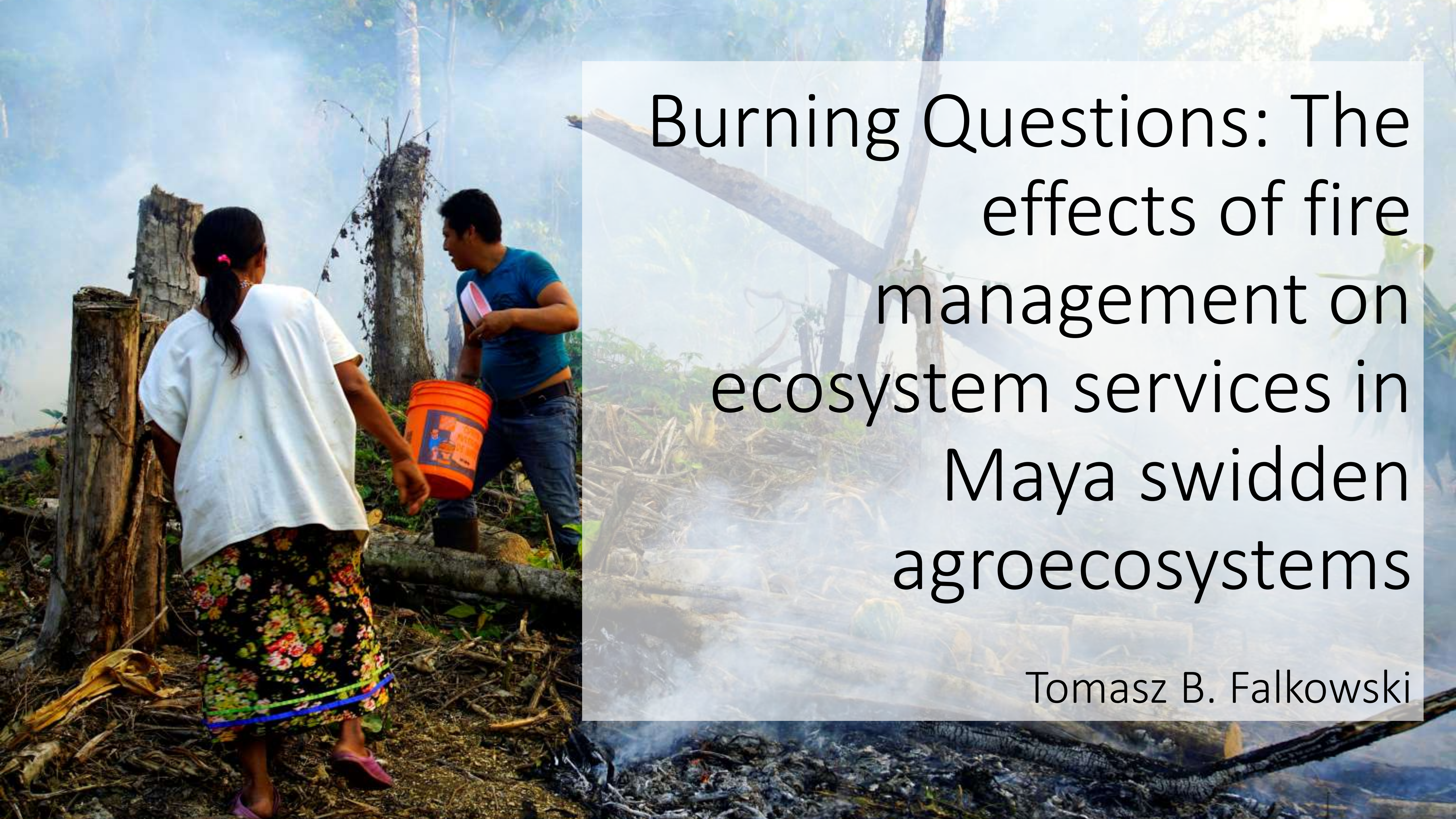


Burning Questions: The effects of fire management on ecosystem services in Maya swidden agroecosystems

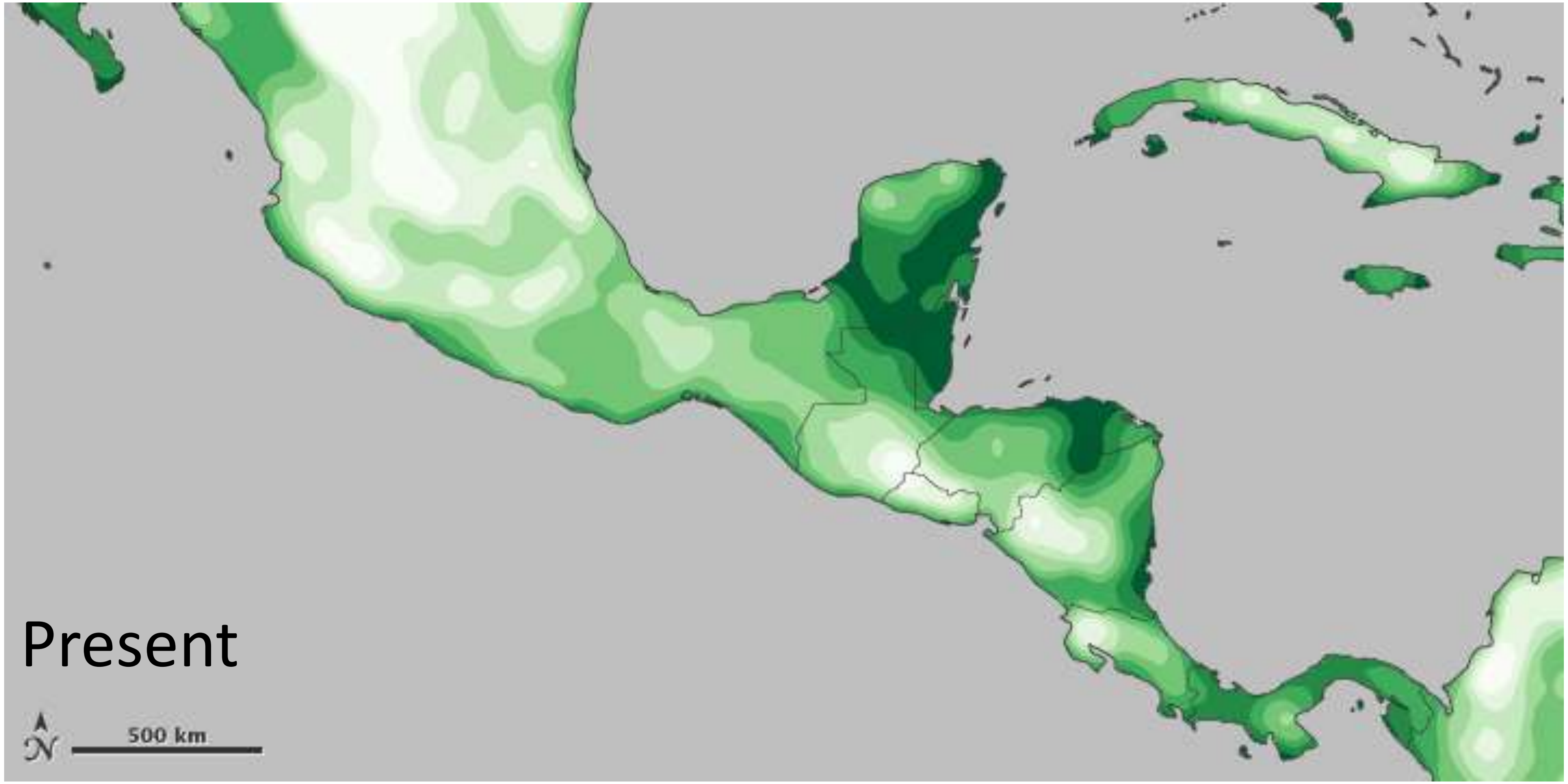
Tomasz B. Falkowski

Slash-and-burn: Good or bad?

"With more people than ever trying to survive in the midst of dwindling natural resources, **[slash-and-burn agriculture's] impact is particularly destructive and unsustainable** ... There are many problems that result…including deforestation…loss of habitat and species; an increase in air pollution, and the release of carbon into the atmosphere."

