8TH INTERNATIONAL WILDLAND FIRE CONFERENCE

GOVERNANCE PRINCIPLES: Towards an International Framework

Effect of Fire Disturbance on Soil Respiration and Nitrogen Availability in Boreal Forest of China

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Long sun Professor

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2023-5-19

BRITISH ECOLOGICAL SOCIETY

IRN Cold Forests

Association for Fire Ecology

NORTHEAST FORESTRY UNIVERSITY 1952

NSFC

CHINA FOREST FIRE MANAGEMENT

Outline

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- Fire Disturbance on Soil Respiration
- Black Carbon Effect on Soil Carbon Stability
- Fire Disturbance on Soil N availability

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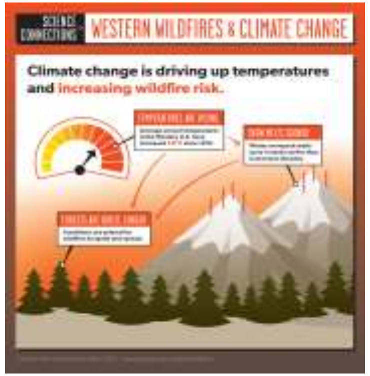
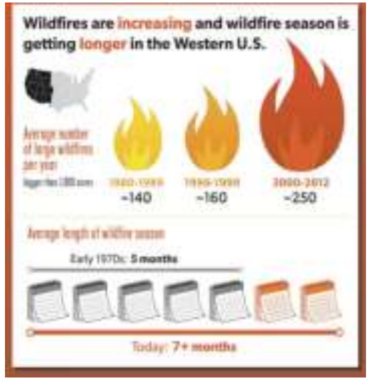
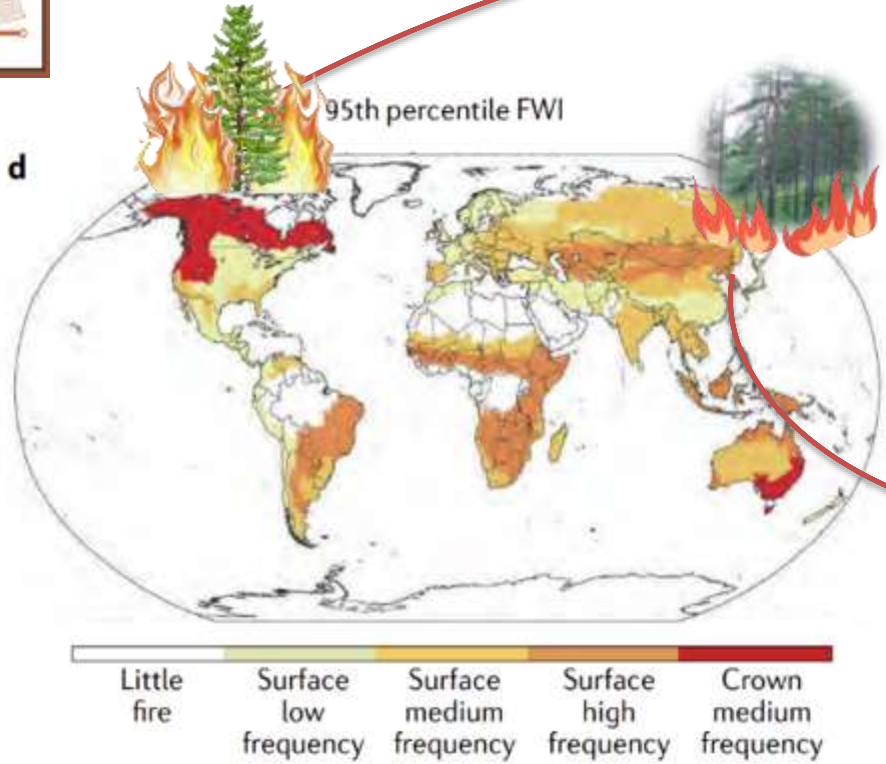




- *Climate Change*
- *Longer Fire Seasons*
- *Extreme Fire Danger*



North American Black Spruce

Asian Larch

(Bowman, David MJS, Nat. Rev. Earth Environ., 2020)

Research Background

➢ *Boreal Forest- Wildfire-Climate feedback*

➢ *Wildfire-Positive feedback*

Mack et al., 2011, *Nature*

LETTER

doi:10.1038/nature10283

Carbon loss from an unprecedented Arctic tundra wildfire

Michelle C. Mack[1], M. Syndonia Bret-Harte[2], Teresa N. Hollingsworth[3], Randi R. Jandt[4], Edward A. G. Schuur[1], Gaius R. Shaver[5] & David L. Verbyla[6]

Walker et al., 2019, *Nature*

LETTER

https://doi.org/10.1038/s41586-019-1474-y

Increasing wildfires threaten historic carbon sink of boreal forest soils

Xanthe J. Walker[1*], Jennifer L. Baltzer[2], Steven G. Cumming[3], Nicola J. Day[2], Christopher Ebert[1], Scott Goetz[1,4,5], Jill F. Johnstone[6,7], Stefano Potter[5], Brendan M. Rogers[5], Edward A. G. Schuur[1,8], Merritt R. Turetsky[9,10] & Michelle C. Mack[1,8]

Zheng et al., 2023, *Science*

Record-high CO_2 emissions from boreal fires in 2021

BO ZHENG, PHILIPPE CIAIS, FREDERIC CHEVALLIER, HUI YANG, JOSEP G. CANADELL, YANG CHEN, IVAR R. VAN DER VELDE, ILSE ABEN, EMILIO CHUVIECO, [...], AND QIANG ZHANG +8 authors Authors Info & Affiliations

SCIENCE • 2 Mar 2023 • Vol 379, Issue 6635 • pp. 912-917 • DOI: 10.1126/science.ade0805

➢ *Wildfire-Negative-feedback*

Randerson et al., 2006, *Science*

The Impact of Boreal Forest Fire on Climate Warming

J. T. RANDERSON, H. LIU, M. G. FLANNER, S. D. CHAMBERS, Y. JIN, P. G. HESS, G. PFISTER, M. C. MACK, K. K. TRESEDER, L. R. WELP, F. S. CHAPIN, J. W. HARDEN, M. L. GOULDEN, E. LYONS, J. C. NEFF, E. A. G. SCHUUR, AND C. S. ZENDER fewer Authors Info & Affiliations

SCIENCE • 17 Nov 2006 • Vol 314, Issue 5802 • pp. 1130-1132 • DOI: 10.1126/science.1132075

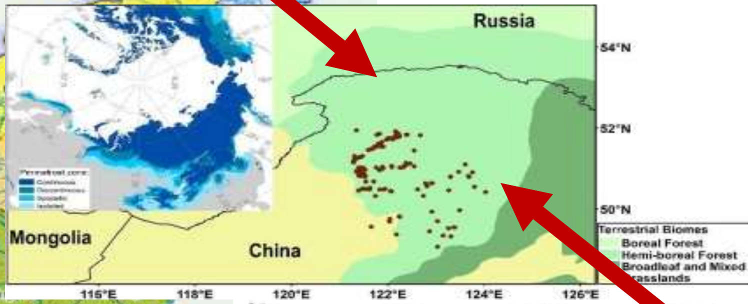
Mack et al., 2021, *Science*

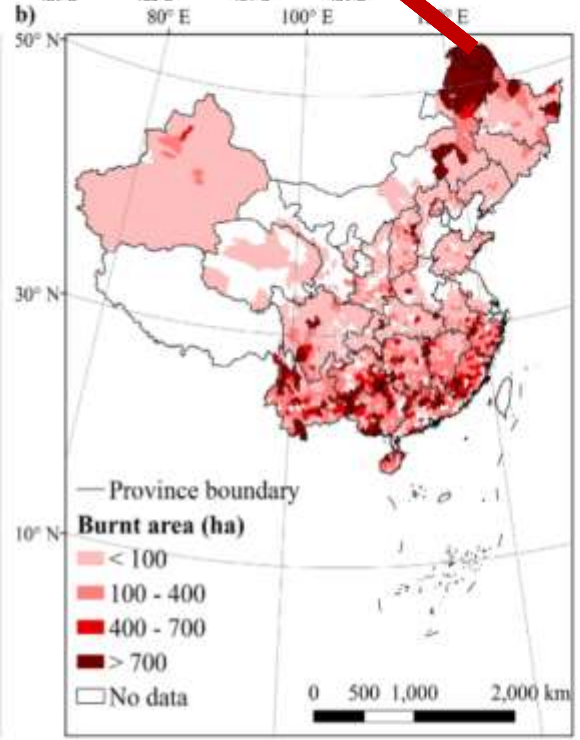
Carbon loss from boreal forest wildfires offset by increased dominance of deciduous trees

MICHELLE C. MACK, XANTHE J. WALKER, JILL F. JOHNSTONE, HEATHER D. ALEXANDER, APRIL M. MELVIN, MÉLANIE JEAN, AND SAMANTHA N. MILLER Authors Info & Affiliations

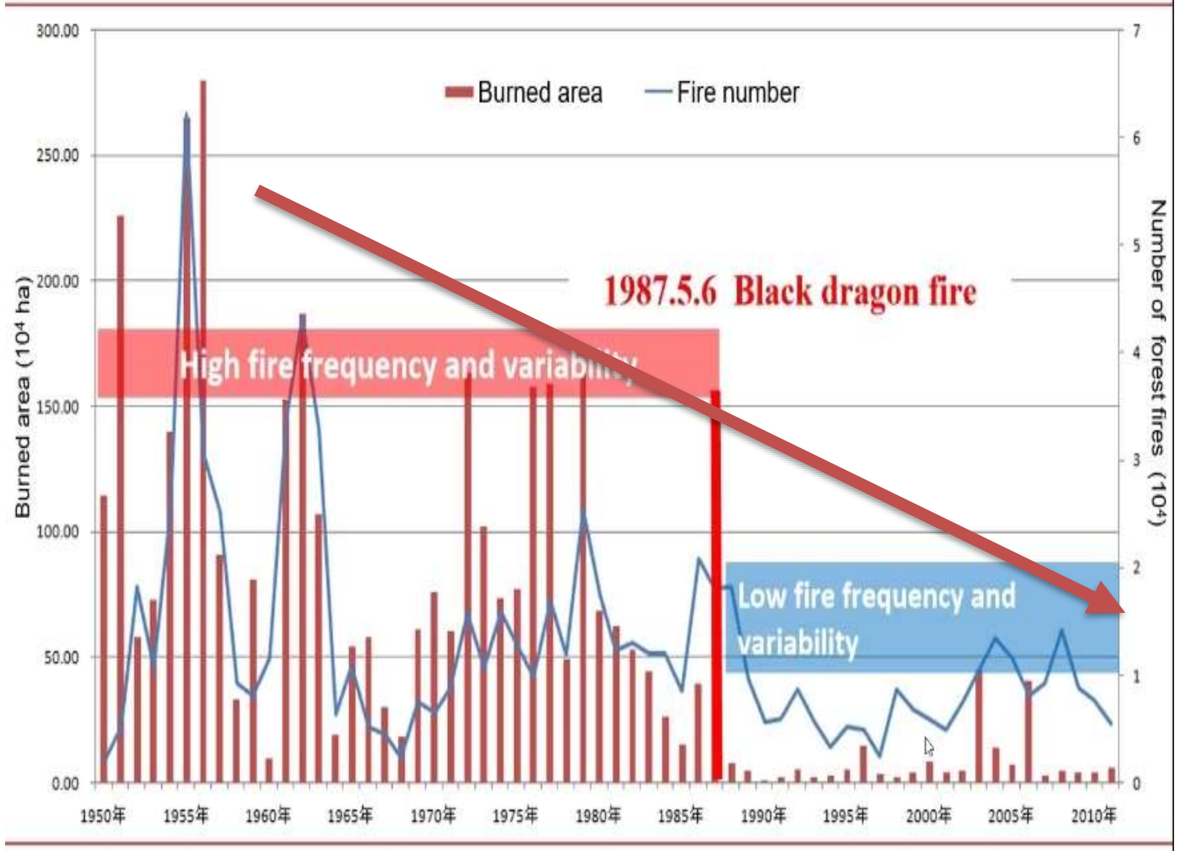
SCIENCE • 16 Apr 2021 • Vol 372, Issue 6539 • pp. 280-283 • DOI: 10.1126/science.abf3903

Research Background





Research Background



- ***Forest Fire in China***
- ***Chinese fire control philosophy***

Research Background

Human Ecology
https://doi.org/10.1007/s10745-020-00183-z

Check for updates

Fire Suppression and the Wildfire Paradox in Contemporary China: Policies, Resilience, and Effects in Chinese Fire Regimes

Jack Patrick Hayes[1]

(Moritz et al., PNAS., 2005)

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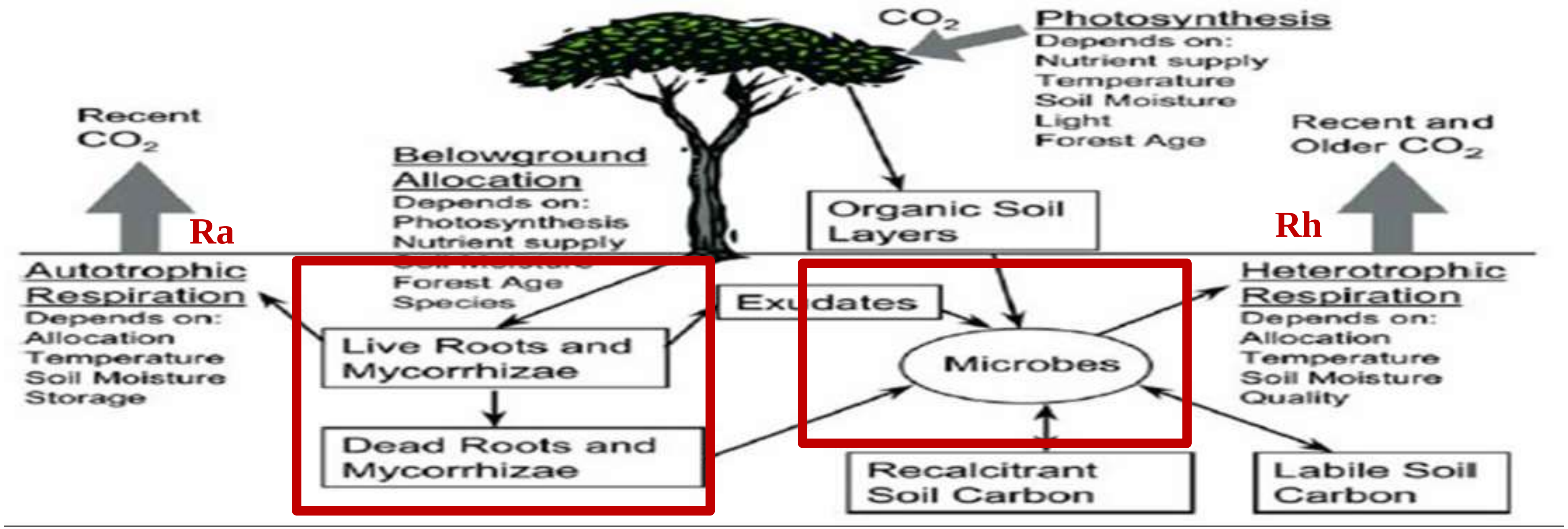
1. Fire Disturbance on Soil Respiration

Fire affects Rs directly by affecting soil microbial activities and plant roots, especially fine roots ,and indirectly by changing soil pH, soil nutrient availability, and substrate quality, which are related to soil microorganisms and fine roots.



