Locust Geographic Information System (GIS) Workshop
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Examples of remote sensing application to locust monitoring in Caucasus and Central Asia (CCA) and elsewhere

- Item 6 of the Provisional Agenda -

In Caucasus and Central Asia (CCA), most applications of remote sensing using satellite imagery pertain to monitoring of the Asian Migratory Locust, *Locusta migratoria migratoria* (Linnaeus, 1758) -LMI. Remote sensing applications for the Italian Locust, *Calliptamus italicus* (Linnaeus, 1758) -CIT- and the Moroccan Locust, *Dociostaurus maroccanus* (Thunberg, 1815) -DMA- are very scarce. Elsewhere, satellite data are routinely used for monitoring and forecasting the Desert Locust, *Schistocerca gregaria* (Forskål, 1775) -SGR- and the Australian Plague locust *Chortoicetes terminifera* (Walker, 1870) -CTE-, but rarely for other locusts.

1. The Asian Migratory Locust (LMI) is one of the most dangerous agricultural pests in CCA, particularly in Russia, Kazakhstan and Uzbekistan. Its main breeding areas cover a total of six million hectares. They are situated in reed stands in the deltas of big rivers such as Volga, Amudarya, Syrdarya, Ural and Ili as well as around big lakes such as Balkhash, Alakol and Zaisan. Annual infested areas in the Lake Balkhash area and the Amudarya River delta can exceed one million hectares.

Satellite imagery was applied to monitor LMI habitats, particularly reeds. With remote sensing, it was possible to reliably (>80% classification accuracy) track the reed distribution in the deltas of the Ili (Kazakhstan) and Amudarya (Uzbekistan) rivers. Satellite data allowed to map the distribution of reeds in early spring or late summer. The first period coincides with LMI hatching, and the satellite-derived information is useful for directing the ground survey teams towards potential nymphal habitats. The second period coincides with the locust oviposition (egg-laying) and such information could be used for locating locust egg-beds. A combination of remote sensing assessments of vegetation and water depth was proposed to forecast the risk of LMI infestations in the Lake Balkhash area. However, to date, applications of remote sensing to LMI monitoring are limited to the use of habitat maps derived from satellite data by the Locust control services in Uzbekistan.

2. The Italian Locust (CIT) is a major agricultural pest in the dry grasslands of the CCA countries, particularly Afghanistan, Georgia, Kazakhstan, Kyrgyzstan, Russia and Uzbekistan. For reference, its geographic distribution area stretches from western Europe up to Mongolia and northern China. CIT is an ecologically plastic species which can settle a wide range of habitats, such as overgrazed pastures, field edges, weedy fallows, etc. CIT often appears in abandoned cropland areas. Fallows with sagebrush *Artemisia spp.* are preferred.

Ground monitoring of CIT presents two important challenges: extremely vast and very heterogeneous areas to survey and extended period of locust hopper development. The latter results in a complex population structure causing problems in choosing the appropriate timing of control. Satellite information may be useful to address the first of the two challenges. From the remote sensing perspective, the identification of CIT habitats is a two-step process. It consists in: 1) distinguishing fallows and other similar disturbed non-crop areas from active cropland; and 2) within those fallows, distinguishing sagebrush associations from non-*Artemisia* shrub cover. The first task can be accomplished through a time-series analysis of images of the same geographic area taken at different seasons or in a historical retrospective. Availability of reliable historical land use information is critical to accomplish this step. As for the second task –identification of sagebrush-based plant associations using satellite data– examples from North America demonstrated its feasibility in a similar semi-arid environment. Landscape heterogeneity adds complexity to the analyses for CIT. Nonetheless, first attempts of mapping CIT habitats in Russia and Kazakhstan using remotely sensed data appeared to be promising. However, as of today, application of satellite data to CIT monitoring is still in its initial research phase.

3. The geographic distribution area of the Moroccan Locust (DMA) stretches for 10,000 km in the east-west direction, from the Canary and Madeira Islands up to southeastern Kazakhstan. Its distribution is discontinuous, consisting of isolated permanent breeding areas, separated from one another by natural obstacles like mountains or water bodies. Many of these areas are located in CCA countries: Afghanistan, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. DMA's typical habitats are foothills with ephemeral vegetation which are used as natural pastures.

The DMA bio-ecology presents certain challenges to its successful monitoring and management. First, the patchiness and mosaic character of DMA habitats make it difficult to characterize them based on satellite data. A recent attempt to map DMA oviposition areas in South Uzbekistan, based on vegetation density and using Landsat data, was only partially successful. It is the only study which applies satellite data to DMA habitat monitoring. Second, the short duration of the hopper instars, which coincides with the development of ephemeral vegetation, limits the availability of the satellite data to a very narrow period of spring time. In the Central Asian and Caucasian countries, where DMA is the most important economic pest, spring is characterized by a high percentage of cloudy days, which is a serious impediment for the use of earth-observing satellites. Third, most DMA breeding areas are located at an altitudinal gradient from 400 to 1,200 m, which requires special techniques and approaches in analyzing satellite data. To sum up, the remote sensing applications to DMA locust habitat monitoring are just making their first and tentative steps.

4. The invasion area of the Desert Locust (SGR) occupies 29 million km^2 in Africa, Southern Europe, Middle-East and South-West Asia. During recessions, when population densities are low, SGR inhabits arid and semi-arid lands covering 16 million km^2 from the Atlantic Ocean to North-West India. Breeding occurs in the areas which received 20–25 mm direct rainfall, and preferred oviposition sites are in sandy soils with a mosaic of grasses, herbs and shrubs.

Reliable and timely identification of the areas where vegetation emerges after rainfall is the main goal of SGR monitoring and the key to its preventive management. Under the preventive mode, locust control units are proactively searching for incipient gregarizing (*transiens*) populations and carry out small-scale control operations before the onset of flight emigration. The applications of satellite data and GIS provided an important advance in SGR monitoring and forecasting. It became possible through financial and institutional support from the FAO, which operates the Desert Locust Information Service (DLIS).

To assess the vegetation, DLIS uses 250-m resolution MODIS imagery, consisting of 16-day cumulative images. Analysis of individual channels provides an even more accurate estimation of ecological conditions in SGR habitats which are subsequently double-checked with survey results. The main goal is to distinguish vegetation areas from bare ground. To that end, Normalized Difference Vegetation Index (NDVI) is used. Besides the vegetation, rainfall is another essential parameter necessary for accurate SGR forecast and risk assessment. DLIS uses rainfall estimates derived from METEOSAT, mainly infrared and visible channels, to understand better the spatial and quantitative distribution of rainfall in SGR breeding areas.

5. Australian Plague Locust (CTE) occurs throughout Australia. Its preferred habitats consist of a mosaic of bare ground for basking and egg-laying, short grass cover for feeding and taller sparse tussocks for night shelter. Multiple information sources, including remotely sensed vegetation and weather data as well as locust infestation data, are integrated into a GIS-based decision support system developed at Australian Plague Locust Commission (APLC). It provides a reliable forecast of CTE and other economic locust and grasshopper species allowing to devise and implement timely and efficient control plans.

For a comprehensive review of remote sensing applications to locust monitoring and management, see:

Latchininsky A.V., 2013. Locusts and Remote Sensing: A Review. *Journal of Applied Remote Sensing.* [DOI: 10.1117/1.JRS.7.075099].

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