Tundra and Alpine
Tundra Biomes

- **Tundras** are characteristic of **Arctic** or **Alpine** regions where the severity of environmental conditions excludes tree growth. 30 days of 10°C ave. temperature and 8 mos cold season.
Tundra Biomes

- **Arctic tundra** occurs north of the boreal forest or taiga and thus form a treeless ring south of the zone of permanent ice (North America, Greenland, Eurasia).

Figure 9.1 Distribution of polar and high mountain tundra ecosystems and representative climatic conditions. Mean monthly temperatures are indicated by the line and mean precipitation for each month is shown by the bars. Station elevation, mean annual temperature and mean annual precipitation appear at the top of each climograph.
Tundra Biomes

- In the Antarctica, tundra area is very small because of the lack of large continental masses. Develops only on certain small Antarctic islands such as South George and MacQuarie Island on several spots on the most northerly extension of Antarctica proper (only 2 flowering plants!)

*Deschampsia antarctica*  
*Colobanthus quitensis*

Only 2 angiosperms - Antarctic hairgrass, pearlwort - on north facing slopes with moss and liverworts

Antarctic Peninsula - 600 mi or 1000 km from South America
Tundra Biomes

- In the wet subAntarctic, tussocks and megaherbs are characteristic

Tussock *Poa litorosa* in subantarctic Campbell Island

Megaherb *Pleurophyllum speciosum* in subantarctic Campbell Island
Tundra Biomes

- **Alpine regions** include Rocky Mountains, European Alps, Himalayas, and Austral-antarctic area (South Island, also Tasmania, Snowy Mts. in Australia).

Alpine summit, Bighorn Natl Forest, 9000ft, Wyoming with *Ranunculus adoneus* (snow buttercup)

Alpine tundra, Summit Lake, SW Idaho Springs, CO - *Rydbergia grandiflora, Polygonum bistortoides* (American bistort)
Tundra Biomes

- Exclude tropical ‘puná’ in Andes and similar high elevation peaks in East Africa (will deal with later). Links of Austral-antarctic region with puna (*Azorella*, Umbelliferae).

Peru - puna, 4300 ft

*Azorella* (Apiaceae)
Tundra Biomes

- Low precipitation; less than 400 mm per year, usually only up to 150 mm — less rain than most subtropical deserts!

- Subzero temperatures most of the year. A short vegetative period of generally less than 50 days between spring and autumn frost.
Tundra Biomes

- Permanently frozen sub-soil. **Permafrost** of variable depth.
- Consequences are physical barrier to roots, low temperatures suppress decomposition and promotes **peat**, and retard water percolation and promotes swampy or boggy conditions.

Locations of permafrost in tundra and high boreal
Tundra Biomes

- **Life forms:** chamaephytes (incl. subshrubs) and hemicryptophytes by far the dominant forms, often cushions

Tasmanian (Mt. Anne), montane cushions, largest in the world, *Abrotanella*, Asteraceae, 12 ft across with $10^6$ stems

Moss campion (*Silene acaulis*) and purple saxifrage (*Saxifraga oppositifolia*) at Svalbard
Tundra Biomes

- **Life forms:** grasses and sedges dominate (e.g., North America: *Poa arctica*, alpine meadow grass; *Carex bigelowii*, rigid sedge)

*Poa arctica* - alpine meadow grass

*Carex bigelowii* - arctic sedge
Tundra Biomes

- **Life forms:** vegetative reproduction common (bulbils or vivipary; eg. *Polygonum viviparum*, alpine bistort)
Tundra Biomes

- **Life forms**: apomixis, wind and “generalized” fly/bee pollinated - incidence of conspicuously-open bowl flowers increases towards the arctic

St. Paul Island, Alaska tundra

*Ranunculus* - buttercup
Tundra Biomes

- **Life forms:** apomixis, wind and “generalized” fly/bee pollinated - incidence of conspicuously-open bowl flowers increases towards the arctic

