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Factors Required to Sustain Pastoral Farming Systems and Forage Supply in Winter Cold Zones in Japan

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일본의 동계한냉지역에 있어서 초지개발과 조사료 공급의 활성화에 필요한 요인

Hidenori Hirota

적 요

동계한냉지역은 연평균기온이 7~12℃인 서늘한 온대지방을 말하며, 일본에서는 東北(Tohoku)지방과 북부 本州(Honshu)지방이 이에 속한다. 이 지역은 광엽낙엽수가 있는 온난지수 65~100 범위에 있는 소기후대와 일치하며, 눈이 덮히는 겨울은 춥고 여름은 상당히 덥다.

이 지역에 있어서 반자연초지의 가축이용은 점차 줄어들고 있으며 북방형 목초로의 개량초지로 바뀌어지고 있다. 또 저지대에서 토지이용 양상은 순수한 수도재배에서부터 사료작물을 비롯한 밭작물 및 원예작물 재배 등으로 변화되고 있다. 일본은 약 200만두의 젖소와 약 280만두의 육우를 가지고 있다.

눈이 오는 겨울은 목초의 생육과 이용기간이 제한되며, 위도에 따라 차이가 있다. 저위도의 밭조건에서 작부체계양상은 지역별로 상당한 융통성을 가지고 있으며, 다년생목초를 이용하거나 또는 1년생 사료작물을 병행하여 이용하고 있다. 그러나 이 지역에서 옥수수-보리의 작부조합은 파종과 수확시 불확실한 날씨 때문에 아직 농가의 선호도가 낮다.

소규모의 영농규모를 가진 농가들은 집단사육으로 생산비를 효율적으로 낮출 수 있으며, 수확과 저장 등 일련의 작업체계 역시 과거 재래적인 기계사용에서 부터 노동생산비를 낮추고 조사료의 품질을 증진시키고자 성능이 우수하면서 다목적인 기계사용으로 빠른 속도로 전환되고 있다.

Ⅰ. INTRODUCTION

Before discussing the given subject, I have to introduce to you some brief information on the drastic changes of statistical data on the animal industry during the past decades in Japan.

Dairy farming is still a dominant part of the animal industry with more than two mil. cows. Cow population has not changed much, but the number of holdings has been decreased continuously from 100,000 in 1982 to 60,000 in 1991. Herd size has increased from 20 to 35. Beef cattle have increased steadily from 2.2 mil. to 2.8 mil. including dairy-beef cattle, while the number of holdings has been decreasing from 350,000 to 240,000 so that the herd size has increased from 7 to 12.

Although these trends look to be preferable as a result of selection to induce more economically efficient full-time households, we still have many latent smallscale holdings, hesitating to close their business in the near future, and many aged farmers suffer from the shortage of workers from the young generation to take over. Young girls do not like to get married to farmers' sons, having a deep prejudice that agricultural work is full of dirtiness, hard work and low income. If you visit our back

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country, you will see many diligent, old bachelors aged over 35, taking care of animals all day long instead of brides.

Ⅱ. CLIMATIC CHARACTERISTICS, VEGETATION AND DEVELOPMENT OF FORAGE AND ANIMAL SYSTEMS

As is well known, Japanese climate is of high precipitation, totalling from 1,100 to 2,400 mm influenced by the monsoon climate, which is too high for grassland farming. Annual precipitation of 800 to 1,200 mm with even seasonal distribution is supposed to be adequate. By the term 'cold region' we define cool, temperate areas, where mean annual temperatures are between 7 and 12℃. We call this district Tohoku District or Northern Honshu. This area coincides with the climatic division of warmth index(WI) with the figures between 65 and 100 as shown in Fig. 1. In this area, winter temperatures range between −3 and +4℃, being similar to those in Korea. But, summer temperature ranges between 20 and 24℃, which is a bit cooler than most districts in the latter as shown in Fig. 2 (Ito, 1985). If we compare the climatic differences between Korea and Northern Honshu, our climate is wetter in winter with much snow and cooler in summer. On the Pacific sides of Northern Honshu, winters are drier with clear days, and on Japan Sea side we have wetter weather and more snow. Snow falls of 4~5 m, with sum of snow amounting to 17 m or more, are not uncommon in public pastures of highlands in Niigata Prefecture. Consequently our annual precipitation often exceeds 2,000 mm.

