydrates. In this respect corn is the most efficient of the common crops and is almost twice as efficient as wheat, rice and other cereal grains. Vegetable crops such as tomatoes, cucumbers, and lettuce and also fruit trees are even less efficient and produce only about one-third the amount of carbohydrate materials as does the same leaf area of a corn plant. This indicates the direction in which we might have to shift if food becomes genuinely critical.

Higher plant populations, improved crop geometry, adequate fertilizer throughout the growing season, irrigation, sprays to increase soil temperature and prevent evaporation and weed emergence, careful use of pesticides; all these can add greatly to the productivity of crops. The efficacy of even more sophisticated procedures has already been demonstrated and unquestionably will be utilized more in the future. The discovery and exploitation of plant hormones and growth regulators has been a major breakthrough in science.

Authorities are agreed that the current average yields of practically all the common food crops can be doubled or tripled and in some cases quadrupled within the next few decades. Biologically this is quite possible. The future will have to judge the economic feasibility.

POTENTIAL PRODUCTION OF MEAT AND LIVESTOCK PRODUCTS

Long range projections indicate that meat products will be the food commodity in shortest supply in the United States. By the year 2000 there will be a national demand for about 75 percent more meat and under present production practices, there is neither the land nor the feed to produce this additional amount. Clearly, new information and new technology must be developed by research.

Beef is the most widely favored meat in America today. It is also the most expensive to produce because of low reproductive rates and low feed conversion efficiencies. Beef cattle now gain 2 to 3 pounds per day in feed lots and require about 10 pounds of feed for 1 pound of gain. Many think the feed conversion rate can be lowered to 7 to 1. Another research possibility is to feed cattle directly on synthetic nitrogen products such as urea. Research indicates that calf crops can be increased from the present 80 percent up to 90 percent. In short, scientists agree that the efficiency of beef production can be doubled by 2000 A.D.

Milk production per dairy cow has risen at the rate of 3 to 4 percent per year for the last several years and shows no sign of leveling off. This rate is expected to continue for the next two or three decades. Thus our dairy product needs seem assured.

Sheep and wool production can also be improved. One real possibility on which our animal physiologists are hard at work is two lamb crops per year from the same herd.

Poultry production has made phenomenal and dramatic improvements during recent years. Today, a 3-pound chicken broiler can be produced in 53 days using 2.2 pounds of feed per pound of meat. It is projected that 3-pound broilers will be raised in the future in 45 days using 1.7 pounds of feed for each pound of meat. Turkeys are also very efficient converters of feed to meat. Presently, a 25-pound turkey can be produced in 25 weeks using about 3.5 pounds of feed to each pound of meat. It is within the biological possibility to produce 30-pound toms in 20 weeks on 60 pounds of feed, ultimately 100-pound toms will be produced.

Average annual egg production per hen has about doubled within the past 40 years. Our current knowledge sets an egg-a-day per hen as the biological limit. Maybe we shouldn't expect the hen of the future to provide the eggs in "membrane envelopes" suitable for packaging. This would save 80 percent of the time of egg production and 50 percent of the energy which the hen now expends. To develop chickens that lay soft shelled eggs consistently will require some very sophisticated animal breeding and physiological manipulation but today's scientists do not think it impossible.

The tone of this article has been deliberately optimistic. I think that the projected production increases are attainable. To do so will require our best efforts and will also require greatly increased financial support. The long range plan to which I have referred envisions a 75 percent increased in manpower and funds by 1977. At the Utah Agricultural Experiment Station this would mean an additional 50 scientists and an increase of about $2 million in the current annual budget. This would presumably provide the research to produce the necessary new information. It would likely cost an equal amount of time and money to get this information to the primary producers and initiate the action programs. I think the great society of America will demand that this be done and will be prepared to foot the bill.

UTAH'S BASIC PROBLEMS OF LAND AND WATER

We have some basic problems to solve in Utah. Their solutions seem to be somewhat beyond the current "conventional wisdom" of the general population. These problems have to do with the resources of land and water. First the land problem — our irrigated farms are too small and too much divided. Many operators of reasonably sized farming enterprises have their farm lands dispersed in four directions from their residence in town! This does not make for efficiency. There is a trend for successful farmers to buy out their neighbors as they retire or choose other occupations. Thus we are progressing toward economically-sized family farms. This trend should be encouraged but it does not appear that it will solve the problem in any reasonable time period.

Modern mechanical production of most crops demands large acreages in large units to justify the machinery and overhead costs. A mechanical tomato harvester costing $25,000 works best in a field of at least 100 acres. A sugar beet farmer should have at least a 50 to 100 acre contract to justify his machinery needs, furthermore this acreage cannot be efficiently handled in a dispersed series of 5 or 10 acre fields. A way must be found to bring about a coalescence of many of our small fields and farms — at least for operating purposes. A good number of present owners of contiguous small farms, many of them only part-time farmers, would undoubtedly find it more profitable to rent their land, on a long term basis, to a large scale operator. The renter would have to have sufficient tenure and authority to remove fences and ditches, level fields and establish productive rotations. Alternatively, owners of small farms might accomplish the same end by forming a corporation and hiring full time managers. Hopefully, under such an arrangement the boundaries of existing farms would ultimately disappear. Surely stock owned in a profitable corporate farm would provide as much security as ownership of an uneconomic small farm. Economic research must show the way.

The land problem in Utah is matched in magnitude by the water distribution problem. The irrigation distributive system which was the wonder and envy of the world in the first half of the 19th century simply does not fulfill our needs in the last half of the 20th. With about 1 million acres of irrigated land we have over 1,000 irrigation companies which own water rights and distribute water. Such divisiveness and duplication of effort in this modern age of specialization, make it impossible for Utah's irrigation farmers to compete. To modernize the land and water tenure systems of Utah is a task greater than that which characterized our progenitors. We will not solve the land and water problems of the state and if we do not, commercial agriculture will retrogress and with it will go at least 40 percent of our industry.

