



Carbon, biodiversity & ecosystem services: exploring co-benefits

Jiangxi Province, China





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ACKNOWLEDGEMENTS

UNEP World Conservation Monitoring Centre would like to thank BMU, GTZ, BfN, HSI and UNEP for financial support, including for the visit of CRAES staff to Cambridge. Special thanks to CRAES and the Key Projects of Basic Scientific Research Business for National Welfare Institutes (No: 2009KYYW12), and to Philip Bubb and Amy Milam.

We are grateful to all those who provided datasets and information: Z.G. Liu from the Jiangxi Academy of Environmental Sciences for biodiversity data; S.B. Kuang from the Jiangxi Academy of Forestry Inventory and Planning for forest inventory data; Department of Ecology, Peking University for the digitized 1:1,000,000 vegetation map of China; Mike Crosby and Gill Bunting of BirdLife International for IBA data and technical support.

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CITATION

Li, G., Lin, X., Ravilious, C., Kapos, V., Bertzky, M., Scharlemann, J.P.W., Dickson, B., Hu, L.L., Wu, X.P., Li, J.S. (2009) *Carbon, biodiversity and ecosystem services: Exploring co-benefits. Jiangxi Province, China*. UNEP-WCMC, Cambridge, UK.

Available online at:

<http://www.unep-wcmc.org/climate/publications.aspx>

Printed in Copenhagen, Denmark, by Cityprint.

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Introduction

The maintenance and enhancement of natural carbon stocks is now considered a key climate change mitigation measure. Emissions from land use change, mainly tropical forest loss, contribute an estimated 17.4% of total anthropogenic greenhouse gas emissions (IPCC 2007), equivalent to around 5.8 Gigatonnes (Gt) of carbon dioxide (CO₂) per year.

Depending on where natural carbon stocks are maintained or enhanced, other natural assets, such as biodiversity, can benefit at the same time. Simple mapping tools can help identify how carbon, biodiversity and other ecosystem services are distributed across the landscape and relate to each other.

At UNFCCC COP14 UNEP-WCMC released *Carbon and biodiversity: a demonstration atlas* (Kapos *et al.* 2008). Using global datasets on carbon storage in terrestrial ecosystems and areas of high priority for biodiversity conservation, this publication illustrated the potential of spatial analyses to assist decision-makers in identifying areas where reducing emissions from land use change could at the same time help to secure biodiversity benefits.

However, to support planning and decision-making at national and sub-national scales, such analyses must be based on data developed at an appropriate scale and should be done in consultation with a wide range of stakeholders to help prioritise among the different benefits and services under consideration.

This report presents data and analyses on areas of high carbon density and high priority for biodiversity in Jiangxi Province, China. The degree of their overlap with protected areas is assessed, and their relationship to the distribution of human population is explored.

China

The People's Republic of China covers an area of 9.6 million km², making it the world's fourth largest country (after Russia, Canada and the USA). Due to its vast extent and latitudinal range, the Chinese climate ranges from subarctic in the north to tropical in the south. Mountains and high plateaus dominate large parts of the country, especially in the West, while in the East hills and deltas are more prominent. As a consequence of this climatic and altitudinal variation, China is rich in biological diversity.

China consists of 23 provinces, 5 autonomous regions, 4 municipalities, and 2 special administrative regions. By the end of 2005, the population was estimated to be almost 1.308 billion (National Bureau of Statistics of China 2006). Population density differs significantly across the country. In the year 2000, human population density in China ranged from 51 people per km² in the west to 452 people per km² in the east (National Bureau of Statistics of China 2001).

Growth rates in carbon dioxide emissions are strongest in rapidly developing countries, such as China (Raupach *et al.* 2007). However, the country is investing increasing effort in developing forest projects that help to secure and sequester carbon. The latest National Forest Resource Inventory Survey of China (2004 - 2008) shows an increase in total forest area to 1.95 million km² (20.4% of land area), and a forest volume of 13.7 billion m³ (State Forestry Administration P.R. China 2009).

Jiangxi Province

Jiangxi Province, in the south-eastern part of China (Map 1), consists of 91 administrative areas (Statistics Department of Jiangxi Province 2005) covering 167 thousand km². The province encompasses a wide altitudinal range (to a maximum of 2 108m) and a broad diversity of ecosystem types. The largest freshwater lake of China, Poyang Lake, is located in the north of the province.