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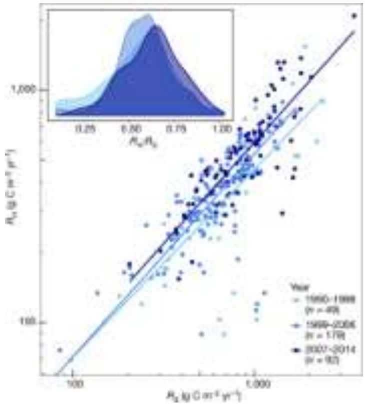
1. Fire Disturbance on Soil Respiration

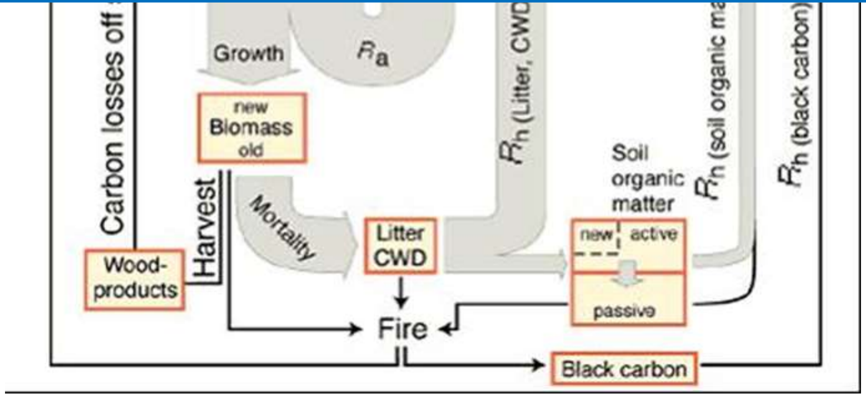
Soil respiration is the primary path by which CO_2 fixed by land plants returns to the atmosphere, which is a key process of carbon cycle in terrestrial ecosystem.

Hypothesis : Fire disturbance will accelerate the increase of Rh: Rs ratio in the boreal forest ecosystem in China.

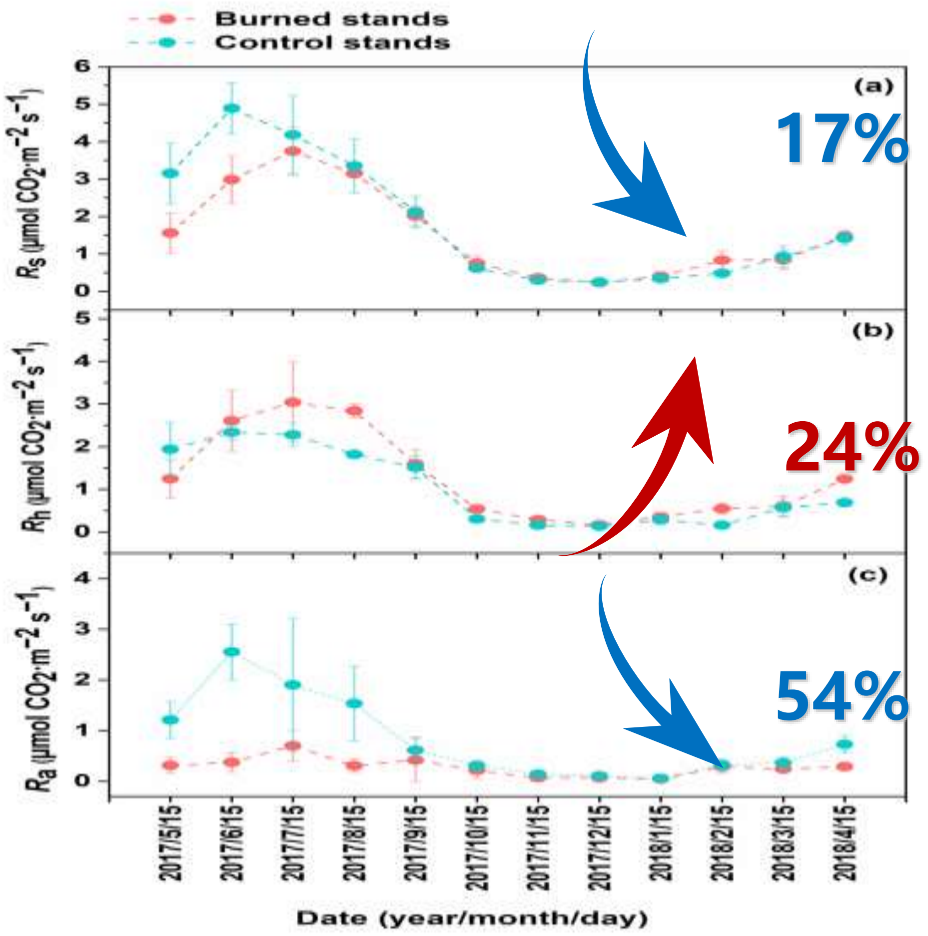


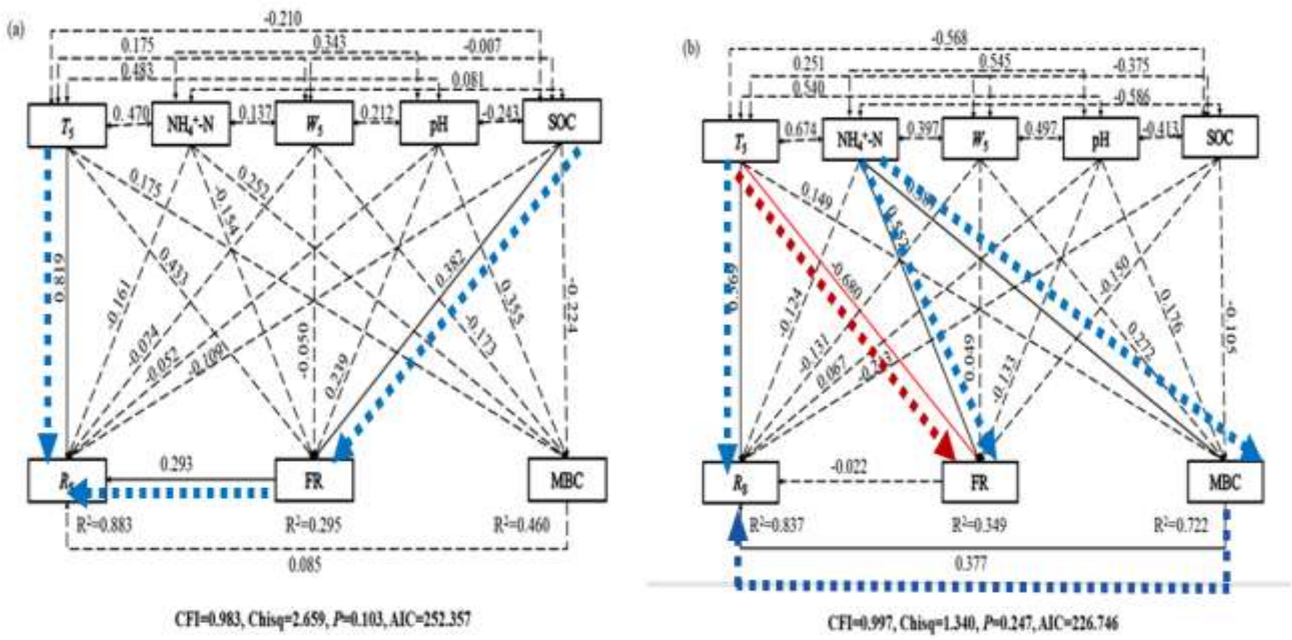
soil surface R_H:R_S ratio increased significantly, from 0.54 to 0.63, between 1990 and 2014 ($P = 0.009$).

NEP=NPP-R_H



Research Contents





Soil temperature was the main abiotic factor that affects Rs in both unburned and burned stands, whereas MBC (microbial biomass carbon), but not FR (fine root biomass), was the dominant biotic driver of Rs after fire in boreal forest of China.

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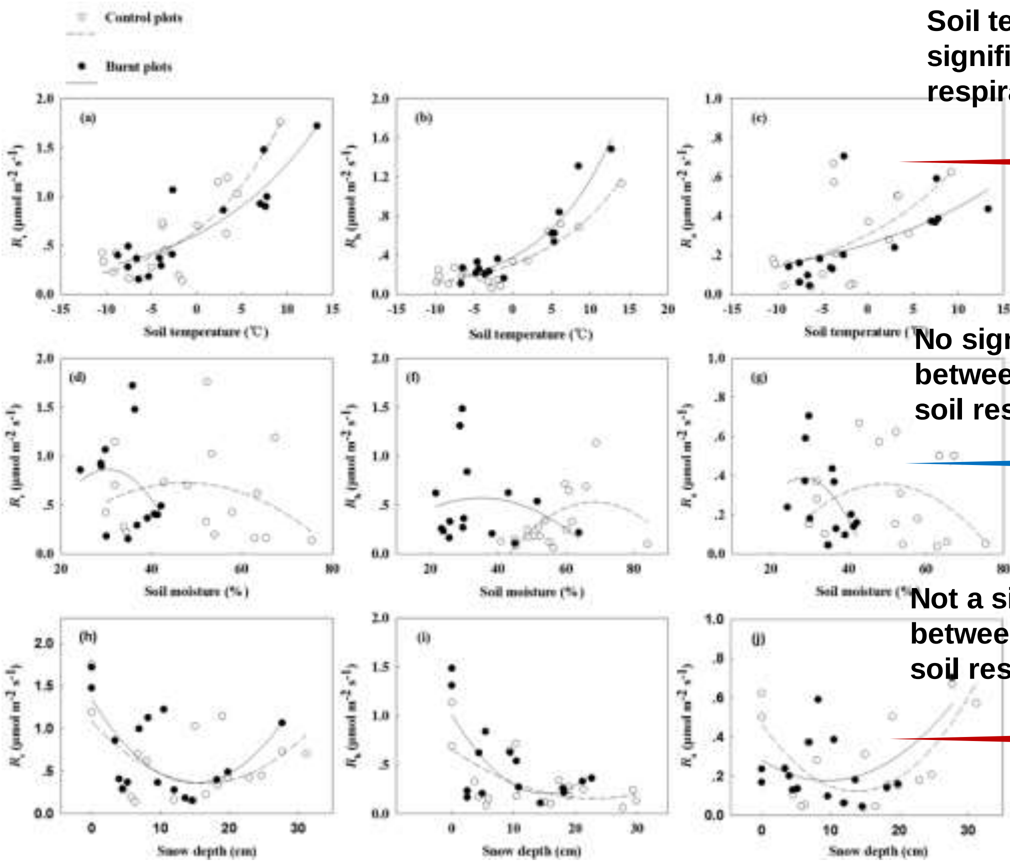
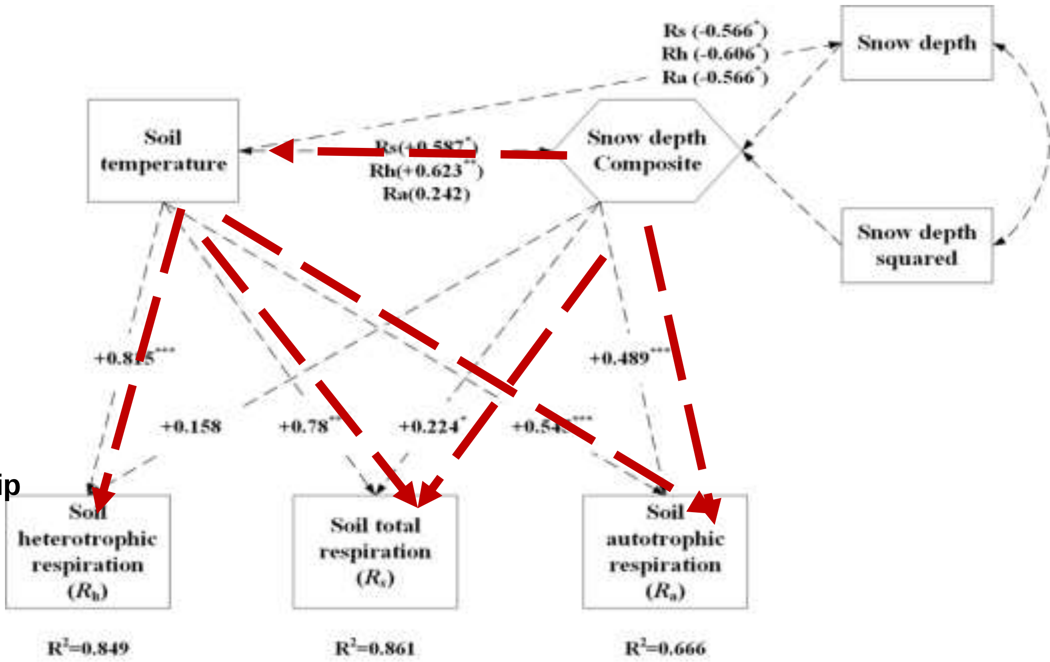


Soil temperature had a significant effect on soil respiration components.