In my judgment there is currently no problem in the state of Utah which is more deserving of the attention of agriculturists, industrialists, legislators, indeed — all citizens. To paraphrase Shou-Nung — if agriculture, the root of the tree, is sick, manufacturing and commerce, which are the leaves, will fall.

Can research help to untie this Gordian knot? We are convinced that it can. It will require the best efforts of our natural scientists and our social scientists. Not only must the physical and economic unknowns of the equation be solved but the minds of men must be persuaded to follow the better way.

In summary, I have argued that research can chart the course whereby agriculture and industry can feed the nation and maintain a suitable environment. I should like to add my belief that a way will be found to feed the whole world.

Finally, I assure you of the resolution of Utah State University and its Experiment Station to conduct such research as will assist in the solution of the problems of our land and water, and other natural resources, and our people problems, to the end that our state may maintain a prosperous agriculture and a buoyant industry and thus play our full role in contributing to the welfare of the people of the state, the nation and the world.

GREENBELT AMENDMENT

(*continued from page* 68)

The assessed percent of market value in this study was based on the appraised market values and assessed values of the sample parcels. This figure was considerably less than the 12.4 percent estimate of the State Tax Commission based on studies of assessed values and sales prices. Research is needed to determine why the two figures differ. If 12.4 percent had been used instead of 5 percent, projected increases in assessed values of agricultural land would have been only 40 percent as large without differential assessment. There would have been no change on "qualified" land under differential assessment.

The sample parcels were divided into "qualifying" and "nonqualifying" parcels according to whether they were presently being used in 1967 for producing crops and/or livestock, and had been for the 3 preceding years. The total assessed value of agricultural land in the county was divided between "qualifying" and "nonqualifying" in the same ratio as the sample.

HUNGRY?
JUST PLUG IT IN!

There seems to be no end to innovation in "convenience food" concepts. Now an inventor comes up with a food package that plugs into an ordinary wall socket . . . heats up the meal. Alco has given its student packaging design award to Pratt Institute student for the idea. Silly? Maybe not. A pre-cooked meat entree could be featured for snack or supper . . . no fuss over pots and pans. Epoxy-coated aluminum foil lining of cardboard container has a printed heating element in it . . . carries current from throw-away plug to inner package. It's all disposable. Our grandchildren may find the method preferable to today's. In fact, our wife might!

ECOLOGY IN ACTION...

The art and science of relocating birds

WAYNE H. BOHL and LOIS M. COX

Throughout America, many native game birds are being totally dispossessed or, at best, are having their natural habitats drastically changed by man. A few species manage to adapt to the changes brought about by such things as overgrazing, new farming methods, drainage practices, urbanization and scientific forestry. Far more, however, simply dwindle in numbers. Declining populations, coupled with intensified hunting pressures, have produced difficult problems for many state Fish and Game Divisions.

In an effort to help solve certain of those problems for at least some areas, a Federal-State cooperative program was started 20 years ago. By learning from their own and others' mistakes, the scientists responsible for the Foreign Game Investigation Program (FGIP) have been able to gradually improve operations both overseas and in the United States. As measured in today's hurry-up world, the FGIP requires uncommon patience from all concerned, especially would-be hunters. But, given sufficient time, the program can eventually provide substantial benefits not only to hunters, but also to ecologists and nature lovers in general.

The FGIP was also established to discourage hit-and-miss introductions of foreign game species by making up-to-date ecological information available to those who want to make such importations. Over the last 20 years, the FGIP biologists have been able to convince a surprising number of interested individuals that their plans for trial introductions should not be activated. In most such cases the introductions were almost certain to fail because they violated certain ecological principles.

Utah State University has been indirectly involved in the Foreign Game Investigation Program since 1962. At that time the program's biologist who has special responsibility for the western states, was headquartered at USU as a Federal Collaborator. USU thus became "home base" for a uniquely conceived and financed exercise in applied ecology.

