Technologies

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Grassland in Hokkaido

MIXED GRASSLAND MANAGEMENT

The grassland stretches as far as the eye can see. Hokkaido Island in the north of Japan is famous for its dairy farming. The scene is pastoral, but farmers are striving with modern technologies to achieve the best quality and yields. One way of doing this is to grow different types of forage for their herds.

Finding the right balance

Generally speaking, there are two types of meadow. The first contains graminaceous forage, which has long and narrow leaves, such as reed canary grass, orchard grass and timothy. The other type is leguminous forage, which has wide leaves, like white clover, red clover and alfalfa. These grasses provide different nutritious substances. For example, leguminous forage contains more protein than graminaceous, while graminaceous species contain more fibre. Farmers mix both types to obtain better milk—and more of it—from their herds.

Farmers have to fertilize their field depending on the proportion of leguminous forage. Because the grasses are perennial plants, this changes after they have sown their field. In the Hokkaido region there are four classes for fertilization:

- Class-1: 30% or more
- Class-2: 15~30%
- Class-3: 5~15%
- Class-4: less than 5%

Until now, farmers would walk their fields to ascertain exactly how much fertilizer to apply, but this process proves costly and time-consuming. This is where satellite imagery comes to their assistance.

This study was a joint research project conducted by
- Hokkaido Institute of Animal Industry
- Konsen Agricultural Experiment Station
- Nagasaki University
- ImageONE


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Leguminous forage (left) and graminaceous forage (right)

Choosing a method

Frequent revisits are vital to acquire cloud-free imagery over short periods of one week, for example, but fortunately Hokkaido falls within the daily revisit zone of the FORMOSAT-2 satellite, which collects multispectral imagery well suited to this type of application. However, using satellite imagery for pasture monitoring poses some technical challenges. It is easy to distinguish grassland from other surfaces, but can we classify leguminous and graminaceous forage and measure the proportion of leguminous using satellite imagery?

Conventional remote-sensing techniques would use ground truth data to measure leguminous forage and then correlate them with satellite data to develop an estimation model. FORMOSAT-2 colour imagery can be used for this purpose. However, the conventional method does not work well due to positioning errors in ground truth data or when atmospheric conditions change after they have been collected. As a result, the estimation model thus derived cannot accurately determine the proportion of leguminous forage. A lot of field data would have to be acquired in varying conditions for precise estimation, meaning that in many cases the advantages of satellite imagery are reduced.

Our solution

We developed an area-independent and time-independent estimation model from simulated FORMOSAT-2 data. First, we collected spectral data for mixtures of forage with a known proportion of leguminous grasses using a portable spectrometer, to enable us to define spectral responses. We collected 30 spectral datasets in the Konsen area on 2 June 2006. Using the spectral responses obtained with the portable spectrometer, we simulated with Modtran software the response that would be obtained in FORMOSAT-2 spectral bands. We then generated a regression model to calculate the proportion of leguminous forage as a function of the FORMOSAT-2 response.

To evaluate the quality of our model, we used FORMOSAT-2 data of the Shintoku area acquired on 24 May 2007. Shintoku and Konsen are more than 100 kilometres apart; the satellite data were collected one year after the ground truth data.

