Chapter 9
Country-Level Use of Satellite Products to Detect and Map Land Degradation Processes

For ecological studies and environmental change research, Pettorelli et al. (2005) distinguish two main groups of satellite products:

(a) Long-term NDVI datasets including the coarse-scale (8–16 km resolution) NOAA–AVHRR time series extending from 1981 to the present and the small-scale Landsat–TM dataset extending from 1982; the use of Landsat products for land-use and land-cover change has been growing because Landsat has a relatively fine resolution for land-use change studies and wave bands extending across the visible, near-infrared, shortwave infrared spectrum (Townshend et al. 2012).

(b) Finer-scale but short-term NDVI time-series datasets which include MODIS–TERRA (250–1000 m resolution) extending from 2000 to the present and the 1 km to 300 m resolution SPOT–VGT dataset extending from 1998 to the present. However, these data are not available free of charge (see Annex 7).

Our approach to assessment of land degradation using satellite data depends on observing changes in total seasonal photosynthesis or primary production through time at continental scales, with the ability to disaggregate to national- and district-level scales when required. This disaggregation is necessary because all actions to halt land degradation must be implemented at the national or subnational scale. NDVI data exist globally at 8 km-resolution since 1981 from the AVHRR and at 250 m-resolution from MODIS since 2000. We recommend that all 8-km NDVI3g analyses should be complimented by comparisons with MODIS NDVI 250-m data for their overlap periods (Fig. 9.1).

What is the possibility of using other sources of primary production data? We could also possibly use the MODIS-derived net primary production product (MOD17) (Running et al. 2004) and chlorophyll fluorescence from the Greenhouse Gases Observing Satellite (GOSAT), the SCanning Imaging Absorption SpectroMeter

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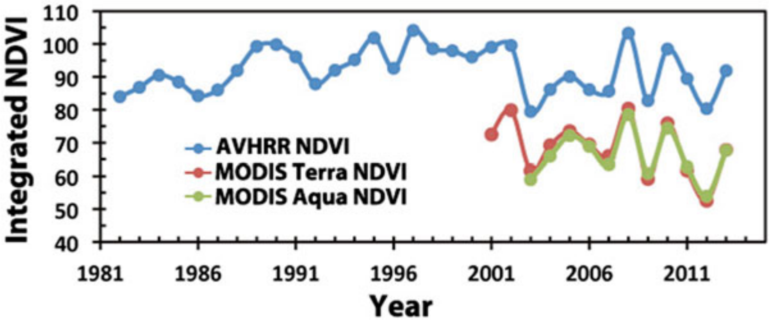

Fig. 9.1 Integrating NDVI values is directly related to gross primary production over the growing season for an area in Moldova. We have taken the NDVI values from Fig. 4.1 and numerically integrated them from the first of March to the end of October for 1981–2013 for the GIMMS NDVI3g dataset, for 2001–2013 for MODIS Terra NDVI, and for 2003–2013 for the MODIS Aqua NDVI data. Note very similar behavior in integrated NDVI values (NDVI days). There appears to be a break point between 2002 and 2003

for Atmospheric CHartographY (SCIAMACHY), or the Global Ozone Monitoring Experiment-2 (GOME-2) instruments (Joiner et al. 2012, 2013), which are alternative products to map and monitor land primary production. The MODIS NPP product is a global-modeled output product and, like many global products, performs less well when disaggregated to the national and district levels; its driving variables are not available at resolutions <1 km. The fluorescence products from SCIAMACHY, GOSAT, and GOME-2 satellites appear to be very useful for measuring primary production; SCIAMACHY data collection begun in early 2002 at a spatial resolution of 30×60 km (Gottwald et al. 2006); GOSAT data start in 2009 and are 10×10 km in spatial resolution (Joiner et al. 2011); GOME-2 data start in late 2006 and have a nadir spatial resolution of $0.5^{\circ} \times 0.5^{\circ}$ (Joiner et al. 2013).

The large spatial scale of these data is because fluorescence measurements are made within several Fraunhofer lines that are only 1 Angstrom (or 0.1-nm) wide so it is necessary to collect fluorescence data over large areas to get enough photons for an adequate signal-to-noise ratio. These coarse spatial scales make disaggregation to the subnational difficult. Recent studies by Joiner and a member of our team, Tucker (*submitted*), have shown that the time integral of fluorescence is linearly and very highly correlated to the NDVI time integral (Fig. 9.2). The NDVI advantage for land degradation studies is that land degradation can be studied over 33+ years with the GIMMS3g dataset at 8 km and for 15 years at 250 m from MODIS NDVI with the potential to downscale with NDVI data at 30 m from Landsat and at 1 m from commercial satellite data.

At present, there is insufficient time history of fluorescence to assess land degradation for these reasons: (1) Although SCIAMACHY fluorescence data started in 2002, their spatial resolution is 30×60 km which is very coarse resolution. (2) Fluorescence data from GOME-2 start in 2006 and from GOSAT in 2009 so we

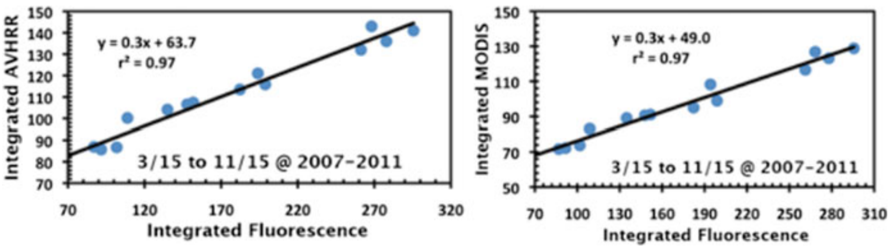

Fig. 9.2 Integrated AVHRR and MODIS NDVI compared to GOME-2 chlorophyll fluorescence for the Russian wheat growing areas of 51°–56°N × 40°–54°E, 47–53°N × 54°–60°E, and 50°–57°N × 60°–72°E from March 15, 2007, to November 15, 2011. Three areas over 5 years provide a sample size of 15 (Yoshida et al. 2014). This figure contradicts the allegations that NDVI saturates and supports our use of the NDVI as being directly related to primary production

don't have enough time history to detect land degradation trends using these data. Twenty years on, satellite fluorescence data may be another tool for quantifying land degradation over large areas at a coarse scale, but, for the present, there is no alternative to NDVI in land degradation assessment.