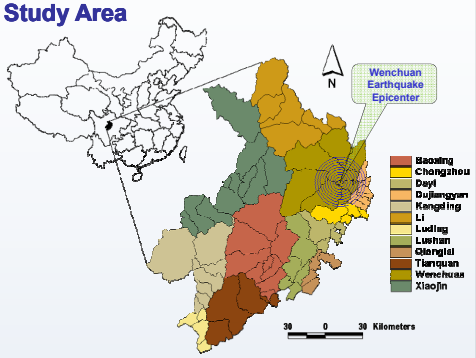
Effects of Government Policies and Natural Disasters on the Patterns of Forest Cover Change in the Sichuan Giant Panda Sanctuary (China)

Andrés Viña, Sandra Batie, Zai Liang, Zhiyun Ouyang and Jianguo (Jack) Liu

Summary

Government policies shape human activities that drive land cover changes and impact wildlife habitats. Since the early 2000s the Chinese government has been implementing two of the largest ecological conservation policies in the world [1]: The Natural Forest Conservation Program (NFCP) and the Grain-to-Green Program (GTGP). At the same time China is also pushing to escalate economic growth through a grand development scheme, the West China Development Program (WCDP). The main goal of this project is to understand the effects of conservation and development programs on the spatio-temporal dynamics of forest cover in the Sichuan Giant Panda Sanctuary. Many townships experienced drastic reductions in the amount of forest cover before the implementation of the NFCP and GTGP, even inside nature reserves [2,3]. This trend was reverted in the years after the implementation of conservation policies. However, some townships are still losing forest cover despite their implementation. These townships are located in the eastern portion of the Sanctuary, which tend to be more subjected to human activities enhanced by the implementation of the WCDP. In addition, some of the net gains in total area of forest cover in Wenchuan County were reversed by the May 12, 2008 Wenchuan earthquake. However, the combined effects of development and earthquake-induced landslides would have severely reduced the area of forest without the implementation of conservation policies.

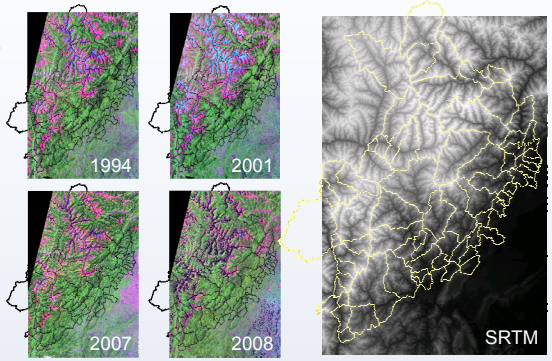
Study Area



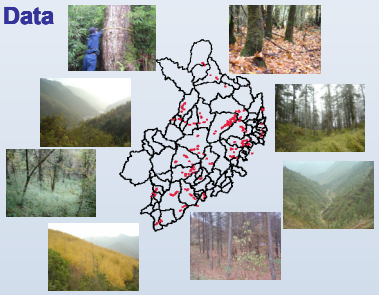
The study area covers 72 townships comprising the UNESCO World Heritage Sichuan Giant Panda Sanctuary in 12 counties (color coded) of Sichuan Province, China. The epicenter of the May 12, 2008 Wenchuan earthquake (one of the worst natural disasters in China during the last 60 years) is also shown.

Remotely Sensed and Topographic Data

Landsat Thematic Mapper (TM) imagery (Path 130, Rows 38 – 39 of the Landsat's Worldwide Reference System) for 1994, 2001, 2007 and 2008 (post-earthquake) were obtained from the US Geological Survey Earth Resources Observation and Science Center (EROS), the Global Land Cover Facility, University of Maryland and from the China Remote Sensing Satellite Ground Station. Digital Elevation Model (DEM) data were obtained from the Shuttle Radar Topography Mission (SRTM).



Field Data



Ground truth points (red dots) acquired using real-time differentially corrected GPS receivers between 2007 and 2009 were used for calibration and validation of the land cover classification of remotely sensed data. Pictures show some landscape characteristics.