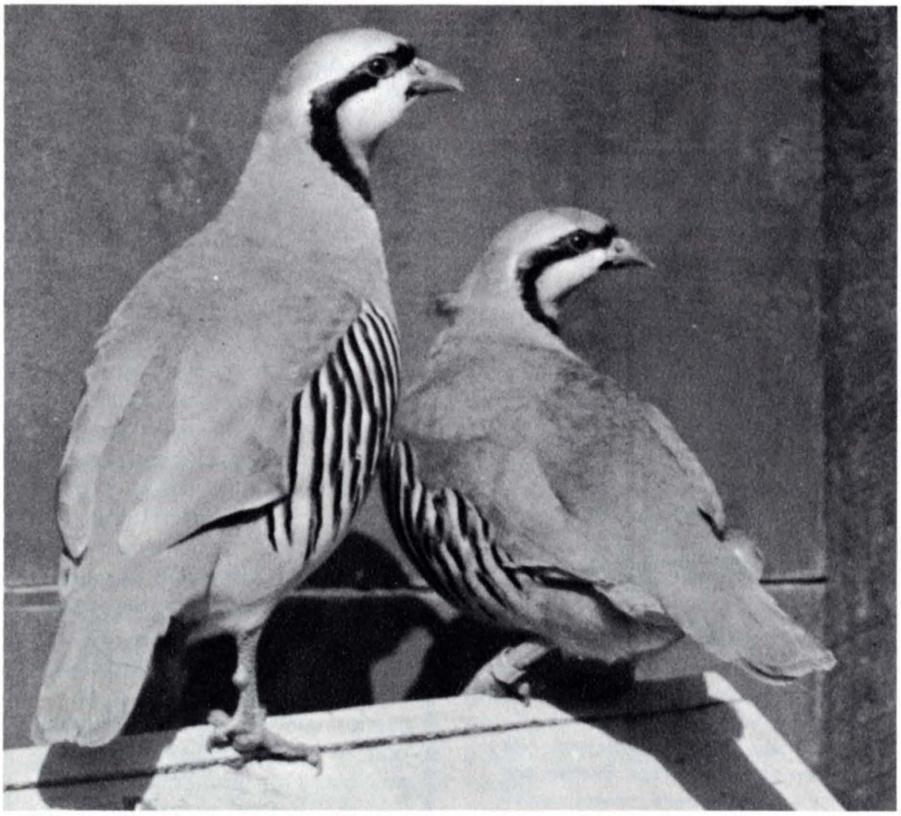

Figure 1. A male (left) and female Turkish chukar partridge on the New Mexico State game farm, Carlsbad. Note the enlarged head depth of the male compared to the female, a secondary sexual characteristic.

SOME HOW'S AND WHY'S

Similar does not necessarily mean equal, especially in the life sciences. A few degrees difference in temperature, or a month's variation in precipitation pattern between two habitats can make one acceptable and the other not, to a particular bird. In ecology, therefore, to hurry is generally to fail, and the FGIP is designed to avoid failures as much as possible.

The purpose of this game bird introduction program has remained the same since it began: to populate habitats never occupied by native species or to repopulate habitats that native

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game bird species have abandoned because of man's modifications. Specific projects are undertaken in answer to requests from individual State Fish and Game Commissions. Each Commission, in turn, bases its requests on ecological appraisals of the state's game-deficient habitat.

Using the individual state's ecological data, FGIP biologists preliminarily evaluate species occupying similar habitats and climates in foreign countries. Their selections can be made from 355 species (678 subspecies) of game birds, exclusive of pigeons, doves, waterfowl, and shorebirds. Once likely prospects have been identified, on-the-scene intensive studies of 2 or 3 years are begun. Some factors that have to be defined include: the species' behavioral and physiological characteristics, with special reference to reproductive efficiency and capacity; specific habitat and climate requirements; general resistance to predation and disease; food habits and relationship to agriculture; ability to withstand hunting pressure; and potential for competing with native U. S. species.

If a particular species looks promising for a state, and the state decides to go ahead, trial introductions are begun. Either eggs, hand-reared young, or wild-trapped birds may provide a starting point. If sufficient numbers of birds can be trapped, they are held in quarantine for 60 days in the country of origin by FGIP personnel. During that time they are observed for disease development and are sometimes inoculated against such possible problems as Newcastle disease. They then move by airfreight to one of the U. S. quarantine stations (either Honolulu or Clifton, New Jersey). The birds are held there for 21 days to further eliminate the likelihood of diseases developing.

The next stop is the requesting state's game farm. In Utah the Fish and Game Division has its farm at Price but will be moving the facilities to Springville within a year. Incoming birds are either held at the game farm for propagation purposes or, if there are enough, they may be released into the wild.

At least 200 to 300 wild-trapped birds, or 3 to 4 times that number of game-farm-reared birds, should be liberated in a given area in each of 3 consecutive years to give the species a reasonable chance to establish itself. The numbers of birds required, trapping difficulties, and other considerations are dictating an emphasis on egg collection and game-farm propagation rather than release of wild-trapped birds. Following a 3-year release period as many as 10 to 12 years may elapse before a valid judgment can be made about the species' survival success. Both State and Federal agencies, however, use the first 3 to 5 years after liberation to try to evaluate the birds' potentials for success or failure.

The search for a pheasant strain that could successfully populate the arid lands south of the present chinese ring-neck's range provides an example of how the system sometimes works. The Afghan white-winged pheasant (cover photo) was finally chosen as the most likely candidate.

Some of these pheasants were released on U. S. game farms in 1959-60. The population was large enough to start transferring to wild habitats in 1963. Hunting began in New Mexico in 1964 and in 1966 in Nevada. Both Arizona and Texas are now experimentally liberating the bird in their southern agricultural areas.

Even after 10 years in the United States the white-winged pheasant remains very wild in its pure form, whether on game farms or in the wild. This is a desirable but difficult characteristic to maintain in game farm birds. Generally, a few months on a game farm tend to modify the normal habits of even wild-trapped birds. Many white-winged pheasant flights, after release in the wild as game-farm stock, amount to a quarter of a mile. That is a long flight for any of our pheasant strains, since pheasants are basically a running-type game bird. Evaluation by State and Federal personnel of the Afghan pheasants' success will continue in New Mexico and Nevada for several more years.

WHO PAYS THE BILL?

