Evapotranspiration: A Critical Process for Understanding Ecosystem Functions and Services

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USCCC 16th, Hailaer， China

Outline

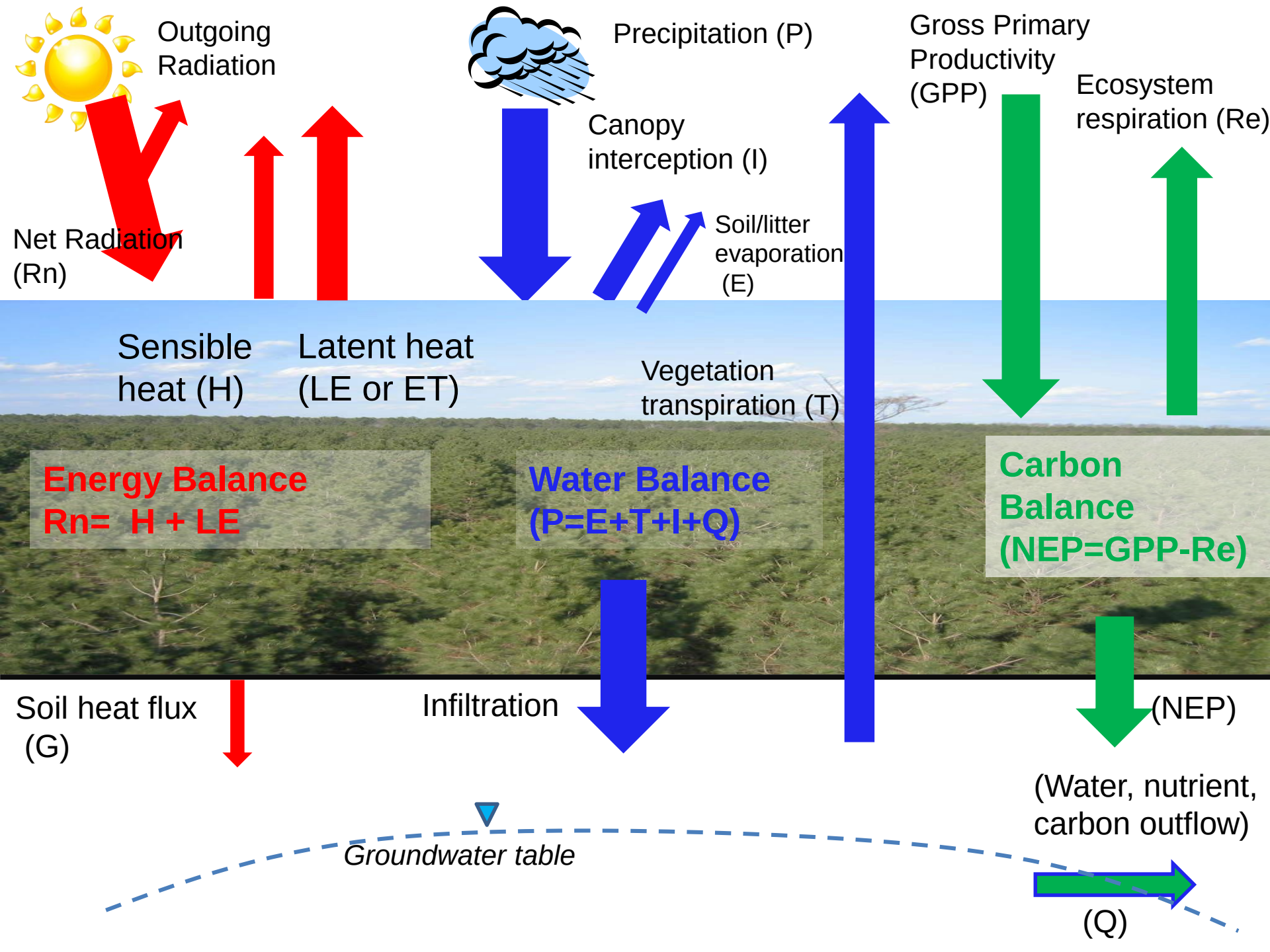
1. What is ET? Why do we care about ET?

2. Recent case studies: Role of ET in regulating energy and water balances (China, US), and ecosystem management

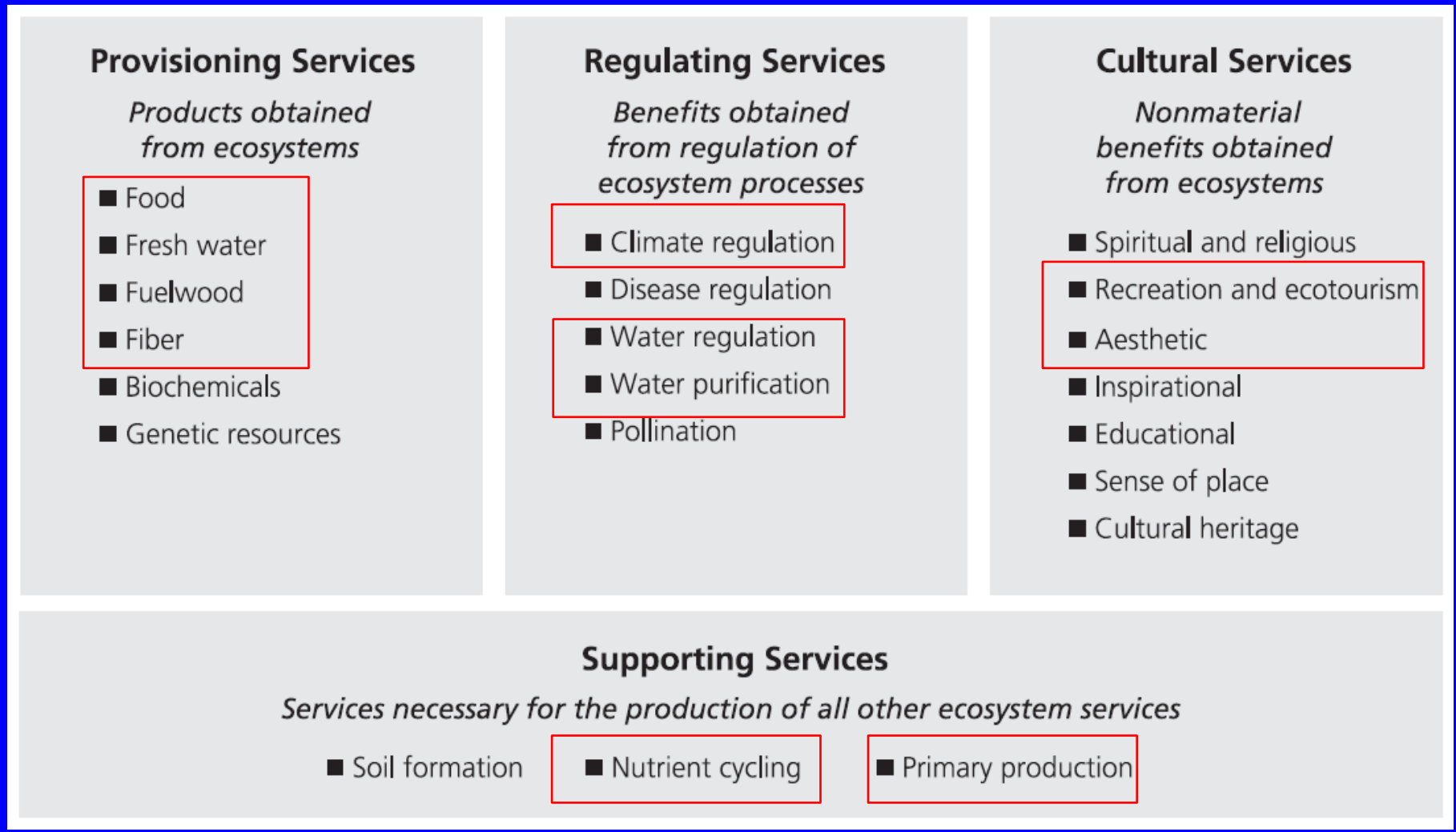
Why ET?

- Hydrologists: It is all about ET, but difficult to measure; residuals (P-Q)
- Climatologists: latent heat; source of water vapor and precipitation
- Ecologists: Carbon in, water out; WUE, focus on T, not ET；biodiversity
- Water managers: focus on water supply; ET = ‘Biological pumps’ or Necessary Evils?


ERROR
RUN OFF
RAIN
WATER SHED BALANCE
ET


Outgoing Radiation
Precipitation (P)
Gross Primary Productivity (GPP)
Ecosystem respiration (Re)
Canopy interception (I)
Net Radiation (Rn)
Soil/litter evaporation (E)
Sensible heat (H)
Latent heat (LE or ET)
Vegetation transpiration (T)
Energy Balance
Rn= H + LE
Water Balance
(P=E+T+I+Q)
Carbon Balance
(NEP=GPP-Re)
Soil heat flux (G)
Infiltration
(NEP)
(Water, nutrient, carbon outflow)
Groundwater table
(Q)