–EcoLogic Development Fund

100 km^2 of tropical moist forest lost annually

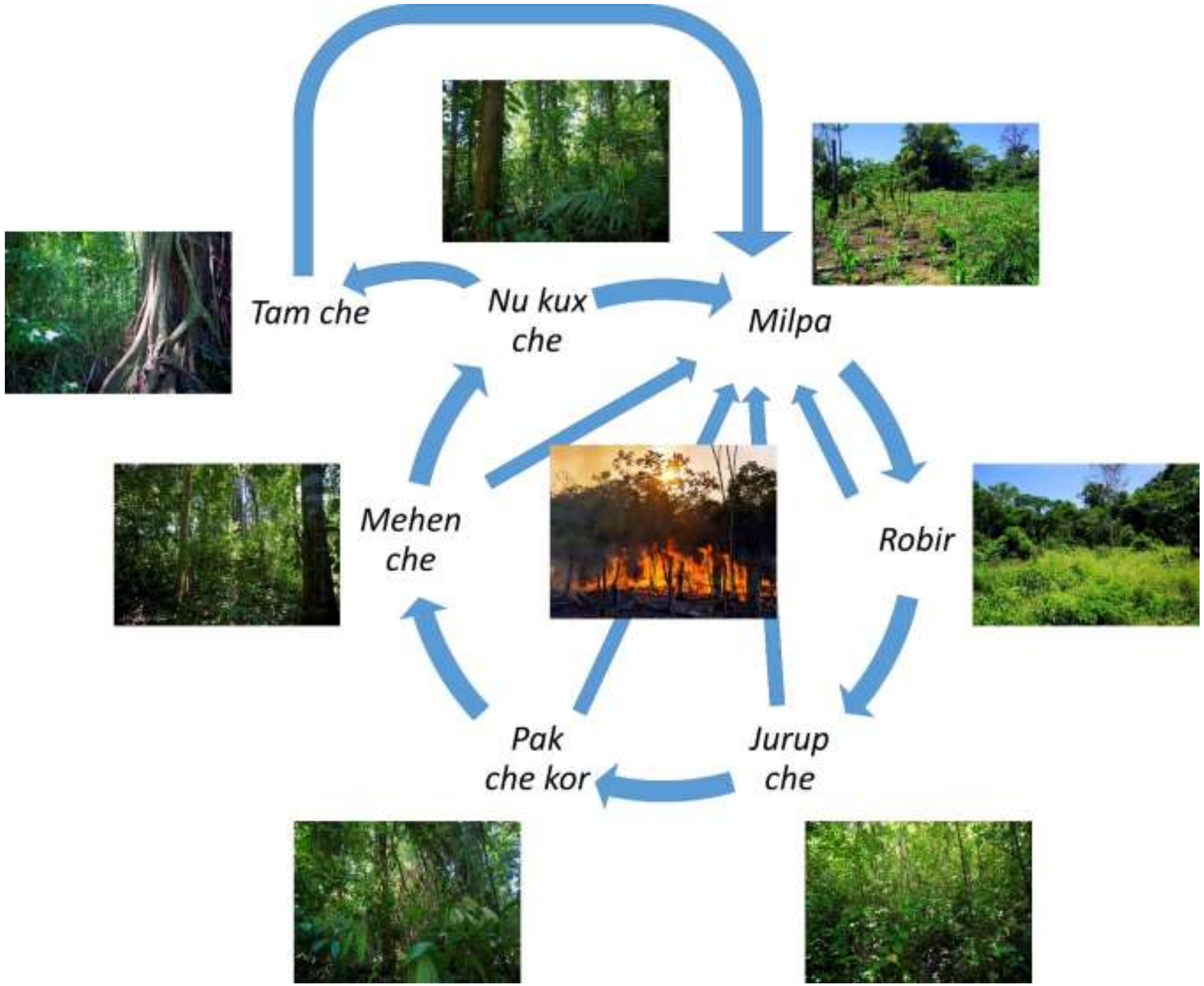


Images courtesy of NASA Earth Observatory

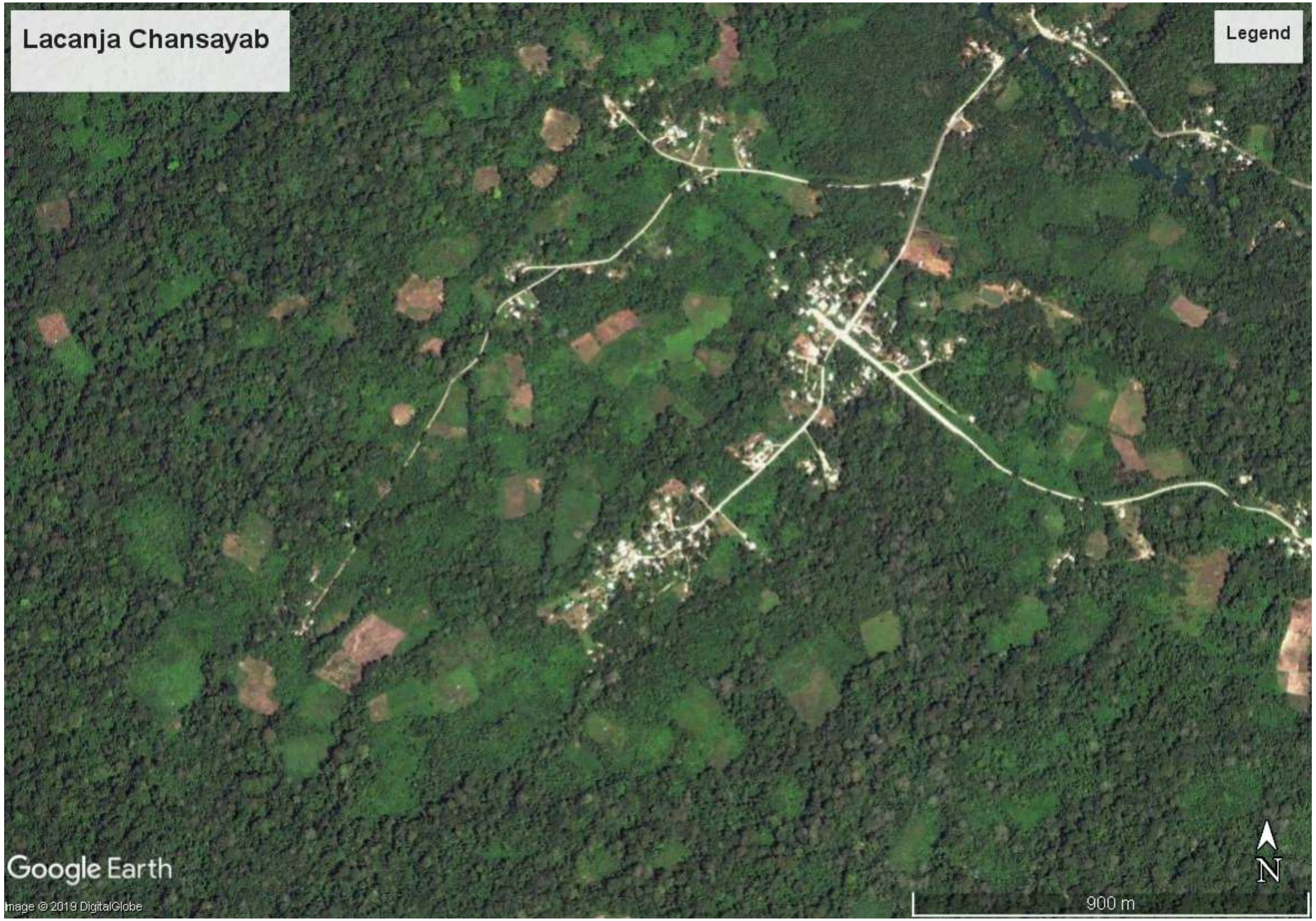

EVITAR LA QUEMA


CONANP
LACANJA CHANSAYAB
YAXCHILAN
CHANKIN LACANTU

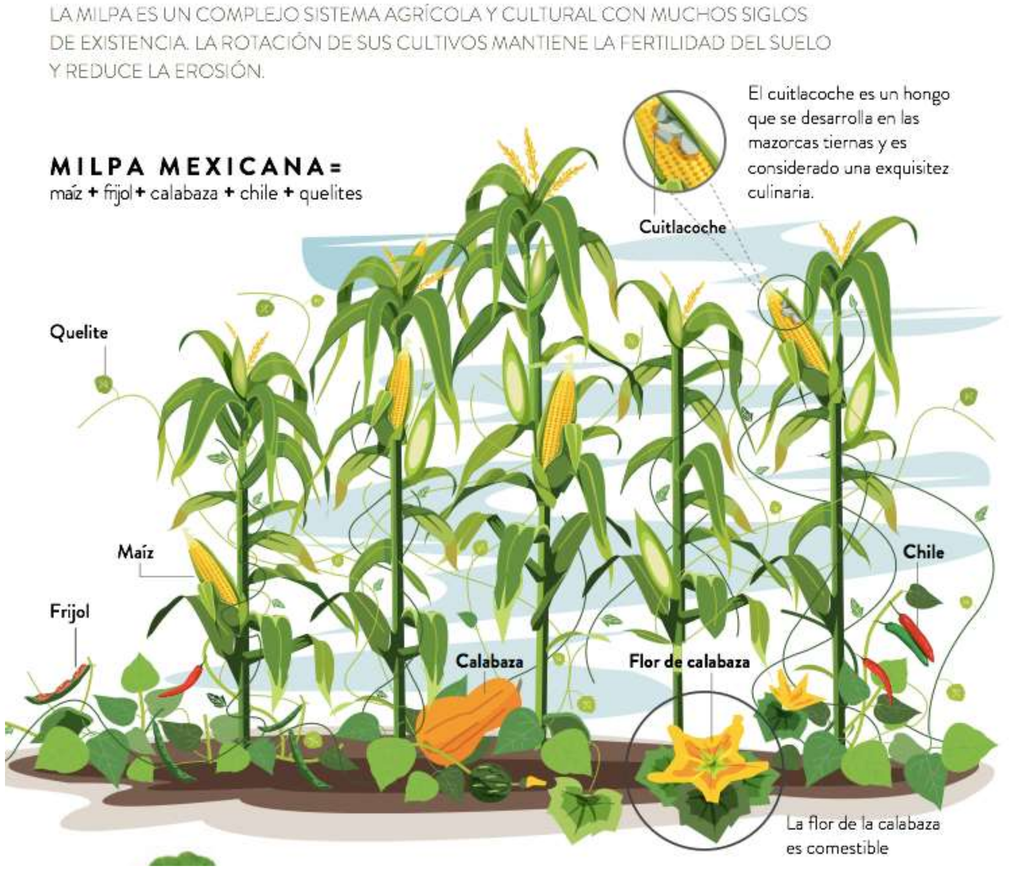
The milpa cycle



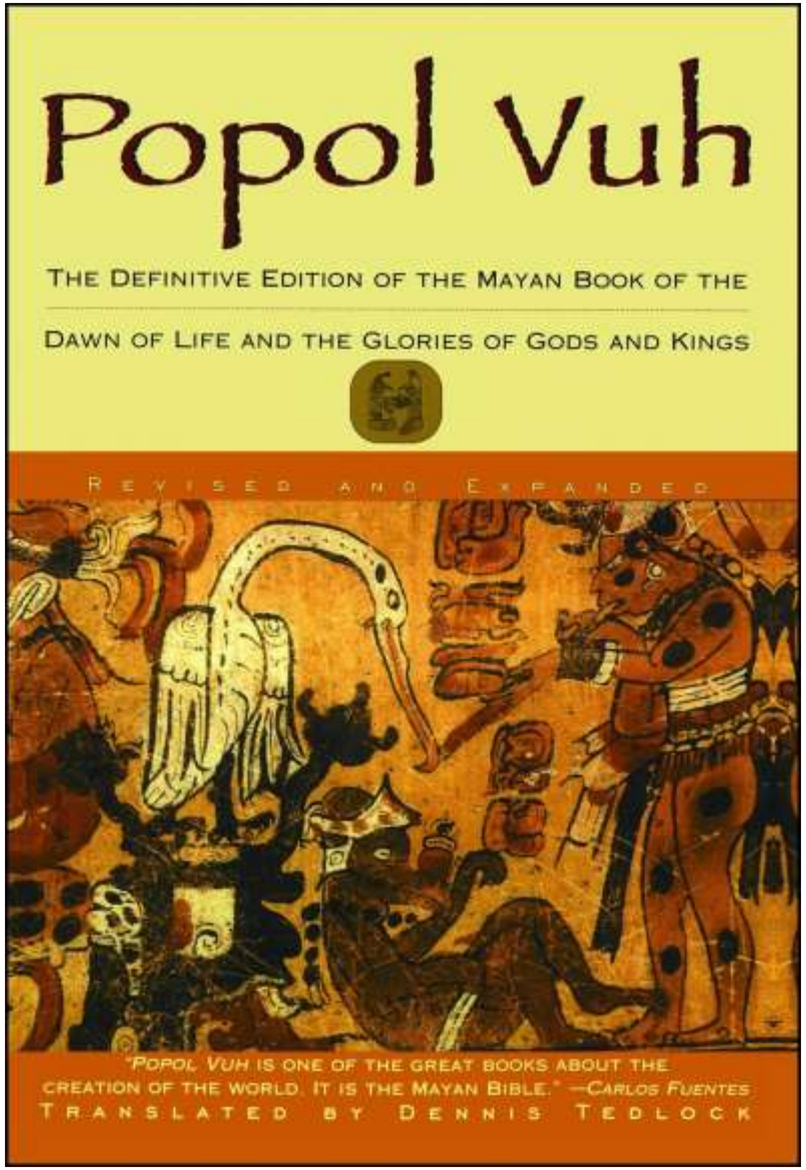
Disturbance makes a heterogeneous **landscape mosaic**



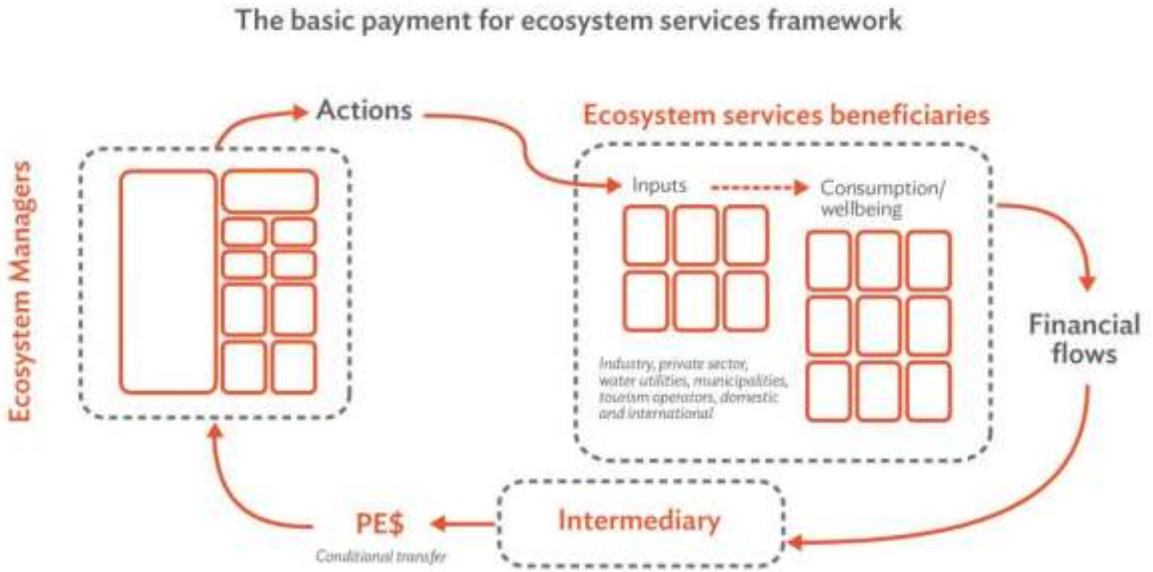
"The making of milpa is the central, most **sacred act**, one which binds together the family, the community, the universe...and its [sic] **social importance often appear to exceed its nutritional and economic importance**...The Maya do not just make milpa to live. They also **live to make milpa**" (Nigh 1976).



