Assessment of NPP and Landcover Change in the Lancang River Basin (Upper Reaches of Mekong River)

LIU Gaohuan     Yao Zhijun
Huang Heqing    Zhang Yili

Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences
Study Area
Some features and basic knowledge in the Lancang (Mekong) Basin

- **Continuity**: Closely linked with Mekong river
  - Geographic coverage: total area of 2,500,000km². It could be divided into three sections: the upper, middle and lower reaches
  - Climate and hydrological change
  - Cultural and inhabitant transition

- **Complexity**:
  - Topography
  - Environment
  - Ecosystem
  - Human activities
The Lancang (Mekong) Area:

（1）The Upper Reach of Lancang River and Shangerila

（2）The middle- and lower reaches of Lancang River in China

（3）Mekong River Basin
The Lancang (Mekong) region has significant academic value

- Complex surface system and gradient changes of resources & environment
- Changes of resources and ecosystem services
- Complete and vertical geographical system
Landcover mapping

18 scenes Landsat TM images covering the whole basin for 1:100,000 landcover mapping.

20 scenes SPOT5 images in typical regions for 1:50,000 landuse mapping.

Field survey and sampling of soil, water, vegetation and household
Spatial Pattern of land cover in 2009
Current landcover (2009)

- Largest area: grass land
- Smallest area: needle forest
- Vertical zoning in middle reaches

<table>
<thead>
<tr>
<th>Vegetation type</th>
<th>Area (km²)</th>
<th>Vegetation type</th>
<th>Area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ever green needle</td>
<td>3119.28</td>
<td>Woody grass land</td>
<td>29780.14</td>
</tr>
<tr>
<td>Ever green broad</td>
<td>25790.73</td>
<td>Sparse grass land</td>
<td>152.63</td>
</tr>
<tr>
<td>Deciduous needle forest</td>
<td>3.43</td>
<td>Pasture</td>
<td>64787.24</td>
</tr>
<tr>
<td>Deciduous broad forest</td>
<td>614.17</td>
<td>Farm land</td>
<td>3300.00</td>
</tr>
<tr>
<td>Mixed forest</td>
<td>14972.17</td>
<td>Mixed farm land and natural</td>
<td>7998.96</td>
</tr>
<tr>
<td>Dense shrub</td>
<td>8894.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sparse shrub</td>
<td>3758.96</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Distribution of land cover

<table>
<thead>
<tr>
<th>Vegetation type</th>
<th>Upper reaches (km²)</th>
<th>Middle reaches (km²)</th>
<th>Lower reaches (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ever green needle</strong></td>
<td>502.48</td>
<td>2565.35</td>
<td>48.23</td>
</tr>
<tr>
<td>Ever green broad</td>
<td>0.00</td>
<td>27.01</td>
<td>25717.85</td>
</tr>
<tr>
<td><strong>Deciduous needle forest</strong></td>
<td>0.43</td>
<td>1.29</td>
<td>1.71</td>
</tr>
<tr>
<td>Deciduous broad forest</td>
<td>1.07</td>
<td>124.33</td>
<td>488.12</td>
</tr>
<tr>
<td>Mixed forest</td>
<td>91.32</td>
<td>8133.16</td>
<td>6718.75</td>
</tr>
<tr>
<td>Dense shrub</td>
<td>3922.95</td>
<td>4559.20</td>
<td>409.02</td>
</tr>
<tr>
<td>Sparse shrub</td>
<td>2293.53</td>
<td>1455.78</td>
<td>6.43</td>
</tr>
<tr>
<td>Woody grass land</td>
<td>134.62</td>
<td>5131.78</td>
<td>24486.51</td>
</tr>
<tr>
<td>Sparse grass land</td>
<td>1.71</td>
<td>14.79</td>
<td>136.12</td>
</tr>
<tr>
<td><strong>Pasture</strong></td>
<td>53745.67</td>
<td>10486.07</td>
<td>495.19</td>
</tr>
<tr>
<td>Farm land</td>
<td>600.88</td>
<td>676.55</td>
<td>2022.14</td>
</tr>
<tr>
<td>Mixed farm land and natural vegetation</td>
<td>22.29</td>
<td>1399.83</td>
<td>6567.62</td>
</tr>
</tbody>
</table>

- **Upper reaches**: grass land cove 88%
- **Middle reaches**: grass and mixed forest cove 55%
- **Lower reaches**: ever green broad leaf forest cove 40%
## Landcover change (2001-2009)

