Future Directions of BNZ Regional Climate Feedbacks Research (Dave McGuire Perspective)

(1) Substantial progress on the effects of **climate**, **fire**, and **top down permafrost thaw** in **uplands** on **vegetation dynamics and biogeochemistry**. Still work to do (such as **insects and pathogens**).

(2) Begun modeling research on the effects of **thermokarst** on wetland vegetation dynamics and biogeochemistry.

(3) Need to begin modeling research on **biogeochemical linkages** of uplands and wetlands to inland surface waters (**lakes and streams**) and **biogeochemistry of inland surface waters**.

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- *Finish two-way coupling of ALFRESCO with DVM-DOS-TEM and GIPL*
- *Additional research on modeling successional trajectories*
- Begin research on modeling the dynamics and effects of insect and pathogen disturbances

Finish two-way coupling of ALFRESCO with DVM-DOS-TEM and GIPL

Air Temperature, Precipitation, Initial Vegetation

Snow Water Equivalent

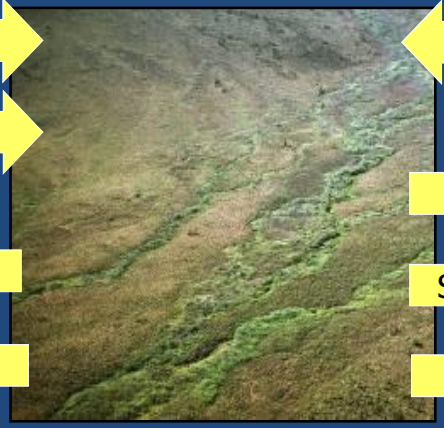
ALFRESCO | **DVM-DOS-TEM** | **GIPL**

Vegetation Type

Burned area

O Horizon Thickness

Vegetation Carbon



Soil Thermal Profile

Vegetation Canopy

Soil Moisture Profile

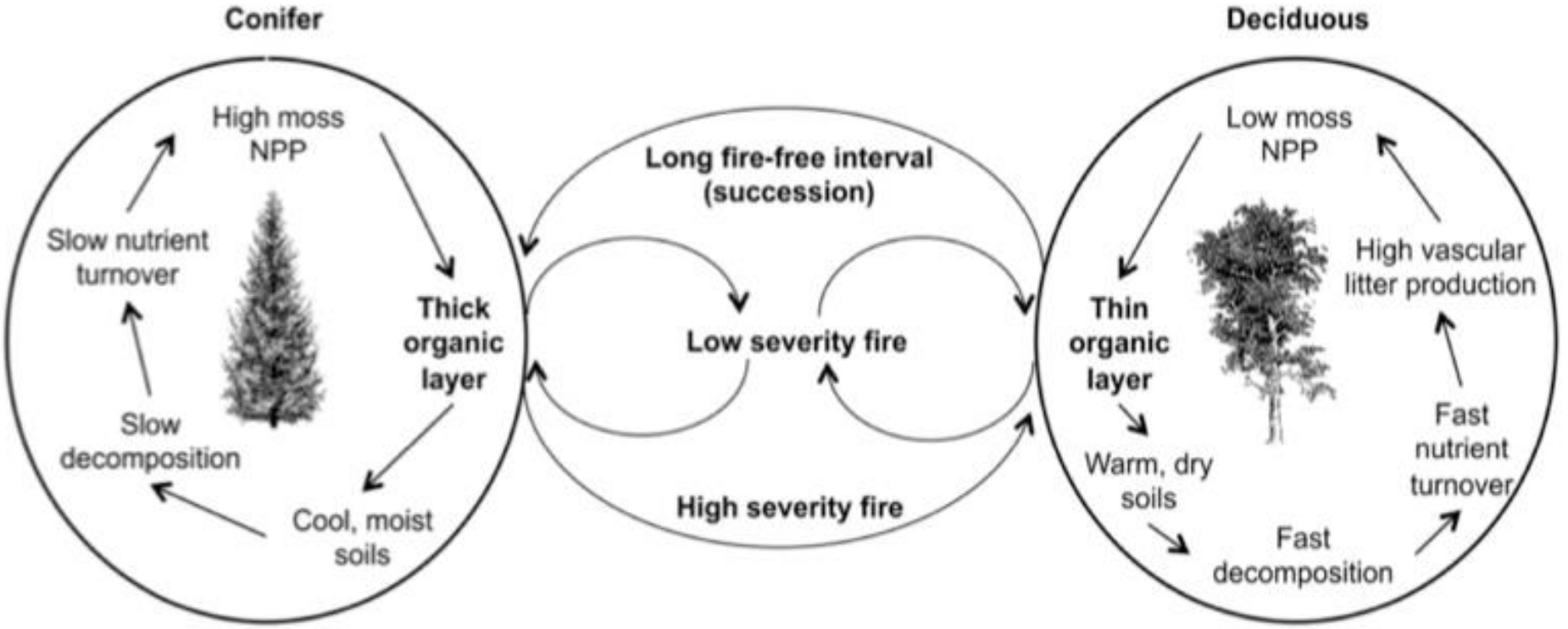
Moss Thickness

Elevation, Slope, Aspect. Historical Fire

Mineral Soil Texture

ALF TEM GIPL

Additional Research on Modeling Successional Trajectories.



(Johnstone et al. 2010)