"The gods, who had not intended to make … beings with the potential of becoming their own equals, limited human sight to what was obvious and nearby. The lords … once had in their possession the **means for overcoming this nearsightedness**. The instrument was not a telescope, not a crystal for gazing, but **a book**. "



Federal PES schemes to address deforestation



UN-REDD PROGRAMME

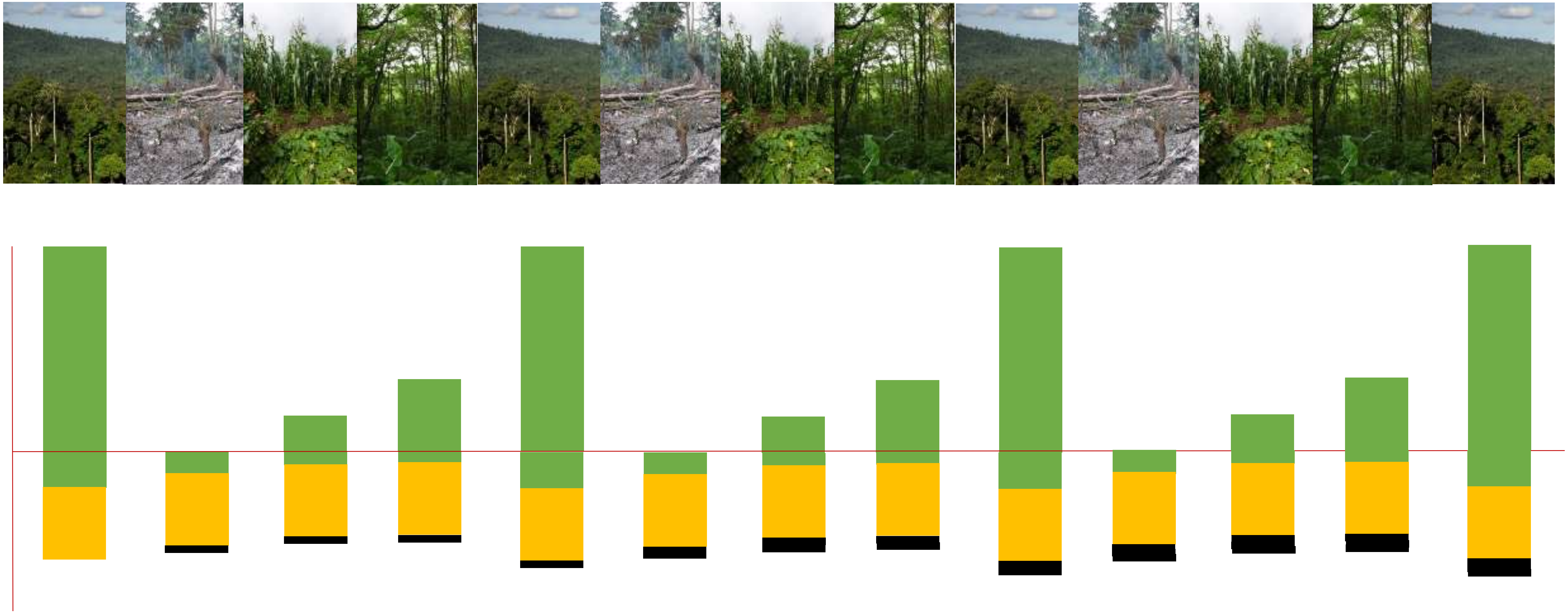
Food and Agriculture Organization of the United Nations

UNDP

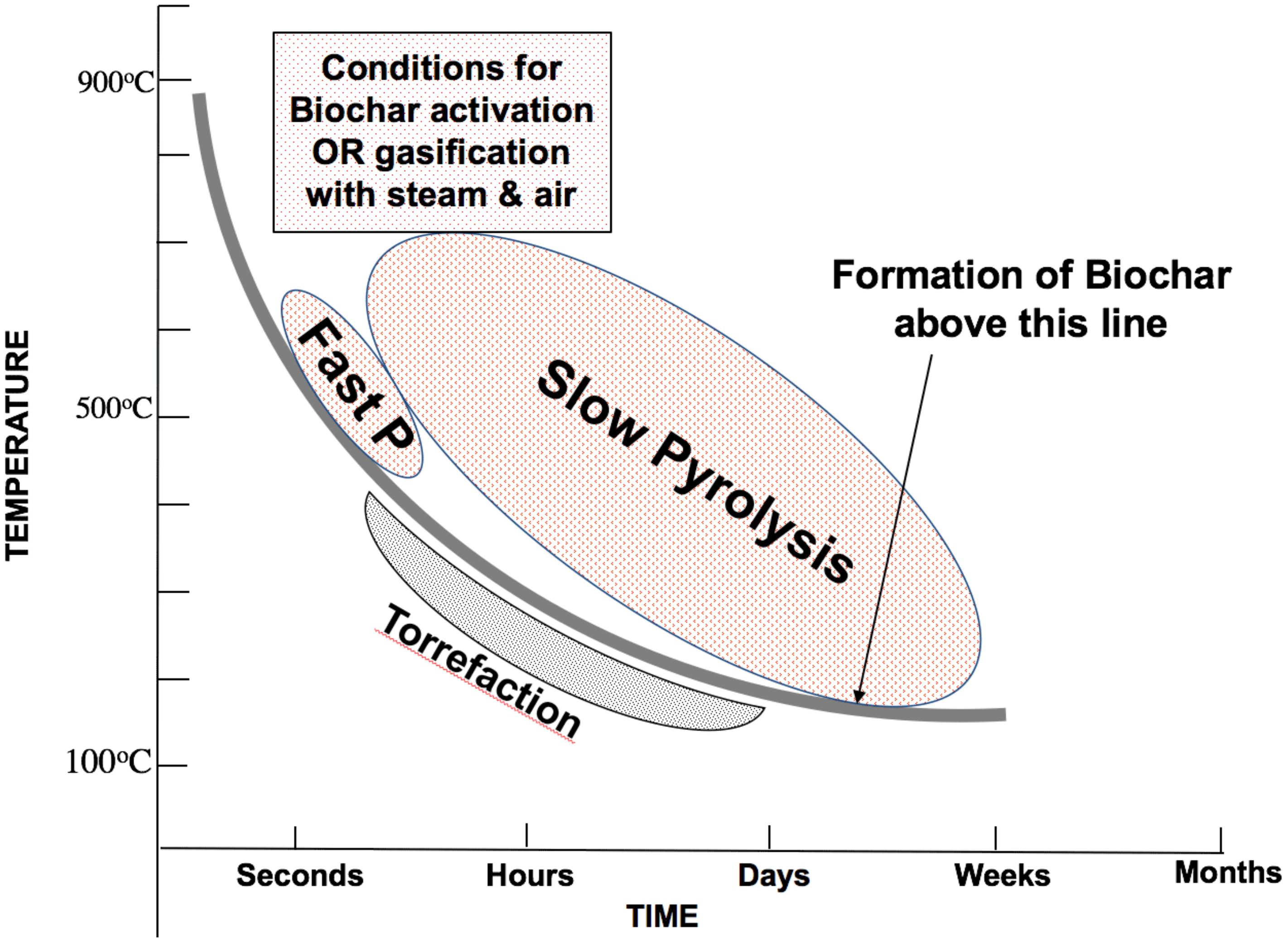
UNEP

"There is no doubt that **large amounts of GHGs are released [through] slash and burn agriculture**. There is a growing realization, however, that these concerns are perhaps less critical in the long term, as this statement **does not take into the account the development of subsequent land cover**…The debate…has therefore moved to how long the net loss stage lasts and whether replacement **land management systems can subsequently act as net sinks for carbon**."