Map 1: Location of Jiangxi Province in the People's Republic of China

Developing relevant data on provincial level

Carbon

Several data sets were combined to generate a map of carbon storage for Jiangxi Province. A vegetation map of Jiangxi Province (Map 2) was derived from the Vegetation Distribution Map of China (EBVMC 2001, resolution 1:1 000 000) and integrated with county-level inventory datasets on carbon in each vegetation type to produce a biomass carbon map. This map was then combined with an existing soil carbon map for the province (Shi *et al.* 2004; 2006) to produce a map of total carbon density for Jiangxi Province (Map 3).

Biodiversity

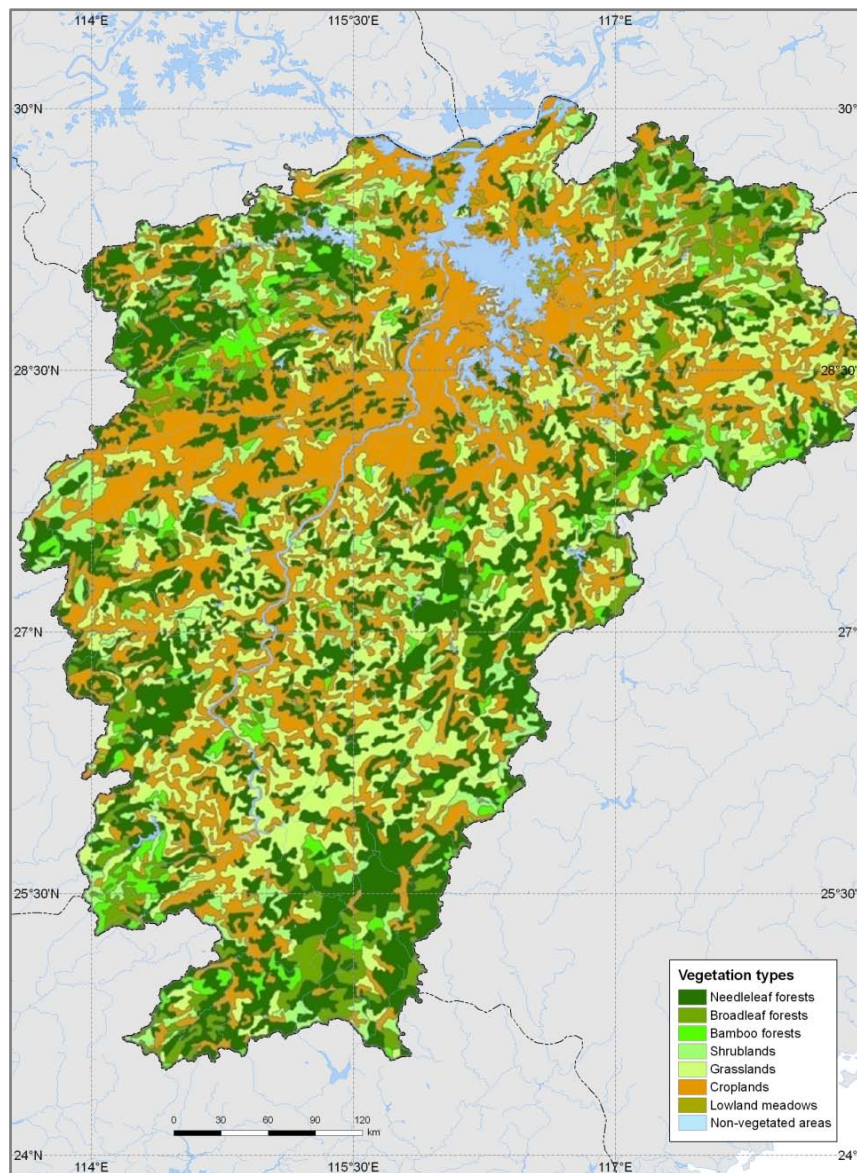
Due to its altitudinal and ecosystem diversity, the territory of Jiangxi Province supports a large number of species (Table 1). Jiangxi's Biodiversity Inventory and Assessment Project (March 2007 - December 2008) evaluated the

biodiversity of the 91 administrative areas at the county level and documented the richness of different taxonomic groups, and of endemic and endangered species (Jiangxi Academy of Environmental Sciences 2008).