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University of Saskatchewan

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UF University of Florida

The drivers of post-fire recruitment composition

Johnstone et al. 2010

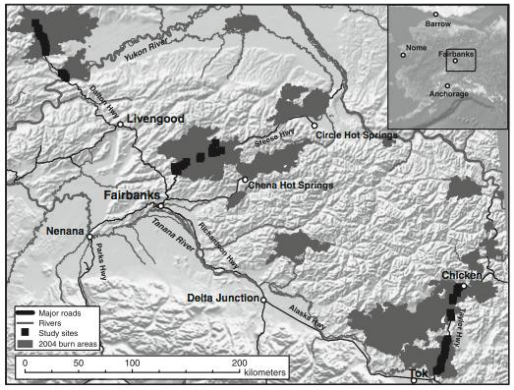
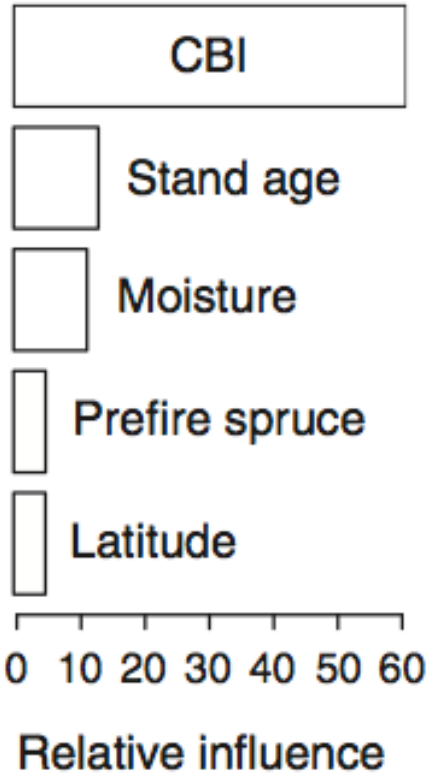
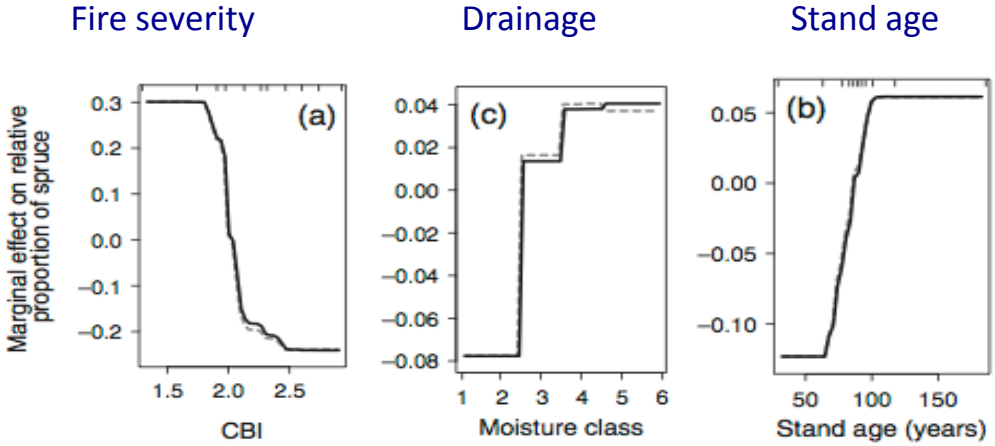


Fig. 1 Map of the study sites in interior Alaska (modified from Johnstone *et al.*, 2009). Solid gray polygons indicate areas that were burned in 2004. Study sites ($n = 90$) are shown as filled black squares in fires that intersected the Dalton, Steese, and Taylor highways. Because of the small scale of the map, symbols overlap for some sites.



Relative dominance of spruce in post-fire recruitment is related to fire severity, pre-fire stand age and drainage conditions.



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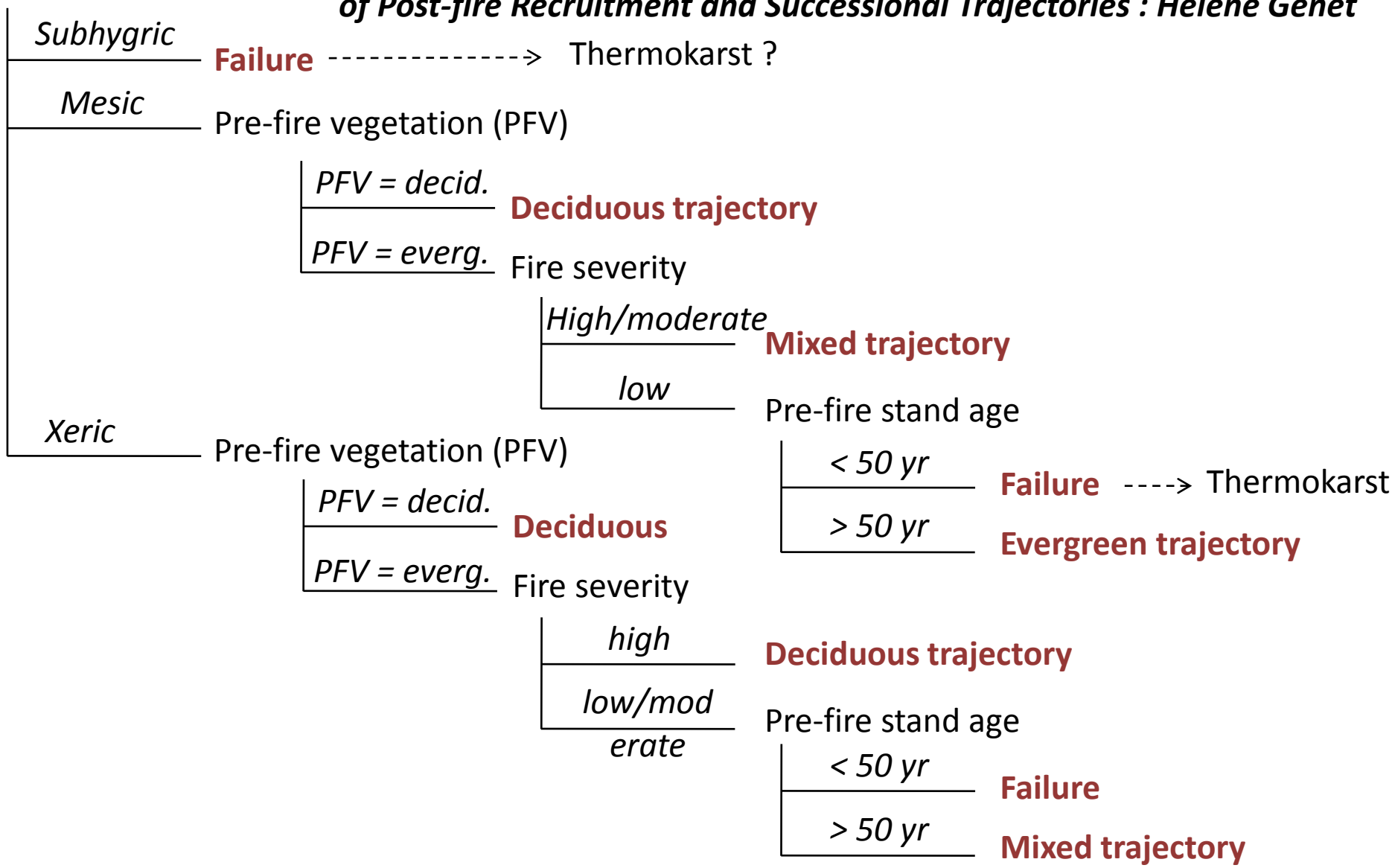
Regression Tree Approach to Modeling Dynamics of Post-fire Recruitment and Successional Trajectories : Helene Genet