No significant relationship between soil moisture and soil respiration components

Not a simple linear relationship between snow thickness and soil respiration composition

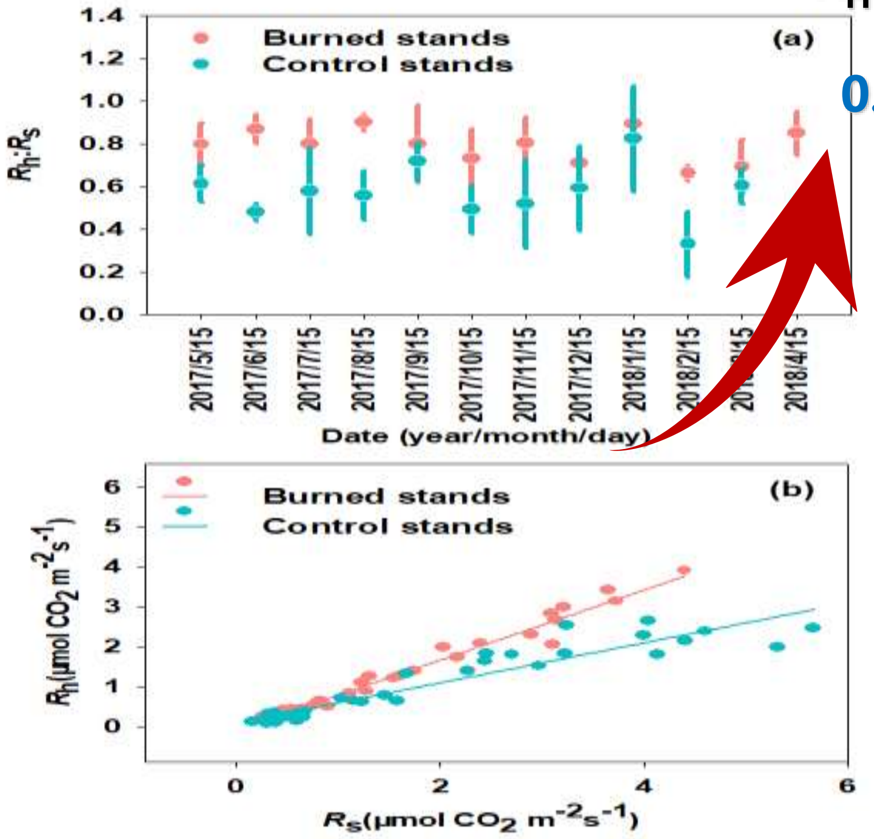


(Hu , Annual of forest science , 2021)

Research Contents

One year after fire disturbance

Growing season

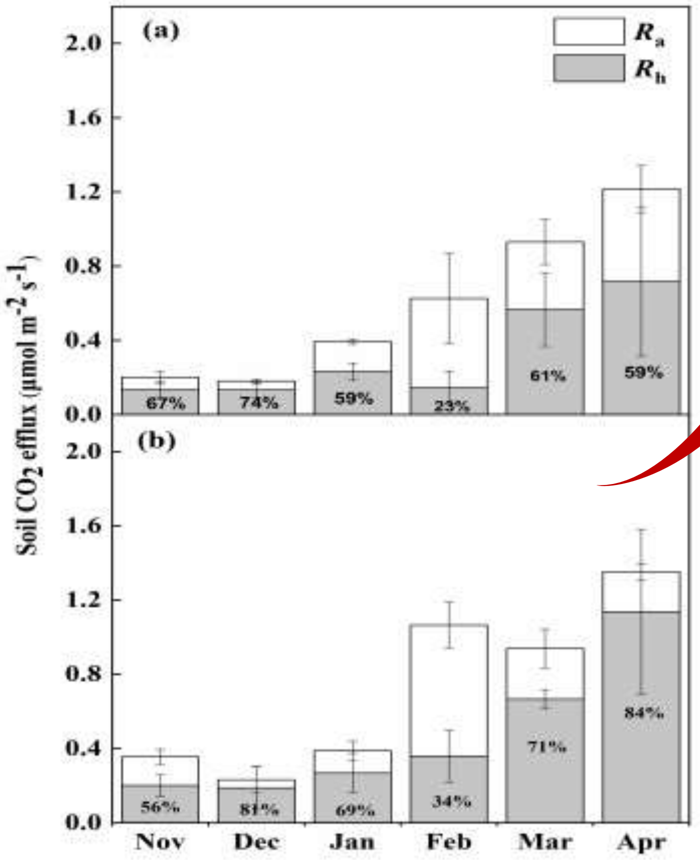


$R_H:R_S$ ratio

0.57:0.79

Geoderma (Hu et al., 2021)

Non-Growing season



$R_H:R_S$ ratio :

0.57:0.66

Annuals of forest science (Hu et al., 2021)

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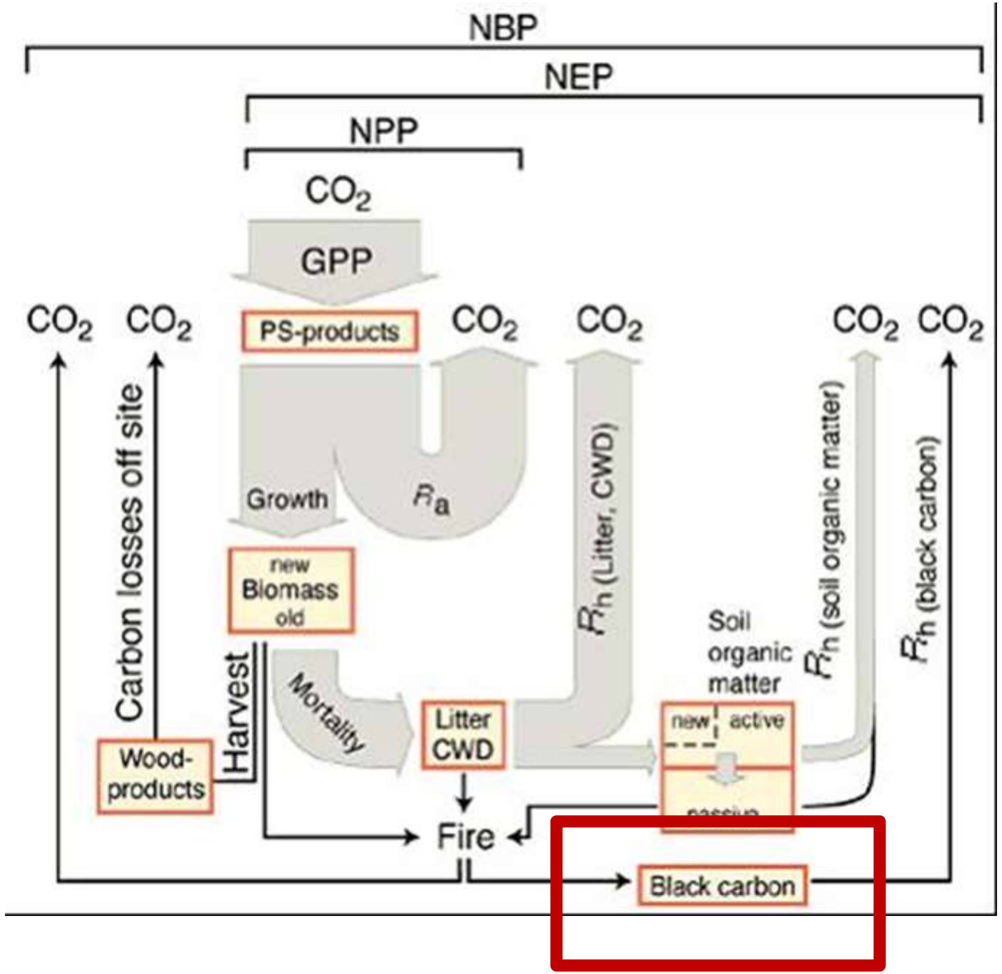
2. Black Carbon Effect on Soil Carbon Stability



Plant Soil (2018) 425:71–85
https://doi.org/10.1007/s11104-018-3568-y

REGULAR ARTICLE

Effects of biochar on carbon and nitrogen fluxes in boreal forest soil

Marjo Palviainen · Frank Berninger · Viktor J. Bruckman · Kajar Köster · Christine Ribeiro Moreira de Assumpção · Heidi Aaltonen · Naoki Makita · Anup Mishra · Liisa Kulmala · Bartosz Adamczyk · Xuan Zhou · Jussi Heinonsalo · Egle Köster · Jukka Pumpanen

Received: 8 October 2017 / Accepted: 9 January 2018 / Published online: 20 January 2018
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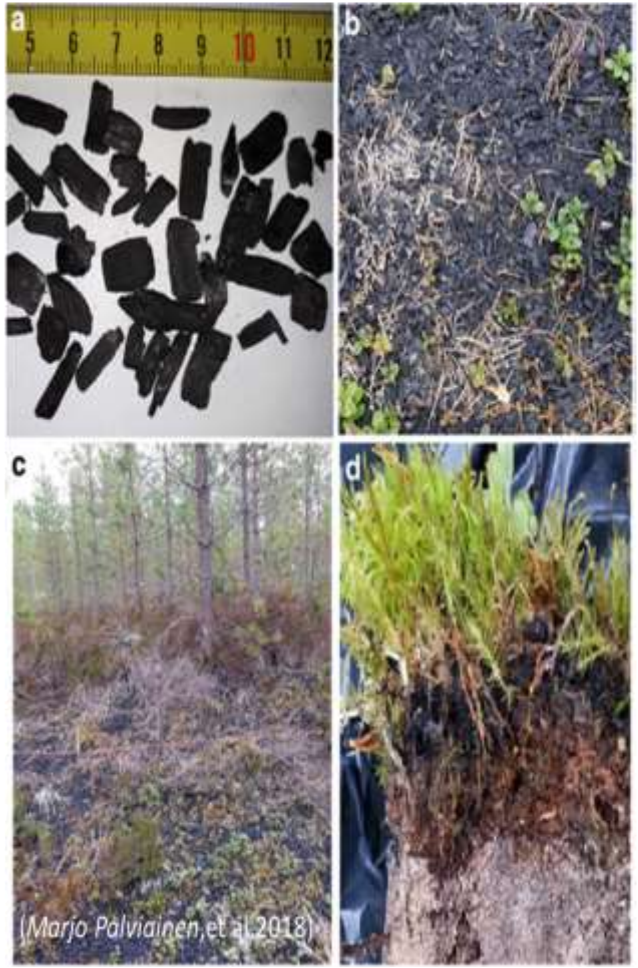
Abstract
Background and aims The addition of biochar to soil may offer a chance to mitigate climate change by increasing soil carbon stocks, improving soil fertility and enhancing plant growth.