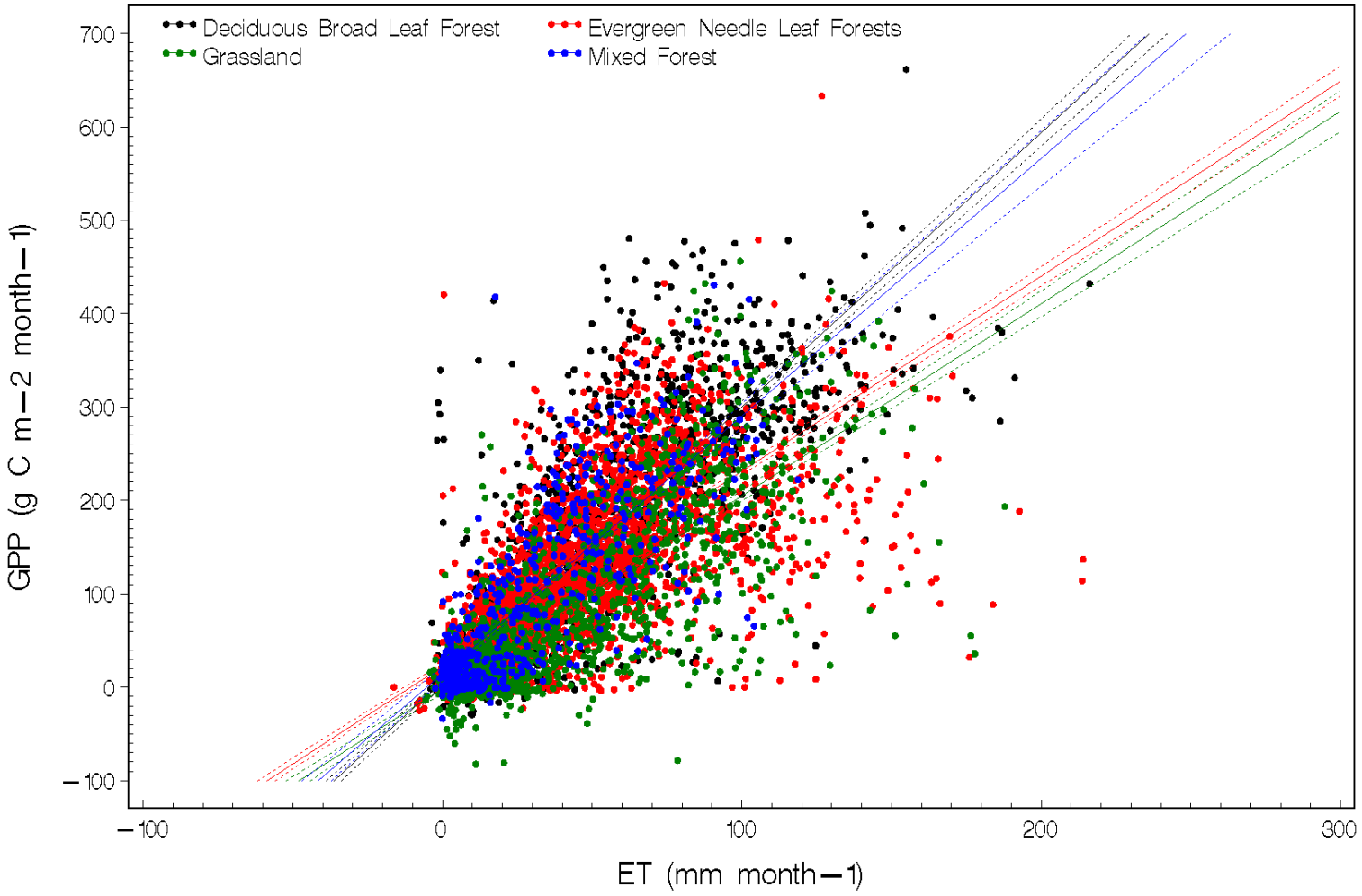
Ecosystem Services



Ecosystem Tradeoffs and Synergies

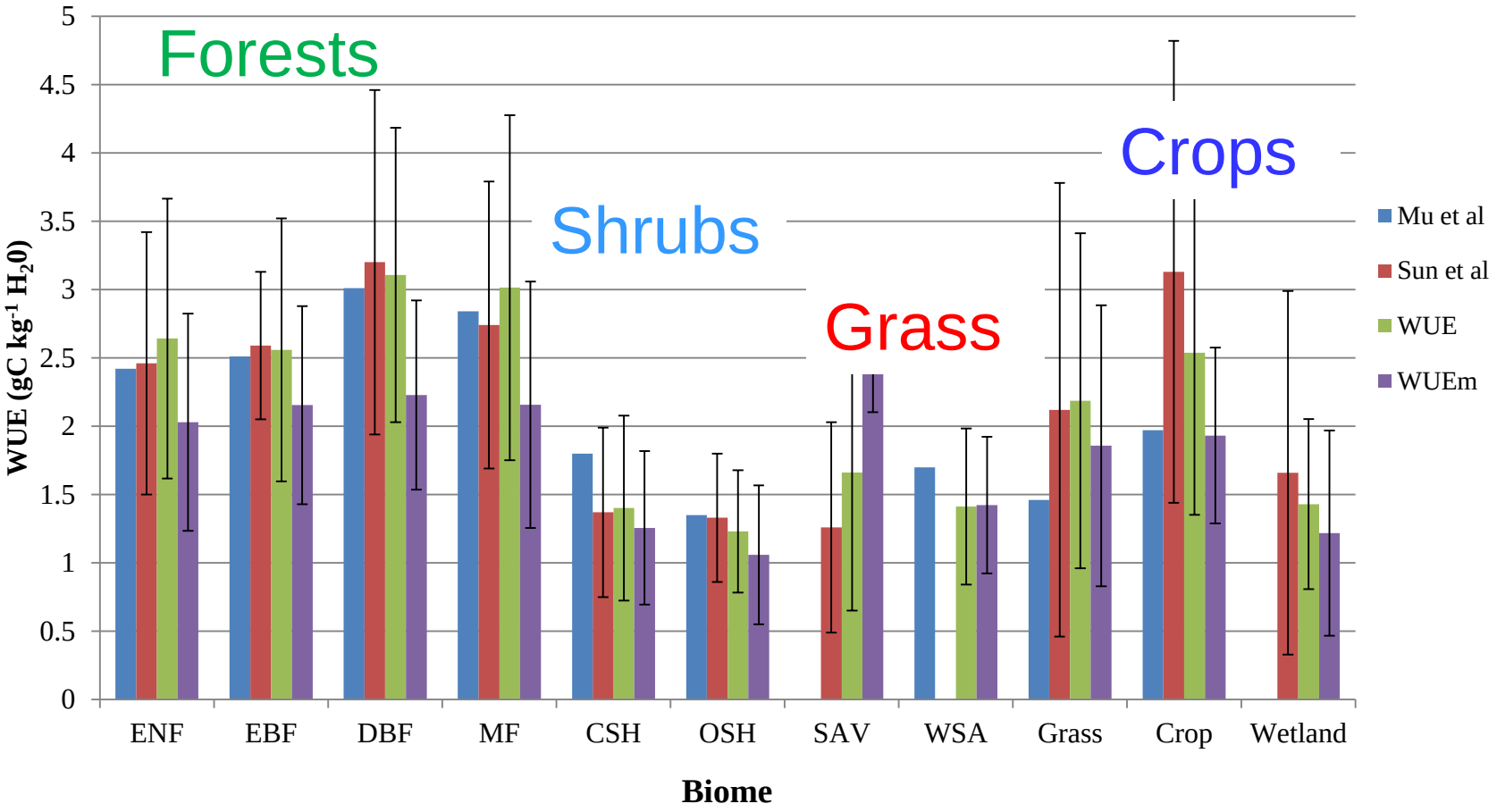
- Carbon and Water
- Water quantity and quality
- Water use and water supply by forests
- Spatial locations (up streams and down streams; upwind and downwind)
- Water and Biodiversity

Water and Carbon Coupling



From Sun et al, JGR-Biogeoscience, 2011

Water Use Efficiency (gC/Kg H_2O)