1. Semi-natural grassland and agroforestry

Most of our vegetation is not the climatic climax, but rather in seral stage, i.e., secondary vegetation (Ito, 1991). Mountains in Northern Honshu are covered by deciduous forest such as

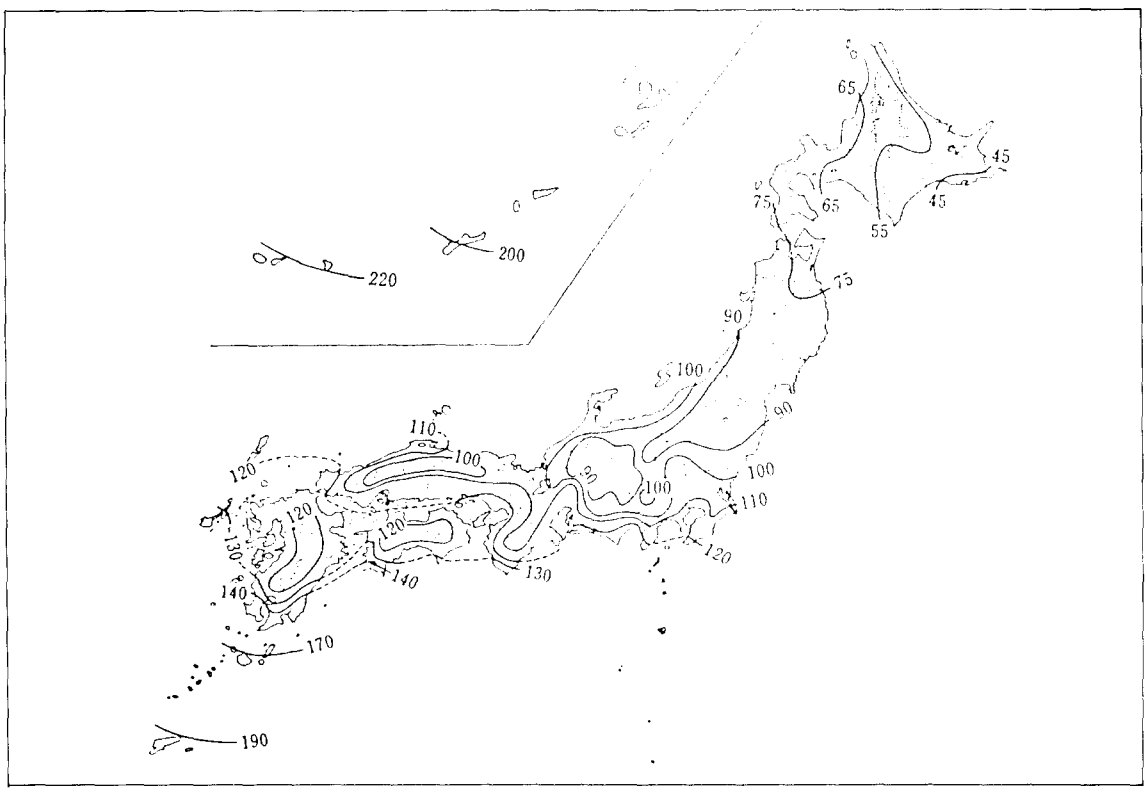

Fig. 1. Isotherm lines by Warmth Index (WI) (Ito, 1991).