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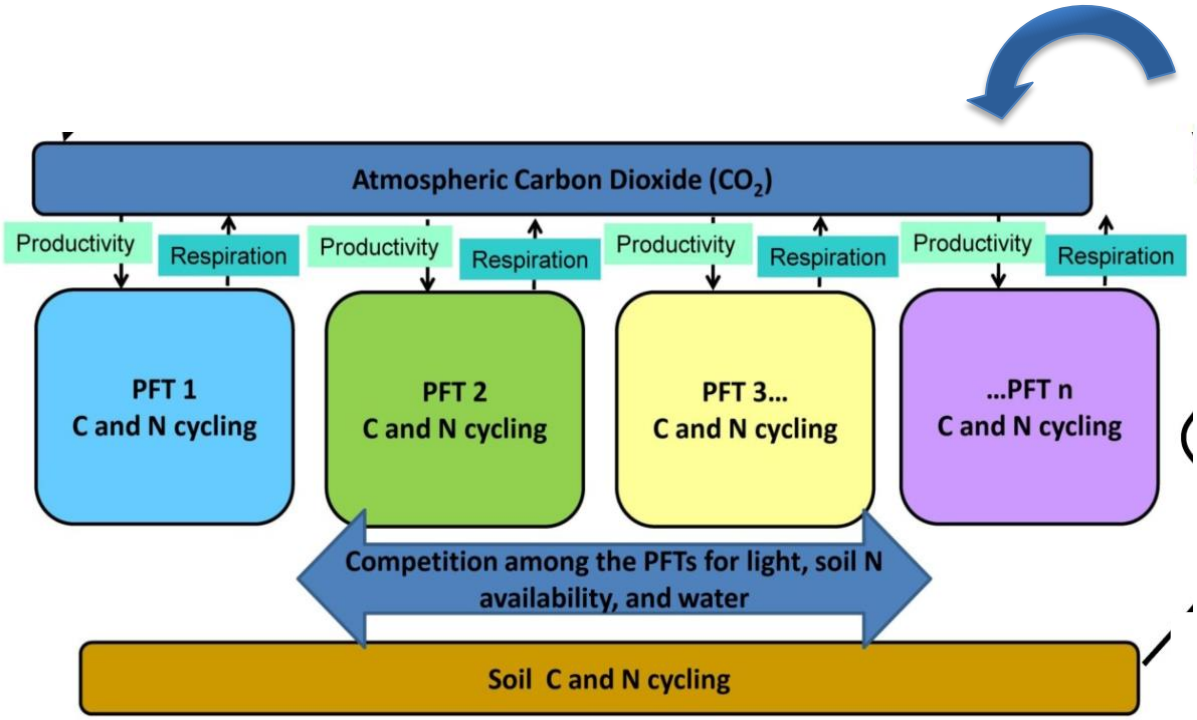
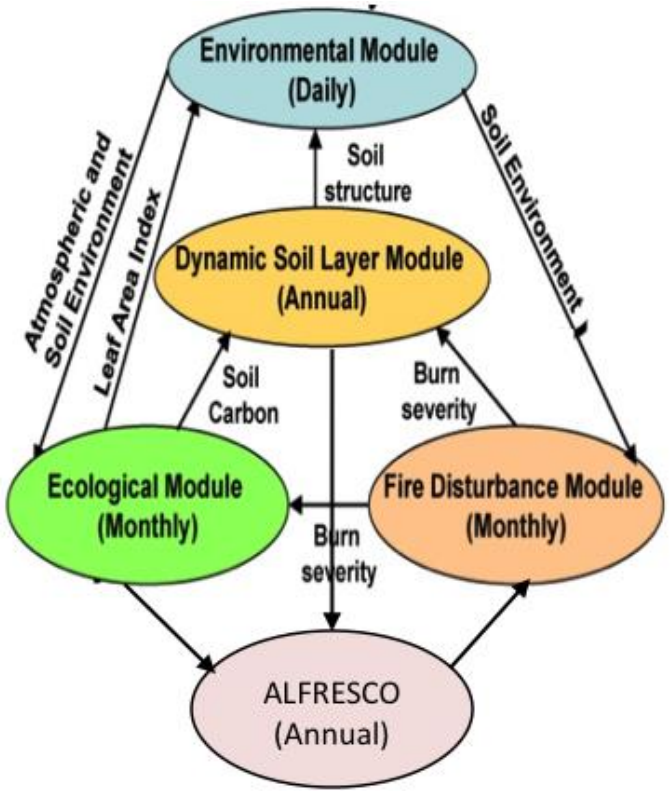
Build Successional Dynamics into DVM – DOS – TEM

The dynamic vegetation model simulates carbon and nitrogen dynamic of various plant functional types, competing for light and nitrogen uptake.





(Euskirchen et al. 2009)

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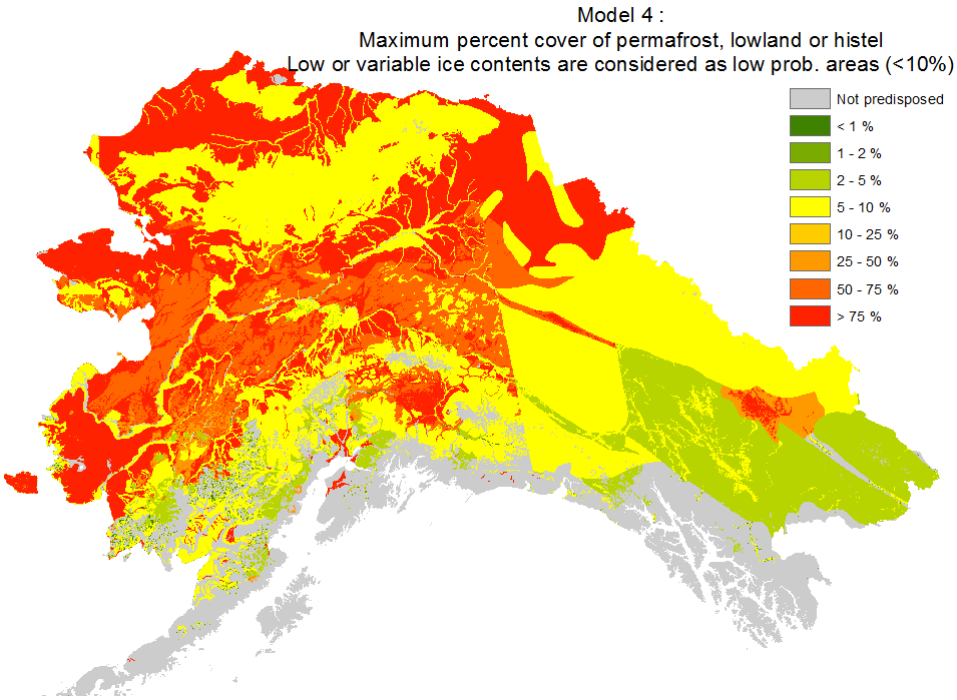
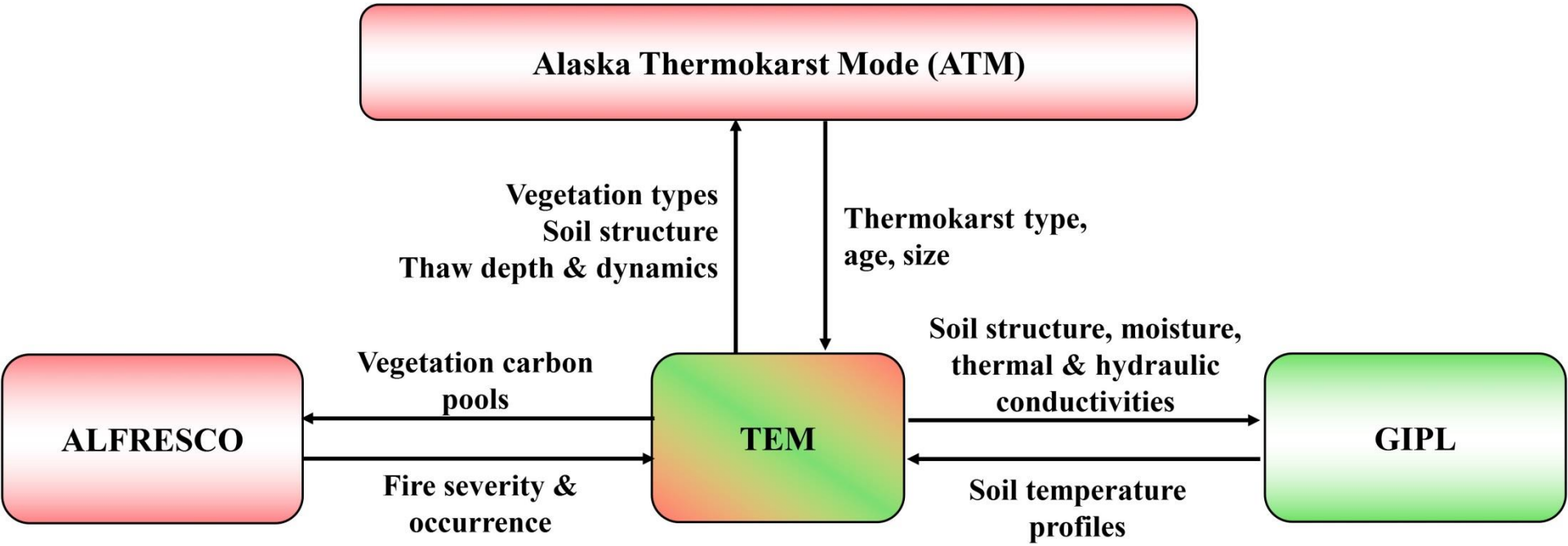
- Development of Alaska Thermokarst Model (ATM)
- Development of Peatland DOS-TEM/DVM-DOS-TEM
- Coupling of ATM with Peatland DVM-DOS-TEM