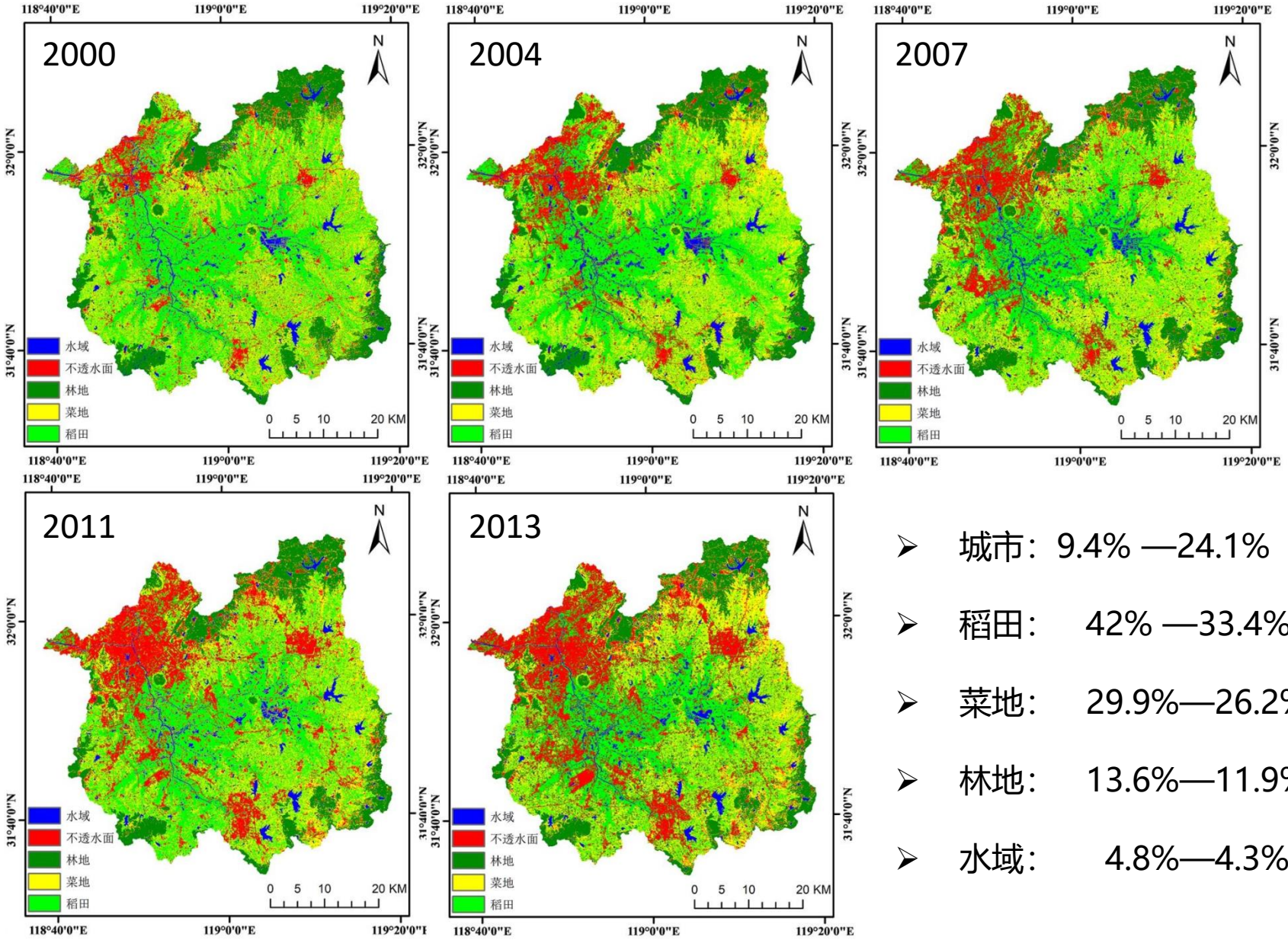


Case Studies: ET Regulating Streamflow and Air Humidity in Urbanized Watersheds

- **Case 1:** 城市化的水文气象效应(南京秦淮河水稻田流域, 长三角）
- **(Urbanization and UHI and UDI)**

- **Case 2:** 城市化对碳水平衡的影响 **(Urbanization Effects on Water and GEP)**

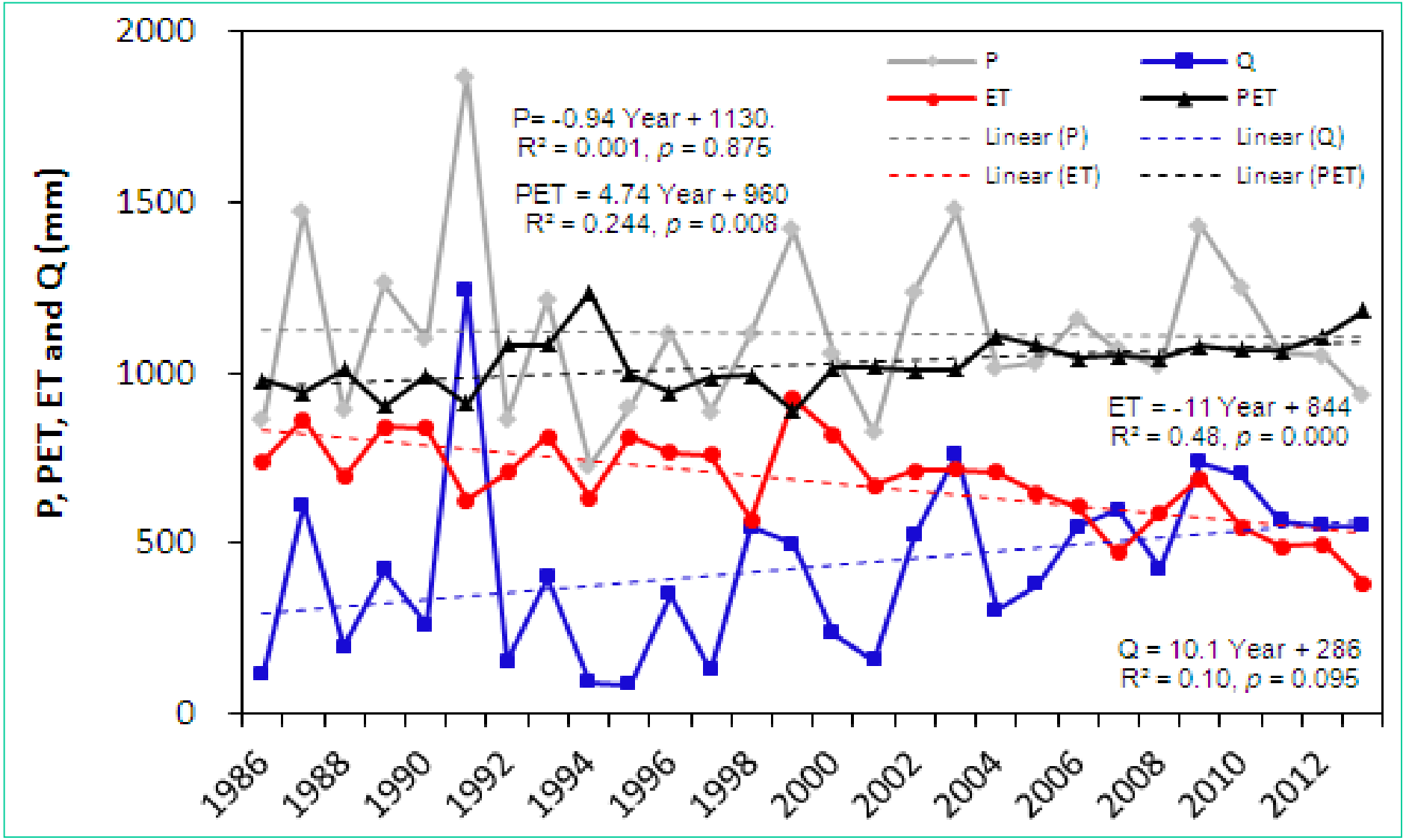
南京秦淮河流域土地利用/覆被变化 (LULCC, Nanjing, China)



- 城市：9.4% —24.1%
- 稻田： 42% —33.4%
- 菜地： 29.9%—26.2%
- 林地： 13.6%—11.9%
- 水域： 4.8%—4.3%

Elevated Runoff by reducing ET

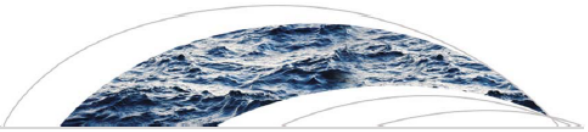
(Hao et al. HESS, 2015)



ET and Urban Dry Isalnd

(Hao et al. Water Resources Research 2018)

AGU100 ADVANCING EARTH AND SPACE SCIENCE



Water Resources Research

RESEARCH ARTICLE

10.1029/2018WR023002

Key Points:

- Proposed urban dry island (UDI) to characterize urbanization effects on reducing atmospheric humidity and elevating vapor pressure deficit
- Enhanced UDI effects are explained by feedback of the ecohydrological cycle to urban land cover change
- Urban heat island and UDI effects are coupled and should be collectively addressed in urban planning and climate change assessment

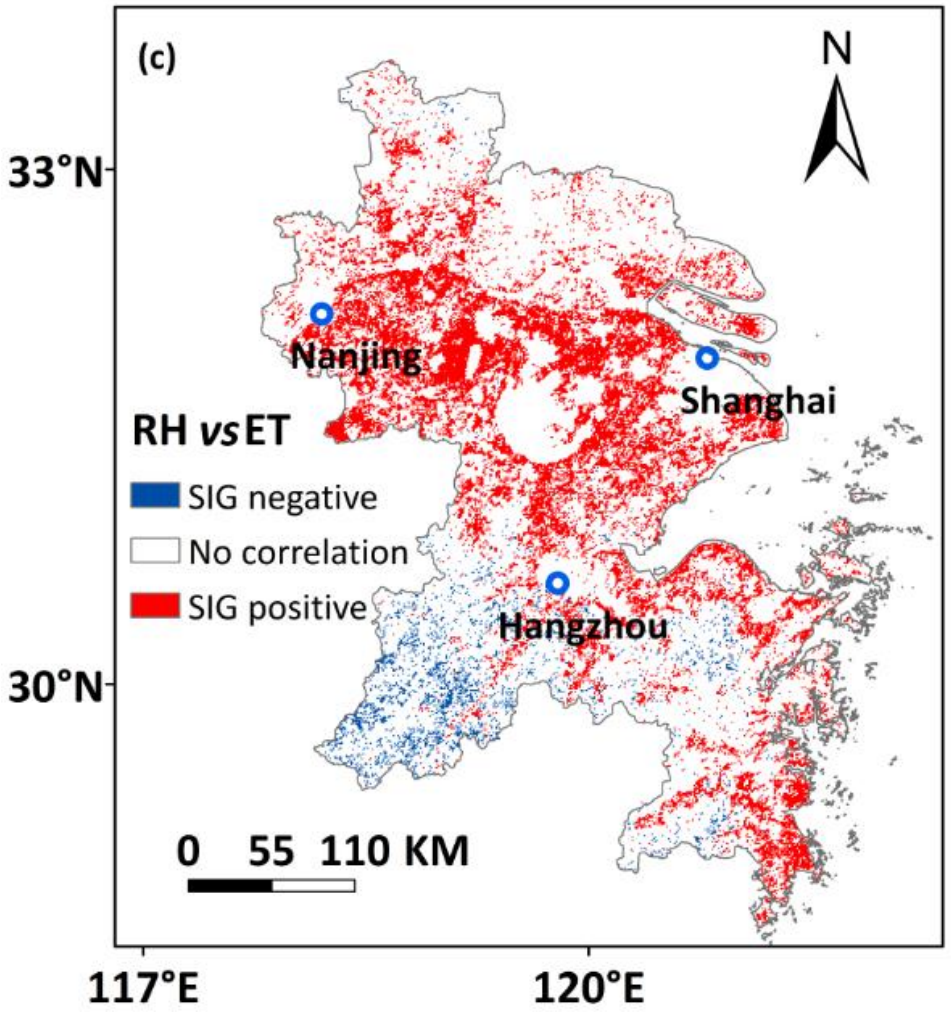
Ecohydrological Processes Explain Urban Dry Island Effects in a Wet Region, Southern China

Lu Hao[1], Xiaolin Huang[1], Mengsheng Qin[1], Yongqiang Liu[2], Wenhong Li[3], and Ge Sun[4]