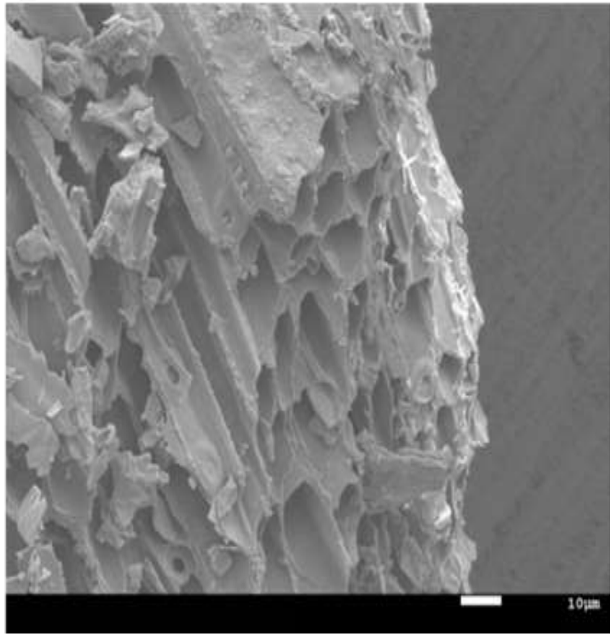
Springer



Research Contents

2. Black Carbon Effect on Soil Carbon Stability

B



Treatments

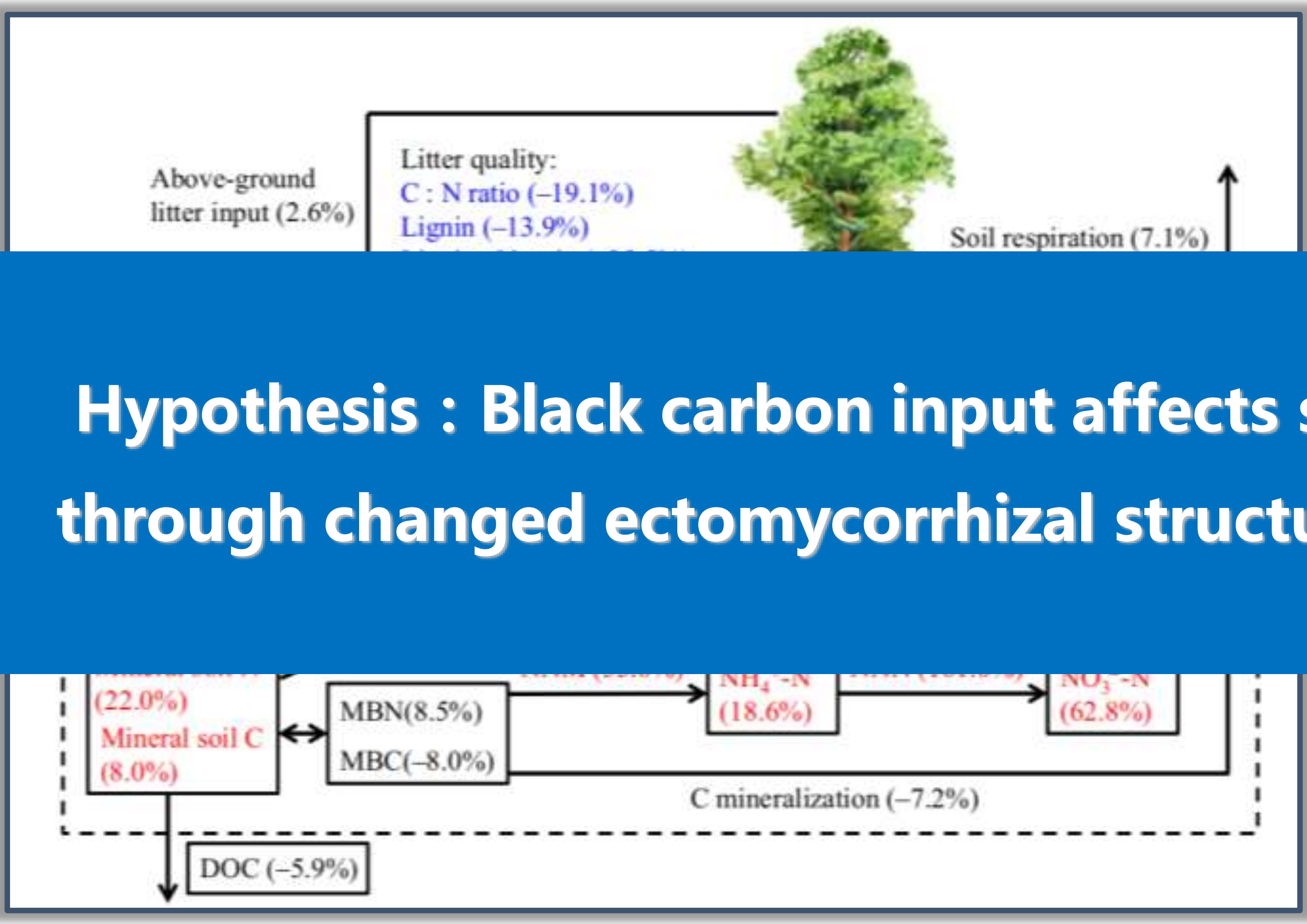
Control （ CK ）

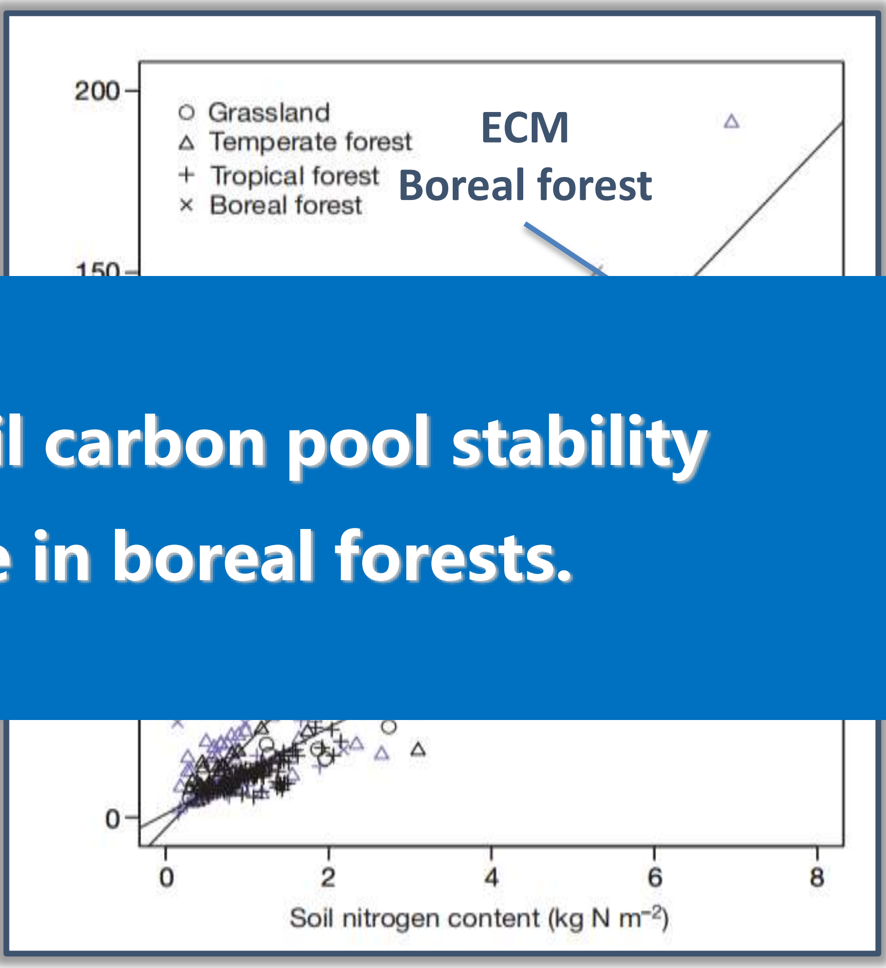
Burned (F)

Remove （ F-C ）

Add BC
10t/hm² (F+C)

Research Contents



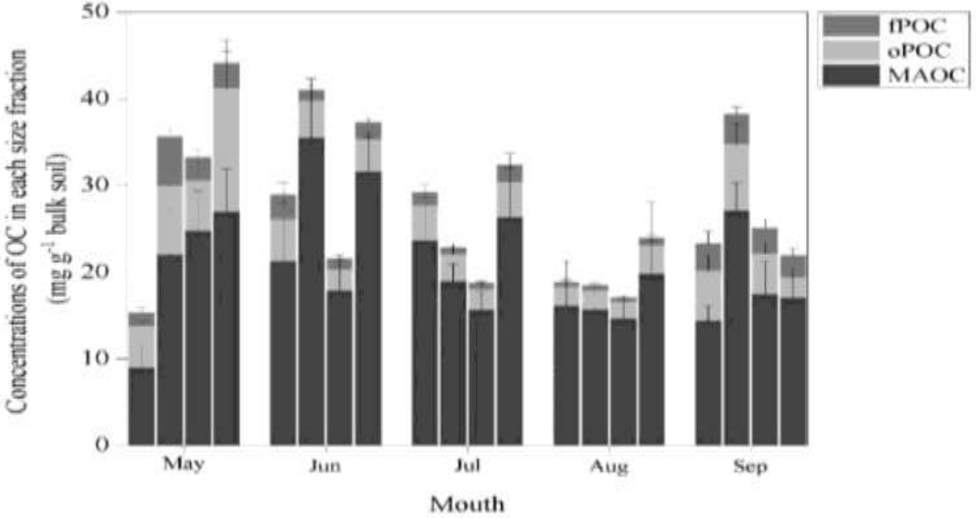


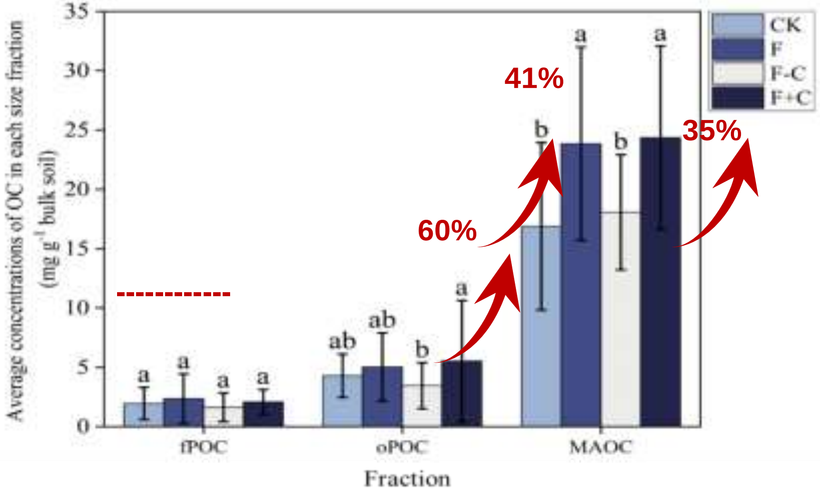
Hypothesis：Black carbon input affects soil carbon pool stability through changed ectomycorrhizal structure in boreal forests.

(Guigang Lin,2017, New Phytologist)
(Colin Averill,2014,Nature)

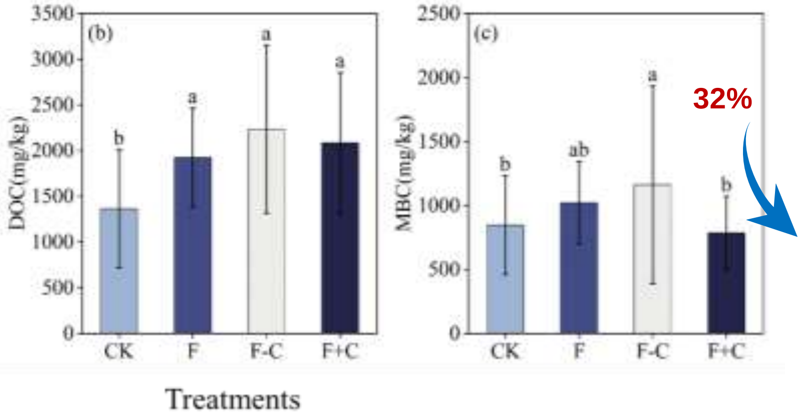
Research Contents

fPOC: Free particulate organic carbon
opoc: Occluded particulate organic carbon
MAOC: Mineral organic carbon





	Month df=4		Treatment df=3		Month * Treatment df=12	
	F	P	F	P	F	P
DOC	8.62	**	23.09	**	11.71	**
MBC	72.46	**	24.15	**	25.04	**
fPOC	70.83	**	6.51	**	13.03	**
oPOC	53.90	**	10.97	**	13.98	**
MAOC	21.66	**	29.73	**	11.83	**



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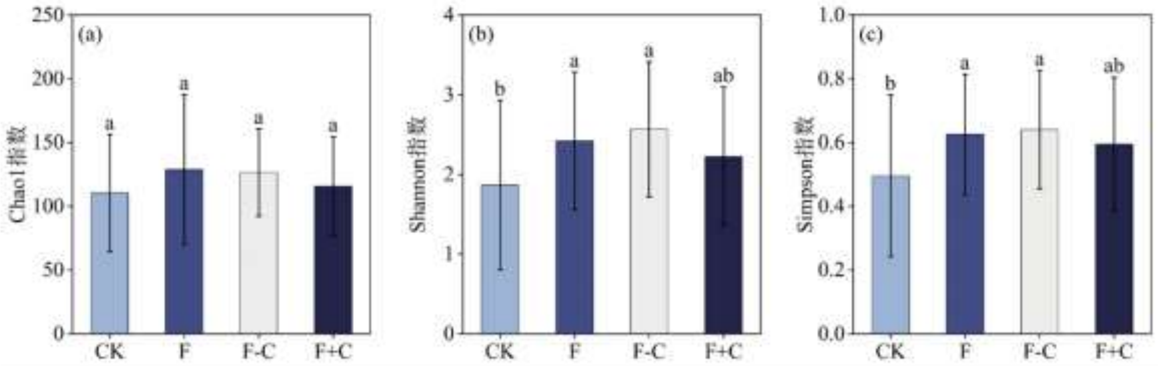
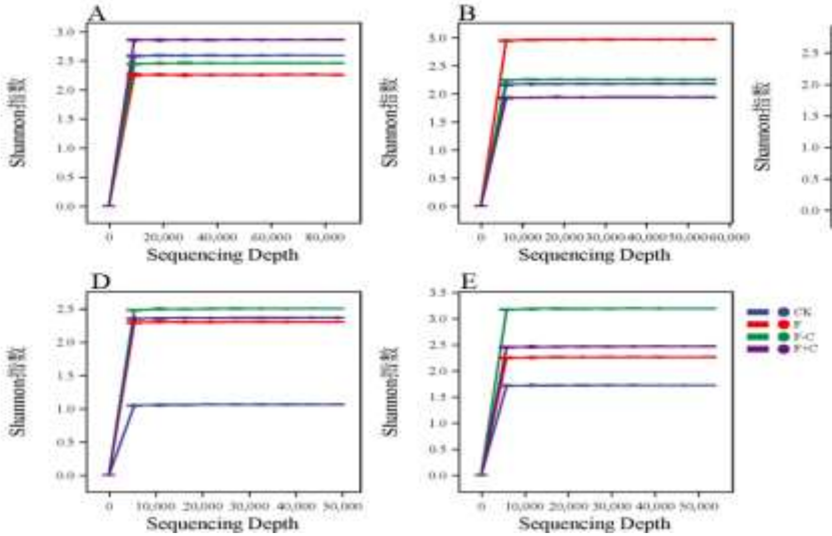
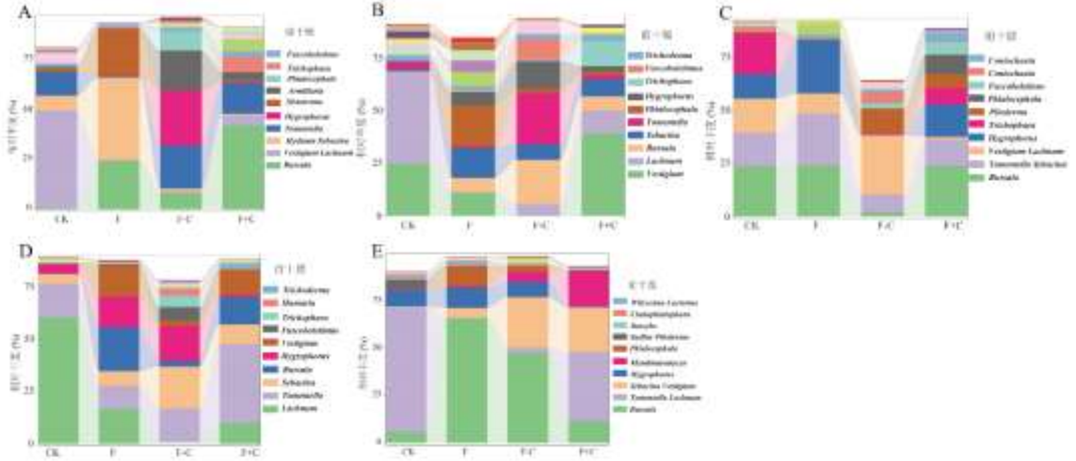
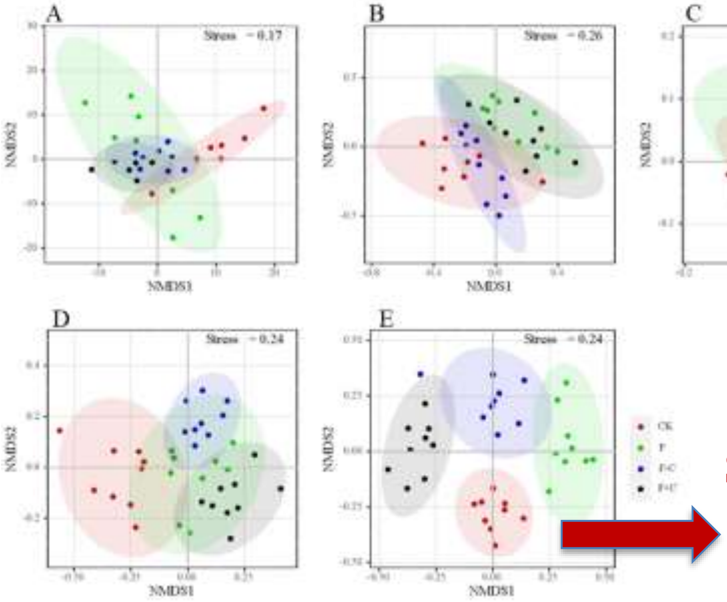
	Month df=4		Treatment df=3		Month * Treatment df=12	
	F	P	F	P	F	P
Chao1	9.65	**	2.21	ns	2.89	**
Shannon	2.17	ns	6.20	**	4.16	**
Simpson	1.63	ns	5.24	**	4.09	**