More than 15 million hunters in the U. S. pay license fees for the privilege of venturing into field and forest, gun in hand. The harvest of foreign game birds in the United

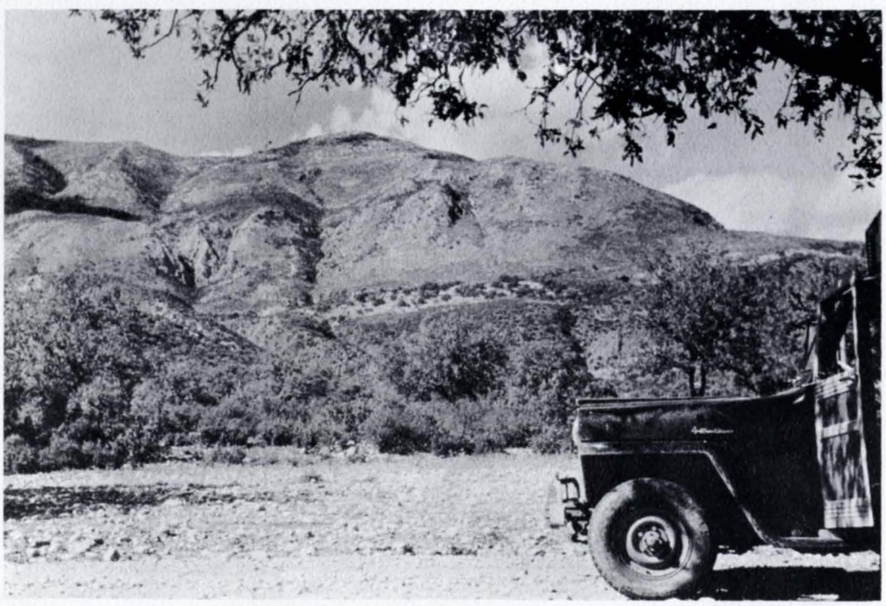

Figure 2. Turkish chukar partridge habitat near Izmir, Turkey. Trial liberation birds from Izmir stock were released in New Mexico, Arizona, Utah and later in California and Hawaii. (Photo by Jim Cox).

States is currently estimated at between 15 and 20 million birds, which includes pheasants, chukars, and Hungarian partridges. But the demand will continue to outpace the bird populations, unless new or complementary species can be found to occupy currently vacant or semi-occupied habitats.

The one scientific program that is working to find the needed species is actually being financed by those who will reap the most benefits, the hunters. Every purchase of arms and ammunition helps pay some of the costs incurred by the two FGIP biologists. These same two men (Gardiner Bump and Wayne Bohl) have been the program's research biologists since 1948 and 1958, respectively.

The Foreign Game Investigation Program's operating expenses within the United States and overseas are, in the main, provided by reverted Pittman-Robertson funds derived from the Federal excise tax of 11 percent on arms and ammunition. Annually, this tax money is apportioned to the State game departments to be utilized for conservation purposes including research and development projects, land acquisition and administration. The actual amount of tax money returned to a given state each year is based on the total land area of the state relative to the number of licensed paying hunters in that state. Birds to be introduced by a State game department can be purchased by them with 25 cents of each dollar coming from State money, and 75 cents from the arms and ammunition excise tax funds.

SOME RESULTS TO DATE

Since 1948 over 23,000 game birds have been shipped to the U. S. from Europe, Asia and South America. These shipments culminated screenings of 110 foreign game birds and more intensive studies of 26.

Utah first participated in the FGIP in the late 1950's. Prior to that time, however, six upland game birds had been introduced into the state. A 1950 Utah Fish and Game publication stated that the ringnecked pheasant, California quail and Hungarian partridge were well established. The bobwhite, Indian chukar and wild turkey were the other three species released. The Indian chukar and wild turkey were reported as not responding well to Utah conditions. By 1967, however, these two species were being hunted, but bobwhite, to date, have not responded well to Utah habitat conditions.

The first FGIP releases in Utah took place over a 4-year period. During those years, 3,000 wild-trapped Turkish chukars were shipped to Utah, Arizona, and New Mexico. The birds apparently disappeared from Arizona. In Utah they seemed to integrate with the previously introduced Indian chukars. The New Mexico birds currently show promise of becoming established as a species in at least a few localities.

In Virginia, Western Iranian-ringnecked pheasant crosses are giving better evidence of success than is the pure Western Iranian stock. A pure Eastern Iranian-ringnecked pheasant cross also seems to be increasing in Virginia. Additionally, the Japanese green pheasant is apparently evolving in its initial Eastern Shore liberation areas.

South Korean ring-necked pheasants are showing promise in Missouri and several other northern states.

White-crested kalij pheasants from the Himalayan Mountains have ex-

Figure 3. Turkish chukars being released in the Guadalupe Mountains of southeastern New Mexico. All birds are leg banded for identification in follow-up studies of survival.

hibited some brood and overwinter survival in mountain woodland areas in Virginia. A second woodland species, the red junglefowl, is doing well in southern warm woodlands of Georgia, Alabama, and Florida.

Black francolin and gray francolin have been hunted recently in the Hawaiian Islands following 1960 introductions. Guam reports that the black francolin has continued to reproduce and is gradually expanding its range. Louisiana has the black francolin well established in the Gum Cove area and two other areas appear promising. These birds are also doing well in portions of Florida. Gray francolin reproduction was reported by California for certain Imperial Valley areas in 1966 and 1967, while Texas has noted indifferent survival for this Indian species.

Bamboo partridges brought from Japan to Hawaii in 1959 are reproducing slowly now on Maui in brushy tree habitats and provide some hunting for persevering sportsmen. Plans for the bamboo partridge in Oregon and Washington call for eventual liberations in the wet brush-grass-tree areas in western portions of each state. Experiments to establish this partridge in the southeastern states have been discontinued because of lack of success anywhere.

Private individuals as well as one or more State Game Departments are continuing small liberation experiments with the bare-throated, Chinese, Sharpe's and Erckel's francolins, Greek chukar, Barbary partridge, French red-legged partridge, and the Himalayan snowcock.

UTAH'S POTENTIAL FOR MORE PARTICIPATION

The next installment of this article will describe some of the difficulties encountered by biologists who study and try to trap birds in foreign lands. Special attention will be given to recent work in South America, which may produce birds of interest to hunters in Utah and neighboring states. The relatively unique problems that Utah has in connection with trying to introduce new game birds will be discussed.