Quantifying the Area Susceptible to Thermokarst

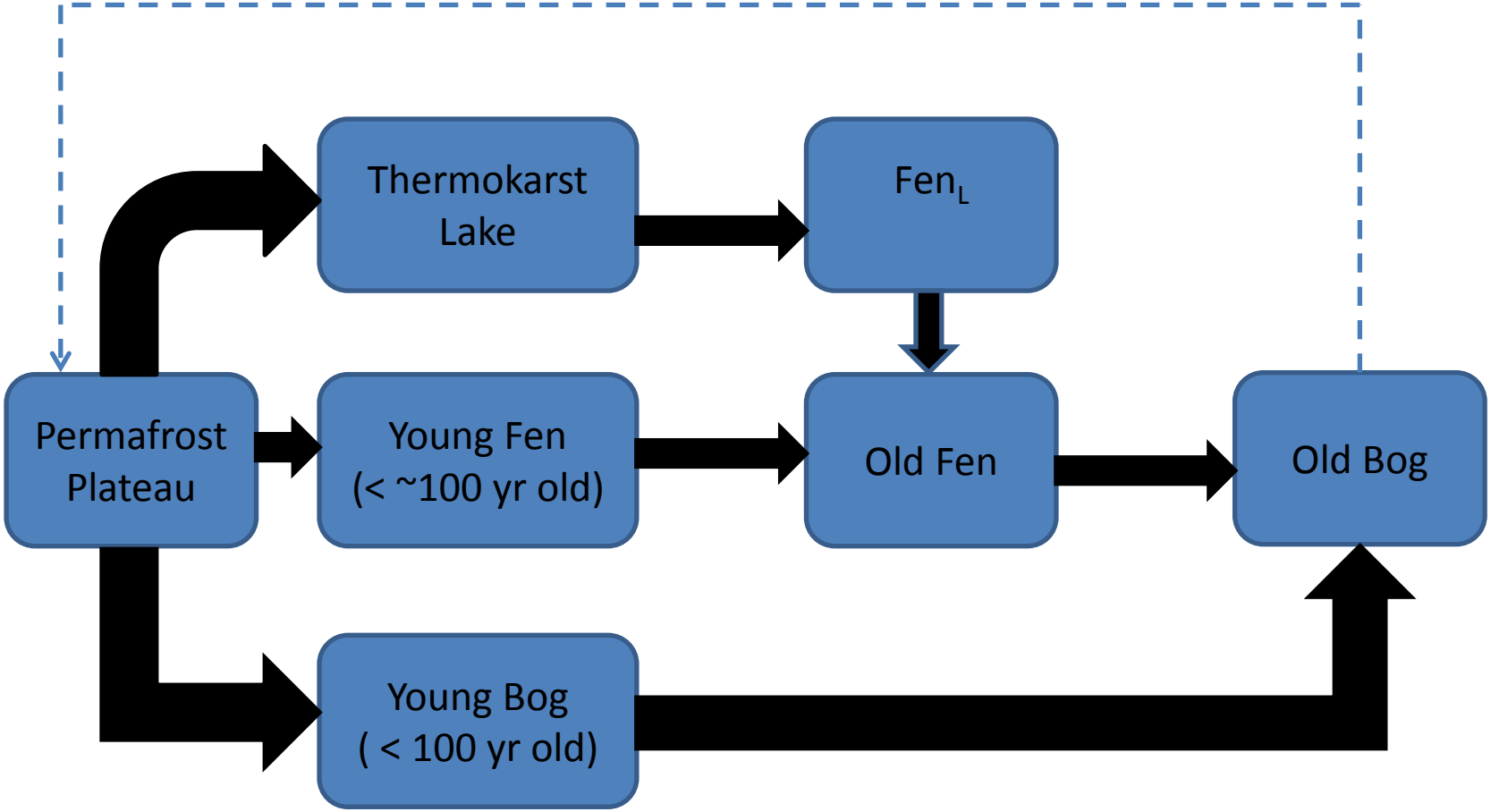
Function of ice content, landscape position (lowlands), presence of peat (histels), and presence of permafrost (from Helene Genet)