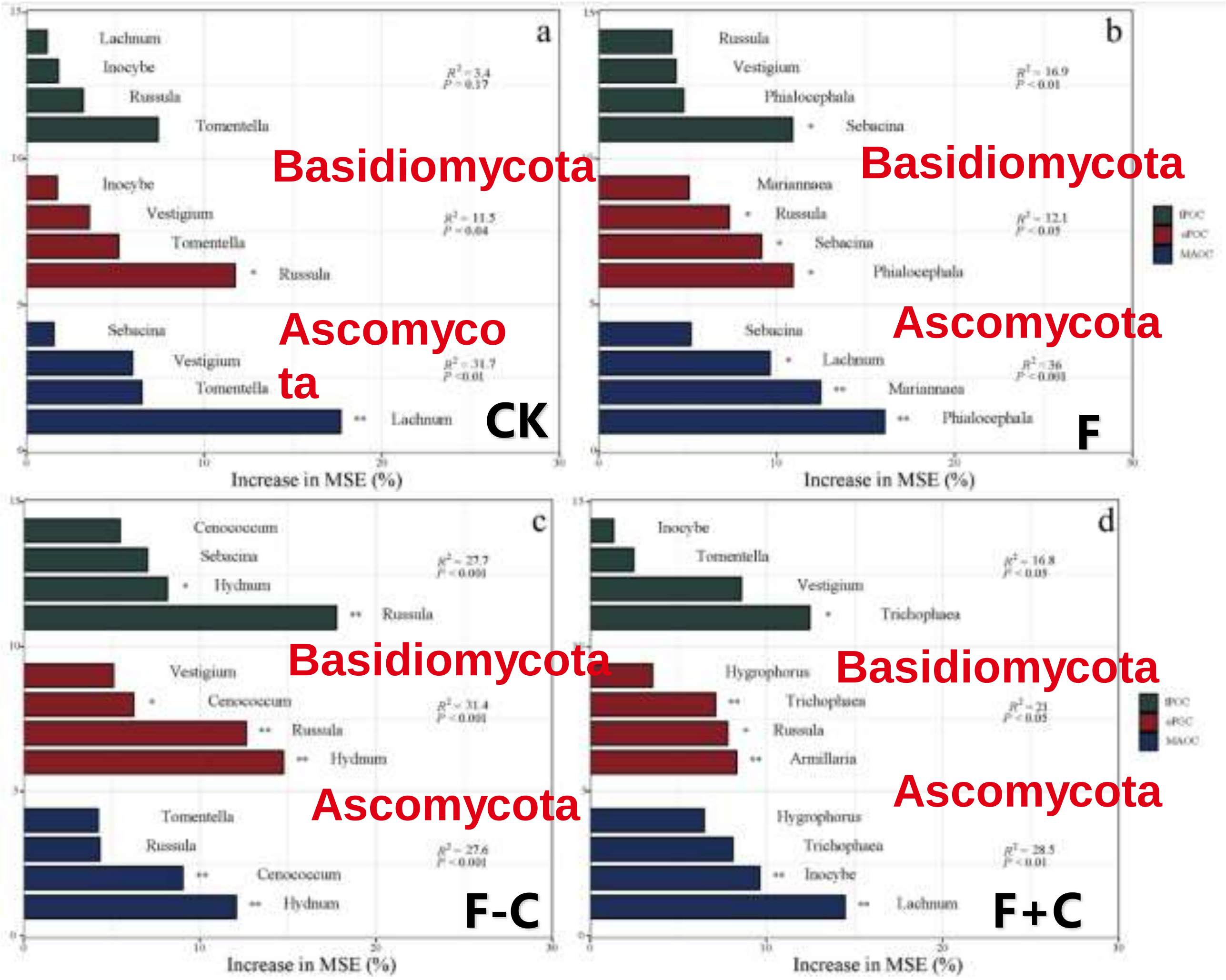






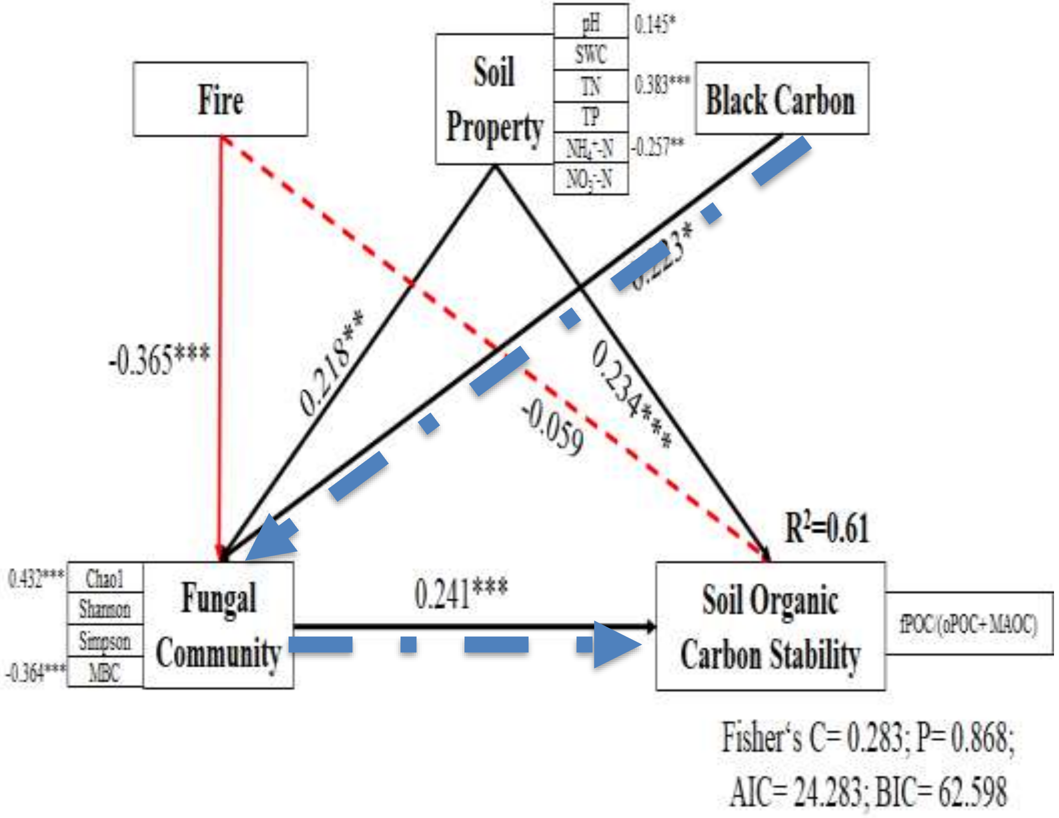
Stucture changed

Research Contents



The effects of ectomycorrhiza on soil carbon pool under different treatments were consistent at the phylum level, but different at the genus level.

Fungal colonization caused by different treatments will affect the stability of soil carbon pool.



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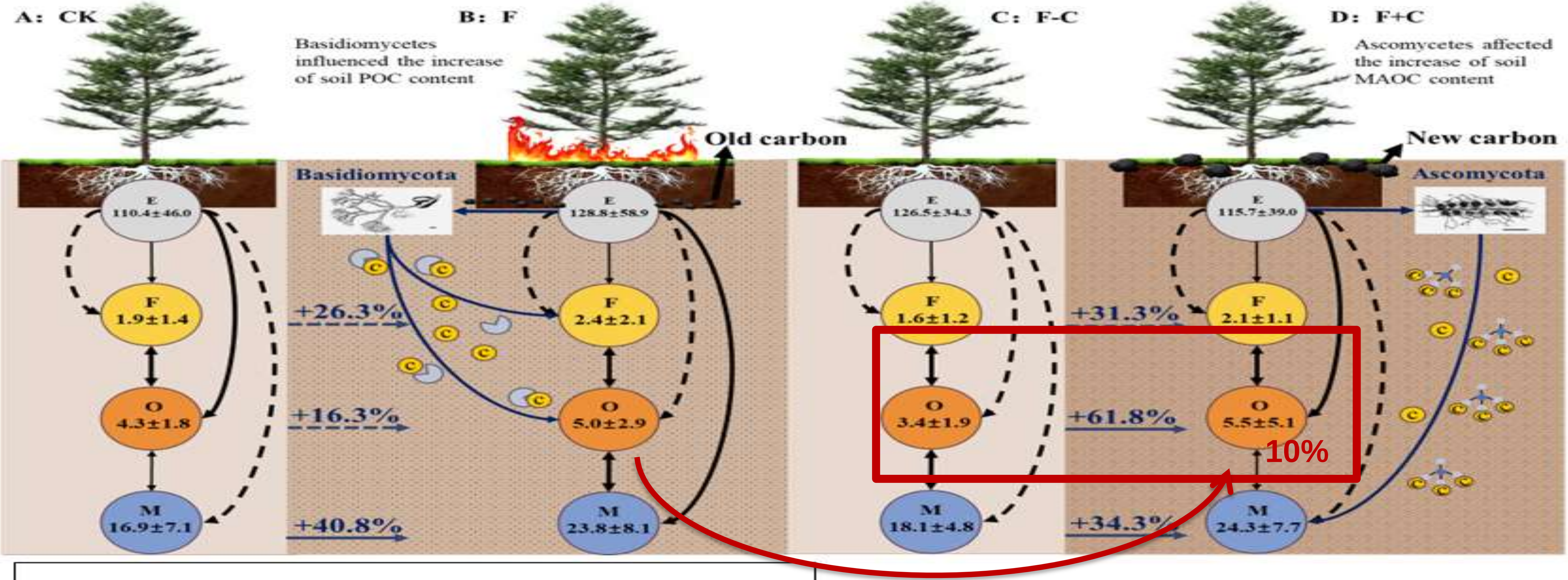

E	Abundance of ectomycorrhizal fungi	23.8±8.1	The organic carbon content of different components
F	Free particulate organic carbon	C	Soil organic carbon
O	Occluded particulate organic carbon		Microorganism
M	Mineral organic carbon		Mineral protected new C

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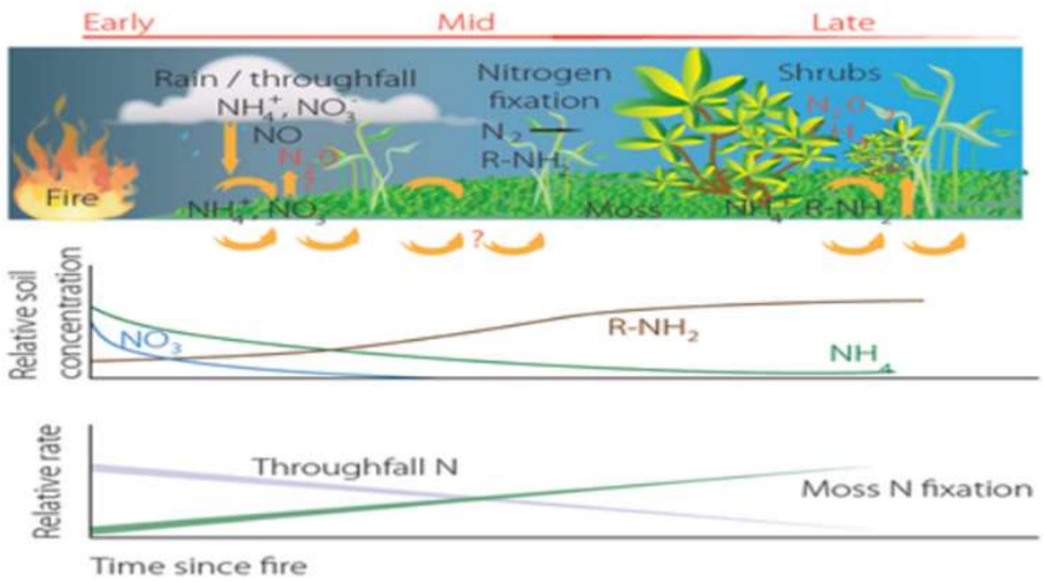
3. Fire Disturbance on Soil N availability

Studying the effect of fire disturbance on the soil N availability in forest ecosystem is of great ecological significance for revealing the succession process of forest ecosystem after fire disturbance and the mechanism of forest ecosystem restoration after fire disturbance.