<table>
<thead>
<tr>
<th>Vegetation type</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ever green needle</td>
<td>2.53</td>
<td>2.02</td>
<td>1.54</td>
<td>1.26</td>
<td>1.41</td>
<td>1.49</td>
<td>1.65</td>
<td>1.84</td>
<td>1.90</td>
</tr>
<tr>
<td>Ever green broad</td>
<td>13.25</td>
<td>15.16</td>
<td>14.85</td>
<td>13.88</td>
<td>12.89</td>
<td>14.15</td>
<td>15.23</td>
<td>16.16</td>
<td>15.70</td>
</tr>
<tr>
<td>Deciduous needle forest</td>
<td>0.01</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td>0.02</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td>Deciduous broad forest</td>
<td>1.17</td>
<td>0.49</td>
<td>0.25</td>
<td>0.27</td>
<td>0.53</td>
<td>0.68</td>
<td>0.55</td>
<td>0.50</td>
<td>0.37</td>
</tr>
<tr>
<td>Mixed forest</td>
<td>9.40</td>
<td>7.97</td>
<td>7.57</td>
<td>8.01</td>
<td>8.43</td>
<td>8.67</td>
<td>8.45</td>
<td>8.75</td>
<td>9.11</td>
</tr>
<tr>
<td>Dense shrub</td>
<td>8.19</td>
<td>6.53</td>
<td>5.73</td>
<td>5.30</td>
<td>5.70</td>
<td>5.50</td>
<td>4.87</td>
<td>5.12</td>
<td>5.41</td>
</tr>
<tr>
<td>Sparse shrub</td>
<td>3.72</td>
<td>2.43</td>
<td>1.71</td>
<td>1.49</td>
<td>1.66</td>
<td>1.92</td>
<td>2.11</td>
<td>2.45</td>
<td>2.29</td>
</tr>
<tr>
<td>Sparse grass land</td>
<td>0.12</td>
<td>0.06</td>
<td>0.03</td>
<td>0.06</td>
<td>0.07</td>
<td>0.09</td>
<td>0.05</td>
<td>0.06</td>
<td>0.09</td>
</tr>
<tr>
<td>Grasse</td>
<td>35.21</td>
<td>38.36</td>
<td>40.01</td>
<td>40.54</td>
<td>39.87</td>
<td>39.49</td>
<td>39.56</td>
<td>39.52</td>
<td>39.44</td>
</tr>
<tr>
<td>Farm land</td>
<td>2.63</td>
<td>2.43</td>
<td>2.42</td>
<td>2.55</td>
<td>2.39</td>
<td>1.94</td>
<td>1.76</td>
<td>1.54</td>
<td>2.01</td>
</tr>
<tr>
<td>Mixed farm land and natural vegetation</td>
<td>3.58</td>
<td>3.08</td>
<td>4.01</td>
<td>4.64</td>
<td>4.21</td>
<td>5.39</td>
<td>6.25</td>
<td>6.38</td>
<td>4.87</td>
</tr>
</tbody>
</table>
Landcover change in upper reaches

Grass land increased 10%, shrub and farmland decreased
Landcover change in middle reaches
Landcover change in lower reaches

Ever green broad leave forest increased 8%, mixed forest decreased 20%
NPP assessment based on improved BEPS model
BEPS: Boreal Ecosystem Productivity Simulation

- landcover
- LAI
- Bio-parameter
- Biomass
- Soil moisture
- AWC
- Soil water balance
- Leaf conductive
- photosynthesis
- Daily NPP, ET
- Yearly NPP, ET
- Radiation
- Temp.-max
- Temp.-min
- Precipitation
- R-humidity
- Snow depth

Distribution of NPP, ET
Total radiation

Total radiation = Direct R + Dispersion R + Addition R
DEM

SLOPE

ASPECT

Surface Shading

Solar Radiation w/m²

Solar Radiation Whole Year Accumulation J/m²
Atmospheric transmissivity

\[ I_{\text{diri}} = I_{\alpha \beta i} T_{\text{cleari}} T_{\text{cloudi}} \]

\[ T_{\text{cleari}} = T_{o i} T_{r i} T_{g i} T_{w i} T_{a i} T_{n i} \]

correction with sensor viewing angle    correction of shadow position
Nitrogen absorbed by vegetation

\[ N_{\text{uptake}} = \min(N_{\text{root}}, N_{\text{av}}, N_{\text{deficit}}) \]

Nitrogen in leaf

\[ \text{leaf}(N) = (N_l - N_{l,\text{min}}) / N_c + N_{l,\text{min}} \]

Photosynthesis adjustment by Nitrogen

\[
\begin{align*}
J_m &= J_{m25} \frac{\text{leaf}(N)}{N_{l,\text{max}}} a_{J_{\text{max}}}^{(T_a-25)/10} \\
V_m &= V_{m25} \frac{\text{leaf}(N)}{N_{l,\text{max}}} a_{V_{\text{max}}}^{(T_a-25)/10}
\end{align*}
\]
**Farquhar model**

\[ A = \min(W_c, W_j) - R_d \]

\[ W_c = \frac{C_i - \Gamma}{C_i + K} \]

\[ W_j = J_m \frac{C_i - \Gamma}{4.5C_i + 10.5\Gamma} \]

**ET model**

\[ ET = T_{\text{plant}} + T_{\text{under}} + E_{\text{plant}} + S_{\text{plant}} + E_{\text{soil}} + S_{\text{ground}} \]
Data

- DEM
- RS data: LAI, Landcover
  MOD03/ MYD03
  MOD05/ MYD05
  MOD06/ MYD06
  MOD10
  TM, SPOT Data

- Observation data: climate, Biomass, NPP
- Sampling data: soil nitrogen, soil texture, soil type, vegetation
Data procession

- point data: Temp-min, Temp-max, precipitation, humidity, snow depth
- Radiation: calculated
- Land cover: remote sensing interpretation
- (AWC): calculated
- Biomass: survey and calculate

Point interpolation area
Increase from northwest to southeast, the lowest is in riverhead region, and the highest is in lower reaches.

- **NPP**: 50 gC/m²·a → 1400 gC/m²·a;
- **GPP**: 100 gC/m²·a → 2500 gC/m²·a;
- **RA**: 50 gC/m²·a → 1600 gC/m²·a.
NPP by month

每月NPP平均值

NPP平均值(gC/m².Month)

月份

上游
中游
下游
Up coming work

1. Land cover change of Lancang river in last 30 years
2. Analysis of landcover change induced NPP changes
3. Comparing of land cover pattern and changes between China and other 5 countries
4. co-relation analysis of hydrology (quantity, quality) change with landcover change
Thanks for your attention