*Saxifraga* - saxifrage

*Cerastium* - chickweed

*Saxifraga* - saxifrage

*Papaver* - poppy
Tundra Biomes

- **Life forms:** Polyploidy

Frequency of **polyploids** (black %) in the floras of various territories in the Northern Hemisphere (from Love and Love, 1974)
Tundra Biomes

- Life forms: Polyploidy

Table 24.1. Frequency of polyploid species of angiosperms in different latitudinal zones in Eurasia and the Arctic. (condensed from Löve and Löve 1957; and Hanelt 1966)

<table>
<thead>
<tr>
<th>Area</th>
<th>Latitude N°</th>
<th>Polyploids, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sicily</td>
<td>36–38</td>
<td>37.0</td>
</tr>
<tr>
<td>Rumania</td>
<td>44–47</td>
<td>46.8</td>
</tr>
<tr>
<td>Hungary</td>
<td>46–49</td>
<td>48.6</td>
</tr>
<tr>
<td>Pardubice, CSR</td>
<td>50</td>
<td>52.3</td>
</tr>
<tr>
<td>Central Europe</td>
<td>46–55</td>
<td>50.7</td>
</tr>
<tr>
<td>Schleswig-Holstein</td>
<td>54–55</td>
<td>54.5</td>
</tr>
<tr>
<td>Denmark</td>
<td>54–58</td>
<td>53.5</td>
</tr>
<tr>
<td>England</td>
<td>50–61</td>
<td>52.8</td>
</tr>
<tr>
<td>SW Greenland</td>
<td>60–62</td>
<td>74.0</td>
</tr>
<tr>
<td>Faroes</td>
<td>62</td>
<td>71.0</td>
</tr>
<tr>
<td>Iceland</td>
<td>63–66</td>
<td>71.2</td>
</tr>
<tr>
<td>Sweden</td>
<td>55–69</td>
<td>56.9</td>
</tr>
<tr>
<td>Finland</td>
<td>60–70</td>
<td>57.3</td>
</tr>
<tr>
<td>Norway</td>
<td>58–71</td>
<td>57.6</td>
</tr>
<tr>
<td>NW Alaska</td>
<td>68</td>
<td>59.3</td>
</tr>
<tr>
<td>Devon Island</td>
<td>75</td>
<td>76.0</td>
</tr>
<tr>
<td><strong>Spitsbergen</strong></td>
<td><strong>77–81</strong></td>
<td><strong>74.0</strong></td>
</tr>
<tr>
<td>Franz Joseph Land</td>
<td>80–82</td>
<td>75.0</td>
</tr>
<tr>
<td>Peary Land</td>
<td>82–84</td>
<td>85.9</td>
</tr>
</tbody>
</table>

Spitsbergen
Tundra Biomes

- **High arctic** - herbs
- **Middle arctic** - dwarf shrub
- **Low arctic** - shrubby heath, small trees

Tundra SubBiomes

Mean July temperature: 0-3 °C
Summer warmth index <6 °C

Fog-shrouded islands near arctic icepack

Dominated by herbs - the “high arctic”

Herb subzone

Papaver - poppy
Tundra SubBiomes

Dominant plant growth forms: Cushion forbs, mosses, lichens

Number of vascular plant species in local flora <50

Herb subzone
Mean July temperature: 3-5 °C
Summer warmth index: 6-9 °C

Transitional to subzone C and together they have been called the “middle arctic”

Prostrate shrub (or Dryas) subzone

Dryas - mountain avens (Rosaceae) & pollen
Tundra SubBiomes

Dominant plant growth form: Prostrate dwarf shrubs

Number of vascular plant species in local flora: 50-100

Prostrate shrub (or Dryas) subzone

*Dryas octopetala*

*Salix herbacea* - least willow

*Salix polaris* - polar willow

*Cerastium regellii* - chickweed
Tundra SubBiomes

Mean July temperature: 5-7 °C
Summer warmth index: 9-12 °C

hemi-prostrate dwarf-shrub
(or *Cassiope*) subzone

*Cassiope tetragona* (Ericaceae) - Arctic bell heather
Dominant plant growth forms: Hemi-prostrate dwarf shrubs, sedges