Development of the Alaska Thermokarst Model



Conceptual Model of Landscape Change Associated with Thermokarst Disturbance



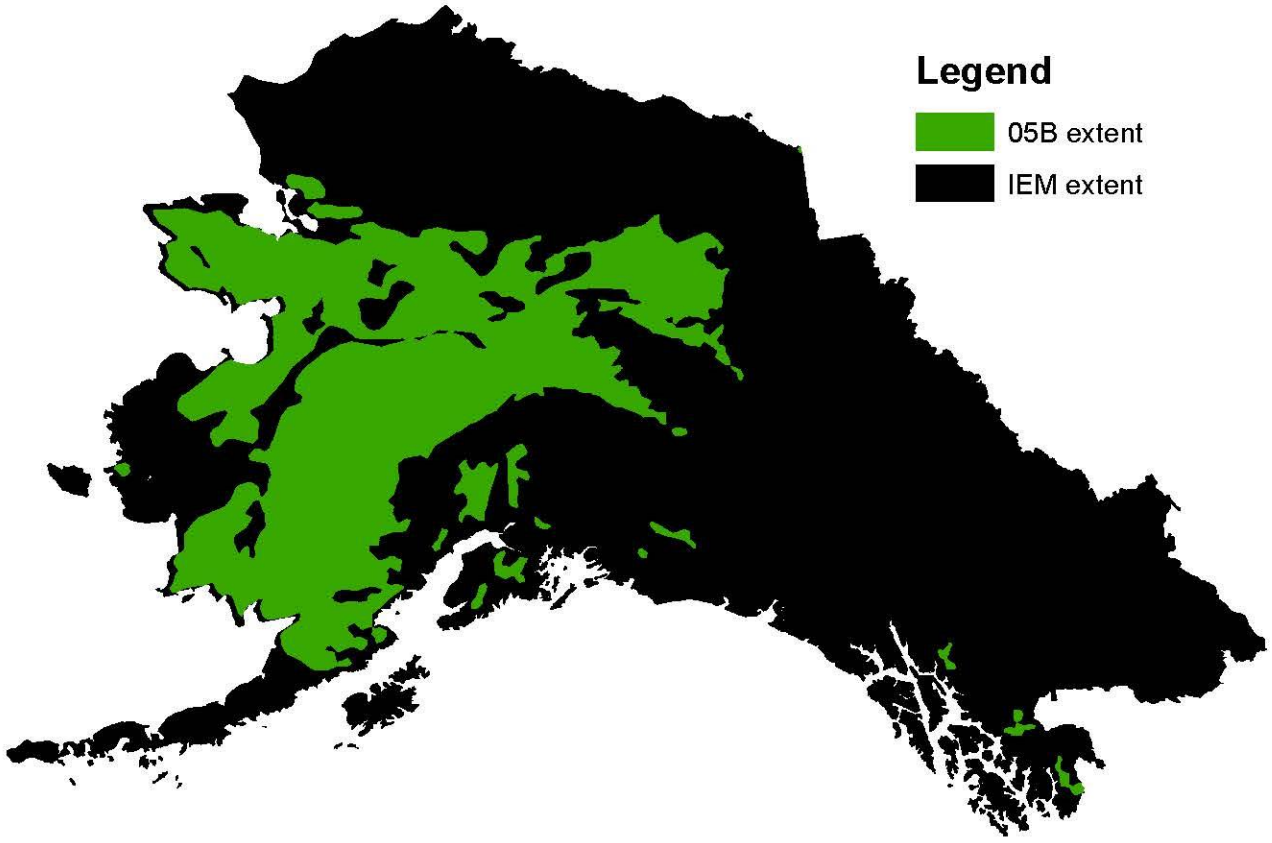
Thermokarst-Prone Landscape Change Questions

- What is the current distribution of land cover types in thermokarst-prone landscapes?
- What are the transition rates among land cover types during the satellite era?
- What are the controls over transition rates (e.g., climate, permafrost, hydrology)?
- How is the distribution of land cover types projected to change in the future?

Biogeochemistry Change Questions in Thermokarst-Prone Landscapes

- *How do land cover transitions in thermokarst-prone landscapes (and associated changes in permafrost and hydrology) influence carbon storage and fluxes in land cover types?*
- How do land cover transitions (and associated changes in permafrost and hydrology) influence the loading of carbon into lake and stream networks ?
- How will climate change (and associated changes in land cover transitions, permafrost, and hydrology) influence carbon dynamics in lakes, stream networks, and wetland complexes?

PERM Region 05B: Discontinuous Boreal Permafrost



Bookkeeping Model: Estimates of Carbon Dynamics of each Land Cover Type (Jen Harden, Jon O'Donnell, Others)

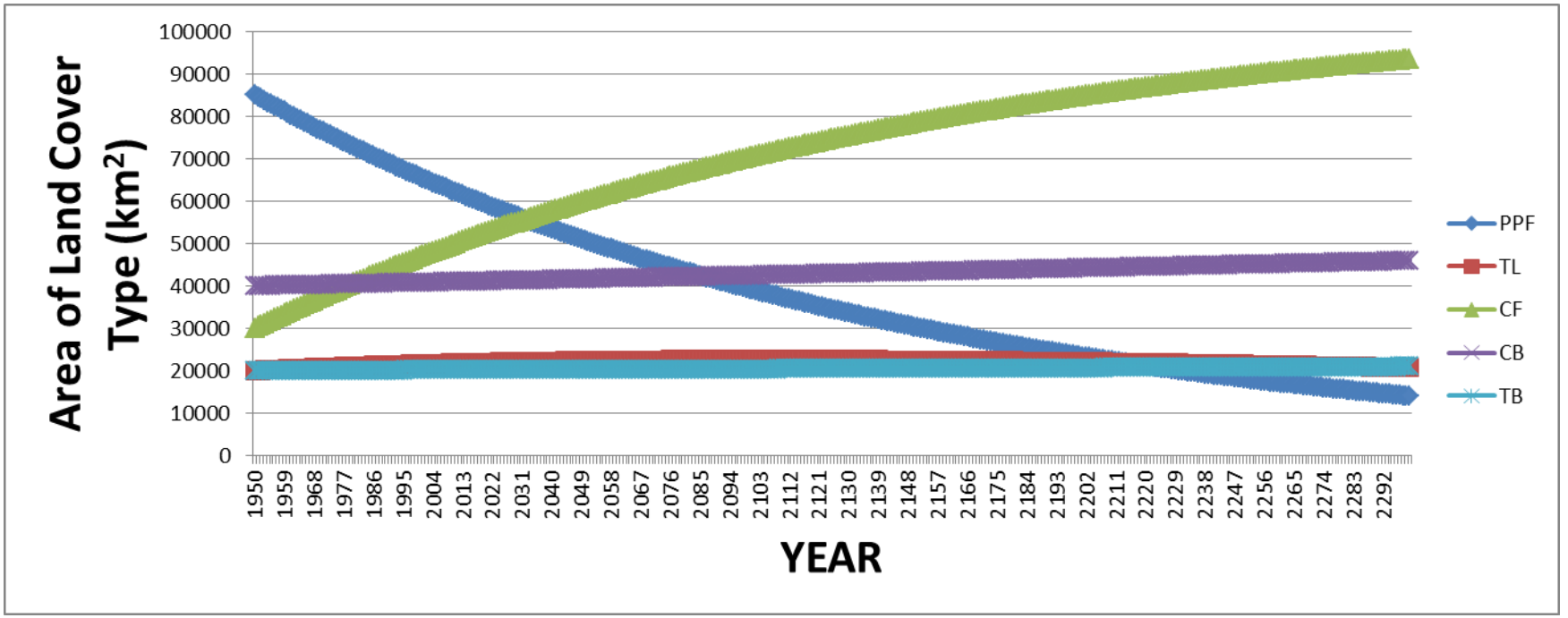
Collapse Bogs (CB)	Delta Shallow SOC (g C m-2 yr-1)	Delta Deep SOC (g C m-2 yr-1)	Delta VEGC (g C m-2 yr-1)
0-50	128	-1085	0
51-100	108	-488	0
100-500	56	-50	0
>500	13	0	0
Permafrost Plateau Forests (PPF)	38	14	0
Treed Bogs (TB)	13	0	0