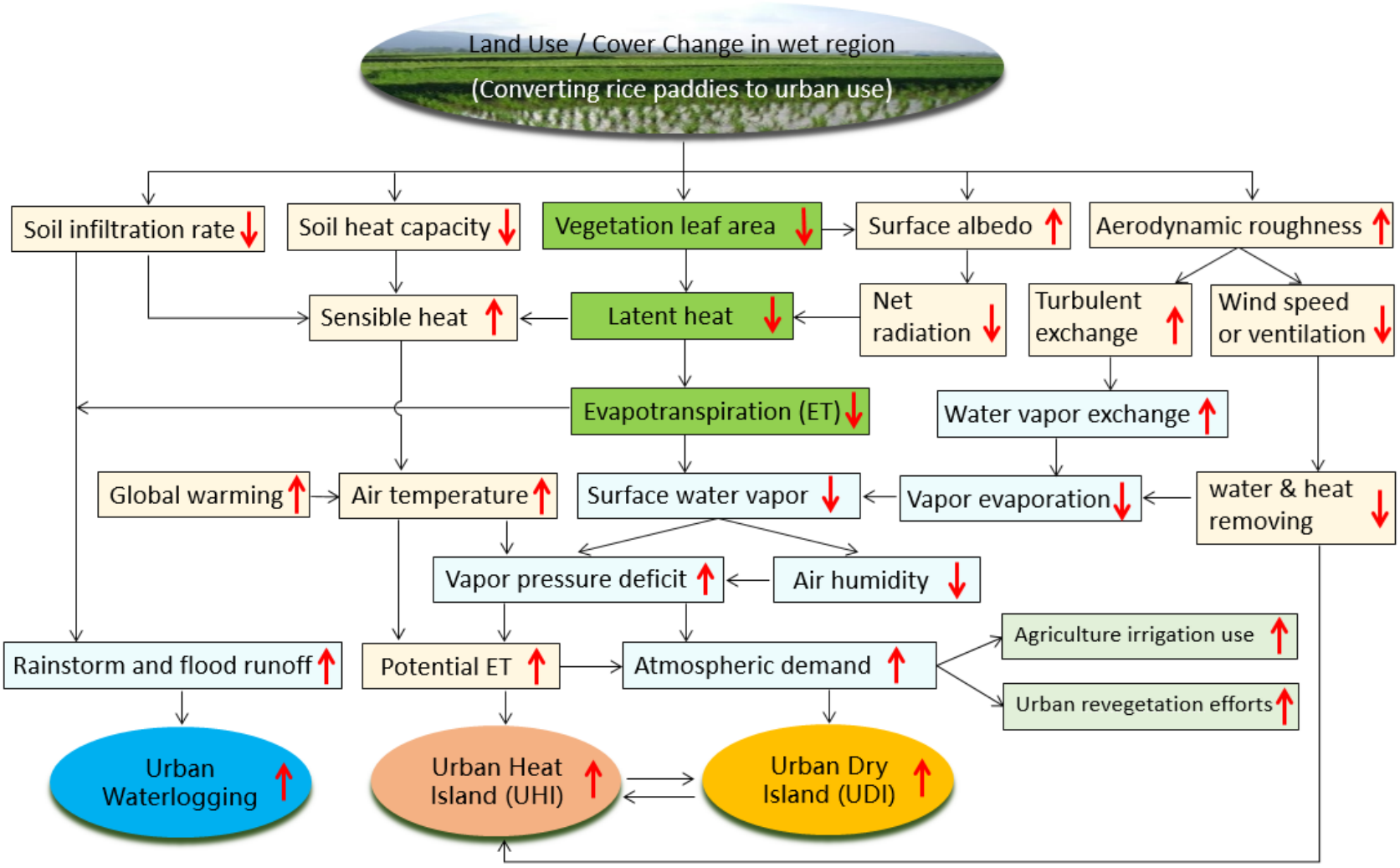
[1]Key Laboratory of Meteorological Disaster, Ministry of Education/Joint International Research Laboratory of Climate and Environment Change/Jiangsu Key Laboratory of Agricultural Meteorology, Nanjing University of Information Science and Technology, Nanjing, China, [2]Center for Forest Disturbance Science, Southern Research Station, USDA Forest Service, Athens, GA, USA, [3]Earth and Ocean Sciences, Nicholas School of the Environment, Duke University, Durham, NC, USA, [4]Eastern Forest Environmental Threat Assessment Center, Southern Research Station, USDA Forest Service, Research Triangle Park, NC, USA

ET and LAI Explains Meteo Change !

(Hao et al. Water Resources Research 2018)



ET Explains Environmental Change



Hao et al. WRR 2018

We are in the News

(Hao et al. Water Resources Research)


扬子晚报

新街口为什么比江宁"更干更热"？

娄勤俭给花港一小同学们回信

勉励孩子们做祖国建设的有用人才，祝全省小朋友"六一"节快乐

刘欣加油！

"乡蝇子"入侵江苏

稀土可能成为中国对美反制筹码？

"青春共读70年" 周六走进江南大学

CLIMATE CHANGE

Research Spotlight

The Urban Dry Island Effect

A study of the Yangtze River Delta shows how urbanization dries out the atmosphere.

SOURCE: *Water Resources Research*

THE SKYLINE 天际新闻网

SEARCH...

首页 > 媒体聚焦

城市里小雨大涝怎么破？南信大教授研究成果登上顶级期刊

2019-05-29 来源：南报网 作者：林雯 谈洁

责编：林雯 访问量： 51

下了一点点雨，怎么就到处涝呢城市遇到的问题。南京信息工程大学院郝璐教授团队的一项针对长三角地果表明，"小雨大涝"并非只是城市排题，这还和区域大范围湿地和森林转导致蒸散变化有关。近日，该成果发资源领域国际顶级期刊《水资源研究Resources Research）上。

www.news.cn 新华网 NEWS

新街口为啥比江宁"更干更热"？"城市干岛"加重"城市热岛"效应

2019年05月29日 09:05:36 来源： 扬子晚报

如果你经常从江宁乘坐地铁到新街口，一下车你就能明显感觉，新街口的温度似乎一直比江宁要高一些。这背后到底是什么原因导致的？近日，南京信息工程大学应用气象学院郝璐教授带领的生态水文气象国际合作团队在针对长三角地区的研究中发现，无论是"城市热岛"效应、"城市干岛"效应，还是"小雨大涝"现象，都与这一区域大范围湿地和森林转为城市用地导致蒸散发变化有关。据悉，该成果发表在水文水资源领域国际顶级期刊《水资源研究》上。

为何新街口比江宁更干更热、秦淮河流域排水不畅？南信大教授为城市环境问题支招

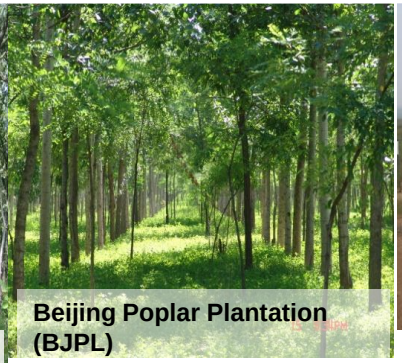
荔枝新闻 2019-05-28 20:13

荔枝新闻讯 在南京苏州这样的亚热带湿润地区，城市气候到底是变得"更湿更热"还是"更干更热"，这个问题一直存在争议。

近日，南京信息工程大学应用气象学院郝带领的生态水文气象国际合作团队在针角地区的研究中发现，无论是"城市热应、"城市干岛"效应还是"小雨大涝"现与这一区域大范围湿地和森林转为城市致蒸散发变化有关。

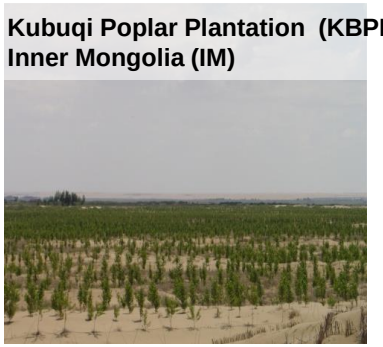
中美碳联盟通量观测网络 （USCCC)

Oak Opening, Toledo, Ohio (OHOO)

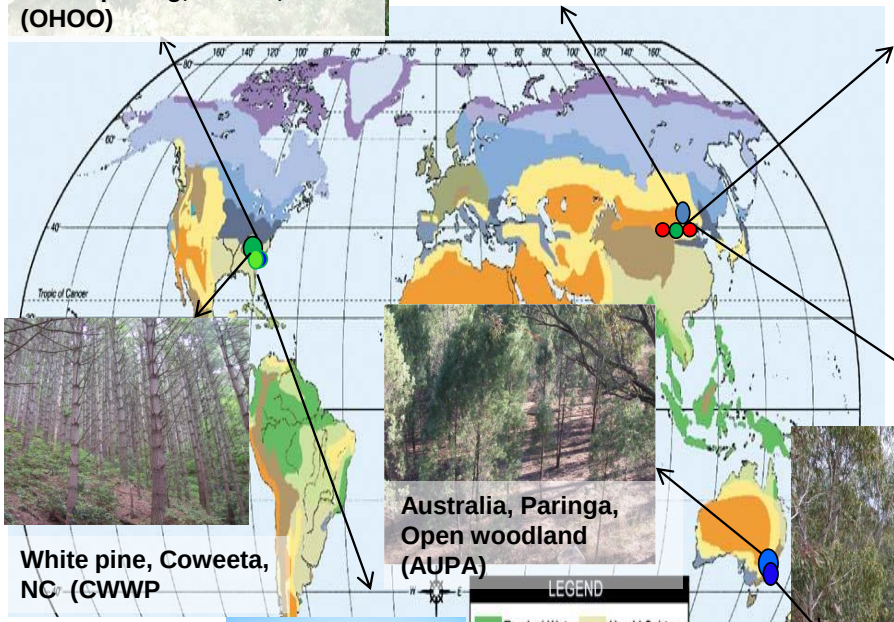


Beijing Poplar Plantation (BJPL)

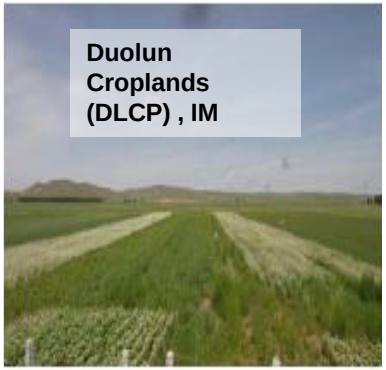
Kubuqi Shrubland (KBSB), Inner Mongolia (IM)



Kubuqi Poplar Plantation (KBPL) , Inner Mongolia (IM)



Duolun Steppe (DLSP) , IM



Duolun Croplands (DLCP) , IM

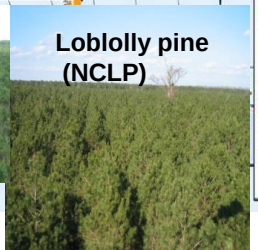
White pine, Coweeta, NC (CWWP

Australia, Paringa, Open woodland (AUPA)

Australia, Castlereagh, Western Sydney (AUWS)

Xilinhot Grazed Grassland (XLDS) , IM

Clearcut (NCCC)



Loblolly pine (NCLP)