Number of vascular plant species in local flora: 75-150

Carex bigelowii - arctic sedge

Juncus trifidus - rush

hemi-prostrate dwarf-shrub (or Cassiope) subzone

Cassiope tetragona (Ericaceae) - Arctic bell heather
Mean July temperature: 7-9 °C
Summer warmth index: 12-20 °C
Dominant plant growth forms: Erect dwarf shrubs, sedges, mosses
Number of vascular plant species in local flora: 125-250

Erect-shrub (or *Betula nana*) subzone
Mean July temperature: 9-12 °C
Summer warmth index: 20-35 °C
Dominant plant growth forms: Low shrubs, tussock sedges, mosses
Number of vascular plant species in local flora: 200-500

Low shrub (or Alnus) subzone
Tundra Biomes

- **Floristics:** Circum-boreal distribution common, Amphi-atlantic, Amphi-pacific often the case as well

*Rhododendron lapponicum* in Wisconsin

*Figure 4.7* The range of *Rhododendron lapponicum* (Lapland rosebay) showing its bicentric distribution in Scandinavia. (Adapted from Gjærevolv, 1963.)
Tundra Biomes

- **Floristics:** Circum-boreal distribution common, Amphi-atlantic, Amphi-pacific often the case as well — sometimes as different *varieties*

*Vaccinium vitis-idaea* var. *minus*  
(mountain cranberry in North America)

*Vaccinium vitis-idaea* var. *vitis-idaea*  
(lingon in Eurasia)
Tundra Biomes

- **Faunistics:** Circum-boreal distribution common as with caribou (North America) and reindeer (Eurasia) — slightly different looking but same species *Rangifer tarandus* (actually a number of subspecies)
Tundra Biomes

- **Faunistics:** other Circum-boreal distributions

- Arctic hare
- Arctic fox
- Arctic squirrel
- Muskox
Alpine Biomes

- **Floristics:** Alpine vegetation does not form continuous expanses but are best characterized as islands.

Eagles Nest Wilderness, Colorado

Alpine meadow distribution - European alps
Alpine Biomes

- **Floristics**: Alpine vegetation shows very close resemblances both in life-forms and in species composition to that of the Arctic tundra. A whole group of species are common to both and referred to as 'Arctic-Alpine' species.

*Salix arctica* - Alpine willow

*Cerastium* - chickweed, Colorado Rocky Mts.
Alpine Biomes

- **Floristics:** Important Alpine families - Gentianaceae (gentians), Primulaceae (primroses)

*Primula farinosa & Gentiana verna*, Austrian alps
Alpine Biomes

- **Floristics:** Important Alpine families - Ericaceae (blueberries), Rosaceae (avens)

*Rhododendrum hirsutum* in Alps

*Dryas*, Switzerland Alps
Alpine Biomes

- **Floristics:** Important Alpine families - Portulacaceae (spring beauty, bitterroot)

*Claytonia megarhiza* - alpine spring beauty - western North America

*Lewisia rediviva* - bitterroot - Montana
Tundra Biomes

- Origins

- forest grew at high latitudes across North America and Eurasia until the late Pliocene (3 mya)

- fossil remains of dawn redwood, swamp cypress, \textit{Ginkgo}, and other broad-leaved genera are common throughout the Canadian Arctic and Eastern Siberia

- Alaska (most of it) switched over from coniferous forest to shrubby and herbaceous tundra during the Pleistocene epoch (2 mya)

- bipolar distributions occur because of high elevation zones in mountain ranges running through North and South America

- the alpine flora in southern Hemisphere appear to be relictual from an extensive tundra flora in Antarctica prior to being covered by ice
Tundra Biomes

- **Future?** environment360 report
- most impacted biome by warming temperatures
- +3-5°F in last 50 years; up to 10°F above pre-industrial levels by 2100
- shift from “herbaceous” to shrub tundra (“tundra” means “treeless plain” in Finnish)
- increased incidence of fire, slumping hillsides
- 2X as much C exists in permafrost as in atmosphere . . .
- . . . and large amounts of methane – even more potent greenhouse gas