Figure 4. The Himalayan snowcock normally lives in barren mountains between 8,000 and 18,000 feet elevation from Nepal, India, and Afghanistan westward into southeast Russia. Weight is 4- to 6-pounds per bird. Nevada plans to experimentally release sizeable numbers of snowcocks in mountains near Elko, 1968-1969. (Photo by Nevada Fish and Game Commission.)

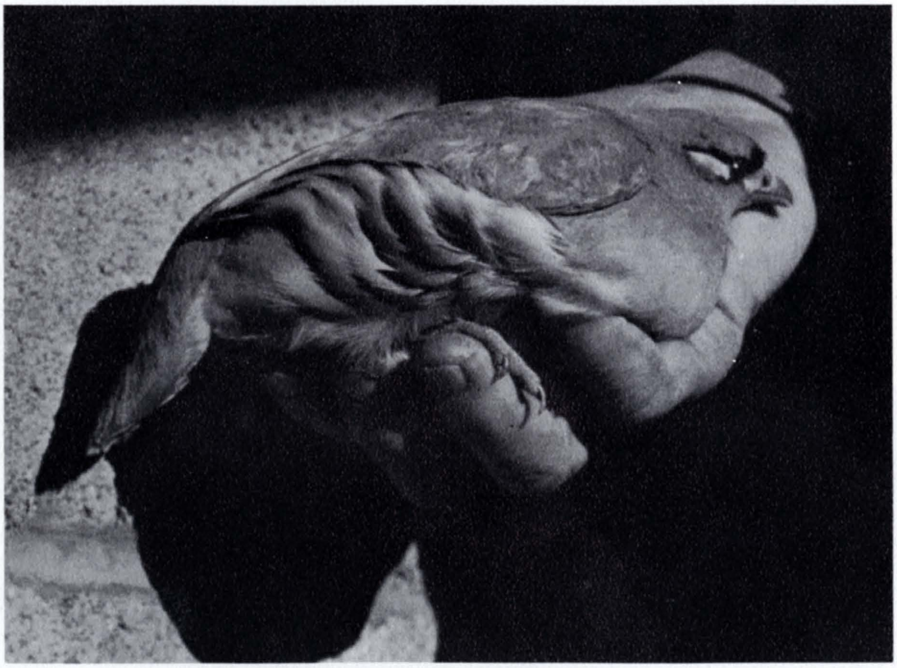

Figure 5. Seesee partridges, 6- to 8-ounce birds resembling the chukar, are scheduled to be released in the rocky, eroded hill areas of the southwest. Utah continues to build its game farm production of these birds towards sizeable wild releases.

MINING WATER IN IRAN

ALLEN LeBARON and MALEK MOHTADI

Everyone knows that provision of water to support agriculture in arid regions is an especially difficult task. Mormon pioneers, for example, early experienced the rigors of this undertaking. But at least most of the heavy labor necessary to divert water supplies for irrigation purposes was performed above ground.

In Southwest Asia and North Africa an important supply of water is obtained by digging underground infiltration tunnels or horizontal wells. The accompanying illustration shows details of the construction and layout of such a tunnel or ghanat. The idea of using ghanats has a Persian origin going back over 2,000 years. Even today thousands and thousands of acres are irrigated, and hundreds of villages receive their sole water supply by this means.

GHANATS AND MOGHANIS

In Iran ghanats exist by the thousands, and certain persons, known as Moghanis, specialize in ghanat digging and maintenance. This business is conducted as a family occupation generation after generation. But it is a hazardous life. Stones may fall down air shafts, or the roof of the tunnel may collapse. The shafts have no ladders, and rope is seldom used; workers brace themselves against opposite walls and inch their way to the surface. Asphyxiation is not unusual, and efforts to clear a stoppage in the tunnel may release a sudden flow that will drown the workers.

Despite these dangers the number of Moghanis is very great because of the number of ghanats still in use. In Iran this has been variously estimated at 20,000 to 40,000, but apparently no one really knows for sure. In any case, the average length is something over 2 miles, and the combined lengths of the tunnels would be great enough to encircle the globe nearly two times. Numerous individual ghanats are 10 to 12 miles long, and some are even known to stretch for a distance of 30 miles underground. The depths of the mother wells also vary within wide ranges. Although the average is about 150 feet, one 500-year-old ghanat in Eastern Iran is purported to be about 1,000 feet deep. In the air or on the ground, travelers are seldom out of sight of ghanat holes.

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No wonder the demand for Moghanis is so great! In South-Central Iran, near Kerman, it is said that one-seventh of the population are ghanat diggers.

GHANATS NECESSARY

Millions of man-days are expended annually on the construction and maintenance of ghanats, for they provide the water from one-third to three-quarters of all irrigation in the country. Life would be virtually impossible without them in many areas, and if a cave-in or some other mishap cannot be repaired owners will be impoverished. The population of one or more villages may be forced to abandon their homes and this means some crop area will revert to desert.