Biodiversity data were combined with carbon data to identify where areas of high carbon density overlap areas of importance for biodiversity.

Table 1: Species richness in China and Jiangxi Province (MEP 2002; MEP 2007)

Species group	China	Jiangxi
Vascular plants	>30 000	4 666
Mammals	607	98
Birds	1 294	464
Amphibians	435	52
Reptiles	412	99
Fish	3 862	220



Map 2: Vegetation types of Jiangxi Province, China, in 7 broad classes (EBVMC 2001)

Protected areas

There were 174 protected areas in Jiangxi Province at the end of 2008 (Department of Nature and Ecology Conservation of the Ministry of Environmental Protection of the People's Republic of China 2009). A spatially explicit dataset was developed by creating

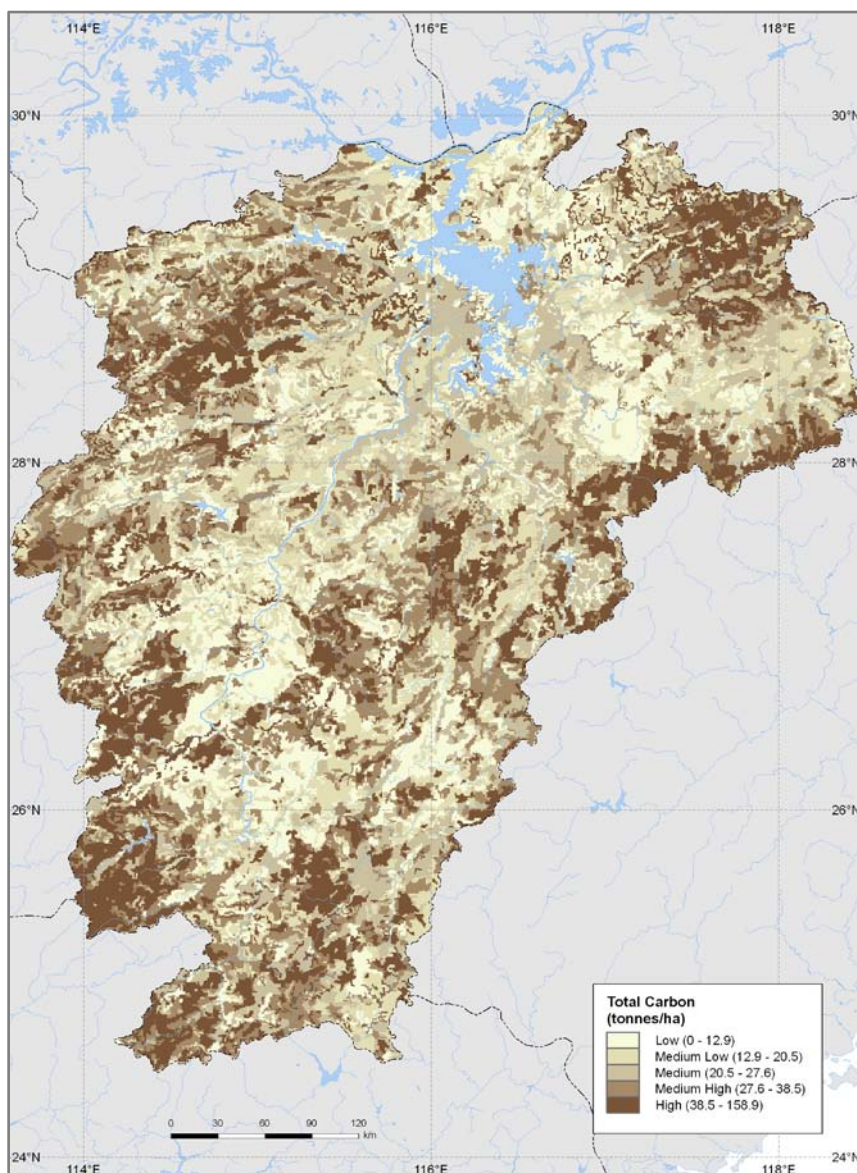
buffers around the point locations for the protected areas to account for their sizes. This newly generated protected areas layer was overlaid with the carbon density map to calculate how much carbon is currently stored in legally designated protected areas.