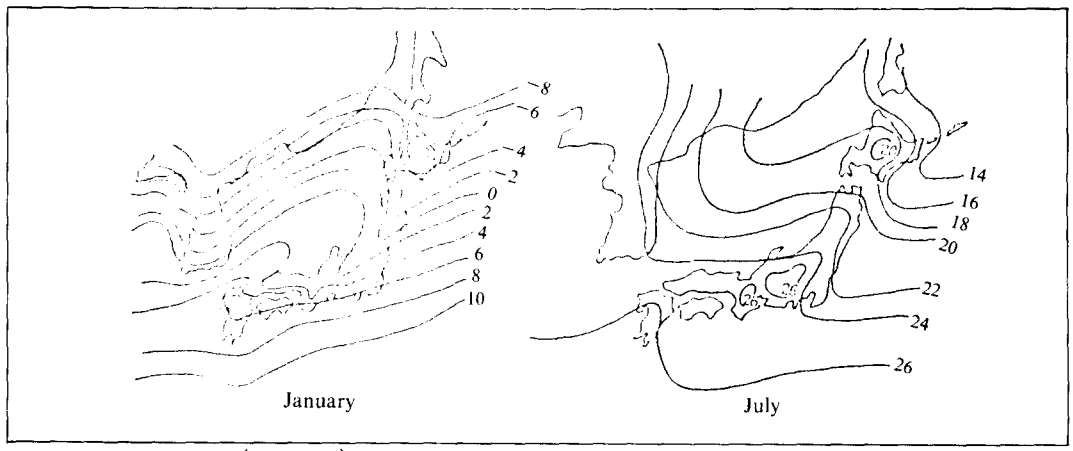

Fig. 2. Isotherm lines (Ito, 1985).

Fagus crenata, Quercus crespula, Acer palmatum, Aesculus turbinata and *Tilia japonica* etc. The understratum vegetation and its succession resulting from human activities, felling, fire, cutting and graz ing, etc. are shown as follows :

Waste stage ---- *Zoysia* stage ---- *Imperata* stage
grazing cutting
cutting ---- *Miscanthus* stage - - - - Forest stage
abandonment

Some reports doubt the presence of *Imperata* stage in Northern Honshu(Yoshida, 1976). In cooler districts, the understratum vegetation moves to *Sasa* type by lenient cutting and to *Zoysia* type by yearly continuous grazing. Both types of the wild grass species have been utilized for hundreds of years mostly with draft animals. Since the 1960's, the role of horses and draft cattle was converted from drafting to meat industry and most animals disappeared from the farmers' barns for slaughter and were replaced by rotary tillers, tractors, transplanters and combines, etc.

With the onset of the industrialization policy, farmers changed their way of living from full-time farming household to part-time farming by working at firms in the town except during the busiest seasons. In this generation the government has promoted the dairy industry by establishing public pastures throughout the country, totalling some 1,160 sites during 20 years to raise the replacements.

There was still a preoccupation that the Japanese Black Cattle are more suited to our indigenous wild grass species rather than the introduced western-type grasses and many newly established public pastures have been grazed by dairy heifers, leaving *Zoysia, Sasa* and *Miscanthus* grasslands for beef cattle.

The carrying capacity of *Zoysia* grassland is estimated to be high at 60~120 CD/ha when well used, but most researchers still recommend feeding supplements to the grazing cattle at 1~2 kg/day. This traditional way of grazing semi-natural grassland with beef cattle is now less popular partly because of our strict registration system of pedigree heifers, and the understocked grasslands are being invaded by thorny bushes and other tree species (Hirota, 1981). Economically it is profitable to graz e pregnant beef cows on such indigenous grasslands, as it is cheaper to maintain the sward. But, unfortunately many farmers' traditional ranching organiz ations are running less actively as they cannot afford to keep this system owing to the sharp decline of the number of animal holdings within the rural community. *Miscanthus*-dominant grasslands have also been used by cutting the grass for hay in addition to restoring material for roof-thatch and other stuff for daily life. To maintain the fodder production, the grasslands were harvested every second year. Since the change-over of animal use,

Miscanthus grasslands are now less utilized except in small-scale beef farmers.

2. Change in land use of cropping fields

Since 1969, the government has had to cope with the overproduction of rice by reducing acreage of paddy field by ca. 30% to 800,000 ha, where barley, soybean, vegetables, fruit trees and forage crops have been planted being subsidized by the reorganization policy on paddy field use. Now the total area used for growing forage crops is 1.1 mil. ha including 400,000 ha of public pastures for raising cattle.

As for public pastures in Tohoku District, 441 pastures on 80,000 ha are being run, keeping 18,000 dairy heifers and 57,000 beef cattle of which 15% were kept throughout the year in 1990.