--Tinker et al 1996

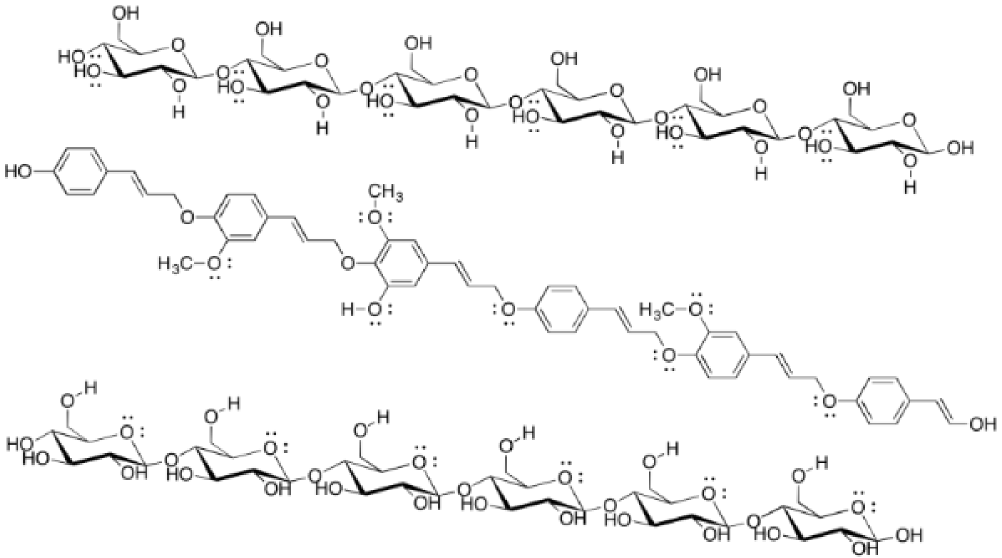


Biochar: Carbon rich product of incompletely burning biomass, typically in low-oxygen conditions

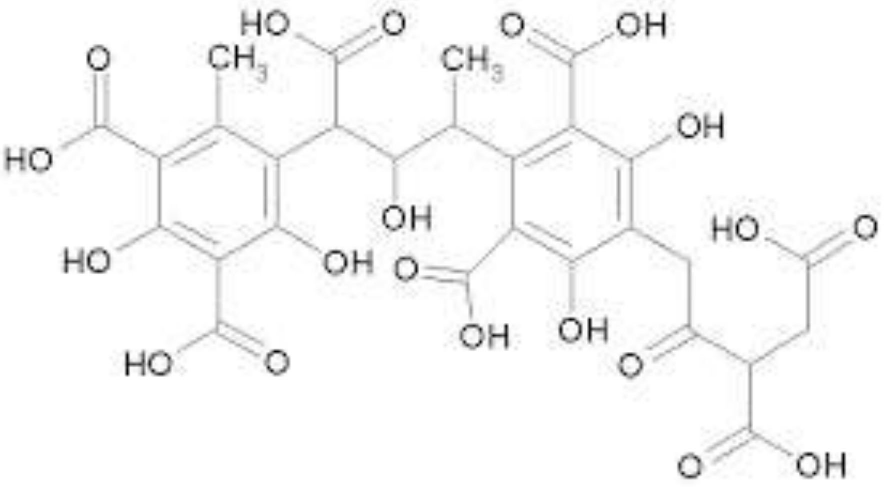


Pyrolysis creates aramotic carbon rings

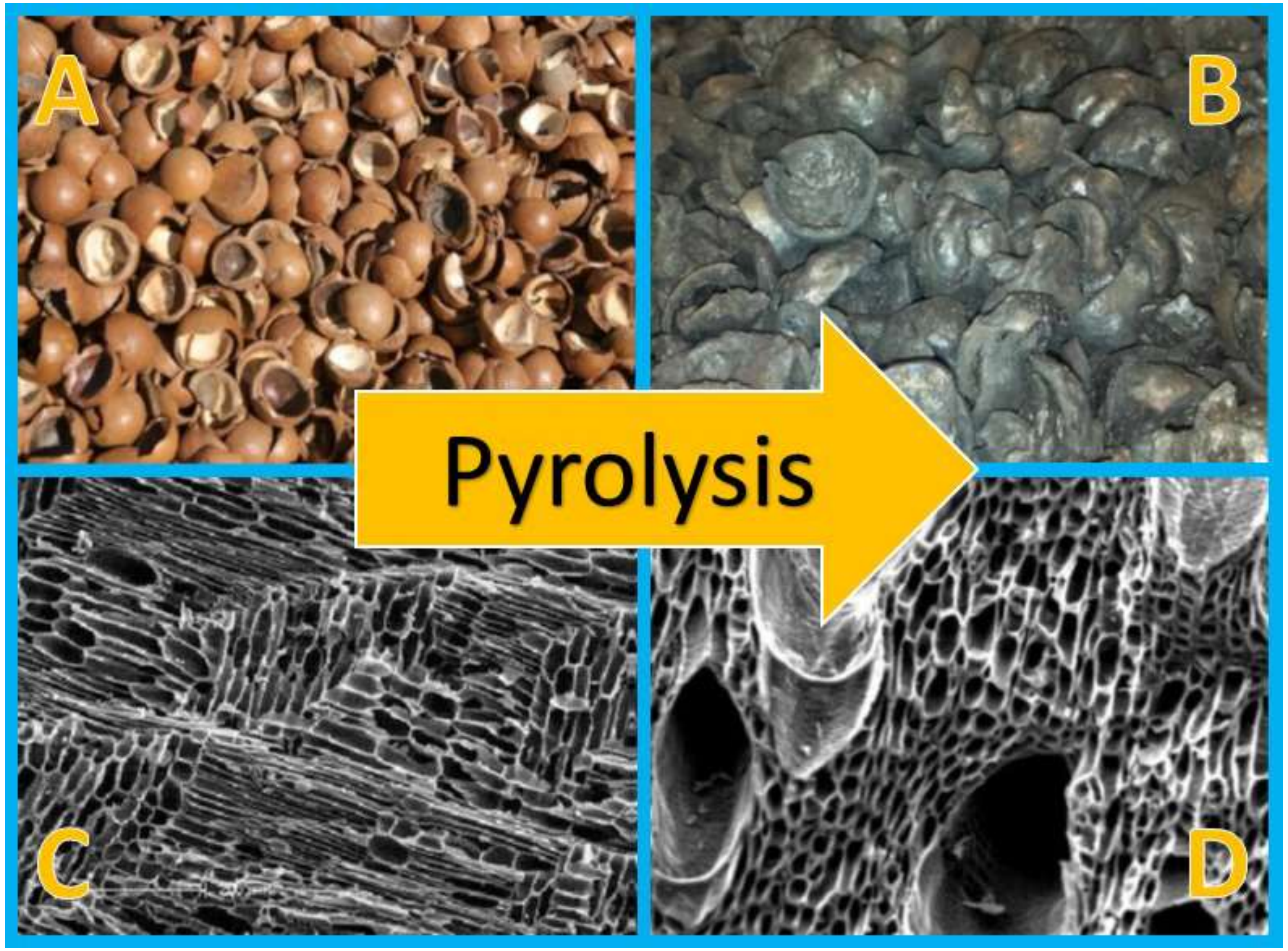
Biomass (cellulose)