Carbon stocks and carbon density

The total carbon stock in the various vegetation types of Jiangxi Province is 0.42 Gt, and the average carbon density is about 25 t/ha (Table 2). The largest carbon stock (0.139 Gt) is in needle leaf forests, which account for about 33% of the provincial total, while non-vegetated areas and lowland meadows contain the least carbon, each accounting for less than 0.5% of the provincial total. The highest average carbon density is found in bamboo forests and

broadleaf forests, while the lowest is in croplands and grasslands (Table 2).

Map 3 shows the spatial distribution of carbon density in Jiangxi Province according to five classes, each of which represents one fifth of the land area of the province. The highest category of carbon density (> 38.5 t/ha) is principally distributed in the mountains around the periphery of Jiangxi.



Map 3: Spatial distribution of carbon density in Jiangxi Province, China

Table 2: Carbon (C) stock (Gt) and carbon density (t/ha) for different vegetation types in Jiangxi Province, China

Vegetation Types	Area [10^4 km^2] (%)	C Density (t/ha)	C Stock [10^{-2} Gt] (%)
Needle leaf forests	4.34 (26.04%)	32	13.85 (32.84%)
Broadleaf forests	1.12 (6.72%)	45	5.07 (12.02%)
Bamboo forests	0.63 (3.78%)	49	3.11 (7.38%)
Shrublands	1.13 (6.80%)	30	3.41 (8.08%)
Grasslands	3.32 (19.89%)	19	6.25 (14.82%)
Lowland meadows	0.08 (0.49%)	25	0.20 (0.48%)
Croplands	5.60 (33.56%)	18	10.10 (23.94%)
Non-vegetated areas	0.45 (2.71%)	4.3	0.19 (0.46%)
Total	16.67 (100%)	25	42.19 (100%)

Carbon and biodiversity

Like carbon, biodiversity is unevenly distributed across the province. To identify areas important for biodiversity, counties were ranked according to their species richness for different taxa. Those counties making up the most species rich third of the province were classified as of high biodiversity importance. For vascular plants, counties with more than 1 886 species were classed as having ‘high vascular plant species richness’ (Map 4). They cover more than 58 thousand km^2 (about 35% of the province) and contain about 0.18 Gt of carbon (over 42% of the provincial total). The areas where high carbon density coincides with high plant richness contain 0.13 Gt C or 32% of the provincial total (Figure 1).

Counties with more than 282 vertebrate species were considered to have ‘high vertebrate species richness’ (Map 5). They contain about 0.14 Gt C (34% of the provincial total). The areas where high carbon density coincides with areas of high vertebrate species richness contain 0.08 Gt C (20.1% of the provincial total) (Figure 2).

The areas of highest plant richness occur in mountainous areas adjacent to the borders of the province, while the areas of high animal richness are found in the lower altitude interior

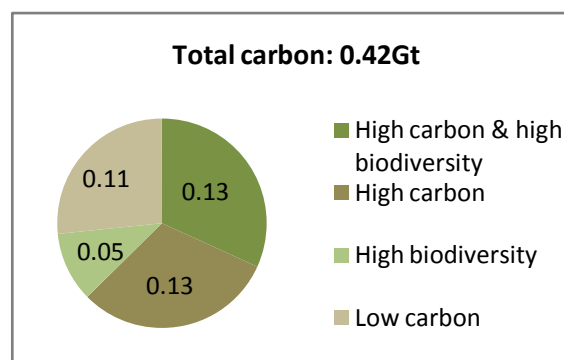


Figure 1: The distribution of Jiangxi's terrestrial carbon stocks in relation to areas of importance for vascular plant species richness