Under such circumstances one can appreciate the tremendous value placed upon a dependable water supply. If a value were put upon the houses, shops, Mosques, and carpet looms of entire villages, it would often be found that the total was as little as one-half the cost of the village ghanat water supply. Sometimes ghanats are village property, but the more usual situation is that they belong only to one or two persons. Ownership of water is the deciding factor in land settlement,

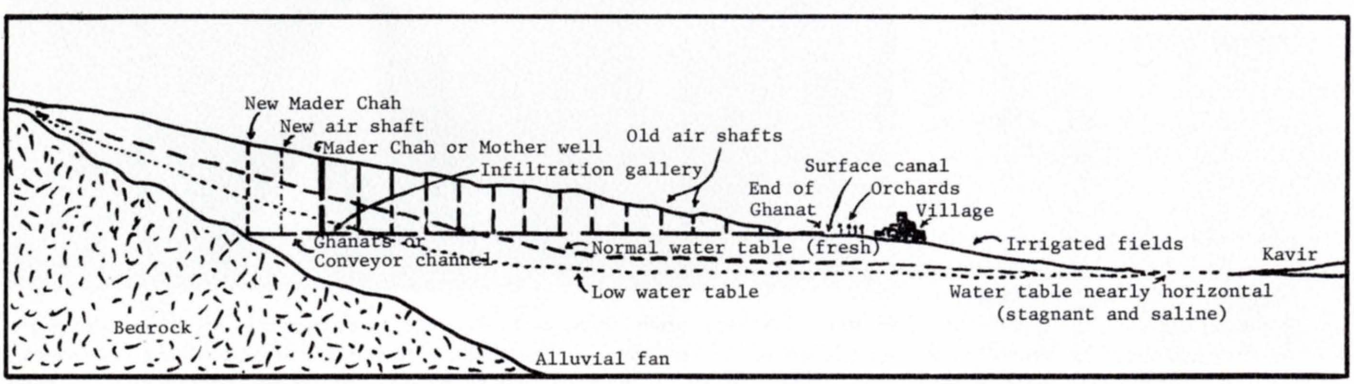

Figure 1. A cross section of a typical Iranian ghanat.

and unused lands may become the property of those who supply water. Prior to land reform, a pattern of sharecropping developed such that the person supplying water would receive at least one-fifth and as much as four-fifths of the crops produced in a given year. Since land reform the water owners have had to continue to provide water to various lands, but at fixed fees. It is said that water owners make certain that their private needs are satisfied before offering any remainder for sale. Thus the water owner continues to have a big effect upon crop production patterns in some areas of Iran.

RE-USING WATER

Unless accumulated clay tends to waterproof ghanat channels, seepage losses may be as high as one-third. Luckily such waste and inefficiency is offset to some degree by various clever methods to satisfy more than one use with the same water or to provide for its successive re-use. For example, seepage from irrigated fields is sometimes recollected and passed into a second or even third ghanat system. Also, where the ground surface is steep enough, the ghanat canal may exit and carry on as an elevated aqueduct. Once it is 10 or 15 feet above ground, it is dropped onto a grain mill which is built half underground. The flow then continues in a new ghanat tunnel and the same process may be repeated. Where a ghanat passes beneath a residential area, aesthetic benefits are derived by placing, at a depth of 20 to 30 feet beneath individual houses, a kind of "family room" situated alongside the flowing stream.

MINING THE WATER

The reason for digging mine-like shafts to obtain water in the deserts of Southwest Asia is easy to understand. In these areas it is difficult to impound and control surface water. Most rain runs quickly off the bedrock of mountain faces and seeps into gravel and sands of bordering alluvial fans within a few miles. Note in figure 1 that the profile of the water table is flatter than the ground surface near the center of the mountain valley but rises near the bedrock of the mountains. A mother well is dug at the margin of the basin to provide a catchment or infiltration area, and the water is then led horizontally from the well base via a gently sloping tunnel that eventually intersects the surface of the ground. From that point the water travels by open canal or ditch to its ultimate destination. The entire underground length of a ghanat is marked by a line of shafts used to lift earth to the surface, to provide air during construction and to facilitate clean-out and maintenance thereafter. A long ghanat system may have several hundred such wells so that the total amount of earth excavated could easily exceed 6,000 cubic yards per mile. Circular rings of piled earth accumulate around the mouth of each shaft and are clearly visible from the air as shown in figure 2. Unstable sections of the horizontal channel are lined

(*continued on page* 92)