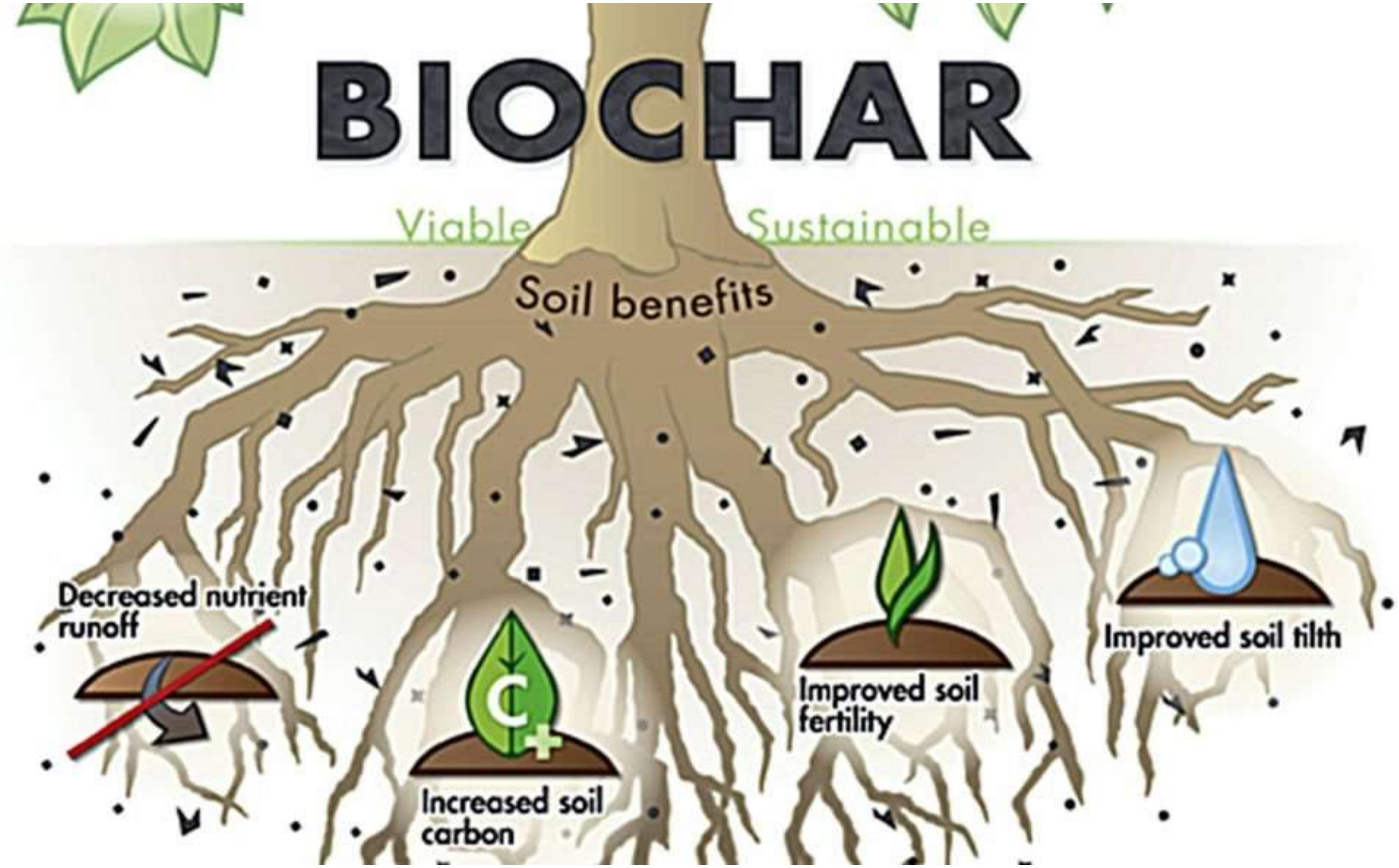
Biochar



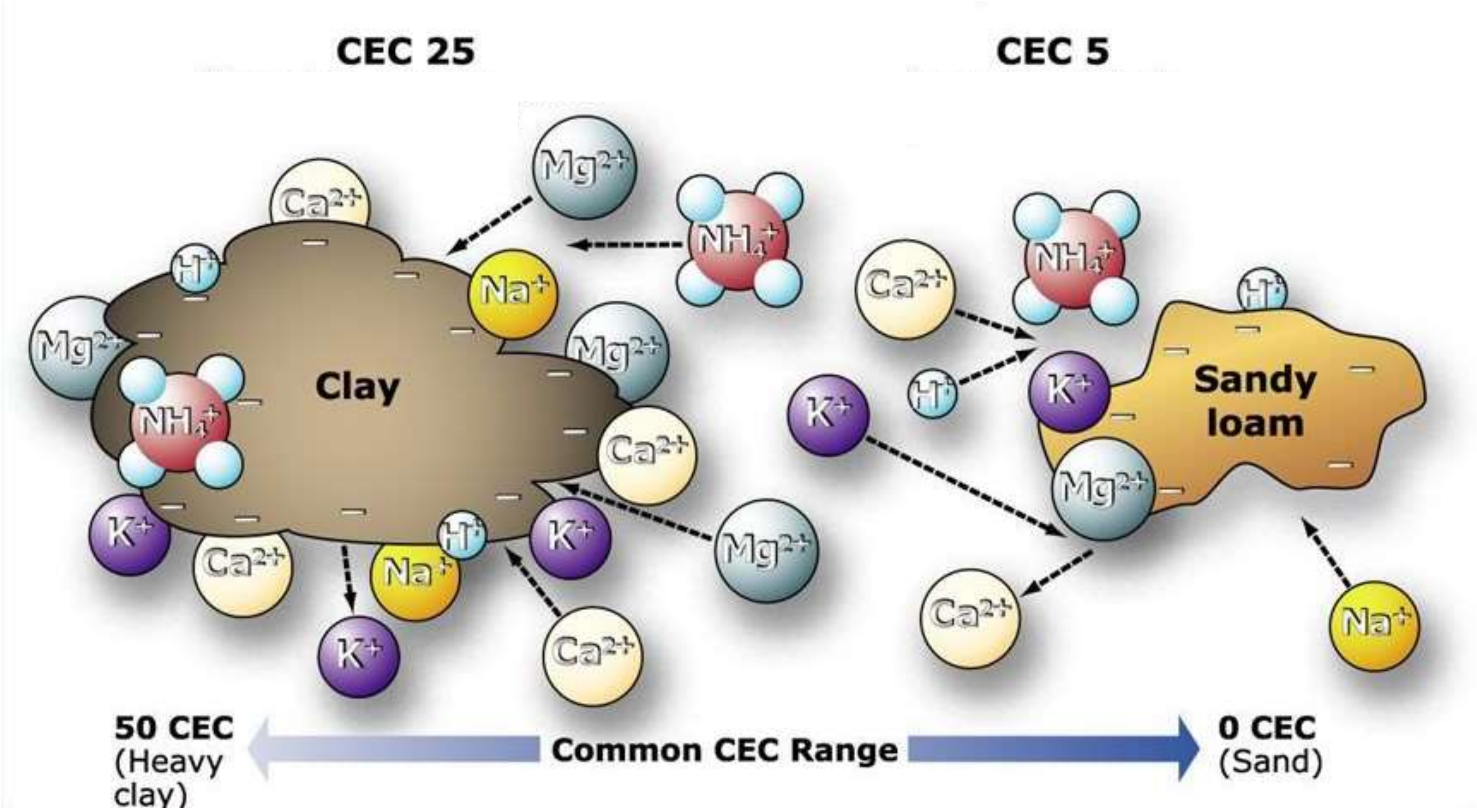
Biochar has **high surface area**



Biochar can improve soil quality



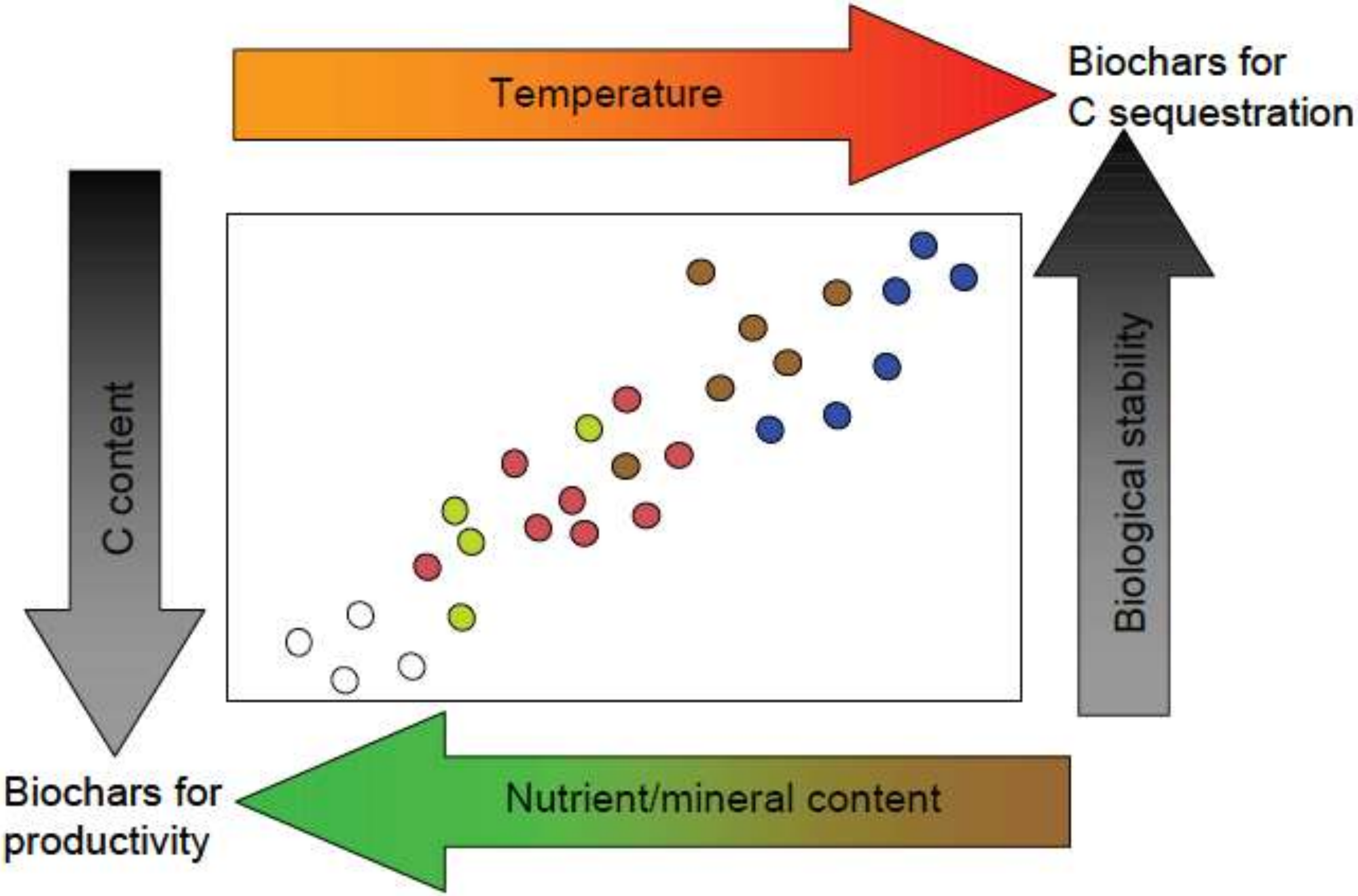
Biochar enhances soil nutrient and water holding capacity