Methods

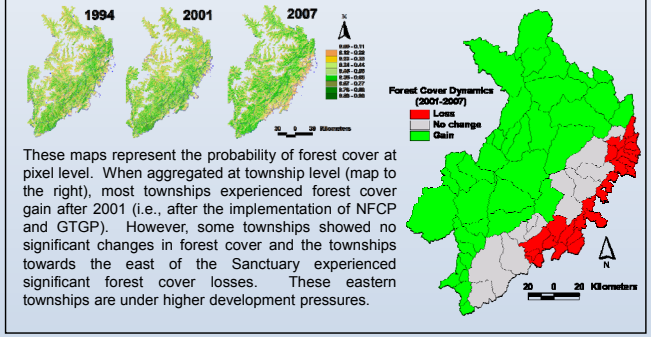
The 1994, 2001 and 2008 image datasets were geometrically and radiometrically registered to the 2007 image dataset and maps of the distribution of forests in 1994, 2001, 2007 and 2008 were obtained using a supervised classification of the Landsat TM data. The classification scheme (fuzzy classifier) was calibrated for the 2007 image dataset using ground control points and the coefficients of the classification were applied to the other datasets. Areas under clouds and cloud shadows were removed from the entire image time series.

Annual rates of forest cover change were calculated as [3]:

$$R = \left[\left(\frac{A_e - A_b}{A_b} \right) \Big/ t \right] \times 100$$

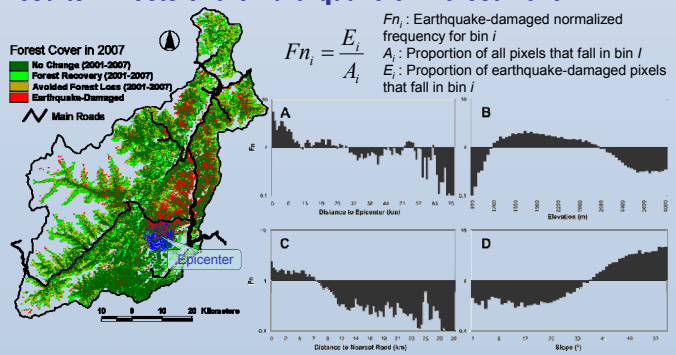
Where R is the forest cover change rate (%) per year, A_b is forest area at the beginning of the period, A_e is forest cover at the end of the period, and t is the number of years between the beginning and ending periods. R takes negative (positive) values if the changes are due to losses (increases) of forest cover.

Results: Effects of Policies on Forest Cover



These maps represent the probability of forest cover at pixel level. When aggregated at township level (map to the right), most townships experienced forest cover gain after 2001 (i.e., after the implementation of NFCP and GTGP). However, some townships showed no significant changes in forest cover and the townships towards the east of the Sanctuary experienced significant forest cover losses. These eastern townships are under higher development pressures.

Results: Effects of the Earthquake on Forest Cover



$$Fn_i = \frac{E_i}{A_i}$$

Fn_i : Earthquake-damaged normalized frequency for bin *i*
A_i : Proportion of all pixels that fall in bin *I*
E_i : Proportion of earthquake-damaged pixels that fall in bin *i*

Damaged forest areas were located close to the epicenter (A), between elevations of 1200 and 2800 m (B), close to roads (C) and in slopes > 38° (D). These damaged areas accounted for ca. 9% of areas that exhibited benefits (i.e., forest recovery and avoided forest loss) from the implementation of NFCP and GTGP in Wenchuan county [4].

Conclusions & Future Work

- In the 1994-2001 period the forests declined at annual rates that varied between 0.6 and 1.8%.
- In the 2001-2007 period the forests recovered at annual rates between 0.5 and 1.9%, although some townships towards the east are still experiencing overall forest cover losses.
- The Wenchuan Earthquake induced drastic losses in forest cover, particularly in the townships in close proximity to the epicenter.
- Without conservation policy implementation the combined effects of development and earthquake-induced landslides would have drastically reduced the forest cover.
- Socio-economic conditions will be integrated to further explain the dynamics of forest cover change across the Giant Panda Sanctuary.

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MICHIGAN STATE UNIVERSITY
UNIVERSITY AT ALBANY
State University of New York