	Net CH4 Emissions (g C m-2 yr-1)	NEE (+ to atmosphere) (g C m-2 yr-1)	DOC Flux (g C m-2 yr-1)
Collapse Fens (CF)	6	-8	2.5
Thermokarst Lakes (TL)	4.6	15	2.5

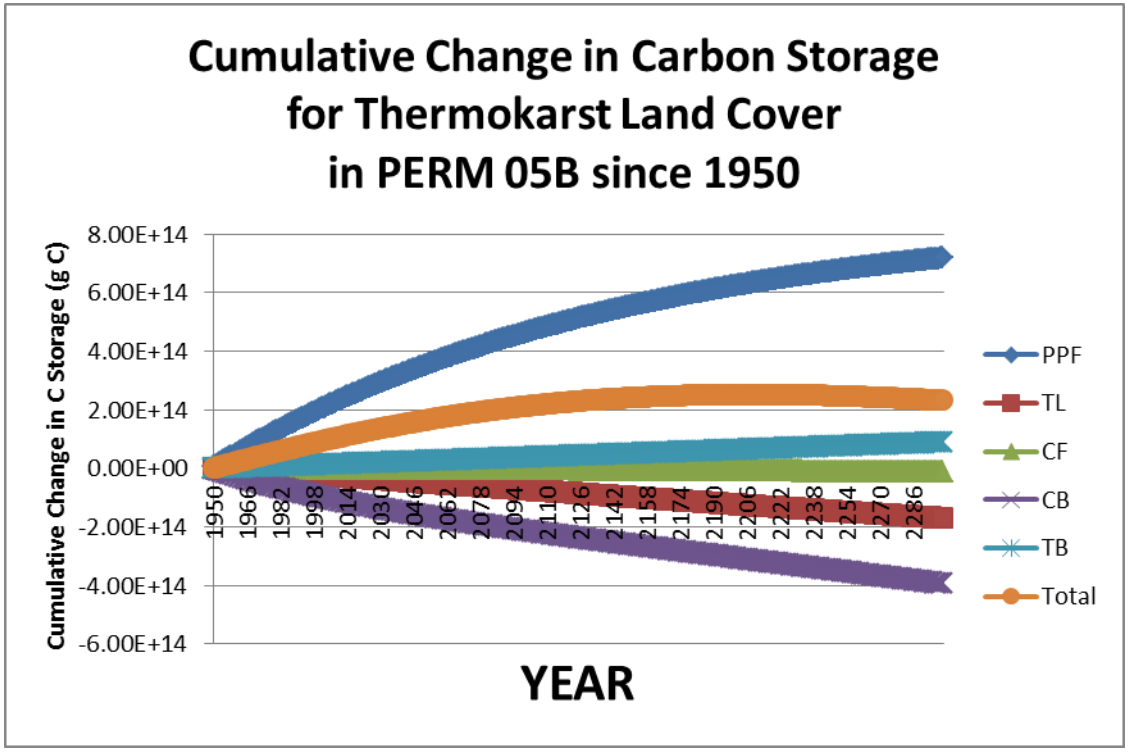
Bookkeeping Model: Transition Rates (Proportion Per Year)

From/To (Proportion)	Permafrost Plateau Forest	Thermokarst Lake	Collapse Fen	Collapse Bog	Treed Bog
Permafrost Plateau Forest (PPF)	NAN	0.0007619	0.0042418	0.0001359	NAN
Thermokarst Lake (TL)	NAN	NAN	0.0012821	NAN	NAN
Collapse Fen (CF)	NAN	NAN	NAN	0.0002	NAN
Collapse Bog (CB)	NAN	NAN	NAN	NAN	0.0001
Treed Bog (TB)	0	NAN	NAN	NAN	NAN

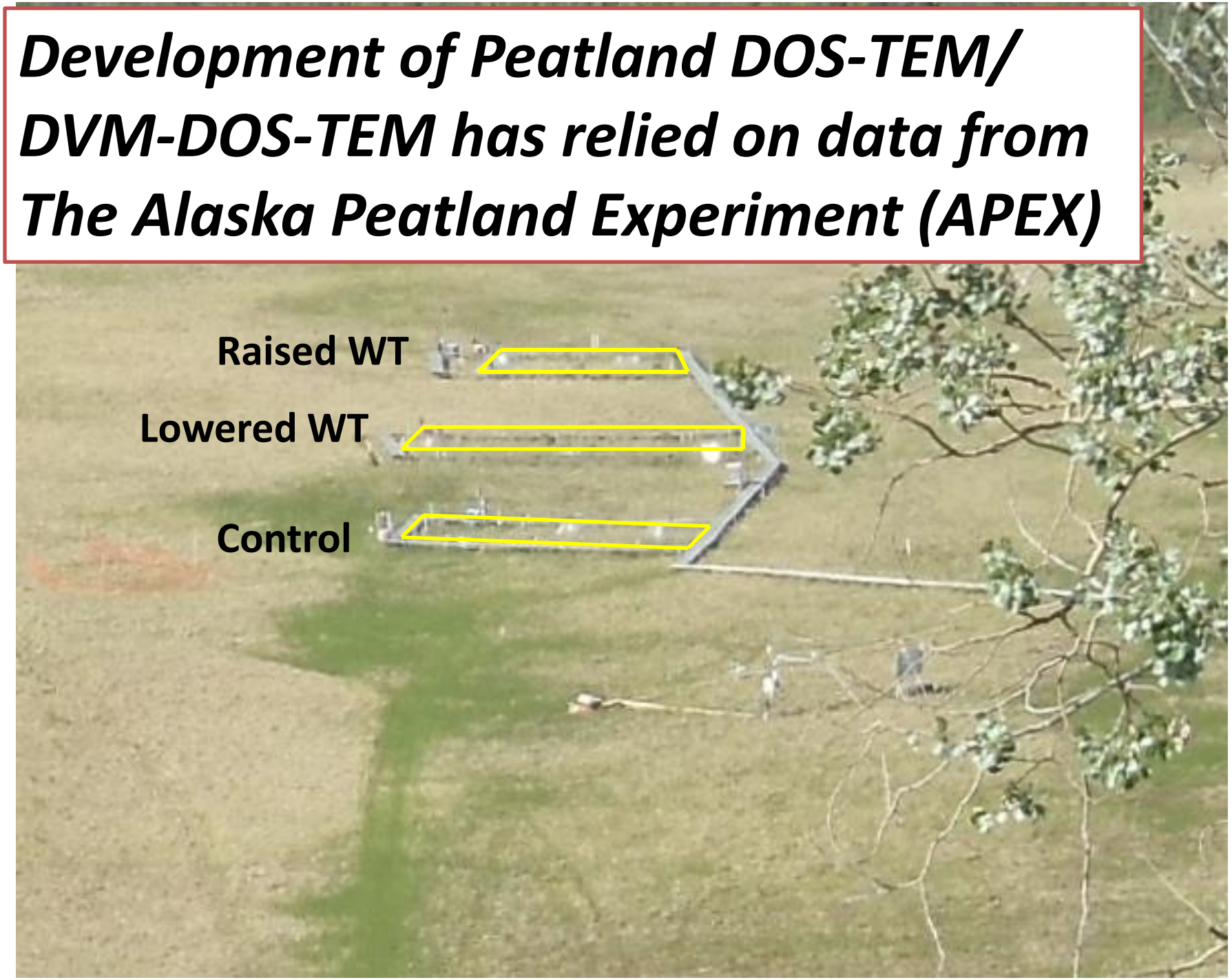
Bookkeeping Model: Dynamics of Thermokarst Land Cover Types 1950-2300 Using Contemporary Transition Rates