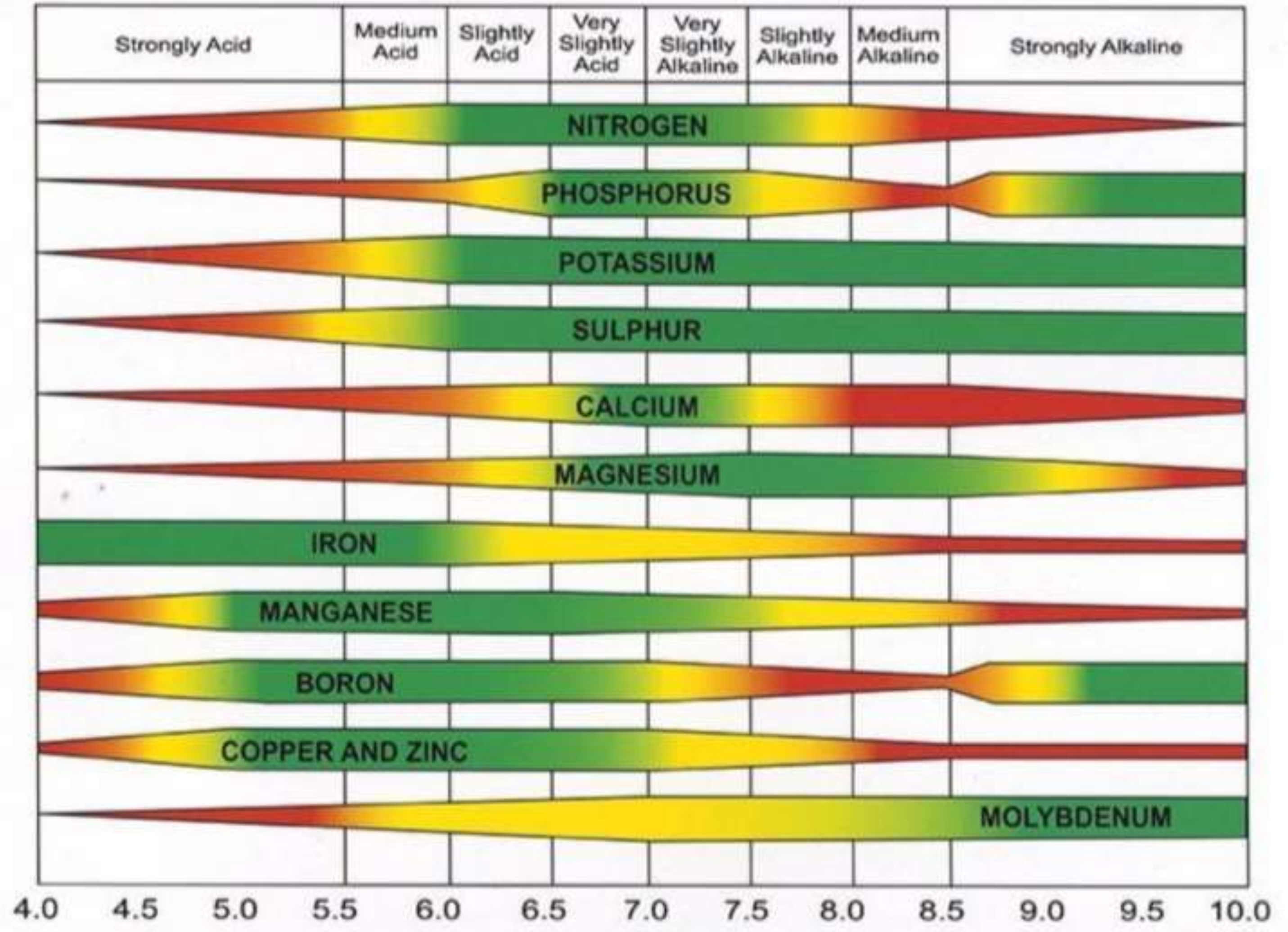
Biochar can be **nutrient rich**

Soil amendment type	Nitrogen (%N)	Phosphorus (%P)	Potassium (%K)
Livestock manure	0.4-4.8	0.2-2.8	0.5-1.7
Legume cover crop	2-2.5	0-0.5	1-2
Compost	1.5-3.5	0.5-1	1-2
Biochar	**0.2-7.8**	**0.02-7.3**	**0.1-5.8**

Biochar can be **carbon rich**



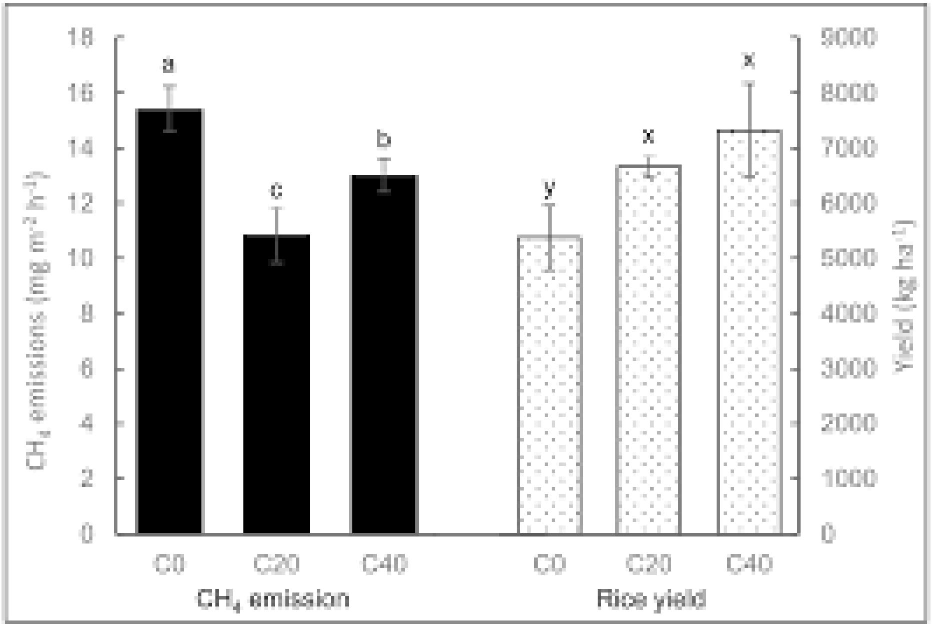
Biochar can **buffer soil pH**

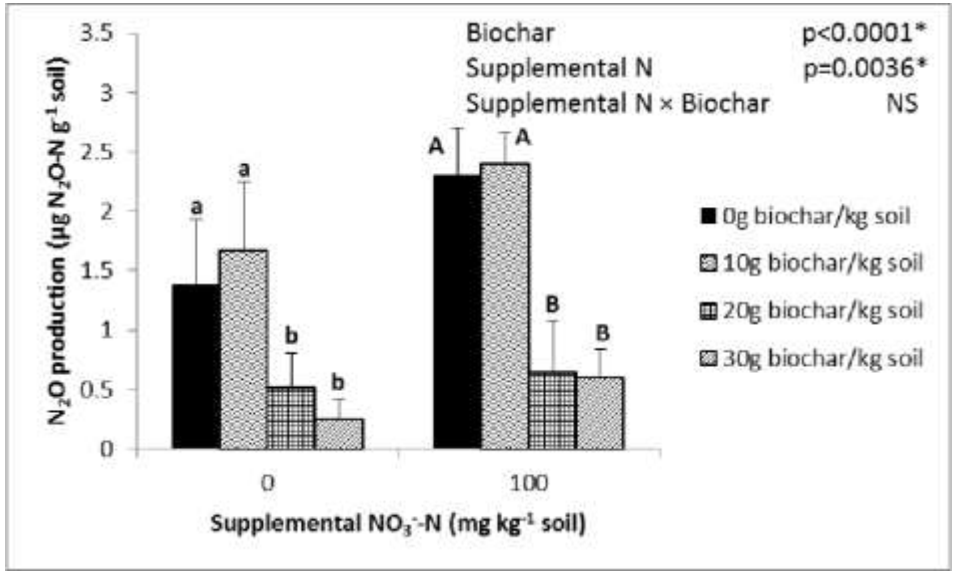


SOURCE: https://www.emporiumhydroponics.com/what-is-ph-1-to-14

Biochar sequesters carbon

Organic matter pool	Mean residence time (years)
Microbial biomass	0.1-0.4
Litter	1-3
Particulate organic matter	5-20
Light fraction organic matter	1-15
Biochar	57-2306





Swidden systems tend to **produce biochar relatively inefficiently**

Table 5 Biomass conversion into charcoal. *n.d.* Not determined

Tree species	Charring temperature (°C)	Production method	Charcoal recovery by weight (%)	*n*	Charcoal C content (%)	C yield (%)	Source
Charring							
Cellulose	300	Laboratory furnace	89.4	2	44.0	92	Shafizadeh and Sekuguchi (1983)
	325		63.3	2	47.9	71	
	350		31.8	2	59.9	45	
	400		16.6	2	76.5	30	
	450		10.5	2	78.8	19	
	500		8.7	2	80.4	16	
Pinus sylvestris (saw dust)[a]	300		43.3	2	68.5	59.2	Glaser et al. (1998)
Robinia pseudoacacia	350		37.9	60	76.4	64.4	Lehmann et al. (2002)
Acacia mangium	450		33.2	65	71.3	52.6	Lelles et al. (1996)
Eucalyptus camaldulensis	450		32.4	25	46.3	54.9	Vital et al. (1994)
Eucalyptus grandis	470		33.8	60	80.7	60.6	Vital et al. (1986)
Deciduous trees	500		30.2	8	84.7	56.8	Zhurinsh (1997)
Leucaena leucocephala	350–400[b]	Metal kiln	27.4	–	83.1	50.6	San Luis et al. (1984)
Coconut trunk	350–400[b]		25.0	–	77.8	43.2	
Mixed tropical wood, Manaus, Brazil	350–400[b]	Brick kiln	41	–	74.8	68.2	Correa (1988)
Miombo woodland	350–400[b]	Earth kiln	23.3	–	n.d.	–	Chidumayo (1991)
Mixed tropical hardwood	350–400[b]	Earth pit	–	–	69.0	–	FAO (1983)
Secondary forest, fruit orchard	350–400[b]	Earth mound	14.3	98	90.0	32.0	Coomes and Burt (2001)
Weighted average[c]			28.5		79.6	49.9	
Charring							
Secondary forest	–	Slash and burn	–		15–23		Seiler and Crutzen (1980)
Secondary forest	–		–		5–10		Crutzen and Andreae (1990)
Primary forest, Manaus, Brazil	–				3.5		Fearnside et al. (1993)
Primary forest, Manaus, Brazil	–				4.7		Graca (1997)
Secondary forest, Altamira, Brazil	–				1.6		Fearnside et al. (1999)
Secondary forest, Manaus, Brazil	–				1.8		
Average					3.0		

Hypotheses

- Q1: How much carbon stored in biomass is converted to biochar (BC) as a result of burning in traditional Maya swidden agroecosystems?