Hybrid seeds of corn and sorghum species have been imported from the USA to 150,000 ha of our fields. Among annual winter crops, tetraploid Italian ryegrass cultivars are widely grown on drained paddy field except in Hokkaido. Acreage of oats is increasing steadily by introducing extra-early cultivars for whole crop silage to harvest in December mostly in Northern Kanto District and the Pacific side of the Southern Tohoku District where the farmers are favored by fine weather at harvest time. *Brassica* species have been less popular because of the laborious work of thinning after sowing and the difficulty of storage after harvest.

3. Altitude and grassland production

Duration of snow cover restricts the period of growth and utilization of pasture grasses, which is affected by the altitude of pastures that exist. Fig. 3 shows that in early winter snow falls come down quickly within three weeks from the highlands down to the lowland fields, and in the next spring snow melts rather slowly from the latter to the former taking eight weeks. Snow mold damage often occurs under this slowly melting snow(Sakai, 1984). It is known that the snow mold damage occurs when the duration of snow cover is longer than eighty days. The fungi concerned are *Typhla incarnata, T. ishikariensis, Sclerotinia borealis, Fusarium nivale* and *Pythium* spp., etc., of which the first fungus is quite common. Mixing rye with ryegrasses in fields at lower altitudes reduces the damage(Hirota et al., 1975). In general, *Festuca arundinacea, Dactylis glomerata* and *Phalaris arundinacea* are planted in these environments.

At the time of snow melting in highlands, air-temperature goes up to 12~15℃ and the grasses have grown in flush already, which leads the ranchers to poorer pasture utilization from the start.

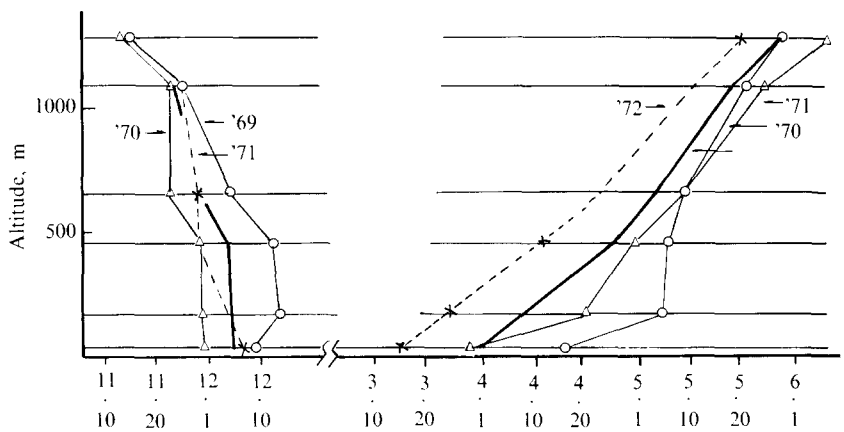

Fig. 3. Duration of snow cover according to altitude.
Date of 1st snow for continuous cover. Date of final snow melt in spring (Sakai, 1975).

Frost heaving injury often occurs in newly-sown grasslands when the seeds were sown in late autumn, particularly in the highlands of the Northern Pacific side, and it is not possible to use rollers on hilly grasslands in order to consolidate the young sward. It is recommended that grass seeds be sown not later than eight weeks before heavy frost or the first date of continuous snow cover.

Until the 1970's, progressive farmers sprayed fungicides, e.g., PCNB or PCP at seven weeks before the first date of continuous snow cover on the ryegrasses to protect the plants from snow mold damage, but this method is not advocated any more because of chemical pollution both to the herbivores and fish living downstream nearby and because of the introduction of new tetraploid ryegrass cultivars which are more tolerant to the disease.

As shown in Fig. 4, cool-season grasses start to grow when the daily mean temperature rises above 5℃ and the grasses are ready to be grazed