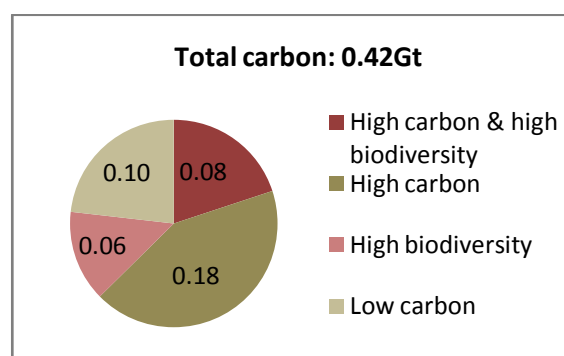
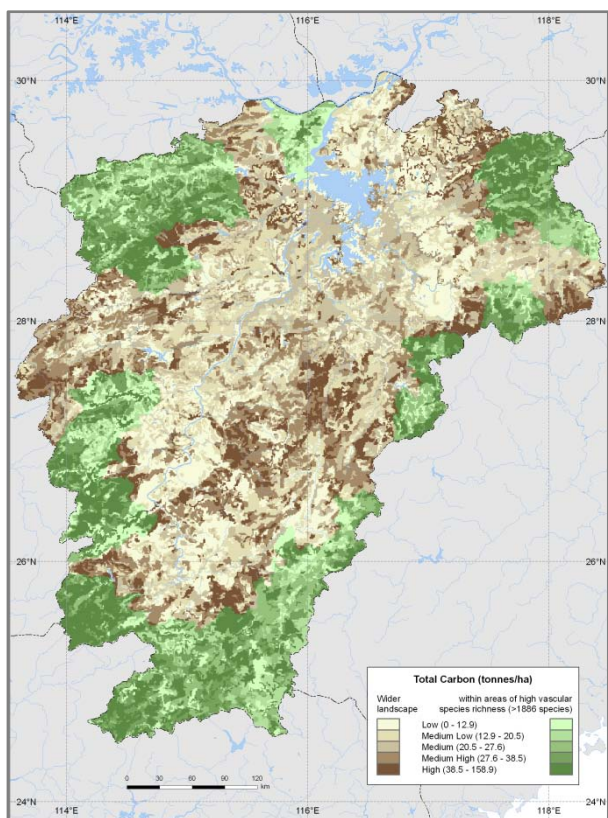
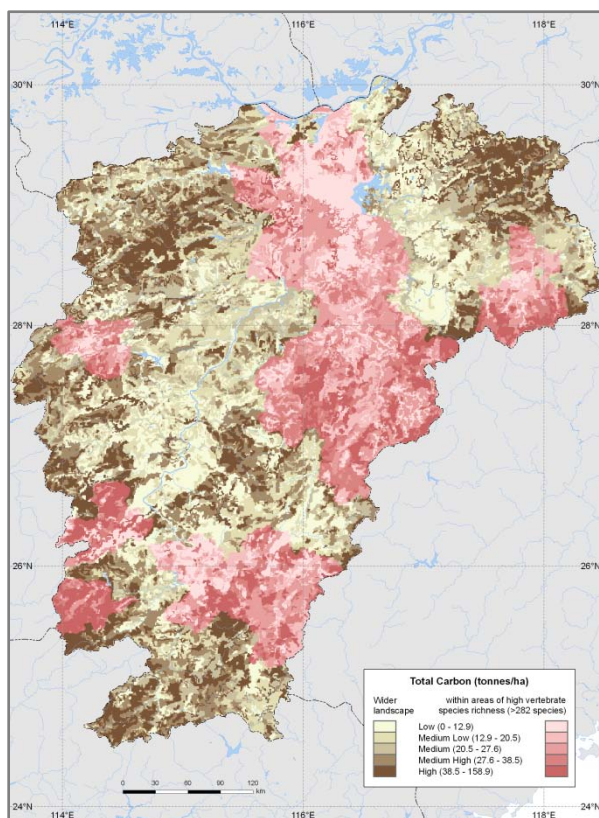


Figure 2: The distribution of Jiangxi's terrestrial carbon stocks in relation to areas of importance for vertebrate species richness

parts of Jiangxi. The small areas that are of high importance for both aspects of biodiversity contain a total carbon stock of 0.05 Gt C.



Map 4: Carbon density and areas of high vascular plant species richness



Map 5: Carbon density and areas of high vertebrate species richness

Biodiversity importance can also be assessed in terms of the distributions of endangered species. Fifteen counties have more than 100 endangered species (Table 3). Most of these counties also have high carbon stock and density: Qianshan, which has most endangered species, also contains high carbon. Xingzi County and Jiujiang District are relatively low in carbon because of their vast non-vegetated areas (Poyang Lake and Yangzi River).