Post-fire forest sucession and N fixation



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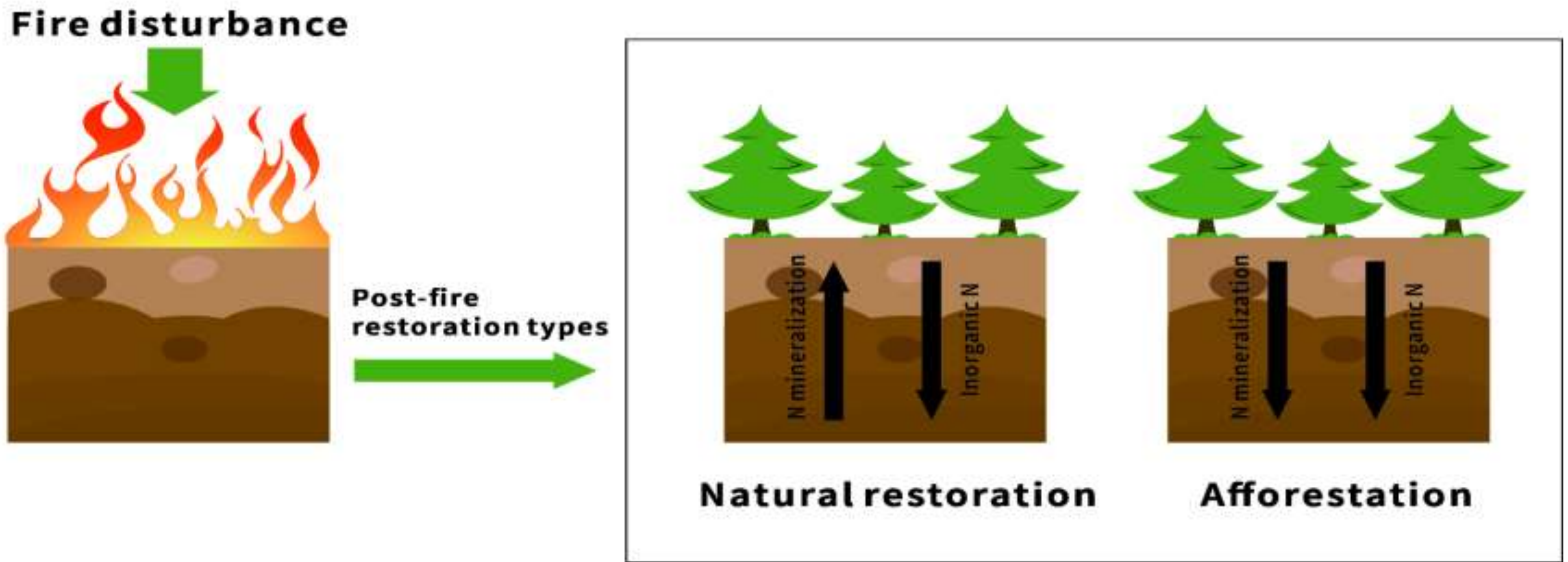
Scientific problems

1. What are the overall effects of wildfire on soil inorganic N?
2. What are the differences in soil inorganic N and net mineralisation rates between naturally restored plots and afforestation plots?

30 year after fire disturbance



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3. Fire Disturbance on Soil N availability

Fire Effect on basic soil characteristics

Soil properties	Plot Type		
	Natural restoration	Afforestation	Control
UL SWC (%)	68.08 ± 23.64^{Aa}	93.48 ± 31.35^{Ab}	114.55 ± 55.47^{Ab}
LL SWC (%)	47.91 ± 16.15^{Ba}	41.19 ± 10.63^{Ba}	49.34 ± 24.65^{Ba}
UL AP (mg kg^{-1})	27.38 ± 17.09^{Aa}	20.14 ± 10.22^{Aa}	26.23 ± 18.64^{Aa}
LL AP (mg kg^{-1})	20.71 ± 10.43^{Aa}	15.27 ± 4.35^{Aa}	22.22 ± 14.53^{Aa}
ULAK（mg kg^{-1}）	560.79 ± 314.97^{Aa}	359.37 ± 150.22^{Ab}	390.73 ± 196.90^{Ac}
LL AK (mg kg^{-1})	239.34 ± 105.97^{Ba}	197.63 ± 142.12^{Ba}	190.19 ± 92.51^{Ba}
UL pH	3.95 ± 0.28^{Aa}	4.02 ± 0.18^{Aa}	4.32 ± 0.24^{Ab}
LL pH	3.87 ± 0.27^{Ba}	3.84 ± 0.22^{Ba}	4.18 ± 0.22^{Ba}
UL TC (g kg^{-1})	76.16 ± 32.03^{Aa}	50.07 ± 9.53^{Aa}	140.88 ± 34.53^{Ab}
LL TC (g kg^{-1})	34.42 ± 17.18^{Ba}	21.59 ± 3.67^{Ba}	50.94 ± 21.35^{Ba}
UL TN (g kg^{-1})	5.72 ± 0.18^{Aa}	5.05 ± 0.7^{Aa}	9.59 ± 1.02^{Ab}
LL TN (g kg^{-1})	3.94 ± 1.14^{Ba}	3.39 ± 1.14^{Ba}	7.25 ± 1.36^{Bb}

The upper layer **soil pH, total carbon, total nitrogen** were in nature restoration and afforestation plots still significantly lower than that in unburned control plots.

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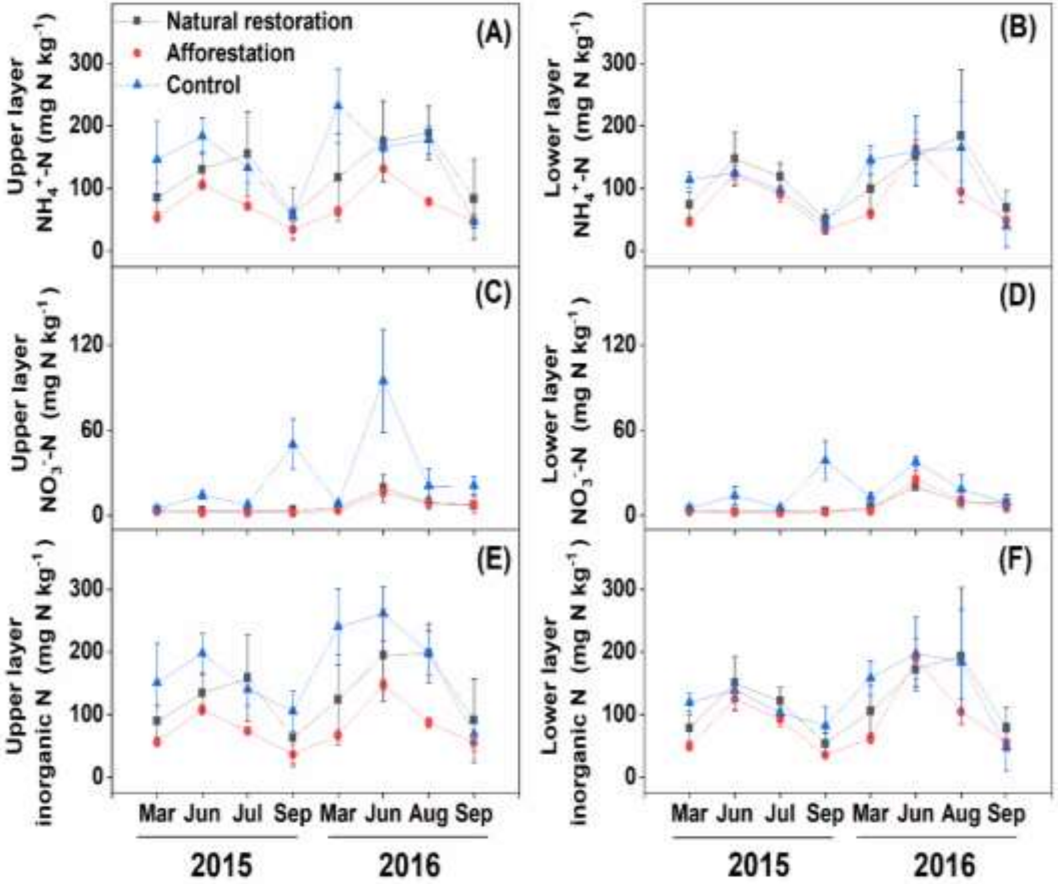
3. Fire Disturbance on Soil N availability



	Natural restoration	
	UL	LL
NH_4^+-N	↑* 70%	↑ 35%
NO_3^--N	↑ 29%	↑ 6%
IO	↑* 67%	↑ 34%

Science of the total environmeant (Hu et al., 2019)

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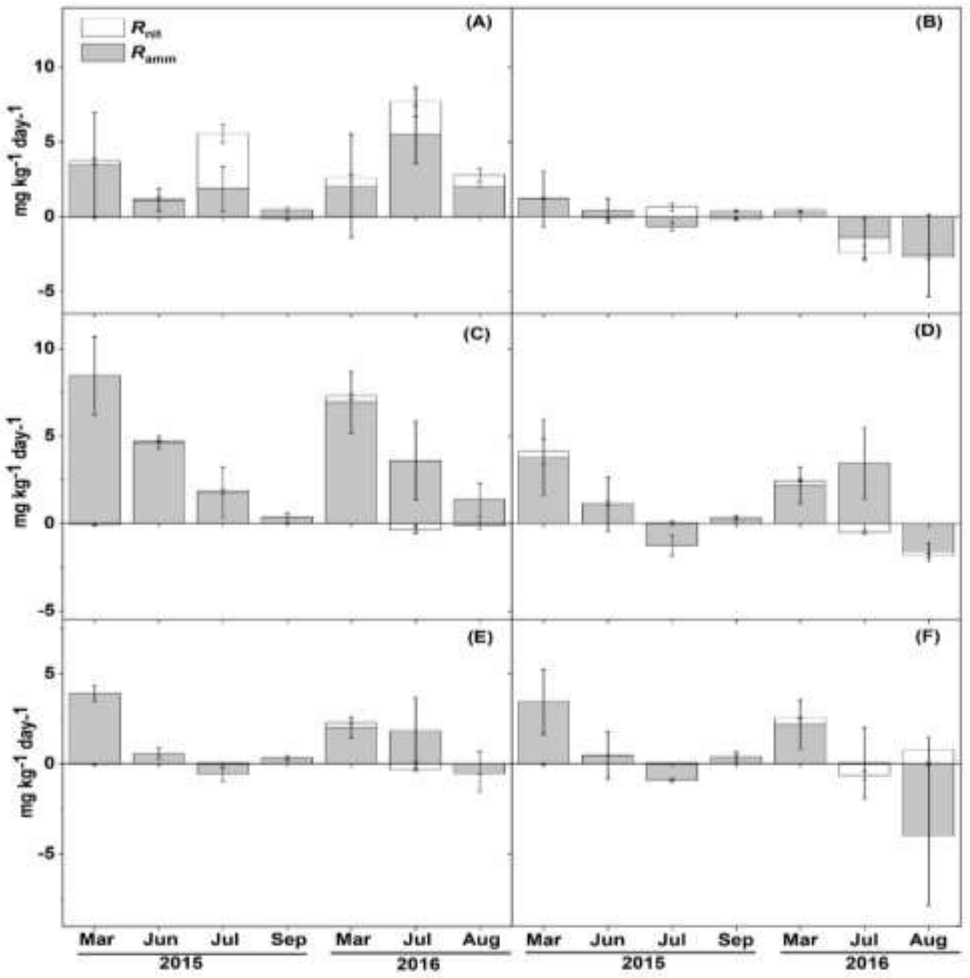
3. Fire Disturbance on Soil N availability



	Natural restoration	
	UL	LL
Ramm	↑*3.5 times	↑ 5.0 times
Rnit	-	-
Rmin	↑* 3.6 times	↑3.8 times