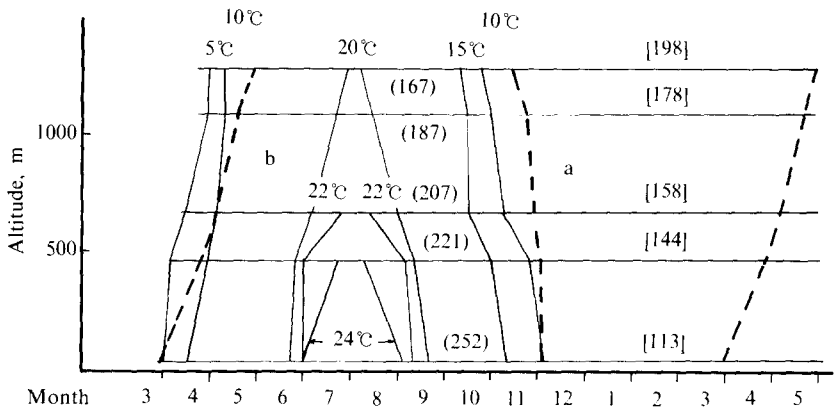

Fig. 4. Environmental restrictions for pasture production.
a; 1st date for continuous snow cover
b; Date of final snow melt in spring (Sakai, 1975).

at around 10℃. This roughly coincides with the date of final snow melting in the end of April at 500 m a.s.l. In the lowland fields, snow melts at the end of March. In late autumn, mean daily temperature goes down to 10℃ at the end of October at 500 m a.s.l. and at higher altitudes it goes down earlier by one month. Therefore, the growing season differs widely from 252 days in the lowland fields to 167 days in the highlands situated above 1,000 m a.s.l. We have several weeks of hot summer with the temperatures above 24℃ in the lowlands that suppress the grass growth. Summer depressions are found up to the lower altitudes of 300 m a.s.l.

Ⅲ. COLD LIMITATIONS FOR FORAGE SUPPLY IN SMALL HOLDERS

Table 1 shows the changes of cropping area of forage crops in Tohoku District during the past two decades. Total area grown with forage crops has been increasing by 1.8 fold. Public pastures have increased to a large extent and the acreage of mixed perennial grasses expanded two folds, followed by corn, 1.3 fold. Sorghum species have increased to 400 ha, but growing this species is not very popular as it is difficult to make good quality silage. Rye, fodder beet, turnips and Chinese milk vetch have been decreasing. The decrease of these minor crops

Table 1. Changes of cropping acreage of forage crops in Tohoku District

	1970	1978	1988
Grasses	54,358ha	87,706ha	118,370ha
Corn	14,474	12,895	18,813
Sorghum spp.	0	77	425
Oats	3,595	424	585
Rye	3,650	1,138	814
Other cereals	–	146	146
Fodder beet	180	262	30
Turnips	2,383	1,552	842
Chinese milkvetch	1,134	13	10
Other fodder crops	643	8,147	4,697
Total	80,414	112,360	144,732

seems to have been caused by the introduction of improved perennial grass cultivars. And it means that the farmers prefer growing perennial grasses to annuals as they are too busy to sow seeds and harvest forage crops both in spring and autumn.

1. Perennials

If the pastures are established successfully, their primary production is maintained at a high level, starting at 11 t DM/ha in the first year and decreasing gradually to 8 t DM/ha until the 6th to 8 th year when managed well. Mixing in legumes such as *Trifolium repens* is not popular as severe insect damage caused by the false melon beetle (*Atrachya menestriesi*) and black cutworm (*Agrotis ipsilon*) often occurs.

2. Annuals

Considering the species adaptability of annual forage crops in this district, the growing period ranges from 250 to 150 days, and farmers grow sorghum, corn and Japanese barnyard millet from south to north as summer growers. Forage oats, barley, and rye are grown as winter growers from warmer parts to the colder. Italian ryegrass is grown in districts with a shorter duration of continuous snow cover in addition to hybrid ryegrasses.

Table 2 shows results of an experimental cropping system carried out at the Fukushima Livestock Experiment Station in 1988. As seen from the table, a cropping system of corn-barley or corn-oats is superior to sorghum-barley cropping, and the figures might be maximal yields in a colder district. But, this double-cropping system is not very popular except in the southern Tohoku District.

Farmers prefer silage making to hay making because of unreliable weather during harvest seasons. Use of a roll-baler connected with the wrapping machine system is becoming popular especially among group farmings. This system is taking over the traditional air-tight silos, FRP silos and stack silos, etc.

In the lowland fields, cropping land is mostly used in leasehold, and is utilized intensively by double cropping with corn, sorghum and ryegrasses, barley or oats for making whole crop silage. But, in Northern Honshu, forage production does not exceed 100 t/ha of fresh herbage because of the climatic restriction.