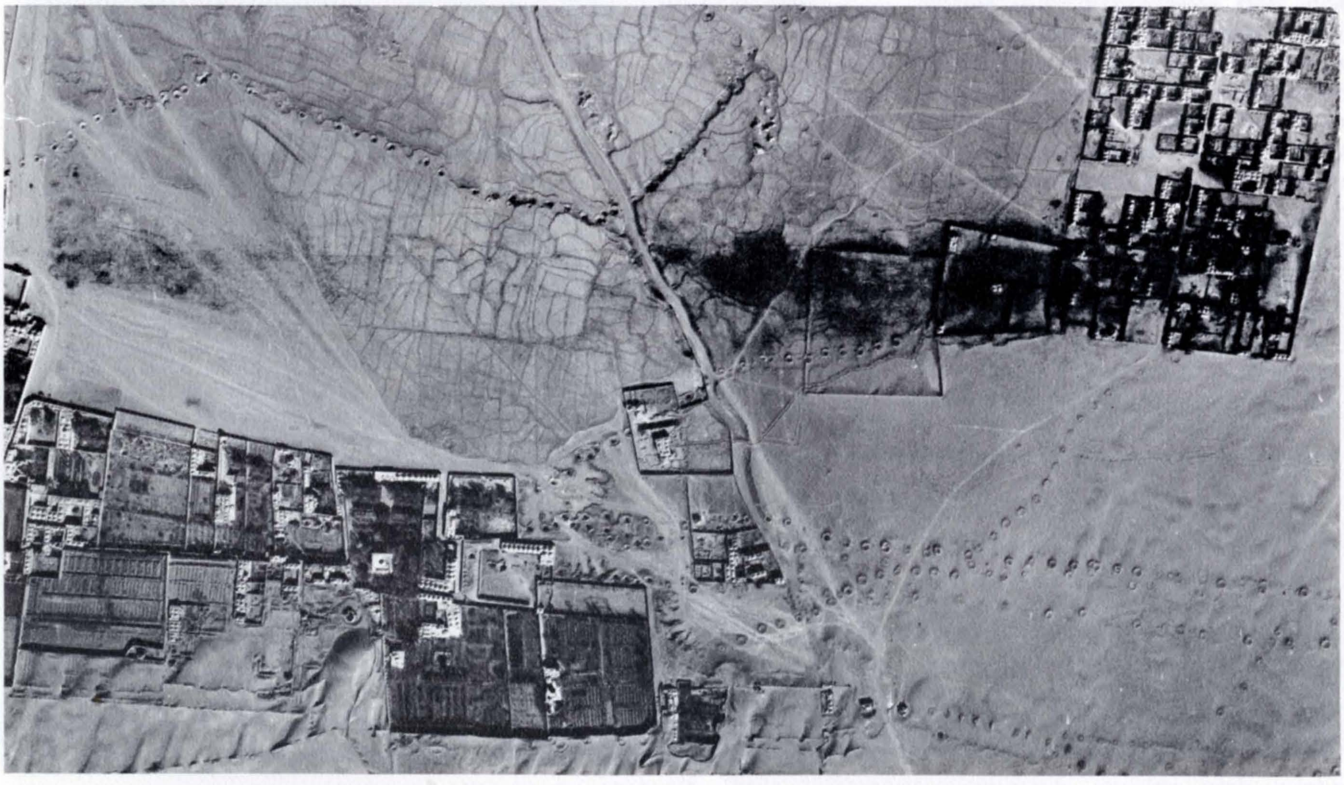

Figure 2. This air view clearly shows the ventilation and repair shafts which are sunk along the line of underground ghanats. As shown, many ghanats run right under the villages.

A NEED FOR RESEARCH...

RANGE RESOURCES AND WATERSHED MANAGEMENT

GERALD F. GIFFORD

An important, often overlooked, function of rangelands is receipt and ultimate disposal of precipitation. The precipitation may fall with low intensity (as with snow or early spring or late fall rains) or in torrents, as typified by summer thunderstorms. Because Utah is abundantly blessed with range resources, the condition and trend of both high-and low-elevation vegetation types (and their respective soils) is of critical importance in determining how such areas respond to rain and snow.

THE PROBLEM

Of prime importance, and requisite to planning by resource managers, is knowledge of precipitation. When does it occur? In what form does it come? How much is received and how fast? How can a given pattern best be described (average, frequency analyses, etc.)? Can certain patterns be modified (as by weather modification) and to what end? For the watershed manager, such information is either absent or available only at scattered locations.

Water, before reaching a defined channel, is generally called overland flow. This flow is somewhat turbulent and, therefore, may carry detached soil particles downslope. The soil particles are originally detached through the beating action of raindrops. Rills or shoestring gullies are formed, and cutting action increases as the rivulets of water increase their load of sediment. How does one stop this phase of land deterioration? What improvement practices and/or protection criteria are needed within various plant-soil complexes? Will spraying, burning, reseeding, pitting, ripping, contour furrowing, plowing, contour trenching, gully plugs, or chaining (figure 1) actually improve the hydrologic performance of an area? To what degree? This, to be sure, is an unexplored field. Finally analyses must define and qualify some degree

Figure 1. How does chaining of pinion-juniper influence watershed values? Is runoff reduced or increased? How much and for how long?

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of increased site productivity or other benefit to mankind through the various manipulative activities. These measured ends must then be remolded into an economical appraisal of derived benefits. Only then can land managers intelligently select from among possible management alternatives with some degree of success.

CAN WE MANAGE WATERSHEDS?

Managing rangeland watersheds to optimize available water and, in most cases, to retain a variety of other uses within the area is feasible and completely warranted. Recognized management procedures include (1) grazing, logging, or construction activities which maintain soil protective cover and minimize surface soil disturbance; (2) cultural activity involving a multitude of range improvement practices; (3) watershed survey and analysis procedures which identify and somewhat quantify potential sources of flood or sediment discharge; and (4) possible remedial measures.

The trained watershed manager is concerned with analysis, protection, repair, utilization, and maintenance of watershed areas for optimum control and conservation of water with due regard to other independent resources. A variety of tools is utilized from many fields of study: geology, geomorphology, geophysics, atmospheric sciences, pedology, vegetative and biotic influences and environmental interrelations, hydrology, sedimentology, watershed technology, economics, and human ecology.

The multiple use concept of rangelands is relatively new, at least from the aspect of congressional recognition. As a result of this concept, watershed management has increased importance in all phases of natural resource management, an importance which demands answers to old, yet unsolved questions.

Rangelands watersheds vary in many respects because of soil differences, elevation, and vegetative characteristics. The environment varies from open park-like sites intermixed with coniferous species and aspen at higher elevations to the desert shrub type at lower elevations. The mountain ranges (figure 2) are the source of streamflows usually with high quality water. The desert and foothill ranges offer minimal water yielding potential except during intense thunderstorms. These downpours cause flash floods of low quality (sediment laden) water.

WHAT IS NORMAL?

The response of vegetation and soils to a particular type of storm is generally unknown for the Intermountain area. Problems associated with various land management alternatives are difficult to solve because, in most instances, normal hydrologic behavior of various plant-soil complexes has not been defined. Some information has been gathered on selected sites, but this information is of limited scope and, therefore, only gross generalities can be derived for situations outside the area studied. Unknowns associated with interception, overland flow and run-off, water use by plants, and sediment production on natural and manipulated landscapes have not been quantified for management sake. The application of present generalizations concerning watershed protection requirements needs to be studied for all range types.