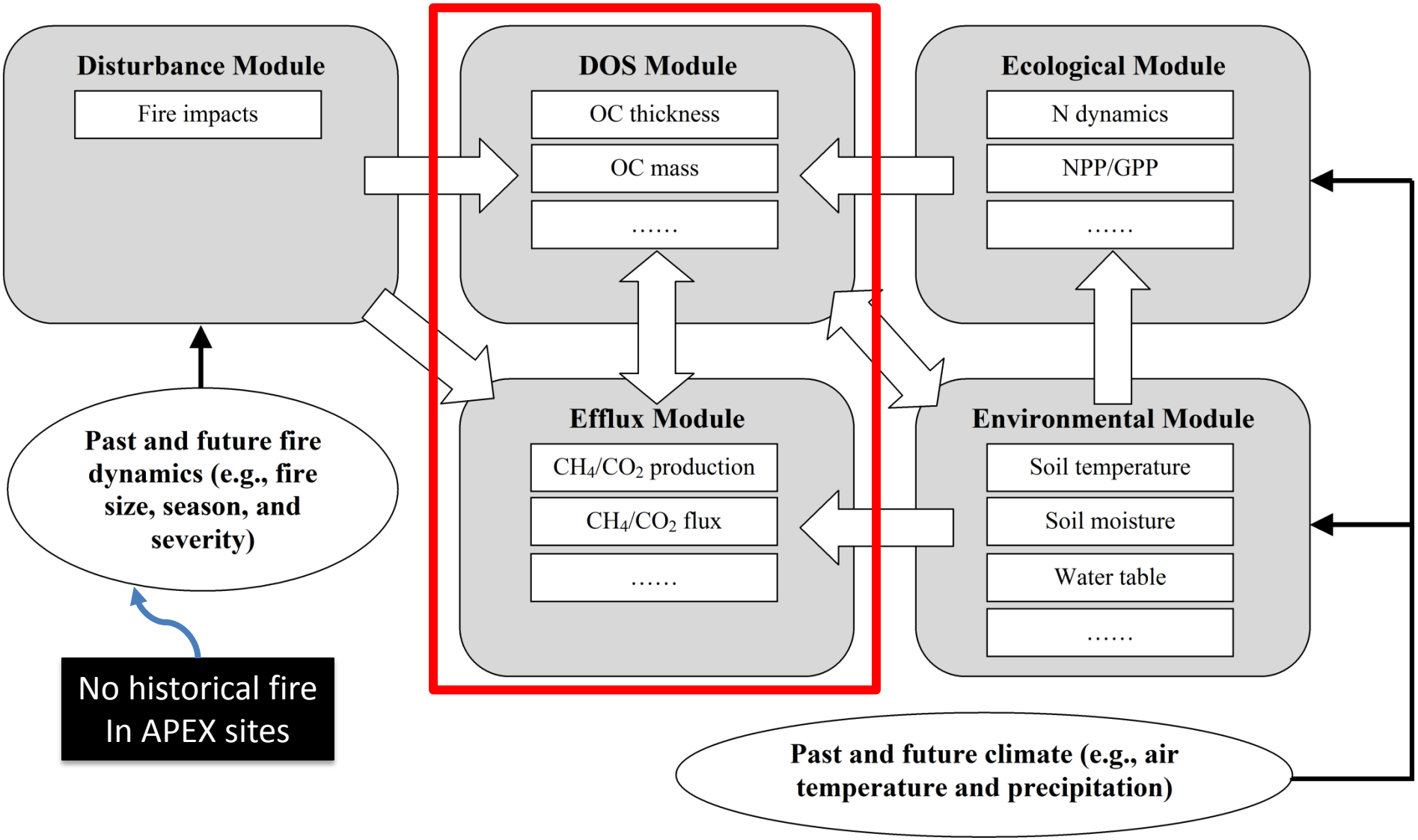
Bookkeeping Model: Consequences of Using Contemporary Transition Rates for Cumulative Changes in Carbon Storage