The trouble with growing forage crops in rotational upland use is that the rented paddy field is not always well-drained and the farmers have to make open drainage around the field combined with growing a moisture-tolerant grass species. Most

Table 2. Forage yield at two-cropping system

(kg/10 a)

Cropping system	Summer crop			Winter crop			Total		
	FM	DM	TDN	FM	DM	TDN	FM	DM	TDN
Corn-barley	4,276	1,372	975	3,654	1,071	596	7,930	2,443	1,553
Corn-oats	6,388	1,739	1,179	3,892	653	416	10,280	2,392	1,595
Sorghum-barley	4,759	1,400	802	3,654	1,071	596	8,413	2,471	1,398

Note: FM; Fresh weight, DM; Dry matter yield, TDN; Total digestible nutrients.

farmers advocate keeping the water table deeper than 40 cm below the surface and draining the water within half a day after heavy rainfall. Another nuisance is our unreliable weather with frequent scattered showers during machinery operation in the afternoon from July to September.

3. Group farming among small holdings

Dairy cows need 4 t DM/yr of roughage. Assuming the crop production is 1~2 t DM/10 a, field space needed is 20~40 a. From feeding standards, breeding beef cows require 1.8 t of forage hay, 0.6 t of wild grass in hay and 1 t of dry rice-straw, which means 10~20 a of cropping fields and the same area of paddy fields (Hirota, 1990). Farmers must explore more land, either by buying or by leasehold in consultation with agricultural cooperatives or farm advisory officers.

Mechanization in grassland farming is a prerequisite in this modern age, but over-investment in machinery by each small holder must not be recommended as it is too expensive. In many districts, group farming is quite common. There are several types of group farming, e.g., renting fields in groups and growing forage crops individually or in smaller groups with three to four holdings, buying machinery subsidized by the government in groups and working together in the cropping fields, harvesting and transporting the forage in groups, etc.

Some farmers buy used implements, others use a leasehold system from the government organizations, village offices or agricultural cooperatives. Agricultural economists advise the dairy farmers to keep the rates of feed cost to milk sold in less than 30% and payed interest to milk sold within 5%.

When alfalfa hay cube is purchased, feed price at TDN basis is estimated to be ca. 100 yen/kg, and then we have to reduce the cost of crop production to cheaper cost, but growing forage crops in rotational fields costs 10 yen/kg in fresh weight and the farmers often harvest lower yield crops owing to unreliable weather and moist soil conditions. If the cost of leasehold is expensive, growing forage crops in the rented fields is not economical because of the crop's commercial value when harvested and because it is a weak competitor against other crops, e.g., rice, vegetables and flowers, etc. So far, our leasehold system has been continuing and the land owners are satisfied with receiving a subsidy of ca. 50,000 yen/10 a by the reorganization policy on paddy field use as subtrogation for land rent. The prospect of growing forage crops on the accessible and fertile land is still uncertain.

Ⅳ. FEED CONSERVATION AND USE OF CROP RESIDUES

The conventional way of making hay with meadow grasses is still popular in both the dairy and beef industries.

* Compact baler system

mower -- conditioner -- tedder rake -- compact baler -- truck -- hay elevator

* Big-bale system

mower-conditioner -- tedder rake -- big baler -- bale fork loader -- truck -- bale loader

Cases of group farming are quite common. In northern Japan, some farmers prefer hay making to silage making as it is less laborious to store in barns and feed to cattle. Constructing a simple type of forced air-dryer, made of pipe frames covered with polythene film and equipped with big electric ventilation facilities has been tried several times with fruitful results. Hay towers using heavy oil for heating were also examined, but neither was successful or popular in Tohoku District.

The traditional way of making silage with corn is still popular as it is the best way of ensuring high-quality silage. A new trend is the introduction of a big baler and wrapping machine. This system seems to be attractive as it takes less time before wrapping and the wrapped forage is safer under unreliable weather.