*Science of the total environmeant (*Hu *et al., 2019)*

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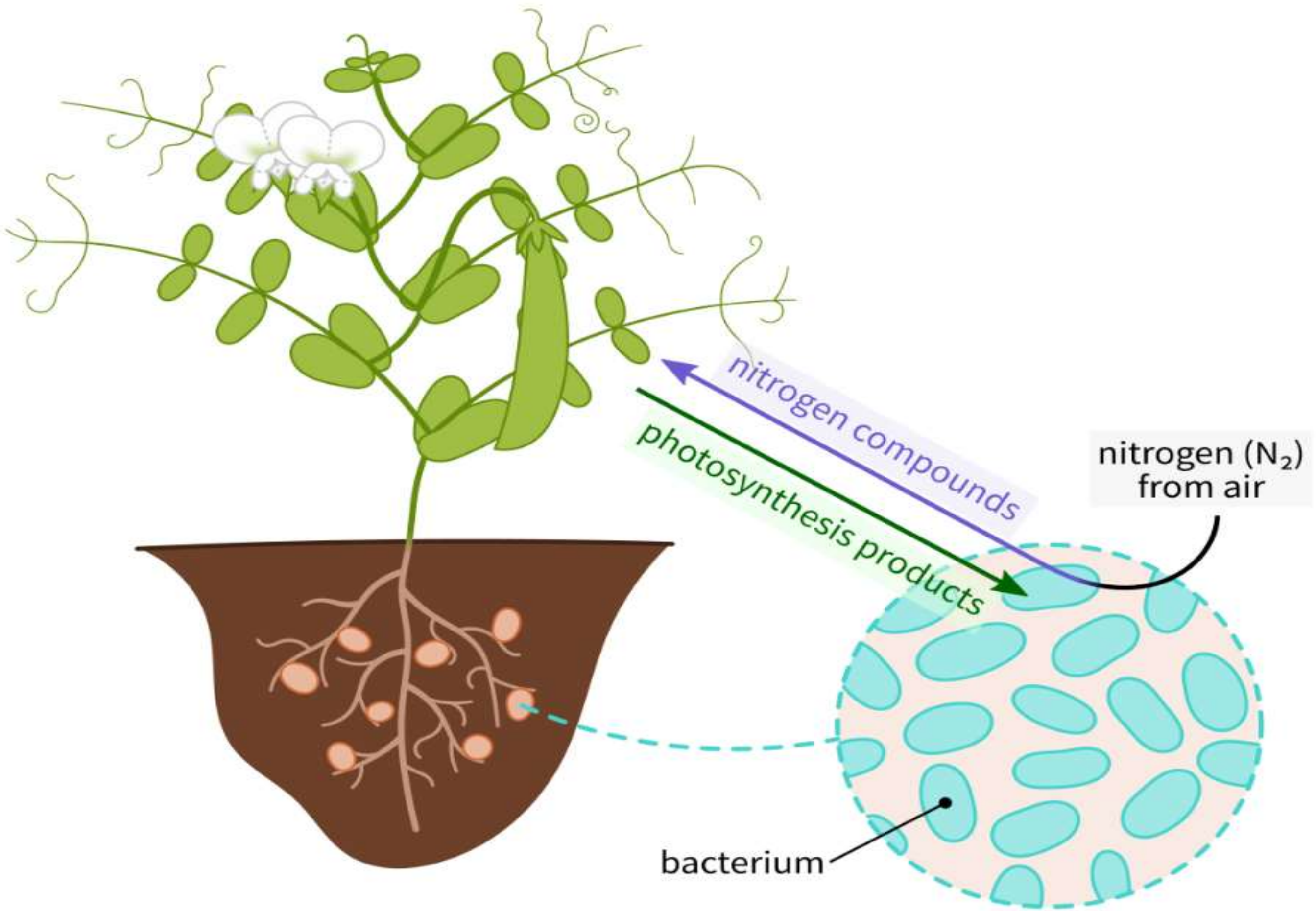
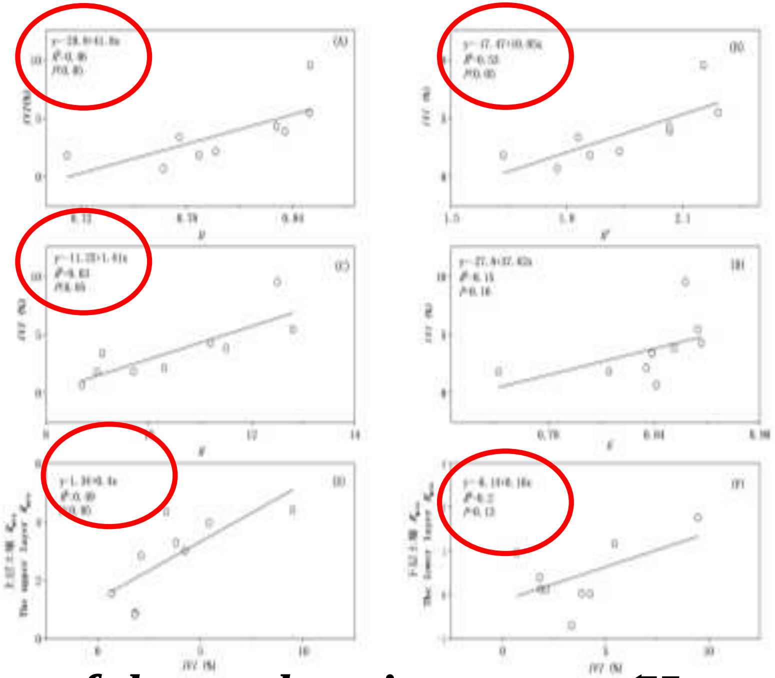
3. Fire Disturbance on Soil N availability



	D	H’	E	IVI
Nature restoration	2.14±0.06[a]	0.85±0.01[a]	0.86±0.01[a]	6.26±2.92[a]
Afforestation	1.75±0.1[b]	0.76±0.04[b]	0.80±0.05[a]	1.44±0.66[b]
Control	1.94±0.03[ab]	0.80±0.03[ab]	0.85±0.02[a]	3.25±1.07[ab]



$M_{C/N}$	-0.454*	0.044		-0.532*	-0.108		-0.571**	0.392

*Science of the total environmeant (*Hu et al., 2019

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Summary

- Fire driving the ratio of Rh:Rs ratio increased in a boreal forest ecosystem of China. Forest fires will potentially cause considerable losses of soil C in a boreal forest ecosystem of China, a pro-active management of forest regeneration should be carried out after forest fire disturbances.

- Black carbon promoted the recovery of ECM fungi community and induced different fungal colonization. Fire and black carbon addition could affect the stability of soil organic carbon pool by affecting the composition of ECM fungi community.

- Soil inorganic N pool remained significantly lower than pre-fire level after fire disturbance 30 years. Natural restoration was more beneficial for the recovery of soil N availability in boreal forest of China after fire disturbance .

Future Research

8TH INTERNATIONAL WILDLAND FIRE CONFERENCE

KEY LABORATORY OF SUSTAINABLE FOREST ECOSYSTEM MANAGEMENT, MINISTRY OF EDUCATION

森林和草原火灾防控理论与技术研究团队

FOREST AND GRASSLAND FIRE PREVENTION AND CONTROL THEORY AND TECHNOLOGY RESEARCH TEAM

团队简介

TEAM PROFILE

团队在我国著名森林防火学家郑焕能教授带领下，于20世纪50年代初率先在森林学中开辟了森林防火教学与研究方向，是我国唯一能够培养和授予森林防火专业学士、硕士、博士学位的单位。团队现有成员10人，其中教授4人，副教授3人，讲师2人，工程师1人。

依托教育部重点实验室，团队系统开展了林火对森林生态系统的影响机理、林火行为、可燃物管理、可燃物含水率监测与模拟、林火预测预报技术、生物防火技术、森林地被可燃物调控技术、林火装备研发等研究。研究成果有效提升我国森林草原火灾理论研究水平，加快森林草原火灾防控技术科研成果转化促进国内森林草原火灾防控技术的整体建设及人才培养。

团队组成

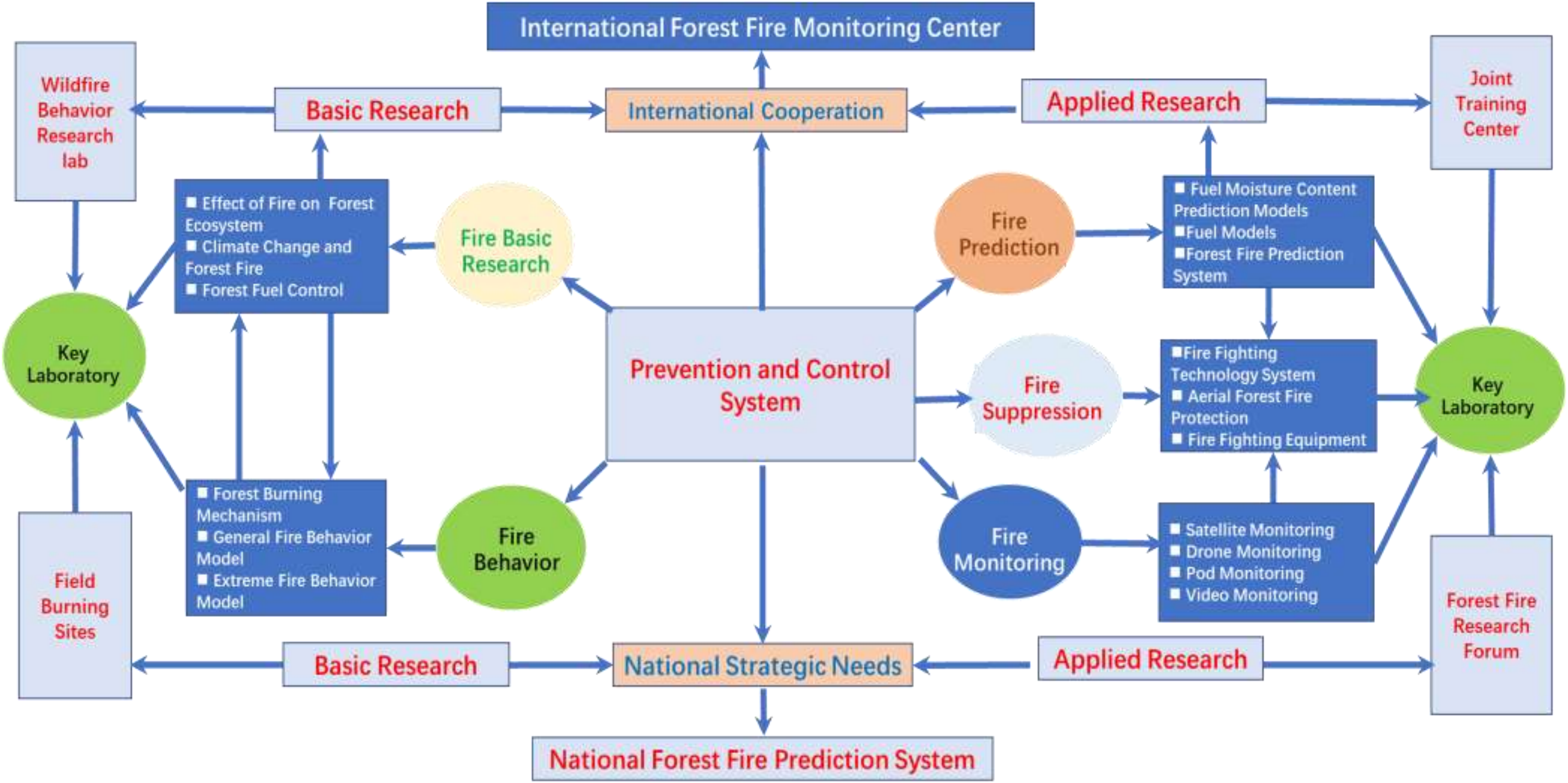
TEAM COMPOSITION

团队负责人：孙龙教授

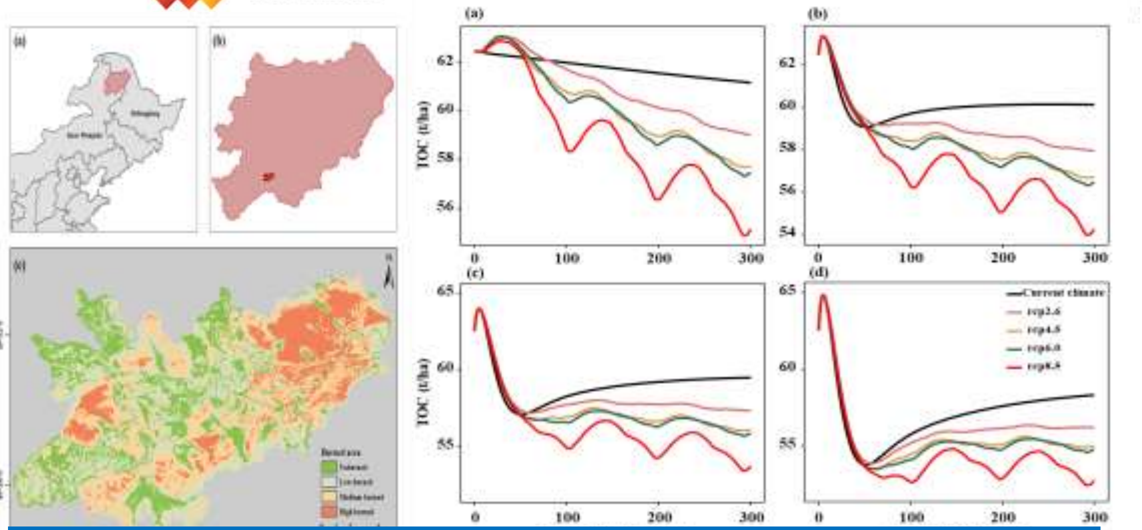
理学博士，教授，博士生导师。现任东北林业大学林学院院长，北方林火管理国家林业和草原局重点实验室主任，森林草原火灾防控技术国家创新联盟理事长。主要从事林火生态学、林火行为、林火监测预警以及森林可燃物调控与管理等研究。先后主持“十三五”重点研发课题、国家自然科学基金面上项目等课题20余项。

