Crest of adjacent uphill "step"

set.





NHI W CHA

2

hull

 Stair-step topography confined to areas of thick till.

CITY

Wilder

 Crests of steps generally contour around drainage basins. 1 0 1 2 km



#### **Process for forming the stair-step topography (moraines)**



# Summer retreat followed by a small advance during the winter forms the recessional moraine; essentially a small push moraine.



Summer recession followed by a small winter advance forms the next moraine.



### Are these annual recessional moraines?







If the ice sheet thinned at 9 m/year, 1,000 m of relief could be exposed in ~110 years If the ice sheet thinned at 13 m/year, 1,000 m of relief could be exposed in ~75 years

Mount Mansfield 1,340 m

## <sup>10</sup>Be Exposure Age Dates, Mount Mansfield

Bedrock 14.0 ∓0.3 ka Bedrock 13.5 ∓0.4 ka

Bedrock k 17.4 ∓0.3 ka ka ∡

14.5 ∓0.3 Bedrock

13.8 **∓0.3 ka Boulder** 

Corbett et al., 2019

Boulder 12.6 ∓0.4 ka Bedrock 15.2 ∓0.5 ka

Boulder 13.6 ∓0.6 ka

|4.0 ∓0.6 ka

**Boulder** 

13.1 ∓0.5 ka Boulder

> Within the error of the technique, exposure age dates indicate rapid thinning of the ice sheet from 1,200 to 400 m at ~13.9 ∓0.6 ka.

### Early Stage of Glacial Lake Winooski

Montpelier

Ice-Proximal varves deposited at Muzzy Brook ~14,100 years BP

orthfield Mountain

Ountain

Green M.

279 m

10 km

5



# Maximum extent of Glacial Lake Winooski in the Winooski and Lamoille River Valleys

- Ice Margin was near here ~14,100
  years ago
- By ~13,800 Glacial Lake Winooski had grown to its full extent.
- Rapid northward growth of Glacial Lake Winooski east of the mountains indicates how quickly the ice sheet was **thinning** and **retreating** east of the mountains compared to ice in the Champlain Valley.

#### **Conclusions**

- Flights of step-like landforms are composed of glacial till.
- Steps rarely have any positive relief.
- These steps generally contour along hillslopes, but can also slope into tributary valleys.
- These landforms may be small push moraines formed during the winter.
- If these landforms are annual recessional moraines, they indicate the ice sheet was thinning between 9 and 13 m/year.
- Rapid thinning of the ice sheet is consistent with exposure age dates and the rapid growth of Glacial Lake Winooski.