Another new trend of making silage from low-quality roughages like rice-straw, wild grasses and stover of field crops, etc., using ammonia gas is attractive as it improves TDN value, CP contents, palatability, storage duration and reduces the cost to conserve. The roughage thus preserved for 2~3 weeks in summer or 3~5 weeks in cooler season is ready for actual feeding. Fortunately this storage system kills eggs of distomiasis of the liver that are frequently found in rice-straw. Problems are that this gas is poisonous to man and not easy to handle at ensiling.

Feeding crop residues to housed cattle has been a traditional custom, e.g., feeding lower leaves of harvested cabbages, buckwheat stover, radish, carrot and unsold fruits, etc., but it is now self-controlled because of pollution from agricultural chemicals. Lees of soybean paste, beer brewer's grains and those of sugar beets are used as feed to a certain extent depending on the proximity to the corresponding factories. Some farmers are interested in feeding chips of timber or even fermented sawdust irrespective of feeding value.

V. FORESTRY/GRASSLAND INTEGRATION, WATER BALANCE AND CATCHMENT USAGE

1. Agroforestry

Grazing cattle and horses in the communal forest during the growing season has a long history of several centuries in many districts including Tohoku District and Sado Island (Hirota, 1981). There were two types of forest grazing. One was grazing herbivores in broad-leaved deciduous forest after thinning the tree canopy down to 60% of original formation to enhance the growth of understratum wild grasses, and the other was to graze herbivores on the new growth of wild grasses after felling all trees and bush followed by transplanting cedar or pine trees. In the latter case, wild grasses could prosper for four to five years until the planted canopy covered whole hills and this type of grassland had a carrying capacity of one beast to the hectare, i.e., 50~60 CD/ha. After many years of this traditional usage, the community of wild grasses has changed to *Zoysia* grassland.

2. Water balance and catchment usage

Compared with deciduous forest, improved grassland retains very little precipitation and water run-off, as low as one tenth of the former (Endo et al., 1983). This is because of the high moisture holding capacity of the forest canopy and the softer, porous structure of topsoil.

In constructing public pastures on slopeland, more than twenty meters of forest is kept untouched at the lower skirts of the catchment in order to absorb abrupt and continuous precipitation, which is efficient in stopping runoff polluted with animal returns.

VI. PRIORITIES FOR RESEARCH AND EDUCATION

Nowadays administration system of our gove-

rnment requires accumulation of academic reports published by academic institutions and public agricultural organizations, and our research people are skillful in performing this type of research. Young people are more interested in basic subjects, such as biotechnology and system analysis, using computers without any concern about actual farming and drastic changes in the rural community.

Now the percentage of aged farmers, older than sixty, has reached 50% and the new comers to take over the farming business have decreased from 37,000 in 1970 to 1,800 in 1990 in the whole country. How can we support our people in the next century? Still we have to rely on our next generation in order to survive. But, I have a hope in finding farmers as friends who are very active in organiz ing neighbor farmers to make groups to defend themselves. They are thirsty for learning current information on new technology. As for grassland science and technology, in which all of us are involved, we have to encourage both young replacements in the field of scientific research and progressive young farmers and their wives. We basic scientists must visit rural villages more frequently and learn much from the inhabitants in order to know what they want. This will be the first step to cope with the threatening liberalization of the market including animal products that has started since April, 1991.

Ⅶ. SUMMARY

The term 'cold region' is defined as a cool, temperate area where mean annual temperatures are between 7 and 12℃. This region is called Tohoku District or Northern Honshu and it coincides with the climatic division of the warmth index between 65 and 100 with the formation of broad-leaved deciduous trees. Winters are cold when the ground is covered with much snow, and it is fairly warm in summer.

Pastoral utilization of semi-natural grassland has been decreasing, being replaced by the improved grasslands sown with cool-season grass species. In the lowland fields, land use has been changed from pure paddy to upland field crops and horticultural crops in addition to forage crops.

Duration of snow cover restricts the period of growth and utilization of pasture grasses according to the altitude. In the fields of lower altitude, cropping systems are versatile depending on the location, e.g., using perennial grasses or combinations of annuals, but double cropping such as the corn-barley system is still less popular in this region owing to unreliable weather at times of sowing and harvesting.

Group farming is an efficient way of reducing cost of herbage production among small holders. Systems of harvesting and conservation are changing rapidly from the conventional mechanization to speedier ones to save labor costs and ensure herbage quality.

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