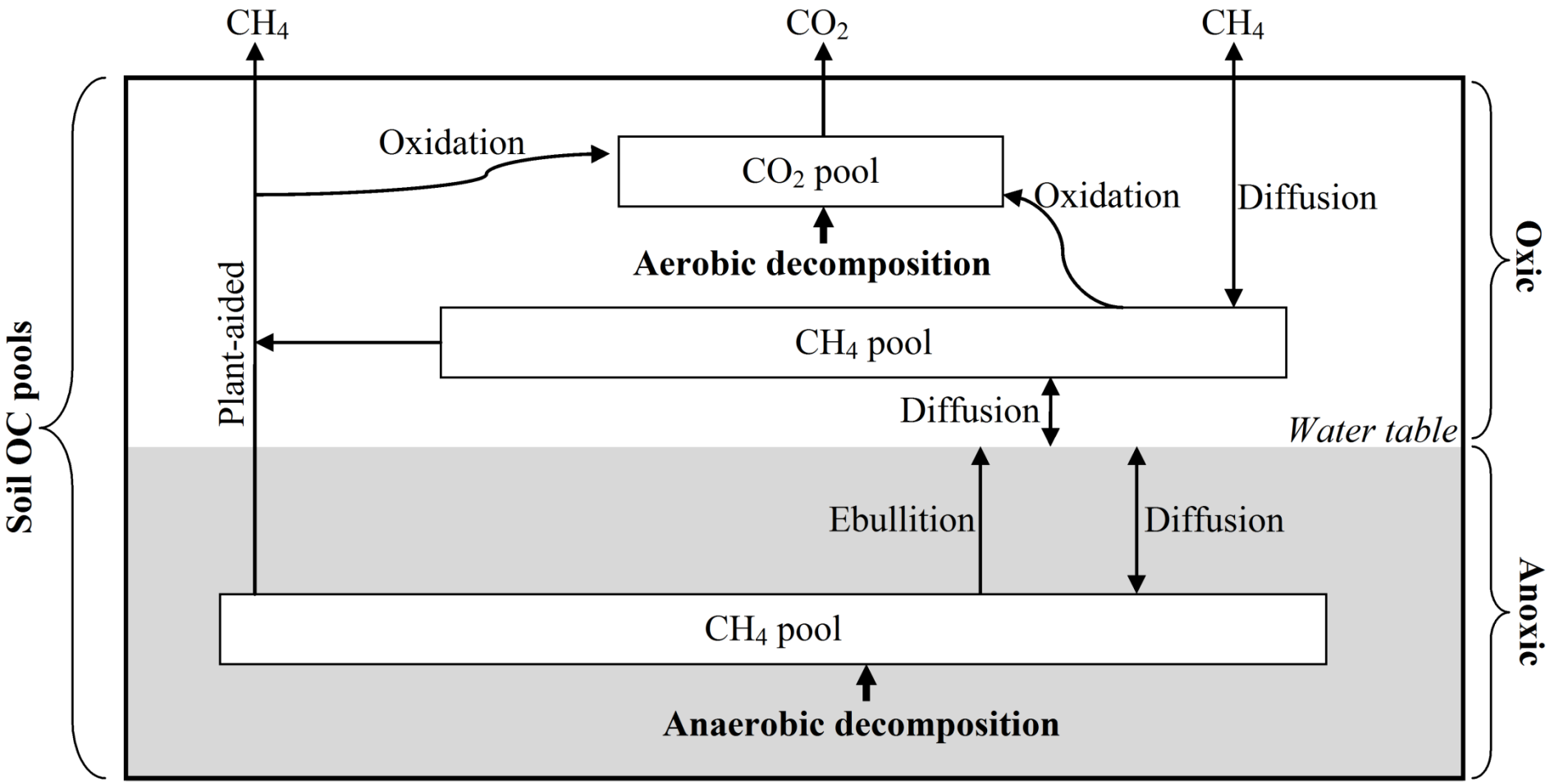
Development of Peatland DOS-TEM/ DVM-DOS-TEM has relied on data from The Alaska Peatland Experiment (APEX)



Peatland-DOS-TEM Model (Fan et al. 2013)

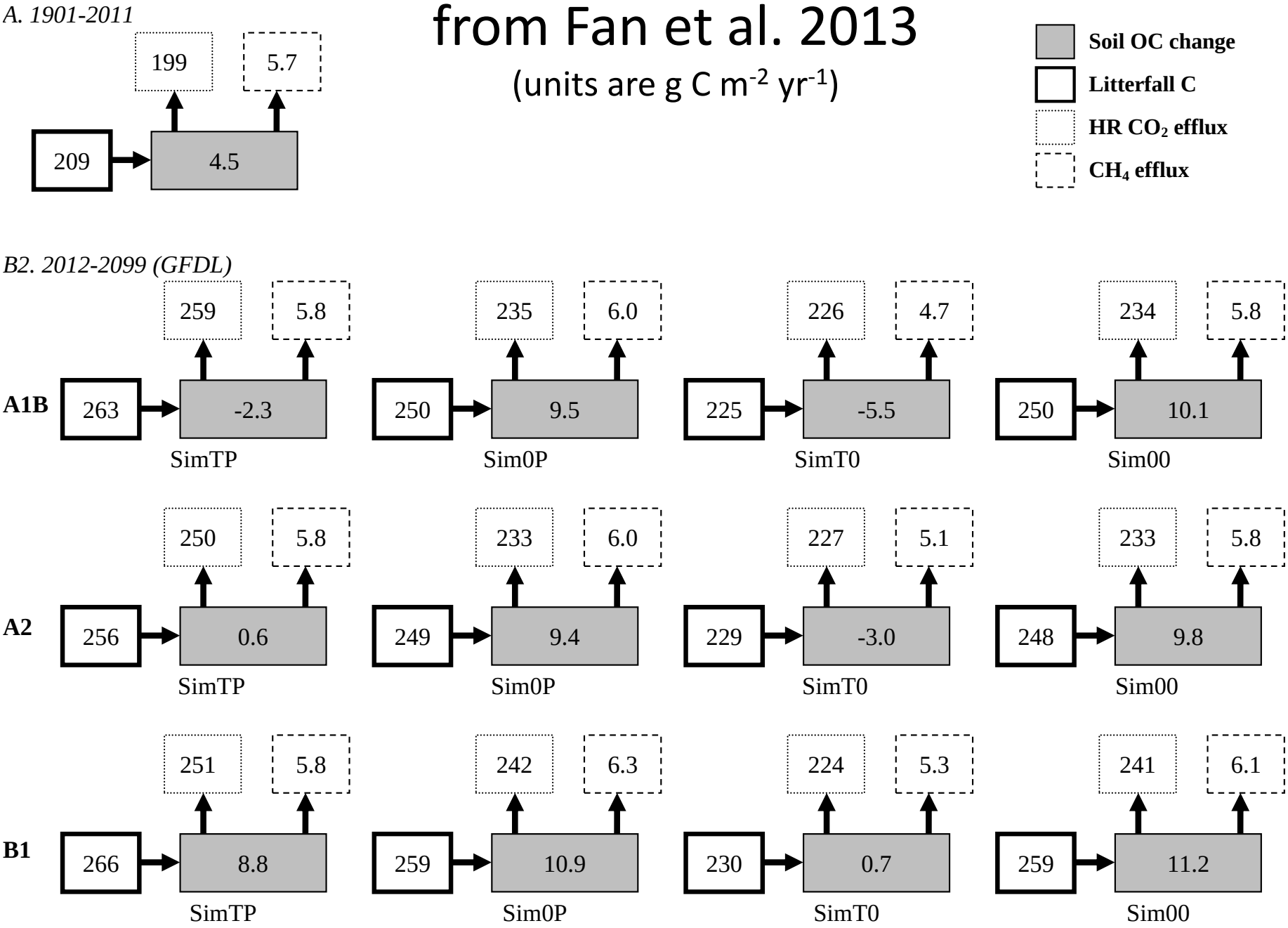


Peatland Model (Fan et al. 2013)



from Fan et al. 2013

(units are g C m^{-2} yr^{-1})



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  Zhaosheng Fan (now DOE-ANL): Fen

  Yanjiao Mi: Collapse Scar Bog, Permafrost Plateau, and biogeochemical consequences of thermokast disturbance based on data from chronosequence studies.
- Coupling of ATM with Peatland DVM-DOS-TEM

  This is an activity of the IEM team (science question: How does coupling (internal feedbacks of the system) influence wetland dynamics and biogeochemistry?)

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- Mack et al. DOE proposal in review
- TEM6 models DOC and DON loading

Addressing Uncertainties in BNZ Research