团队成员

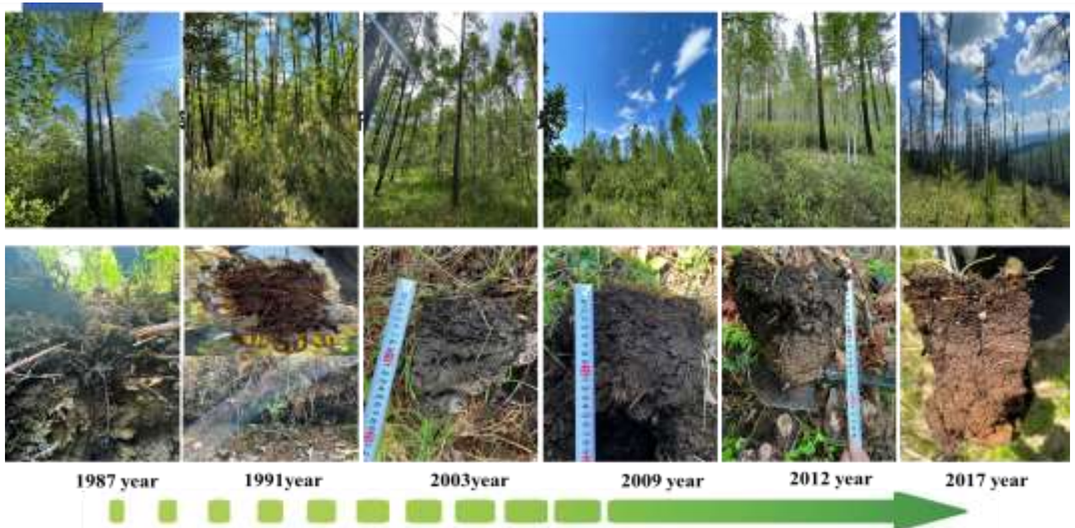
Future Research



Future Research

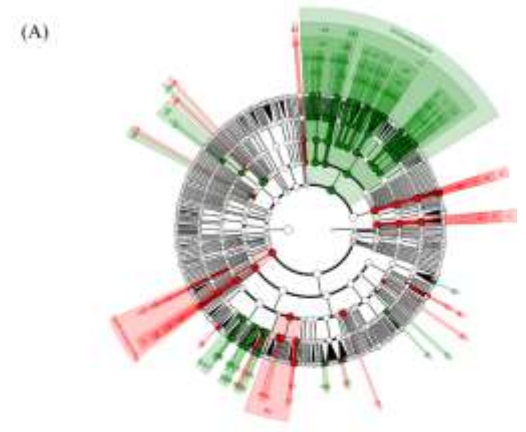


Climate change effect post-fire carbon pool

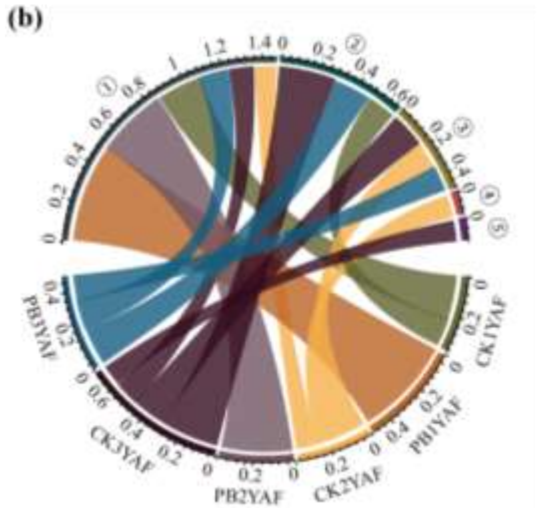


Post-fire vegetation recovery effect on carbon pool

Pescribed burning effect on forest ecosystem



Microorganism



Vegetation

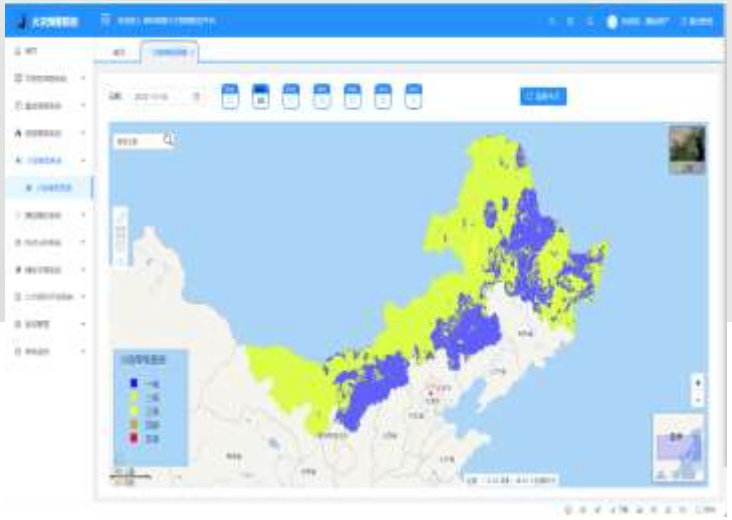
8th INTERNATIONAL WILDLAND FIRE

Future Research

森林草原火灾预警防控平台

Forest grassland fire prediction and prevention platform

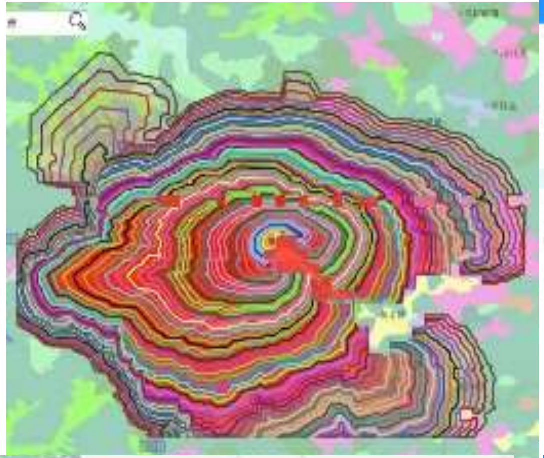
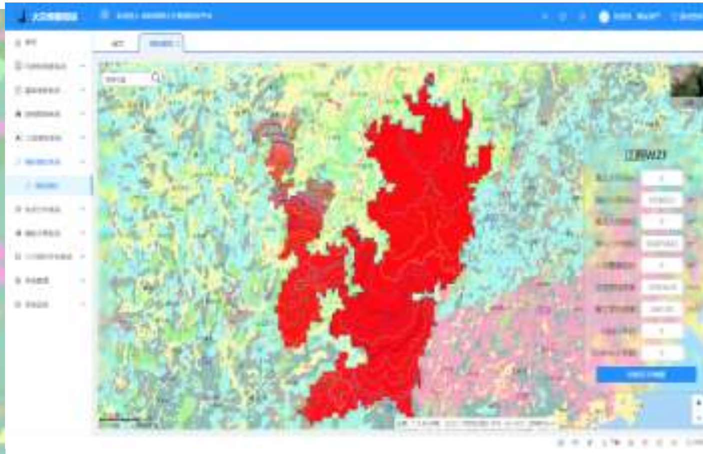
火险等级、蔓延模拟、可燃物管理、辅助决策、损失评估

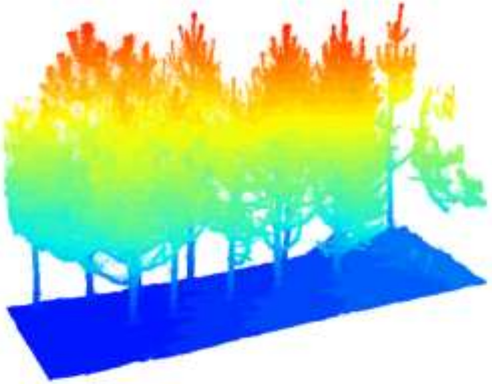
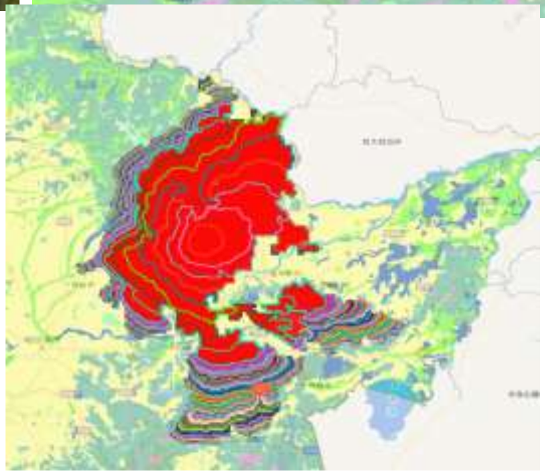
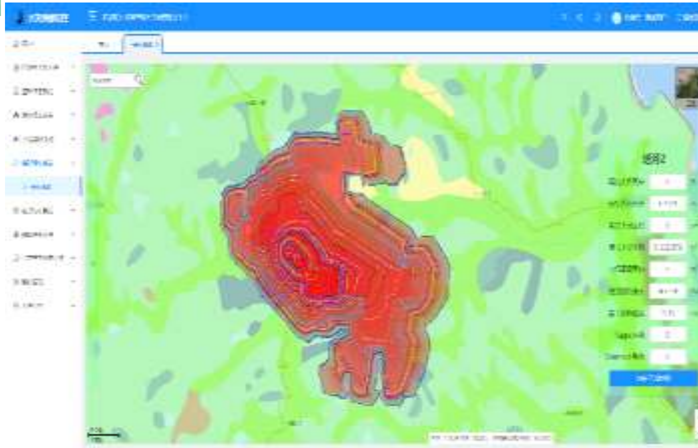


Future Research

Fire behavior and forest fire spread system

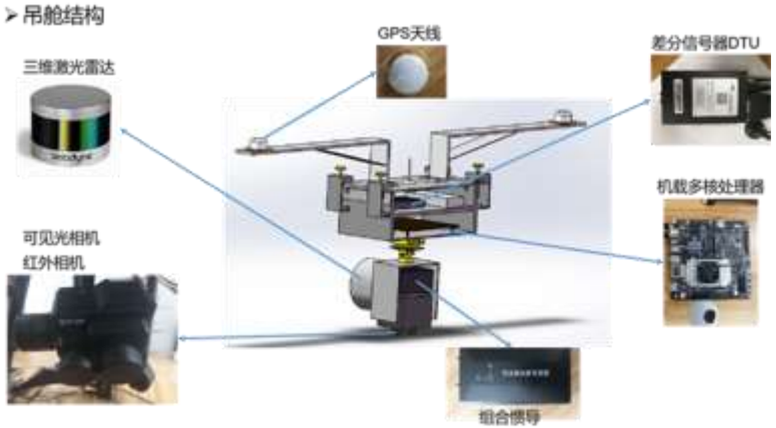


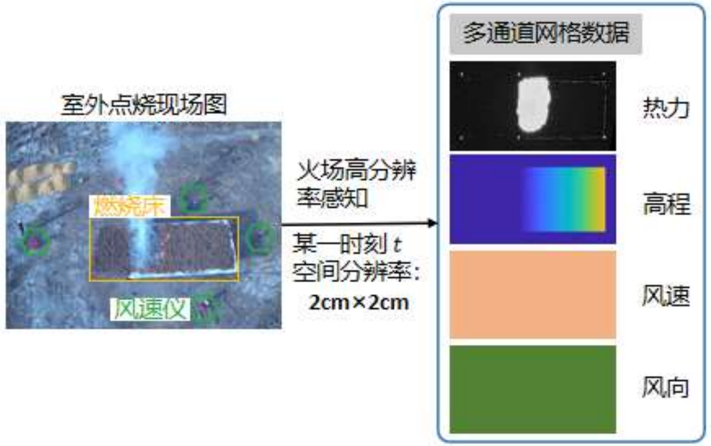




Future Research

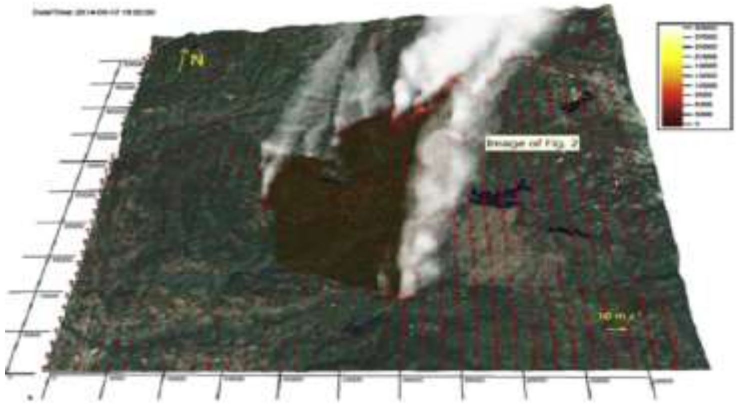
Accurate identification of large scale fire lines and extreme fire behavior



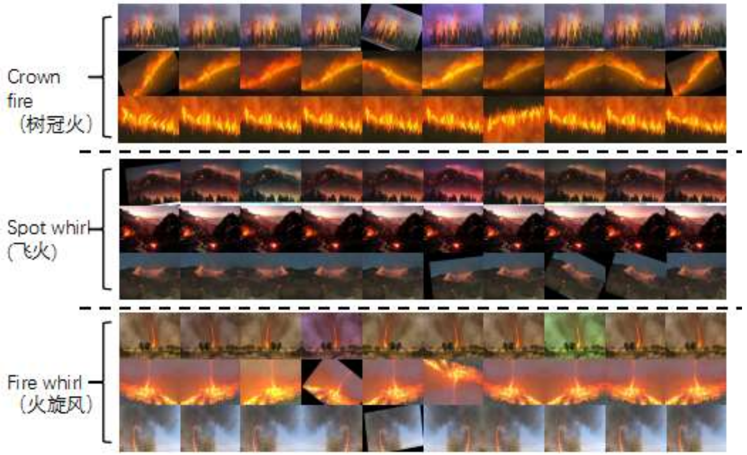
Drone pod



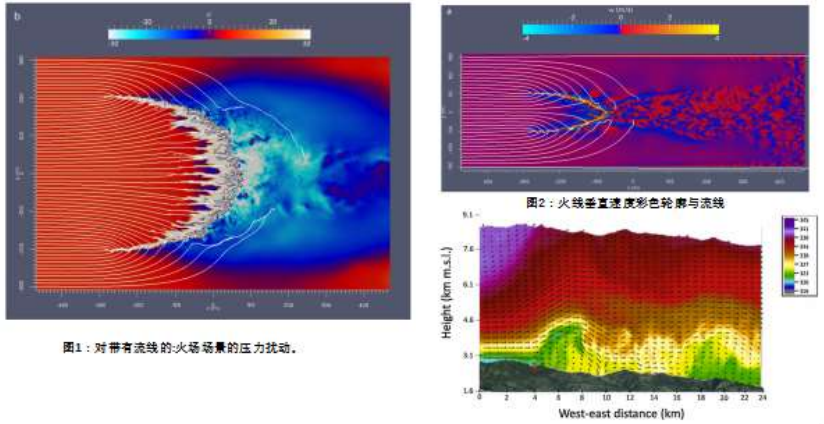
Multi-channel fire state map



Real-time fire data and GIS system integration



Construction of extreme fire visual feature data set



Low altitude multimodal data fusion extreme fire behavior recognition

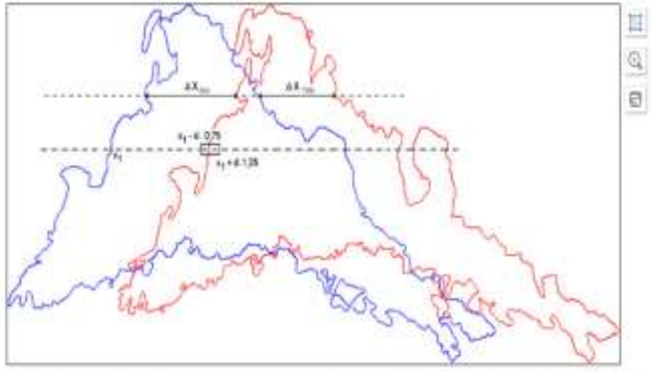


Figure 4. Estimation of disparity and corresponding point-correlation window in the left and right image

Speed of fire spread

Thanks for you attention！