Xilinhot Fenced Grassland (XLSP) , IM

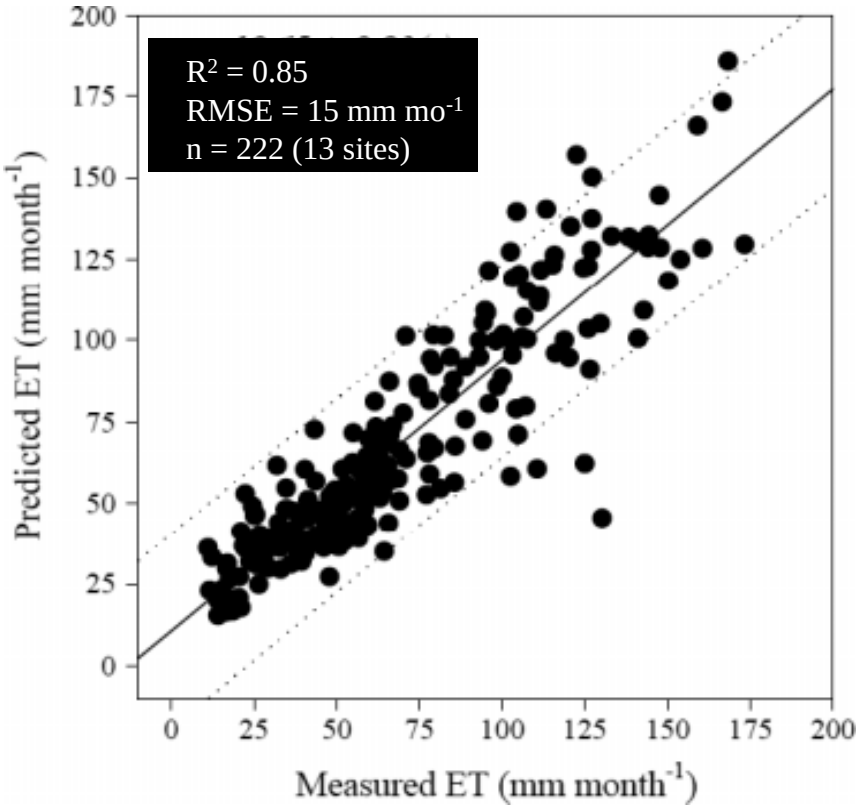
ECOHYDROLOGY
Ecohydrol. (2010)
Published online in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/eco.194

月尺度蒸发散模型

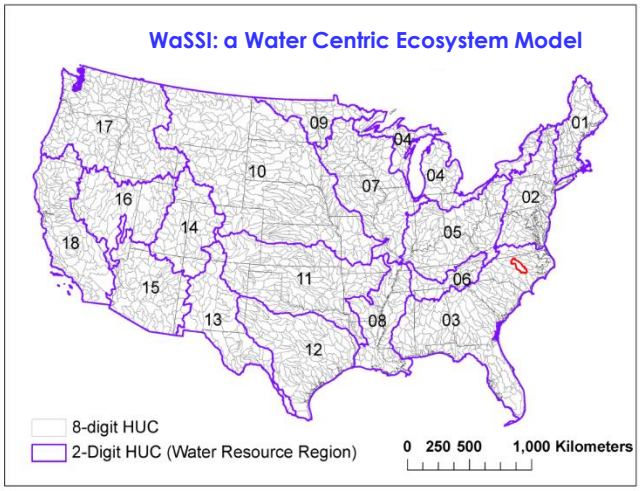
A general predictive model for estimating monthly ecosystem evapotranspiration

Ge Sun,[1]* Karrin Alstad,[2] Jiquan Chen,[2] Shiping Chen,[3] Chelcy R. Ford,[4] Guanghui Lin,[3] Chenfeng Liu,[5] Nan Lu,[2] Steven G. McNulty,[1] Haixia Miao,[3] Asko Noormets,[6] James M. Vose,[4] Burkhard Wilske,[2] Melanie Zeppel,[7] Yan Zhang[5] and Zhiqiang Zhang[5]

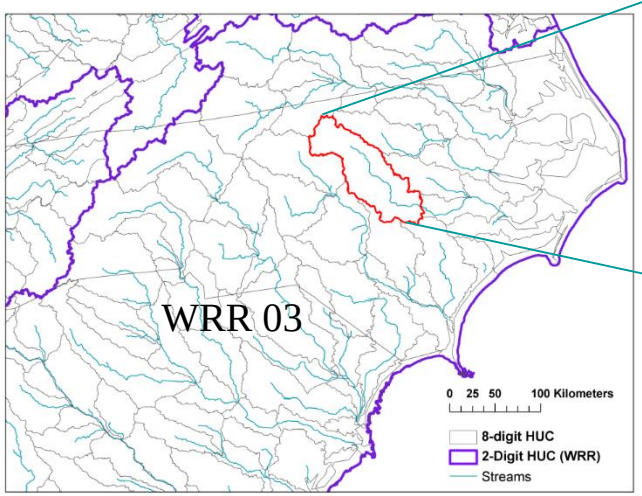
$$ET = 11.94 + 4.76*LAI + PET*(0.032*LAI + 0.0026*P + 0.15)$$