Water used by plants is receiving increased attention. What plants will provide the necessary watershed protection yet transpire a minimum of water? Can trees (pinion-juniper or aspen, for instance) be replaced by grass with resultant increased water yields? At what cost, and for how long will benefits last? By what methods can streambank erosion be minimized? Is it possible to avoid or minimize channel losses, as perhaps by piping water across critical channel sections? Can chemicals which will defoliate or physiologically affect water loss from plants be used successfully? If so, when, where and how much?

THE ANSWERS?

Only through increased research activity can the many unknowns, of which a few have been mentioned, be recognized, defined, and ultimately quantified. Programs involving training of qualified individuals are needed, and support should be given to such endeavors. Study of watershed values associated with rangeland environments has been sadly neglected in research literature to date, and managements suffers because of it. Through research, education, and extension, the phase "art and science of good land management" can be changed to "science of good land management."

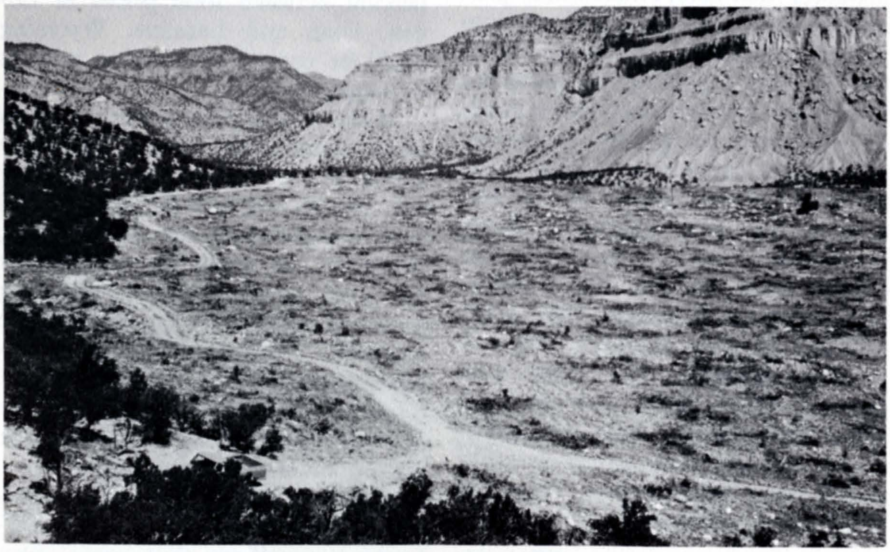

Figure 2. High elevation rangeland watersheds provide high quality water for a multitude of uses.

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FOOD RETAIL PRICE DIFFERENCES

(*continued from page* 79)

stores had lowest prices in at least one of the food categories. Only one store had lowest or equally low prices in each of the six categories.

The magnitude of price difference between the highest and lowest priced store varied by food categories. The greatest difference, about 19 percent, was for produce. Of all the categories, produce was least comparable among stores with respect to quality. Few items of fresh fruits and vegetables were brand labeled. In addition, perishability render these products non-comparable with passage of time and changes in environmental conditions. It seems likely that at least a part of the variations in produce prices among stores could be attributed to quality variations. All other categories varied from lowest to highest prices by 10 percent or less with differences being greatest for frozen foods, meat, and canned foods. Staples with a difference of about 2 percent were least, followed by dairy products with a 3 percent difference. For each food category there were two to four stores whose prices were not significantly different while prices at other stores were either higher, lower or both higher and lower.

In pointing out price difference among stores in the Logan market, it should not be inferred that all other conditions are the same. It is recognized that when shoppers patronize a given store they purchase a whole bundle of services which are inseparable from the products. Some consumers shop almost exclusively on the basis of price, some quite naively assume that prices are identical in all stores, while others deliberately choose their major food store for non-price reasons even though they are aware of price differences.

Food prices are measurably and significantly different between markets and among stores in the same market. The difference of about 4 percent between food prices in Logan, Utah and Laramie, Wyoming could be caused by location relative to supply sources.

While regular food prices in Logan were significantly lower in some stores, the differences were not great nor consistently low or high for all food categories in the same stores. Shoppers can make greatest savings on food purchases by comparing prices of individual items among the available outlets. Shopping newspaper specials of all stores will likely result in greatest savings than by consistently shopping the store where regular prices are lowest.

The fact that food price levels among stores are significantly different is evidence that some store operators use price as a means to attract and hold consumers.

MINING WATER IN IRAN

(*continued from page* 89)

with oval-shaped tiles of baked clay, about 1 yard in height, 18 inches in width, and 6 to 8 inches in length. This shape is essential to lower them individually down the air shafts.

Personnel in the Utah Agricultural Experiment Station are currently assessing the long-term prospects for major Iranian agricultural commodities under a grant from the United States Department of Agriculture. These prospects are intimately linked to existing and planned ground water developments. Although drilled wells, utilizing diesel or gasoline pumping equipment, are no longer uncommon in Iran, ghanats continue to be constructed. Their initial cost is probably higher than a comparable tube well and their flows are unregulated and may vary considerably from season to season. Over the long-run, however, their costs may actually be favorable. Once constructed, maintenance costs are almost certain to be much lower than the operating costs of a tube well. They do not require an attendant, and some have lasted several hundred years. Low wages for rural labor, 50 to 70 cents per day, are the foundation of continued ghanat construction feasibility. Obviously the need for water is great, but wage rates and age-old construction methods indicate the low worth placed upon human effort in situations where there is a near total absence of job alternatives for the "lower" classes.

MORE MEAT

Today, the livestock and meat industry produces 12 billion more pounds of meat than 20 years ago to provide an additional 29 pounds of meat per person to a population that has increased by 53 million people.

. . . And for a smaller proportion of their after-tax income!