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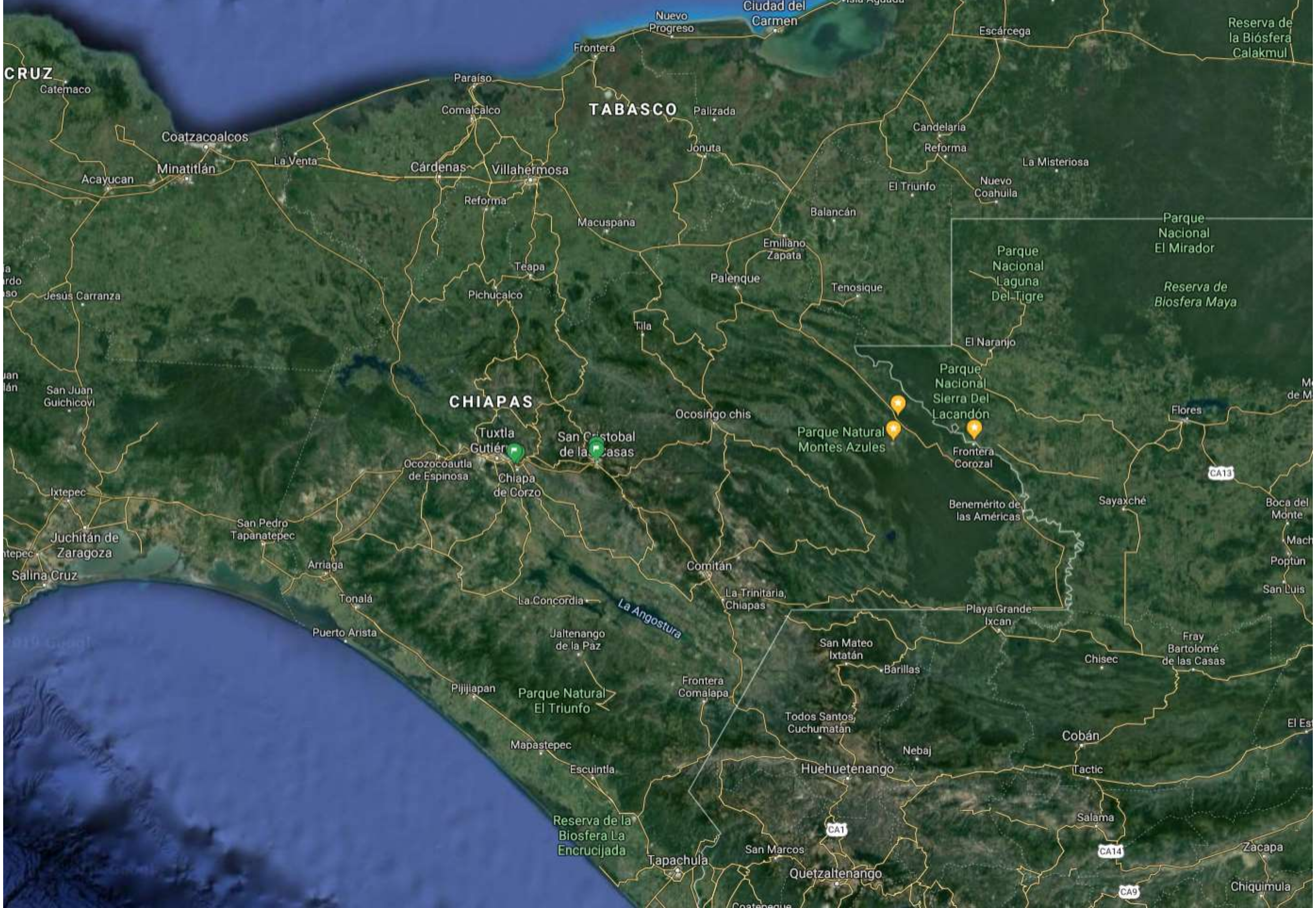
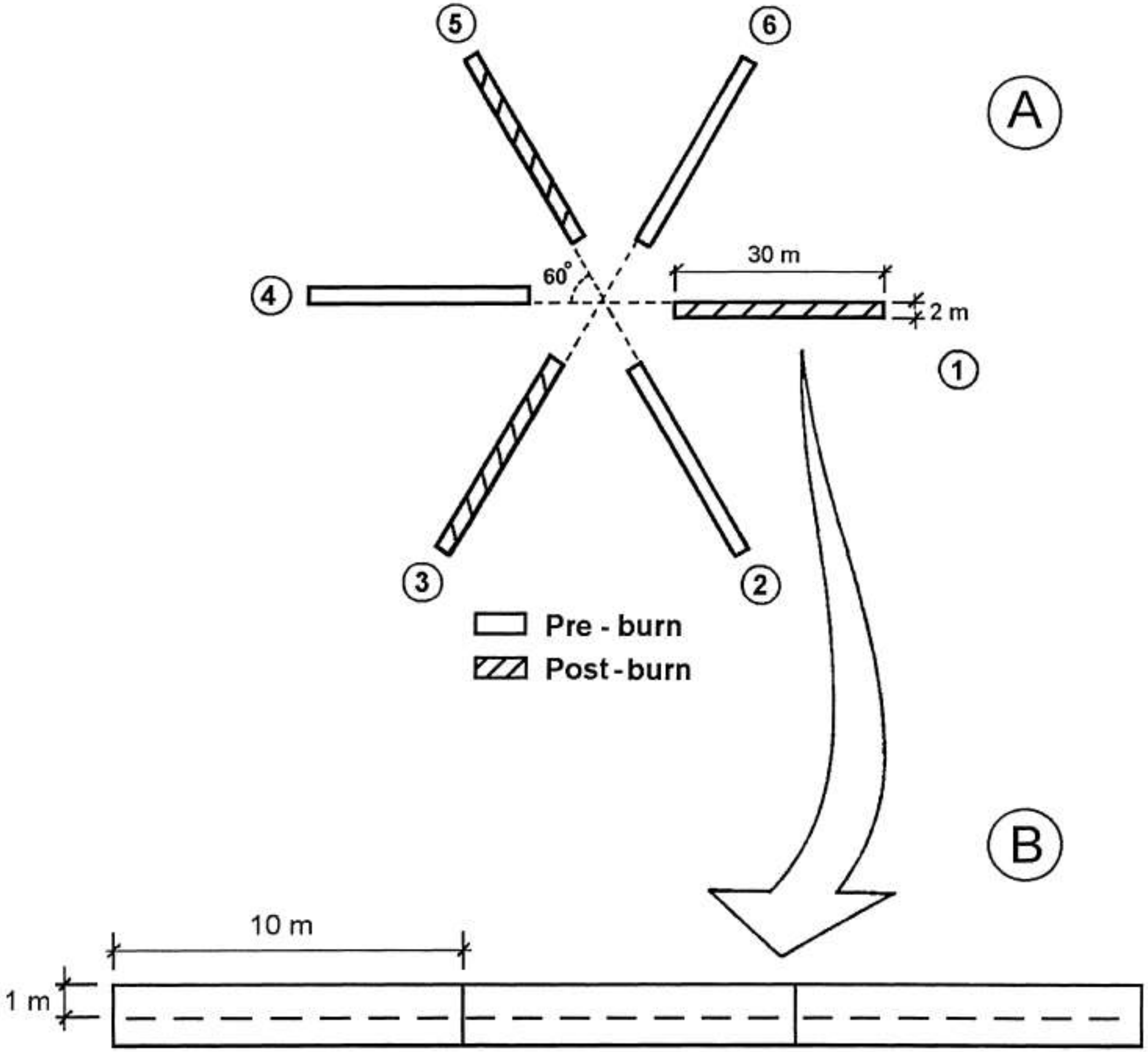
- Q3: What environmental and management factors influence BC quantity and quality?