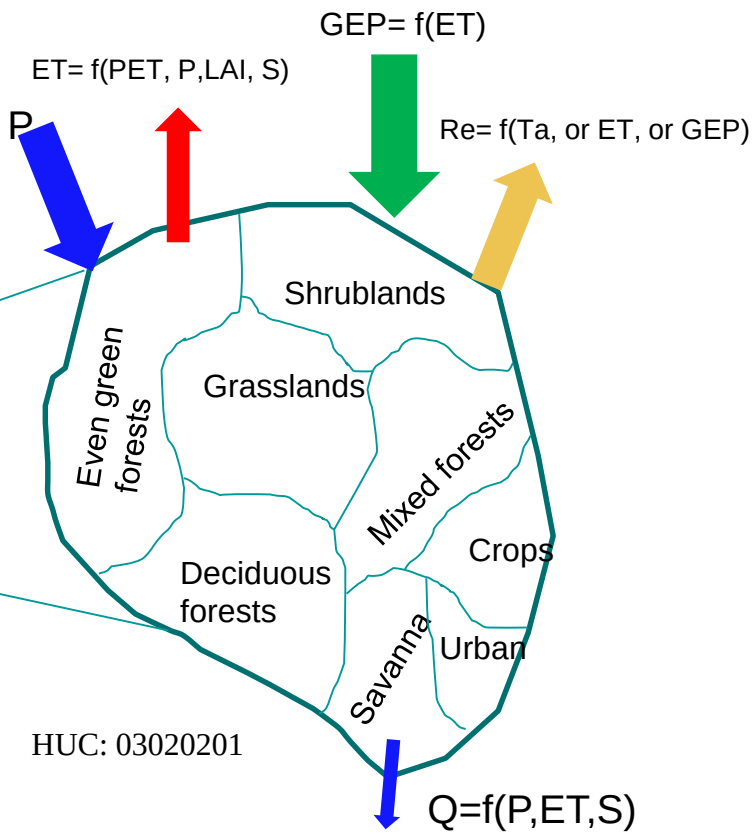


Model Validations with ET are Rare

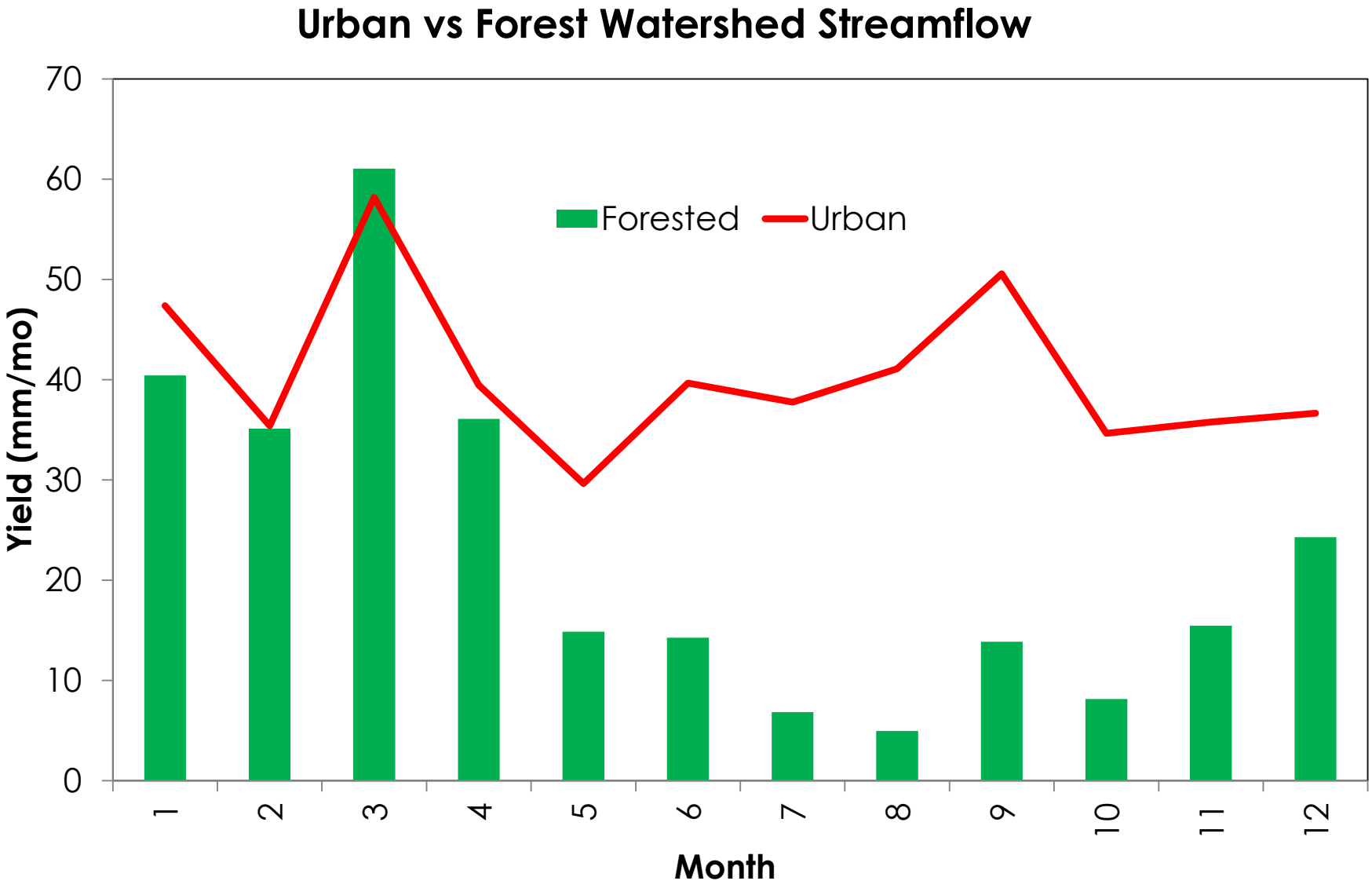


Water balance	Carbon balance
$\Delta S = P - Q - ET$	$NEE = -(GEP - Re)$



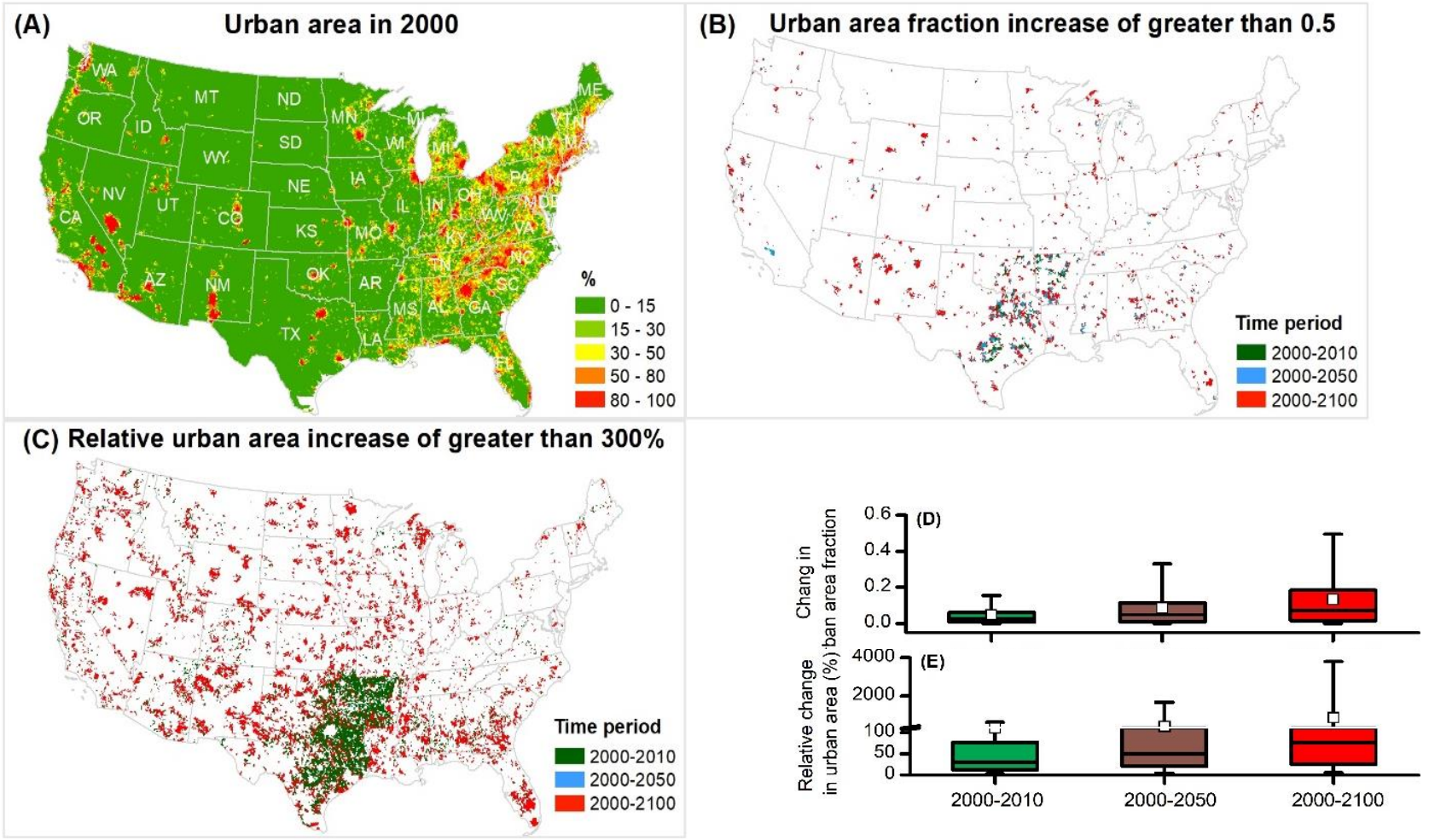


Sun et al, JGR-Biogeoscience, 2011


Urban vs Forest Watershed Streamflow
Yield (mm/mo)
70
60
50
40
30
20
10
0
Forested
Urban
1
2
3
4
5
6
7
8
9
10
11
12
Month

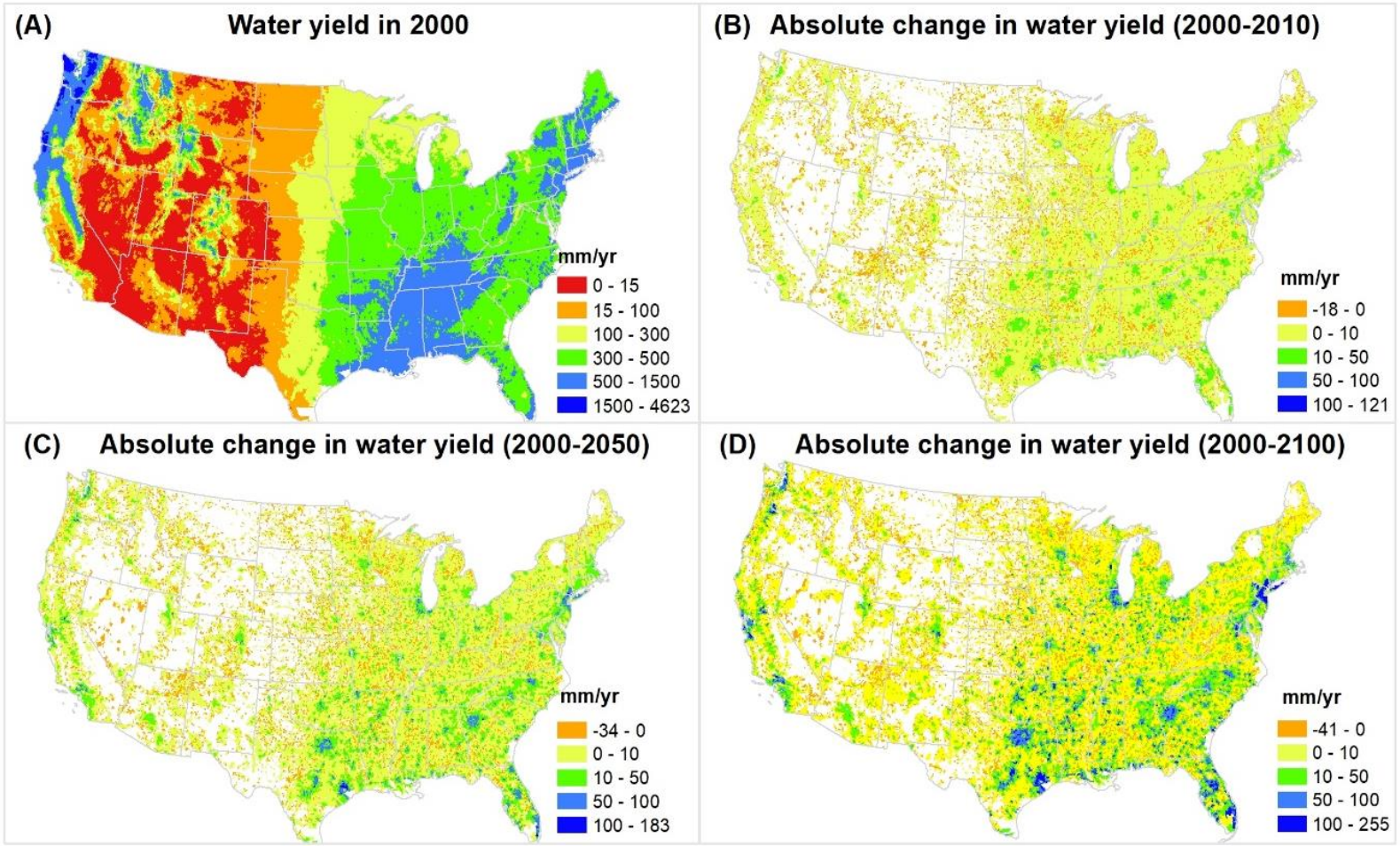
Projected Urbanization Effects on Water Yield in 2040

(Submitted HESS, 2019; Li C. et al.)