Table 3: Total carbon stock and mean carbon density in the 15 counties with more than 100 endangered species

County	Number of Endangered Species	Carbon Stock	Carbon Density
Qianshan	168	High	High
Zixi	139	Medium High	High
Longnan	137	Medium High	High
Quannan	124	Medium High	High
Dingnan	122	Medium	Medium High
Jinggangshan City	118	Medium High	High
Xingzi	112	Low	Low
Yifeng	110	High	High
Anyuan	109	High	High
Lichuan	108	Medium	Medium High
Xunwu	107	Medium High	Medium
Xiushui	106	High	Medium High
Guangchang	102	Medium	Medium High
Jiujiang District	101	Low	Medium Low
Anfu	100	Medium High	Medium

Carbon and protected areas

The 174 protected areas in Jiangxi Province are distributed in 67 of the 91 counties and cover an area of 11 011 km² or 6.6% of the province (Map 6). Together, they store 29 Mt of carbon, or about 7% of the provincial total. Of the carbon in protected areas almost 22 Mt is in high and medium high carbon density areas (Figure 3).

About 10% of the high carbon density area of Jiangxi is in protected areas. Protected areas contain about 7.5% of areas of high importance for vascular plant species richness and 7.4% of those important for vertebrate species richness.

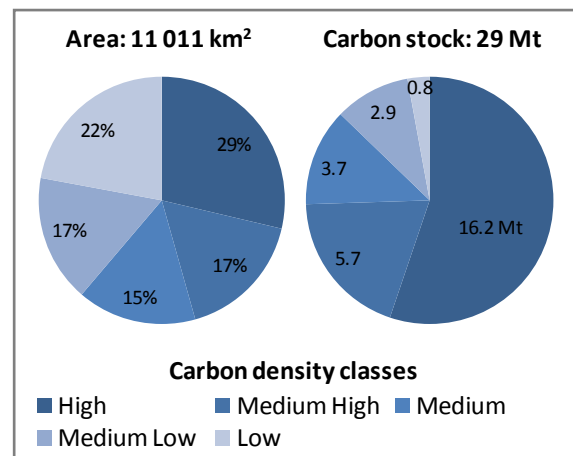
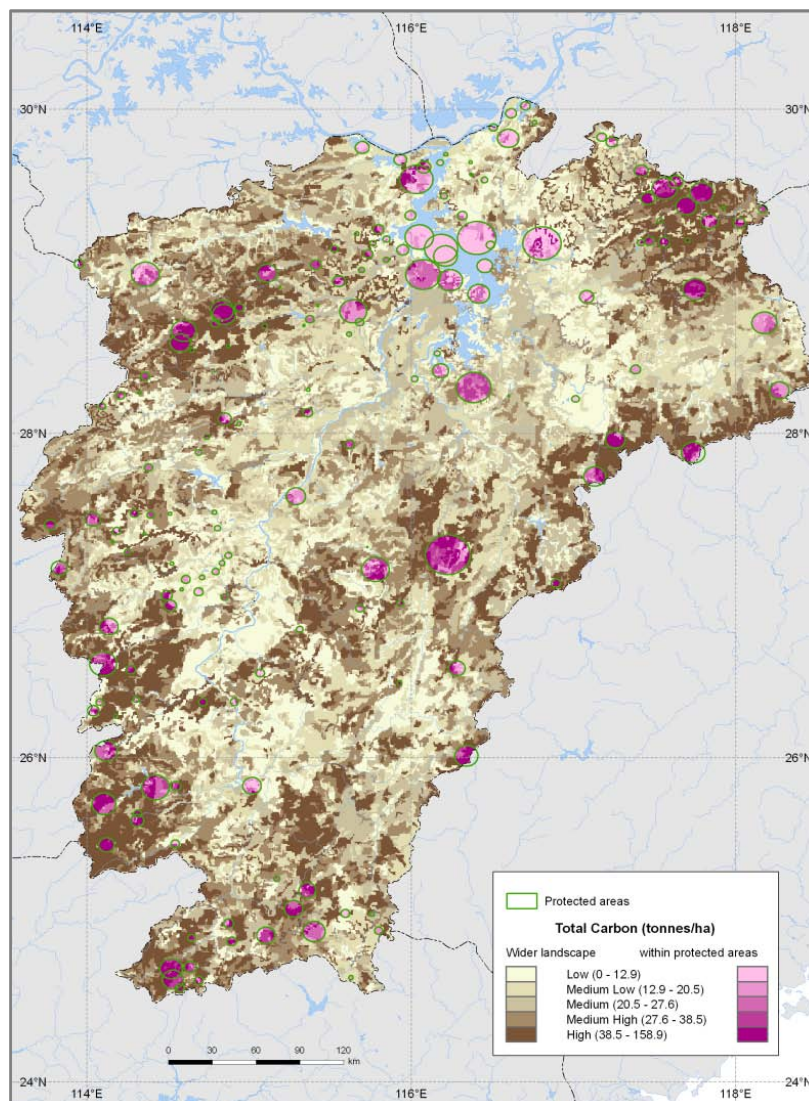