Hypotheses

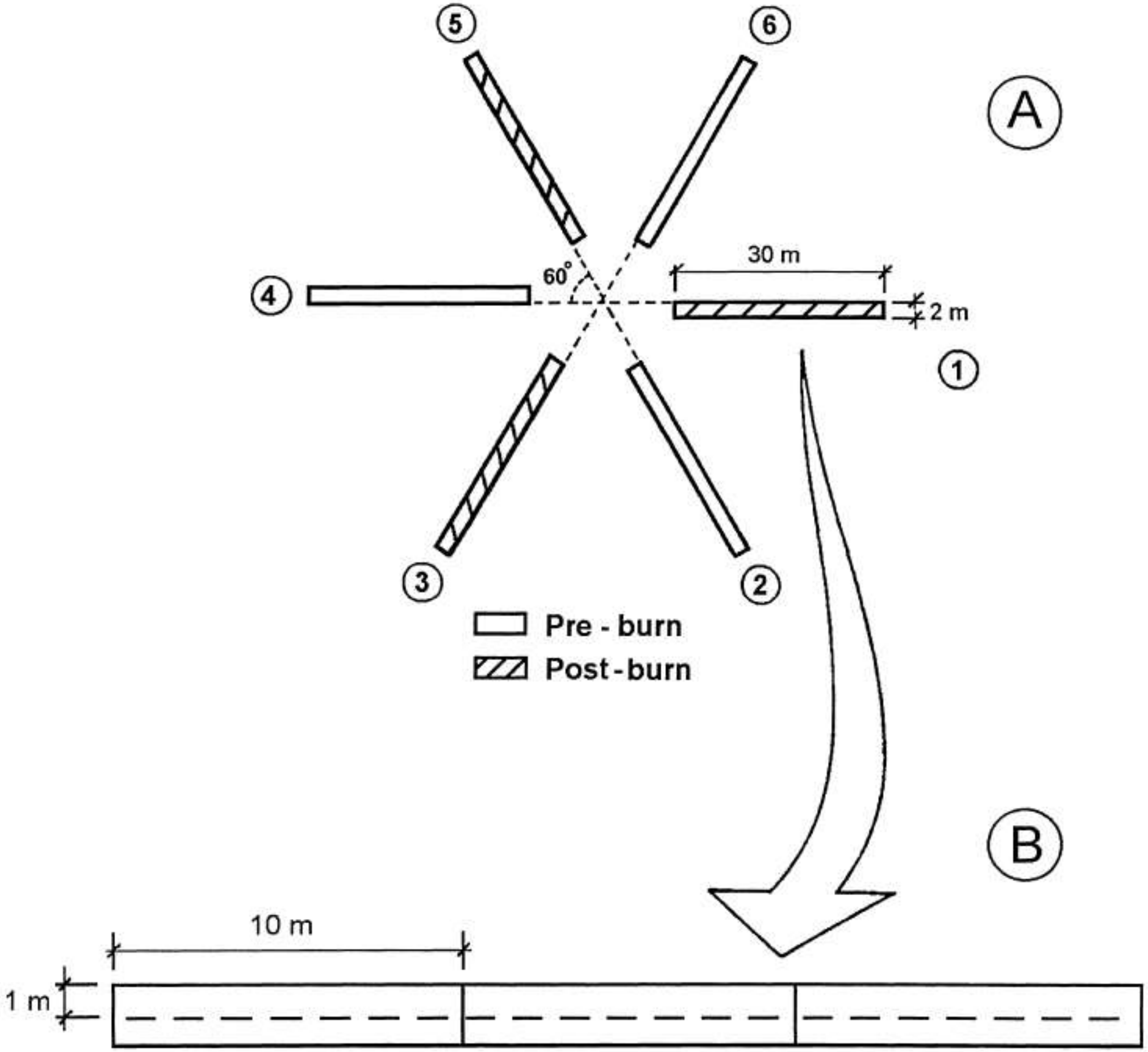
- Q1: How much carbon stored in biomass is converted to biochar (BC) as a result of burning in traditional Maya swidden agroecosystems?
- Q2: How and to what degree do cultural and biophysical factors influence BC quantity and quality?
- Q3: How quickly do BC pools turn over during traditional *milpa* cycles?
- Q4: Does fire management differ between individual farmers? How and why? How has it changed over time?



Nuevo Progreso
Ciudad del Carmen
Escárcega
Reserva de la Biósfera Calakmul
CRUZ
Catemaco
Frontera
Paraíso
TABASCO
Palizada
Comalcalco
Coatzacoalcos
Candelaria
Reforma
Jonuta
La Venta
Minatitlán
Acayucan
Cárdenas
Villahermosa
La Misteriosa
El Triunfo
Nuevo Coahuila
Reforma
Balancán
Macuspana
Parque Nacional El Mirador
Emiliano Zapata
Parque Nacional Laguna Del Tigre
Teapa
Palenque
Tenosique
Reserva de Biosfera Maya
Jesús Carranza
Pichucalco
Tila
El Naranjo
Parque Nacional Sierra Del Lacandón
San Juan Guichicovi
CHIAPAS
Ocosingo chis
Flores
Tuxtla Gutiérrez
San Cristobal de las Casas
Parque Natural Montes Azules
Frontera Corozal
Ocozocoautla de Espinosa
Chiapa de Corzo
CA13
Ixtepec
Benemérito de las Américas
Sayaxché
Boca del Monte
San Pedro Tapanatepec
Juchitán de Zaragoza
Poptún
Arriaga
Comitán
Salina Cruz
San Luis
La Trinitaria, Chiapas
Tonalá
La Concordia
La Angostura
Playa Grande Ixcan
Puerto Arista
Jaltenango de la Paz
San Mateo Ixtatán
Barillas
Fray Bartolomé de las Casas
Chisec
Pijijiapan
Frontera Comalapa
Parque Natural El Triunfo
Todos Santos Cuchumatán
Cobán
Nebaj
Mapastepec
Huehuetenango
Tactic
Escuintla
Reserva de la Biosfera La Encrucijada
Salama
CA1
San Marcos
CA14
Zacapa
Tapachula
Quetzaltenango
CA9
Chiquimula



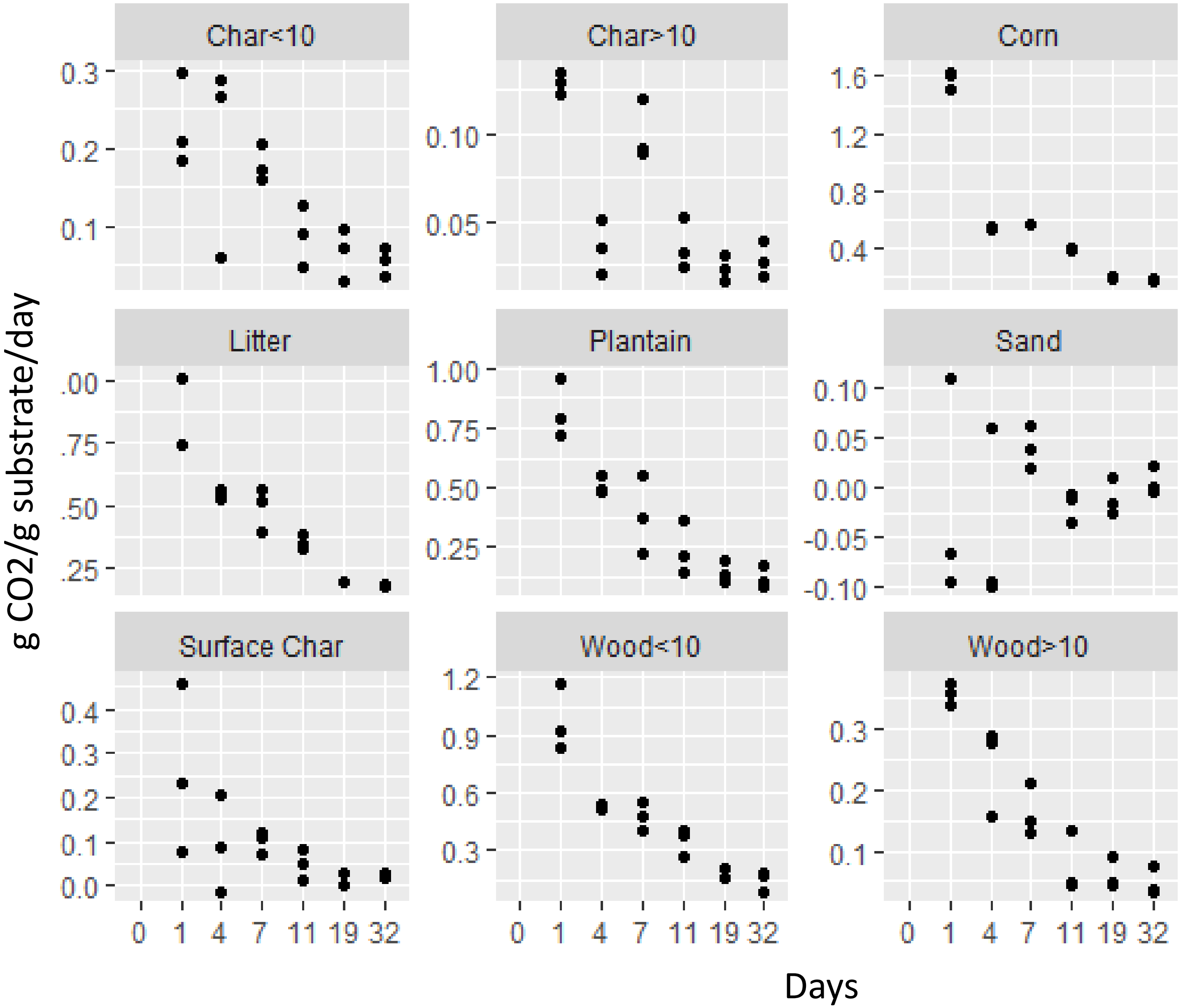
5
6
A
30 m
60°
4
2 m
1
3
2
Pre - burn
Post - burn
B
10 m
1 m



A
B
5
6
4
1
3
2
60°
30 m
2 m
10 m
1 m
Pre - burn
Post - burn

C Pool	Before burning (kg C /field)	After burning (kg C/field)	Mean percent change
Herbaceous litter	5,637 ± 2,852	2,536 ± 1,734	-55.01%
Wood<10 cm DBH	81,535 ± 41,087	18,380 ± 11,672	-77.46%
Wood>10 cm DBH	142,440 ± 60,460	96,386 ± 60,544	-47.78%
Soil surface char	0	28,926 ± 12,463	NA
Adhered char (<10cm DBH)	0	464 ± 182	NA
Adhered char (>10cm DBH)	0	10,230 ± 5,234	NA
Total	*229,612 ± 73,235*	*156,922 ±* 63,145	*-31.65%*


15


Char<10
Char>10
Corn
Litter
Plantain
Sand
Surface Char
Wood<10
Wood>10
g CO2/g substrate/day
Days

Char is **more stable** than biomass

Variable		P value	Tukey post-hoc comparison test
Successional stage	-	<0.001	-
Material	Litter	<0.001	D
	Wood<10	<0.001	C
	Wood>10	<0.001	B
	Ash	0.298	A
	Char>10	0.745	A
	Char<10	0.999	A
Successional stage x Material	-	0.989	-

Tentative conclusions

- Traditional Maya fire management produces a **surprisingly high amount of biochar**

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- Large quantities of **aboveground biomass remain after burning**
- Mineralization rates: **Biochar << Biomass**
- Biochar **quantity and quality depends on successional stage** burned
- **Limited influence of management** differences…for now.

“**Slash and burn farmers are victims of deforestation** even though they may appear to be the villains.” –Rambo 1990

Future work

- Other ecosystem services provided beyond carbon sequestration?

Future work

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- Weather conditions’ influence on biochar production?

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- Other ecosystem services provided beyond carbon sequestration?
- Weather conditions’ influence on biochar production?
- Participatory and transformational research; cultivating collaboration through decolonial methodologies


Gracias! Ba'yo tech!