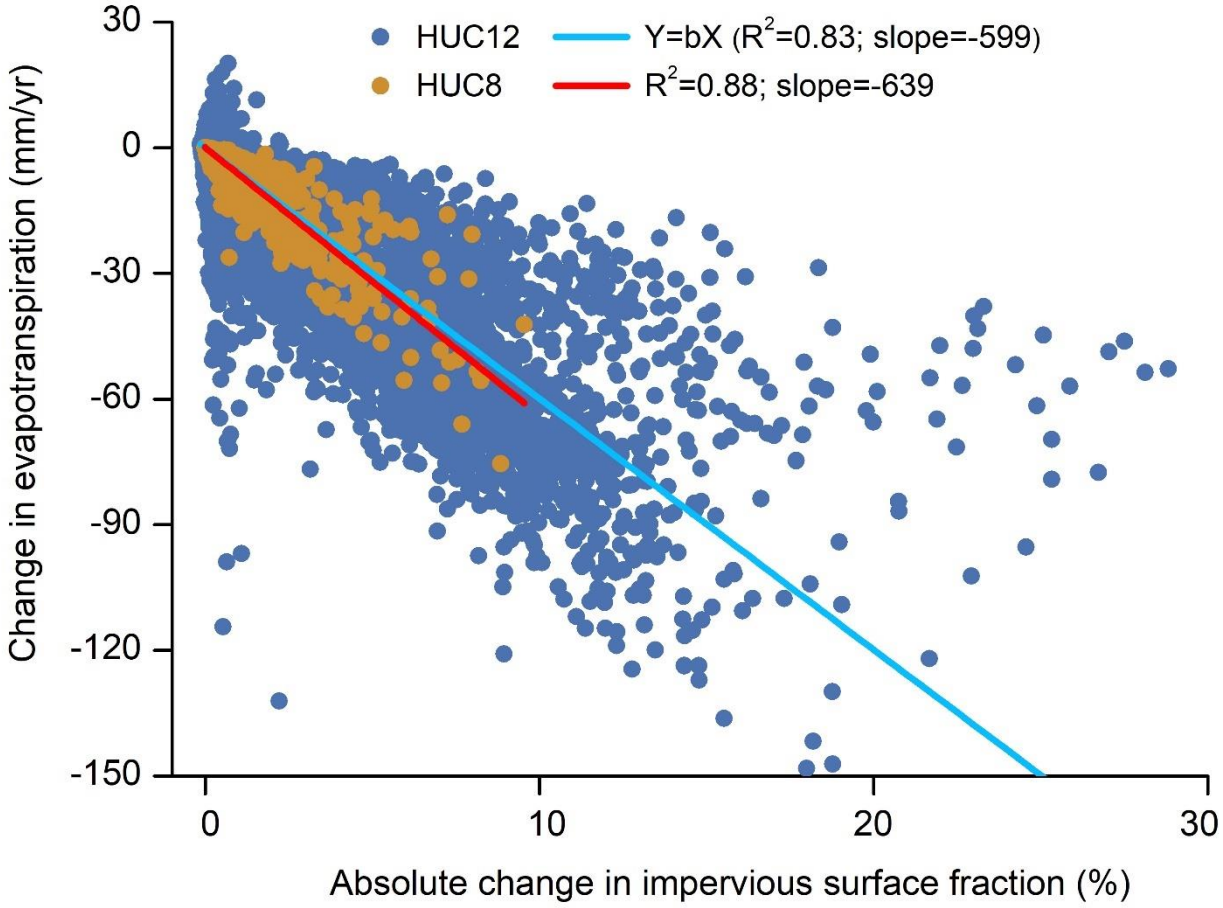


Projected Urbanization Effects on Water Yield in 2040

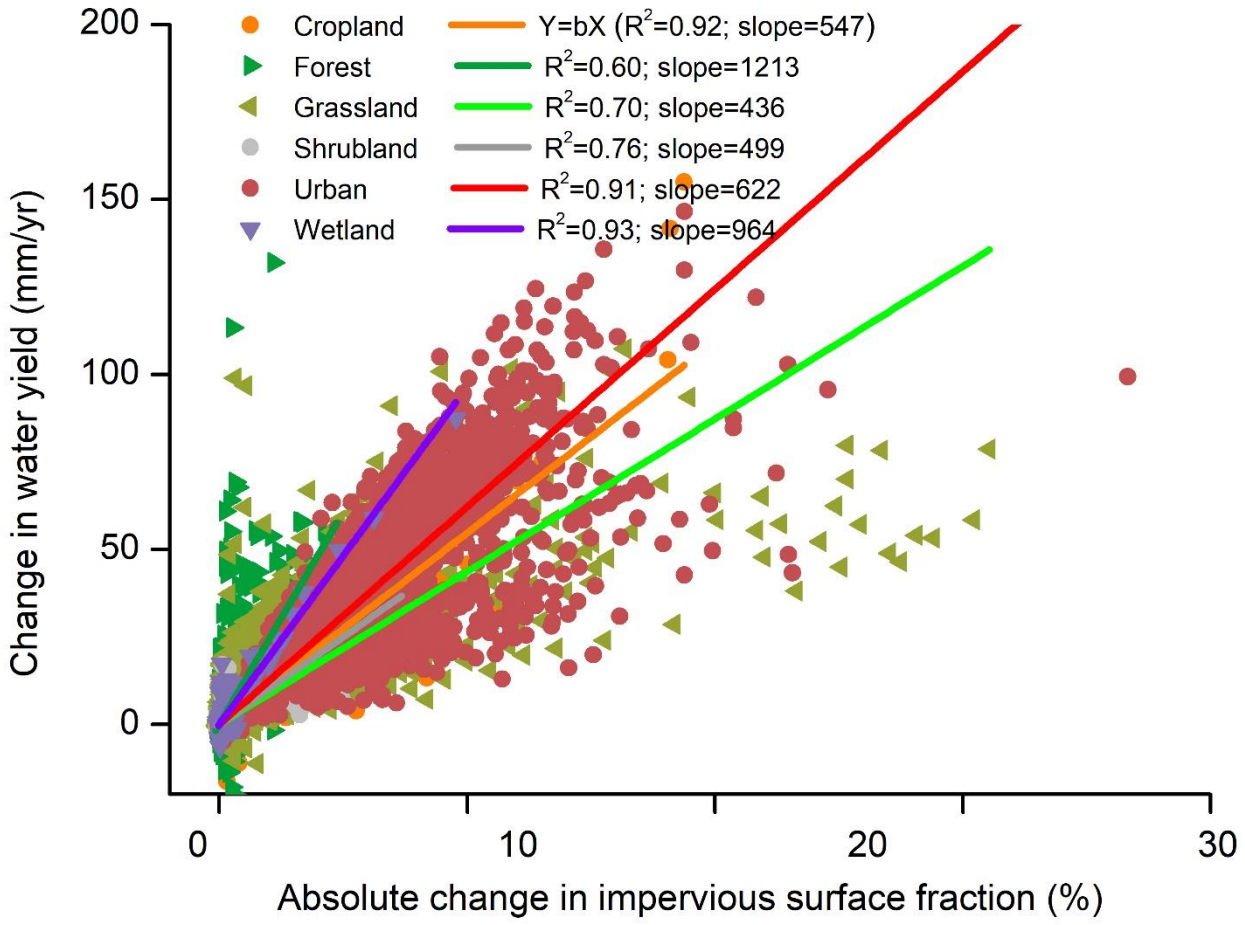
(*Submitted to HESS, Li et al., 2019)*



Projected Urbanization Effects on Water Yield in 2040 (Submitted HESS, 2019)

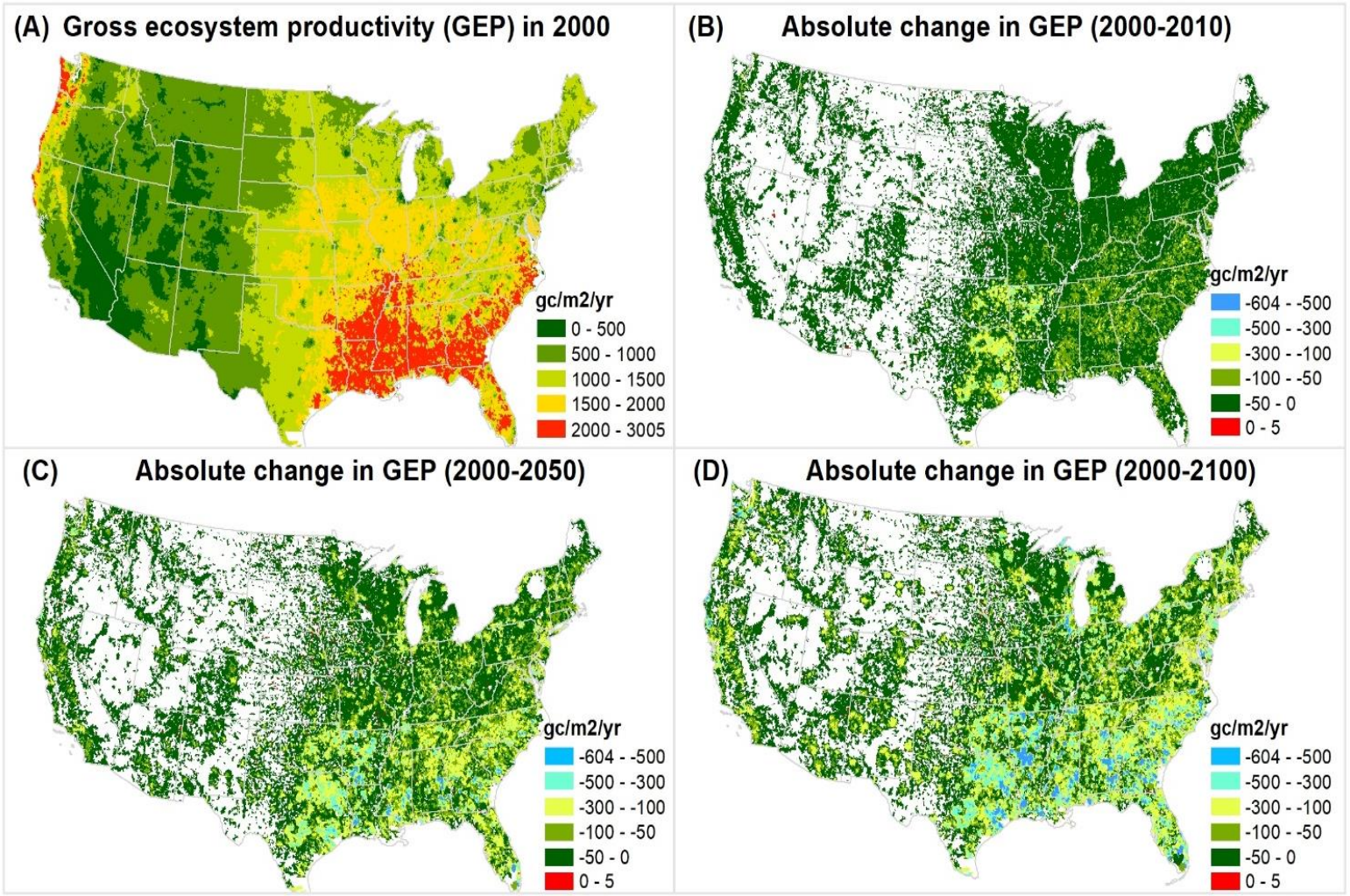


Projected Urbanization Effects on Water Yield in 2040 (Submitted HESS, 2019)



Projected Urbanization Effects on GEP-Water Tradeoffs

(Submitted J of Hydrology, 2019; Li C. et al.)