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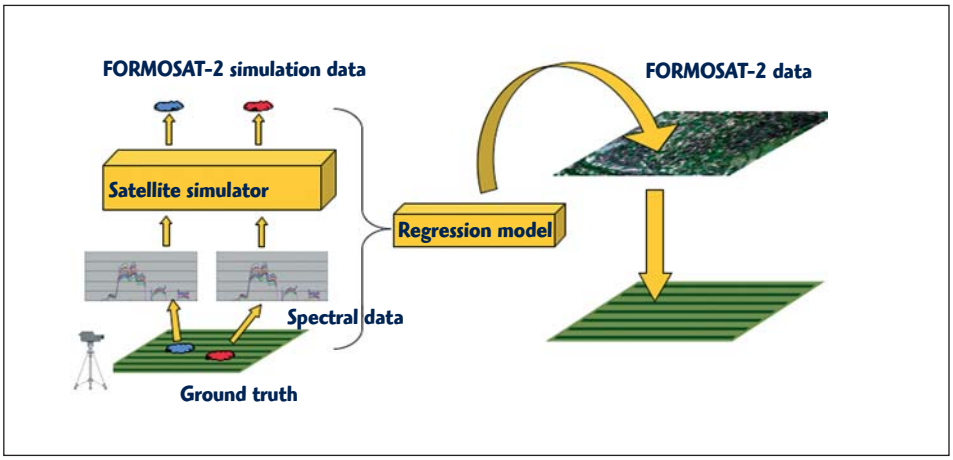
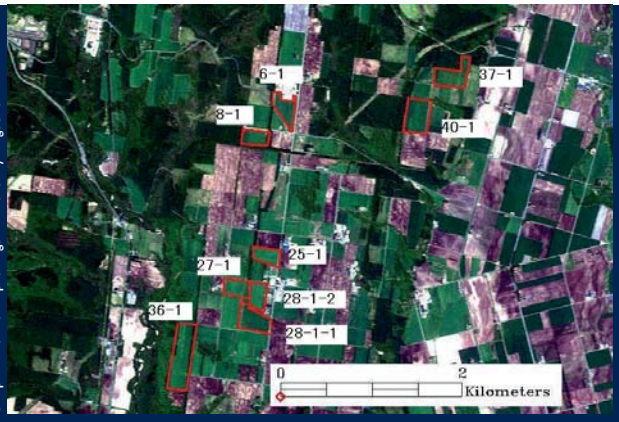
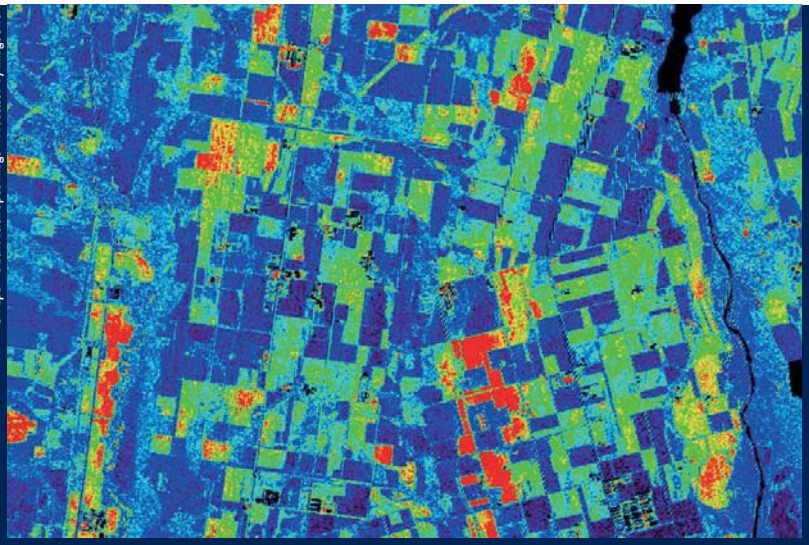
ESTIMATION SCHEME





FORMOSAT-2 IMAGE OVER SHINTOKU



ESTIMATED PROPORTION OF LEGUMINOUS FORAGE IN SHINTOKU AREA

Red: high
Blue: low

>>> Using the conventional method, we would have been obliged to collect new ground truth data for this particular location over the same period. We selected eight fields for the evaluation, each with three validation sample datasets. At the same time, we generated a model with seasonal atmospheric conditions for the Konsen area. The estimation model was then applied to the FORMOSAT-2 data. Figure 6 shows the consistency of the estimated and real proportion of leguminous forage. The standard deviation of the estimation error is 3.5% and the contribution (R2) is 62%. Figure 6 shows the estimated leguminous proportion over the Shintoku area with the developed model.

The estimated accuracy of 3.5% is good enough to estimate the proportion of leguminous forage for fertilizer planning. Once we have collected ground truth data, we can generate the estimation model for different locations and periods. This feature should help farmers to manage their grassland better. Currently, the model's limitations and conditions are being studied for other areas. In the future, a newly developed Japanese hyperspectral sensor is expected to be used as a complementary source of information. ■

MORE INFORMATION:

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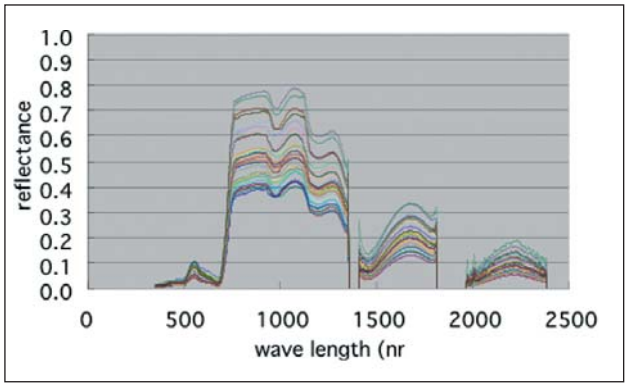
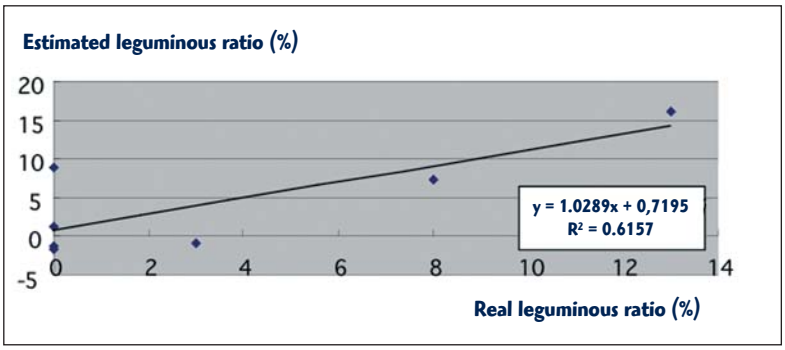
SAMPLE OF SPECTRAL DATA





VALIDATION OF THE ESTIMATION MODEL OF LEGUMINOUS RATIO