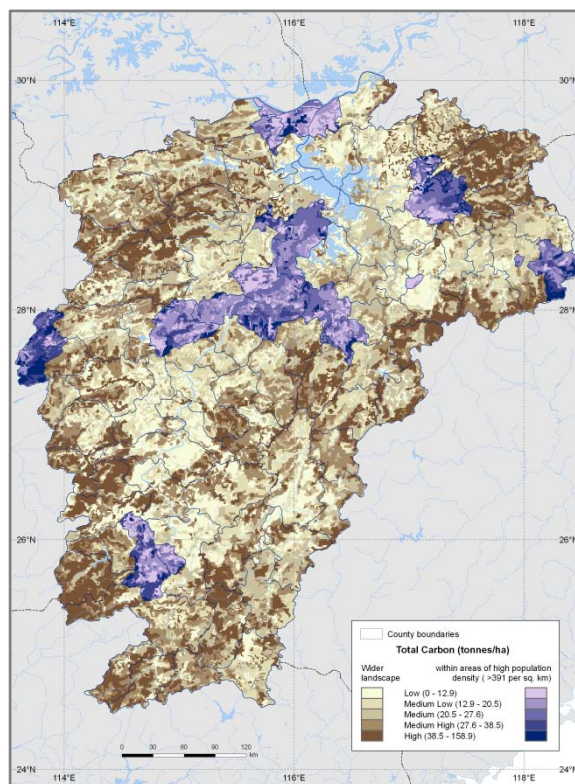
Figure 3: Carbon in protected areas in Jiangxi Province, China



Map 6: Carbon density and protected areas in Jiangxi Province, China

Population

Jiangxi Province has 43.6 million inhabitants, of whom 26.1% are 'non-agricultural' (Statistics Department of Jiangxi Province 2005). The mean population density of the province is 261 people per km² with the highest population densities occurring in the four major cities (Shangrao City: 5 707 people per km²; Nanchang District: 3 725 people per km²; Yingtan District: 1 531 people per km²; and Ganzhou City: 1 282 people per km²; Map 7). High carbon densities and high population densities coincide principally in the west of the province, near Pingxiang. Nanchang District has high vertebrate species diversity. In the north, near Jindezhen, high human population densities may influence areas with both high biodiversity importance and high carbon densities, and significant numbers of people may be affected by efforts to secure carbon and/or biodiversity values through REDD and other actions.



Map 7: Population density and mean carbon density of each county in Jiangxi Province, China

Conclusions

As a first step towards informing decision-making about managing carbon, this study shows that carbon stock and density vary across Jiangxi Province, and that areas with high carbon density and those of importance for biodiversity do not always coincide. This information will be crucial in guiding decisions about where to conserve forests and where to improve their management or enhance their carbon stocks, all actions that can contribute to climate change mitigation. Where biodiversity importance is high but carbon density low, it is less likely that carbon management will help safeguard biodiversity. On the other hand, in places where both values are high, carefully chosen actions, such as including more of the high-carbon lands in protected areas, can help

to secure biodiversity as a co-benefit from carbon management. Depending on how carbon management is implemented, humans may benefit through retention of forest ecosystem services and possible carbon payments, and/or suffer through loss of access to forest resources such as non-timber products.

To plan more effectively for carbon management and its co-benefits in Jiangxi, these initial analyses need to be expanded. In particular, analyses of more detailed spatially-explicit data on protected areas and on changes to carbon stocks, as well as inclusion of other ecosystem services such as water regulation, will be important to maximise co-benefits in Jiangxi Province.

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The benefits of actions to maintain and enhance carbon stocks for climate change mitigation can be increased by taking into account the distribution not only of carbon, but of other ecosystem services, such as biodiversity. Here, we map the distribution of carbon stocks in relation to that of biodiversity in Jiangxi Province, China. Other relevant factors, such as protected area distribution and human population density, are also related to carbon and biodiversity distributions. A new map of carbon in Jiangxi's ecosystems has been produced for this analysis.



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