Take Home

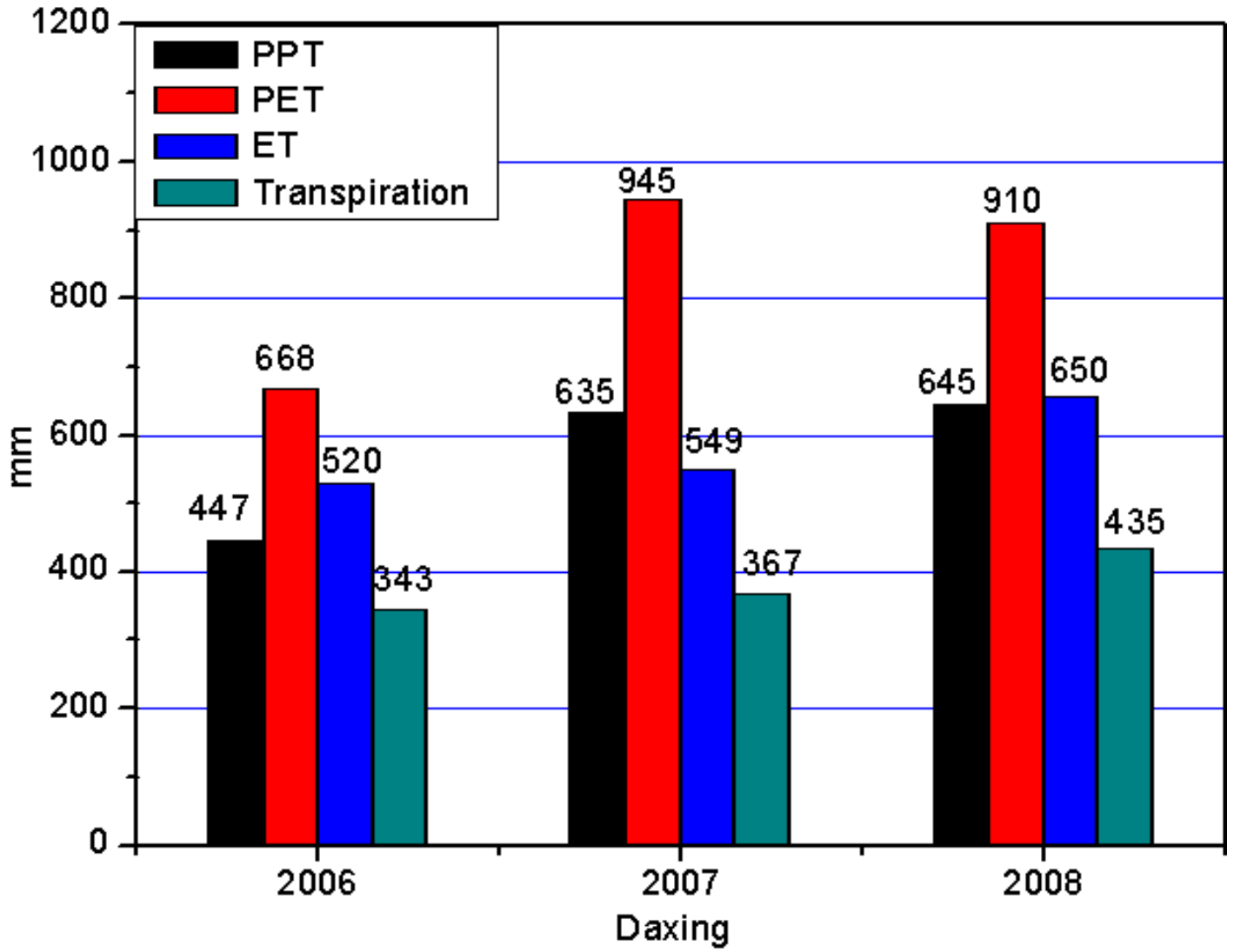
1. **ET is major linkage to ecosystem functions and services**

2. **Ecosystems need a lot of water to realize the ecosystem services (climate moderation, pollution abatement, soil erosion control ..)** 森林抽水机，碳汇，湿地空调机功能

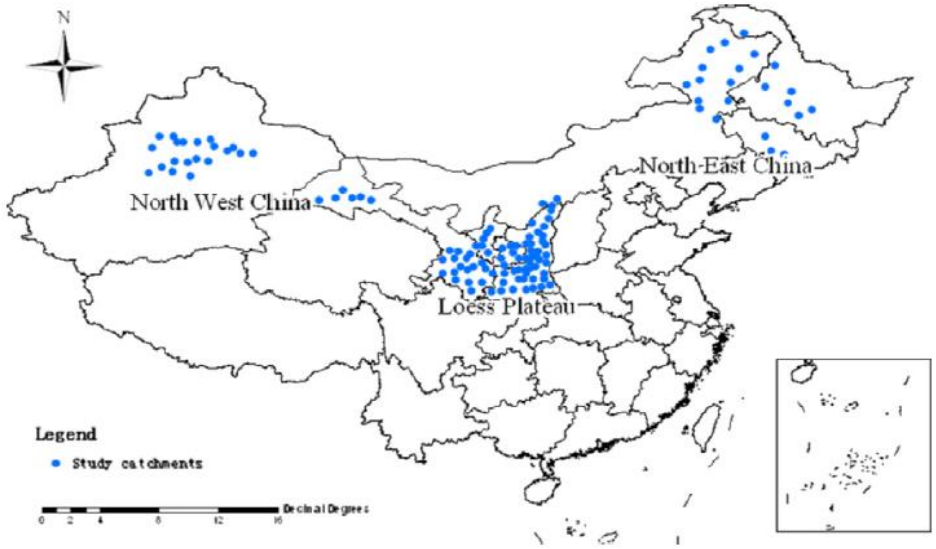
3. **Water shortage major challenge under climate change and urbanization** 水资源危机

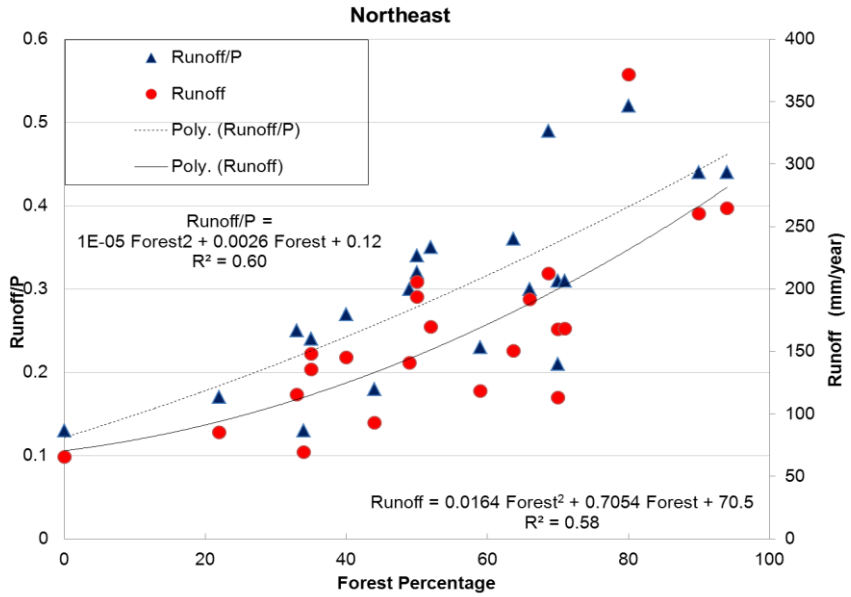
北京大兴杨树林水量平衡

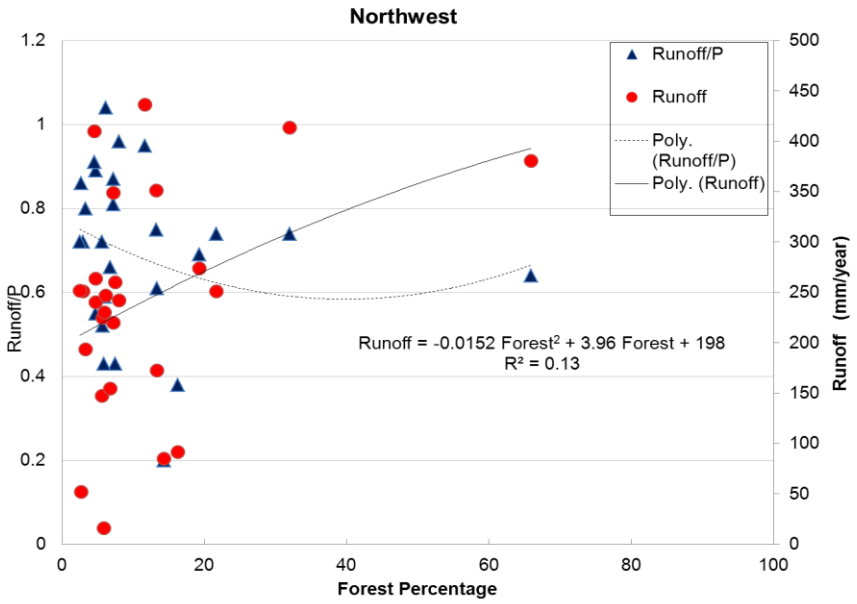
(Beijing Forestry University Data Dr. Zhiqiang Zhang)

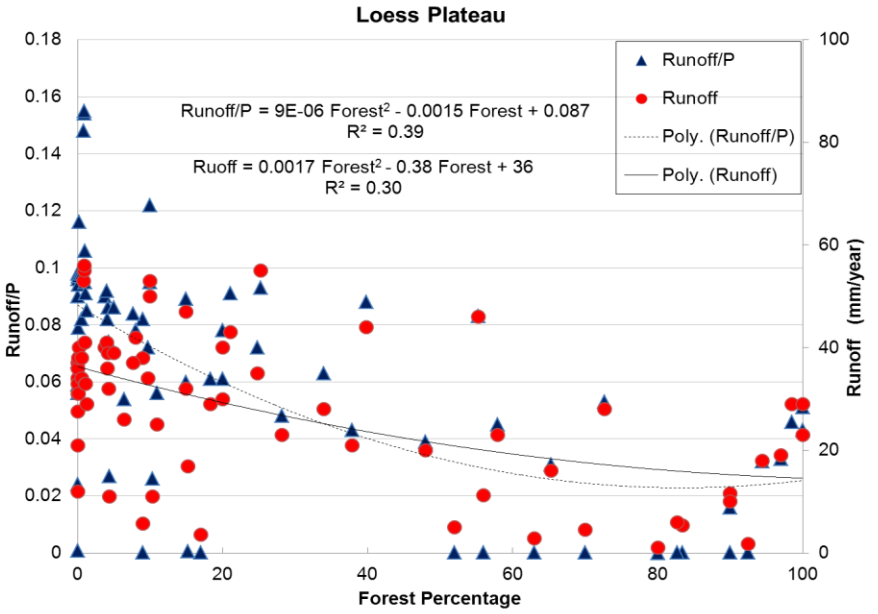


SGCP









(Wang et al. For Eco Man 2014)