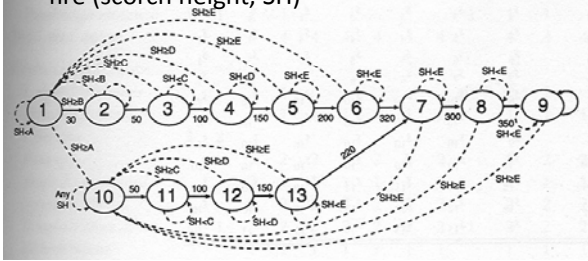


Successional Pattern for 13 Montana Habitat Types (Van Wagner 1973)

- Transitions are determined by stand age or fire (scorch height, SH)



Shugart 1998

Successional Pattern for 13 Montana Habitat Types

- State-transition matrix for successional changes
- System has 7 operators
- T_{time} = passage of time
- $T_{<A}$ = fire with scorch height < A
- T_{AB} = fire with scorch height between A and B
- likewise T_{BC} , T_{CD} , T_{DE} , $T_{>E}$

System states	Operators						
	T_{time}	$T_{<A}$	T_{AB}	T_{BC}	T_{CD}	T_{DE}	$T_{>E}$
S_1	S_1	S_1	S_1	S_1	S_1	S_1	S_1
S_2	S_2	S_2	S_2	S_2	S_2	S_2	S_2
S_3	S_3	S_3	S_3	S_3	S_3	S_3	S_3
S_4	S_4	S_4	S_4	S_4	S_4	S_4	S_4
S_5	S_5	S_5	S_5	S_5	S_5	S_5	S_5
S_6	S_6	S_6	S_6	S_6	S_6	S_6	S_6
S_7	S_7	S_7	S_7	S_7	S_7	S_7	S_7
S_8	S_8	S_8	S_8	S_8	S_8	S_8	S_8
S_9	S_9	S_9	S_9	S_9	S_9	S_9	S_9
S_{10}	S_{10}	S_{10}	S_{10}	S_{10}	S_{10}	S_{10}	S_{10}
S_{11}	S_{11}	S_{11}	S_{11}	S_{11}	S_{11}	S_{11}	S_{11}
S_{12}	S_{12}	S_{12}	S_{12}	S_{12}	S_{12}	S_{12}	S_{12}
S_{13}	S_{13}	S_{13}	S_{13}	S_{13}	S_{13}	S_{13}	S_{13}

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Successional Pattern for 13 Montana Habitat Types

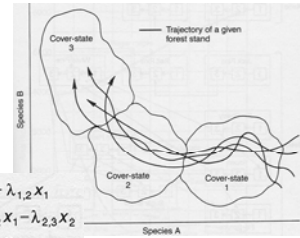
- Table with relative abundance of species in successional states
- Trees (> or <1.4m height), shrubs and subshrubs, forbs and grasses

	Importance values for system states												
	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}
Trees > 1.4 m in height													
<i>Picea canadensis</i>	3	2	1										
<i>Picea canadensis</i>	2	2	2	1	1					3	3	2	
<i>Pinus strobus</i>	4	4	5	5	5	6	6			4	4	5	
Trees < 1.4 m in height													
<i>Picea canadensis</i>	1	1											
<i>Picea canadensis</i>	1	1								1	1	1	
<i>Pinus strobus</i>	1	1	1	1	1	1	1	1	1	1	1	1	1
Total tree cover													
species and subshrubs	4	4	4	4	4	4	4	4	4	4	4	4	4
<i>Juniperus communis</i>	2	1								2	1		
<i>Prinosilla fruticosa</i>	1	1	1	1	1	1	1	1	1	1	1	1	1
<i>Ribes</i> spp.	2	2											
<i>Spiraea canadensis</i>	1	2	2	2	2	2	2	2	2	1	2	2	
<i>Spiraea betulifolia</i>	2	2	2	2	2	2	2	2	2	2	2	2	
<i>Symphoricarpos albus</i>	1	1	2	2	2	2	2	2	2	1	2	2	
<i>Berberis speciosa</i>	1	1	1	1	1	1	1	1	1	1	1	1	
<i>Total shrub cover</i>	2	2	4	4	4	4	4	4	4	2	4	4	4
Forbs and grasses													
<i>Galium aparine</i>	1	1	1	1	1	1	1	1	1	1	1	1	1
<i>Carex sp.</i>	2	2	3							2	3		
<i>Poa annua</i>	1	1	1	1	1	1	1	1	1	1	1	1	1
<i>Gnaphalium</i>	1	1	1	1	1	1	1	1	1	1	1	1	1
<i>Arca</i> spp.	2	1	1	1	1	1	1	1	1	2	1		
<i>Alnus</i> spp.	1	1	1	1	1	1	1	1	1	1	1	1	1
<i>Populus</i> spp.	2	2	1	1	1	1	1	1	1	2	1	1	1
<i>Total forb and grass cover</i>	5	5	5	5	5	5	5	5	5	5	5	5	5

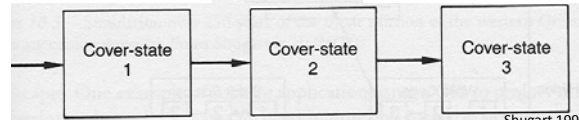
Shugart 1998

B. Differential Equations

- Forest succession of a large region
- Stand trajectories
- Compartment diagram
- Differential equations



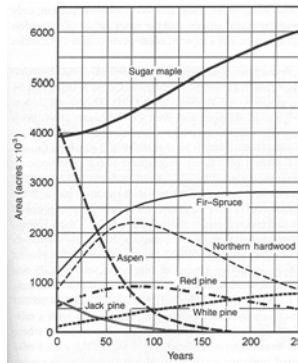
$$\begin{aligned} \dot{x}_1 &= F_1 - \lambda_{1,2} x_1 \\ \dot{x}_2 &= \lambda_{1,2} x_1 - \lambda_{2,3} x_2 \\ \dot{x}_3 &= \lambda_{2,3} x_2 \end{aligned}$$



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B. Differential Equations

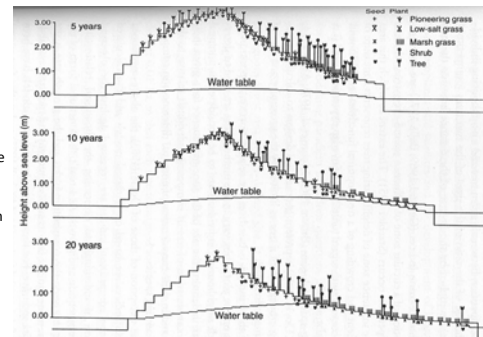
- Simulation of the mesic part of the Western Great Lakes system over 250 years



Shugart 1998

DUNE Simulation

- Patterns and dynamics of a barrier island vegetation
- Open ocean is to the left
- Over time the island moves landward and the water table on the right side of the island forms brackish marsh with scattered shrubs
- Shugart et al. 1988



Shugart 1998